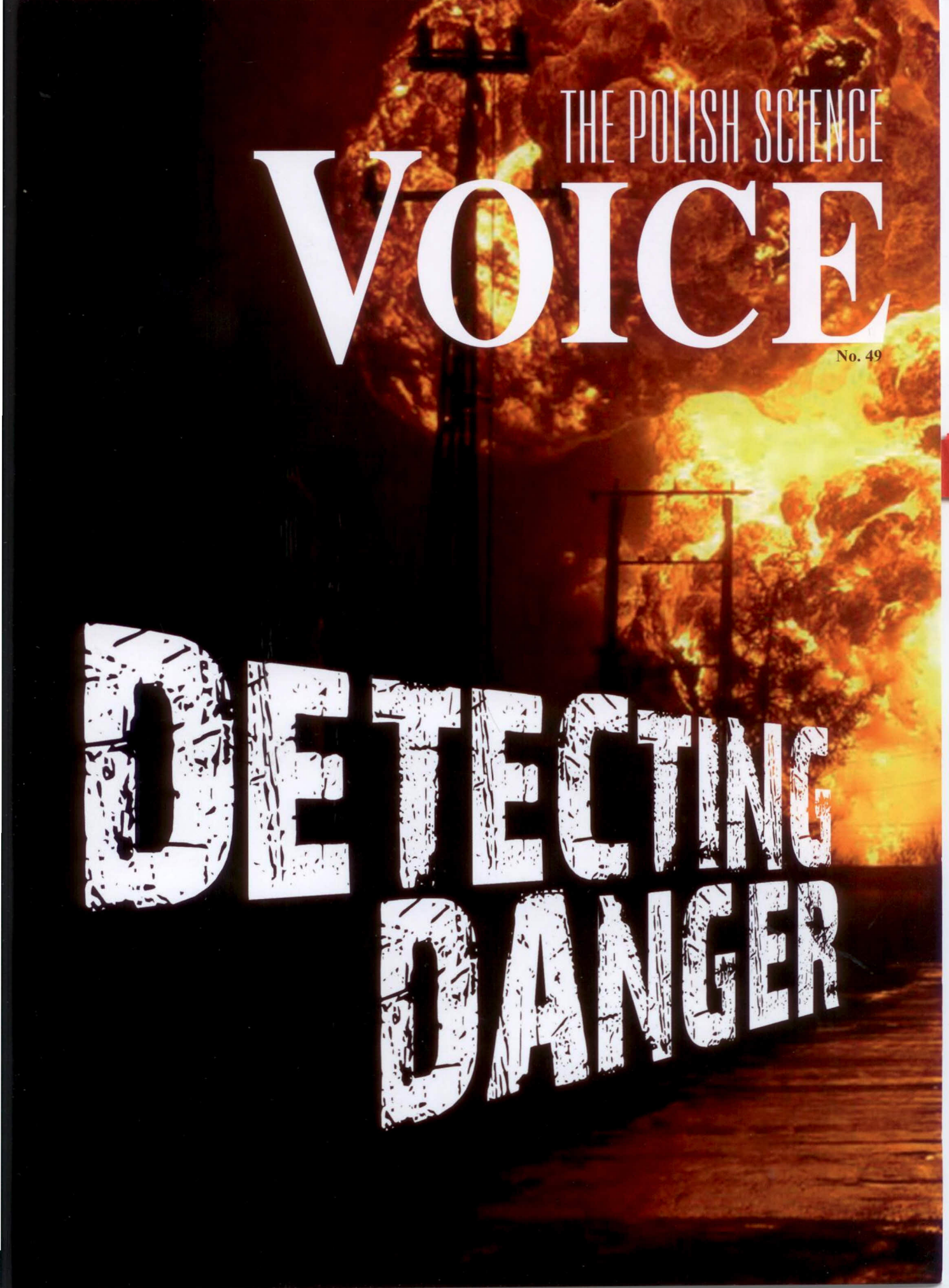


THE POLISH SCIENCE

VOICE

No. 49

DETECTING DANGER

AVIATION VALLEY

POLISH SCIENTISTS IN AEROSPACE COMPETITION

Light aircraft built of intelligent materials that report damage and can adjust to variable operating conditions might sound like science fiction, but that is the kind of innovation that the state-of-the-art, safe and economical aviation sector expects.

Design engineers have taken up the challenge to turn the idea into reality at the Aeronet Dolina Lotnicza (Aviation Valley) Center for Advanced Technology in Rzeszów, southeastern Poland. Their response to the growing market demand is a project entitled Modern Materials Technology Used in the Aerospace Industry (PK Aero), using funds from the Innovative Economy Operational Program. Building on the knowledge base of many years of Poland's aerospace industry, PK Aero is a huge industrial undertaking that involves immense funds and the vast intellectual resources of the research institutions which take part in it.

