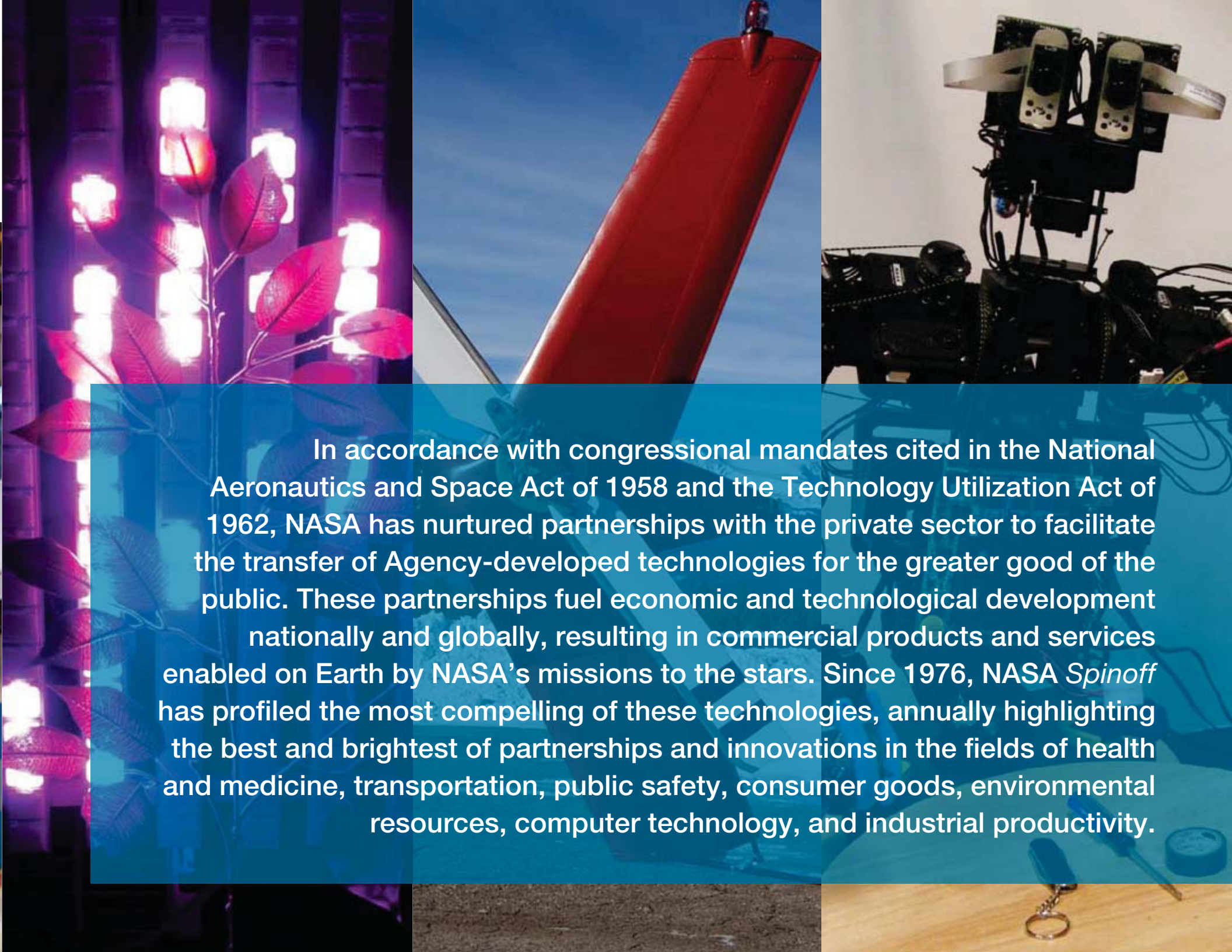
National Aeronautics and Space Administration

NASA Technologies Benefit Society

spinoff

2010



In accordance with congressional mandates cited in the National Aeronautics and Space Act of 1958 and the Technology Utilization Act of 1962, NASA has nurtured partnerships with the private sector to facilitate the transfer of Agency-developed technologies for the greater good of the public. These partnerships fuel economic and technological development nationally and globally, resulting in commercial products and services enabled on Earth by NASA's missions to the stars. Since 1976, NASA *Spinoff* has profiled the most compelling of these technologies, annually highlighting the best and brightest of partnerships and innovations in the fields of health and medicine, transportation, public safety, consumer goods, environmental resources, computer technology, and industrial productivity.

