

SPINOFFS OF TOMORROW



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in your **life**
than you **think.**

Since 1976, NASA's annual *Spinoff* publication has featured the best examples of commercialized NASA technology.

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Introduction

Space technology benefits you every day in a variety of ways.

In addition to NASA's many commercialized technologies, called spinoffs, the space agency also has a host of technologies that are available for licensing and partnership opportunities. Thousands of American businesses have benefited from partnering with NASA to license technology and leverage NASA expertise. These partnerships have resulted in billions of dollars in generated revenue, billions more in saved costs, and tens of thousands of new jobs.

Each of our 10 field centers is making unique advances in a variety of fields, from aeronautics and information technology to biomedical devices and materials science. This brochure features just a few examples of industry-ready technology on offer at each center—advances made possible thanks to NASA's ongoing investments in research and development.

More information about any of the following technologies can be found by following the links at the end of each article. If you'd like to see a complete listing of all available NASA technologies, visit <http://technology.nasa.gov>.



Daniel Lockney
Technology Transfer Program Executive
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Ames

High-Speed 3D Laser Scanner

Versatile, fast 3D scanning with Internet connectivity and a small footprint

Ames Research Center now offers its patented 3D Laser Scanner surface scanning and profiling technology for license, a technology that won the 2008 NASA Government Invention of the Year Award. Originally developed for critical, real-time inspection of damage to the thermal protection tiles of the space shuttle, this advanced system can be used for a wide range of commercial applications from product quality control to autonomous navigation.

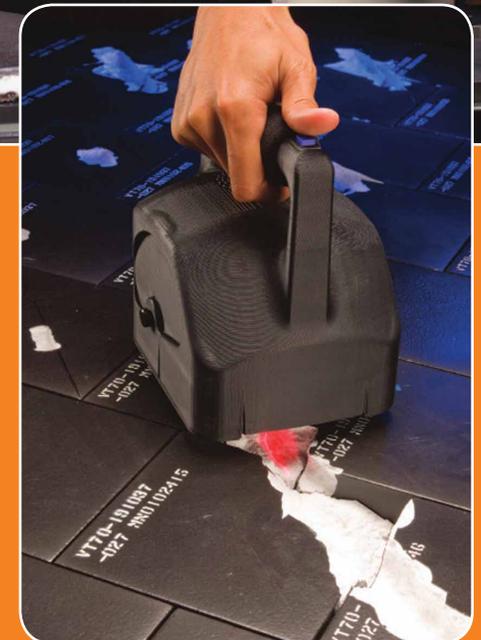
Powered by the onboard Surface Profiling and Characterization Engine (SPACE) processor, the 3D Laser Scanner provides real-time analysis of surfaces ranging from the small (such as circuit boards) to the large (such as panels or roads). No other 3D scanner offers the same combination of speed, resolution, size, power efficiency, and versatility. In addition, it can be used wirelessly, unencumbered by cables. Results of a scan are available in real time, whereas conventional systems scan over the surface, analyze the scanned data, and display the results long after the scan is complete.

Benefits

- High-speed, 3D scans create more than 600,000 3D points/second—among the highest available
- Provides results in real-time from the integrated SPACE processor
- Can scan areas sized from square centimeters to square meters
- Detects details smaller than .001 inches
- Small, lightweight, and power efficient: over 1,000 scans from the rechargeable lithium battery
- Offers wireless or gigabit ethernet wired connectivity

Applications

- Inspection of aircraft and spacecraft fuselage surfaces, wings, and more
- Autonomous navigation by mobile robots
- Inspection of pipelines (oil, natural gas, water) for corrosion-related defects
- Optical 3D scanning of printed circuit boards for inspection and positioning
- Dental scanning and inspection of orthodontic devices
- Dermatology/healthcare scanning (inspection and tracking of moles)
- Road surface profiling



Future Air Traffic Management Concepts Evaluation Tool

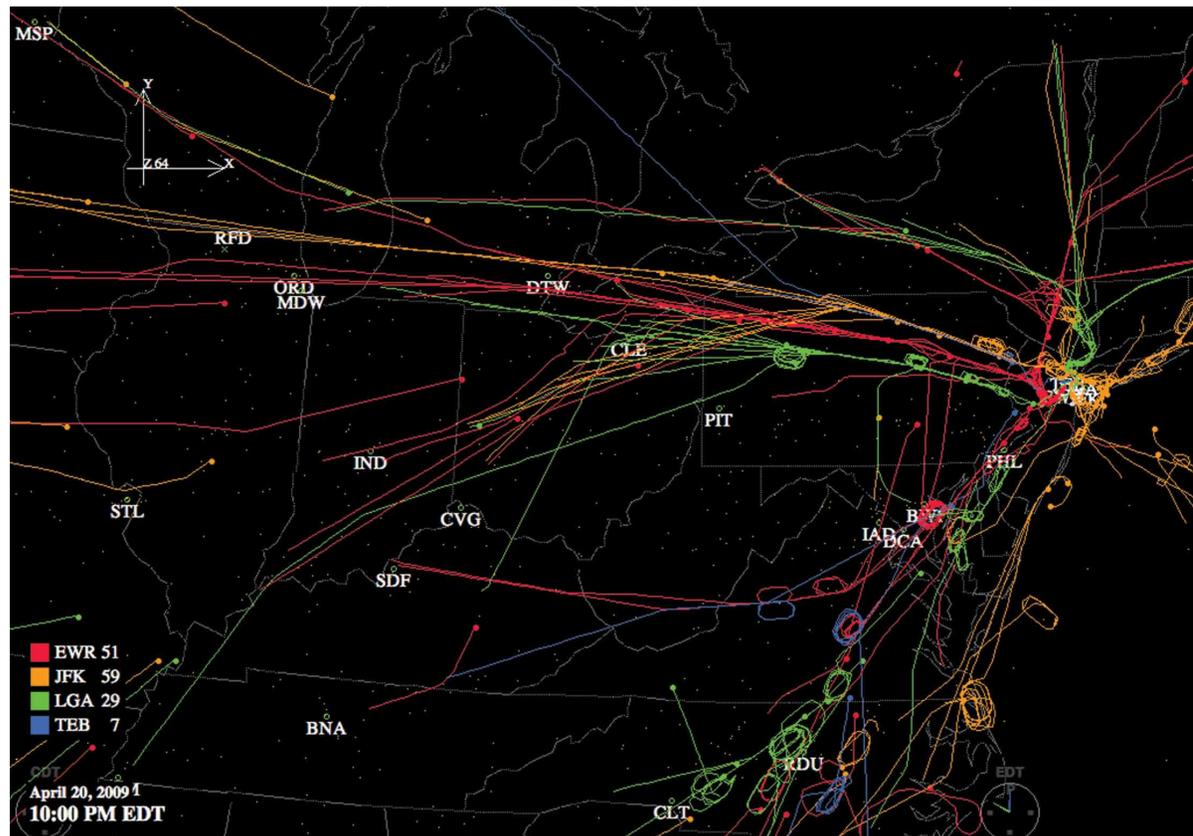
Comprehensive software eases air traffic management