The project began in July 2008 and will continue until 2014, comprising research and then commercialization of the results. The anticipated outcome includes innovative metallic and composite materials, modern technology to produce and process the materials—complete with unconventional techniques to combine them—and aircraft components built of the materials. The research and tests are discussed with aviation companies regularly, because feedback from potential users will help make future commercialization much more successful.

According to project coordinator Prof. Romana Ewa Śliwa, from the Ignacy Łukasiewicz Rzeszów University of Technology, this is the first time that the science sector and industry are working together on such a large scale. "The results of this joint effort will benefit entire generations," Śliwa said. "We are going to provide the aviation sector with ultra-light materials and technology that will radically improve flight safety along with the economics of flying."

The project involves 400 outstanding Polish researchers who work in different fields of expertise at 11 science and research institutions, including the Rzeszów University of Technology. Their industrial partner is the Aviation Valley Association of Aviation Industry Businesses, which brings together over 90 companies. The PK Aero project covers 15 main tasks which were identified based on needs indicated by the Polish aerospace industry during, for example, the Foresight research project in aviation. "The world is looking forward to lighter and more durable aircraft constructed of intelligent and thus safer materials," said Śliwa. "These are the expectations we want to address."

Research teams affiliated with the Aeronet Aviation Valley Center for Advanced Technology are working to enhance the properties and durability of materials

"We are going to provide the aviation sector with ultra-light materials and technology that will radically improve flight safety along with the economics of flying."
Prof. Romana Ewa Śliwa

used to build, for example, aircraft engine components that heat up to very high temperatures. The researchers are developing technology to produce different kinds of highly specialized coatings and composite materials based on polymers, metals and ceramics. The end products will be resistant to very high temperatures such as those caused by fires. The other objective is an extremely durable material with a monocrystalline structure for use as a coating on such parts as turbine blades in aircraft engines.

Composite materials are usually lighter than metal, so aircraft made of them can weigh less and consume less fuel, making them cheaper in use. Composites are also more durable than materials made from a single constituent, which improves flight safety. For example, it will be possible to embed special sensors in composite aircraft plating to constantly monitor the aircraft's condition and track down any defects that might occur. "Plating with such properties is considered intelligent material," said Śliwa.

Laboratories around the world have been on a quest to develop intelligent materials to help prevent dangerous failures and identify weak spots in aircraft. How would a system like that work? Suppose an airplane is in mid-air and, unbeknownst to the pilot, one of its many structural elements gets damaged. Even if caused by colliding with a bird, such damage can have tragic consequences. An array of sensors embedded in the turbine blade coating could avert a disaster by sending data on the problem to a computer with appropriate software. The computer would analyze the problem, determine the type of damage and suggest what should be done about it.

Obviously, composite materials cannot remedy all problems, because any damage radically weakens their superb mechanical properties. Addressing this issue, one of the PK Aero research teams is working to develop a new generation of more crack-resistant materials. These include metal-composite laminates that combine the properties of metal and fibrous polymer composite. Apart from preventing cracks caused by repetitive strain, the laminates are fireproof and resistant to lightning discharges and corrosion.

Researchers working on the laminates are testing ways to take advantage of the unusual properties displayed by graphene, an allotrope of carbon which takes the form of atom-thin sheets. The super-durable material, the study of which led to a Nobel Prize in physics, might solve problems tied with mounting de-icing systems in the blades, rotors and wings of helicopters and airplanes. Most systems used at present hinge on electrical heating wires. The Polish researchers are seeking a method to incorporate graphene into composite materials with a polymer matrix to enhance the heat and electrical conductivity of the wires in the de-icing systems. Pursuing the goal, Prof. Henryk Galina from the Rzeszów University of Technology is using the results of research conducted by scientists in the northwestern city of Szczecin, who have shown that better conductivity can be obtained if the composite materials contain just 1 percent of graphene.

