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RESEARCH NEWS

05 | 2015 ||

1 Detecting skin cancer quickly

Melanoma is aggressive and life-threatening. If it is not detected early, the prospects of recovery drop. Screening is complicated, though. Together with several project partners, Fraunhofer researchers have developed an assistance system that helps dermatologists with diagnosis.

2 WPC furniture with low flammability

Wood is a popular material in interior design, but its water absorbency limits its use in bathrooms, where natural wood easily becomes discolored or moldy. Fraunhofer scientists and partners have developed a wood-polymer composite material for furniture that is resistant to humidity and has low flammability.

3 Generating eco-friendly power with metal rotor blades

Wind turbines deliver environmentally friendly electricity. Yet the fiber-reinforced plastics often used in very large rotor blades are almost impossible to recycle. Not so with steel blades: since these are composed of steel, their recyclability exceeds 90 percent. Plus they cost significantly less than comparable plastic blades.

4 Automated counting of tumor cells in blood

Biological and medical scientists have been using flow cytometry to count cancer cells for the past 40 years. But the large instruments are expensive and can only be operated by trained personnel. By contrast the PoCyton cytometer developed by Fraunhofer researchers is cheap to produce, no bigger than a shoebox, and automated.

5 Improved detection of radio waves from space

Geodesy is the scientific discipline that deals with the measurement of the Earth. One of the measurement techniques it employs uses radio waves from far-distant objects in space to determine factors such as the movement of tectonic plates. A high frequency amplifier promises to boost the performance of the radio telescopes this method requires.

6 Economic and effective security design

Operators of infrastructures such as power grids and airports are expected to ensure a high level of security – but their financial means are limited. Fraunhofer researchers have developed an analysis tool for evaluating the effectiveness and economic viability of different security measures as part of an EU-funded project.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 66 Fraunhofer Institutes and research units at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 24,000, who work with an annual research budget totaling 2 billion euros. About 70 percent of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the Americas and Asia serve to promote international cooperation.

Editorial Notes:

RESEARCH NEWS l Frequency: monthly l ISSN 09 48 - 83 83 | Published by Fraunhofer-Gesellschaft l Communications l Hansastraße 27 l 80686 München l Phone +49 89 1205-1333 l presse@zv.fraunhofer.de | Editorial Staff: Beate Koch, Britta Widmann, Tobias Steinhäußer, Janine van Ackeren, Tina Möbius l Reprints free of charge.We encourage you to favor the online version and newsletter via www.fraunhofer.de/fhg/EN/press. This bulletin is also available in German as FORSCHUNG KOMPAKT.

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Detecting skin cancer quickly

According to the German Cancer Society, around 200,000 people contract skin cancer every year. Melanoma is particularly dangerous. Once it has penetrated deeper layers of skin, the prospects of recovery drop to less than ten percent. Routine screening is the only way to detect critical skin changes at an early stage. A doctor uses a dermatoscope – a magnifier that peers into deeper layers of skin – to examine abnormal moles, called melanocytic nevus by experts, for features such as size, texture and edges and to observe whether they change over time. Since most people have many moles, the procedure is time consuming. What is more, keeping an eye on changes such as the growth of individual moles is difficult since a doctor often cannot identify them with absolute certainty during the next exam.

Full body scanner helps diagnose skin conditions

At the initiative of and together with the University Clinic for Dermatology and Venerology in Magdeburg as well as the partners Dornheim Medical Images GmbH and Hasomed GmbH, researchers at the Fraunhofer Institute for Factory Operation and Automation IFF have developed a full body dermatological scanner intended to help doctors diagnose skin conditions in the future. "The scanner delivers standard data for the evaluation of skin. At the same time, it improves documentation of the development every single conspicuous mole," says Dr. Christian Teutsch from the Fraunhofer IFF. When the exam starts, the surface of the patient's skin is scanned from different positions and broken down into approximately one hundred individual scans. Such image documentation already exists. "The crucial point, however, is that the actual size and changes in growth cannot be clearly discerned solely on the bases of scans," explains Teutsch. That is why the Dermascanner generates additional scanned 3D data, which are fused with the 2D scans, thus assigning a scale to every single pixel in the image. The experts are integrating several 3D sensors in the scanner so that this functions. The sensors and cameras are calibrated so that their location in space is known precisely. The beams of light from the camera striking the mole can be assigned a precise 3D distance. Even when different scans have not been taken from the exact same distance – which is hardly likely – the doctor can apply the scale to determine the actual proportions precisely. The scanned data and scans are fed into analysis software and analyzed and presorted by automatic classification. The software compares any existing earlier scans of development with current images. "Our technology detects growth upwards of half a millimeter," says Teutsch. Another advantage is that the scanned 3D data enables a doctor to clearly locate every single mole again.

