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RESEARCH NEWS

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1 European space scout

The growing quantity of space debris is a serious threat to satellites and other spacecraft, which risk being damaged or even destroyed. A new European space surveillance system is being developed to ward off the danger of collisions in orbit. Fraunhofer researchers are supplying the receiver for the radar demonstrator system.

2 Ride-sharing for road freight

Around 20 percent of trucks on German roads are traveling empty, at a huge cost to the transportation companies concerned. Also from an ecological and traffic-management standpoint, it would be better if such journeys could be avoided. A new auction platform aims to improve truck space utilization.

3 Extreme testing for rotor blades

Wind turbines are growing bigger and bigger – the diameter of their rotor blades could soon reach 180 meters. But that creates a need for larger test rigs capable of accommodating the blades for load testing. One of the largest-ever experimental test rigs, for blades measuring up to 90 meters in length, will shortly go into operation.

4 Lightning-fast materials testing using ultrasound

For years, ultrasound has proven to be a valuable tool in non-destructive materials testing. However, the demands of modern production conditions are increasing all the time. Researchers at Fraunhofer have now developed a new, more reliable process that delivers testing results at a rate that is up to a hundredfold higher.

5 Rotten meat doesn’t stand a chance

When it comes to packaged fish or meat, it is nearly impossible to distinguish between fresh goods and their inedible counterparts. Researchers have now developed a sensor film that can be integrated into the package itself, where it takes over the role of quality control. And if the food has spoiled, it changes color to announce the fact.

6 Crash sensor boosts safety in warehouses

For reasons of workplace safety, storage shelves in warehouses are subjected to routine testing of their stability. These inspection rounds are time-consuming and deliver just a snapshot in time. Researchers have devised a wireless, sensor-based system to provide continuous monitoring of the condition of storage shelves.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 60 Fraunhofer Institutes at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 18,000, who work with an annual research budget totaling 1,65 billion euros. Roughly two thirds of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the USA and Asia serve to promote international cooperation.

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European space scout

Orbital space is like a busy highway, with countless satellites constantly circling Earth and occasional visits by stray asteroids, comets and meteorites. The region is also strewn with debris from human space activities such as burnt-out rocket stages and fragments of disintegrated spacecraft, which are transforming it into an orbiting junk yard. It is estimated that there are currently around 20,000 objects with a minimum diameter of ten centimeters in orbit around Earth, including 15,000 in the low Earth orbit at an altitude of between 200 and 2,000 kilometers. These objects travel at a speed of up to 28,000 kilometers per hour, which means even the smallest particles measuring a centimeter or less in diameter are capable of causing serious damage to any satellite they encounter, or even completely destroying it. Only two years ago, in February 2009, a retired satellite collided with one of the Iridium communication satellites. The International Space Station ISS has to perform four to five evasive maneuvers each year.

In the light of this potentially disastrous situation, the European Space Agency ESA decided to take concrete action by launching a Space Situational Awareness (SSA) program, which runs from 2009 through to the end of 2011, to create the basic framework for a new, European response to this problem. At present, Europe does not possess the necessary high-resolution radar systems capable of tracking all of the smaller items of space debris. For this, the experts have to rely on data supplied by the American Space Surveillance Network. The new European system is to be built up in stages between 2012 and 2019 at locations that have yet to be defined.

ESA has awarded a contract to the Spanish company Indra Espacio to design and construct a radar demonstrator. The company has in turn called on the services of the Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR in Wachtberg to help with the construction of the demonstrator – a contract valued at 1.4 million euros. The Spanish company will develop the transmitter array, leaving the Fraunhofer scientists to develop the receiver system. The Fraunhofer experts are experienced in the design of radar systems: they already operate the TIRA (Tracking and Imaging Radar) system to detect objects in space. "TIRA is a mechanically steerable system that can be used to obtain images of discrete objects in high resolution. The new surveillance system, by contrast, uses an electronically steerable, inertia-free antenna that can be positioned very quickly. Unlike TIRA, it can observe a large number of objects simultaneously, detecting their position to a high degree of accuracy and sensitivity," says FHR department head Dr. Andreas Brenner. This is an essential

