

National Aeronautics and Space Administration



# spinnoff



National Aeronautics and Space Administration  
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# 2020

# Health and Medicine

Some of NASA's most important spinoffs have stemmed from the need to keep astronauts healthy in some of the most remote, unusual environments possible. So it's no surprise that technology invented to monitor astronauts' health in space or assess their balance after they return from months of weightlessness are now improving healthcare for the general population. But the ability to conduct research and manufacture products in zero or partial gravity is also leading to medical advances.



## 1 Remote Monitoring Promotes Community Health beyond Hospitals

Starting with the Gemini Program, Spacelabs Healthcare worked with Johnson Space Center to develop a system to send data on astronauts' body temperature, heart rate, breathing cycles, and blood pressure to ground stations during flight. The Snoqualmie, Washington-based company quickly saw potential in healthcare on the ground, and today, Spacelabs Healthcare telemetric monitoring systems are in most hospitals around the world. The company is now expanding into community health monitoring—for example, sophisticated, diagnostic-level health monitors that can be worn home and alert doctors if the patient needs intervention.



## 2 Balance Scale Predicts, Helps Prevent Falls

Astronauts returning to Earth often experience balance problems. Two interns at Johnson Space Center helped develop a way to measure a person's balance control. They went on to found Houston-based Zibrio Inc., which released the home version of its balance scale in 2019. The device assigns users a score, and an app lets them explore possible causes and solutions for balance issues, which can change based on various factors. Testing showed the scale could even predict the likelihood of a subject falling.



## 3 Low-Outgassing Space-Grade Coatings Cover Electronics, Sensors, Pacemakers

Over the last three decades, the Outgassing Lab at Goddard Space Flight Center has tested and validated 10 varieties of Parylene—ultrathin coatings that protect circuit boards and other equipment in space. Like all the lab's testing data, the Parylene results are listed in a publicly accessible database, where any researcher can learn that the materials, made by Indianapolis-based Specialty Coating Systems Inc., are stable and release virtually no volatile compounds. The coatings' terrestrial applications include automobile electronics systems, coronary stents, and surgical needles.



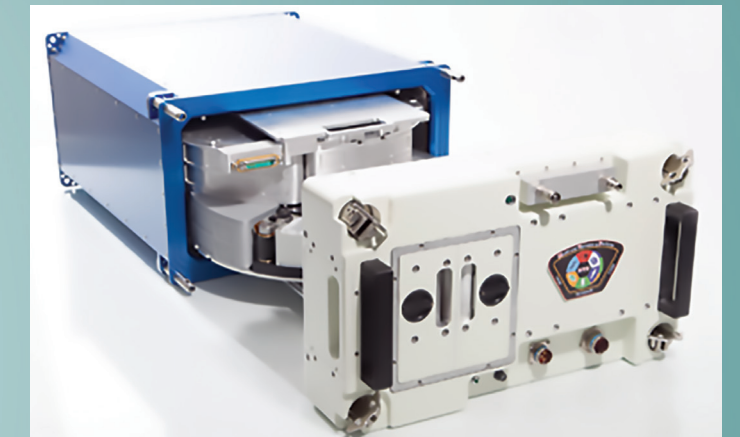
## 4 Fiber-Optic "Nerves" Enable Sensitive Surgery Tools

Intelligent Fiber Optic Systems (IFOS) Corporation's first funding came from NASA SBIR contracts to develop optical fibers with strain and temperature sensors etched at intervals into their cores, a technology with many possible applications. SBIR funding from Johnson Space Center let the Santa Clara, California-based company adapt the technology to enable tactile sensing in a robot's fingers. IFOS has used that capability to create sensitive surgical tools, which it has sold to university research labs and is putting into clinical testing.



## 5 Variable-Gravity Device Enables Medical, Pharmaceutical Research

NASA knows little about the long-term effects of partial gravity, such as what astronauts experience on the lunar surface. So Johnson Space Center awarded SBIR contracts to Techshot Inc. to build the Multi-Use Variable-Gravity Platform now on the space station. The device uses centrifugal force to simulate different levels of gravity and is available for use by any commercial, academic, or government researchers. Modules suiting any experiment's needs can be snapped in. In addition to space exploration, partial gravity can have implications for basic biological processes.



## 6 Space Station Research Platform Paves the Way for Zero-G Manufacturing

The space station offers a unique platform for learning how to take advantage of zero gravity to benefit people on the ground. That's what motivates Lexington, Kentucky-based Space Tango, which sells lab space in orbit. In addition to being hosted on the space station (which supplies power and a data connection), the company designed its modular TangoLabs with help from safety and engineering groups at Johnson Space Center. Today, the company has launched over 100 experiments for clients ranging from researchers to Fortune 500 companies.



# Transportation

Space travel is the most daunting travel humans have undertaken. The need to minimize weight and to create and optimize new vehicle designs, for example, has led to innovations in software and materials that are useful in many fields. NASA also develops technology that helps the private sector follow it into space, where companies are putting satellites into orbit and preparing to venture deeper into the solar system.



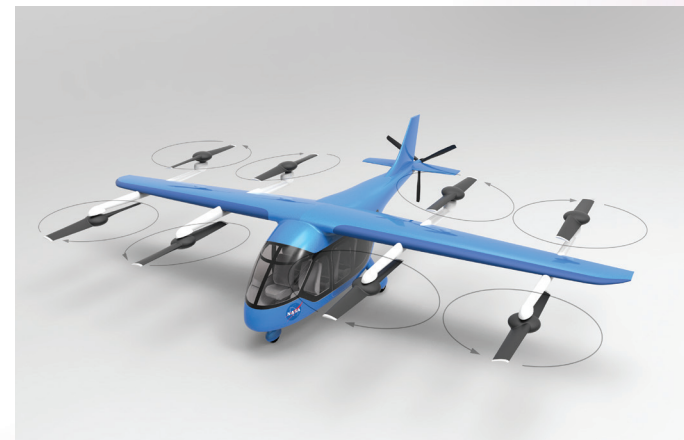
## 7 Pressure Vessels Improve Transportation of Liquid Fuels

The “gas tank” of a rocket holds fuel in the form of liquid or gas, and those special tanks will now be used for moving similar substances on Earth. Huntsville, Alabama-based Cimarron Composites LLC is licensing several of the original patents and leveraging a Space Act Agreement to commercialize this space resource. The new composite overwrapped pressure vessel approved for highways by the U.S. Department of Transportation started with work done at Marshall Space Flight Center.



## 8 Weight-Estimating Software Helps Design Urban Air Taxis

Designing new concepts for aircraft opens a universe of uncertainty. One important detail is weight, which can be difficult to estimate on a brand-new design. Software built by Long Beach, California company M4 Engineering Inc., with help from SBIR funding from Ames and Langley research centers, as well as NASA-developed and NASA-spinoff software, speeds up and simplifies the process. Today, many companies use the software, either through license or in consultation with M4, to help design new aircraft.