With thousands of planes flying overhead in the United States at any given time, there is an urgent need for tools that help avoid air traffic incidents and delays. Ames Research Center is offering the opportunity to license and codevelop the Future Air Traffic Management Concepts Evaluation Tool (FACET). FACET performs powerful computational simulations for evaluating advanced concepts of air-traffic management. It includes a program that generates a graphical user interface, plus programs and databases that implement computational models of weather, airspace, airports, navigation aids, aircraft performance, and aircraft trajectories.

Actual air traffic data and weather information are utilized to evaluate an aircraft's flight-plan route and predict its trajectories for the climb, cruise, and descent phases. The dynamics for heading and airspeed are also modeled by FACET, while performance parameters such as climb/descent rates and speeds and cruise speeds can also be obtained from data tables. Resulting trajectories and traffic flow data are presented in a 3D graphical user interface. The software is modular and written in the Java and C programming languages. Its potential applications include reroute conformance monitoring algorithms that have been implemented in one of the Federal Aviation Administration's nationally deployed, real-time operational systems.

Benefits

- Decreases airline accidents
- Swiftly generates as many as 15,000 aircraft trajectories on a single desktop or laptop computer
- Provides trajectories and traffic flow data presented in an easy-to-use, 3D graphical user interface



Applications

- Air traffic management
- Development of enhanced flight routing strategies that can
 - save fuel
 - preserve airline schedules
 - reduce passenger delays and missed connections



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Armstrong

Global Elevation Data Adaptive Compression Algorithms

Greater compression and faster decompression of digital terrain maps

Armstrong Flight Research Center is offering its patent-pending Global Elevation Data Adaptive Compression Algorithms to provide compression and rapid decompression of digital terrain maps (DTMs) in constrained computing environments. The primary purpose of these algorithms is to create and utilize highly compressed digital terrain data representing the geographical areas of the entire world to enable Automatic Ground Collision Avoidance Systems (Auto-GCAS) for high-performance fighter aircraft. The data is formatted to be accessible anywhere in the world in real-time and also allows for control of data resolution to support the complete range of high-performance aircraft operations. Other uses include applications that require large databases of graphical information to be deployed through restricted environments such as tablets and smartphones.

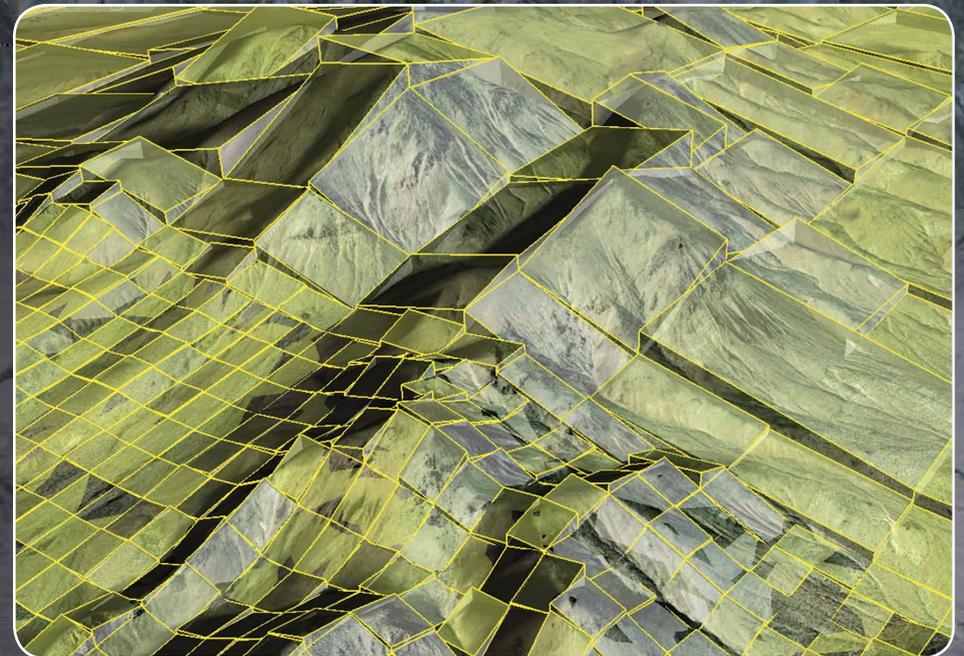
The software provides an extensive and highly efficient compression capability for continental and global-scale DTMs, along with a real-time decompression capability to locally decompress and render map data in the vicinity of a fast-moving airplane. A key feature of the innovation is its ability to render local terrain maps in real time for an Auto-GCAS in a high-performance airplane that may need to deviate from a planned flight path due to unexpected and dynamic events.

