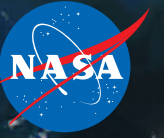


National Aeronautics and Space Administration



SPINOFF



**NASA TECHNOLOGY
TRANSFER PROGRAM**

National Aeronautics and Space Administration
Technology Transfer Program
NASA Headquarters
Washington, DC 20546

www.nasa.gov

NP-2021-09-2986-HQ

2022

SPINOFF Features

How will we feed the world's burgeoning population of billions amid a changing climate, increased urbanization, and other challenges? Is there an effective way to clean the air to slow the spread of potentially life-threatening viruses? What can you do to get better rest if your circadian rhythm is thrown off? The answers to these important questions may just come from space. Read on to learn more.



A Moveable Feast: Plant Research for Space Advances Earth Agriculture

NASA's vertical farm, the first in the country, provided a foundation for expanding the controlled environment agriculture industry



Redefining 'Data Farm'

To convert existing buildings into indoor farms, Bowery Farming Inc. of New York City is leveraging the vertical farm structure NASA originated, along with the expertise of employees who participated in NASA-funded plant-growth research projects.

*Bowery Farming,
Kennedy Space Center*

Space-Inspired Farming

Plenty Unlimited Inc. of San Francisco relied on data published by NASA about the first controlled environment vertical farm in the United States to design and build a highly automated urban farm that uses 1% of the water traditional agriculture requires.

Plenty Unlimited, Kennedy Space Center



Specialized Spuds

Dramatic greenhouse yields at CSS Farms LLC of Watertown, South Dakota, are the result of a NASA-developed hydroponic growing method specifically for root vegetables such as potatoes.

CSS Farms, Kennedy Space Center



Plant-Growth R&D

Building on plant data from NASA growth experiments, Green Sense Farm Holdings Inc. of Portage, Indiana, develops and automates optimal growing conditions for plant varieties for Earth-bound indoor farmers.

*Green Sense Farms Holdings,
Kennedy Space Center*



NASA Helps Drones Take Flight

The agency has helped develop the foundational technology and systems that are enabling remotely piloted aircraft to fill our skies



Remotely Piloted and Global

While helping NASA develop detect-and-avoid algorithms that eventually validated new safety standards, San Diego-based General Atomics developed its own system to help aircraft, including drones, avoid collisions.

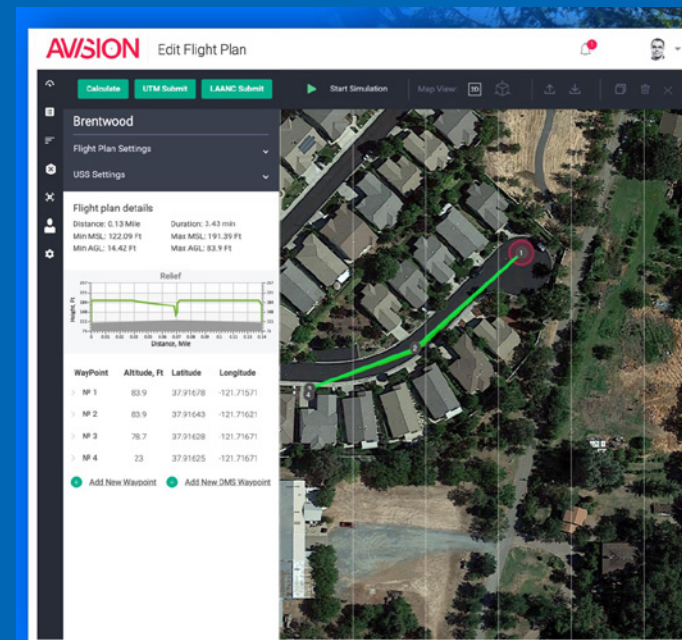
General Atomics, Langley Research Center



Flying Your Own Drone

After working with engineers at NASA under a Space Act Agreement, Santa Monica, California-based Avision developed its own drone management app to help pilots navigate small drones in low-altitude airspace.