## 9 Plane-Launched Rocket Opens Up Space for Small Satellites

Small satellites have had to piggyback on larger missions, restricting when they could launch and to what orbit. Virgin Orbit, located in Long Beach, California, is eliminating that constraint with its LauncherOne rocket, a small rocket that launches after a plane carries it up 35,000 feet. Under NASA's Flight Opportunities program, Ames Research Center helped model the aerodynamic performance of the plane/rocket configuration, and Marshall Space Flight Center and Glenn Research Center experimented with 3D-printed bimetallic combustion chambers that will bring down Virgin's manufacturing costs.



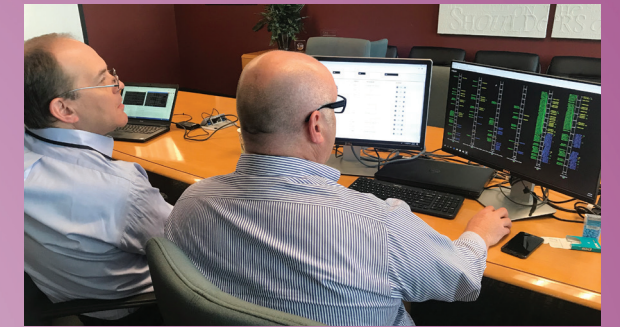
## 10 Flash Lidar Enables Driverless Navigation

A special 3D imager, a global shutter flash lidar, is helping NASA sample an asteroid and could soon help cars safely navigate the road. With SBIR and other project funding from multiple centers including Langley Research Center, Santa Barbara, California-based Advanced Scientific Concepts Inc. improved and tested global shutter flash lidar, which instantly creates a 3D map of its surroundings on a focal plane array with thousands of pixels. Today Continental AG, which bought the company, markets the technology for driverless cars, and the original team, as ASC LLC, sells it for military, commercial aerospace, and marine applications.



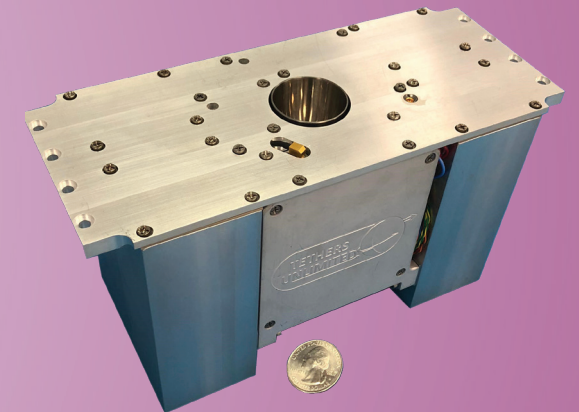
## 11 Virtual Airspace Hosts a Training Program for Air Traffic Managers

Training air traffic controllers and managers to keep flights running smoothly in increasingly crowded skies is a key aspect of efforts to modernize the national airspace. That's why Leesburg, Virginia-based Mosaic ATM built the COMETTS training platform, which simulates conditions—including flights, communications, and weather—for air traffic manager trainees. Developed with SBIR funds from Ames Research Center, the platform works within the ATM-X Test Bed, an Ames project to help designers test their aviation concepts under realistic conditions.



## 12 Water-Powered Engines Offer Satellite Mobility

Thrusters powered by electrolyzed water have been integral to NASA's plans for deep-space exploration since the 1960s. With funding from SBIR contracts with Ames Research Center and through NASA's Tipping Point solicitation, Tethers Unlimited Inc. of Bothell, Washington, has built the first practical water-electrolysis engines. Electrolysis separates water into oxygen and hydrogen, which NASA has long used for rocket fuel. It's safe and easy to store and can likely be foraged from asteroids and other bodies in space. An early application is CubeSat thrusters.



## 13 Unique Sensors Will Improve Aerodynamic Design, Aircraft Performance

A series of NASA SBIR contracts, most of them with Langley Research Center, let Interdisciplinary Consulting Corporation (IC<sup>2</sup>) of Gainesville, Florida, invent the first commercial devices to directly measure the localized force that passing air exerts on the surface of a vehicle model, known as wall shear stress. This force accounts for about half of a vehicle's overall drag, and the ability to observe it directly is improving wind tunnel testing and aerodynamic simulation software used to design aircraft and other vehicles.



## 14 Doppler Lidar Makes Self-Driving Cars Safer

Navigational Doppler lidar, created to land spacecraft safely, can help self-driving cars successfully navigate rush-hour traffic. Lidar helps in the process of identifying objects such as cars, buildings, and people while providing their speed and direction, if any. Thanks to Hampton, Virginia-based Psionic LLC's technology license and Space Act Agreement with Langley Research Center, the company is enabling a cost-effective lidar for cars to “see” where they're going.



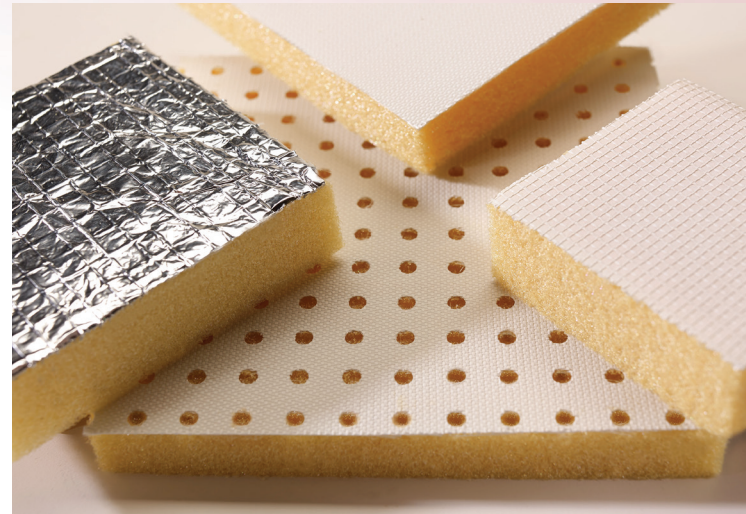
# Public Safety

Safety is an obvious challenge for space travel, and meeting it has led to countless spinoffs over the years. But other projects aimed at airline safety, drone guidance, and measuring greenhouse gases in the atmosphere have also led to products that improve safety on Earth. In one case, expertise with launch systems, rovers, and other NASA technology led to a system that could prevent the next offshore drilling disaster.



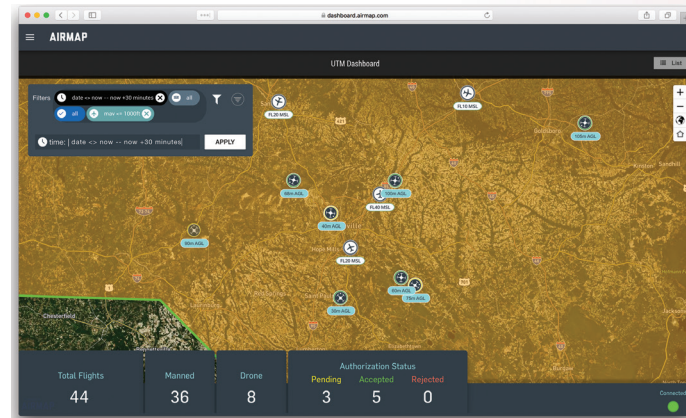
## 15 Polyimide Foam Offers Safer, Lighter Insulation

Under the Fire Resistant Materials Engineering Project of the 1970s, Johnson Space Center and a contractor invented methods to turn a particular polyimide into durable, lightweight, fireproof foams for thermal and acoustic insulation, known as Solimide. Now owned by Boyd Corporation, the Solimide plant in Magnolia, Arkansas, produces about 6.5 million board feet of the material annually. It's used in nearly all U.S. airliners and Navy ships, as well as many other applications around the world.