Benefits

- Controls error induction maximums for user-defined geographical areas from lossless to infinite and incorporates different areas seamlessly in a single compressed DTM
- Performs rapid, high-performance decompression in real-time constrained computing environments
- Integrates more than 250 billion separate pieces of terrain information into a single compressed file
- Features technology flown and tested on several different platforms including high-performance fighter aircraft
- Enables implementation on existing aircraft systems without upgrading computer hardware; offers industry standard C, C++ code base and map formats

Applications

- Commercial and military aircraft Auto-GCAS
- Marine electronic charting systems
- Weapons guidance systems
- Software that analyzes terrain routes or continual surfaces
- Gaming systems
- Medical software



Battery Monitoring System

Assessing real-time battery health wirelessly with commercial, off-the-shelf parts

Battery health monitoring is an emerging technology field that seeks to predict the remaining useful life of battery systems before they run out of charge. Such predictive measures require interpretation of large amounts of battery status data. Engineers at Armstrong Flight Research Center have developed a battery data acquisition and logging system that processes and reports analog sensor data in real time for wireless transmittal. When used in combination with customized, NASA-developed algorithms, the Armstrong innovation provides a means to collect, process, and transmit this critical remaining useful life data.

Constructed with commercial, off-the-shelf parts, this low-cost and novel battery monitoring system is adaptable to multiple types of battery chemistry, creating cross-platform capabilities for a wealth of sensing needs. Measurements taken include voltage, temperature, and state of health for multiple batteries simultaneously. The methodology not only provides time-to-failure estimates but also generates a probability distribution over time that best encapsulates the uncertainties inherent in system models. Such information enables a real-time monitoring capability beyond that which is currently available, particularly for applications where unanticipated battery performance may lead to catastrophic failures, such as aerospace and medical device systems.

Benefits

- Prevents occurrence of catastrophic battery failure by predicting the remaining useful life of battery systems
- Processes large amounts of data and reports results wirelessly
- Effectively monitors the health of multiple batteries simultaneously
- Reliable, critical, real-time monitoring capability that allows an immediate and controlled response to avoid battery failure
- Uses commercial, off-the-shelf parts, increasing affordability and contributing to a lightweight, compact footprint
- Provides a rugged, robust platform with the potential for miniaturization

Applications

- Electric unmanned aerial vehicles
- Electric, hybrid, and plug-in hybrid electric vehicles
- Light rail systems
- Medical devices
- Robotics
- Industrial instruments
- Grid stationary power systems
- Portable power packs



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High-Temperature, Low-Melt Viscosity Imide Resins for Liquid Molding

Fabricating resin transfer molding composites for aerospace components

Glenn Research Center is inviting companies to license or establish partnerships to develop its patented high-temperature, low-melt viscosity imide resins for composite fabrication into aerospace components. Produced by a solvent-free melt process, these resins exhibit high glass transition temperatures, low-melt viscosities, long pot-life, and are amenable to resin transfer molding (RTM) and vacuum-assisted resin transfer molding (VARTM).

RTM imide resins can be melted and injected into fiber preforms under pressure or vacuum. The resins also can be made into powder prepregs with unlimited out-time by melting the resin powders so that they fuse onto fibers. RTM imide resins display high softening temperatures (370–400 °C) and excellent toughness. This technology was developed to make polyimide resins from novel asymmetric dianhydrides (a-dianhydrides) and kinked diamines to achieve low-melt viscosities that are amenable to low-cost RTM and VARTM, while retaining high-temperature performance above 300 °C. These a-dianhydride-based RTM imide resins display low-melt viscosities that cannot be achieved using normal symmetric dianhydrides.

Benefits

- High-temperature capability, performing above 300 °C, which exceeds conventional RTM resins for aerospace applications
- Can be cured in 2 hours without releasing any volatiles
- Offers a 30 percent cost savings by fabricating complex parts more economically
- Improved safety and eliminates the need for hazardous organic solvents

Applications

- Aircraft propulsion
- Airframe vanes, ducts, and bushings
- Missiles
- Rockets
- Polymer laser sintering



Nickel-Titanium Ball Bearings

Shockproof, super-elastic, and corrosion-immune bearings

Many aerospace bearing and mechanism failures can be traced back to the inadequacy of currently available materials: conventional hardened bearing steels are prone to corrosion, and bearings made from corrosion-resistant alloys and plastics are relatively soft and prone to wear. To address these issues, NASA has developed rolling element (ball) and sliding bearings utilizing NiTiNOL 60 (60NiTi), a nickel-titanium alloy that offers a broad combination of physical properties that make it unique among bearing materials.

NASA partnered with Abbott Ball Company Inc. to develop the basic material and shared expertise in using powder metallurgy for a new material production technique. Glenn Research Center is now offering an innovative ball bearing made with an advanced intermetallic alloy for licensing.

60NiTi is hard, electrically conductive, readily machined prior to final heat treatment, easily lubricated, and nonmagnetic. It is also highly resistant to corrosion because it contains no iron and cannot rust. Furthermore, it belongs to the family of super-elastic materials and exhibits the uncanny ability to withstand extreme loads and stresses without incurring permanent damage such as Brinell dents.