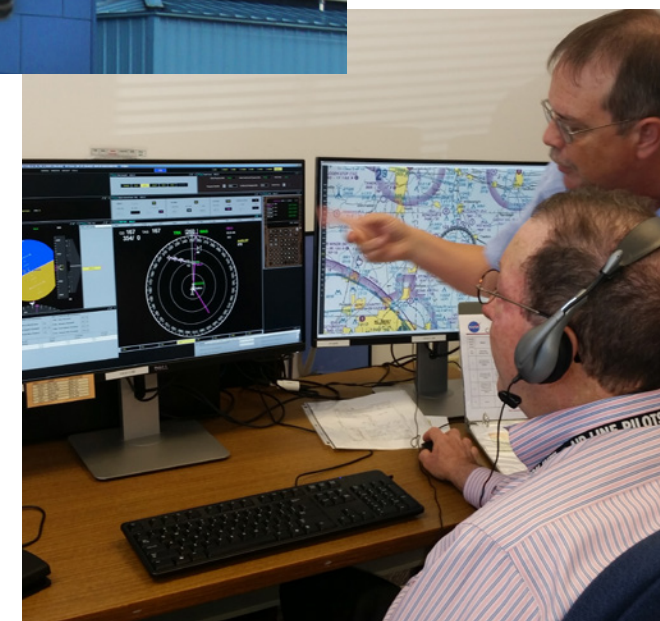
Avision, Ames Research Center



Simulations, Live Flights, and Flight Simulators

After helping NASA develop a drone flight testing environment that incorporates both live and virtual aircraft, Yorkville, New York-based AX Enterprize LLC continued to enhance the system so its own customers could continue to use it.

AX Enterprize, Langley Research Center



On the Ground and in the Cloud

Beavercreek, Ohio-based CAL Analytics LLC's commercially available detect-and-avoid system for drones was informed by the company's work testing an Air Force detect-and-avoid system against NASA algorithms.

CAL Analytics, Langley Research Center

Safely Detoxifying Soil and Groundwater with NASA Technology

Revolutionary iron emulsion created an eco-friendly alternative to costly site decontamination

Cheaper, Faster, More Effective Brownfield Cleanup

Toxicological and Environmental Associates Inc. of Miramar Beach, Florida, developed SourceKill using a non-exclusive license for NASA's eco-friendly emulsified zero-valent iron (EZVI) technology to reduce on-site chemicals to their harmless components.

Toxicological and Environmental Associates, Kennedy Space Center



Improving Toxic Site Remediation

Freeport, Illinois-based Provectus Environmental Products Inc. manufactures EZVI for its clients and other remediation companies using a non-exclusive patent license to support the safe removal of chlorinated hydrocarbon compounds from soil and water.

Provectus Environmental Products, Kennedy Space Center

Tackling Worldwide Environmental Cleanup

Terra Systems Inc. of Claymont, Delaware, uses a non-exclusive license for EZVI to clean up brownfield sites in the United States and overseas.

Terra Systems, Kennedy Space Center

Eliminating Persistent Chemicals from Soil and Groundwater

A non-exclusive license for patented NASA technology that safely removes toxins at a spill site enables Woodard & Curran Inc. of Portland, Maine, to help companies mitigate damage and comply with EPA standards.

Woodard & Curran, Kennedy Space Center



Clean Air Tech for Spacecraft Helps Fight Pandemic

Clean air, always a priority in space, gained importance on Earth in slowing virus spread

From Plants in Space to the Human Race

Air purifiers made by ActivePure Technologies LLC, based in Dallas, proved able to eliminate the SARS-CoV-2 virus in enclosed spaces, and the company had a model approved for medical use in 2020. The devices use photocatalytic oxidation, pioneered under funding from NASA in the 1990s as a way to improve plant growth in spacecraft.

ActivePure Technologies LLC,
Marshall Space Flight Center



Spacecraft: The Ultimate Indoor Environment

TFI Environmental Inc. of Toronto based several of its Respicaire air purifiers on NASA-funded research into the use of photocatalytic oxidation to scrub the air in a spaceborne plant-growth chamber. TFI's devices proved able to kill the novel coronavirus and found widespread demand during the pandemic.

TFI Environmental, Marshall Space Flight Center



'Electronic Nose' Smells Trouble

After NASA and the Italian Space Agency sent an "electronic nose" for testing on the space station, its inventors founded Airgloss SRL in Rome and incorporated the technology into an air-quality sensor, which can also calculate the risk of COVID-19 spread in an indoor space.

