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Motion Control and Automation Technology

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Sensor Tecnology

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October 2016 www.techbriefs.com Vol. 40 No. 10

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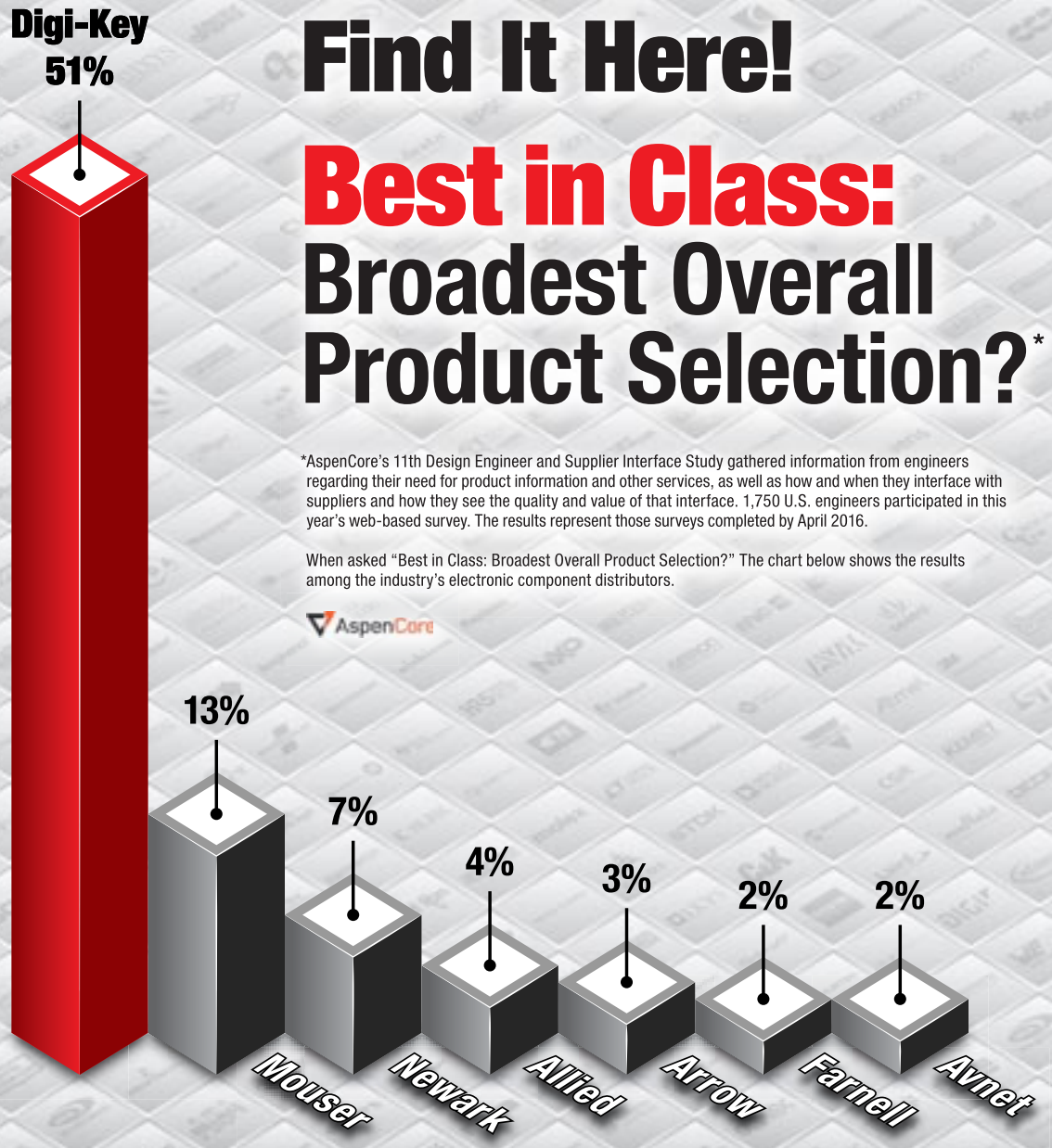
Best in Class: Broadest Overall Product Selection?*

*AspenCore's 11th Design Engineer and Supplier Interface Study gathered information from engineers regarding their need for product information and other services, as well as how and when they interface with suppliers and how they see the quality and value of that interface. 1,750 U.S. engineers participated in this year's web-based survey. The results represent those surveys completed by April 2016.