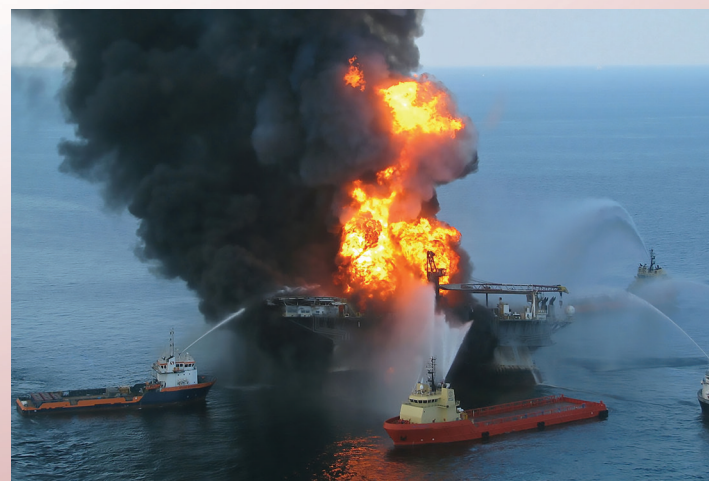
## 16 AirMap Guides Drones toward Widespread Use

Autonomous flying vehicles have incredible potential to change how we use the skies. But first we need a system to safely track them. Engineers at Ames Research Center envision a future where drone operators share trajectories and flight plans with each other, and onboard algorithms and sensors ensure aircraft safely avoid each other. Santa Monica, California-based AirMap Inc. worked with NASA and other industry partners to develop its AirMap UTM platform, which already enables more than 100,000 drone flights per day.



## 17 Rockets, Rovers Spur New Offshore Drilling Safety Technology

After Bastion Technologies Inc., a company with a long history at Marshall Space Flight Center and other NASA locations, helped investigate the *Deepwater Horizon* oil spill, the company sought a way to prevent such a disaster. Using the knowledge of propellants, mission assurance, and structural analysis its employees gained at NASA, the Houston-based company invented its SureShear product for subsea blowout preventers. Rather than using pressurized gas, SureShear burns a solid propellant to power rams that quickly and reliably shear and seal a well's drill pipe.



## 18 Wool Mask to Fight Fires in Space Inspires Fire Equipment on Earth

Auckland, New Zealand-based Lanaco adapted one of its wool filters to prolong the life of the mask astronauts would wear in the event of a fire on the Orion spacecraft. Work on the project, through a Johnson Space Center contract with Jacobs Engineering Group, inspired Lanaco to develop filters for firefighting on Earth. The company expects the work will also inform its sheep breeding program, which aims to maximize the strengths of wool as a filter material.



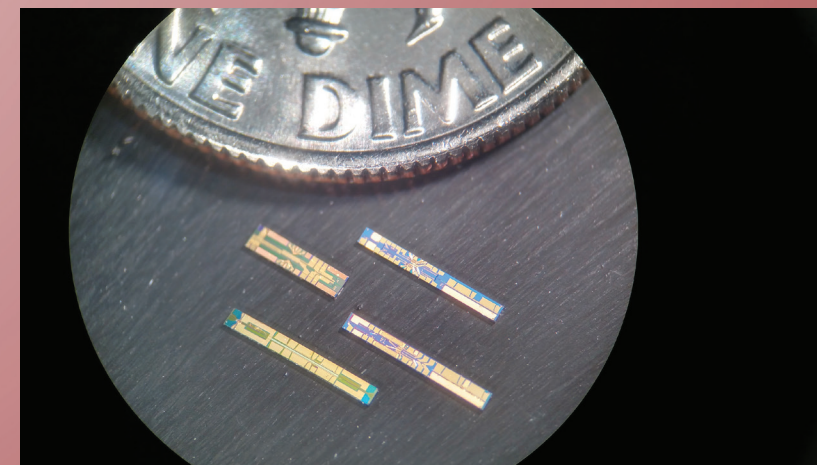
## 19 Autonomous Drone Navigation System Ends Reliance on GPS

When regulations are issued to allow self-piloted drones to fly beyond operators' line of sight, one requirement will be that they be able to navigate without GPS. SBIR contracts from Ames Research Center funded one company's development of a simultaneous localization and mapping system that can do just that. Pittsburgh-based Near Earth Autonomy has sold prototypes of the technology and is working with companies and agencies to adapt it for disaster site surveillance, building and infrastructure inspection, and military reconnaissance.



## 20 Smaller, Cheaper Lasers Can Detect Gas, Monitor Structures, Take Tissue Images

SBIR and Tipping Point contracts from Goddard Space Flight Center helped Freedom Photonics of Santa Barbara, California, develop tunable lasers for sensing methane and other gases. The lasers are much smaller, cheaper, and more efficient than alternatives and have possible applications in environmental monitoring, the oil and gas industry, and other fields. Advances made under Armstrong Flight Research Center SBIR funding have helped the company develop capabilities that could be used for structural monitoring and medical imaging.



# Consumer Goods

When you look around your home, do you see NASA spinoffs? The astronaut experience has inspired many consumer goods since the early days of the space program. Some, such as freeze-dried foods and radiant barrier insulation, are classics. Others are brand new, such as a joystick that allows drones to be controlled with a single hand and a massage chair incorporating research on astronauts' posture. Research on power systems and nanoparticles has also ended up in consumers' hands.



## 21 Astronaut Experience Inspires Single-Handed Drone Flight Controller

Scott Parazynski's astronaut experience helped him create a joystick that controls drone flight with a single hand and will one day, he hopes, revolutionize robotic surgery. Parazynski, who is also a physician, used the expertise he gained at Johnson Space Center and in space to build a more intuitive controller for robotic surgery. While working on FDA approval, he adapted the controller for the growing commercial drone market. His Houston-based company, Fluidity Technologies Inc., launched the FT Aviator in November 2018 and quickly garnered hundreds of pre-orders.



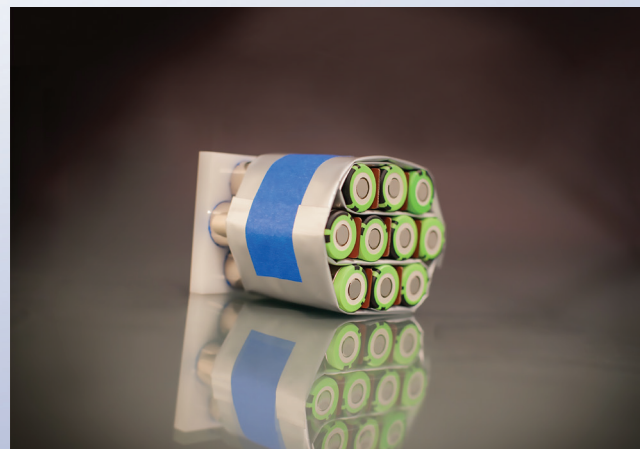
## 22 Freeze-Dried Foods Nourish Adventurers and the Imagination

Freeze-dried food is commonplace today, thanks in part to NASA, which helped innovate many of the modern techniques during early research into food preservation for space exploration. In particular, NASA's advances made freeze-dried meals easier to rehydrate without boiling water. Capitalizing on the interest in astronauts in the early 1970s, the gift shop at Ames Research Center reached out to Boulder-based American Outdoor Products, already using NASA's improved techniques for its freeze-dried foods, and asked them to create "astronaut ice cream." The company now sells it around the world.



