



NASA JSC **Technology Transfer & Commercialization** Office



Patents available for Licensing

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Introduction

For more than five decades, NASA's Johnson Space Center (JSC) has led our nation and the world on a continuing adventure of human exploration, discovery, and achievement. The center plays a vital role in transcending the physical boundaries of our planet to further our knowledge and enhance our quality of life. JSC proudly manages NASA's human spaceflight functions including International Space Station. JSC is home to the NASA astronaut corps and is responsible for training space explorers from the United States and our space station partner nations. JSC also serves as NASA's lead center for life sciences research and applications.

The Technology Transfer and Commercialization Office (TTO) at NASA's Johnson Space Center (JSC) is charged with the transfer and commercialization of NASA-sponsored research and technology as well as the use of JSC's unique research and development capabilities and facilities. The office works with entrepreneurs, companies, and investors, helping them license NASA-developed technologies so they can bring them to the marketplace. All technologies included in this document are available for licensing and commercialization.

For more information on how to work with the JSC TTO, visit our website (<http://technology.jsc.nasa.gov>) or send us an email to jsc-techtran@mail.nasa.gov.



Aerospace



**technology opportunity**

Hypoxia Detection and Warning System

Method and apparatus for monitoring oxygen partial pressure in air masks



Researchers at NASA's Johnson Space Center have developed an innovative oxygen warning system capable of detecting and preventing oxygen deprivation, or hypoxia, in the user. If oxygen partial pressure dips below a safe, predefined level, the sensor's alarm and aggressive vibration are capable of arousing an individual who may have become impaired by symptoms of hypoxia such as drowsiness, slowed reaction times, and blackouts. The partial pressure warning system can be incorporated into virtually any commercially available oxygen mask.

Benefits

- **Effective:** The “nose beater” vibration and high-pitched alarm alerts an individual who may otherwise be too groggy to respond to hypoxia.
- **Targeted for hypoxia:** The sensor measures the partial pressure of oxygen, which correlates more highly with hypoxia than the measurements of other oxygen sensor systems that typically only measure oxygen concentration.
- **Precise:** The sensor monitors oxygen partial pressure within the air mask, rather than within the supply air, allowing for more accurate analysis of the air the user is actually breathing.
- **Fail-safe:** The sensor functions independently of the oxygen or air system, so it can provide accurate detection and warnings in the event of an oxygen system failure.
- **Easy to implement:** The system relies on communication wiring already present in oxygen masks and therefore requires minimal modifications and production costs.



Applications

- Military aviation
- Firefighting
- Respiratory and life support systems
- Scuba diving
- Underwater welding
- Mountain climbing
- Industrial sites with hazardous-breathing environments

Technology Details

NASA's oxygen sensor was originally developed to reduce the incidence of hypoxia in aircraft pilots. The innovation has several applications beyond aerospace, including oxygen systems for the military, firefighting, scuba diving, mountain climbing, as well as medical oxygen systems.

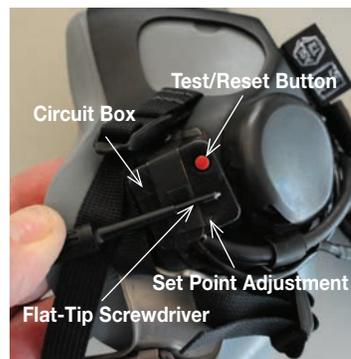
How it Works

The oxygen partial pressure sensor and vibrating alarm is composed of an electrochemical oxygen sensor, a voltage comparator, and a vibrator motor. All of these components are installed directly within the breathing mask. When the partial pressure of oxygen in the system falls below a predefined set point, as measured by the electrochemical oxygen sensor, the voltage comparator triggers the vibrator motor to deliver vibration within the mask. In the event of an oxygen system malfunction, this sensor's vibration provides immediate warning that hypoxia conditions exist. The sensor's vigorous tactile and aural stimulation allows the user to take corrective action before succumbing to the dangerous, and potentially fatal, effects of hypoxia.

Why it is Better

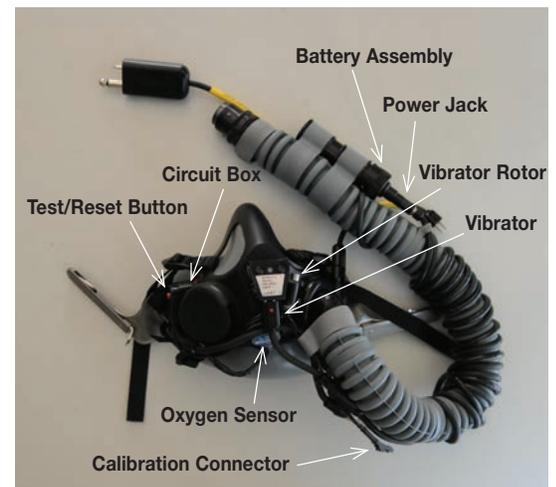
Currently available oxygen sensors are limited in three important ways:

1. Oxygen concentration sensors are not capable of monitoring oxygen partial pressure.
2. Sensors are typically placed upstream of the oxygen breathing system, which makes it hard to detect problems in connections, hoses, mask fit, etc.
3. Other sensors do not provide tactile stimulation when hypoxia is detected.



Circuit box showing red test/reset button and alarm set point adjustment

This sensor measures the product of oxygen concentration and total ambient pressure (oxygen partial pressure). Thus the sensor will trigger the alarm circuitry for low oxygen concentration at constant total pressure, constant oxygen concentration at low total pressure, and any combination of low oxygen concentration and low total pressure that drops the product below a user-defined set point. The high-pitched alarm provides a warning system that alerts the user, along with others in the vicinity, of life-threatening hypoxia conditions, and the "nose beater" vibration is vigorous enough to stimulate the user to take corrective action.



Patents

Johnson Space Center has received patent protection (U.S. Patent No. 7,040,319) for this technology.

Licensing and Partnering Opportunities

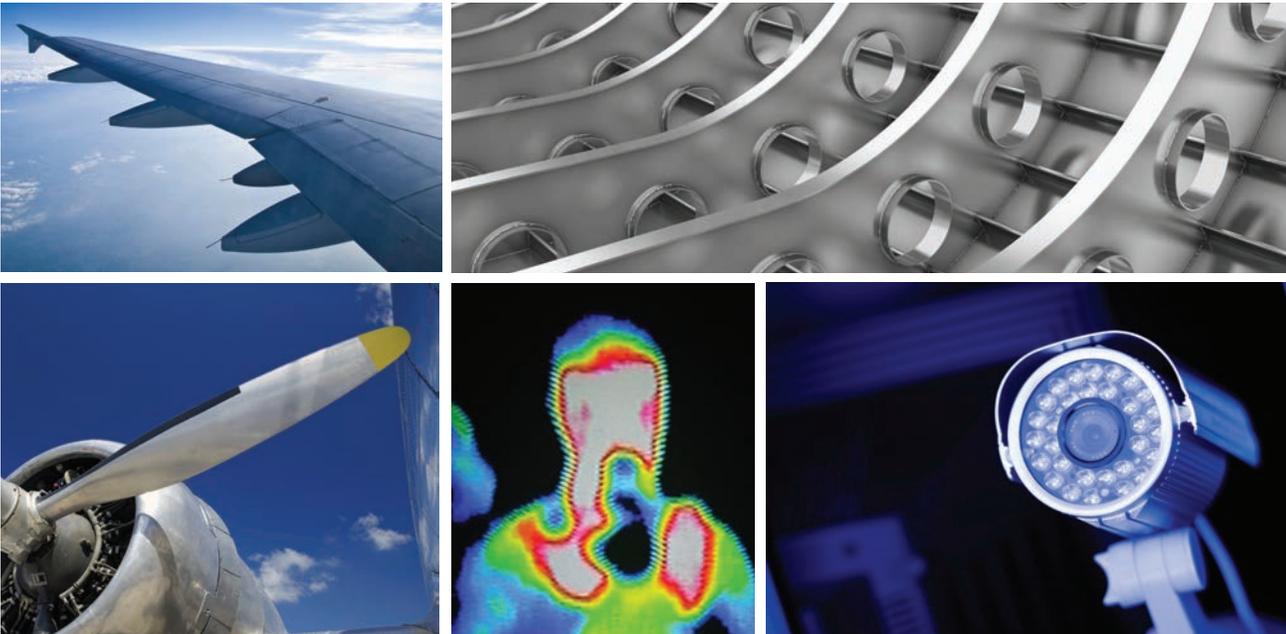
This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing this Method and Apparatus for Monitoring Oxygen Partial Pressure in Air Masks (MSC-23309-1) for commercial applications.



technology opportunity

Flash Infrared Thermography Software

Computer simulation and data analysis software for nondestructive testing and evaluation of composite and metallic materials



Researchers at NASA's Johnson Space Center (JSC) have developed an effective, cost-efficient, infrared (IR) flash thermography software program capable of detecting anomalies, such as voids, cracks, and delamination, in composite and metallic structures. Using an innovative IR contrast methodology, this software accurately measures flaw depth, width, and diameter. The software has applications in aerospace, as well as nondestructive testing and evaluation, IR camera manufacturing, and IR thermography analysis.

Benefits

- **Precise:** Provides detailed characterization of flaw shape, size, depth, and location
- **Robust:** Provides objective, repeatable, numerical measurements of subsurface anomalies
- **Camera and operator independent:** Normalizes data which reduces errors due to operator and equipment variability
- **Versatile:** Can be used to analyze composite or metallic materials and flat or curved surfaces
- **Cost-efficient:** Can be incorporated easily and inexpensively into existing equipment



Applications

- Nondestructive testing and evaluation of materials and surfaces in the following areas:
 - Aerospace (e.g., aircraft wings, propeller blades)
 - Power generation (e.g., turbine blades, pipelines)
 - Manufacturing (e.g., welds, adhesive joints, semiconductors)
 - Chemical and petrochemical industries
- IR camera manufacturers
- Software developers

Technology Details

JSC's flash IR thermal data analysis software identifies and evaluates delamination-like defects in materials and components.

How it Works

Originally developed as a nondestructive evaluation technique for the space shuttle, this innovation analyzes raw IR thermography data to detect anomalies, such as voids, cracks, or delamination, in both composite and metallic materials. In IR thermography applications, a pulse of infrared light is directed onto a material and the reflected thermal response of the material generates an infrared image. If a defect is present in the subsurface of the material, heat flowing at the structure's front surface will be impeded relative to the surrounding, defect-free regions. Variations in the thermal diffusivity of the material manifest themselves as anomalies in the thermal image of the test surface. This innovative flash IR thermography analysis uses the evolution of measured pixel intensity over time, and compares it with a calibrated empirical simulation, to evaluate anomaly depth and size.

Why it is Better

Critical components in aerospace structures, although optimized for performance, can be difficult, if not impossible, to inspect adequately due to the complexity of structural design and/or the use of advanced materials. This computer simulation and data analysis software offers a robust, repeatable, objective measurement of subsurface defects. It is capable of analyzing composite or metallic materials and flat or curved surfaces. Currently available commercial thermography software does not distinguish between image contrast and temperature contrast and therefore provides less accurate characterization of defects. Furthermore, because this software normalizes data, it provides more stable measurements and greatly minimizes errors due to operator variability.

Patents

Johnson Space Center is currently seeking patent protection for this technology.

Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Flash IR Thermography Contrast Computer Simulation and Data Analysis Software (MSC-24444-1 and MSC-24506-1) for commercial applications.

