



SPINOFF



2013

NASA Spinoff Technology Across the Nation



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This map details the geographic location of each company that appears in *Spinoff* 2013. For a deeper look at how spinoffs have benefited your state and local economy, scan this code.



While NASA takes us farther into the universe every day, it also makes sure its innovations benefit us here on Earth. NASA *Spinoff* highlights the Agency's most significant research and development activities and the successful transfer of NASA technology, showcasing the cutting-edge research being done by the Nation's top technologists and the practical benefits that come back down to Earth in the form of tangible products that make our lives better. Since 1976, *Spinoff* has profiled more than 1,800 of the most compelling of these technologies, annually featuring the best and brightest of partnerships and innovations in the fields of health and medicine, transportation, public safety, consumer goods, energy and environment, information technology, and industrial productivity.



Health and Medicine

1

Innovative Software Tools Measure Behavioral Alertness

To monitor astronaut behavioral alertness in space, Johnson Space Center awarded Philadelphia-based Pulsar Informatics Inc. SBIR funding to develop software to be used onboard the International Space Station. Now used by the government and private companies, the technology has increased revenues for the firm by an average of 75 percent every year.



2

Miniaturized, Portable Sensors Monitor Metabolic Health

In order to measure astronauts' metabolic rates in space, Glenn Research Center partnered with Case Western University and the Cleveland Clinic to develop the Portable Unit for Metabolic Analysis (PUMA). Cleveland-based Orbital Research licensed and then modified PUMA to help the US Navy assess pilot oxygen problems and is now designing a device that can be used in hospitals.



3

Patient Simulators Train Emergency Caregivers

Johnson Space Center teamed up with Sarasota, Florida-based METI (now CAE Healthcare) through the STTR program to ruggedize the company's patient simulators for training astronauts in microgravity environments. The design modifications were implemented in future patient simulators that are now used to train first responders in the US military as well as fire departments and other agencies that work in disaster zones.



4

Solar Refrigerators Store Life-Saving Vaccines

Former Johnson Space Center engineer David Bergeron used his experience on the Advanced Refrigeration Technology Team to found SunDanzer Refrigeration Inc., a company specializing in solar-powered refrigerators. The company has created a battery-free unit that provides safe storage for vaccines in rural and remote areas around the world.



Through technology transfer partnerships, NASA innovations become a vital part of our Nation's healthcare industry. From solar-powered refrigerators that keep vaccines cool to handheld diagnostic devices, advances from NASA research boost fitness, improve medical instruments, enhance disease treatments, and save lives.

5

Monitors Enable Medication Management in Patients' Homes

Glenn Research Center awarded SBIR funding to ZIN Technologies to develop a platform that could incorporate sensors quantifying an astronaut's health status and then communicate with the ground. ZIN created a device, developed the system further, and then formed Cleveland-based FlexLife Health to commercialize the technology. Today it is part of an anti-coagulation management system for people with cardiovascular disease.



6

Handheld Diagnostic Device Delivers Quick Medical Readings

In a 1962 speech, President John F. Kennedy said, "We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills." Fast-forward to 2013, and the Space Agency has its sights set on even greater challenges: human explorers going farther than ever before, with the ultimate goal of putting astronauts on the surface of Mars.

Deep space missions, though, will require new feats of engineering. Among other challenges, NASA will have to develop intricate systems to ensure astronauts' health and safety. As a part of this effort, Glenn Research Center awarded SBIR funding to Cambridge, Massachusetts-based DNA Medical Institute to develop a device capable of analyzing a variety of health indicators in a simple test. The company responded with the rHEALTH sensor, which can use a single blood sample to measure dozens of biomarkers using nanostrip technology. "[Nanostrips are] kind of similar to urine analysis or pH test strips," says Eugene Chan, the company's founder. "The big difference is we've shrunk that technology over a billion-fold in volume so that we can implement that at the blood cell level."

The technology will prove useful not only in space but on Earth as well, especially in rural areas without easy access to labs.



Transportation

7

Experiments Result in Safer, Spin-Resistant Aircraft

After causing a whopping 8,000 stall-spins in test aircraft, the General Aviation Spin Program at Langley Research Center devised the first-of-its-kind guidelines for designing more spin resistant aircraft. Thanks to NASA's contributions, the Federal Aviation Administration introduced the Part 23 spin resistance standard in 1991. Los Angeles-based ICON Aircraft has now manufactured a new plane, the ICON A5, for consumer recreational flying that meets the complete set of criteria specified for Part 23 testing.