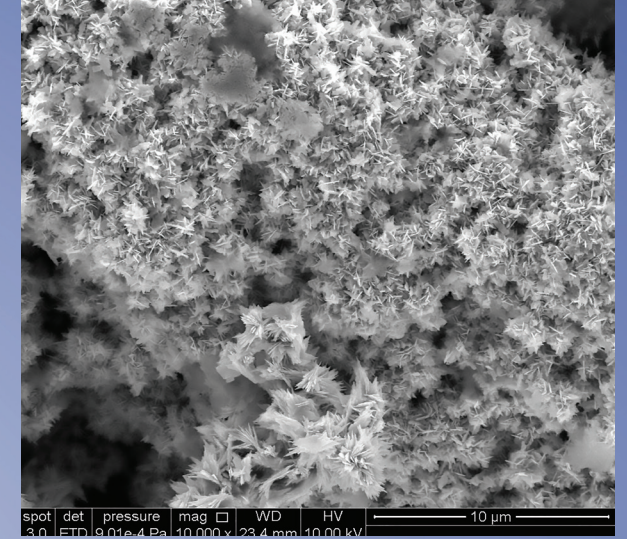
## 23 Carbon-Fiber Heat Sink Makes Batteries Safer for Electric Cars, Bikes, and More

Keeping modern energy-dense batteries from overheating (and sometimes even exploding) is an important challenge. Campbell, California-based KULR Technology specializes in the field. In collaboration with Johnson Space Center, the company recently created a thermal runaway shield for lithium-ion battery packs that promises to improve safety in battery-operated devices from cars to bikes and more. The company also licensed a patent co-owned by NASA for an internal short-circuit device that makes it much easier to test batteries, which KULR sells to its customers to help them improve their in-house safety testing.



## 24 Nanotechnology Repairs Engine Damage in Cars

Repairing worn engine parts instead of replacing them could save consumers millions of dollars in parts and labor costs annually. Colfax, Washington-based TriboTEX LLC gives drivers a way to do just that with a nanoparticle lubricant called TriboTEX that fills in grooves and other wear patterns resulting from friction. A NASA fellowship from the Washington Space Grant Consortium helped fund the initial research. Now more than 30,000 cars and trucks are getting the benefits of increased oil pressure, improved gas mileage, and increased torque.



## 25 Zero-Gravity Body Posture Influences Acupressure Massage Chair

How the human body acts in microgravity influences the equipment and procedures NASA develops, as well as consumer products on Earth. Johnson Space Center neutral body posture research revealed the positions an astronaut's body assumes in space, and that same data is used for a robotic medical massage chair. LURACO Health and Beauty LLC, based in Arlington, Texas, created a zero-gravity setting for the i7 PLUS to leverage a person's weight to enhance the acupressure massage to speed healing, alleviate pain, and reduce stress.



## 26 Spacesuit Insulation Protects Personal Devices

Can a case that protects phones and tablets from the extremes of heat and cold, keeps out sand and dirt, floats, and has drop protection also look cool? Yes, and eXclaim IP LLC of Cornelius, North Carolina, has done it using the radiant barrier insulation used in spacesuits developed at Marshall Space Flight Center. The versatile NASA technology reflects more than 90 percent of solar radiation to prevent devices from overheating and retains heat to keep technology from freezing.



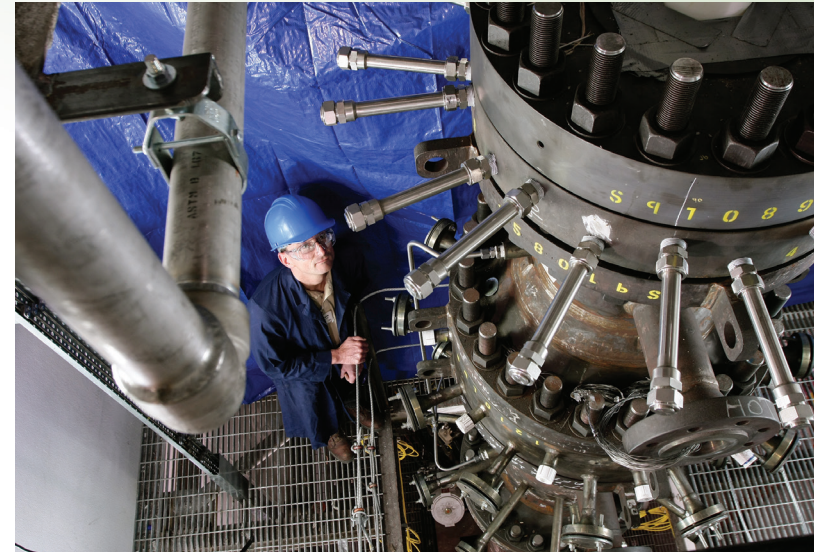
# Energy and Environment

Making the best use of, and protecting, the environment around us—whether on a spacecraft, another planet, or here at home—is crucial to our health and survival. In this section, read about how our Earth-observing satellites are helping farmers produce more with less water and how expertise in rocket engineering led to a technique that lessens the environmental impact of burning coal. Other innovations include a fuel cell that runs equipment at oil wells, reducing the need to vent greenhouse gases, and a laser that is a key part of weather-forecasting satellite tools.



## 27 Rocket Expertise Assists Transition to Green Energy

Economic prosperity is tied to the consistent availability of cheap energy. Coal's abundance makes it a cheap resource to generate electricity and a major source of toxic pollution. An alternative to burning coal for power—gasification—is getting a boost from NASA rocket expertise developed by companies working with Marshall Space Flight Center. Des Plaines, Illinois-based Gas Technology Institute is leveraging this expertise to help developing countries use coal in a less environmentally damaging manner.



## 28 Satellite Imagery Helps Farmers Cut Water Use in Half

Irrigation accounts for around 80 percent of fresh water use across the United States. Oakland, California's Tule Technologies Inc. aims to improve irrigation efficiency by calculating how much water plants are using and losing daily, in part thanks to data from multiple satellites built at Goddard Space Flight Center. Today, the company sells its systems to grape, almond, and other growers across California, who use the data to cut their water use in half or get higher yield with the same amount of water.