Airgloss, Kennedy Space Center



Lighting in a Bottle

NASA's lighting research gives people on Earth better rest and helps plants grow

LED Lights for Sleep and Sanitizing

Healthe Inc. of Orlando, Florida, based on experience designing spacecraft lighting for NASA and using NASA-funded circadian research, developed automated LED bulbs to promote healthy sleep-wake cycles. The company further developed the technology into a method of sanitizing air with ultraviolet light.

Healthe, Johnson Space Center



LEDs Provide for Plants

Building on experience from working on circadian and grow lamps for NASA, VividGro of Chicago developed solid-state LED technology into more efficient grow lights for indoor agriculture.

VividGro, Kennedy Space Center



SPINOFF Capsules

NASA works continually to uncover mysteries of the universe, and as you have seen, many of its innovations have been adapted to benefit all of us. Read on for additional examples. For more, visit spinoff.nasa.gov

Microbes Help Trees Clean Up Pollution

Bacteria-fortified trees now eliminating pollution were first field-proven with help from NASA

The use of symbiotic bacteria to help trees eliminate environmental contaminants got its first field test at a NASA center, leading to the formation of Moffett Field, California-based Intrinsyx Environmental. The company's trees are now cleaning up pollution across the country.

*Intrinsyx Environmental,
Ames Research Center*



Test Rockets Prepare for Distant Landings

Rocket-powered vehicles for testing lander navigation systems support space companies



Needing to test space landing systems on Earth, NASA funded a small startup, Masten Space Systems, based in Mojave, California, to develop a rocket-powered testing platform that now supports the aerospace industry.

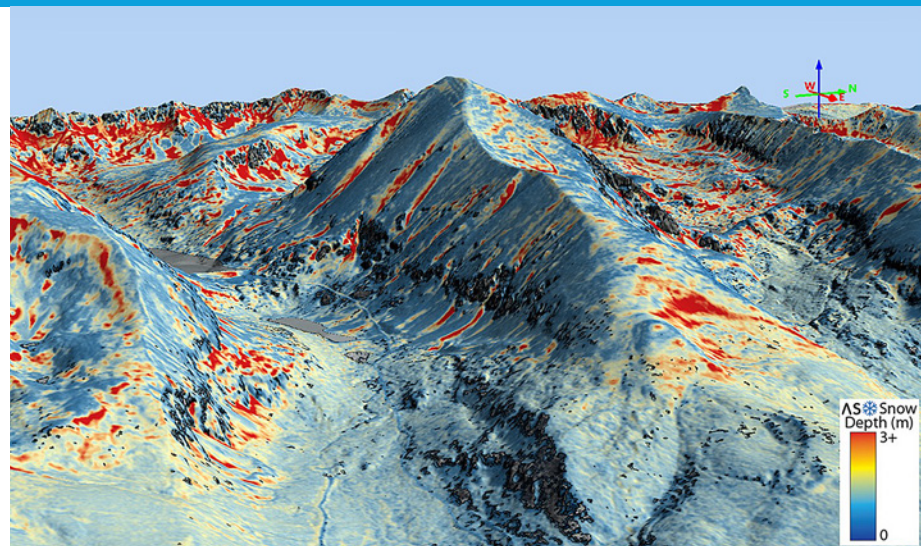
*Masten Space Systems, Armstrong Flight Research Center,
NASA Headquarters*

Getting Water Out of Snow with NASA Tech

Sensors attached to an airplane measure snowpack in mountains to calculate the water it contains

Calculating the amount of water in mountain snowpack is now possible with NASA-developed technology. Airborne Snow Observatories Inc. measures the depth and quality of snow to accurately calculate when and how much water will be available downstream.