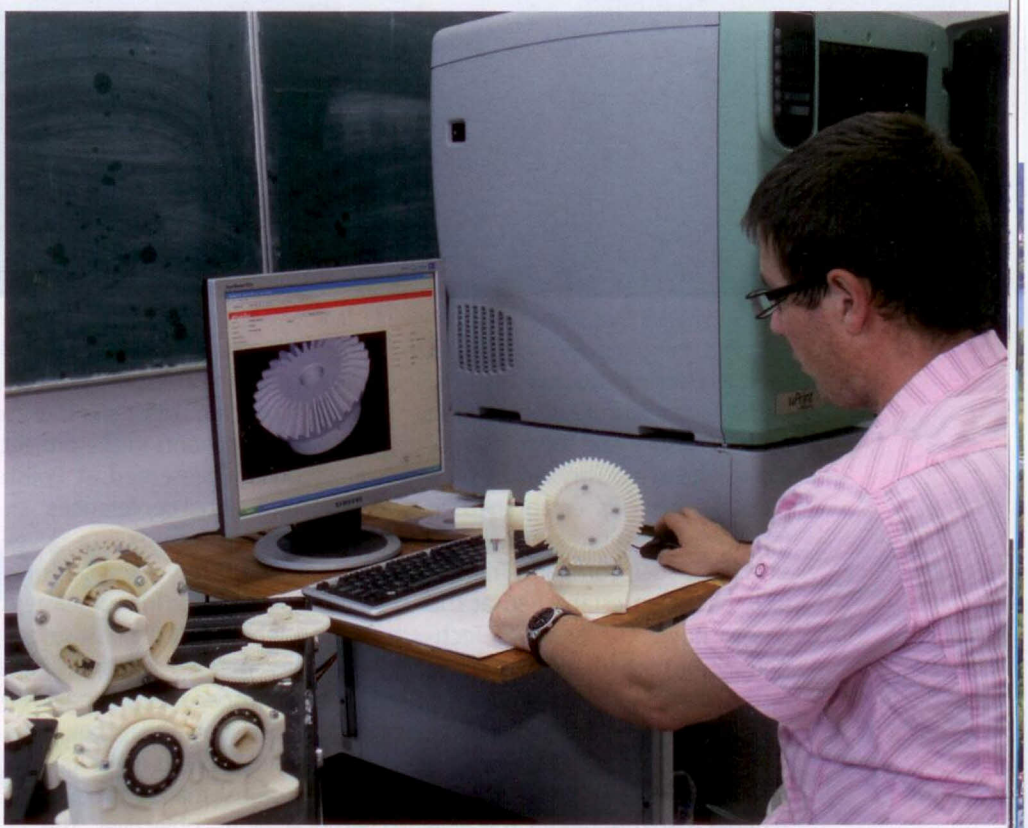
The idea for the PK Aero project came from the Rzeszów University of Technology, which is coordinating the work. The grant application was put together

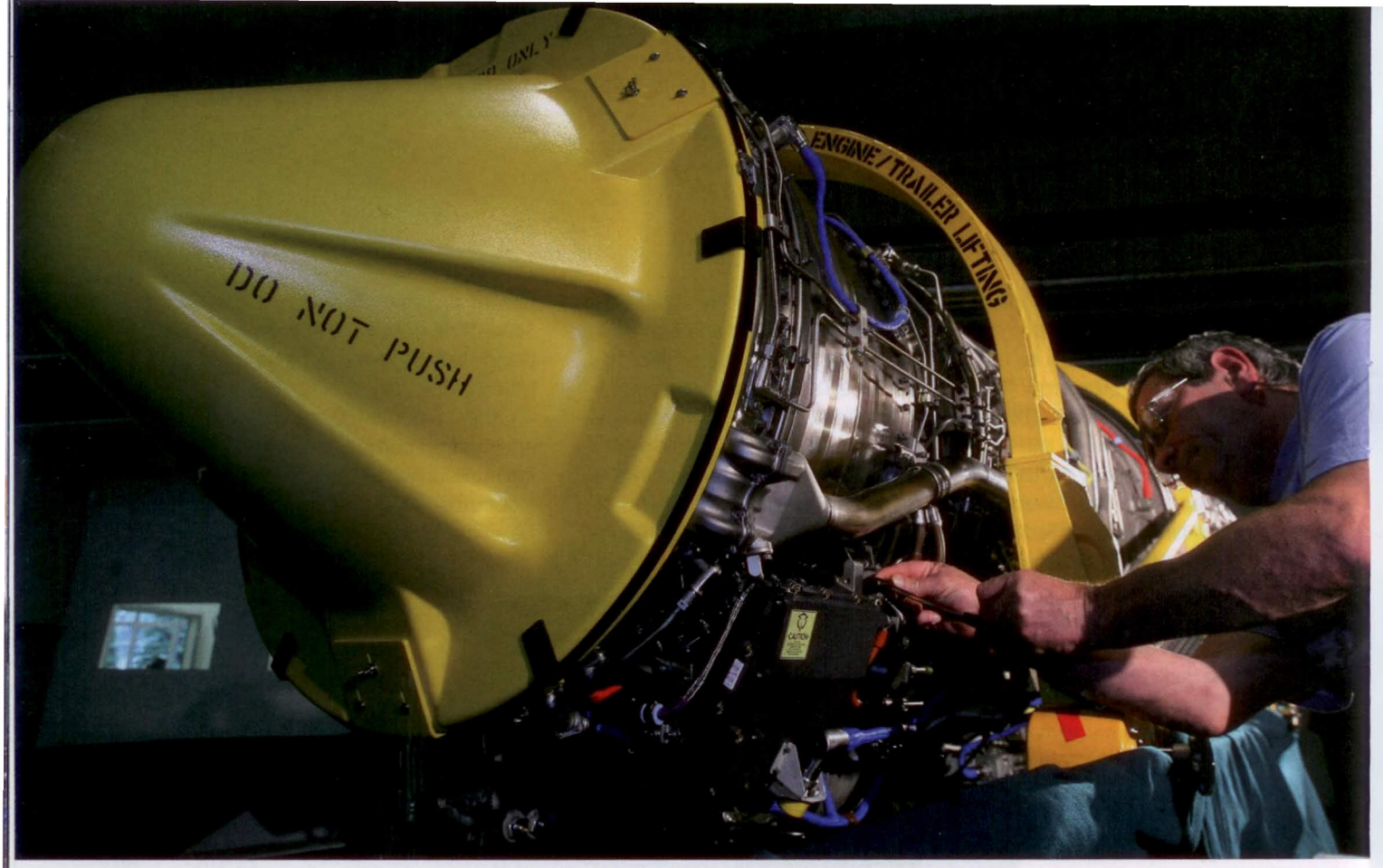
jointly with the university's partners in the aviation sector to ensure that the planned results would help the sector grow. The Rzeszów University of Technology is working together with the universities of technology in Lublin, Częstochowa, Łódź and Warsaw, the Silesian University of Technology, the University of Rzeszów, the Institute of Fluid-Flow Machinery of the Polish Academy of Sciences (PAN) in Gdańsk, the Institute of Fundamental Technological Research, the Polish Academy of Sciences, the Institute of Aviation, and the Air Force Institute of Technology. The work is progressing fast, but the progress in aerospace technology is even faster, which is why results produced by the research are constantly discussed with the aerospace industry. Since more than 90 companies, members of the Aviation Valley Association of Aviation Industry Businesses, are involved in inspecting and discussing the research results, the researchers have to regularly adjust the ideas and solutions they come up with to the ever-changing demands of the aviation sector and the outcome of other research conducted around the world. Keeping up with the world's best concepts and solutions will ensure better commercialization opportunities for the consortium's products.