requirement, given the objective of having from 15,000 to 20,000 objects on the radar for at least ten seconds each day. "Our receiver system, that uses a phased-array antenna as the sensor, is capable of capturing radar signals reflected by satellites and space debris in up to eight directions at the same time," says Brenner. In its final version, the surveillance radar will be able to detect objects in geostationary orbit at an altitude of approximately 36,000 kilometers above the surface of the Earth, but its power will be mainly concentrated on the low Earth orbit at an altitude of between 200 and 2,000 kilometers, where it will be capable of detecting particles of debris measuring down to a few centimeters in diameter. The data this system collects is likely to be of interest to numerous users, including not only European government departments and space agencies but also satellite operators, insurance companies, energy suppliers and telecommunications companies.

The demonstrator is scheduled for delivery to ESA at the end of this year. It will then undergo a one-year test phase. A decision on who will construct the full system has yet to be taken, but Brenner hopes that ESA will recognize the importance of his department's expertise and incorporate its know-how in the final version. In any case, the radar receiver's versatility is undeniable, and the core components are equally suitable for use in other applications such as air traffic control at airports.

Fragments of disintegrated spacecraft can damage or even destroy operational satellites. (© ESA)

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Ride-sharing for road freight

Many transportation companies in Germany have a serious problem: their trucks are only carrying part loads or returning to base empty. In the German road freight sector, the number of kilometers driven without a load has stagnated at around 20 percent since 2006. But experts expect the volume of road freight to increase dramatically in the near future, and innovative concepts will be needed to prevent a parallel increase in the number of empty trips.

Such journeys are uneconomical for the freight carriers, who can only operate at a profit if their vehicles are used to maximum capacity. For this reason, the companies often take on more orders than they can actually carry using their own fleet. They then select the shipments that can be combined to form profitable, fully loaded round trips. The rest are passed on to subcontractors. But this is an unsatisfactory solution, for two reasons: firstly because subcontractors are expensive, and secondly because the volume of orders is often still too low to allow optimized journey planning for all the vehicles in the fleet.

The solution proposed by researchers at the Fraunhofer Institute for Industrial Mathematics ITWM involves pooling orders and allowing different carriers to pick those that fit best with their available capacity. To help them to do so, the scientists have developed a prototype software platform that will enable freight service providers to set up a collective organization with shared access to orders. "Our software provides an auction platform with integrated planning functions. It offers several advantages over the existing Internet-based freight exchanges used by transportation companies to offer and accept loads," says Dr. Heiner Ackermann of ITWM. "The online freight exchanges only handle single shipments. At present, it is not possible to group multiple shipments because of the time and effort involved in coordinating transactions over the Internet," says Ackermann. He illustrates his point with the following example: "A single shipment might be too small to justify the extra mileage, but if it can be combined with a second shipment, the trip could be worthwhile after all. Our auction platform allows multiple offerers and takers to communicate in real time. It enables them to pick the most suitable offers to fill their spare capacity, which in turn reduces costs." Ackermann's colleague Hendrik Ewe describes how the auction system works: "Each company lists the orders that don't fit in with their regular journey planning. After the close of bidding, the best offer is selected and the shipment is assigned. The software uses specially developed algorithms to calculate how the proceeds are to be divided up between the offerer and the taker."

The platform, which can be interfaced to different databases, is made up of modules: The "marketplace", where offered shipments are advertised, is installed on a central server. The "bidding assistant" is a client application that runs on terminals at the freight carriers' premises. The freight companies can use its automatic search function to search for offers in the marketplace. The tool provides route planning suggestions, including the choice of vehicle to carry a specific shipment. "Our software is designed for transportation companies wishing to work together on a long-term basis and build up a relationship of trust," adds Ackermann. This isn't possible in the anonymous environment of Internet-based freight exchanges.

In a pilot study using real-life data from the profit centers of a major German freight carrier, the ITWM researchers have demonstrated that their auction platform has genuine cost-saving potential. The researchers are now looking for transportation companies willing to test the concept.

A new auction platform aims to replace the pen-and-paper method of journey planning.
(© Fraunhofer ITWM)

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Extreme testing for rotor blades

Only when you are standing beside a wind turbine can you appreciate the immense size of the wind turbine and its rotor blades. The largest wind turbines operating in the world today have rotor blades over 60 meters long – roughly equivalent to three truck-and-trailer units end-to-end. Within the next ten years, manufacturers of high-output wind turbines for offshore wind farms plan to produce blades up to 90 meters long. The prototypes of these new blades have to be tested and certified before they can go into production, and that requires equally as large testing facilities.

The Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) in Bremerhaven is preparing for these outsized rotor blades. In early summer IWES will be inaugurating a new facility with the capability of testing rotor blades up to 90 meters long. The central feature of the new test facility will be a tiltable 1000 metric tons steel and reinforced concrete mounting block. Hydraulic cylinders used to tilt the block and additional cylinders to load the blade will allow the IWES engineers to bend a rotor blade as easily as a finger to a blade of grass. Preparations for testing begin by firmly mounting the flange of the rotor blade to the tilt block while the tip of the rotor blade projects upwards at a slight angle. Loading cables are attached at various locations along the blade and to hydraulic cylinders mounted on the floor. When all the cables and hydraulic cylinders are in place, the loading and tilting are initiated. As the tilt block is rotated and the tip of the blade begins to move upward, the rotor blade bends as its upward movement is counteracted by the loading cables pulling downwards. This unique testing setup allows for the blade tip of 90 meter blades to be bent through a distance of 25 meters.

The IWES researchers and engineers will be building upon their prior rotor blade testing experience with the new 90 meter testing facility. A test facility for rotor blades up to 70 meters long was opened at IWES in Bremerhaven in 2009, but it is not equipped with a tiltable mounting block. "The big advantage of the hydraulic tiltable mounting block is that it allows us to set up the ideal configuration for conducting tests with high precision in a minimum amount of time," says Falko Bürkner, who leads the rotor-blade testing team at IWES. This is especially important when testing the blades under extreme conditions, which involves subjecting the blades to the maximum theoretical loading it has been designed to withstand, i.e. 100% of the design load. This is always an anxious moment for the manufacturer: are our calculations accurate, is the structure robust enough?

The new test facility is not solely devoted to extreme load testing, but is also outfitted to simulate the cyclic forces acting on the rotor blades as they rotate due to the force of the wind. The wind and in turn rotation of the turbine causes constantly changing forces to act on the carbon or glass fiber reinforced materials of the rotor blades. "There is no other engineered rotating system in which the materials must support so many changes in the load parameters," says Bürkner. This fatigue loading is simulated in the new facility by a hydraulic cylinder which alternately pushes and pulls on the blade, causing it to vibrate at its horizontal and/or vertical resonant frequencies. A full series of extreme load and endurance tests takes around four months to complete. During this time, the blade is subjected to the same loads that it would normally have to withstand in 20 years of operation. Bürkner is confident that the new facilities will enable the institute to continue its mission well into the future. "We have a full schedule for the next twelve months – and that is even before the new test hall opens on June 9, 2011." IWES experts will be present at the Hannover Messe on April 4-8, 2011 (Hall 27, Stand H 24) to present a 3-D film of their biaxial rotor-blade testing and provide information for other new testing options. An open day for members of the public will be held at the new rotor-blade test center on June 11, 2011.

The new facility will enable the institute's engineers to perform load tests on rotor blades measuring up to 90 meters in length. (© Fraunhofer IWES)