Airborne Snow Observatories, Jet Propulsion Laboratory

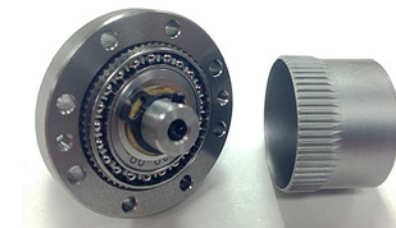
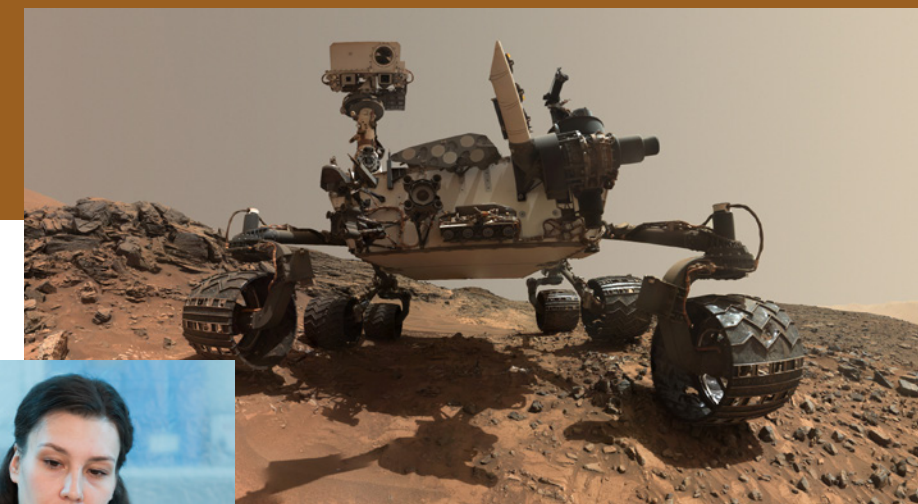


The 'Cobot' Revolution Is Coming

Bulk metallic glass could slash prices of collaborative robots and lead to advanced 3D-printed metals

Founded by JPL's foremost pioneer of metallic glasses and metal 3D printing, Pasadena, California-based Amorphology Inc. aims to turn multiple NASA patents into cheaper robot gears and much more.

Amorphology, Jet Propulsion Laboratory



From a Lightbox to Lamps

Wireless LED lamps keep people's circadian rhythm in check



When a lighting engineer wanted to make something new to help people get the rest they needed, NASA research allowed Ario Inc. of Seattle to create a wirelessly controlled LED lamp that is now seeing use in homes and hospitality.

Ario, Johnson Space Center

Swinging the HAMR

NASA technology and experience bring hybrid aircraft to the skies

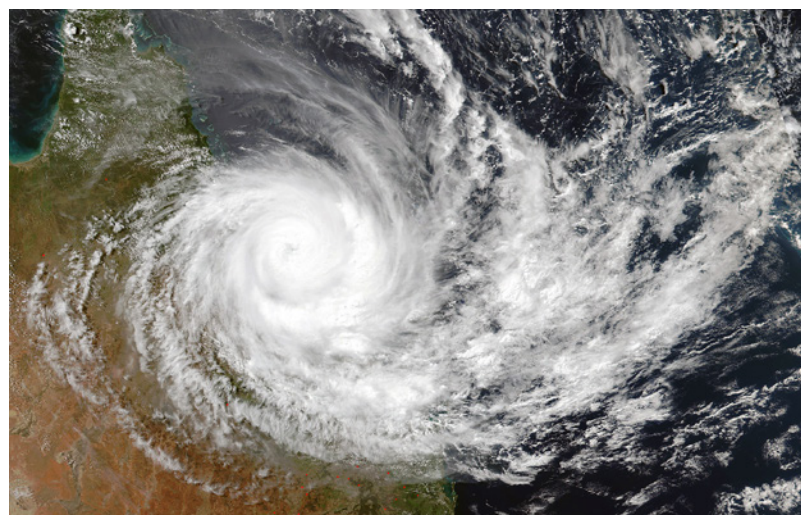


Founded by a former NASA engineer working with licensed technology he invented at Langley Research Center, Advanced Aircraft Company LLC of Hampton, Virginia, has built a hybrid-engine aircraft capable of outlasting battery-powered drones.

Advanced Aircraft Company, Langley Research Center

Satellite Software Helps Global Forecasting

Satellite scheduling software helps to consolidate data acquisition and improve weather forecasting

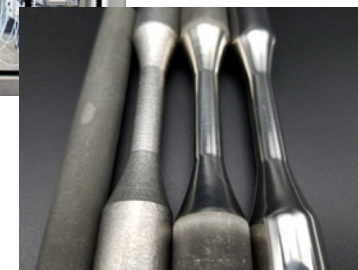


Experience gained while working on NASA satellite systems helped Orbit Logic Inc. of Greenbelt, Maryland, make improvements to NOAA's Earth-observing satellite scheduling capabilities, which will be used to get weather-tracking data down to Earth more efficiently.