"We wanted to design a plane that was spin-resistant," says Kirk Hawkins, founder and CEO of ICON. "If it wasn't for the NASA work, there would be no FAA standard, and we wouldn't have done this." Hawkins compares the A5's spin resistance to antilock brake systems in cars: the plane automatically reacts to potentially dangerous conditions—including a pilot's natural reaction of pulling back on the flight stick, which can exacerbate the problem—with effective countermeasures that keep the flight under control.

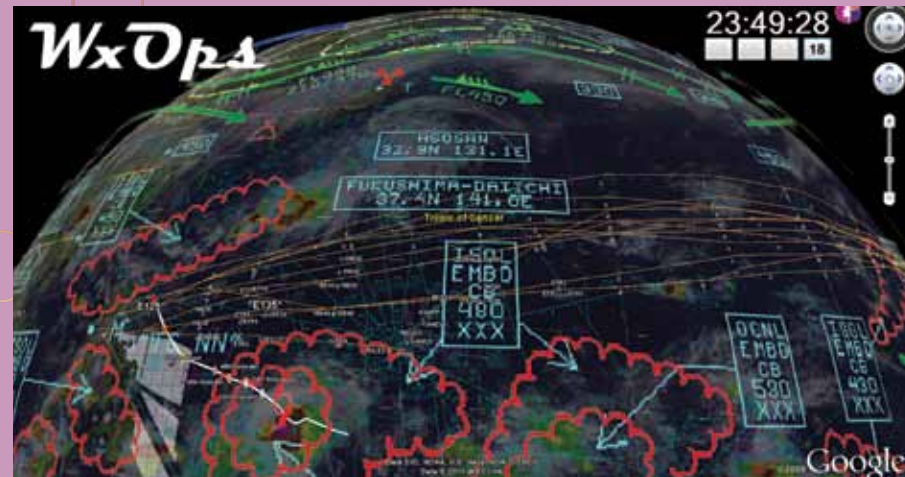
Alongside the A5's safety elements, it boasts a number of additional features based on the idea, "If you can drive, you can fly." The interior instrument layout resembles that of a sports car, and the key safety controls are grouped in one easy-to-reach cluster. ICON has already received more than 1,000 orders for the A5 from flight schools, flying clubs, resorts, and adventure companies.



8

Interfaces Visualize Data for Airline Safety, Efficiency

As the A-Train Constellation orbits Earth to gather data, NASA scientists and partners visualize, analyze, and communicate the information. To this end, Langley Research Center awarded SBIR funding to Fairfax, Virginia-based WxAnalyst Ltd. to refine the company's existing user interface for Google Earth to visualize data. Hawaiian Airlines is now using the technology to help manage its flights.



9

Data Mining Tools Make Flights Safer, More Efficient

A small data mining team at Ames Research Center developed a set of algorithms ideal for combing through flight data to find anomalies. Dallas-based Southwest Airlines Co. signed a Space Act Agreement with Ames in 2011 to access the tools, helping the company refine its safety practices, improve its safety reviews, and increase flight efficiencies.



10

NASA Standards Inform Comfortable Car Seats

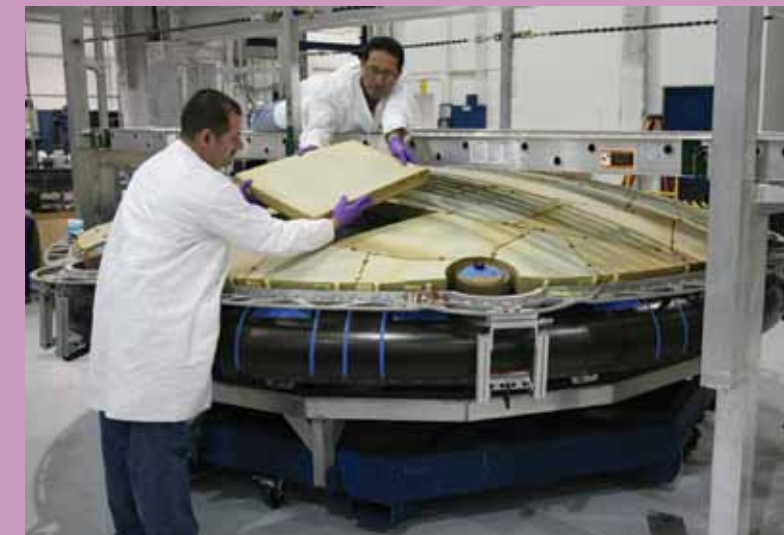
NASA developed standards, which included the neutral body posture (NBP), to specify ways to design flight systems that support human health and safety. Nissan Motor Company, with US offices in Franklin, Tennessee, turned to NASA's NBP research for the development of a new driver's seat. The 2013 Altima now features the new seat, and the company plans to incorporate the seats in upcoming vehicles.