"A single patient frequently has several hundred moles," says Prof. Harald Gollnick, Director of the University Clinic for Dermatology and Venerology. When such a high risk patient visits the doctor again after a while, common methods of examination cannot discern whether the location and size moles on skin covered with pigmentation

spots are still identical. According to Gollnick, "The new full body, early skin cancer detection system makes a nearly standard evaluation of skin condition and changes possible for the first time."

"The diagnosis itself is and remains the doctor's purview," stresses Teutsch. Doctors have both the scan results and the scans with an additional 3D depth map, which records the distance of the individual pixels in the scan, at their disposal to make a diagnosis. Since minimal changes of an abnormal mole can already be significant, the scanned and image data have to be comparable at any time and also among different equipment. That is why another important aspect of development was the standardization of the Dermascanner – another of the Fraunhofer IFF's specializations. "We calibrate every relevant element such as light sources and convert the scans into a standard color space," explains Teutsch. This assures that effects such as fading luminosity over time do not affect the results.

The Dermascanner is just about ready to be marketed. The first pilot systems have been built. What is more, the project team was recently awarded the 2014 Hugo Junkers Award for Research and Innovation in Saxony-Anhalt for its development by the Ministry of Higher Education, Research and Economic Affairs (www.hugo-junkers-preis.de). Now, investors have to be found in order to mass produce the skin scanner.

The Dermascanner scans the surface of a patient's skin from different positions and divides it into around one hundred individual images. (© Dirk Mahler/Fraunhofer IFF) | Picture in color and printing quality: www.fraunhofer.de/press

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WPC furniture with low flammability

Resource-saving wood-polymer composites (WPCs) are the latest trend in materials for garden furniture and other outdoor applications, especially for terrace decking and also for weatherboarding and fencing panels. As part of the EU-sponsored LIMOWOOD project, researchers at the Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut WKI in Braunschweig are now collaborating with industrial partners in Belgium, Spain, France and Germany on the development of materials suitable for pressing into moisture-resistant WPC boards for indoor furniture manufacturing.

These boards are composed of around 60 percent wood particles and 40 percent thermoplastic material, generally polypropylene or polyethylene. Both wood and plastic components can be sourced from recycling streams. The wood component in WPC boards can be replaced by other lignocellulose products derived from the fibrous part of plants such as hemp or cotton, or the husks of rice grains and sunflower seeds. All of these materials are 100-percent recyclable. Moreover, the pressed WPC boards produced by the WKI researchers are formaldehyde-free. "The controversial question of formaldehyde emissions due to the binder used in conventional pressed wood products is therefore not an issue in this case," says WKI research scientist Dr. Arne Schirp.

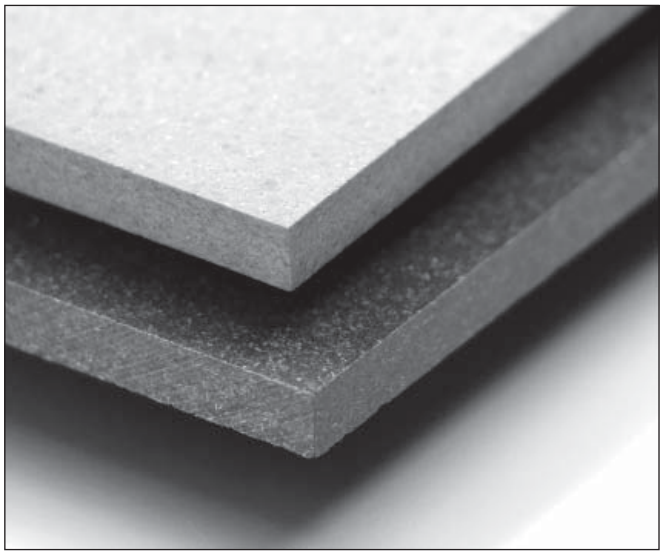
Tests prove low flammability of WPC boards

