



# NASA Technology Spinoffs: Improving Life on Earth

Many science-fiction writers envisioned the 21st century as space-like living on Earth. Although fictitious gizmos such as chrome-embellished molecular transporters, electroplasma gear and magnaspanners never came into being, other innovations such as wireless communications, medical telemetry, memory metal and robots are now a reality, thanks to NASA technology.



Many technologies developed for space have found uses on Earth. Sunglasses, the computer mouse, magnetic resonance imaging, smoke detectors, quartz watches and bar codes are just a few of the 30,000 commercial applications of space technology that have entered the consumer market since the 1950s.

NASA invests in contracts with small businesses for innovations that can be adapted to space applications. The agency also looks at its own space-inspired technology to license to private companies. Partnerships and licenses of NASA-developed technologies help increase the number of scientific discoveries and their benefit to the general public, while decreasing the cost of the space program for taxpayers.

## Food For Thought

For years, astronauts aboard the space station have been looking toward the future of human spaceflight and how we might feed permanent colonies on other planets. Mastering plant growth with little or no gravity could also give Earth-bound farmers new techniques to increase the quality and quantity of crop yields.

Research includes reducing or eliminating lignin production. Plants need lignin to stand upright under the force of Earth's gravity. It must be removed using a costly and environmentally harmful process to produce paper. The space station's gravity-free environment has helped scientists learn how to reduce the lignin content of plants, which could decrease the costs and pollution associated with producing paper.

## Growing Tomatoes From Trash

Even in the deep reaches of space, humans produce trash. But when space is limited and everything must be reused, astronauts could use trash to help grow food.

Through grant and research assistance from NASA, scientists at three universities found that biogases produced by decomposing trash can fulfill the needs of a space-age greenhouse. Methane, the primary emission, is piped into the greenhouse boiler and used to fuel the hot water heating system and generate electricity. This system, with many other features, takes only 90 days to germinate and produce a tomato harvest.



The garden can produce 10 times the amount of tomatoes grown outdoors in a similar space, or 10 pounds of tomatoes per square foot per year – with no pesticides. Scientists are experimenting with other food crops.

### **No Bad Apples Ruining the Bunch**

Almost half of the fresh fruits and vegetables harvested each year in the United States are lost to spoilage – more than 27 billion pounds of fruits and vegetables annually.

Produce emits ethylene gas that gets trapped in storage facilities and refrigerators, accelerating the ripening and spoilage. Research funded by NASA and licensed to KES Science and Technology Inc. has led to an ethylene scrubber. The Bio-KES removes 99 percent of the ethylene by passing air over titanium dioxide pellets.

Shuttle astronauts used Bio-KES in space. It could prolong the life of produce during deep-space travel.

### **Healthier Living Can Be Rocket Science**

NASA's many medical innovations have changed the diagnosis and treatment of diseases and improved the quality of countless lives. Space station crew members have done over 70 experiments, many documenting the effects of zero gravity on the human body, to gain knowledge to fight medical problems on Earth.

### **Space Shuttle Fuel Pump Technology Helps Children's Hearts Heal**

After two decades of development, what started as a desk-sized space shuttle main engine turbopump is now ready to save children's lives thanks to a collaboration between famed heart surgeon Dr. Michael DeBakey and NASA.

The MicroMed-DeBakey VAD weighs less than four ounces and has only one moving part. The device has been implanted in over 240 adult patients to keep them alive until a donor heart is available. It also has been credited with allowing weakened hearts enough time to repair themselves, eliminating the need for a transplant.



### **Catching Cardiac Concerns Quicker**

Every day 680 Americans die from Sudden Cardiac Death (SCD). Ninety-five percent die before reaching a hospital. For years, cardiologists have lacked the tools to diagnose high-risk patients.



Now, thanks to NASA technology, Cambridge Heart Inc. has produced the only U.S. FDA-approved tool to identify individuals with a high risk of SCD. The Microvolt T-Wave Alternans Test measures heartbeat patterns too small to be detected by an electrocardiogram.