11

Heat Shield Paves the Way for Commercial Space

The Phenolic-Impregnated Carbon Ablator (PICA) heat shield, a lightweight material designed to withstand high temperatures, was used for the Stardust's reentry into Earth's atmosphere. Hawthorne, California-based SpaceX later worked with the inventors at Ames Research Center to outfit PICA on its Dragon capsule, which is now delivering cargo to and from the International Space Station through NASA's Commercial Resupply Services contracts program.



12

Air Systems Provide Life Support to Miners

A spacecraft's interior is a protective cocoon that provides a breathable atmosphere—but it's also a bubble of air that must be constantly purged of impurities. Each of NASA's space shuttles, for example, was equipped with its own air revitalization system whose numerous components were dispersed throughout the vehicle.

With the close of the Space Shuttle Program, NASA, in accordance with its goal of promoting commercial space flight, has partnered with several US companies under its Commercial Crew Development program to develop privately operated space vehicles and supporting technologies capable of fulfilling that transport role. One of those companies, Paragon Space Development Corporation, wanted to develop a compact air purification system that would combine all of the shuttle's discrete parts into a single, dependable module that could be installed onto any commercial spacecraft.

Paragon has now commercialized the technology in an environment that shares many of the dangers of space: mineshafts deep underground. In the event of a disaster, miners can climb into a refuge chamber, which scrubs them of contaminants as they enter. The units can then sustain workers with clean air and supplies for days as they await rescue.



13

Coatings Preserve Metal, Stone, Tile, and Concrete

John B. Schutt, a chemist at Goddard Space Flight Center, created a coating for spacecraft that could resist corrosion and withstand high heat. After retiring from NASA, Schutt used his expertise to create new formulations for Daytona Beach, Florida-based Adsil Corporation, which now manufactures a family of coatings to preserve various surfaces. Adsil has created 150 jobs thanks to the products.



14

Robots Spur Software That Lends a Hand

While building a robot to assist astronauts in space, Johnson Space Center worked with partners to develop robot reasoning and interaction technology. The partners created Robonaut 1, which led to Robonaut 2, and the work also led to patents now held by Universal Robotics in Nashville, Tennessee. The NASA-derived technology is available for use in warehousing, mining, and more.



15

Cloud-Based Data Sharing Connects Emergency Managers

Under an SBIR contract with Stennis Space Center, Baltimore-based StormCenter Communications Inc. developed an improved interoperable platform for sharing geospatial data over the Internet in real time—information that is critical for decision makers in emergency situations.



16

Catalytic Converters Maintain Air Quality in Mines

At Langley Research Center, engineers developed a tin-oxide based washcoat to prevent oxygen buildup in carbon dioxide lasers used to detect wind shears. Airflow Catalyst Systems Inc. of Rochester, New York, licensed the technology and then adapted the washcoat for use as a catalytic converter to treat the exhaust from diesel mining equipment.



There's more space in your life than you think—especially in your home and among the products you use every day. NASA technologies often find their way into consumer applications, enhancing educational software, keeping those wearing business attire cool, and providing clean drinking water for weekend campers and adventurers.

17 NASA-Enhanced Water Bottles Filter Water on the Go

Thanks to recent NASA science missions, researchers are finding that water may be more plentiful in space than we had previously believed. Nevertheless, space is still practically a desert, where every drop of water must be collected from every possible source and filtered for reuse. On the International Space Station, a filter developed under the SBIR program now recycles and recirculates moisture from wastewater, urine, and even sweat.

Greenbrae, California-based ÖKO developed a water bottle employing the same NASA filter to purify water for consumers on the go. Whether traveling, hiking, or camping, users can take water from surrounding sources such as lakes and streams and make it drinkable simply by squeezing it through the bottle. Thanks to its NASA-derived filter, ÖKO's bottle is rated effective for use in more than 120 countries.