Orbit Logic, Goddard Space Flight Center

Some Engineering Is Only Skin Deep

Ability to finish surfaces of 3D-printed superalloys improves performance for engines, industry

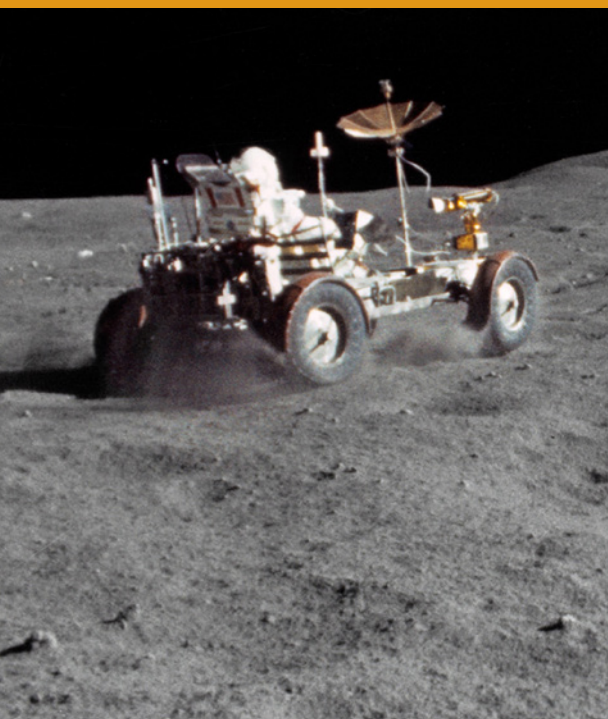


Additive manufacturing with superalloys promised cheaper, better rocket engines, but rough surfaces reduced performance of 3D-printed parts. With NASA SBIR funding, REM Surface Engineering of Southington, Connecticut, developed a solution.

REM Surface Engineering, Marshall Space Flight Center

Measuring Moon Dust to Fight Air Pollution

NASA's need to contain hazardous lunar dust led to technology that senses other pollutants



Working as a contributor on a NASA NextSTEP lunar habitat project, Lunar Outpost Inc. developed an air-quality sensor system to detect and measure the amount of lunar soil in the air that also detects pollutants on Earth.