Benefits

- Low friction and high hardness properties make bearings wear-resistant and long-lasting
- Better and more easily lubricated, as oils without corrosion inhibitors can be used
- Bearings are lower-weight and more efficient than alternatives
- A unique combination of properties increases the dent resistance of the bearings
- Fully commercialized production process with many standard ball sizes available

Applications

- Spacecraft and satellite mechanism bearings subjected to high static and shock loads
- Corrosion-resistant mechanical components (bearings, gears, and mechanisms) for medical, marine, and food processing machinery
- Air, surface, and marine transport systems



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Goddard

Estimated Spectrum Adaptive Postfilter Algorithm

Improve the quality of images and video sequences

Goddard Space Flight Center invites companies to license a new, patented technology proven to enhance the image quality of compressed grayscale or color JPEG images and MPEG video clips commonly used on websites, online applications, and streaming media. The Estimated Spectrum Adaptive Postfilter (ESAP) algorithm helps to improve the objective and subjective quality of these images as well as enhance their perceptual visual quality, as compared to baseline JPEG images.

Default video and image encoding algorithms for JPEG, MPEG, and HDTV files produce many quality-reducing blocking effects when operating at low bit rates. Previous techniques to overcome this problem were mostly nonlinear filtering methods based on limiting, local pixel statistics rather than on more accurate local frequency content. These techniques offer lower subjective quality than the techniques based on Goddard's algorithms. In addition, ESAP can be cost-effectively implemented in firmware to enable real-time image results. The algorithm can be commercially developed to enable enhanced video and image quality that is superior to previous techniques and the default JPEG or MPEG compression parameters.



Benefits

- Minimizes the loss in image quality that occurs in compressed images
- Yields minimal blurring of an image's true edges while significantly reducing the blocking artifacts resulting from high image compression
- JPEG-compliant, adhering to the coded stream syntax of the Independent JPEG Group
- Can be implemented in firmware or a fast processor, eliminating the need for additional overhead expenses

Applications

- Web-ready images
- Streaming video
- Moderate-rate HDTV broadcasts

Modulated X-ray Source

Bringing X-ray tubes to the digital age

While medical imaging has advanced over the years, X-ray sources have remained relatively unchanged. Much like old vacuum-tube technology, standard X-ray tubes are driven by a hot filament that emits electrons that strike a target to generate radiation. Hot filaments require warm-up time and are not conducive to rapid switching. Like vacuum-tube designers before the advent of the transistor, most X-ray equipment designers have not considered how a more functional X-ray source could enable other imaging and therapy innovations.

Originally developed for deep-space astronomy and communication applications, Goddard Space Flight Center's patent-pending Modulated X-ray Source (MXS) technology replaces the hot filament with simple light-emitting diode (LED), photocathode, and electron multiplier components. Any electrical signal delivered to the LED generates UV light that triggers the photocathode to generate electrons that can be optionally amplified by an electron multiplier.

Benefits

- By moving from a hot to cold cathode, the MXS enables X-rays to be switched on and off in less than a nanosecond
- More robust than standard X-ray sources, with decreased warm-up times and increased device life
- Easy to manufacture, as all designs and functioning prototypes are based on commercial off-the-shelf components that are small and low cost
- Allows for customized dose controls to minimize radiation exposure in medical settings—particularly advantageous for children and pregnant women
- Enables X-ray communication that is secure, fast, long-range, and more energy efficient than current or next-generation laser-based space communication

Applications

- Precise and low-dose medical imaging
- Dynamic imaging
- X-ray based communications
- Chemical and material identification and analysis



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Finding Individuals for Disaster and Emergency Response

Detecting heartbeats under large piles of rubble

Quickly detecting living victims buried in rubble or other debris greatly increases their chances of rescue and survival—this is especially true in situations where there are multiple rubble piles or a large amount of debris. The ability to rapidly assess whether there are living victims at a particular site enables rescuers to use resources effectively and to save more lives.

Finding Individuals for Disaster and Emergency Response (FINDER) uses low-power microwave radar to detect small movements from breathing and the heartbeat of a buried person, even when the signal must pass through feet of building debris and rubble. It searches for the unique characteristics of human breathing and heartbeat to distinguish between humans, animals, and mechanical movement. It can also distinguish between multiple victims, since each person's breathing and heartbeat patterns are different. FINDER can be carried by a first responder, set up near the building, and produce search results in a few minutes. The results of each search are saved, allowing several large buildings or areas of debris to be searched quickly.

Benefits

- Quickly directs rescuers to where the victims are
- Allows first responders to make the best use of the “golden hour,” or the window of time where a victim's rescue greatly increases the chances of survival
- Doesn't require a responsive or conscious victim, and can separate human biomarkers from those of animals or environmental noise
- Successfully detects heartbeats
 - Through more than 20 feet of broken debris, including concrete with reinforcing mesh
 - At distances up to 50 feet from rubble piles or up to 100 feet away from woods

Applications

- Urban search and rescue
- First responders
- Federal, state, and local emergency management
- Immigration and customs enforcement



Image courtesy of the United States Navy

QuakeSim Software Tool

Understanding earthquake fault processes and improving forecasting

QuakeSim is a NASA-sponsored software tool for studying earthquake-vulnerable areas that was created and is maintained by the Jet Propulsion Laboratory (JPL) in collaboration with the University of Southern California; Indiana University; the University of California, Davis; and the University of California, Irvine. Co-winner of NASA's 2012 Software of the Year Award (see page 166), QuakeSim uses NASA data to digitize fault behavior in three dimensions for modeling and statistical evaluation purposes. It runs on various platforms, including desktop and high-end computers.