By choosing appropriate additives, the researchers were able to enhance the fire-retardant properties of their WPC boards. They initially developed their formula on a laboratory scale, using commercially available, halogen-free fire retardants which were added to the wood-polymer mixture during the melt phase. The first step involved determining the limiting oxygen index of the item under test: this parameter defines the behavior of plastics or wood-filled plastic compounds when exposed to flames. It represents the minimum concentration of oxygen at which the material will continue to burn after catching fire. The higher this value, the lower the material's flammability. Schirp and his colleagues obtained the best results with a combination of fire retardants such as red phosphorus and expanded graphite. The limiting oxygen index of WPC boards treated in this way extends up to 38 percent, provided the wood particles they contained were also flame-proofed. By comparison, the limiting oxygen index of a standard wood particle board is 27 percent, and that of an untreated WPC board is 19 percent. Even in a single-flame source test, in which a Bunsen burner is held against the test sample, the treated WPC boards demonstrated a high fire resistance. Even after 300 seconds' exposure, the boards didn't catch fire. By contrast, the reference samples – of a standard wood particle board and an untreated WPC board – caught fire and continued to burn.

Another particular feature of the new WPC material is that it absorbs very little water and is thus highly suitable for use in bathrooms and kitchens. Even after being immer-

sed in boiling water for five hours, the material emerges intact, whereas conventional wood particle board was completely destroyed by this test. The only limiting factor on applications of WPC is its inability to support high static loads. But even here, it has been possible to increase its bending strength to a level that far exceeds that of conventional particle board by utilizing a judicious mix of component materials.

Wood-polymer composites can be produced in many ways. The most commonly used processes are injection molding and extrusion, in which the various components – wood fibers, thermoplastic materials, and additives – are melted under high pressure at a high temperature and formed in a continuous mold. Arne Schirp's team has placed its focus on press technology, because it is the best way to produce boards for use in furniture construction. "The resulting boards have the same visual appeal as all-wood products and can be glued or screwed together to produce attractive furniture. They're suitable for all decorative, non-loadbearing elements." But there are many other applications for wood-polymer composites, including exterior weatherboarding of buildings, the construction of trade-show booths, and interior fittings for houses and ships. Through their development work, the partners in the LIMOWOOD project aim to fill the gap between the high and low ends of the furniture market, which ranges between expensive and not necessarily ecologically sound materials and cheap products made of particle or fiber board, which at present are mainly produced using formaldehyde-based binders. The WKI researchers will be presenting prototypes of their flame-resistant WPC boards at the Interzum trade show in Cologne from May 5 to 8 (Boulevard, B077).



WPC board without (above) and with (below) flame-proofing. (© Fraunhofer WKI) | Picture in color and printing quality: www.fraunhofer.de/press

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Generating eco-friendly power with metal rotor blades

Wind turbines feed eco-friendly power into the grid. To keep their weight down, the majority of larger rotor blades are made from fiber-reinforced plastics. These materials are rarely recycled at present, in part because it is very complicated to do so. Researchers at the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz are therefore focusing on metal, and especially steel, as a blade material. In smaller installations, the greater weight of the steel blades is inconsequential; as installations get larger, light alloys can be used to keep blade weight down. Collaborating with colleagues from the Free University Brussels (VUB) in the HyBlade project, Fraunhofer IWU is developing the required aerodynamics as well as the necessary manufacturing process chains. Manufacturing steel blades offers numerous advantages. "First, it makes turbines significantly more ecological, since more than 90 percent of the steel can be recycled – so using metal rotor blades makes wind power truly environmentally friendly," explains Marco Pröhl, a researcher at the IWU. "What's more, compared to similar blades made of fiber-reinforced plastic, the cost of rotor blade mass production drops by as much as 90 percent – and the blades can be manufactured more accurately."