"The materials that have been created for specific use by NASA are state of the art because of the extreme conditions they are subjected to," says Mohssen Ghiassi, founder of the company. "They are superior to anything else out there."



18 Brainwave Monitoring Software Improves Distracted Minds

Neurofeedback technology developed at Langley Research Center to monitor pilot awareness inspired Peter Freer to develop software for improving student performance. His company, Fletcher, North Carolina-based Unique Logic and Technology Inc., has gone on to innovate technologies for improving workplace and sports performance, monitoring drowsiness, and encouraging relaxation.



19 Thermal Materials Protect Priceless, Personal Keepsakes

NASA astronaut Scott Parazynski led the development of materials and techniques for the inspection and repair of the shuttle's thermal protection system. Parazynski later met Chris Shiver of Houston-based DreamSaver Enterprises LLC and used concepts from his work at Johnson Space Center to develop an enclosure that can withstand 98 percent of residential fires.



20 Home Air Purifiers Eradicate Harmful Pathogens

Marshall Space Flight Center funded the University of Madison-Wisconsin to develop ethylene scrubbers to keep produce fresh in space. Akida Holdings of Jacksonville, Florida, licensed the technology and developed Airocide, an air purifier that can kill airborne pathogens. Previously designed for industrial spaces, there is now a specially designed unit for home use.



21 Thermal Materials Drive Professional Apparel Line

Johnson Space Center investigated phase change materials (PCMs) to use in spacesuit gloves to help maintain comfortable temperatures. Years later, Boston-based Ministry of Supply developed a dress shirt that incorporated the NASA-derived PCMs, could wick away moisture, and also control odors and bacterial growth. Deemed Apollo, the shirt performs like active wear and is available in white and oxford blue.



22 Radiant Barriers Save Energy in Buildings

Langley Research Center needed to coat the Echo 1 satellite with a fine mist of vaporized metal, and by collaborating with industry the center was able to develop "radiant barrier technology." In 2010, Ryan Garrett learned about a new version of the technology resistant to oxidation and founded RadiaSource in Ogden, Utah, to provide the NASA-derived technology for applications in homes, warehouses, gymnasiums, and agricultural settings.



Energy and Environment

23

Open Source Initiative Powers Real-Time Data Streams

Under an SBIR contract with Dryden Flight Research Center, Create Inc. developed a data collection tool called the Ring Buffered Network Bus. The technology has now been released under an open source license and is hosted by the Open Source DataTurbine Initiative. DataTurbine allows anyone to stream live data from sensors, labs, cameras, ocean buoys, cell phones, and more.



Shuttle Engine Designs Revolutionize Solar Power

The Space Shuttle Main Engine was built under contract to Marshall Space Flight Center by Rocketdyne, now part of Pratt & Whitney Rocketdyne (PWR). PWR applied its NASA experience to solar power technology and licensed the technology to Santa Monica, California-based SolarReserve. The company now develops concentrating solar power projects, including a plant in Nevada that has created 4,300 jobs during construction.



25

Procedure-Authoring Tool Improves Safety on Oil Rigs

Dark, cold, and dangerous environments are plentiful in space and on Earth. To ensure safe operations in difficult surroundings, NASA relies heavily on procedures written well ahead of time. Houston-based TRACLabs Inc. worked with Ames Research Center through the SBIR program to create an electronic procedure-authoring tool, now used by NASA and companies in the oil and gas industry.



26

Satellite Data Aid Monitoring of Nation's Forests

The USDA Forest Service's Asheville, North Carolina-based Eastern Forest Environmental Threat Assessment Center and Prineville, Oregon-based Western Wildlands Environmental Threat Assessment Center partnered with Stennis Space Center and other agencies to create an early warning system to identify, characterize, and track disturbances from potential forest threats. The result was ForWarn, which is now being used by federal and state forest and natural resource managers.



27

Mars Technologies Spawn Durable Wind Turbines

"It all started with ecological life support systems for exploration," says David Bubenheim, a senior research scientist at NASA's Ames Research Center. In the early 1990s, NASA was planning for an extended stay on Mars, and Bubenheim and his Ames colleagues were attempting to create a complete ecological system to sustain human crewmembers during their time on the Red Planet.

"The main barrier to developing such a system," he says, "is energy." Mars has no power plants, and a regenerative system requires equipment that runs on electricity to do nearly everything. The team turned to wind power technology for part of their solution. Northern Power Systems, based in Barre, Vermont, received an SBIR contract to develop and test wind power technology for use on Mars. The company tested its turbines at the South Pole, a place with conditions as harsh as one might encounter on Mars.