Personal Aircraft Point to the Future of Transportation

NASA's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, as well as a number of Agency innovations, have helped Duluth, Minnesota-based Cirrus Design Corporation become one of the world's leading manufacturers of general aviation aircraft. SBIRs with Langley Research Center provided the company with cost-effective composite airframe manufacturing methods, while crashworthiness testing at the Center increased the safety of its airplanes. Other NASA-derived technologies on Cirrus SR20 and SR22 aircraft include synthetic vision systems that help pilots navigate and full-plane parachutes that have saved the lives of more than 30 Cirrus pilots and passengers to date. Today, the SR22 is the world's top-selling Federal Aviation Administration (FAA)-certified single-engine airplane.

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Ducted Fan Designs Lead to Potential New Vehicles

In 1994, aerospace engineers Rob Bulaga and Mike Moshier formed Trek Aerospace Inc., based in Folsom, California, to develop personal air vehicles using a novel ducted fan design. The company relied on Ames Research Center for a great deal of testing, the results of which have provided greater lift, lowered weight, more power, and improved maneuverability. The technology has been applied to three models: the Dragonfly UMR-1, the Springtail EFV, and the OVIWUN, a small-scale version that is for sale through the company's Web site. It is safer than a manned vehicle, and its size makes it relatively difficult for it to damage itself during test flights the way a larger mass, faster craft could.

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Winglets Save Billions of Dollars in Fuel Costs

The upturned ends now featured on many airplane wings are saving airlines billions of dollars in fuel costs. Called winglets, the drag-reducing technology was advanced through the research of Langley Research Center engineer Richard Whitcomb and through flight tests conducted at Dryden Flight Research Center. Seattle-based Aviation Partners Boeing—a partnership between Aviation Partners Inc., of Seattle, and The Boeing Company, of Chicago—manufactures Blended Winglets, a unique design featured on Boeing aircraft around the world. These winglets have saved more than 2 billion gallons of jet fuel to date, representing a cost-savings of more than $4 billion and a reduction of almost 21.5 million tons in carbon dioxide emissions.

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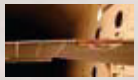

Sensor Systems Collect Critical Aerodynamics Data

With the support of Small Business Innovation Research (SBIR) contracts with Dryden Flight Research Center, Tao of Systems Integration Inc. developed sensors and other components that will ultimately form a first-of-its-kind, closed-loop system for detecting, measuring, and controlling aerodynamic forces and moments in flight. The Hampton, Virginia-based company commercialized three of the four planned components, which provide sensing solutions for customers such as Boeing, General Electric, and BMW and are used for applications such as improving wind turbine operation and optimizing air flow from air conditioning systems. The completed system may one day enable flexible-wing aircraft with flight capabilities like those of birds.

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Coatings Extend Life of Engines and Infrastructure

MesoCoat Inc., of Euclid, Ohio, collaborated with Glenn Research Center to provide thermal barrier coating (TBC) technology, developed by Glenn researcher Dongming Zhu, to enhance the lifespan and performance of engines in U.S. Air Force legacy aircraft. The TBC reduces thermal stresses on engine parts, increasing component life by 50 percent. MesoCoat is also producing metal cladding technology that may soon provide similar life-lengthening benefits for the Nation's infrastructure. Through a Space Act Agreement with Glenn, the company employs the Center's high-density infrared arc lamp system to bond its cladding materials for demonstration prototypes; the coating technology can prevent corrosion on metal beams, pipes, and rebar for up to 100 years.