The Rzeszów University of Technology has one of Europe's most advanced aerospace materials research laboratories. The lab's equipment includes a diffractometer to study the orientation of monocrystals, which enables researchers to accurately and relatively quickly assess the parameters of internal monocrystalline structures. The more than zl.17 million which the National Center for Research and Development assigned to the project has also been spent on upgrading research equipment at institutions taking part in it.

Since the rapid progress in this field of science is highly competitive, the results of the PK Area research will be subject to patent protection. A total of 60 patent applications have been planned of which 32 patents are already registered, and several other applications are pending approval at the European and Polish patent offices. "One of the patent applications is the 'double-headed rivet' which is the product of unconventional, advanced techniques used to combine different materials and fasten aircraft components," said Śliwa. "The use of the special rivet bonds will make aircraft assembly much easier."

Other patents concern liquid epoxies and compounds with low inflammability and high thermal resistance. Patent protection will be awarded to a motion and measurement system for tool-setting probes, a method for producing "triple-rosette" front flanges and several methods for plastic forming of different products, including a method and an apparatus for rotary compression of hollow parts, and a method for plastic formation of toothed shafts. A patent application is also under way for a method for diffractometer-based assessment of the parameters of internal





monocrystalline structures.

The commercialization of the project's results and the transfer of the results to industry will be handled by spin-offs established at the research institutes and universities. One such company, Transfer B+R, has been established at the Częstochowa University of Technology, and other universities and institutions are planning similar moves. As the project nears completion, many more such spin-offs are expected to emerge.

Other than the spinoffs, the added value of the innovation that the project will bring is a tremendous opportunity for those involved to win promotions and degrees. The PK Aero project will result in 64 doctoral and 12 postdoctoral dissertations, 410 expert publications, and 106 master's theses. New developments in the project are regularly presented at Polish and international conferences.

PK Aero also presents a development opportunity to the entire Podkarpacie region in southeastern Poland, which over the past several years has emerged as Poland's center for aerospace technology. The region's Aviation Valley has done a lot to help Poland make its mark on the global market for aviation. As one of its objectives, the PK Aero project aims to start a group of innovative technical solutions in which Poland could become the world expert. For example, Poland leads the way in producing aircraft engines and engine components and constructing airframes, helicopters and light and ultralight aircraft. The PK Aero project was awarded the Quality of the Year mark twice in 2010 and 2011 by the Polish Center for Testing and Certification. The organization's experts take into account factors such as transfer of innovation to the economy, efficient work on research projects, the significance of research accomplishments in Poland and abroad, and good cooperation between research institutions and the market and other organizations.

The PK Aero project is being carried out under the Polish Aerospace Strategic Research Program as part of the Polish Aerospace Technology Platform.

Karolina Olszewska

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INNOVATIVE ECONOMY
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