Medical & Biotech





technology opportunity

Preservation of Liquid Biological Samples

Simple preservative technology that requires no refrigeration



The National Aeronautics and Space Administration (NASA) seeks interested parties for the commercial application and manufacturing for the preservation of liquid biological samples technology. This technology is a method for adding a patented preservative to a commercial off-the-shelf collection kit. This proprietary process coats the interior of the storage vial with the patented preservative chemical cocktail. For example, this additive in conjunction with centrifuging, allows saliva samples to be stored at room temperature for up to six months. The preservative technology can be used with different biological liquid samples and in different clinical applications that require long-term storage of biological samples at ambient temperatures.

Benefits

- **Ambient Storage:** The preservative technology adapts to commercial off-the-shelf bio-sampling units and allows for storage at room temperature
- **Safe & Non-toxic:** The chemicals are non-toxic, edible compounds
- **Long-Term Storage:** Extends the shelf life of some liquid biological sample up to six months
- **Flexible:** Can be dispensed in solid, liquid and coated forms.
- **Fully Contained:** A closed-system that is ready for use in a physicians office



Applications

- Diagnostic Medicine
- Therapeutics
- Immune Disorders
- Drug, Alcohol, and DNA Testing

Commercial Opportunity

- Patent Pending
- U.S. Patent(s)
- Copyrighted
- Available to License
- Available for No-Cost Transfer
- Seeking Industry Partner for Manufacturing

Technology Details

Ambient storage technology for biological samples was developed to support pharmacology research conducted on the Shuttle Mir experiments. The technology has a broad application for clinical diagnostic medicine on Earth.

How it Works

This technology is a chemical cocktail intended for preservation of biological samples like blood and saliva. The present invention includes combining the liquid biological sample with the preservative comprising of sodium benzoate in an amount of at least 0.15% of the sample (weight/volume); and citric acid in an amount of at least 0.025% of the sample (weight/volume). The preservative can be dispensed in different platforms such as coated sample collection tubes like vacutainers and Sarstedt saliva collection devices, coated preservative discs, compressed tablets or capsules, or in metered dispensers such as dropper bottles and syringes that can be used for preservation of larger volume samples.



Applications and Status

This preservative method can be used with a variety of liquid biological sample including but not limited to saliva, tears, urine, blood, serum, plasma, sweat, feces, mucous, breast milk, bone marrow, and spino-cerebral fluid. The preservative is useful for routine and special clinical chemistry testing in adverse and remote site medical facilities, rural and disaster zone clinical operations, home healthcare diagnostics, pediatric and geriatric medicine and sports medicine operations. Therapeutic drug monitoring, hormone and biomarker research and therapeutics, AIDS diagnostic kits, and other immune deficiency biomarker assessments are other potential applications for this preservative.

A new clinical concept for the prototype has been identified and is awaiting commercial partnership for manufacturing. A third party study was conducted using the patented preservative in blood samples. They were tested at the same time for 23 different assays in stability studies. During the 11 day study, the blood samples were successfully preserved.

Patents

The invention, "Preservation of Liquid Biological Samples," is protected under U. S. patent number 6,133,036 issued on October 2000, and patent number 6,716,392 issued on April 2004.

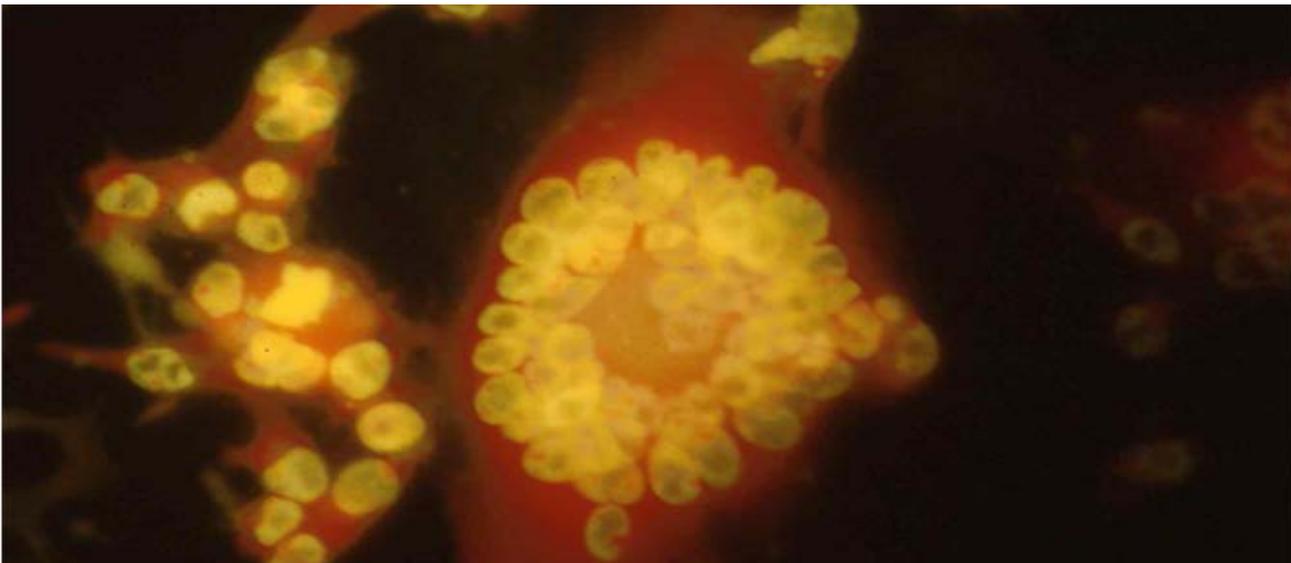
Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing MSC-22616-2, -3.

**technology opportunity**

Rapid Detection of Shingles (Varicella Zoster Virus- VZV)

Point-of-care diagnostic device detects within an hour



The National Aeronautics and Space Administration (NASA) seeks interested parties for the commercial application of the VZV virus detection kit for the rapid detection of the herpes zoster (shingles) virus. Currently, approximately 1 million people per year in the US are diagnosed with shingles based on clinical observation. NASA and University of Colorado scientists were the first to detect VZV DNA in saliva of astronauts during spaceflight and later in shingles patients. Based on this new discovery, a virus detection kit for use with saliva is in development at NASA. This point-of-care diagnostic device is rapid, simple to use, does not require expensive lab equipment, and detects the VZV virus in less than one hour in a physician's office. This is a platform technology that can be used to detect other viruses.

Benefits

- **Point-of-Care Testing:** A testing diagnostic device for use in a physician's office
- **Rapid Results:** Detects virus in less than one hour
- **Simple and Non-Invasive:** Diagnosis is performed by testing a saliva specimen
- **Disposable:** Diagnosis is performed by testing a saliva specimen



Applications

- Physicians Office
- Hospitals
- Testing
- Research

Commercial Opportunity

- Patent Pending
- U.S. Patent(s)
- Copyrighted
- Available to License
- Available for No-Cost Transfer
- Seeking Industry Partner for Manufacturing

Background

Market

There are an estimated 1 million cases of shingle each year in the US and almost half of the cases occur in adults after the age of 60. In a subset of these patients, the virus causes acute to chronic pain and multiple severe disorders such as meningitis, multiple cranial nerve palsies, blindness, etc.



Existing Technology

Current diagnostic tests for the VZV virus include the Polymerase Chain Reaction (PCR) assay or the immunofluorescent tests. These tests require blood, spinal or blister fluid that is obtained using invasive methods and costs hundreds of dollars. The fluid sample is normally sent out to a reference lab unless the clinic has the expensive test equipment and trained personnel available to analyze the test sample, where results are obtained within days. In the meantime the disease is rapidly progressing unless anti-viral drugs were prescribed by the physician. Other methods include taking samples from wounds and examining them under a microscope. These methods are not overly successful since VZV and herpes simplex virus (HSV) cells have similar appearance, and both of these procedures are invasive and painful.

Technology Details

How it Works

The saliva sample is collected and added to an antibody attached to micromagnetic beads. A chemical solution containing the antibody and horseradish peroxidase (HRP) is added to the mix. A solution of luminol is washed through the device and as it reacts with the HRP, light is emitted to indicate the VZV presence.

A clinical study of 54 patients was conducted to establish the presence of the shingles virus in saliva with current

diagnostic methods. Research was performed to select the most appropriate antibody for this VZV detection kit. The next step is to develop a prototype and perform a blind test study with the appropriate antibody to demonstrate the efficacy of this innovation in a patient population.

Why it is Better

The VZV Detection Kit can be inexpensive, disposable, and fully contained. It detects the virus in less than 60 minutes in a doctor's office performed by their staff. The kit allows for early diagnosis and treatment of the VZV virus which in turn allows patients to avoid progressively, worsening pain and possibly an acute rash and blisters. A percentage of shingles patients can also avoid much higher treatment costs and more severe pain caused by damage to the nerves from the virus. For some patients, the virus causes nerve damage that could worsen if anti-viral treatment is not given to the patient. In some instances, the nerve damage is so severe that the patient continues to have extreme pain years after elimination of the virus. This method would also eliminate the frequently painful practice of examining the wounds to find evidence of the virus, creating a more patient-friendly environment when testing for the virus in possibly infected individuals.

Patents

A provisional application was filed August 2008; an international patent application was filed in August 2009; and a non-provisional application was filed February 2011 for this technology. A joint ownership agreement is in place between University of Colorado and NASA.

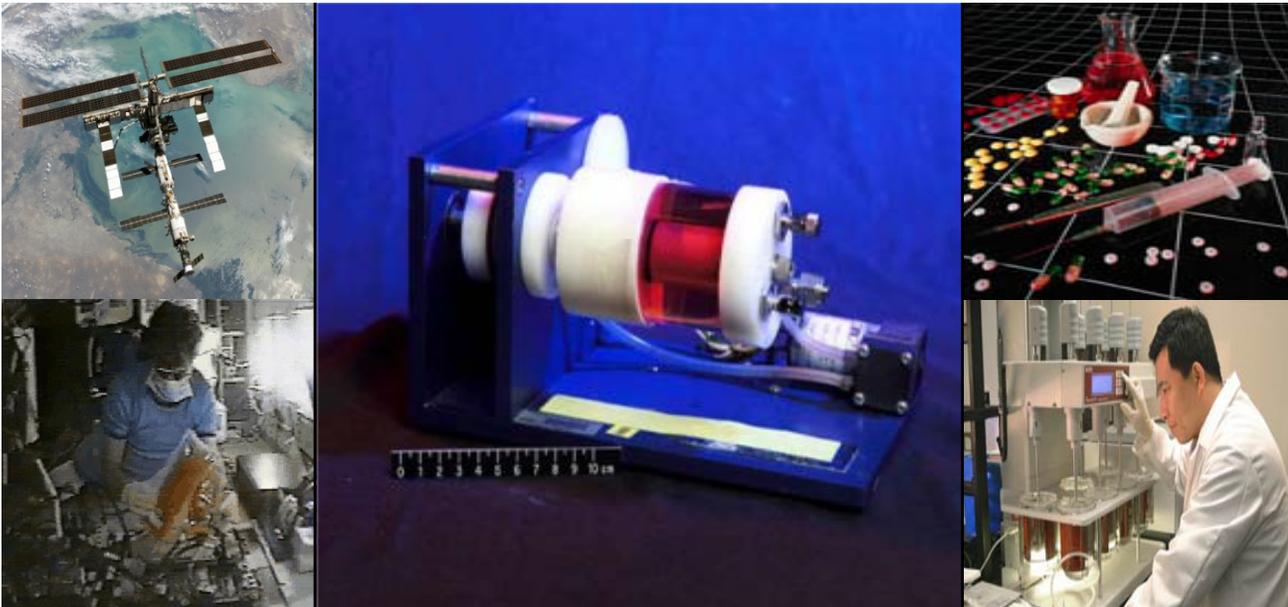
Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing MSC-24451-1 and MSC-24451-PCT for commercial applications.



technology opportunity

New High-Yield Method for Producing Functional Proteins



Innovators at NASA Johnson Space Center have invented a method that produces three-dimensional, natively glycosylated proteins in a rotating bioreactor by using mammalian cells instead of recombinant RNA/DNA cells. Erythropoietin, interferon, granulocyte stimulating factor and vitamin-D3 are some of the natural proteins produced by this method. These substances are commonly used to treat cancer, diabetes and hepatitis. This new production method produces a higher molecular unit per volume than existing methods and reduces the manufacturing steps in the current production process because the use of bacteria is no longer needed to produce the proteins.