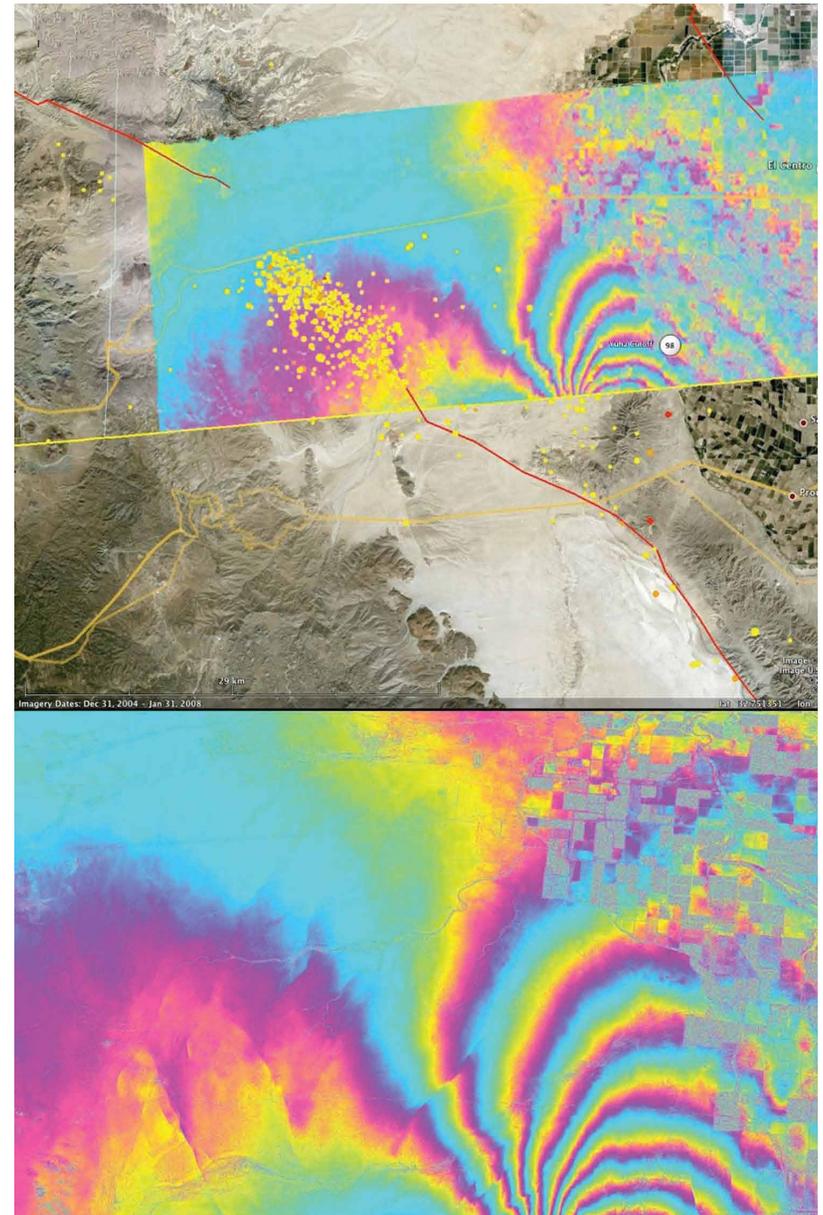
The software gives researchers new insights into the causes and results of earthquakes, such as permanent land shifts. It has made an impact on intermediate earthquake forecasting, including being used to create a digital fault model of California—the first of its kind—and assisting in multiple government earthquake response exercises. QuakeSim is available for licensing and partnership opportunities and can be used for both research and disaster response planning.

Benefits

- Allows scientists to aggregate various data sources and complex models into an earthquake simulation and forecasting tool
- Simplifies data discovery and access and enables efficient data mining with its pattern recognizers
- Provides techniques to understand the relationship between the observable patterns of earthquakes and the underlying, nonlinear stress-strain dynamics that cause them
- Uses a unique suite of tools (the QuakeSim portal) that allows users to create and save projects utilizing the QuakeTables database—a web-accessed, public database of faults

Applications

- Emergency response planning
- Scientific studies
- Earthquake hazard maps
- Targeting earthquake-vulnerable structures for retrofitting
- Damage and loss estimates



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Johnson

Hypoxia Detection and Warning System

Method and apparatus for monitoring oxygen partial pressure in air masks

Johnson Space Center has 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.

This sensor measures the product of oxygen concentration and total ambient pressure, or oxygen partial pressure. The alarm's circuitry can be triggered by any combination of low oxygen concentration and low total pressure that drops the product below a user-defined set point. Vigorous tactile and aural stimulation allows the user to take corrective action before succumbing to the dangerous, and potentially fatal, effects of hypoxia.

Benefits

- An effective "nose beater" vibration and high-pitched alarm alerts an individual who may otherwise be too groggy to respond
- Measures the partial pressure of oxygen, which correlates more highly with hypoxia than oxygen concentration, which is what other oxygen sensor systems typically measure
- Precisely 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
- 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 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



X1 Robotic Exoskeleton

Wearable device that can inhibit or assist movement

Derived from the Robonaut 2 project at Johnson Space Center and designed in partnership with the Florida Institute for Human and Machine Cognition and Houston-based Oceanering Space Systems, NASA's X1 robotic exoskeleton may someday help astronauts stay healthier in space and assist paraplegics and others in walking on Earth.

The device is a 57-pound robot that a person can wear over his or her body to assist or to inhibit movement in his or her leg joints. The X1 legs are worn with a harness that reaches up a person's back and around his or her shoulders. There are 10 degrees of freedom, or joints: four motorized joints at the hips and the knees, and six passive joints that allow for sidestepping, turning, and pointing and flexing a foot on the robot. There are also numerous adjustment points that allow the apparatus to be used in many different ways. While still in the research and development phase, the X1 is functioning. NASA's primary focus is continued development, evaluation, and improvement of the technology.