Lunar Outpost, Kennedy Space Center

From Spacesuits to Racing Suits

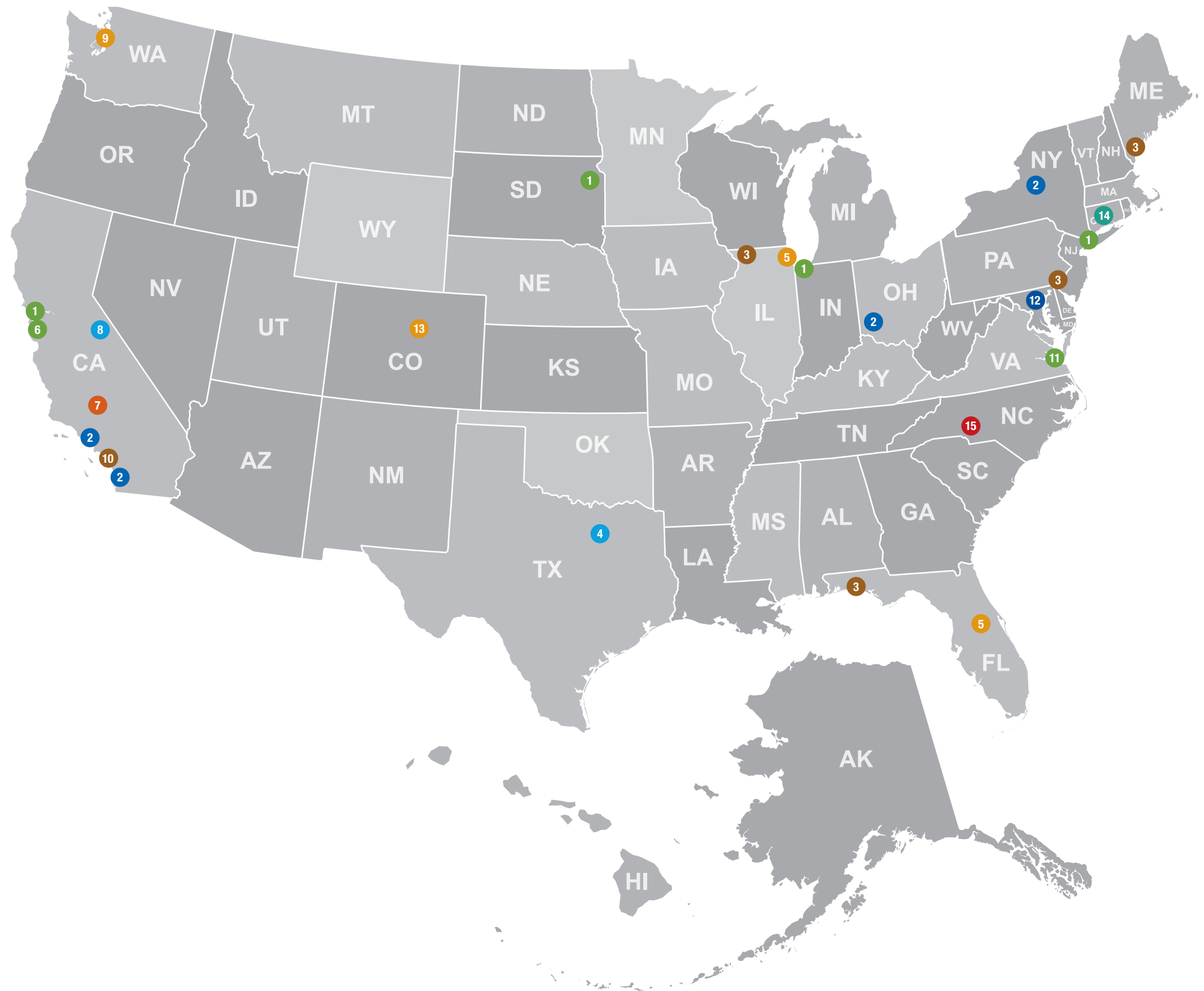
NASA-funded materials give race car drivers more comfort and better performance



Walero Ltd., whose U.S. distributor is in Mooresville, North Carolina, uses phase-change materials originally developed for spacesuits under an SBIR with NASA's Johnson Space Center in specialized undergarments to help keep race car drivers cool in the cockpit.