When asked "Best in Class: Broadest Overall Product Selection?" The chart below shows the results among the industry's electronic component distributors.

AspenCore



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NASA Tech Briefs

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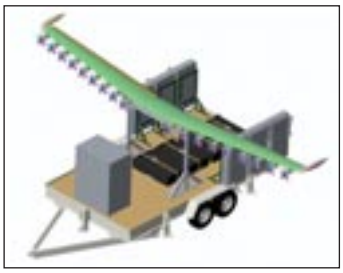

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New for Design Engineers

Special Supplements

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Selected editions only

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Product of the Month

National Instruments (Austin, TX) released LabVIEW 2016 system design software.

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On the cover

NASA's Jet Propulsion Laboratory has developed an endoscope with a tiny camera that produces 3D images from inside the brain. Operations with MARVEL (Multi Angle Rear Viewing Endoscopic tooL) would not require surgeons to take out large parts of the skull. Learn more about MARVEL and other NASA imaging technologies in the article on page 12.

(Image courtesy of NASA)

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UP FRONT

Linda Bell
Editorial Director

Editor's Choice

Understanding the characteristics of a weather system is vital to predicting the path and severity of storms such as hurricanes and typhoons. The surface air pressure over the ocean is one of the key characteristics used in making those predictions. A new technology addresses gaps in the area of weather forecasting as a result of the inability to accurately detect atmospheric pressure above the ocean. Find out more on page 20.

Robot Challenge Winners Chosen

The West Virginia University Mountaineers of Morgantown took home $750,000 as winners of NASA's Sample Return Robot Challenge, the culmination of five years of competition that began in 2012, and drew more than 50

teams. Teams were challenged to autonomously search for and retrieve up to 10 samples without the aid of certain Earth-based technologies.

Visit www.nasa.gov/robot

Next Month in NTB

The November issue will include a special section on the winners of the 2016 Create the Future Design Contest. Learn how these prize-winning ideas — and their innovators — will shape the future of design and technology.

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Breaking Barriers in 3D Printing

Recently, I had the opportunity to see next-generation manufacturing technologies in use that truly demonstrate "a significant leap forward," as Ilan Levin, CEO of Stratasys stated. On display for the first time to the public at last month's IMTS show in Chicago, the Stratasys Robotic Composite 3D Demonstrator and Infinite-Build 3D Demonstrator present a customer-centric approach to 3D printing and additive manufacturing.

The Robotic Composite 3D Demonstrator is an 8-axis 3D printer with both additive and subtractive capability for large or complex composite parts and tools. Stratasys and Siemens worked together on the system, which features industrial motion control hardware and design-to-3D printing software capabilities from Siemens. The technology enables the manufacture of strong, lightweight composite structures for industries such as automotive and aerospace. It provides directional material placement for strength, while reducing the need for support structures.

The Infinite-Build 3D Demonstrator builds parts with unlimited length at 10x speed, and production-quality accuracy and repeatability. It addresses the need for large, lightweight thermoplastic parts in sizes that measure in feet, rather than in inches. In a new approach to fused deposition modeling (FDM), the system literally turns the traditional 3D printer concept on its side to print on a vertical plane for practically unlimited part size in the build direction. Boeing played an influential role in defining the requirements and specifications for the demonstrator. Boeing is currently using the technology to explore the production of low-volume, lightweight parts that previously were not possible due to limited size.

The Infinite-Build 3D Demonstrator produces large tools and production parts with part-to-part repeatability.

Watch a video of the demonstrators in action on Tech Briefs TV at www.techbriefs.com/tv/3D-print

OSIRIS-REx Begins its Journey

NASA's first asteroid sampling mission launched into space on September 8, beginning a journey that could revolutionize our understanding of the early solar system. The Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) spacecraft is designed to rendezvous with, study, and return a sample of the asteroid Bennu to Earth.