By 2000, the wind turbine technology had won an R&D 100 Award from *R&D Magazine*, and since then, says Bubenheim, "It's been duplicated and put in a lot of places around the globe." Today, more than 200 NASA-derived Northern Power 100s are in operation around the globe and are reducing carbon emissions by 50,000 tons annually. The turbines are currently generating electricity for consumers located everywhere from Alaska to the Bahamas to the Italian countryside.



28

Programs Visualize Earth and Space for Interactive Education

Kevin Hussey and others at the Jet Propulsion Laboratory produced web applications to visualize all of the spacecraft in orbit around Earth and in the Solar System. Hussey worked with Milwaukee, Wisconsin-based The Elumenati to rewrite the programs, and after licensing them, the company started offering a version that can be viewed on spheres and dome theaters for schools, museums, science centers, and other institutions.



Information Technology

Powerful computing technology drives many of NASA's most ambitious missions. Many of the tools developed to support research in space can be found in private cloud-computing networks, electronic components for satellites and other spacecraft, and sensors that monitor important machinery.

29 Processor Units Reduce Satellite Construction Costs

As part of the effort to build the Fast Affordable Science and Technology Satellite (FASTSAT), Marshall Space Flight Center developed a low-cost telemetry unit which is used to facilitate communication between a satellite and its receiving station. Huntsville, Alabama-based Orbital Telemetry Inc. has licensed the NASA technology and is offering to install the cost-cutting units on commercial satellites.



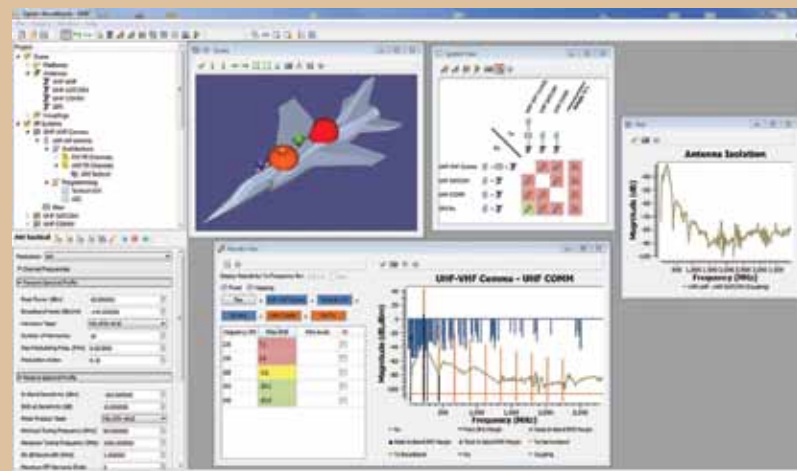
30 Software Accelerates Computing Time for Complex Math

Ames Research Center awarded Newark, Delaware-based EM Photonics Inc. SBIR funding to utilize graphic processing unit (GPU) technology—traditionally used for computer video games—to develop high-computing software called CULA. The software gives users the ability to run complex algorithms on personal computers with greater speed. As a result of the NASA collaboration, the number of employees at the company has increased 10 percent.



31 Simulation Tools Prevent Signal Interference on Spacecraft

NASA engineers use simulation software to detect and prevent interference between different radio frequency (RF) systems on a rocket and satellite before launch. To speed up the process, Kennedy Space Center awarded SBIR funding to Champaign, Illinois-based Delcross Technologies LLC, which added a drag-and-drop feature to its commercial simulation software, resulting in less time spent preparing for the analysis.



32 Software Simplifies the Sharing of Numerical Models

Scientists at NASA not only focus on advancing space exploration; they study what is happening in the Earth's atmosphere as well. The Global Climate Modeling program at Goddard Space Flight Center's Institute for Space Studies, for instance, is tasked primarily with developing paired atmosphere ocean models that simulate Earth's climate system when influenced by a variety of variables, including greenhouse gases, aerosols, and solar effects. Given how critical this work is, NASA frequently shares its models and simulations with graduate students and other researchers outside the Agency. But the traditional way that this has been done—by sending the code to the recipient to deploy on his or her own computer—is fraught with potential problems.