Benefits

- **End Product:** Natural, 3-D, functional proteins and biomolecules
- **Scientific Advancement:** Compatible with human or animal physiology by eliminating bacterial toxicity
- **Manufacturing Process:** Reduces production space by using bioreactors
- **Production:** Time is reduced because fewer steps are required in the process to produce proteins
- **New Research and Development:** New method can be used to produce new protein types as well as newer biomolecule strains



Applications

- Bioengineering
- Biochemical
- Laboratory
- Medical
- Pharmaceuticals

Commercial Opportunity

- Patent Pending
- U.S. Patent(s)
- Copyrighted
- Available to License
- Available for No-Cost Transfer
- Seeking Industry Partner for Manufacturing

Technology Details

Why this was Developed

Scientists at NASA Johnson Space Center, looking for ways to simulate the microgravity environment here on Earth discovered the bioreactor. The bioreactor was used as an experiment on the Space Shuttle and International Space Station many times. NASA scientists also discovered uses for the bioreactor on Earth and used it to develop new methods for growing three dimensional cell cultures in simulated microgravity.

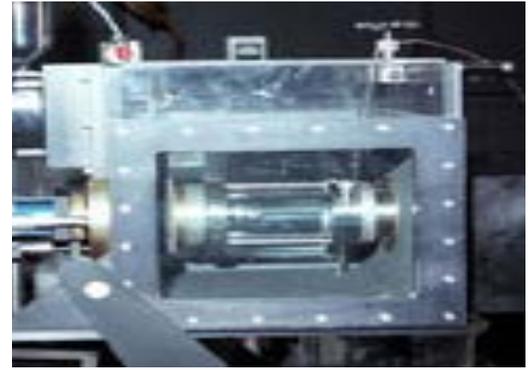
How it Works

This innovation uses mammalian cells in a cell-culture vessel with a cylindrical outer wall that rotates slowly about a horizontal axis (bioreactor) as small shear stresses are applied to the cells. These stresses are small enough to prevent damaging cells and allows tissue-like assemblies to form on an orderly basis. Combining the effects of gravitation and rotational techniques creates an environment which in many ways mimics the human and animal physiology thereby allowing the production of three dimensional functional proteins.

Findings

Applying this novel technique resulted in the following discoveries:

1. Human and rodent kidney cells were grown and maintained receptors for two types of common toxins: nephrotoxic amino glycoside antibiotics and myeloma light chains.
2. Human kidneys expressed the enzyme 1- α -hydroxylase, which can be used to generate an active form of vitamin D, known as 1-25-dihydroxy D₃.
3. A mixture of mammalian kidney cells enriched in renal fibroblasts secretes erythropoietin (EPO), which is the hormone that regulates the production of red blood cells.



Testing apparatus for the production of proteins

Patents

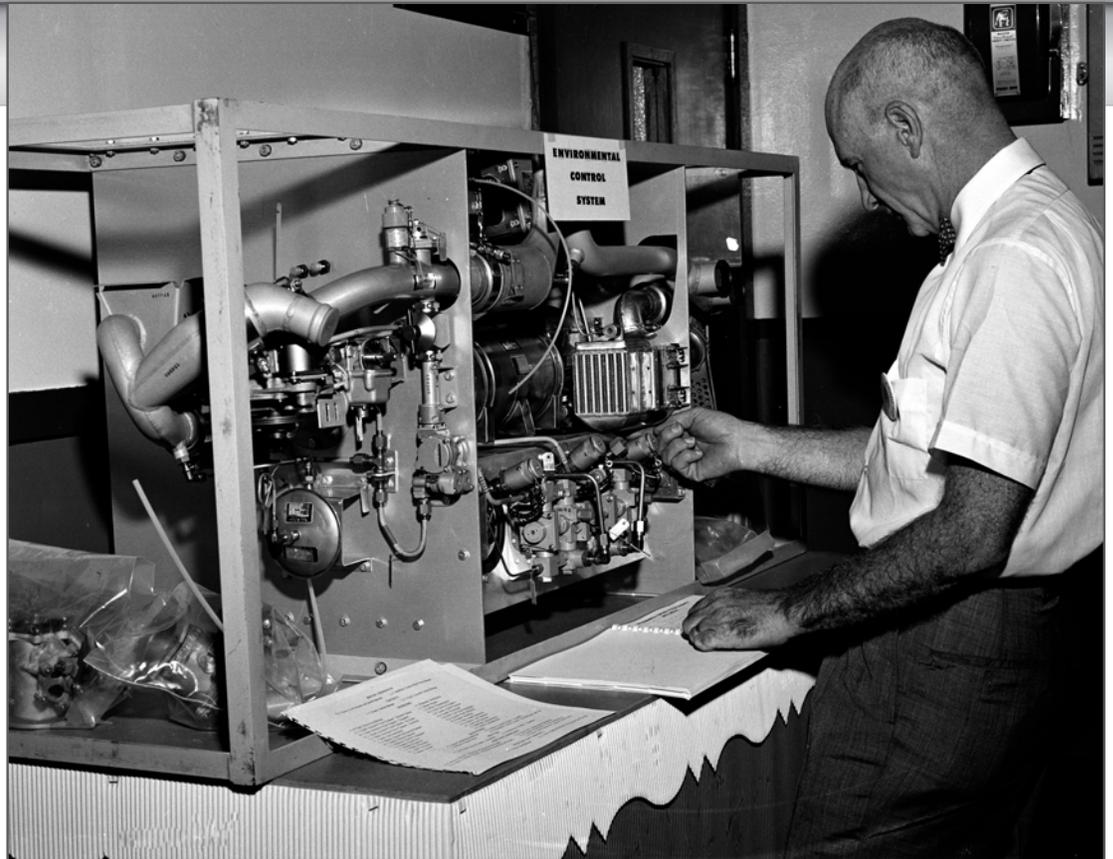
NASA has patented this technology under U.S. Patents 6,730,498, 6,946,246, 7,198,947 and 7,972,821 “Production of Functional Proteins: Balance of Shear Stress and Gravity” and are jointly owned with Tulane University.

Licensing and Partnering Opportunities

This technology is part of NASA’s Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry.

NASA invites companies to consider licensing this technology (MSC-22859) for commercial applications.

Green Technology



technology opportunity

Solar-Powered Refrigeration System

A proven, environmentally friendly solution that eliminates the need for batteries



Innovator Michael Ewert (pictured above) is the inventor of the solar-powered refrigeration system.

Innovators at NASA's Johnson Space Center have patented a proven, solar-powered refrigeration system that eliminates reliance on an electric grid, requires no batteries, and stores thermal energy for efficient use when sunlight is absent. The innovation uses a variable speed, direct current (DC) vapor compression cooling system, connected to a solar photovoltaic (PV) panel via novel electronic controls. This environmentally friendly system is ideal for use in commercial or household refrigerators, freezers, vaccine coolers, or solar ice-makers. It is particularly ideal for off-grid applications.

Benefits

- **Environmentally friendly:** Harnesses the energy of the sun to reduce dependence on fossil fuels and eliminates the need for batteries that can be damaging to the Earth upon disposal
- **Longevity:** Operates continuously for years as proven by prototype units tested at various locations around the world
- **Scalable:** Suits applications in a wide range of sizes, from portable 50-liter coolers to building-size air-cooling systems



Applications

- Refrigerators
- Freezers
- Ice-makers
- Coolers
- Building air-cooling systems

Technology Details

How It Works

Johnson Space Center's solar-powered refrigeration system employs a PV panel, vapor compressor, thermal storage and reservoir, and electronic controls. The process that makes the refrigeration possible is the conversion of sunlight into DC electrical power, achieved by the PV panel. The DC electrical power drives the compressor to circulate refrigerant through a vapor compression refrigeration loop that extracts heat from an insulated enclosure. This enclosure includes the thermal reservoir and a phase change material. This material freezes as heat is extracted from the enclosure. This process effectively creates an "ice pack," enabling temperature maintenance inside the enclosure in the absence of sunlight.

Proper sizing of the highly insulated cabinet, phase change thermal storage, variable speed compressor, and solar PV panel allow the refrigerator to stay cold all year long. To optimize the conversion of solar power into stored thermal energy, a compressor control method fully exploits the available energy. Other power optimization measures include:

- Smoothing the power voltage via a capacitor, providing additional current during compressor start-up
- Monitoring the rate of change of the smoothed power voltage using a controller to determine if the compressor is operating below or above the available power maximum, enabling adjustment of the compressor speed if necessary
- Replacing the capillary tube in the refrigerator system with an expansion valve, improving energy efficiency in certain operating conditions

These adjustments to the compressor operation contribute to the conversion of the majority of the available solar power into stored thermal energy. Applications may include a cold side water loop or incorporation of the evaporator into the thermal storage. Electronic controls also can be added to provide backup power from an alternative power source such as an electric grid.

Why It Is Better

The standard use of AC electricity supplied by the electric utility to power a single-speed vapor compression cooling system in a moderately insulated cabinet ties refrigerators to an electric grid and limits where they can be used. This prohibits their use in off-grid applications and maintains a dependence on fossil fuels for power. For these reasons, the demand for solar appliances of all kinds is increasing. However, other existing solar refrigerators use batteries, presenting a number of disadvantages. Batteries add expense, and their use and disposal cause undesirable maintenance and environmental consequences. Heat-driven cooling systems, such as absorption cycle, can also be solar powered, but their thermodynamic efficiency is not as good as vapor compression, they require more complex solar collectors, and they do not scale down in size as well.

In contrast, the solar-powered refrigeration system developed at Johnson Space Center is environmentally friendly because it eliminates the need for an electric grid or batteries and provides enough reserve thermal storage for cooling in the absence of continual sunlight.

Patents

NASA's Johnson Space Center has received patent protection for this technology: U.S. Patent No. 6,253,563. This technology is also closely related to U.S. Patent Nos. 6,469,487 and 6,453,693.

Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to inquire about the licensing possibilities for the Solar-Powered Refrigeration Technology (MSC-22970-1) for commercial applications.

technology opportunity

Battery Management System

A novel circuit that provides simple, reliable, and safe battery management for high-voltage battery systems.



NASA seeks interested parties to license the Battery Management System (BMS) developed by innovators at Johnson Space Center. NASA's BMS features the ability to monitor and balance the charge of individual battery cells that are in series and provide fault detection of individual cells in parallel within a battery pack of hundreds of cells. The circuit uses fewer connections (pins) than competing technologies, which reduces complexity and improves reliability. It offers a safe and potentially low-cost management system for high-voltage battery systems, including lithium-ion (Li-ion) battery systems that are used in electric vehicles and other next-generation renewable energy applications.