Metal blades can also be produced more quickly. Provided that processes are run in parallel – for instance, that a new metal sheet is fed into the production line as soon as the first blade has completed the first process step – then a completed rotor blade rolls off the conveyor belt roughly every 30 seconds. With fiber-reinforced plastics, the same process usually takes several hours.

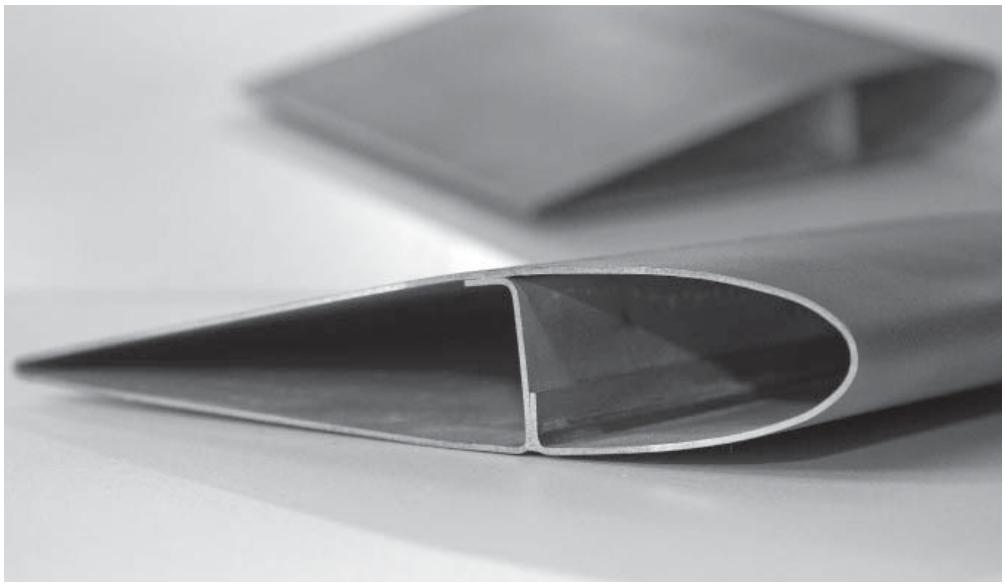
Suitable for large-scale and automated manufacturing processes

The primary cause of these differences lies in the manufacturing process. Fiber-reinforced plastic blades often require significant manual processing: first, a suitable mold has to be made for the blades. Depending on the production variant, workers layer fiber mats in this mold, inject resin, and leave the component to harden for several hours in an oven. This produces two half shells; once their edges have been trimmed, the halves can be glued together. These steps can be performed simultaneously, as in sheet metal blade manufacturing – but that doesn't make them any quicker. It would take dozens of installations running in parallel to produce plastic blades at the same rate as metal ones.

In contrast, it is easy to automate the manufacturing metal rotors: the processes are similar to those in the auto industry, which means they are suitable for series production. The researchers start with a flat sheet of metal, which they fold using a bending die to give it a typical blade shape. Next, they laser weld the edges to form a closed profile. After placing the preformed piece in a tool with the desired final shape, the researchers then pump a reusable water-oil mixture into the interior of the blade and

put it under several thousand bars of pressure. This is equivalent to the pressure experienced underwater at a depth of many thousands of meters. This effectively inflates the blade, giving it its final form. "The fact that we're shaping the blade from the inside out lets us compensate for any inaccuracies in previous steps," explains Pröhl. "The geometry ends up perfect after the first production step, with the blades matching the flow profile milled into the tool to within 0.1 millimeters."

The researchers have already produced a blade 15 centimeters wide and 30 centimeters long, using it to optimize the individual processing steps. Their next step will be to produce an entire rotor for a vertical axis turbine with 2.8-meter-long blades and a diameter of two meters. Once it is installed at a test site for small wind turbines on the Belgian coast, it will be put through its paces.