In 2018, OSIRIS-REx will approach Bennu and map and study it in preparation for sample collection. In July 2020, the spacecraft's 11-foot arm will reach out and perform a five-second "high-five" to stir up surface material, collecting at least 2 ounces (60 grams) of small rocks and dust in a sample return container. OSIRIS-REx will return the sample to Earth in September 2023.

Find out more about the spacecraft's camera systems in the article on page 12.

Visit www.nasa.gov/osiris-rex

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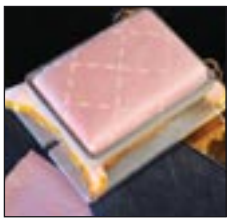
Products of Tomorrow

The technologies NASA develops don't just blast off into space. They also improve our lives here on Earth. Life-saving search-and-rescue tools, implantable medical devices, advances in commercial aircraft safety, increased accuracy in weather forecasting, and the miniature cameras in our cellphones are just some of the examples of NASA-developed technology used in products today.

This column presents technologies that have applications in commercial areas, possibly creating the products of tomorrow. If you are interested in licensing the technologies described here, use the contact information provided. To learn about more available technologies, visit the NASA Technology Transfer Portal at http://technology.nasa.gov.



▶ Low-Density, Flexible Ablators

Ames Research Center has developed low-density, flexible ablators that can be fabricated into heatshields capable of being packaged, stowed, and deployed in space. This flexible Thermal Protection System (TPS) can be used to cover and thermally protect a large, blunt shape that provides aerodynamic drag during hypervelocity atmospheric flight. It can be used with minimal modification for large aeroshells whose deployment relies mainly on mechanical means and through inflation. Applications include systems engineering, thermal protection systems, materials engineering, and mechanical engineering.

Contact: Ames Research Center
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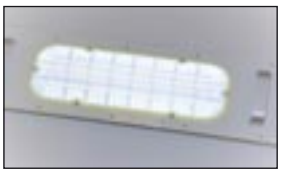
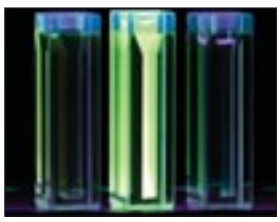
E-mail: ARC-TechTransfer@mail.nasa.gov
http://technology.nasa.gov/patent/TB2016/TOP2-215



▶ Lighting System to Improve Circadian Rhythm Control

Kennedy Space Center developed a programmable solid-state general illumination fixture with full intensity and color temperature control. This new lighting assembly uses a microcontroller with power relay to adjust color temperature and perceived intensity to simulate a practical diurnal cycle. The Lighting System to Improve Circadian Rhythm Control was designed and built to help regulate the sleep cycles of astronauts working on the International Space Station (ISS) and during long-duration spaceflight. On Earth, this technology can be used to help treat jet lag, shift work sleep disorder, and non-24-hour sleep/wake disorder (frequently affects those who are totally blind).

Contact: Kennedy Space Center
Phone: 321-867-7171
E-mail: Jonathan.J.Leahy@nasa.gov
http://technology.nasa.gov/patent/TB2016/KSC-TOPS-52



▶ Biomarker Sensor Arrays for Microfluidics Applications

A method to manufacture biomarker sensor arrays with nanoscale resolution and active regions on the order of 1 micron was developed at Jet Propulsion Laboratory. The technique applies nanolithographic direct-write techniques to the fabrication of silane chemistry sensors on a transparent substrate. This novel technology enables extremely fine patterns of detectors suitable for multicolor imaging of single-molecule samples at resolutions far below the diffraction limit. The extremely small size of these sensors allows for rapid, highly specific screening for hundreds of functionalities within a single, small, integrated microfluidics chip.

Contact: Jet Propulsion Laboratory
Phone: 818-354-7770
E-mail: Mark.W.Homer@jpl.nasa.gov
http://technology.nasa.gov/patent/TB2016/NPO-TOPS-14

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Who's Who at NASA

Edward Chow, AUDREY Program Manager, Jet Propulsion Laboratory, Pasadena, CA

Edward Chow leads the development of AUDREY, the Assistant for Understanding Data through Reasoning, Extraction, and sYnthesis. The artificial-intelligence system captures a variety of sensor data, including gases, temperature, and GPS signals. By sending alerts through a mobile device or head-mounted display, AUDREY could soon be used to guide first responders through dangerous conditions.