Benefits

- **Safety:** Improves safety of high-voltage batteries and decreases the occurrence of thermal runaway and catastrophic failures
- **Reliability:** Utilizes a low pin count, causing reduced complexity and increased reliability
- **Dual-purpose:** Detects the individual bad cells within series and parallel cells
- **Extended battery life:** Manages battery cells within a string, which increases the life of battery systems
- **Decreased battery damage:** Prevents damage from too much or too little voltage
- **Limited charge current:** Balances cells by adding charge to individual cells after main charge is complete
- **Low cost:** Provides a less expensive alternative to existing, commercially available solutions



Applications

- Electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs)
- Telecommunications backup systems
- Space mission critical battery backup systems
- Uninterruptible power systems
- Electric utility storage for renewable energy
- High-voltage critical battery systems

Technology Details

This technology was initially developed to provide battery management for high-voltage critical battery systems in NASA spacecraft. It is comprised of a simple and reliable circuit that detects a single bad cell within a battery pack of hundreds of cells and it can monitor and balance the charge of individual cells in series. Johnson Space Center's BMS is cost effective and can enhance safety and extend the life of critical battery systems, including high-voltage Li-ion batteries that are used in electric vehicles and other next-generation renewable energy applications.

How it Works

The BMS uses saturating transformers in a matrix arrangement to monitor cell voltage and balance the charge of individual battery cells that are in series within a battery string. The system includes a monitoring array and a voltage sensing and balancing system that integrate simply and efficiently with the battery cell array, limiting the number of pins and the complexity of circuitry in the battery. The arrangement has inherent galvanic isolation, low cell leakage currents, and allows a single bad or imbalanced cell in a series of several hundred to be identified. Cell balancing in multi-cell battery strings compensates for weaker cells by equalizing the charge on all the cells in the chain, thus extending battery life. Voltage sensing helps avoid damage from over-voltage that can occur during charging and from under-voltage that can occur through excessive discharging.

Another capability of this technology is fault detection of a single bad cell in parallel with hundreds of other cells in a battery string. Small saturating transformers in the circuit measure the current in each cell with minimal impact on the battery impedance, and provide intrinsic electrical isolation with a low pin count. This fault detection circuit can be used simultaneously with the voltage sensing circuit on a string with many cells in both series and parallel.

Why it is Better

This innovation offers significant advantages over competing technologies. In conventional systems, cell monitoring and balancing are achieved either through complex electronic circuitry at each cell or via electrical connectors having multiple contacts that connect to external circuitry. This can be complicated, cumbersome, and potentially damaging when used with high-voltage batteries. This novel BMS technology provides a much safer cell balancing method that uses fewer pins. Instead of balancing charge across the entire string of many cells in series and parallel, this technology charges only the individual cell needing the charge. Because of its simple, efficient, and cost-effective design, this technology is well suited for use with Li-ion batteries in EVs, PHEVs, and HEVs.

Patents

NASA's Johnson Space Center has filed for patent protection for MSC-24466-1 and is seeking patent protection for MSC-24509-1.

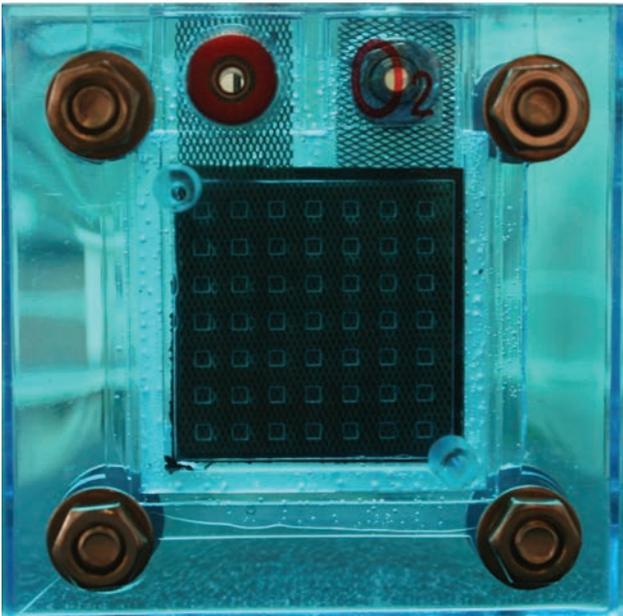
Licensing and Partnering Opportunities

This technology is being made available as part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Battery Management System (MSC-24466-1 and MSC-24509-1) for commercial applications.

technology opportunity

Fuel Cell Power System with Self-Regulating Control of Parasitic Loads

Simplifying control strategies with load-dependent voltage



Innovators at NASA's Johnson Space Center (JSC) have developed a method for efficiently controlling parasitic power in fuel cell systems. "Parasitic power" refers to power required for internal system maintenance rather than for the system's primary purpose of net power output. Originally designed for spacecraft, this novel method employs a single self-regulating control signal that does away with overly complex control strategies and external power controllers, such as electronic power control units, sensors, and thermostatic controllers. In situations where efficiency and reliability are crucial, this innovative method simplifies and reduces operating costs for fuel cell power systems.

Benefits

- **Efficient:** Boosts power output, making added power available for necessary maintenance tasks
- **Simple:** Eliminates the need for complex control strategies
- **Reliable:** Optimizes parasitic load control without an external power source
- **Cost-Effective:** Conserves power by adjusting parasitic loads proportional to need, reducing total fuel cell power costs



Applications

- Cars, buses, and material handling vehicles (such as forklifts) that run on fuel cells
- Distributed energy storage systems for Smart Grid applications
- Next generation renewable energy applications
- Telecommunications back-up systems
- Deep-sea oil drilling operations
- Uninterruptible power supplies
- Fuel cell critical power systems where reliability and efficiency are primary concerns (such as military vehicles, aircraft, and undersea vehicles)

Technology Details

Fuel cell systems typically must control several parasitic power functions such as pumps for circulating coolant or reactant gases, electric heaters for maintaining operating temperatures, and centrifugal water separators. Operating these functions steadily at their full power is wasteful and reduces the overall efficiency of the power system. This unique method allows smooth adjustment of parasitic control voltages in situations where the power demand from parasitic devices depends on the power output of the fuel cell power system.

How It Works

The method takes advantage of the operating characteristics of fuel cell stacks, particularly the fact that voltage drops off with increasing current density in greater extremes than with battery-based power systems. In one configuration, the innovation uses two or more fuel cell stacks (one or more primary and a parasitic-load stack) in parallel. Between the negative ends of the fuel cell stacks, a device that is to be controlled from a parasitic power standpoint is placed with its positive electrical power input feed from the negative terminal of the primary stack. The negative output terminal of the parasitic powered device is attached to the negative terminal of the parasitic power stack (see Figure 1).

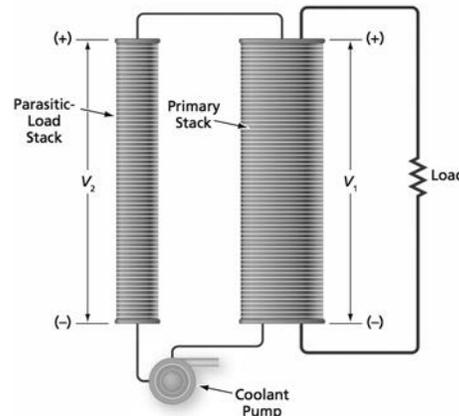


Figure 1. The voltage applied to the coolant pump ($V_2 - V_1$) would increase as V_1 decreases with increasing current through the load.

As the electrical power output of the fuel cell system increases, the voltage of the primary stack decreases as a function of the voltage versus current density response of the particular fuel cells incorporated into the primary stack. As the primary stack voltage decreases, the voltage difference between the primary and parasitic stacks increases, resulting in current flow through the parasitic device. By carefully selecting cell stack areas, numbers of cells in the two stacks, and resistance of the parasitic power device, the system will operate in a self-regulating, load-following manner.

Why It Is Better

Conventional methods of controlling parasitic power involve active control features such as electronic power units, electrical or mechanical thermostatic control, current sensors, and variable frequency inverters. Such features increase overall system complexity and reduce reliability. Most existing methods work by turning a parasitic device on and off as requirements change, which is less efficient than the continual adjustment offered by JSC's novel method.

Patents

Johnson Space Center is seeking patent protection for this technology.

Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing this Self-Regulating Control of Parasitic Electric Loads in Fuel Cell Power Systems technology (MSC-24169-1) for commercial applications.

Communications



technology opportunity

Portable Wireless Signal Booster

Increases signal strength for commercial wireless products



Innovators at NASA Johnson Space Center have invented a portable communications signal booster that is currently available for licensing. Originally designed to improve communications for lunar missions, this lightweight, portable device can boost incoming signals to improve local reception for cell phones, laptops, satellite and Wi-Fi internet receivers without the need for power plugs, cables or batteries. This portable signal booster can be configured as an umbrella or window shade for easy deployment and compact storage. This technology has the flexibility to be designed in different shapes and sizes to offer variations in booster strength and degree of directional focus.

Benefits

- **High performance:** 7-15 dB gain increase
- **Cable-free:** Requires no physical connection to wireless devices
- No power plugs nor batteries required
- Compact, portable and lightweight
- Easy to set up, easy to store
- Simple, low-cost manufacturing

Potential Uses:

- Boost “dead zones” at home and work
- Provide wireless communications systems for field, emergency and rescue workers
- Enhance hunting, camping and other remote/outside experiences
- Support RFID/wireless sensor networks



Applications

- Military
- Remote Industrial
- Logistics
- Home and Work
- Outdoor Activities
- Field Work
- Travel
- Auto

Commercial Opportunity

- Patent Pending
- U.S. Patent(s)
- Copyrighted
- Available to License
- Available for No-Cost Transfer
- Seeking Industry Partner for Manufacturing

Technology Details

Why it was Developed

Communications are of paramount importance in conducting space missions, and an antenna's signal strength is vital to the success of any mission. All antennas have a limited range. NASA needed a mobile signal booster that could be placed as needed to supplement any weak spots encountered by an astronaut crew at the site once a baseline system was deployed. Like all space hardware, the booster needed to be durable, compact and lightweight.

How it Works

This innovation successfully integrates the classic "Fresnel Ring" model into a conductive fabric structure. The result is an ultra-light, deployable device that acts as a lens to significantly enhance the realizable gain of an antenna.

A Fresnel Ring design on the booster is specially shaped to cancel specific phases of the radiated signal. This makes other more desirable parts of the signal more prominent.

Different variations of shapes of the booster can be offered. A round, medium-size unit could expect to increase signal gain in all directions by about 7 dB. A larger, elliptical-shaped unit could expect to increase signal gain in a focused direction by up to 15 dB.

Patents

NASA Johnson Space Center has received patent protection (U.S. Patent No. 8,384,614) for this technology. This technology is related to the patented technology, U.S. Patent No. 7,126,553.

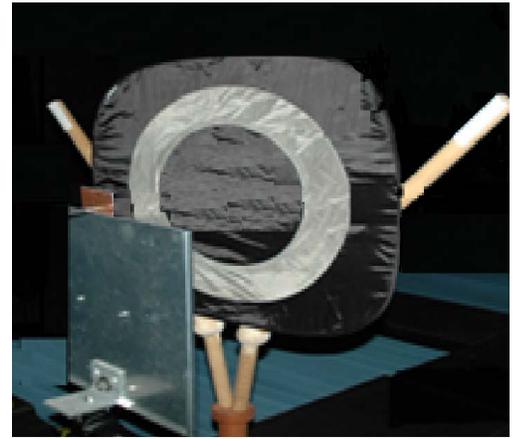


Figure 2: Prototype of a Portable Signal Booster designed to deploy and fold/store in a similar manner as a car sun shade.