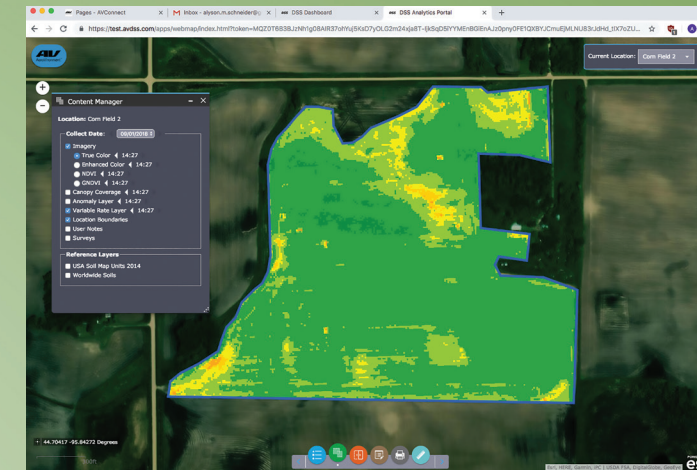
## 29 Gas Processors Turn Oil Drilling Emissions into Fuel for Sale

Robert Zubrin founded Pioneer Astronautics in the 1990s, and the company devised a multitude of technologies for space exploration. Several developed under SBIR contracts with Johnson Space Center would take apart molecules abundant on Mars and reassemble them into useful resources. Realizing that some of this technology could be adapted to the oil and gas industry, Zubrin spun off Lakewood, Colorado-based Pioneer Energy. The company now markets Flarecatcher and Vaporcatcher systems that turn what used to be waste products and greenhouse gas emissions into fuel.



## 30 Field-Scanning Drone Gives Farmers Better Data

Flight enables access and perspective impossible from the ground. A field-scanning drone—designed by Los Angeles-based AeroVironment using expertise in autonomous flight engineering gained on NASA's high-altitude, solar-powered, unmanned airplanes—now makes that perspective more accessible for farmers. Sold as Quantix, the drone is giving farmers better data about their sprawling fields, helping increase yield or farm more efficiently. The company also used the same expertise to help the Jet Propulsion Laboratory build a helicopter for Mars, set to become the first vehicle ever to fly there.



## 31 Versatile Fuel Cells Stop Natural Gas Emissions at Oil Wells

A Jet Propulsion Laboratory engineer taught two California Institute of Technology students how they might make a fuel cell based on their professor's invention of a crystal that conducts protons at record speeds. The students and professor started a company offering fuel cells now used at oil drilling sites to run pneumatic equipment traditionally powered with high-pressure methane, a greenhouse gas that drillers then vent. Based in Pasadena, California, SAFCell also works with another company to make wearable fuel cells for the military.



## 32 Laser Enables Precise Measurements for Weather Forecasting, Industry

Although Hurricane Irma devastated many areas, accurate forecasts helped countless residents prepare. Helping inform those forecasts? Temperature and humidity information from the Cross-Track Infrared Spectrometer, built out of Langley Research Center, which scans the atmosphere from a polar-orbiting satellite. A crucial laser that measures the alignment and proximity of mirrors within the instrument to sub-micrometer levels was built by ABB Inc., whose U.S. headquarters is in Cary, North Carolina. Today, ABB sells hundreds of industrial spectrometers per year with that laser, which is smaller and requires less power than previous options.



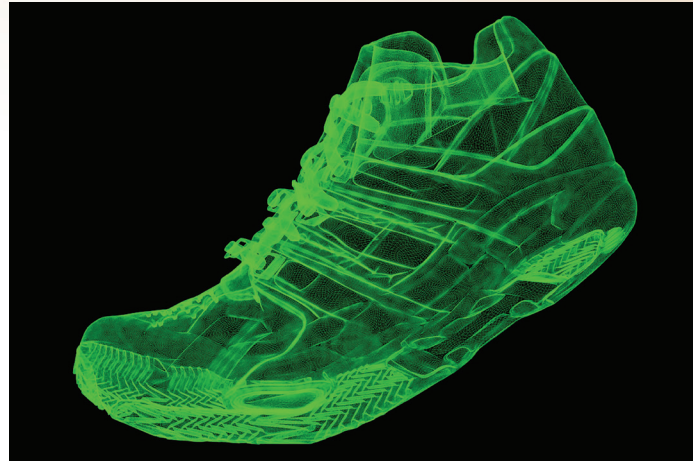
# Information Technology

We interact with software constantly, on our phones, in our cars, on our televisions. Even home appliances are getting “smart.” But we may not realize other ways computer power affects our daily lives—for example, many of the products we use, from shoes to aircraft and more, were designed with the help of supercomputers. Other software is readying our infrastructure for a new wave of drone flight that may soon deliver products or ferry riders across town. And simulation software helps optimize the systems by which computers communicate with each other. Before they were improving our lives, the advances making these new applications possible started at NASA.



## 33 Beowulf Clusters Make Supercomputing Accessible

In the 1990s, efforts to develop supercomputers were stalling well short of Government goals until a pair of computer engineers at Goddard Space Flight Center successfully used a new, open source operating system to turn a cluster of standard computers into a single supercomputer. Known as the Beowulf cluster, the technology dramatically reduced the cost of supercomputing, and most of the world’s top supercomputers today are based on it. Minneapolis-based Nor-Tech custom-builds Beowulf clusters for customers that use them primarily to design products through modeling and simulation.



## 34 Mission Control Conference System Enables Global Collaboration

Conference calling is easy and common, but it requires complicated technology that didn’t exist before the 1980s, when NASA wanted to improve its own communications system. Originally, NASA’s global and space networks required constant manual reconfiguration. To upgrade to a digital system, the communications division at Goddard Space Flight Center called on Pittsburgh-based Compunetics. The company created a conference bridge that allowed connections and conferences to be reconfigured instantly and automatically. The company has since sold millions of similar systems worldwide based on what it created for NASA.



## 35 Swarming Technology Lets Drones Work as a Team

As U.S. skies become more crowded, NASA wants to help aircraft coordinate with each other autonomously. Langley Research Center granted SBIR funding to help Heron Systems Inc., based in California, Maryland, advance its Multi-Agent Cooperative Engagement (MACE) technology—software and hardware that allows drones to cooperatively allocate tasks and resources and plan flight paths without the help of an operator. MACE has immediate applications in military training and could soon help monitor crops and infrastructure before eventually helping to manage U.S. airspace.



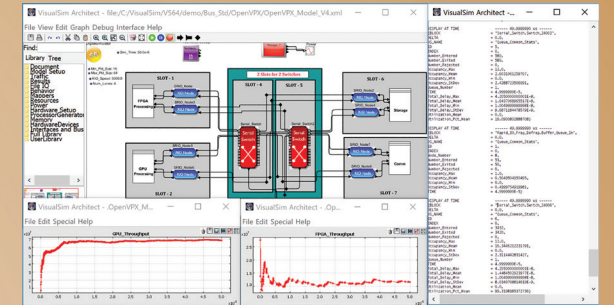
## 36 AURA Software Tackles Uncertainty in Complex Systems

Langley Research Center awarded SBIR contracts to Charlottesville, Virginia-based Barron Associates Inc. to build on earlier work the company did with Langley to predict the performance of aircraft diagnostic and control systems. The result, Algorithms for Uncertainty Representation and Analysis (AURA), can determine uncertainties and probabilities of various outcomes in a single calculation. AURA has been used to validate autonomous systems for planes and drones and to predict how drug molecules might behave in the body, but it can be applied to any complex system.