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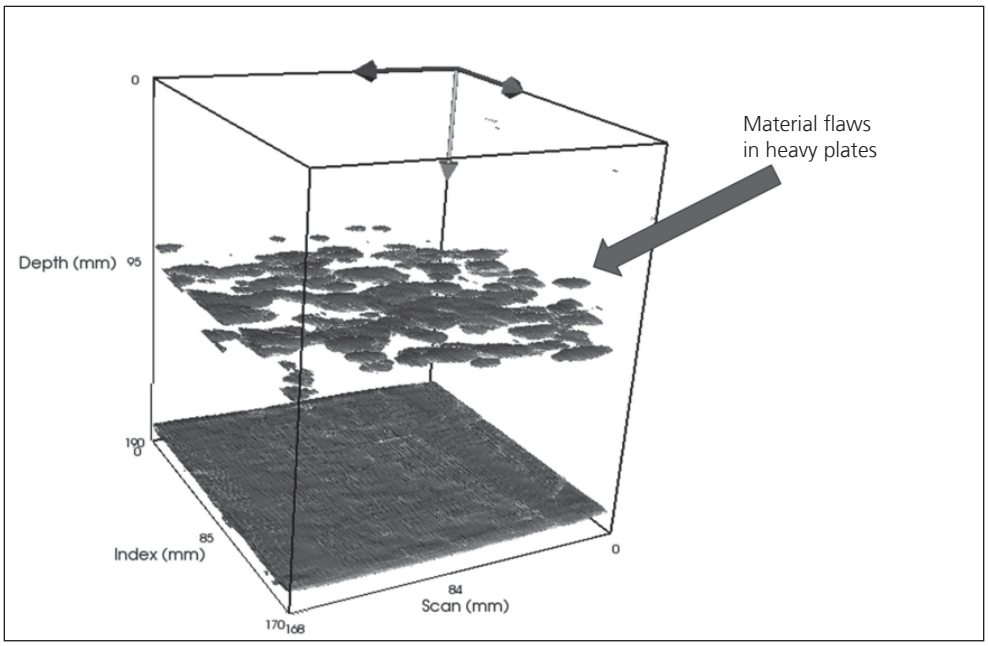
Lightning-fast materials testing using ultrasound

Expectant mothers are familiar with the procedure: the physician examines them with an ultrasound apparatus that displays lifelike images of the fetus on the monitor. The application of this technology has been customary in medicine for years; in materials testing though, it has been used only in relatively rudimentary form to date. Researchers at the Fraunhofer Institute for Non-Destructive Testing IZFP in Saarbrücken have adapted the conventional sonar procedure – a simple ultrasound method – and have succeeded in generating three-dimensional images with the aid of innovative software. At the same time, they have increased the testing rate a hundredfold.

Many areas of quality assurance or production for the construction industry call for reliable testing methods: be it pipelines, railway wheels, components for power plants, bridge piers or items mass-produced by the thousands, there is a need to ensure that deep down the items produced are free from tiny fissures or imperfections. For many years, ultrasound has proven a valuable tool in non-destructive materials testing. An ultrasonic transducer radiates sound waves into the workpiece, and the time the signals require to travel and be reflected back indicates where material defects are located. Scanning workpieces in this way is relatively time-consuming, since, an inspection tact can only register a single beam angle. Thus many measurements must be performed to assemble the composite image suitable for evaluation of inspection results.

However, this approach is too slow if ultrasound testing is to be integrated in ongoing production or applied to large components. That is why Dr.-Ing. Andrey Bulavinov and his team at IZFP have developed a new method that works at up to 100 times the speed. "We no longer use the sonar method that emits a sound field in just one particular direction. Instead, we use the probe – which experts refer to as a "phased array" – to generate a defocused, non-directional wave that penetrates the material," the engineer explains. "What we get back are signals coming from all directions, and the computer uses these signals to reconstruct the composite image." In a manner similar to subterranean seismic testing, it analyzes physical changes the wave encounters in the material – diffraction and heterodyning – and uses this information to determine the conditions within the material itself. "We follow the sound field," Bulavinov notes, "and calculate the workpiece characteristics on the basis of that." Similar to computer tomography in medicine, in the end we receive three-dimensional images of the examined object where any imperfections are easy to identify. The startling thing about this approach is that with it, a fissure is now visible even if the ultrasound was not specifically directed at it.

I-Deal Technologies, an IZFP spinoff, markets testing systems based on this principle. "The method is suitable for virtually all materials used in the aerospace as well as the automobile industry, particularly for lightweight materials," managing director Bulavinov emphasizes. "Our method is even suited for use with austenitic steel – a type of steel that currently can be tested with traditional ultrasound methods only to a very limited degree." Upon request, the researchers also offer a fully automated quantitative analysis of the ultrasound test results. The IZFP is also demonstrating this method at Control 2011, the International Trade Fair for Quality Assurance, in Stuttgart from May 3-6 (Hall 1, Stand 1502).