Walero, Johnson Space Center

NASA SPACE TECH WHERE YOU LIVE

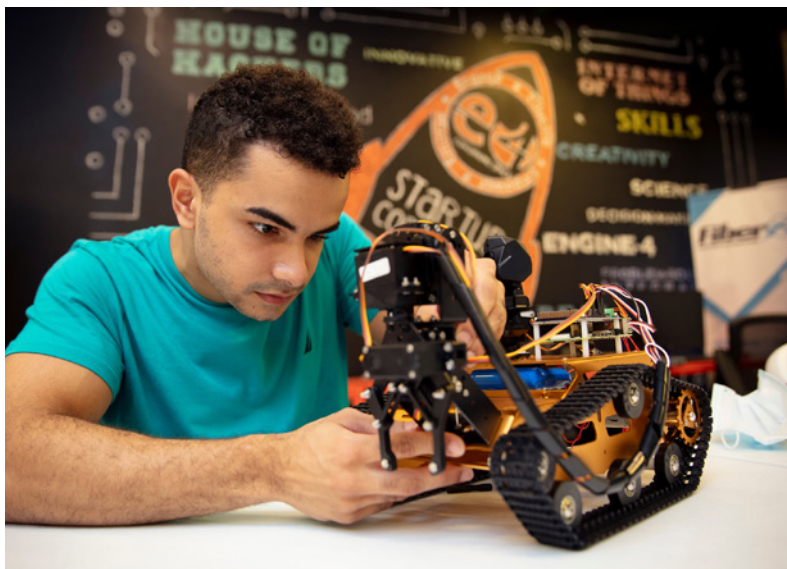


Article/Technology	Company, Location
1 A Moveable Feast: Plant Research for Space Advances Earth Agriculture	Plenty Unlimited, San Francisco, CA Green Sense Farm Holdings, Portage, IN Bowery Farming, New York, NY CSS Farms, Watertown, SD
2 NASA Helps Drones Take Flight	Avison, Santa Monica, CA General Atomics, San Diego, CA Cal Analytics, Beavercreek, OH AX Enterprize, Yorkville, NY
3 Safely Detoxifying Soil and Groundwater with NASA Technology	Proectus, Freeport, IL Toxicological and Environmental Associates, Miramar Beach, FL Woodard & Curran, Portland, ME Terra Systems, Claymont, DE
4 Clean Air Tech for Spacecraft Helps Fight Pandemic	ActivePure Technology, Dallas, TX TFI Environmental, Toronto, Canada Airgloss, Rome, Italy
5 Lighting in a Bottle	Healthe, Orlando, FL VividGro, Chicago, IL
6 Microbes Help Trees Clean Up Pollution	Intrinsyx Environmental, Moffett Field, CA
7 Test Rockets Prepare for Distant Landings	Masten Space Systems, Mojave, CA
8 Getting Water Out of Snow with NASA Tech	Airborne Snow Observatories, Mammoth Lakes, CA
9 From a Lightbox to Lamps	Ario, Seattle, WA
10 The 'Cobot' Revolution Is Coming	Amorphology, Pasadena, CA
11 Swinging the HAMR	Advanced Aircraft Company, Hampton, VA
12 Satellite Software Helps Global Forecasting	Orbit Logic, Greenbelt, MD
13 Measuring Moon Dust to Fight Air Pollution	Lunar Outpost, Denver, CO
14 Some Engineering Is Only Skin Deep	REM Surface Engineering, Southington, CT
15 From Spacesuits to Racing Suits	Walero, Mooresville, NC

Improving the Ways NASA Brings Technology Down to Earth

A Better Way to Transfer

The NASA Technology Transfer program is charged with making technologies created during mission work widely available to industry. But that isn't all the program is doing to ensure these transfers lead to commercial products and services that benefit the public. Learn more about the program's entrepreneurial training resources, cohort and accelerator opportunities, and even how NASA technology can end up in the classroom on spinoff.nasa.gov.



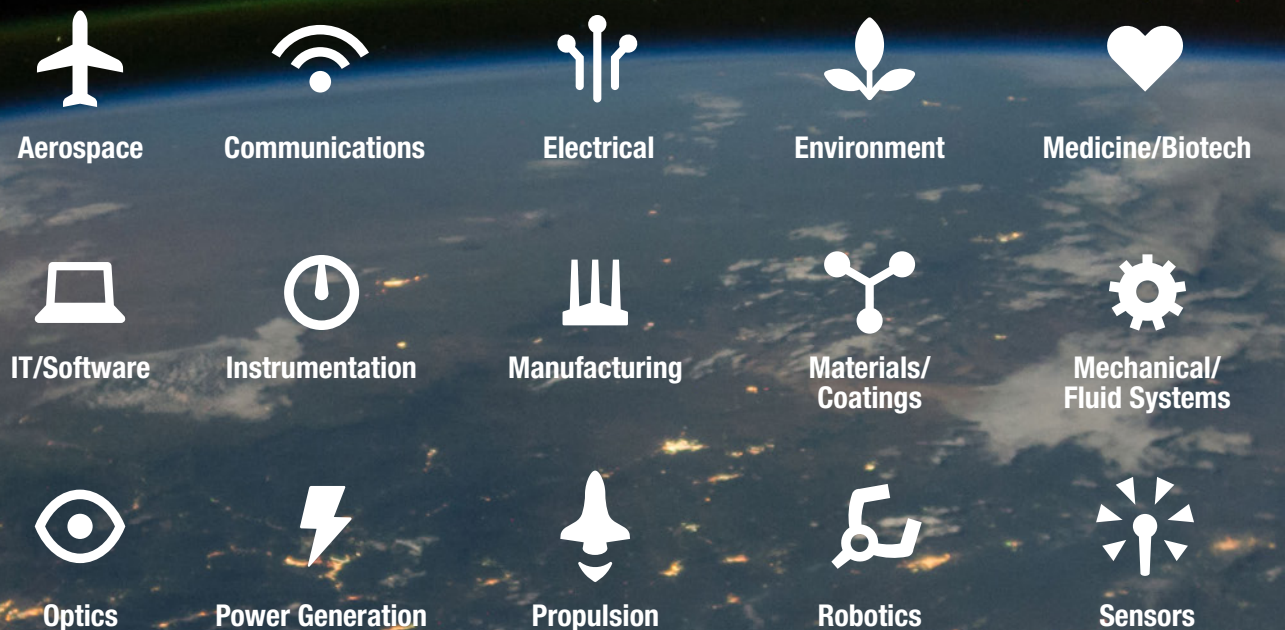
Will the next spinoff be yours?