Prototype

Figure 2 illustrates a prototype of the portable signal booster in a ring configuration that was tested in the Anechoic Chamber at NASA-JSC. The "sun shade" part of this prototype is 220 sq. in. when deployed and is about 31 sq. in. when folded for storage.

Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry.

NASA invites companies to consider licensing (MSC-24525) Deployable Fresnel Rings for commercial applications.

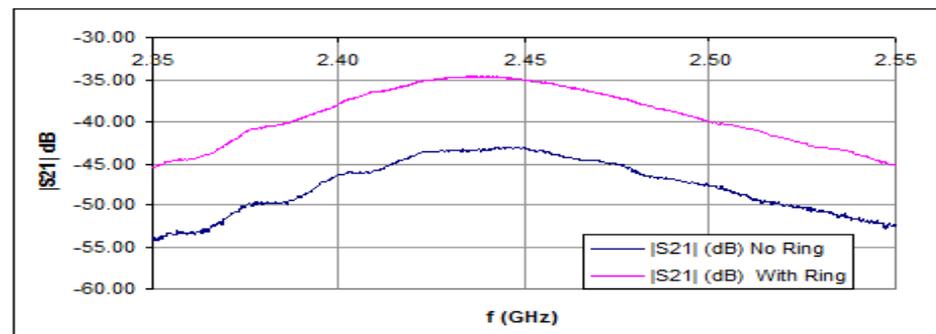


Figure 1: Results of the gains with no signal booster ring (in blue) and with signal booster ring (red)



technology opportunity

Real-Time Tracking System Uses Ultra-Wideband RF Signals

Pinpointing emergency and military personnel in remote or hostile environments



A real-time locating system (RTLS) developed at NASA's Johnson Space Center (JSC) uses ultra-wideband (UWB) radio frequency (RF) signals for tracking and reporting the position of transmitter-equipped people and objects in a variety of environments. The technology has 100 to 1,000 times finer granularity than conventional narrowband RF RTLS systems and achieves a tracking resolution of less than 1 percent of the range (tested up to 3,500 feet). Originally designed for use in tracking lunar and Mars rovers, robots, and astronauts during exploration missions, the technology has a number of terrestrial applications including long-range tracking of emergency, military, and mining personnel in limited access or hostile environments where global positioning systems are not reliable.

Benefits

- **High performance:** Operates in proximity to other radio communication systems with little or no perceptible mutual interference due to low power spectral density of UWB pulses
- **High resolution:** Offers high temporal resolution (on the order of picoseconds) due to waveform shape and short duration of UWB pulses
- **Accurate:** Permits precise measurements of propagation time while transmitting data due to high fidelity of timing circuitry and superior granularity
- **Scalable:** Offers ability to increase system range, with additional cells
- **Dual use:** Provides a simultaneous communication channel in addition to precision locating capabilities



Applications

- Aerospace rovers, robots, and astronauts on exploratory missions
- Emergency workers (firefighters, police, and emergency medical personnel) in limited access areas where GPS is not reliable
- Military personnel and equipment on battlefields and in other hostile environments, supply depots, and base operation locations
- Mining industry to locate and communicate with underground personnel
- Oil companies for use in drilling operations
- Commercial and museum environments for tracking high-value inventory

Technology Details

UWB systems coexist with other RF systems, such as Wi-Fi and cellular, due to their wide bandwidth and extremely low power spectral density. These systems are particularly useful for fine-resolution ranging, communication, and ground-penetrating radar applications in military and law-enforcement settings where GPS is not reliable.

How It Works

The JSC-developed innovation builds upon conventional UWB hardware by incorporating tracking methodology and algorithms in addition to external amplifiers for signal boost. The tracking methodology is a triangulation calculation consisting of Angle of Arrival (AOA) and Time Difference of Arrival (TDOA) using a cross-correlation peak detection method. By directly estimating TDOA information from UWB pulses, the method achieves the high temporal resolution (on the order of picoseconds) needed to measure AOA with extreme precision.

The system uses a PC to synchronize and process data in real time from two receivers, or clusters, to display the position of the transmitter-equipped person or object. The interface software enables the PC to access the two data sets simultaneously through separate sockets. In the data collection process, data segments from each receiver are interleaved with those from the other receiver in chronological order of collection. Within the PC, the data segments are stored in a separate buffer; therefore, the contents of the buffers are representations of the same UWB pulse waveform arriving at the two receivers at approximately the same time. This data synchronization provides the separate and simultaneous collection of waveform data that the tracking algorithm requires for accurate real-time tracking.

Why It Is Better

Conventional AOA tracking methods use antenna arrays to extract phase information from a continuous sinusoid signal and then convert phase information to angle information. Due to characteristics of the continuous signal, resolution obtained this way is low, resulting in tracking errors. In contrast, the JSC method combines the advantages of accurate TDOA information achieved using UWB technology with the geometric advantages of two-cluster tracking to provide accurate location information at long ranges.

Patents

Johnson Space Center has received patent protection (U.S. Patent No. 8,116,350) for this technology.

Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing this technology for Ultra-Wideband (UWB) Two-Cluster Angle of Arrival (AOA) Passive Tracking System Design technology (MSC-24184-1) for commercial applications.

technology opportunity

Ad Hoc Selection for Voice Over Internet Streams

A method and apparatus for distributing audio streams, in the form of encrypted data packets, to the personal computers of authorized listeners in near real time.



NASA seeks interested parties to license the Ad Hoc Selection for Voice Over Internet Streams technology developed by engineers at Johnson Space Center. This technology features the ability to select specific audio streams from one or more sources and then convert them into a multicast to the user's audio player. This selection ability benefits the user by allowing a wide range of information and/or data to be monitored from a remote location using existing network technologies in near real time.

Benefits

- **Flexible and compatible with industry standards:** Uses proven, standard Voice over Internet Protocol (VoIP) technologies that are currently used in commercial Internet voice and video conferencing systems
- **Private:** Features real-time encrypting of the multicast audio streams to ensure privacy and integrity
- **High capacity:** Integrates multiple audio streams into a real-time, single-audible source without the need for a dedicated connection
- **Individuality:** Allows users to receive audio at any location and individually control volume and muting for each of the audio streams
- **High quality and efficient:** Provides a high-fidelity system with excellent reproduction of voice, using relatively small bandwidth at a low cost



Applications

Audio Multicasting and Monitoring

- Air-traffic training applications
- EMS communications
- Telemedicine, stock exchange, and other information and data sharing

Technology Details

This technology was initially developed to broadcast multiple audio streams through the NASA MCC VoIP system. It is comprised of hardware and software that affect simultaneous, nearly real-time transmission of as many as 21 separate audio streams into multicast streams to authorized listeners via the MCC Intranet and/or the Internet. The technology has provided significant benefits to NASA by enhancing situational awareness among flight-support personnel and management who are located outside of the Mission Control Center (MCC), and it has excellent potential to provide similar benefits in commercial applications.

How it Works

In this patented system, the audio distribution process begins with feeding the audio signals to analog-to-digital converters. These converters create digital streams of MP3 VoIP audio packets. The resulting digital streams are sent through an audio Intranet, using a user datagram protocol (UDP), to a server that converts them to encrypted multicast data packets. These packets then are routed throughout the network to provide access to one or more audio streams concurrently on personal computers of authorized users. By using Internet Protocol (IP) multicast, the total data-processing load on the portion of the system downstream of and including the encryption server is the total load imposed by all of the audio streams being encoded, regardless of the number of listeners or the number of streams being monitored concurrently by listeners.

An authorized user's personal computer must be equipped with special purpose, audio player software. When a user launches the program, the system prompts the user to provide identification and a password. Access control is provided in two ways: (1) the program is hard-coded to validate the user's identity and password on a list maintained on a domain-controller computer, and (2) the program verifies that the user is authorized to have access to the audio streams.

Once both access control checks are completed, the audio software presents a graphic display that includes audio stream and volume control buttons. The user can select up to 21 streams to monitor simultaneously and can mute or adjust the volume of each stream individually.

Why it is Better

This innovation offers significant advantages over competing technologies because it allows multiple users to monitor the activities taking place at various locations by integrating multiple audio streams into a single source in real time. Users can access the audio streams from home, office, or a remote location, and they can individually control volume and muting. The technology is compatible with industry standards, offers excellent sound reproduction, and adds users automatically for networks supporting multicast traffic. The technology does not require dedicated connections, and the total data-processing load on the distribution system is relatively minimal, allowing for wide and secure distribution at low cost.

Patents

NASA's Johnson Space Center has received patent protection for this technology: U.S. Patent No. 7,415,005.

Licensing and Partnering Opportunities

This technology is being made available as part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Ad Hoc Selection of Voice Over Internet Streams Technology (MSC-23349-1) for commercial applications.

technology opportunity

Extended Range RFID and Sensor Tag

An energy-efficient method for increasing the range of SAW RF tags for passive RFID and sensor systems



NASA's Johnson Space Center has developed a novel technology that enhances the performance of surface acoustic wave radio frequency (SAW RF) tags for passive radio frequency identification (RFID) and sensor applications. This innovation significantly extends operational range without necessitating additional transmit power. Conversely, it can reduce transmit power requirements for shorter range passive RFID systems. The inherent temperature- and pressure-sensitive qualities of the SAW RF components also render this device ideal for remote sensing applications.

Benefits

- **Extended range:** Provides an effective means of scaling the operational distance of RFID and passive wireless sensor capabilities
- **Improved accuracy:** Offers enhanced range estimates and bearing angle (angle of arrival) measurements for real-time location systems
- **High efficiency:** Delivers either greater range without a corresponding increase in required power or allows for substantially lower transmit power while operating in typical passive RFID ranges
- **Inherently rugged:** Operates effectively in challenging conditions and at extreme temperatures



Applications

- Real-time location systems for first responder personnel and assets
- Hospital patient tracking
- Vehicle and container tracking in harsh conditions
- Remote temperature and pressure tracking for applications such as food processing and distribution

Technology Details

Passive RFID tags offer a popular option for RFID tracking applications. Lightweight and requiring no battery, these devices are inexpensive to the point of being disposable. Seeking to develop robust tracking and positioning systems for use on the lunar or planetary surfaces, as well as for space vehicle proximity operations, JSC researchers developed a simple yet effective method for overcoming a characteristic disadvantage of the technology: limited range.

How It Works

This scalable technology uses a pair of phase-matched SAW RF tags coupled with a Van Atta antenna array. Typically composed of piezoelectric lithium niobate or quartz, SAW RF tags convert the interrogating signal into a surface acoustic wave, which is then encoded with the tag's unique identification number as the wave encounters a series of reflectors etched in the crystal. With the ID added, the modulated signal then converts back to electromagnetic energy and is transmitted back to the interrogator. The influence of temperature and pressure on the reflected signal can also be measured, making the devices useful as remote sensors.

The Van Atta antenna component receives the interrogating signal and then, once the signal has been imprinted with the code from the SAW RF tags, reflects it in the direction of its arrival. The result is passive beam-steering and tracking of the interrogator without prior knowledge of its location. The increased gain provided by the array allows for extended range or for reduced transmit power from the interrogator within shorter distances.

Why It Is Better

In its simplest form, a basic two-element building block, this technology's innovative SAW-Van Atta array combination provides a 37% increase in free space range over existing passive RFID technologies—without need for additional power. To achieve the same range increase without this innovation, a 250% boost in transmit power would be required. The simplicity of the technology's design allows users to achieve this enhanced performance using commercially available SAW crystals—no modifications required—and the array is scalable to include additional coupled elements to further increase the directionality and thus range of the system.