Technology demonstrator: formed from a 1.0 mm steel sheet and featuring integrated, folded reinforcement, the rotor blade was given its final shape with the help of an oil-water mixture. (© Fraunhofer IWU) | Picture in color and printing quality: www.fraunhofer.de/press

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Automated counting of tumor cells in blood

Both chemotherapy and radiotherapy place a high burden on the patient's body. Their discomfort could be reduced if it was possible to reliably ascertain the results of this treatment, but until now the only way to do this was by computerized tomography (CT) scans. A quicker and simpler analysis technique may soon be available, within a couple of years. All the PoCyton flow cytometer needs is a sample of the patient's blood, and within a short time the attending physician will know how many tumor cells are circulating in the blood. Cancerous growths release cells into the bloodstream, and their number provides an indication of how effective the therapy has been: If the number of cancerous cells decreases in the course of treatment, it shows that it has been effective.

Smaller, faster and easier to operate

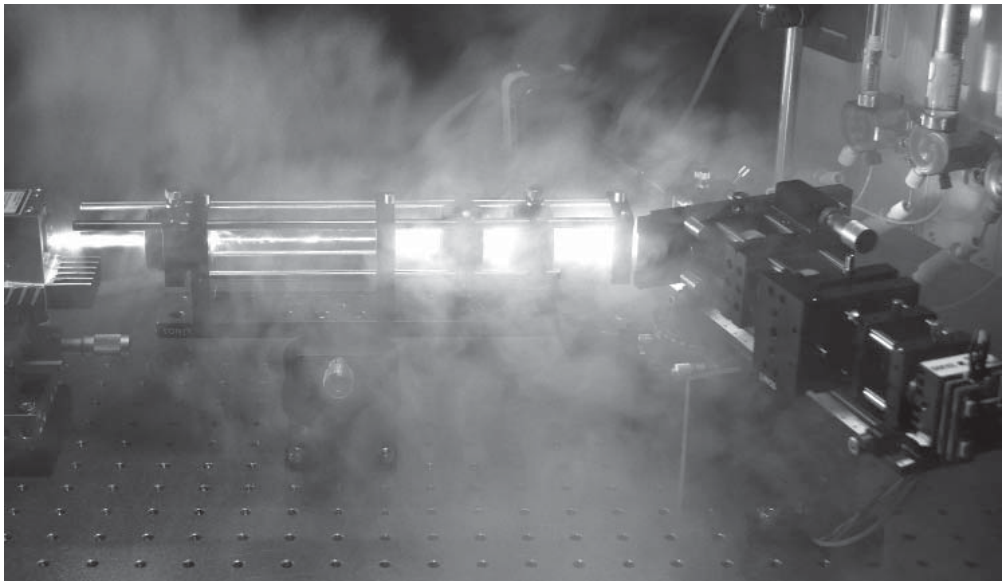
Existing flow cytometers are capable of measuring the quantity of tumor cells circulating in the bloodstream but they often cost up to 300,000 euros and take up a huge amount of space – equivalent to two washing machines. Moreover, each test cycle lasts several hours. All in all, such techniques are too expensive and time-consuming for everyday clinical practice. A further downside of these cytometers is that they can only be operated by trained specialists and require daily recalibration. An alternative is the PoCyton device developed by researchers at the micro-engineering branch of the Fraunhofer Institute for Chemical Technology in Mainz (IMM). As Dr. Michael Baßler, research scientist at ICT-IMM, explains: "Our flow cytometer enables such tests to be carried out around twenty times faster. Their cost is also lower by several magnitudes, which takes us into a new dimension that makes these devices much more affordable for clinical applications." Another advantage of the new flow cytometer is the use of miniaturized components that have reduced its size to that of a shoebox. Measurements are carried out automatically, and no calibration is necessary.

Flow cytometry works on the following principle: A fluorescent dye is injected into the blood, and the dye molecules bind to the tumor cells, leaving all other cells unmarked. Whereas until now the physician had to add the dye to the blood sample manually, this now takes place automatically in the PoCyton process. The blood is funneled through a narrow focal area, causing all suspended cells to pass one by one in front of a laser spot detector. The light causes the cells to which the dye has attached itself – the tumor cells – to fluoresce, enabling the device to detect and count them. This narrow passage is the key to the PoCyton process. "We designed it in such a way that the throughput is 20 times greater than in conventional cytometry," says Baßler. At the same time, its geometry was chosen to ensure that no cells pass in front of one another. In this way the scientists can be sure that the system registers every single object flowing past the detector – and that no cell is hidden behind another. Such errors could have dramatic consequences, because a mere ten-milliliter sample of blood

contains around one billion suspended objects. Of these, only five are circulating tumor cells, even in a severely sick patient. The researchers have mastered the individual steps such as adequate sensitivity, automatic sample preparation, and analysis. They are now combining these separate process steps to create a fully function demonstrator which they expect to complete by the summer of 2015.