Benefits

- Device is lightweight and proven to be more comfortable and easier to wear and adjust than other exoskeleton devices
- High-performance capabilities offer mobility assistance and can expand rehabilitation programs
- When combined with NASA-developed walking algorithms, X1 can potentially produce high torques to allow for assisted walking over varied terrain, including stair climbing
- Coupled with a spacesuit, X1 can provide additional force when needed during exploration

Applications

- Space exploration
- Long-term astronaut health
- Assistive walking devices
- Rehabilitation
- Gait modification
- Offloading large amounts of weight from wearer



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Kennedy

Regolith Advanced Surface Systems Operations Robot

Teleoperated robotic platform excavates in hard-to-reach locations

Kennedy Space Center is soliciting licensees for its Regolith Advanced Surface Systems Operations Robot (RASSOR) excavator. RASSOR is a teleoperated mobile robotic platform with a unique space regolith excavation capability. Its design incorporates net-zero reaction force, thus allowing it to load, haul, and dump space regolith under extremely low gravity conditions with high reliability. RASSOR could also be scaled up and used for terrestrial mining operations in difficult-to-reach or dangerous locations.

Regolith excavation is desired in future space missions for the purpose of in situ resource utilization to make local commodities (such as propellants and breathing air) and to pursue construction operations. The RASSOR excavator can traverse steep slopes and rough terrain, and its symmetrical design enables it to operate in reverse so that it can recover from overturning by continuing to dig in the new orientation. RASSOR has wireless control, telemetry, and onboard transmitting cameras, allowing for teleoperation with situational awareness. The unit can be programmed to operate autonomously for selected tasks.

Benefits

- Lightweight materials and foldable design reduce launch weight and payload dimensions
- Can operate in extremely low gravity conditions
- Platform can traverse steep slopes and rough terrain, and reversible design allows continued operation even if unit is overturned
- Wireless control, telemetry, and onboard cameras provide teleoperation and situational awareness
- Platform design can be scaled up or down to meet project requirements: smaller sizes are suitable for space missions, and larger designs could be used for terrestrial mining in hazardous or hard-to-reach locations

Applications

- Extraterrestrial in situ resource utilization
- Extraterrestrial construction operations
- Space mining of regolith and water ice
- Robotic terrestrial mining operations
- Autonomous and teleoperated sand mining



Activated Metal Treatment System

Environmentally friendly remediation treatment for contaminated paints

Kennedy is seeking partners interested in the commercial application of the Activated Metal Treatment System (AMTS) for treating polychlorinated biphenyls (PCBs) in paints. PCBs have been shown to cause cancer in animals and to have other adverse effects on immune, reproductive, nervous, and endocrine systems. Although the production of PCBs in the United States has been banned since the late 1970s, many surfaces are still coated with PCB-laden paints.

Current physical removal methods are able to strip off PCB-containing paint from surfaces; however, these methods typically create a new waste stream that must be treated according to Toxic Substances Control Act regulation. In contrast to these methods, AMTS extracts PCBs and breaks them down into benign byproducts while on the structure. Therefore, no additional treatment for PCBs is required. Also, because the treated surface can be reused following application, AMTS has advantages over other methods and often opens up recycling opportunities that would not have been possible prior to the application of AMTS.

Benefits

- No impact on the structure or the material beneath the paint, and the surface can be repainted on reused following application
- Treats PCBs in place and requires none of the costs associated with transporting, treating, or disposing of a secondary waste stream
- Total costs are anticipated to be less than comparable costs for media blasting
- Has been shown in lab-scale and field-scale tests to remove approximately 80 percent of PCBs from paint within 4 hours, and approximately 100 percent of PCBs within 48 hours
- Produces benign byproducts

Applications

- Painted structures such as buildings and ships
- Concrete surfaces contaminated by PCB-laden transformer oil
- Caulks and other adhesives
- Electrical equipment
- Soils (ex situ)
- Other PCB-contaminated debris



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Langley

Game and Simulation Control

Adapting controls to users' physiological state

Langley Research Center has developed a technology at the forefront of a new generation of computer and video game environments that trains mental skills beyond eye-hand coordination and that encourages the personal improvement—not just diversion—of the user.

The technology is derived from previous research on automatically adapting flight deck controls based on user feedback, performed under Langley's Intelligent Integrated Flight Deck Technology (IIFDT) program. New research has enabled modulation of the manual inputs that a player makes to joysticks, controllers, and image recognition video input devices. The new input device allows a player to control inputs to a video game by adjusting his or her physiological state, such as heart rate and breathing, in addition to standard controller or video inputs.

The current capability has been successfully prototyped using the Nintendo Wii console and wireless Wii remote as well as the Xbox console and Kinect motion-sensing device. Prototypes have been designed and are being developed to extend the current capability to the PlayStation Move and other similar game platforms.

Benefits

- Introduces, for the first time, user-control interaction with the Wii video game system via the user's physiological signals
- Can be used with several physiological signal-measuring devices (heart rate, muscle tension, and brainwave activity)
- Wireless operation with third-generation gaming consoles
- Use of LED infrared communication reduces device power consumption
- Encourages health-enhancing physiological self-regulation skills and therapeutic amplification of healthful physiological characteristics

Applications

- Consumer brain-computer interface devices
- Biofeedback equipment
- Third-generation video game systems
- Third-party video game peripherals
- Physical therapy
- Athletic training
- Mind-body medicine



Spinoffs of Tomorrow

Advanced Actuators and Transducers

Hybrid actuator systems can recover environmental energy to power devices

Actuators and transducers are deployed in devices to harvest mechanical energy as electrical energy and to convert stored electrical energy into mechanical energy. By developing a transducer based on advanced electroactive materials, NASA has produced a design that can harvest orders of magnitude more energy in a given application than traditional solutions, yielding more power to drive devices and to store in batteries. The hybrid actuator system (HYBAS) uses both an electroactive polymer and an electroactive ceramic, achieving enhanced displacement performance from a single power supply and greatly reducing electrical consumption while simultaneously improving mechanical displacement compared to current state-of-the-art actuators.