The natural ruggedness of the SAW RF components also provides an advantage over silicon RFID tags. SAW RF tags have an operational temperature range of at least -230°C to 315°C and are highly resistant to radiation-induced failure. The tags' inherent temperature and pressure dependence allows the devices to track environmental information in addition to their RFID tracking capabilities.

Patents

Johnson Space Center has filed for patent protection for this technology.

Licensing and Partnering Opportunities

This technology is being made available as part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Extended Range RFID and Sensor Tag technology (MSC-24346-1) for commercial applications.

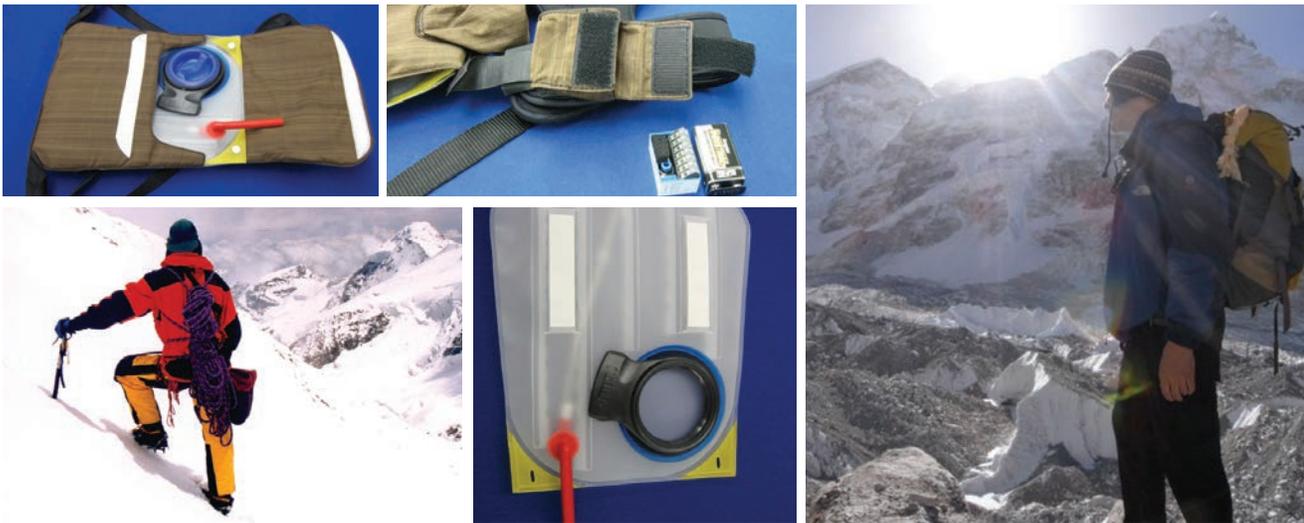
Consumer Products



technology opportunity

An Ultra-Efficient, Freeze-Resistant Hydration System

The technology is designed for rugged, cold, and high-altitude conditions



NASA's Johnson Space Center is offering an innovative freeze-resistant hydration system for licensing.

The technology substantially improves on existing hydration systems that cannot prevent water from freezing in the tubing, container, and mouthpiece in the harshest conditions on earth. This technology is designed to work to -40°C and 15-mile-per-hour winds over a 12-hour summit day, and likely well beyond. Field testing was performed at Mt. Everest in May, 2009.

The device was originally conceived and designed by an astronaut-mountaineer who recognized the great risk of dehydration in high mountains and the lack of sufficient technology to meet this important need.

Benefits

- **Improved Safety:** Dehydration is a life-threatening complication for high-altitude climbers. The device will provide 2-3 liters of liquid beverage (water, tea, or nutritional supplement) over the course of a full summit day.
- **Lightweight:** The straw is insulated with aerogel or other highly efficient insulators, a feature that allows the heating system to work without extra thickness or weight.
- **Multiple approaches:** The technology uses passive transfer of body heat in one option, an intermediate variant system in another, and a battery-powered microcontroller in a third.
- **Numerous applications:** Although designed for climbers, it has applications for cold weather sports enthusiasts (skiers, snowboarders, snowmobilers, hunters), rescue crews, and military personnel.



Applications

- Mountain climbers
- Downhill skiers
- Cross-country skiers
- Winter campers
- Snowmobilers
- Hunters
- Law enforcement and rescue personnel
- Defense environments, including SEAL, underwater, and deep sea use

Learn more about field testing of this product on Mt. Everest by visiting Co-Inventor and former NASA Astronaut Scott Parazynski's climbing blog at: <http://www.onorbit.com/everest>

Technology Details

How it Works

The High Altitude Hydration System works three different ways. The first, passive thermal control, uses aerogel insulation on the outside of the conformal fluid reservoir and around the drink straw. The bottle is mounted to an inner layer of clothing and the insulated straw is pulled from underneath the suit for a sip, then tucks back into the clothing. The second uses a braided copper wire attached to the drink straw and insulating aerogels to allow body-generated heat to keep the drink straw and water conformal fluid reservoir from freezing. A third method uses a microcontroller and tape heater to keep the drink tube warm and free of ice crystals.

Why it is Better

Even when a water conformal fluid reservoir and drink straw are zipped into a down suit, water freezes under extreme conditions. This poses a health hazard, particularly to high-altitude climbers who mouth-breathe, as mouth-breathing causes substantial fluid loss (in exhaled breaths). Climbers of 8,000-meter peaks get only 1 liter or less of fluid on summit days because their drink bottles freeze so quickly.

Neoprene, an alternative, is much less effective because it performs poorly compared to aerogels and requires a thickness that would make the straw difficult to handle. Using body heat is very efficient in this configuration, and is a welcome source of warmth at the beginning of a summit climb day.

Patents

Johnson Space Center filed for patent protection for this technology in December, 2009.

Licensing and Partnering Opportunities

This technology is being made available as part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the High Altitude Hydration System technology (MSC-24490-1) for commercial applications.

technology opportunity

Roadway Barrier for Decelerating and Retaining a Moving Vehicle

Nets and straps capture the vehicle to control dangerous, high-impact collisions



Researchers at NASA's Johnson Space Center have developed a roadway barrier system capable of slowing and capturing vehicles in high-impact collisions. Energy-absorbing straps deploy for controlled deceleration, protecting the driver from a life-threatening collision. Nets capture the vehicle, greatly reducing the possibility of secondary impacts on other vehicles or innocent bystanders. The roadway barrier can be used on our nation's streets and highways, in amateur and professional auto racing, at security checkpoints, in homeland security to redirect an explosive force away from high value targets, and in vulnerable areas of schools or public parks to protect pedestrians.

Benefits

- **Safer:** Enhances survivability for drivers in high-impact collisions, catches debris from explosions, and protects innocent bystanders
- **Cost-efficient:** Inexpensive to transport, install, maintain, and replace
- **Easy to implement:** Allows for simple set up and maintenance of modular panels
- **Effective:** Stops a vehicle traveling at 80 miles per hour within 8 feet
- **Durable:** Deflects vehicles in low-impact collisions without breaking away



Applications

- Professional and amateur auto racing
- Homeland security
- Highway safety
- Secured facilities

Technology Details

NASA's deceleration-limiting roadway barrier was originally developed as a hatch restraint device for use on the space shuttle. The innovation has several applications beyond aerospace, including high-speed auto racing, highway safety, and homeland security.

How it Works

The deceleration-limiting roadway barrier is composed of three components:

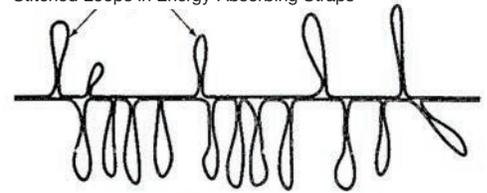
1. High-strength straps provide controlled resistance to decelerate the vehicle.
2. Net or mesh, secured to anchors by energy-absorbing straps, capture the vehicle.
3. Energy-absorbing panels deflect vehicles that collide only tangentially with the roadway system.

High-strength straps deploy under a predefined tensional load. The net, sandwiched between two panels and anchored to form a segment of a barrier or crash wall, catches an oncoming vehicle and dissipates much of its kinetic energy through ripping of the stitches in the load-limiting straps. The panel facing the roadway is capable of withstanding small impacts and only breaks in the event of a high-impact collision.

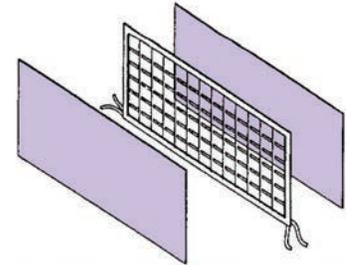
Why it is Better

Existing rigid barriers designed to stop a moving vehicle are typically made of unyielding materials, such as reinforced concrete, and offer little or no opportunity for controlled deceleration. This deceleration-limiting roadway barrier protects drivers by reducing the impact of a collision and drastically improving the driver's chances of survival. Furthermore, it protects innocent bystanders by capturing the vehicle and preventing it from rebounding into nearby drivers and/or pedestrians. The system is inexpensive to install and maintain, it can be transported easily, and damaged sections can be replaced within minutes. In addition, the barrier system can be installed in cramped or crowded spaces (a car traveling at 80 miles per hour can be stopped safely within just 8 feet).

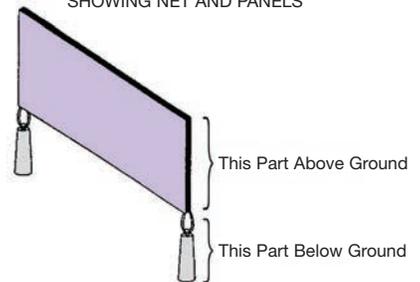
Stitched Loops in Energy-Absorbing Straps



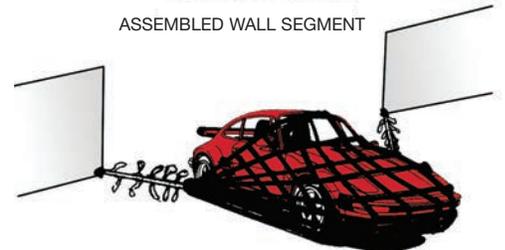
LOAD-LIMITING LANYARD



EXPLODED VIEW OF WALL SEGMENT SHOWING NET AND PANELS



ASSEMBLED WALL SEGMENT



CAR AFTER CRASHING INTO WALL

Patents

Johnson Space Center has received patent protection (U.S. Patent No. 6,997,637) for this technology.