Legionella risk assessment by testing water quality in situ

Potential applications of PoCyton go beyond the counting of tumor cells. For example, in collaboration with Swiss company rqmicro the researchers intend to use the device to detect legionella bacteria in drinking water. These members of the staphylococcus family can cause the sometimes deadly lung infection known as Legionnaires' disease. Until now, the only way of testing domestic drinking water involved sending a water sample to a laboratory and waiting about ten days for the results. For this is the time needed to multiply the water-borne bacteria in a Petri dish so that their concentration can be measured. "Our flow cytometer can perform the same analysis within an hour," says Baßler. A plumber can use the portable device to test the water in situ. All he has to do is place a water sample in the device and start the process. According to rqmicro, a commercial version of the product should be available within about two years.



The measuring channel that forms the key component of the cytometer is visible on the right-hand side of the image. (© Fraunhofer ICT-IMM) | Picture in color and printing quality: www.fraunhofer.de/press

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Improved detection of radio waves from space

Together with their Spanish colleagues from the Instituto Geográfico Nacional and the University of Cantabria, researchers from the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg have developed a very sensitive high frequency amplifier for radio telescopes used on Earth. The amplifier generates extremely little internal electromagnetic noise and will help measure our planet from space more precisely than ever before. The position of radio telescopes will be pinpointed with a precision to approximately one millimeter – a tenfold improvement in accuracy. The measurement technique relies on radio telescopes picking up radio waves emitted by objects in space; the more accurately scientists can determine the positions of the radio telescopes, the more precisely they can measure various characteristics of the Earth. "Because the radio telescopes are placed far apart at sites all round the world, they detect the radio waves at different times," explains Dr. Mikko Kotiranta, a researcher at Fraunhofer IAF. Determining the exact distances between telescopes becomes a matter of the accuracy with which these time lapses can be measured – a process in which every picosecond, or trillionth of a second, counts. Combining several of these measurements allows scientists to determine with the greatest accuracy variables such as the length of day and the movement of tectonic plates, poles and the Earth's axis. "This information is useful for a number of applications, for instance determining satellites' orbits with greater precision," says Kotiranta.

The radio waves in question come from quasars, which are supermassive black holes at the center of galaxies billions of light years away from Earth. As with any other celestial object, quasars are constantly moving through space, but they are so far away from Earth that from our perspective they appear to stand still. We also see them as a point-like objects, which makes them ideal fixed points of reference for measuring the Earth. By the time the radio waves are picked up by the radio telescopes, however, the signal is extremely weak. This is because of the enormous distance they have had to travel through space. Another obstruction to obtaining a clear signal detection is the interfering electromagnetic noise generated by all bodies at temperatures above absolute zero – 0 Kelvin or minus 273 degrees Celsius. From an electromagnetic perspective, absolute zero would be the temperature required for total silence. "The general rule is that the colder it is, the less noise is generated," says Kotiranta.

A low-noise amplifier that works in the freezing cold

To address this problem, the researchers took a previous model of the amplifier and put it in an extra-cold freezer at a temperature of 22 Kelvin, or minus 251 degrees Celsius. Extreme conditions that exceed the capacities of electronic components. Or perhaps not? To find out, the researchers at Fraunhofer IAF developed a mathematical model that describes how radio frequency circuits should be designed if they are to function at extremely low temperatures. Teaming up with their project partners, the researchers

developed a microwave amplifier in the cleanroom and the laboratory, which was then tested at different temperatures. They used the results to refine the model so that its forecasts corresponded more closely with the recorded data. This updated model provided the basis for a new amplifier prototype, which the researchers continued to refine until they finally succeeded in developing a low-noise amplifier that fulfilled all the necessary requirements: an amplifier that works perfectly even at extremely low temperatures and the interfering electromagnetic noise of which was minimized.