To ease the sharing of climate models with university students, Goddard Space Flight Center awarded SBIR funding to Reston, Virginia-based Paragon Computation Inc., a company that specializes in cloud computing. The firm developed Frontier CODE, a software program capable of running climate models over the Internet, and it also created an online environment for people to collaborate on developing such models. Among other things, the software allows users on any platform—Windows, Mac, or Linux—to run a simulation without compromising the quality of its output. The company is now targeting financial sectors, oil and gas companies, and biotechnology and nanotechnology firms for Frontier CODE's software-as-a-service capabilities.



33 Virtual Machine Language Controls Remote Devices

Kennedy Space Center worked with Blue Sun Enterprises, based in Boulder, Colorado, to enhance the company's virtual machine language (VML) to control the instruments on the Regolith and Environment Science and Oxygen and Lunar Volatiles Extraction mission. Now the NASA-improved VML is available for crewed and uncrewed spacecraft, and has potential applications on remote systems such as weather balloons, unmanned aerial vehicles, and submarines.



34 Micro-Accelerometers Monitor Equipment Health

Glenn Research Center awarded SBIR funding to Ann Arbor, Michigan-based Evigia Systems to develop a miniaturized accelerometer to account for gravitational effects in space experiments. The company has gone on to implement the technology in its suite of prognostic sensors, which are used to monitor the integrity of industrial machinery. As a result, five employees have been hired.





Industrial Productivity

35

Reactors Save Energy, Costs for Hydrogen Production

While examining fuel-reforming technology for fuel cells onboard aircraft, Glenn Research Center partnered with Garrettsville, Ohio-based Catacel Corporation through the Glenn Alliance Technology Exchange program and a Space Act Agreement. Catacel developed a stackable structural reactor that is now employed for commercial hydrogen production and results in energy savings of about 20 percent.



36

Cameras Monitor Spacecraft Integrity to Prevent Failures

Is there—or was there ever—life on Mars? In August 2012 NASA's Curiosity rover touched down on the planet's surface in an attempt to answer what has become one of modern science's most burning questions. In preparation for such an endeavor, the rover had to be equipped with the latest technologies, including a set of high quality, radiation-hardened cameras able to capture sharp, vibrant images of the Martian terrain time and time again.

To develop the cameras, the Jet Propulsion Laboratory enlisted the help of San Diego, California-based Malin Space Science Systems Inc. (MSSS). The company parlayed knowledge gained during its NASA work to develop an off-the-shelf line of cameras designed to help troubleshoot problems that may arise on satellites in space.

When a satellite's building and launch costs can easily soar into the hundreds of millions—or even billions—of dollars, the investment in a reliable camera system to keep eyes on its performance is a prudent investment in added security. Says Michael Ravine, MSSS's advanced projects manager, "You want to see what your spacecraft is doing. You want to monitor the deployments of your antennas and solar arrays . . . [and] see what is going on around your spacecraft. Being able to see your spacecraft can possibly avert some pretty disastrous things from happening."

37

Testing Devices Garner Data on Insulation Performance

To develop a test instrument that could measure the thermal performance of insulation under extreme conditions, researchers at Kennedy Space Center devised the Cryostat 1 and then Cryostat 2. McLean, Virginia-based QinetiQ North America licensed the technology and plans to market it to organizations developing materials for piping and storage tank insulation, refrigeration, appliances, and consumer goods.



38

Smart Sensors Gather Information for Machine Diagnostics

Stennis Space Center was interested in using smart sensors to monitor components on test stands and avert equipment failures. Partnering with St. Paul, Minnesota-based Lion Precision through a Cooperative Agreement, the team developed a smart sensor and the associated communication protocols. The same sensor is now commercially available for manufacturing.



39

Oxygen Sensors Monitor Bioreactors and Ensure Health and Safety

In order to cultivate healthy bacteria in bioreactors, Kennedy Space Center awarded SBIR funding to Needham Heights, Massachusetts-based Polestar Technologies Inc. to develop sensors that could monitor oxygen levels. The result is a sensor now widely used by pharmaceutical companies and medical research universities. Other sensors have also been developed, and in 2013 alone the company increased its workforce by 50 percent.



40

Vision Algorithms Catch Defects in Screen Displays

Andrew Watson, a senior scientist at Ames Research Center, developed a tool called the Spatial Standard Observer (SSO), which models human vision for use in robotic applications. Redmond, Washington-based Radiant Zemax LLC licensed the technology from NASA and combined it with its imaging colorimeter system, creating a powerful tool that high-volume manufacturers of flat-panel displays use to catch defects in screens.