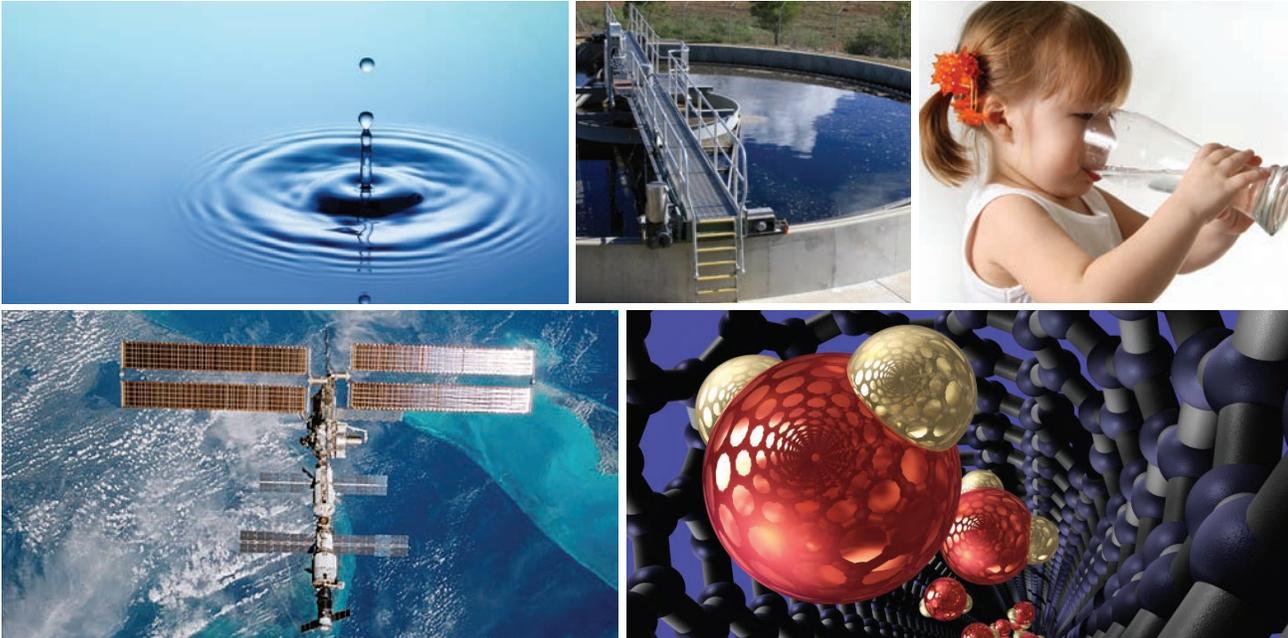
Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing this technology for the Deceleration-Limiting Roadway Barrier (MSC-23178-1) for commercial applications.

technology opportunity

Filtering Water with Acoustics Nanotube Technology

Effectively eliminates contaminants from water supplies



Innovators at NASA's Johnson Space Center have developed a filtration device to eliminate contaminants from water supplies. Originally developed to purify wastewater for reuse aboard the International Space Station, the innovation is applicable to numerous situations on Earth where there is a need to collect potable, medical-grade water from a contaminated water supply. The unique aspect of the technology is its use of acoustics rather than pressure to drive water through small-diameter carbon nanotubes. The invention requires less power than conventional filtration systems and is well-suited to a variety of water processing needs.

Benefits

- **Effective:** Produces clean water by eliminating contaminants
- **Efficient:** Requires less power than conventional filtration systems, enabling remote operation and solar power options
- **Flexible:** Does not depend on gravity for water to flow through the system
- **Scalable:** Allows for use of a single filter or a large bank of integrated filters, depending on filtration needs
- **Widely applicable:** Suits applications for a variety of water processing needs, ranging from industrial to consumer applications



Applications

- Municipal water facilities
- Medical facilities
- Laboratories
- Distilleries
- Desalination plants
- Industrial facilities
- Wastewater treatment facilities
- Consumer markets

Technology Details

This water filtration innovation is an acoustically driven molecular sieve embedded with small-diameter carbon nanotubes. Turning the idea of filtration on its head, this technology pushes water away from contaminants, rather than removing contaminants from water.

How It Works

Water enters the device and first contacts the filter matrix, which can be made of polymer, ceramic, or metallic compounds, depending on end-use requirements. Carbon nanotubes within the matrix allow only water molecules to pass through, leaving behind any larger molecules and contaminants.

The unique aspect of the technology is its use of acoustics to help drive water through the filter. An oscillator circuit attached to the filter matrix propagates acoustic vibration, further causing water molecules to de-bond and move through the filter. This use of acoustics also eliminates dependence on gravity (and thus filter orientation) to move water through the device. When water exiting the system diminishes to a pre-determined set point, a cleaning cycle is triggered to clear the sediment from the inlet of the filter, reestablishing the standard system flow rate. Unlike other filtration systems, flushing of the filter system is not required.

Why It Is Better

Existing water filtration technologies are generally plagued by limited performance, high energy consumption, and high costs. New filtration and treatment techniques designed to mitigate these problems generally depend on pressure to drive water through the filtration system. The combination of acoustics and small-diameter carbon nanotubes in this innovation make it an effective and efficient means of producing contaminant-free, clean water.

Patents

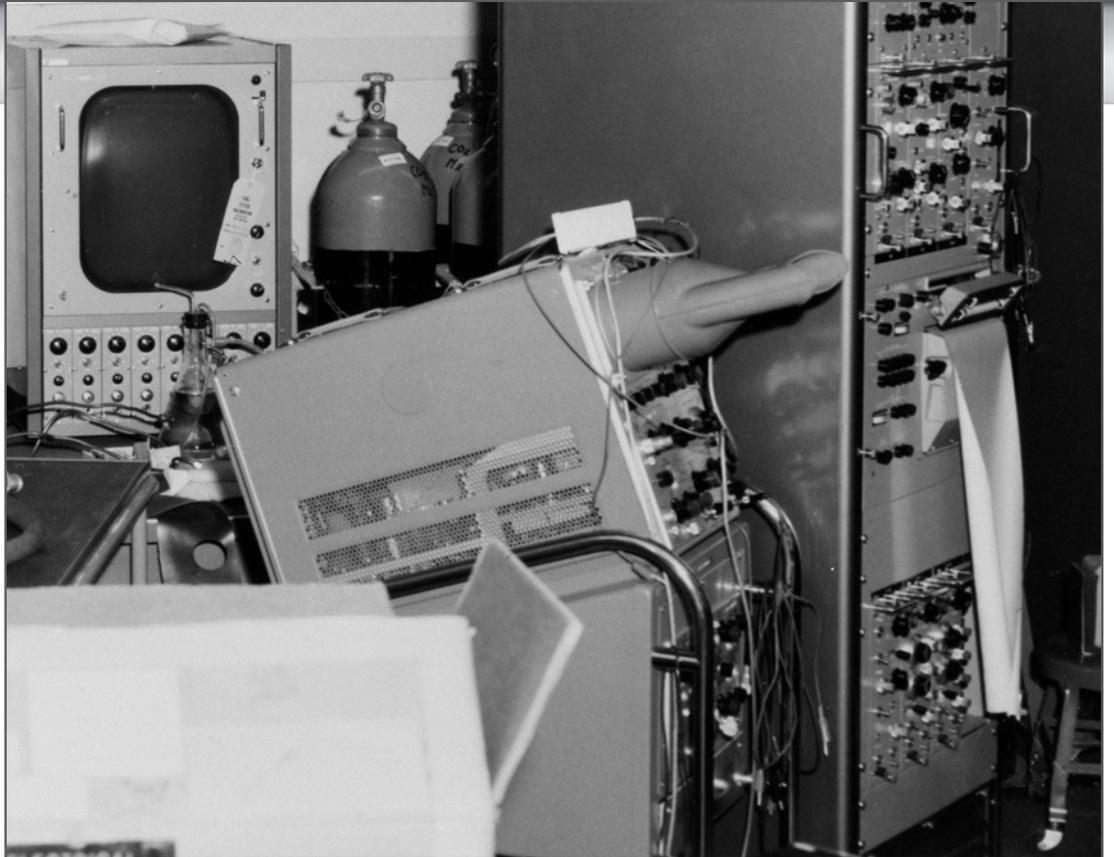
Johnson Space Center has received patent protection (U.S. Patent No. 7,935,259) for this technology.

Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing this Water Filtering Device technology (MSC-24180-1) for commercial applications. Supporting technologies are available as well:

- MSC-24508-1 – Method for Making a Microporous Membrane
- MSC-24353-1 – Deluxe Model Water Filtration Device

Electrical



technology opportunity

FPGAs with Reconfigurable Fault-Tolerant Redundancy

Enables users to choose increased capacity over redundancy



NASA's Johnson Space Center has developed a technology that enables selective reconfiguration of field programmable gate arrays (FPGAs) and similar devices between redundant and non-redundant operation, to meet application needs for the right mix of reliability and high capacity. This innovation allows the flexibility of firmware redundancy while maintaining the efficiency and simplicity of hardware-based redundancy.

Benefits

- **Increased capacity:** User-defined programming provides triple redundancy in only the most critical areas.
- **Improved performance:** Hardware TMR saves at least one "logic level" over firmware redundancy, providing hardware redundancy performance without sacrificing necessary capacity.
- **Lower manufacturing cost for end users:** Higher capacity allows smaller FPGAs for end users, reducing unit and circuit board costs significantly.
- **Lower development cost for end users:** No need to implement TMR into firmware shortens the required design time.
- **High efficiency:** Configuration memory does not have to be separately voted because at least two configuration bit errors are required to circumvent the voters.



Applications

This technology will be beneficial primarily in the high-radiation environments found in the aerospace industry. Key FPGA types include:

- Radiation-tolerant SRAM-based FPGAs
- Radiation-tolerant flash-based FPGAs

For example:

- Signal processing for software radio
- Sensor data analysis
- Automated docking
- Landing sensor data processing (e.g., LiDAR processing)
- Hazard detection and avoidance
- Network packet routing
- Video processing and video display updates
- Communications network infrastructure (e.g., cell phone base stations and high-reliability network data routing)

Technology Details

Typical FPGAs either provide fixed redundant circuitry that enables tolerance of faults such as a single event upset (SEU) or single event transient (SET), or they provide no redundancy at all and the user must program any required redundancy in firmware, causing high overhead costs. Although hardware redundancy provides high performance and assurance, many applications only need to be partially protected from SEU/SET, and other parts of the applications require higher capacity.

How It Works

This innovation uses a hardware implemented voting scheme with two modes—Redundancy Mode, which provides full triple redundancy protection, and Split Mode, which eliminates redundancy protection in selected areas to increase capacity. With Split Mode, end users have the option of choosing the amount of redundancy in their design but can still implement TMR in an efficient manner.

The device has three identical sets of functional units, routing resources, and majority voters that correct errors. It modifies the voter to accept a mode input, which specifies whether ordinary voting is to occur or redundancy is to be split. In Redundancy Mode, the voters work in the usual manner, producing an output corresponding to the two inputs that agree. In Split Mode, each voter selects a different input and conveys this to the output. By changing the operation of the voters, the sections can operate independently.

A single event upset assumes that only one fault will occur in a voting group within one voting cycle, and thus, the fault can be eliminated by majority voting. The only connection between the three sections of the device is through the voters.

The voters also effectively mask errors in the configuration memory because all data passing between sections pass through the voters. At least two configuration bit errors in unrelated (non-adjacent) parts of the device are required to circumvent the voters.

To partition an application, the device is divided into independently configurable blocks. When operating in Split Mode, additional routing resources are used to communicate between the split sections in a block. This additional routing also requires at least two configuration bit errors to generate an error in a redundant block.

Because both the register (storage) elements and combinational logic are redundant, this method protects against SEU in the storage elements and SET arising in the combinational logic.

Why It Is Better

Because up to 95% of the device's capacity can be designed for normal, non-redundant operation in Split Mode, minimal silicon space (or capacity) is used when a device manufacturer includes this capability. Developers have the ease of use of hardware redundancy. The application benefits from the speed and low power of hardware redundancy, from protection against errors in both logic and register elements, and from high capacity when needed for non-redundant implementation.

Patents

Johnson Space Center has received patent protection (U.S. Patent No. 7,859,292) for this technology.

Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing this technology for FPGAs with Reconfigurable Fault-Tolerant Redundancy (MSC-24464-1) for commercial applications.