Langley's technology applies a new design for improved performance and maintains the ability to capitalize on future gains from breakthrough materials. Generated power could be simply stored in a battery or serve as a compact power source for wireless sensor networks for applications such as health monitoring, biomedical applications, and environmental safety alert systems.

Benefits

- Low-volume, lightweight, high mechanical-to-electrical power conversion efficiency
- Superior performance compared to single-element designs
- Harvests orders of magnitude more power than existing technologies while requiring no power supply
- Custom design specifications possible due to configurable material selection
- Advanced materials further enhance the system's characteristics

Applications

- Precision machinery, optical devices, drug delivery, underwater navigation, and microphones
- For aerospace: active noise-vibration control, aerodynamic control, and surveillance
- For defense: surveillance, remote sensor networks, and deploy actuators
- Mobile consumer electronics and power supplies
- Power supplies and actuation for implants and wearable medical devices



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Marshall

Advanced Magnetostrictive Regulator and Valve

Offering all-electric, highly accurate, and low setpoint drift properties

Marshall Space Flight Center is offering for license a set of unique magnetostrictive (MS) technologies. The components are lightweight, compact, highly precise, and can operate over a wide range of temperatures and pressures. MS materials used in valves developed at Marshall allow the valve to be opened and closed via application of a magnetic field to the outside of the valve envelope. This all-electric design enables highly accurate and highly reactive regulation. As the current changes, the magnetic field strength adjusts, causing the valve poppet to reposition, bringing the pressure back to the setpoint.

This process contains all moving parts inside the pressure shell, eliminating the need for feedthroughs or mechanical seals. Typical valves used in many applications suffer from leaks and failures and are often considered unreliable. In contrast, Marshall's approach using MS materials eliminates the issues of seal leakage, friction, and wear. It uses fewer moving parts, offering greater reliability, safety, and longer life. The components are also at least one order of magnitude faster in response time in reacting to transients in supply pressure when compared to current control regulation methodologies.

Benefits

- Reduces the number of valves used in typical regulated pressure systems
- Offers precise operation and control with fast responses
- Uses fewer moving parts and no external or dynamic seals for increased reliability
- Continuously senses ambient conditions and self-adjusts to maintain precise control
- Capable of operating over a wide range of pressures, temperatures, and harsh environments
- Features a compact, lightweight design that allows alternate redundant, parallel pathways to be implemented without substantially increasing cost or weight

Applications

- Pressure-fed rocket propulsion systems
- Aircraft engines
- Automotive fuel systems
- Manufacturing and processing for petrochemicals, plastics, and pharmaceuticals
- Industrial machinery and power equipment
- Biomedical devices and drug metering systems



Benefits

- Does not require the removal of soft goods or part disassembly for testing
- Offers a streamlined method of leak detection with minimal, lightweight components
- Detects large, medium, and very small leaks
- Adapts easily for rapid in-line or batch testing
- Operates without the need for a vacuum pump, gas spectrometer, or chemical bath

Applications

- Specialized military and aerospace sensors and equipment
- Automotive components
- Electronic equipment such as semiconductors, thermostats, switches, and optical devices
- Consumer goods packaging
- Pharmaceuticals



Hermetic Seal Leak Detection

Nondestructive testing of container and instrument seals

Innovators at Marshall Space Flight Center have developed a unique apparatus ideal for use in non-destructive testing of hermetic seals of containers or instrumentation. The device is capable of detecting both large and small leaks and can be calibrated to characterize the relative leak rate. Its simple design does not require specialized gasses and eliminates the need for expensive instrumentation such as a mass spectrometer. The leak detection system chamber can be of any size or shape to accommodate any type of sealed object.

The technology offers a highly sensitive method of detecting leaks in airtight seals that is more streamlined and lower in cost than other available methods with similar sensitivity. Low in cost and simple to manufacture, the patent-pending technology is ideal for use in many industries, from aerospace applications to food packaging and commercial goods.



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Stennis



Piezoelectric Sensor Monitoring System

In situ measurement particularly suited for accelerometers

Stennis Space Center is soliciting partners interested in the commercial application of a patented in situ measurement system for monitoring the performance of piezoelectronic sensors, particularly accelerometers. With this technology, characteristics such as resonant frequency, response, cable status, connectivity, bonding, and linear range can be determined. Sensors can be tested in a very wide frequency range without removing them from their mounted locations and without requiring specially constructed transducers or special wiring. Assessments can be performed in situ and can be conducted with handheld test equipment or integrated into instrumentation systems.

Using this monitoring system, degraded sensor performance can be quickly and economically identified. The testing system is not limited to identifying degraded performance in the sensor's piezoelectric elements; it can detect changes within the entire sensor and sensor housing. Physical contact with the sensor is not necessary; therefore, monitoring can be done as far away as 250 feet, or longer if certain provisions are made.

Benefits

- Allows simplified testing that does not require physical contact
- Does not require removing mounted sensors or sending them to a calibration lab, which reduces costs
- Increased testing parameter range; provides both normal and as-mounted resonant frequencies
- Improved accuracy, providing entire frequency response over the range of the device (unlike commonly used shaker tables)
- Illuminates in situ problems; can identify degraded sensor bonds, faulty cabling, and sensor damage

Applications

- Accelerometers
- Automotive sensors
- Structural sensors
- Sensors for manufacturing equipment
- Any application where vibration is monitored
- Any piezoelectric sensor
- Nondestructive testing

Conical Seat Shut-Off Valve

Unique hardware design eliminates the need for an actuator

A novel, moveable valve that controls the flow of pressurized working fluids is now being offered by Stennis for partners interested in the technology's potential commercial applications. This valve consists of a hollow, moveable floating piston pressed against a stationary solid seat, and it can use the working fluid or an external pressure source to seal the valve.