41

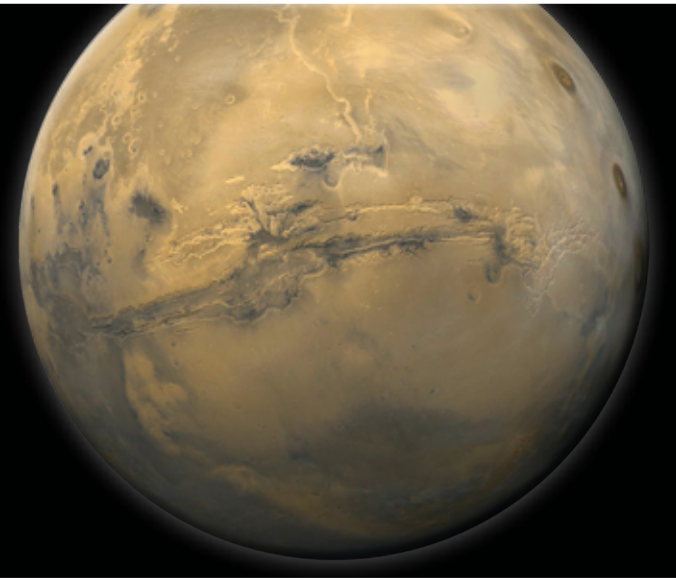
Deformable Mirrors Capture Exoplanet Data, Reflect Lasers

To image and characterize exoplanets, Goddard Space Flight Center turned to deformable mirrors (DMs). Berkeley, California-based Iris AO, Inc. worked with Goddard through the SBIR program to improve the company's microelectromechanical DMs, which are now being evaluated and used for biological research, industrial applications, and could even be used by drug manufacturers.



For 2013, NASA's *Spinoff* publication unveils the stories behind 41 innovative technologies now used on Earth. With origins in Agency missions, each spinoff now benefits the public in the form of commercial products. NASA technology saves lives and enhances our quality of life, reduces costs, creates jobs, and increases revenue. But that is not all you will find in *Spinoff* 2013.

41



FROM MARTIAN SOIL

More than any other place in the Solar System, Mars embodies the mystery, allure, and challenge of deep space exploration. From rovers to orbiters, Mars has been the target of more NASA missions than any other planet outside Earth. And NASA Administrator Charles Bolden recently called the Red Planet "the ultimate destination in our solar system for humanity." *Spinoff* 2013 profiles dozens of NASA technologies that were originally designed for missions to Mars but which are now enhancing life on Earth—real returns on our Nation's investment in some of the Agency's most daring accomplishments.



SPINOFFS OF TOMORROW

American businesses stand to gain by working with NASA. In addition to its many spinoffs already benefitting society, NASA has a host of technologies that are available for licensing and partnership opportunities, capitalizing on the unique advances the Agency is making in a variety of fields. In this year's publication you'll find 18 industry-ready technologies that are now on offer, as well as information on how to partner with us.

BUILDING THE FUTURE, TOGETHER

Each year, *Spinoff* features the latest examples of how NASA technology, data, expertise, and formal collaborations are benefitting society through the Agency's numerous partnerships with government agencies, foreign governments, domestic and international businesses and organizations, academia, and ordinary citizens like you. Partnership news in *Spinoff* 2013 includes satellites the size of a coffee mug, one of the world's longest zebra migrations, futuristic experimental aircraft, zero-emissions public transportation, and much more!



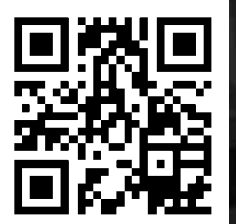
AWARD-WINNING TECHNOLOGIES

A tiny sensor that connects to your phone and can detect chemicals in the air. The most accurate earthquake forecasting tool yet invented. Next-generation spacesuits that might one day see an asteroid or the surface of Mars. NASA's remarkable successes in technology, innovation, and leadership are regularly honored with awards granted by government and industry alike. This year's publication details more than a dozen awards given to individuals, mission teams, and NASA field centers for their cutting-edge achievements.



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in your life
than you think.

To learn about all of this and more, and to get your own free copy of *Spinoff* 2013, scan this code or visit <http://spinoff.nasa.gov>.





There's more space in your life than you think.

NASA's investment in technology yields spinoffs that have saved hundreds of thousands of lives, created tens of thousands of jobs, reduced billions of dollars in costs, and generated billions of dollars in revenue.

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