This technology originally was developed to determine whether spaceflight increases the risk of heart arrhythmias.

### **Prostate Cancer Treatment**

A NASA-designed computer simulator intended to predict a patient's temperature profile could soon be used in prostate cancer treatment. It uses microwave energy introduced by a catheter to heat and kill benign cancer cells in the prostate.

"Thermal heating profiles within the body tissue are calculated using the microwave and thermal properties of body tissue to determine proper heating times and power levels," said inventor Dickey Arndt, who is credited with 21 patented inventions at NASA.

### **Bioreactor Cell Culture Growth**

A cell culture growth device developed as part of a space medicine program at Johnson Space Center allows testing of cancer and virus treatments without harming patients. The bioreactor cultivates three-dimensional cells in a rotating vessel, simulating the way cells grow within the human body. Designed to grow cell cultures in weightlessness, the bioreactor has achieved cell cultures in space and on Earth that nearly replicate cell growth within the body.

## Spacey Sports Safety

Protective equipment is an important part of any sport. NASA technology has increased player performance while protecting players from injuries.

### Solutions For Hot Situations

Next time you are watching a NASCAR race, think about NASA. New protective suits, based on NASA's spacesuit technology, protect drivers from the racetrack's extreme heat.



Nextel Ceramic Textiles and Composites from 3M offer space-age protection and innovative solutions for hot situations. With superior thermal protection, Nextel fabrics, tape and sleeveings outperform other high-temperature textiles, permitting engineers and manufacturers to handle temperatures of up to 2,500 degrees Fahrenheit. These fibers also offer excellent chemical resistance, low thermal conductivity, thermal shock resistance, low porosity and unique electrical properties.

The origins of Nextel Ceramic Textiles and Composites go back to the early days of the Space Shuttle Program, when NASA scientists worked to improve high-temperature tiles and textiles to withstand the intense heat and pressures of reentry.

### Moon Shoes

"Moon Boot" material has revolutionized athletic footwear, improving shock absorption and providing superior stability and motion control.

Al Gross, a NASA Apollo Program engineer, used his space expertise to improve athletic shoes. He substituted DuPont's Hytrel plastic for foam materials in the shoe's mid-sole to eliminate cushioning loss caused by body weight. An external pressurized shell and stress-free "blow molding" process adapted from NASA spacesuit technology was also used. The resulting compression chamber mid-sole allowed the popular shoemaker AVIA Inc. to reconfigure designs for specific sports and provide a "first step" toward a durable, foamless, non-fatiguing mid-sole.

## Shock-Absorbing Helmets

No professional player would step onto the field without protective gear. Based on NASA technology, Temper Foam was used in helmets; shoulder, hip, thigh and knee football pads; baseball chest protectors; and soccer shin guards.

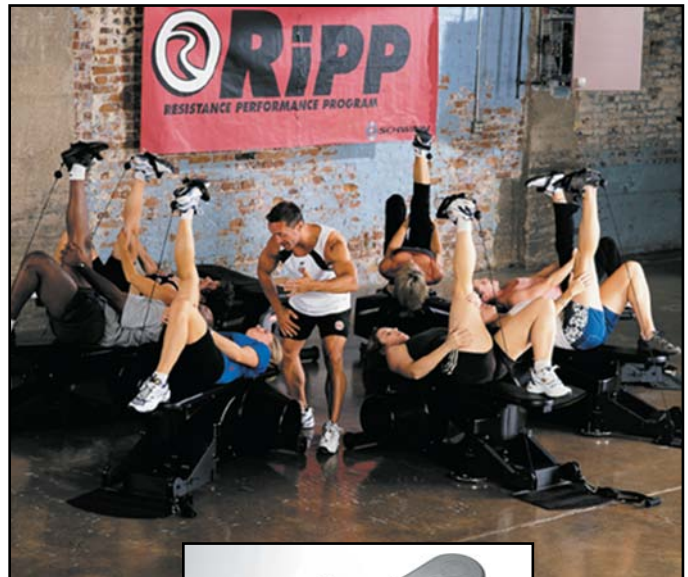
The key to shock reduction is a high-tech interior padding. Licensed to Kees Goebel Medical Inc., Temper Foam was developed in the early 1970s at NASA's Ames Research Center to protect astronauts from the forces experienced during liftoff. This open-cell polyurethane silicone plastic foam exhibits about 340 percent less shock from impact. It takes the shape of impressed objects but returns to its original shape even after 90-percent compression.