This open/closed valve has a novel balanced piston so it can be designed to always seat with the same amount of force, allowing the use of metal-to-metal seats as well as soft seats. Additionally, this valve design, even when used in large, high-pressure applications, does not require large conventional valve actuators, and the valve stem itself is eliminated. Actuation is achieved with the use of small, simple solenoid or hand valves. This design also eliminates the need for many seals used with existing ball valve and globe valve designs, which also commonly cause failure. Coupled with the elimination of the valve stem and conventional valve actuator, valve reliability and seat life are greatly improved, reducing downtime and maintenance costs.

Benefits

- Allows for a wide range of design parameters, including pressures from ambient to 15,000 psi and sizes from less than 1 inch to greater than 10 inches
- Can be manufactured from a variety of metals and operate on cryogenic gas lines
- Constructed using only five major parts without stem seals or packing glands that can leak
- Does not require an external large pneumatic, hydraulic, or motor actuator
- Stationary metal-to-metal seat improves valve reliability
- The combination of features eliminates the actuator, reducing the physical size and cost of the valve

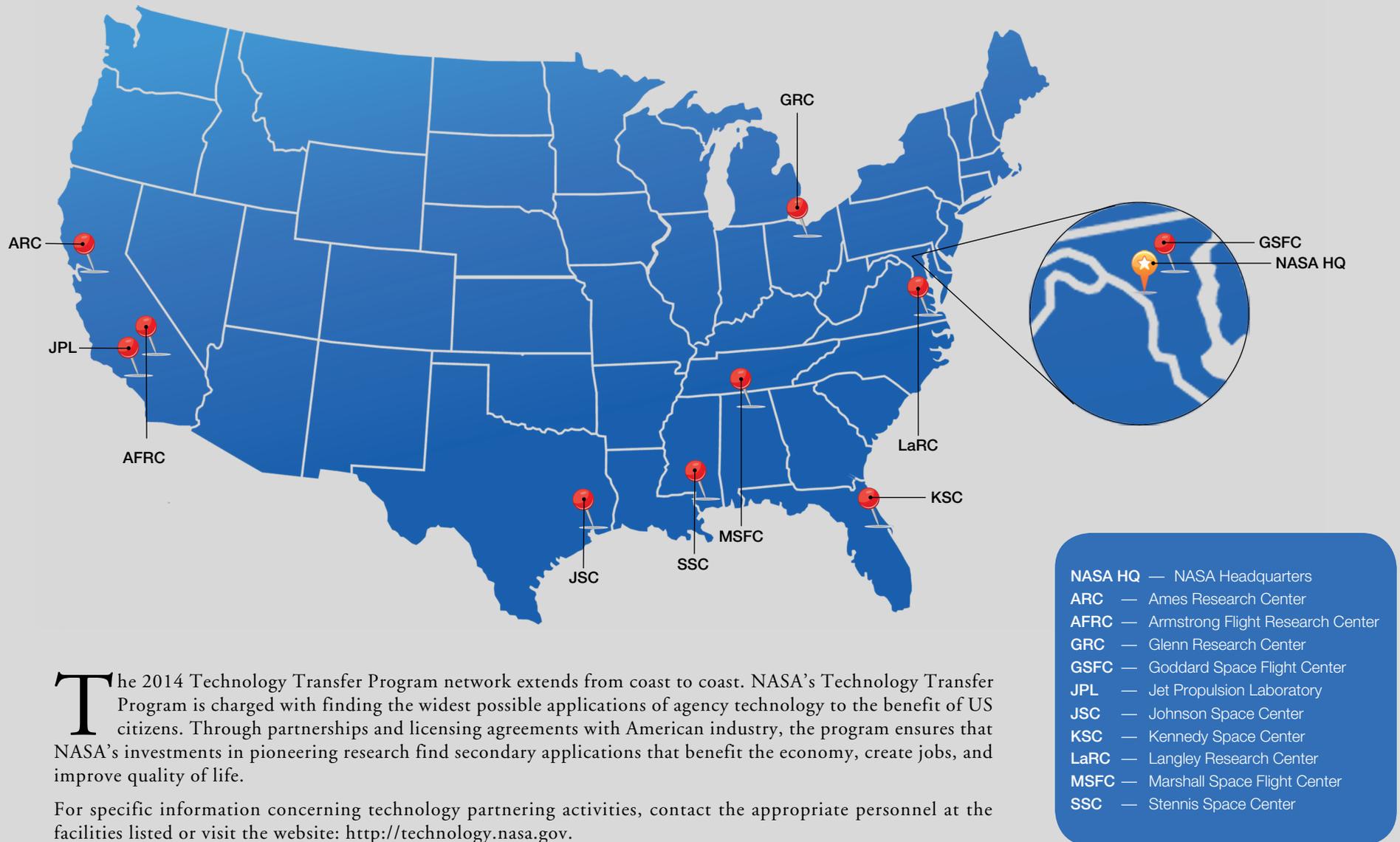
Applications

- Power plants
- Petrochemical plants
- Refineries
- Pressurized storage tanks



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NASA Technology Transfer Program Network Directory



The 2014 Technology Transfer Program network extends from coast to coast. NASA's Technology Transfer Program is charged with finding the widest possible applications of agency technology to the benefit of US citizens. Through partnerships and licensing agreements with American industry, the program ensures that NASA's investments in pioneering research find secondary applications that benefit the economy, create jobs, and improve quality of life.

For specific information concerning technology partnering activities, contact the appropriate personnel at the facilities listed or visit the website: <http://technology.nasa.gov>.

 **NASA Headquarters**

 **The Technology Transfer Office** at each of NASA's 10 field centers represent NASA's technology sources and manage center participation in technology transfer activities.



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