Thanks to a new ultrasound method, material defects can now be displayed in three dimensions. (© Fraunhofer IZFP)

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Rotten meat doesn't stand a chance

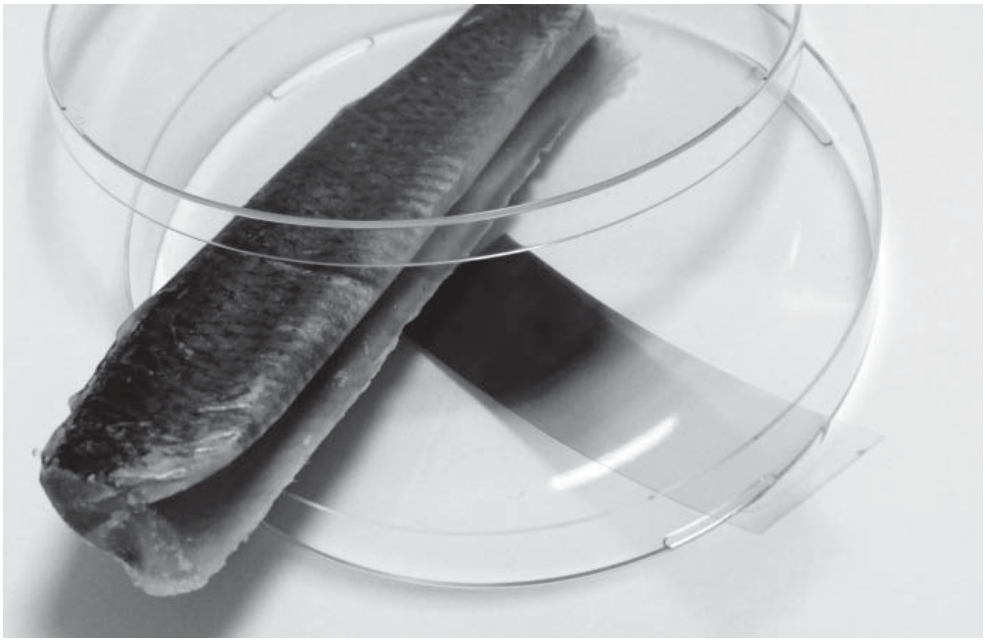
Is the vacuum-packed chicken leg really still fresh and edible? Looks alone do not tell the whole story. And the "best-before" date is no guarantee, either. Scandals involving the sale of rotten meat have added to the uncertainty, and the customer him- or herself may be shortening the shelf life through improper storage. This is an area in which a sensor film developed by the Fraunhofer Research Institution for Modular Solid State Technologies EMFT in Munich can immediately give a green – or rather: yellow light, or warn of spoiled goods. EMFT developed the film in a project sponsored by the German Federal Ministry of Education and Research.

The sensor film is integrated into the inside of the packaging, where it responds to biogenic amines. Amines are molecules produced when foods – fish and meat foremost among them – decay. They are also responsible for their unpleasant smell. If amines are released into the air within the packaging, the indicator dye on the sensor film reacts with them and changes its color from yellow to blue. "Once a certain concentration range is reached, the color change is clearly visible and assumes the task of warning the consumer," explains Dr. Anna Hezinger, a scientist at EMFT. This is not only interesting when it comes to identifying foods that have become inedible. Many people are also extremely sensitive to the presence of certain amines. Which makes a warning all the more important for them.

"Unlike the expiration date, the information on the sensor film is not based on an estimate but on an actual control of the food itself," Hezinger emphasizes. At the same time, the system is very inexpensive. This is important if it is to be used on a broad scale. Other solutions – such as electronic sensors, for instance – would lead to a steep increase in the price of packaged meat. Things that come in direct contact with food products must also meet high standards. "Food safety is ensured by a barrier layer between the sensor film and the product itself. This barrier is only permeable to gaseous amines. The indicator chemicals cannot pass through," Hezinger explains.

Scientists are also working on a measurement module with a built-in sensor film. Employees in the food and packaging industries can use the module to test the freshness of food products directly. The device objectively analyses the color response while at the same time providing a more precise result than is possible with the human eye. This also permits an exact identification of intermediate shades of color. Dr. Anna Hezinger and her team are currently looking for partners in industry with which to

further develop and produce the sensor film and measurement module.