### Space Station Workout

Astronauts aboard the space station must exercise to avoid muscle and bone deterioration in zero gravity. With astronauts' missions lasting up to six months, the equipment must meet strict size and performance requirements.

With NASA funding, SpiraFlex Inc. created the Resistive Exercise Device (RED), a compact resistance machine that duplicates the benefits of weight lifting. The RED works with Flexpacks molded into a range of shapes that provides maximum resistance with pulleys and spokes.

The system is used on the space station and in fitness centers across the country.



## Improving Lives One Innovation at a Time

NASA innovations come in all shapes, sizes and categories.

### Solid Smoke Maintains Temperate Temperatures

In space, temperatures can plunge below 300 degrees Fahrenheit, four times colder than winter in Alaska. But that is no cold crisis thanks to Spaceloft, an Aerogel cloth designed for NASA missions and arctic Earth expeditions.



Aerogels were invented 70 years ago and are the lightest solid known to humans; however, they are extremely fragile and expensive to make. Aspen Systems created the Cryogel process that turns Aerogels into flexible and durable blankets, sheets, beads and molded parts for space applications. Later, Aspen created the Spaceloft materials that can easily be inserted into the lining of jackets, creating an inexpensive, breathable, waterproof jacket.

NASA is using Spaceloft to develop space gloves for Mars missions, while Aspen Systems is expanding its line of high-temperature Aerogel products.

### Direct Broadcasting TV

Millions of television viewers watch their favorite programs via NASA technology.

NASA pioneered the concept of digitally based, direct-broadcast satellites that provide direct services. The Applications Technology Satellite-6, launched in 1974, was an educational experiment designed to test new methods and applications of satellite communication capabilities.

Building on that innovation, Hughes Electronics Corp. invested \$750 million to develop a system that included three high-powered satellites and a broadcast center. DirecTV, which began in 1991 as an alternative to cable, now offers over 210 channels and has more than six million customers.

National Aeronautics and Space Administration

**Lyndon B. Johnson Space Center**  
Houston, Texas 77058

[www.nasa.gov](http://www.nasa.gov)



### Very Effective Vet Visits

If only veterinarian visits could test and treat an animal in 30 minutes or your money back. Well, now they can.

Using NASA technology from the Skylab II space station, Abaxis Inc. converted a biochemical analyzer for astronauts to monitor their physiological functions into an instant, point-of-care testing machine for animals. Small and inexpensive enough for use in every veterinarian clinic and mobile vet unit, the VetScan Chemistry Analyzer eliminates the need for follow-up visits and diagnoses preexisting medical conditions before surgery, avoiding life-threatening complications.

The machine requires only two drops of blood, and the VetScan can be used with both domestic and exotic animals. A complete list of test results is produced in fewer than 15 minutes.

### Clocks With Rocks

To keep missions on time, General Time Corp. developed electrically stimulated quartz crystals. Quartz provides a stable time base, giving clocks an accuracy of one minute a year. By vibrating up to 4,194,304 times a second, the clocks keep millions of people on time around the globe.

### To Extend Life To There

Solar energy, flat-screen televisions, battery-powered tools, desktop computers and bulletproof vests have all been developed from NASA technology.

The challenges NASA will face in putting astronauts on the moon and Mars will require the ingenuity of thousands of people and new technologies. Through the Vision for Space Exploration, new doors will be opened and new commercial markets created as humans head into the cosmos.

For additional information about NASA's spinoffs, visit:  
<http://www.sti.nasa.gov/tto/spinoff.html>

For more information about NASA's patented technologies and information about licensing or partnership opportunities, visit the JSC Technology Transfer and Commercialization Web site: <http://technology.jsc.nasa.gov/>