## 37 Simulation Software Optimizes High-Speed, Efficient Data Networks

In 2010, the Jet Propulsion Laboratory (JPL) sought a new computer communications protocol for spacecraft. This set of standards defines the physical and functional qualities of communication systems within or between computers. JPL settled on the Serial RapidIO protocol and wanted to use VisualSim—electronics simulation software by Sunnyvale, California-based Mirabilis Design Inc.—to model its behavior. The center partnered with Mirabilis to build a RapidIO simulation capability, which is now available to other industries that use the protocol, such as data centers, supercomputing, communications, and automation.



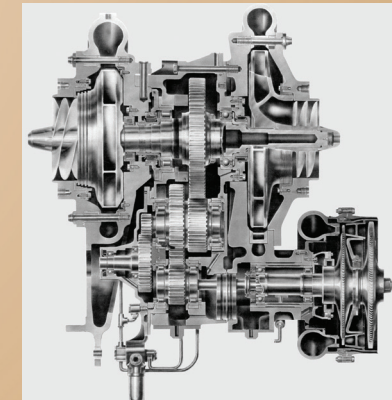
## 38 Data Visualization Platform Helps Missions Fly

Software designed at Ames Research Center helps mission controllers see at a glance what’s happening and when there’s a problem. The web-based platform, Open MCT, can display streaming and historical data, imagery, timelines, procedures, and other data visualizations and can be quickly configured and reconfigured. Now that it is open source and freely available, it has many users, including the Planetary Society, based in Pasadena, California, which adopted Open MCT to visualize the data coming in from LightSail 2, a spacecraft that navigates Earth orbit with solar power.



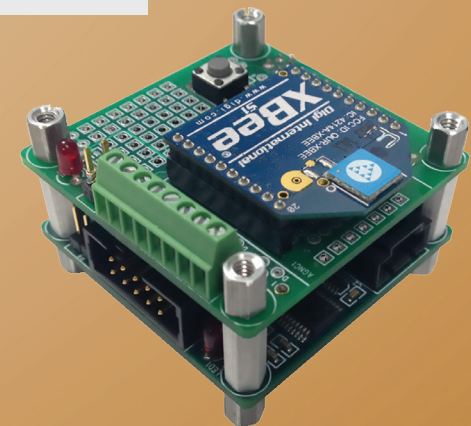
## 39 Turbopump Modeling Software Propels Fluid-Flow Simulations

As the commercial space economy grows, both established and start-up aerospace companies are doing work that was previously performed by NASA and other Government entities. To make sure they have the same powerful tools to design and improve spacecraft, Marshall Space Flight Center is making Generalized Fluid System Simulation Program (GFSSP) licenses available through Denver-based Mode Technologies Group. This testing and analysis program is available to businesses and educational institutions, with three new licenses sold in 2019.



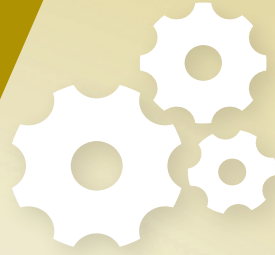
## 40 Smart Sensor Networks Monitor System Health—and Themselves

Stennis Space Center awarded Simi Valley, California-based American GNC Corporation several SBIR and STTR contracts to develop smart sensor networks that monitor systems to detect and predict faults. The technology can also detect faults in its own sensors. The work led to the company’s Reconfigurable Embedded Smart Sensor Node and its Smart Transducer Integrator, which can gather information from many sensors, package it, and deliver it wirelessly.



# Industrial Productivity

In space, a broken or worn part can be catastrophic—and, especially with uncrewed spacecraft millions of miles from home, repairs are often impossible. With that in mind, we have pioneered many technologies using or improving groundbreaking materials, such as metallic glass and aerogels, that help protect our machinery and are now doing the same for industrial and manufacturing plants on the ground, saving huge costs and improving productivity. Other innovations track flows within pipelines, improve training for the manufacturing of sensitive electronics, and create an entirely new class of solid-state humidity sensors.



## 41 Metallic Glass Coatings Improve Power Plant, Oil Rig Productivity

A tough, durable, versatile coating with the atomic structure of glass helps keep power plants running. NASA has been working on the material, called liquid metal or metallic glass, at least since the 1980s. That work continues today at the Jet Propulsion Laboratory's Metallurgy Facility. Spring, Texas-based Liquidmetal Coatings LLC, which licenses the original NASA-funded technology, created a range of coatings that protect vital components at power plants, petrochemical refineries, and oil and gas drilling sites around the world.



## 42 Aerogel Insulations Save Millions in Industrial Applications

Beginning with two SBIR contracts from Kennedy Space Center, Aspen Systems worked with NASA to develop the first sturdy, practical aerogel insulations. The effort spun off into Northborough, Massachusetts-based Aspen Aerogels, a 300-person company with over \$100 million in annual revenue. While the ultra-lightweight, super-insulating materials appear in many consumer products, their primary applications are in power plants, steam distribution systems, buildings, pipelines, and other industrial applications all over the world, where they conserve energy and reduce costs and downtime.



## 43 Revolutionary Battery Replacement Leads to a New Humidity Sensor

Developing a new power source material to replace batteries resulted in an unexpected outcome—a solid-state humidity sensor. Technologists at Marshall Space Flight Center partnered with Roscid Technologies Inc. of Woburn, Massachusetts, to test the new energy storage material that uses nanotechnology and non-toxic ingredients. It performed so well that Roscid licensed the technology to create a new class of industrial humidity sensors.



## 44 Printed Polymer Makes Integrated Airplane Parts

Additive manufacturing, or 3D printing, makes it possible to manufacture entirely new structures or integrate existing ones into single components. But for applications like aerospace, high-grade structural materials and extensive testing are required. As part of the America Makes initiative, a public-private partnership to advance research in and applications for additive manufacturing, Goddard Space Flight Center teamed up with private companies on a project to investigate the properties of PEKK, a high-grade polymer, and now Stamford, Connecticut-based Hexcel Corporation is selling the material and 3D printing parts for spacecraft and aircraft.



## 45 Zero-Leak Valve Holds Tight in Demanding Environments

Liquid leaks in the space station can cause serious problems. So when NASA needed a new fine-mist water fire extinguisher to use in zero gravity, the contents had to stay contained. A zero-leak valve manufactured by Doering Company LLC in Clear Lake, Minnesota, proved to be a perfect fit. After Glenn Research Center funded several SBIR grants for ADA Technologies to develop the hand-held fire suppression system, the same class of zero-leak valve is now stopping leaks in several industries on Earth.