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Public Safety

Radiometers Optimize Local Weather Prediction

Radiometrics Corporation, headquartered in Boulder, Colorado, engaged in Small Business Innovation Research (SBIR) agreements with Glenn Research Center that resulted in a pencil-beam radiometer designed to detect supercooled liquid along flight paths—a prime indicator of dangerous icing conditions. The company has brought to market a modular radiometer that resulted from the SBIR work. Radiometrics' radiometers are used around the world as key tools for detecting icing conditions near airports and for the prediction of weather conditions like fog and convective storms, which are known to produce hail, strong winds, flash floods, and tornadoes. They are also employed for oceanographic research and soil moisture studies.

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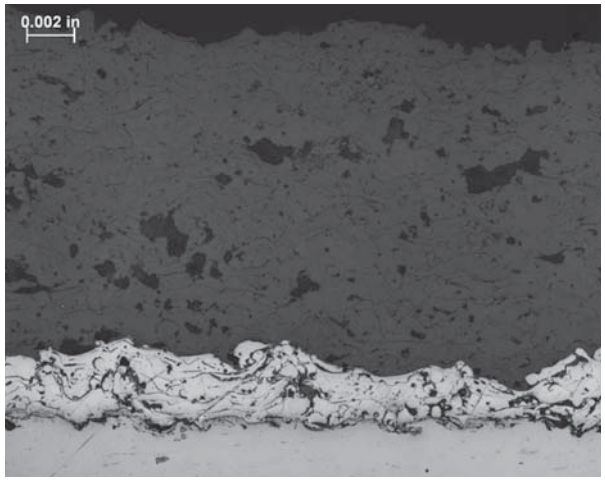
Coatings Extend Life of Engines and Infrastructure

Originating Technology/NASA Contribution

Every time a jet engine is started, it goes through a thermal cycle of extreme temperatures, reaching as high as 2,700 °F within the engine's combustor. Over time, the expansion and contraction of engine parts caused by this cycle lead to cracking and degradation that shortens an engine's lifespan and eventually necessitates costly replacement.

Among the many ways that NASA works to advance aviation are efforts to improve the life and performance of jet, or gas turbine, engines. Glenn Research Center scientist Dongming Zhu performed groundbreaking work developing thermal barrier coatings (TBCs) that outperform other TBC technologies, providing an unrivaled means of protecting these engines from the degrading effects of thermal stresses, prolonging their lifespans, and enhancing their reliability and fuel efficiency.

TBCs are ceramic coatings with low thermal conductivity, insulating the metal parts they are applied to and reducing thermal fatigue. The ceramic component is typically composed of zirconium oxide (zirconia) stabilized in a particular crystal structure through the addition of yttrium oxide (yttria). Through the addition of other oxides, Zhu created modified yttria-stabilized zirconia TBCs with both initial and post-exposure thermal conductivities that are even lower than existing coatings. Zhu's breakthrough thermal and environmental barrier coating work was recognized by *R&D Magazine* in 2007 with an "R&D 100" award as one of the year's 100 most technologically noteworthy inventions.



The ZComP 844 nanocomposite thermal barrier coating (TBC) has about half of the thermal conductivity of standard thermal barriers. Applying the TBC to engine components can result in a 50-percent increase in component life as a result of reduced thermal stress.

Now, through collaboration with a private industry coatings leader, Zhu's NASA research is helping extend the service of military aircraft.