Our technology is ready for you at technology.nasa.gov

Our portfolio includes:

- More than 1,200 patented technologies
- Hundreds of innovations now in the public domain
- More than 700 software codes

Whether you're looking to start a new company using NASA technology, enhance an existing product, or create a new product line, you can gain a competitive edge in the marketplace by putting NASA technology to work for you.



**NASA TECHNOLOGY
TRANSFER PROGRAM**

BRINGING NASA TECHNOLOGY DOWN TO EARTH

Spinoffs of Tomorrow

Each year we document dozens of spinoff success stories, but the work of the Technology Transfer program is ongoing. Our technology portfolio contains many exciting innovations ready for an enterprising company or entrepreneur to license and develop into a commercial product.

Here are four examples that we think show great promise.

To learn more about – and get started licensing – these or any of the others in our extensive portfolio, please visit technology.nasa.gov.

Lotus Coating

Mitigating dust accumulation and repelling liquids

Keeping out the dust that accumulates on the Moon, comets, and other planets is no half-hearted chore. The dust can be abrasive and damaging, both for astronauts breathing it in and the sensitive electronics they and robotic explorers rely on.

Goddard Space Flight Center has developed a unique formulation of a lotus leaf-like nano-textured dust mitigation coating that is durable and transparent and can be applied to a variety of rigid and flexible surfaces. It can be brushed or sprayed on or applied through spin coating.

The coating also has super-hydrophobic properties and can prevent a variety of particles, liquids, or ice from sticking to the coated surface. It can be used for space and aeronautical applications, as well as ground applications.



Remote Sensing Toolkit

Online portal offers easy access to NASA Earth-observation data

NASA's policy making remote sensing data freely and publicly available has long benefited the scientific community, other government agencies, and nonprofit organizations – but there is significant untapped potential for commercialization. NASA's Technology Transfer program has created an online resource to promote wider use of this data and the software tools needed to work with it.

Through its constellation of Earth-observation satellites, NASA collects petabytes of data each year. With the Remote Sensing Toolkit, users will now be able to find, analyze, and use the most relevant data for their research, business projects, or conservation efforts. The toolkit provides a simple system that quickly identifies relevant sources based on user input. The toolkit will help users search for data, as well as ready-to-use tools and code to build new tools.



Unlock Devices with Unique Heartbeats

HeartBeatID

Forget complicated and easy-to-hack passwords: modern devices protect privacy by requiring a unique biometric feature, like a fingerprint, to unlock or authenticate a user. And now NASA has invented a next-generation system for biometric identity verification – using heartbeats.

Engineers at Ames Research Center have devised a method and associated system for authenticating or declining to authenticate an identity by at least 192 statistical parameters for electrical signals associated with heart waves.

It can be used in everything from replacing an individual's computer passwords to accessing a bank account.

Camera Made for High Vibration and Harsh Environments

Ruggedized infrared camera

Researchers at Marshall Space Flight Center have developed a ruggedized infrared camera system for harsh environments. Advanced modifications allow the camera to survive high-vibration environments, such as spacecraft launches, and improve heat removal for operation in a range of harsh conditions including a vacuum.

The camera assembly has been fully tested in extreme conditions including high vibration, shock, vacuum, and temperature cycling. Although designed for space applications, the assembly can work in harsh environments on Earth, too.