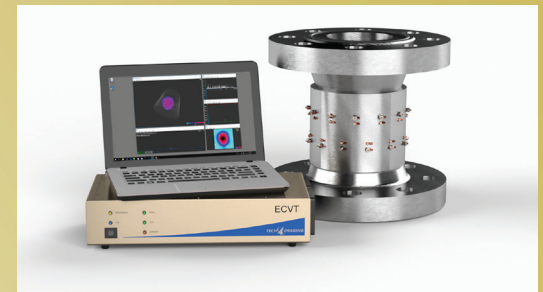
## 46 Pulsed Laser Innovations Power Nobel-Winners' Research

Astronauts regularly post tweets from orbit, and images stream across the solar system, but the amount of data coming from space is growing rapidly. We need more bandwidth, and the best solution is laser communications. San Jose, California-based PolarOnyx Inc. specializes in very fast-pulsed lasers, which are ideal for space-to-ground transmissions. The Jet Propulsion Laboratory funded multiple SBIR contracts over the years that have helped the company develop and perfect its lasers, and it has sold more than 400 since 2005, including to multiple Nobel Prize winners.



## 47 New Imaging Technique Measures Unseen Flows

In the interest of studying interactions of liquids and gases in zero gravity, Johnson Space Center awarded SBIR contracts to Tech4Imaging LLC of Columbus, Ohio. The company had invented a technique that used electrical signals to create a 3D image of solids and gases inside a pipe or vessel. With the SBIR funding, the company developed the ability to distinguish water and oil and also improved resolution. The technology has clear applications in the oil industry, as well as manufacturing, testing infrastructure, and medical imaging.



## 48 Separation Device Launches New Science Payloads

Rockets typically come in stages, optimized for different parts of the launch. Ensuring each stage separates correctly is complicated and crucially important. The Interstellar Boundary Explorer spacecraft (IBEX) needed three separation devices. Silver Spring, Maryland-based Planetary Systems Corporation had a proven track record with their Lightband devices, so the Goddard Space Flight Center team called on them to build a lighter model that would work for IBEX. The resulting product completely replaced its predecessor and paved the way for the company to double in size.



## 49 Tiny Pulsed Lasers Have Medical, Industrial, Military, Environmental Applications

To pack more instruments into the Mars 2020 rover than its predecessors, NASA had to shrink components. SBIR contracts overseen by Goddard Space Flight Center paid Q-Peak Inc. of Bedford, Massachusetts, to develop a high-powered, pulsed-energy laser of unprecedented tinness for one of the rover's spectrometers. Based on that work, the company's Moonbow lasers pack technology that would normally fill a shoebox into a housing the size of a matchbox. These lasers could be used to treat glaucoma in developing countries, as well as in spectroscopy, lidar, and military applications.



## 50 Electrostatic Discharge Training Improves Manufacturing Practices

The shock you might get when touching a doorknob is electrostatic discharge, and when you're building sensitive electronics, it can wreak havoc. Goddard Space Flight Center's Alvin Boutte and others across NASA devise and implement protocols to minimize electrostatic discharge. One tool that helps is a training seminar conducted by Moffett Field, California-based RMV Technology Group. Boutte and others have provided feedback that has helped shape and improve the course, and now that same training is helping the company's other training clients, including the U.S. military and universities.





# SPINOFFS OF TOMORROW

*Spinoff* 2020 profiles dozens of products and services that are already improving lives, creating jobs, and enhancing the bottom line for businesses. But NASA has thousands more technologies ripe for commercialization. This year's *Spinoff* features 20 of NASA's best industry-ready technologies on offer, including:

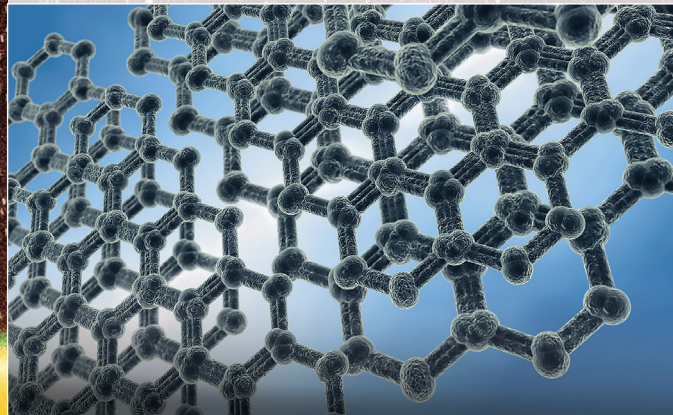


## HACKER ALERT SYSTEM

Hackers and suspicious activity are a common challenge in complex computer systems. Goddard Space Flight Center has developed a process to detect unauthorized access by monitoring typical user behavior across multiple workstations, mobile devices, and facilities.

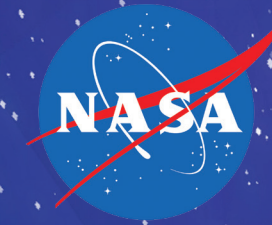
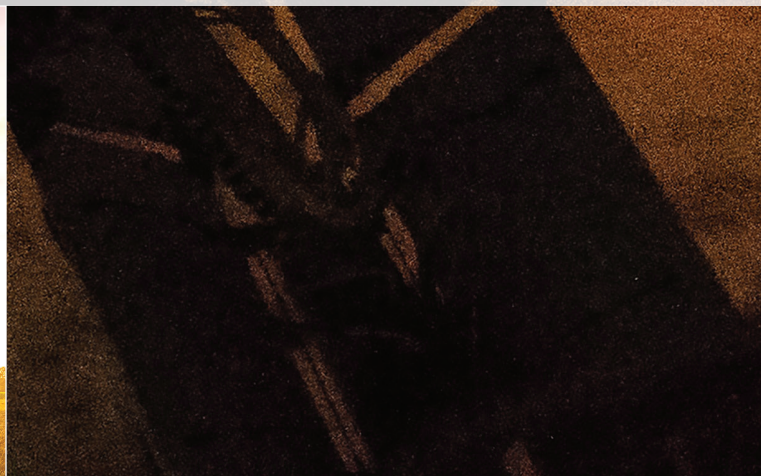
## NANOSENSOR FOR DIAGNOSING ILLNESS

Analyzing a person's breath can reveal the presence of volatile compounds, called biomarkers, that give clues for a diagnosis and can help choose the right treatment. Ames Research Center has invented an array of nanosensors for real-time breath measurement, which can provide a fast and accurate diagnosis.



## FIBER-OPTIC SENSING PORTFOLIO

A NASA-developed fiber-optic sensing system can give ultrafast, reliable measurements of shape, stress, temperature, pressure, strength, operational load, and liquid level. The technology has the potential to be used in a wide variety of fields in addition to aeronautics, such as in wind turbines or in biomedical devices.