The sensor film changes color, from yellow to blue. Proof positive that this fish is spoiled.
(© Fraunhofer EMFT)

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Crash sensor boosts safety in warehouses

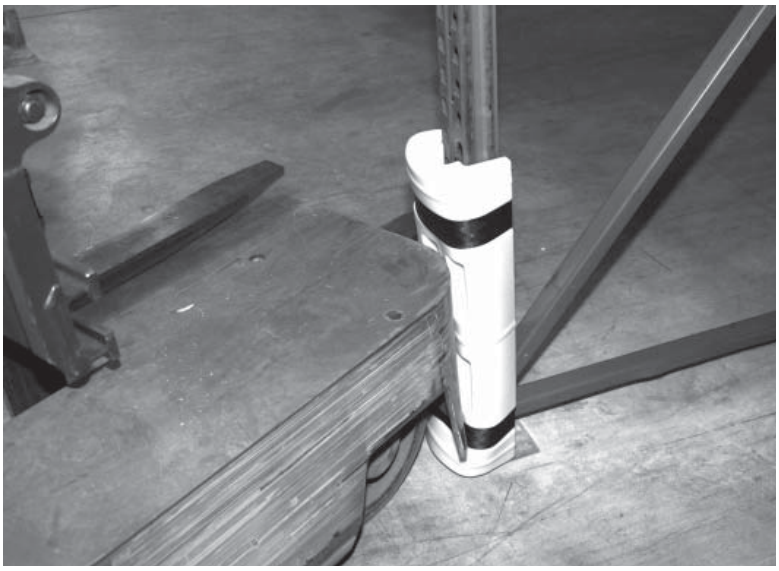
At the end of a long day on the job, the warehouse employee wants to deposit the last palettes quickly before heading home. With a little too much momentum he steers his forklift toward the shelf and collides with a shelf support. This is an everyday situation in large warehouses in which employees often have to maneuver goods through the narrow aisles, often under time pressure. Even harmless-seeming collisions are not really safe though, because over time they may in fact destabilize the shelf supports. In the worst case, the high-rack storage can come crashing down – a serious hazard for the employees below. This is why the supports must be routinely checked for any damage. Up until now, an employee has to inspect each shelf individually – a laborious and time-consuming process. A further drawback: If a support is damaged immediately after an inspection, it goes undetected until the next round. A more effective and reliable protection is afforded by a new monitoring system developed by researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg, in collaboration with IWS Handling GmbH. With the aid of a network of wireless sensors, the condition of each individual support can be monitored around the clock. "Since DIN EN 15635 was introduced, the demands on the operation of shelf systems have increased significantly. Regular inspections have become indispensable as a result," according to Dr. Weiner, managing director at IWS Handling.

Typically, to protect them from collisions, the supports are fitted with a kind of air cushion designed to absorb the impact. "We have integrated sensors in this protective fitting that measure the pressure within the air cushion," explains Frederic Meyer, project manager at IMS. If an air cushion is collided with, the sensor registers the change in interior pressure and reports this via radio relay to a central control station. This is located in the warehouse manager's office. Repeaters positioned at several points throughout the warehouse receive the messages from the sensor nodes and smoothly pass these along to the control station. All the warehouse manager needs to do is glance at the base station to know when and where the last collisions took place within the hall. The system automatically provides him or her a report of whether the impact was harmless, of medium strength or serious. While no immediate measures are required for light collisions, in the event of a category three incident the warehouse manager immediately will send an employee to the shelf in question.

Energy management played a central role in developing this new technology. "After all, the use of such a system only pays off if you aren't constantly having to replace

the batteries in the sensors," Meyer adds. The researchers in Duisburg have configured the system so that the electronics spend most of their time in energy-saving sleep mode. Only when a fluctuation in pressure occurs do the sensor nodes "wake up" and switch to active status. At certain intervals, though – the settings can be varied individually – each sensor node sends a "sign of life" along with its current battery status to a repeater. This ensures that the failure of a signal node will not go unnoticed and is reported to the control station.

The scientists expect to have realized a first demonstrator model by the end of March, which they will then present at the Euro ID (April 5-7 in Berlin) and Sensor + Test (June 7-9 in Nuremberg) trade fairs. A field test is planned for a larger warehouse facility as well. The project is sponsored by the "Otto von Guericke" German Federation of Industrial Research Associations.



If a forklift collides with the air cushion, a sensor within the protective device sends pressure change information to a central control station. (© Fraunhofer IMS)

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