This technology is currently in use in a newly constructed radio telescope belonging to the Instituto Geográfico National in Yebes in Spain. "Initial trials are already being conducted," says Kotiranta. The project partners plan to start using the radio telescope for geodesy purposes from September onwards, for instance to measure the movement of tectonic plates. Three more large radio telescopes – each with a diameter of over 13 meters – are currently being constructed. These telescopes will be built in the Azores and the Canary Islands, and are due to enter service by the end of 2015 and 2016 respectively. The four new telescopes will form part of the worldwide network of radio telescopes known as VGOS (Very Long Baseline Interferometry 2010 Global Observing System). "Most telescopes date back to the 1970s and 1980s, and their technology is no longer state of the art. The new generation of telescopes will offer considerably more performance and provide us with information about our planet that is more accurate than ever before," finishes Kotiranta.

The dish of the radio telescope based in Yebes, Spain, measures more than 13 meters across. Here, the researchers will implement their high-performance radio wave reception technology for the first time. (© Instituto Geográfico National) | Picture in color and printing quality: www.fraunhofer.de/press

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Economic and effective security design

Storms are capable of paralyzing entire cities. Only recently, in the first week of April, large parts of Germany were deprived of power due to hurricane-force winds. Rail services were cancelled, elevators were blocked, and computer screens went blank. Such extreme weather events often subside as quickly as they arrive but their effects reveal the Achilles heel of modern society, namely our dependence on critical infrastructures such as the power grid. Hence the urgent need for effective security measures. Other public infrastructures, such as airports and road networks, are similarly in need of increased security. "Quite simply, all operators of critical infrastructures want to increase security in order to ward off acts of sabotage and other malicious attacks. At the same time, they also have to make sure such measures are cost effective," says Prof. Jan Jürjens of the Fraunhofer Institute for Software and Systems Engineering ISST, describing the basic dilemma.

Researchers at the Dortmund-based institute have teamed up with international partners in the EU's SECONOMICS project to develop an analysis tool that will enable infrastructure operators to evaluate existing and planned security measures in terms of their effectiveness and cost-efficiency. "Our system provides a founded basis for decisions that will enable users to optimize their security without over-stretching their financial resources," says Jürjens.

Software provides a graphical map of security-related weak points

The starting point is a customized risk analysis of the current situation. The ISST researchers have developed a model-based software solution containing scenarios for different infrastructures. "After studying the security-related aspects identified during site visits, we put together a set of mathematical algorithms that allow us to determine their interrelationship," explains Jürjens. In the case of airports, for example, relevant parameters include the number of security checks, the human resources available, and imposed security regulations such as the presence of liquids in carry-on baggage. In order to tailor the analysis to specific circumstances, the user enters data concerning each of these factors via the user interface – for example staffing levels at the security gate. The risk analysis software uses these data to create a model scenario and present the results in the form of a graphical diagram. As well as revealing existing weak points, this simulation can also be used to verify the effectiveness and cost-efficiency of planned security measures by varying different parameters, for instance by increasing the number of available personnel. This type of walk-through analysis helps to predict the effect of individual measures on overall security and calculate the necessary investments.

In addition to finding a smart way of correlating the various security aspects, the scientists were also faced with the challenge of managing large quantities of heteroge-

neous data. "Evaluating the effectiveness of security measures involves factoring in a large number of individual components – a process that, in order to be user-friendly, requires fast processing speeds," says Jürjens. This is where the ISST's many years of experience in big data management has proved to be an advantage.

The analysis tool has already demonstrated its practical use in case studies conducted by the project partners, including the evaluation of a U.K. power supply network, Barcelona's subway system, and a Turkish airport. The software has also been in use for many years at Fraunhofer ISST for consultations with research clients. The project's final results were recently presented in Brussels. A number of new scenarios are being prepared and, in a next step, the project partners aim to produce a marketable version of their virtual toolbox.

Measures to assure the security of rail stations and other public infrastructures have a high priority. A new software package enables operators to analyze the effectiveness and cost-efficiency of existing and planned security measures. (© Fraunhofer ISST) | Picture in color and printing quality: www.fraunhofer.de/press

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