Partnership

"NASA is the world leader in thermal barrier coatings," says Andrew Sherman, founder and CEO of MesoCoat Inc., based in Euclid, Ohio. A subsidiary of Powdermet Inc., also based in Euclid and itself a NASA partner through the **Small Business Innovation Research (SBIR)** program, MesoCoat was founded in 2007 to develop and commercialize new coating techniques. Through a collaborative agreement with Glenn and under contract with the U.S. Air Force, MesoCoat is employing a specific composition of Zhu's TBC technology to prolong the lifespan of engines in the Air Force's aging, legacy aircraft. Since the commercial application is currently only for government use, no licensing agreement was required, though MesoCoat is engaged in discussions for commercial licensing terms.

"It's very difficult to get new parts for these older engines," says Sherman, "so the Air Force needs new technologies to extend the life of components" such as combustor cans and afterburner nozzles. The company's NASA-derived technology is providing an ideal, cost-effective solution for this need.

Product Outcome

Branded ZComP 844, MesoCoat's nanocomposite TBC has cluster formations that inhibit radiation transfer in the TBC and improves the coating's stability, Sherman explains, so that it has about half of the thermal conductivity of conventional thermal barriers.

"The NASA solution allows us to reduce the thermal conductivity, which reduces the engine part temperature as well as smoothes out thermal cycles, making them slower, much more uniform, and taking a lot of the thermal stresses off the part," says Sherman. "By halving the thermal conductivity, we're shaving around 30 to 50 degrees off the part temperature. As a result, you're looking at a 50-percent increase in component life." Reducing the thermal stresses on engine components also results in better performance and fuel efficiency.

Other methods for combating thermal fatigue, such as applying thicker layers of other TBCs or changing engine operating conditions, are either less effective or entirely unfeasible, Sherman says. The ZComP 844 TBC can be applied at almost no additional cost, he explains, by simply inserting the enhanced TBCs into the normal maintenance cycle when the coatings are stripped and replaced.

While MesoCoat's NASA-developed TBC promises to provide longer component life, improved fuel economy, and better operating efficiency for other commercial engine applications in the future, the company is engaged in another NASA partnership that may soon provide similar lifespan-enhancing benefits to the Nation's aging infrastructure.

Combating the effects of corrosion—a significant threat to highways, bridges, and other structures around the country—costs the U.S. economy over $270 billion annually, according to the Federal Highway Administration. MesoCoat has developed a complete metal cladding system, called CermaClad, that provides a quickly applicable, environmentally friendly, and cost

effective method for extending the maintenance-free life of steel structures like bridge beams, water and oil pipes, and rebar. Employing inexpensive, inert nanocomposite cermet (ceramic and metallic) materials that are bonded to the metal surface using a high-density infrared (HDIR) arc lamp, CermaClad provides a cheaper, lighter, and nontoxic alternative to welded cladding methods and bioactive, carcinogenic materials like chromates. The resulting coating, which can be applied at rates 100 times faster than weld overlays, can prevent any degradation for periods up to 100 years, Sherman says.

While the technology is not yet commercial, MesoCoat has validated the product with "a number of very large customers" and is creating demonstration scale prototypes and fusion clad components thanks to a Space Act Agreement with Glenn that allows the company to make use of the Center's 200-kilowatt HDIR lamp system.

The arc lamp technology was originally used by NASA for simulating heat fluxes that occur during the reentry of spacecraft into Earth's atmosphere, as well as for thermal testing of combuster liners. As a student at the University of Cincinnati and a NASA intern, Craig Blue adapted the technology for coatings applications and is currently advancing its uses at the Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. MesoCoat secured the commercialization rights to the "R&D 100" award-winning innovation from ORNL and expects CermaClad to provide a solution that overcomes the biggest obstacle to infrastructure improvement: cost.

"It's pretty much understood that we could solve the problem of deteriorating infrastructure if we wanted to. It's a sheer economic issue," Sherman says. "The real novelty of CermaClad is the productivity of it, which allows us to apply metal and ceramic coatings at the same rate you can spray paint today."

A key to this potential becoming reality, he says, is MesoCoat's NASA partnership.