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# NASA Spinoff Technology across the Nation

## Health and Medicine

1. Remote Monitoring Promotes Community Health beyond Hospitals (WA)
2. Balance Scale Predicts, Helps Prevent Falls (TX)
3. Low-Outgassing, Space-Grade Coatings Cover Electronics, Sensors, Pacemakers (IN)
4. Fiber-Optic "Nerves" Enable Sensitive Surgery Tools (CA)
5. Variable-Gravity Device Enables Medical, Pharmaceutical Research (IN)
6. Space Station Research Platform Paves the Way for Zero-G Manufacturing (KY)

## Transportation

7. Pressure Vessels Improve Transportation of Liquid Fuels (AL)
8. Weight-Estimating Software Helps Design Urban Air Taxis (CA)
9. Plane-Launched Rocket Opens Up Space for Small Satellites (CA)
10. Flash Lidar Enables Driverless Navigation (CA)
11. Virtual Airspace Hosts a Training Program for Air Traffic Managers (VA)
12. Water-Powered Engines Offer Satellite Mobility (WA)
13. Unique Sensors Will Improve Aerodynamic Design, Aircraft Performance (FL)
14. Doppler Lidar Makes Self-Driving Cars Safer (VA)

## Public Safety

15. Polyimide Foam Offers Safer, Lighter Insulation (AR)
16. AirMap Guides Drones toward Widespread Use (CA)
17. Rockets, Rovers Spur New Offshore Drilling Safety Technology (TX)
18. Wool Mask to Fight Fires in Space Inspires Fire Equipment on Earth (New Zealand)
19. Autonomous Drone Navigation System Ends Reliance on GPS (PA)
20. Smaller, Cheaper Lasers Can Detect Gas, Monitor Structures, Take Tissue Images (CA)

## Consumer Goods

21. Astronaut Experience Inspires Single-Handed Drone Flight Controller (TX)
22. Freeze-Dried Foods Nourish Adventurers and the Imagination (CO)
23. Carbon-Fiber Heat Sink Makes Batteries Safer for Electric Cars, Bikes, and More (CA)
24. Nanotechnology Repairs Engine Damage in Cars (WA)
25. Zero-Gravity Body Posture Influences Acupressure Massage Chair (TX)
26. Spacesuit Insulation Protects Personal Devices (NC)

## Energy and Environment

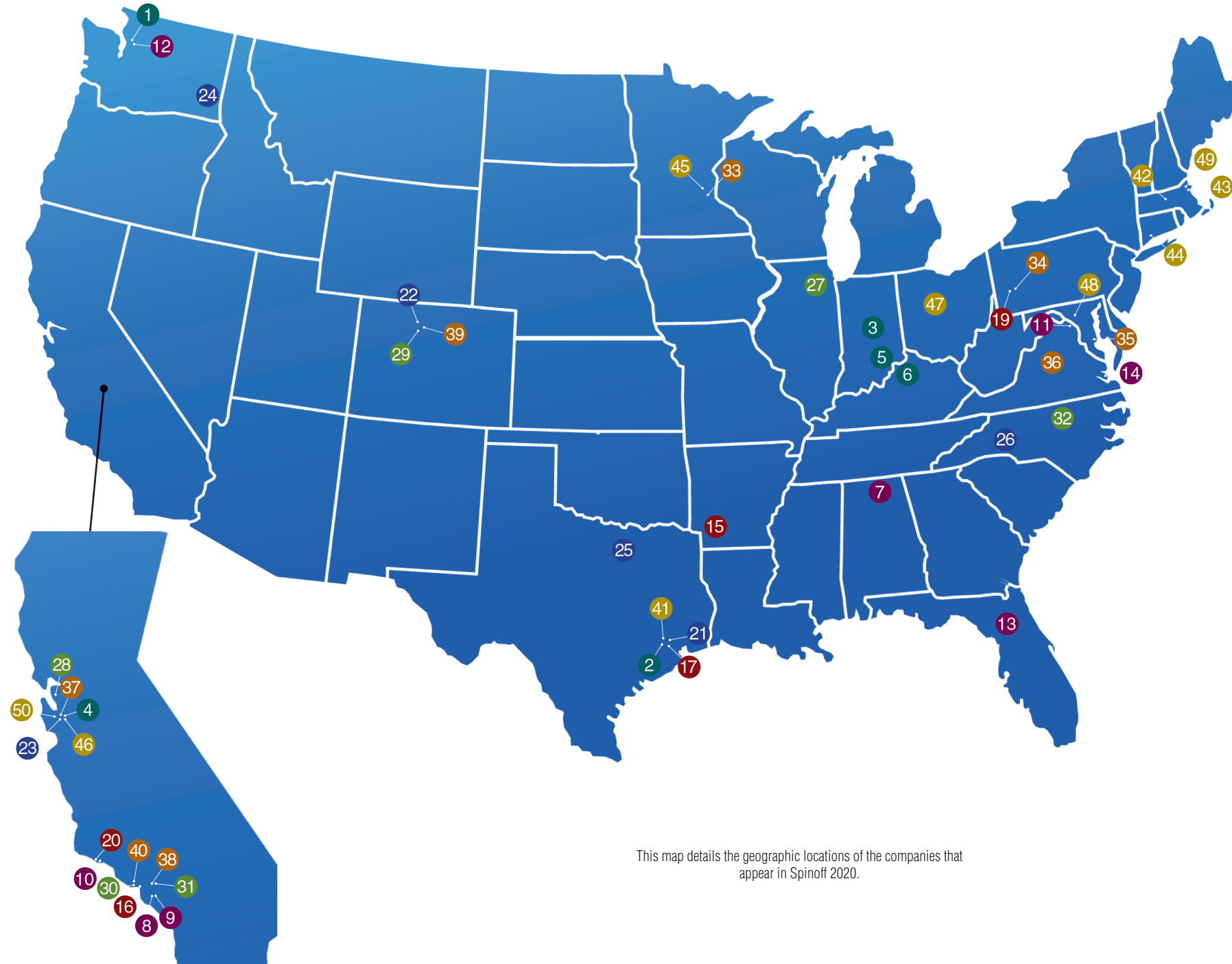
27. Rocket Expertise Assists Transition to Green Energy (IL)
28. Satellite Imagery Helps Farmers Cut Water Use in Half (CA)
29. Gas Processors Turn Oil Drilling Emissions into Fuel for Sale (CO)
30. Field-Scanning Drone Gives Farmers Better Data (CA)
31. Versatile Fuel Cells Stop Natural Gas Emissions at Oil Wells (CA)
32. Laser Enables Precise Measurements for Weather Forecasting, Industry (NC)

## Information Technology

33. Beowulf Clusters Make Supercomputing Accessible (MN)
34. Mission Control Conference System Enables Global Collaboration (PA)
35. Swarming Technology Lets Drones Work as a Team (MD)
36. AURA Software Tackles Uncertainty in Complex Systems (VA)
37. Simulation Software Optimizes High-Speed, Efficient Data Networks (CA)
38. Data Visualization Platform Helps Missions Fly (CA)
39. Turbopump Modeling Software Propels Fluid-Flow Simulations (CO)
40. Smart Sensor Networks Monitor System Health—and Themselves (CA)

## Industrial Productivity

41. Metallic Glass Coatings Improve Power Plant, Oil Rig Productivity (TX)
42. Aerogel Insulations Save Millions in Industrial Applications (MA)
43. Revolutionary Battery Replacement Leads to a New Humidity Sensor (MA)
44. Printed Polymer Makes Integrated Airplane Parts (CT)
45. Zero-Leak Valve Holds Tight in Demanding Environments (MN)
46. Pulsed Laser Innovations Power Nobel-Winners' Research (CA)
47. New Imaging Technique Measures Unseen Flows (OH)
48. Separation Device Launches New Science Payloads (MD)
49. Tiny Pulsed Lasers Have Medical, Industrial, Military, Environmental Applications (MA)
50. Electrostatic Discharge Training Improves Manufacturing Practices (CA)



This map details the geographic locations of the companies that appear in Spinoff 2020.