Manufacturing

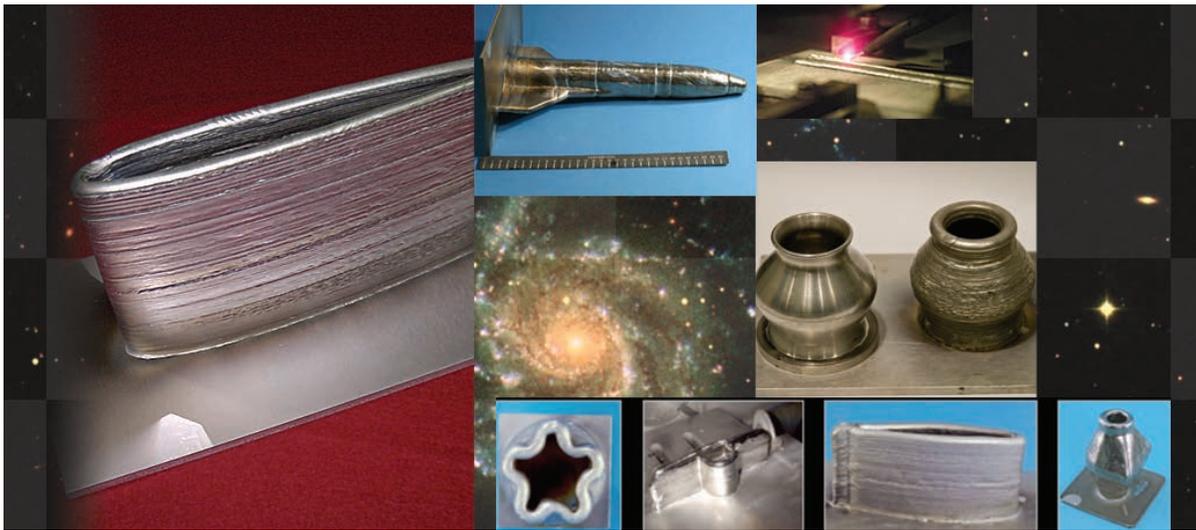




technology opportunity

NASA's EBF3: The Future of Art-to-Part Manufacturing

Cutting costs, reducing waste, expanding capabilities



NASA is making tomorrow's rapid prototyping and manufacturing technologies available today. Companies are invited to license an innovative system for performing electron-beam freeform fabrication (EBF3) that offers significant advantages over traditional e-beam and laser-based systems. The core of NASA's EBF3 system uses a wire-feed design to deliver quality parts that are better than cast and similar to wrought materials while minimizing excess material. Multiple wires can be used to create new alloys or layered parts. The system costs significantly less to build than others, enabling companies previously hesitant to enter the market to compete and win in the expanding rapid prototyping and additive manufacturing market.

Benefits

- **Lower material costs:** Wastes less material than traditional subtractive manufacturing (i.e., machining) processes
- **High strength parts:** Uses real engineering alloys, such as Ti-6Al-4V and Al 2219, in standard wire forms, rather than specialized metallic powders required with direct metal laser sintering processes
- **Compound material properties:** Allows deposition of multiple alloys to create parts where material chemistry can vary according to functional part requirements (e.g., changing cross-sectional strength on an airplane wing spar)
- **Lower power, higher safety:** Requires less power than machines derived from traditional e-beam welders, which lowers operational power costs and radiation, thereby increasing operator safety
- **Versatile part envelope:** Produces a wide range of part sizes, from a few inches to tens of feet
- **Mobile and rugged:** Can be relocated and has been successfully demonstrated on an aircraft in 0-g flight without requiring time-consuming alignment procedures



Applications

Medical

- Human bone replacement parts

Automotive and motorsports

- Custom and replacement parts

Aerospace structural components

- New structural components with high buy-to-fly ratios (such as bulkheads or complex housings)
- Replacement parts for aging aircraft

Replacement parts in remote or hostile locations

- Military forward-operating locations
- Seafaring ships
- Offshore oil rigs
- Polar research stations

Three-dimensional models for new designs

- Rapid iterative prototyping

Metals deposition and treating

- Plating, structural mending, and spot etching and heating

Technology Details

Companies currently providing only laser-based services (e.g., 3D stereolithography, direct metal laser sintering) can use NASA's EBF3 system to expand their offerings and take advantage of the benefits of e-beam manufacturing, while companies with e-beam fabrication will appreciate that EBF3 eliminates many of the safety and shielding requirements necessary with higher power systems that are derived from e-beam welding technologies.

How it works

The core of the EBF3 system is an electron-beam gun, wire feeder, and positioning system enclosed in an aluminum vacuum chamber. Like other e-beam systems, the NASA system focuses the beam to melt a material, in this case metal wire, which is then accurately deposited layer by layer according to computer-aided design (CAD) data to fabricate a three-dimensional structural part without the need for a die or mold.

Unlike other e-beam systems, which operate at 60–200 kV, NASA's technology can create parts using about 20 kV accelerating voltage. The system can be used to make parts from a wide range of materials (e.g., titanium, aluminum, nickel, stainless steel) as well as alloyed and layered parts via multiple wire feeds. The size of parts will be dependent upon the size of the system's build envelope, which can be scalable from a few inches to tens of feet or even larger.

Why it is better

The EBF3 system offers the promise of a nearly unrestricted part build envelope. The complete unit can be as small as an office desk or even smaller with an umbilical cord to the required power supply and vacuum pumps. A system that integrates EBF3's vacuum-isolation enhancement with a maneuverable, positioning arm eventually will be capable of building any size or shape complex part.

NASA's EBF3 system is less expensive than other systems. NASA installed its system for \$250K; however, a commercialized system is expected to cost significantly less. Plus, the low-power design offers significantly reduced operating costs and minimizes the shielding required to comply with radiation safety regulations.

Other cost savings are possible because of the NASA system's reduced use of material. EBF3 uses a full 100% of the material for the part with no residual material contamination. This offers an advantage over powder-based e-beam systems, which require residual material to be recaptured and recertified before reuse. Parts made with NASA's EBF3 system can be used or shipped immediately with only minimal need for cooling.

Because two or more wires can be fed into the system, EBF3 can manufacture multi-material parts, including new alloy-based parts or layered parts with better surface properties. For industrial plating applications, EBF3 could offer a high-quality alternative to traditional plating (e.g., chrome plating) while enabling better compliance with environmental regulations. The technology works exceptionally well with such alloys as Ti-6Al-4V and Al 2219.

Patents

NASA has patented this technology (U.S. Patent No. 7,168,935) and has other patents pending.

Licensing and Partnering Opportunities

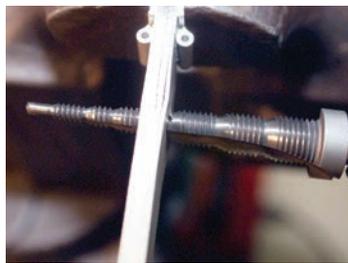
This technology is being made available as part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Wire-Feed E-Beam Freeform Fabrication technology (MSC-23518-1) for commercial applications.



technology opportunity

Self-Advancing, Step-Tap Drill Bit

For reduced fatigue, improved safety, and greater efficiency



*Photo Descriptions: **Top left:** Flight-certified, step-tap drill bits for threaded holes that stop at the required size step. **Top right:** Crew training using the step-tap drill bit in the Pistol Grip Tool (PGT) drill driver on a Shuttle leading edge test article. **Bottom left:** Co-inventor Charlie Camarda on STS 114 Return to Flight with step-tap drill bits. **Bottom right:** Drilling a test piece of previously damaged leading edge material with a prototype step-tap drill bit.*

NASA's Johnson Space Center invites interested companies to license its patented self-advancing, step-tap drill bit. Originally developed for Space Shuttle repair (it now flies on every Shuttle mission), this novel, stepped drill bit features a cutting edge that concurrently enlarges a hole as it cuts threads—a feature not available in other stepped drill bits. The drill bit advances itself into the work material similar to a screw, eliminating the need to apply external axial force. This unique technology greatly improves the safety and efficiency of handheld drilling while reducing operator fatigue, making it ideal for high-volume and heavy-duty construction applications and home shop use.

Benefits

- **Reduced fatigue:** Features a unique self-advancing component that eliminates the need for continuous axial force, decreasing physical work effort
- **Improved safety:** Reduces the risk of the work piece tearing or spinning in the operator's hand because the drill bit does not grab the work piece
- **Greater efficiency:** Allows operators to work more quickly and productively without the need to change drill bits and taps when drilling different sized holes



Applications

Construction and home shop use, especially:

- Drilling holes larger than 0.5 inch
- Drilling vertically oriented holes
- Repetitive drilling
- Overhead drilling

Technology Details

How It Works

The self-advancing, step-tap drill bit uses a cutting edge to simultaneously enlarge a hole and cut threads. The drill bit is stepped, enabling an increase in the diameter of the hole with each step. To prevent the threads from stripping caused by the required cutting forces between the drill bit and the work material, the thread pitch (number of threads per inch) and diameter increase for each step are adjusted for the material type and thickness. The diameters of the steps are in increments of 0.030–0.060 inch (0.8–1.5 mm). The tip typically has a diameter of 1/8–3/16 inch (3.2–4.8 mm).

The thickness of the work piece to be drilled and tapped determines the length of the pilot-drill section chosen, so that the pilot hole is completed before engagement of the first tap section. If the cutting-edge geometry of the drill bit is optimized for the material to be drilled, only a relatively small axial force (typically a few pounds) must be applied when drilling the pilot hole. Once the first tap section engages the pilot hole, no additional axial force is necessary because the thread engagement between the tap and the work piece provides the axial force, seamlessly advancing the drill bit. A stop-lip or shoulder at the shank end of the widest tap section prevents further passage of the drill bit through the hole.

Why It Is Better

Applied axial drilling forces for handheld drills can be quite large, often as much as 75 lb (about 330 N) when drilling holes up to approximately 1 inch (25 mm) in diameter. With non-self-advancing drills, an operator often must bear down with near full body weight to facilitate downward drilling. When using such non-self-advancing drills, vertical, overhead, and repetitive drilling is extremely fatiguing and limits worker productivity. In addition, applying a large axial force with a handheld drill can be dangerous because the drill bit can grab the work piece, causing the work piece to spin or tear the drill and work piece from the operator's hand.

Other drilling technologies include drill bits that make a single-sized hole, step drills that enable hole enlargement, taps that thread one size of a pre-existing hole, and a simple combination of a single-sized drill and a tap (for tapping after a hole has been drilled). Combining any of these technologies will not result in a functional, self-advancing, step-tap drill. Rather, the innovation developed at Johnson Space Center is a precise combination of step size, cutting angle, thread advance, and flute design, producing a drill bit that all but eliminates the need to apply external axial force while concurrently cutting and threading a hole. This significantly reduces operator fatigue, increases safety and efficiency, and enables drilling larger holes in thinner materials with a standard, commercially available drill.

Partners licensing and commercializing this innovative technology can manufacture and market the drill bits in several optimized designs and sizes for purchase individually or as a set. Marketable variations include:

- A set designed to leave a tapped hole for threading standard-sized fasteners
- A set to leave a hole through which to pass the shank of standard-sized fasteners
- A set for large holes
- Sets optimized for metal, plastic, and brittle ceramics

Patents

Johnson Space Center has received patent protection (U.S. Patent No. 7,357,606) for this technology.

Licensing and Partnering Opportunities

This technology is part of NASA's Technology Transfer Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to inquire about the licensing possibilities for the Self-advancing Step-tap Drill Bit (MSC-23954-1) for commercial applications.

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