"Bringing NASA expertise and facilities to bear allows us to outcompete anyone else in the world." ❖

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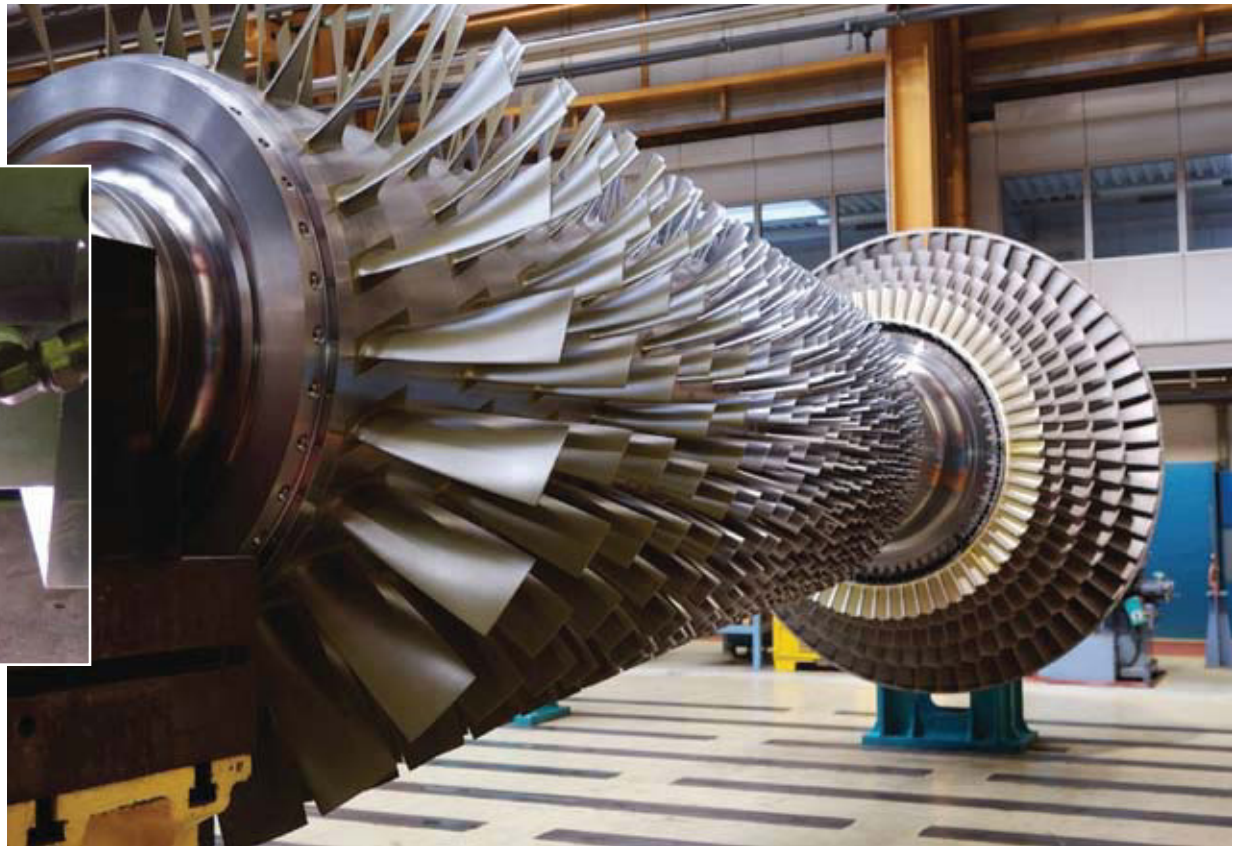

MesoCoat Inc.'s CermaClad technology uses a high-density infrared arc lamp (above) to bond the cladding material to metal surfaces, preventing corrosion for up to 100 years. While this technology extends the lifespan of infrastructure like steel beams and pipes, the company's ZComP 844 TBC extends the life of gas turbine engine components (right) and hardly adds any cost to normal maintenance cycles.