NASA Tech Briefs: What is AUDREY?

Edward Chow: AUDREY is our attempt at creating a next-generation artificial-intelligence system that thinks like a human. In our work, we combine human cognitive system [capabilities] with some of the latest machine learning techniques. AUDREY is a system that can look at a massive amount of data, reason and learn from it, and then apply findings right back into processing data. It becomes a sort of positive-feedback loop.

NTB: What kinds of data are being collected?

Chow: It depends on the applications. For the Next Generation First Responder (NGFR) program [part of a five-year commitment from the Department of Homeland Security Science and Technology Directorate], responders actually have sensors on their body — temperature sensors, heartbeat sensors, and gas sensors. They can pick up sensory information from the Internet of Things (IoT). You see more and more sensors now going into buildings, and more intelligence monitors on a network. We pick up information from a variety of different sources.

The key is that AUDREY has to be smart enough to know what context — what conditions — is absolutely necessary for a first responder to see. Firefighters are busy fighting fire. Police officers are busy doing their job. We only want to provide necessary insight.

NTB: How does AUDREY make a decision, given the massive amount of data being collected?

Chow: AUDREY is run in the cloud. [Critical] information is based on GPS location of the sensor. The variety of environmental information provides the context necessary for AUDREY to make smart decisions.

NTB: How does a user receive alerts?

Chow: When the technology makes smart decisions, an alert message is shown as a display on an Android cellphone. There will be a warning sound from the [device]. We are also working on virtual reality/augmented reality glasses that provide users with voice prompts and visual guidance. Imagine fighting fire in a building. With augmented-reality glasses, we can provide the right pointer information to firefighters, and then they can follow directions safely out of the building.

NTB: What is most exciting about this technology?

Chow: With AUDREY, we can capture human knowledge and process more data than a human has the energy to do. My dream is to one day have a personal AUDREY helping me to process all the data around me, to save me time so I can do the innovative things that I'm designed to do.

To learn more about AUDREY, read a full transcript, or listen to a downloadable podcast, visit ***www.techbriefs.com/podcast****.*

Seeing Closer and Clearer with NASA Imaging Technology

PolyCam (center), MapCam (left), and SamCam (right) make up the OSIRIS-REx Camera Suite, responsible for most of the visible light images that will be taken by the spacecraft. (University of Arizona/Symeon Platts)

From mapping asteroids and planets, to recording rocket engine tests, to seeing farther into the human brain, NASA's imaging technologies are giving scientists and engineers closer, more detailed views than ever before.

NASA's Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-Rex) spacecraft launched on September 8 to the near-Earth asteroid Bennu to harvest a sample of surface material and return it to Earth for study. But before the science team selects a sample site, they can find out a bit about Bennu's elemental make-up.

To determine the composition of Bennu's surface, the team equipped the spacecraft with the OSIRIS-REx Camera Suite (OCAMS), developed by the University of Arizona. OCAMS consists of three cameras: PolyCam, MapCam, and SamCam. These cameras will "see" the asteroid as the spacecraft first approaches it. OCAMS will then provide global image mapping and sample site imaging and characterization. Finally, OCAMS will record the entire sampling event during the touch-and-go (TAG) maneuver.

PolyCam is an 8" long-range telescope that will first locate the asteroid from 2 million kilometers away. It identifies hazardous areas and performs high-resolution imaging of Bennu's surface at short range.

MapCam is a medium-range camera that searches for satellites and outgassing plumes around Bennu. It maps the asteroid in color, and provides images to construct topographic maps. Its filter wheel and five-element lens system allow both panchromatic (clear) and wideband spectral imaging in the blue, green, red, and near-infrared.

SamCam is a close-range camera that verifies both the act of acquiring the sample during the TAG sampling maneuver, and images the sampling mechanism after attempting sample collection.

A Brain View from the Inside

To operate on the brain, doctors need to see fine details on a small scale. A tiny camera that could produce 3D images from inside the brain would help surgeons see more intricacies of the tissue they are handling, and lead to faster, safer procedures. An endoscope with such a camera is being developed at NASA's Jet Propulsion Laboratory in Pasadena, CA.

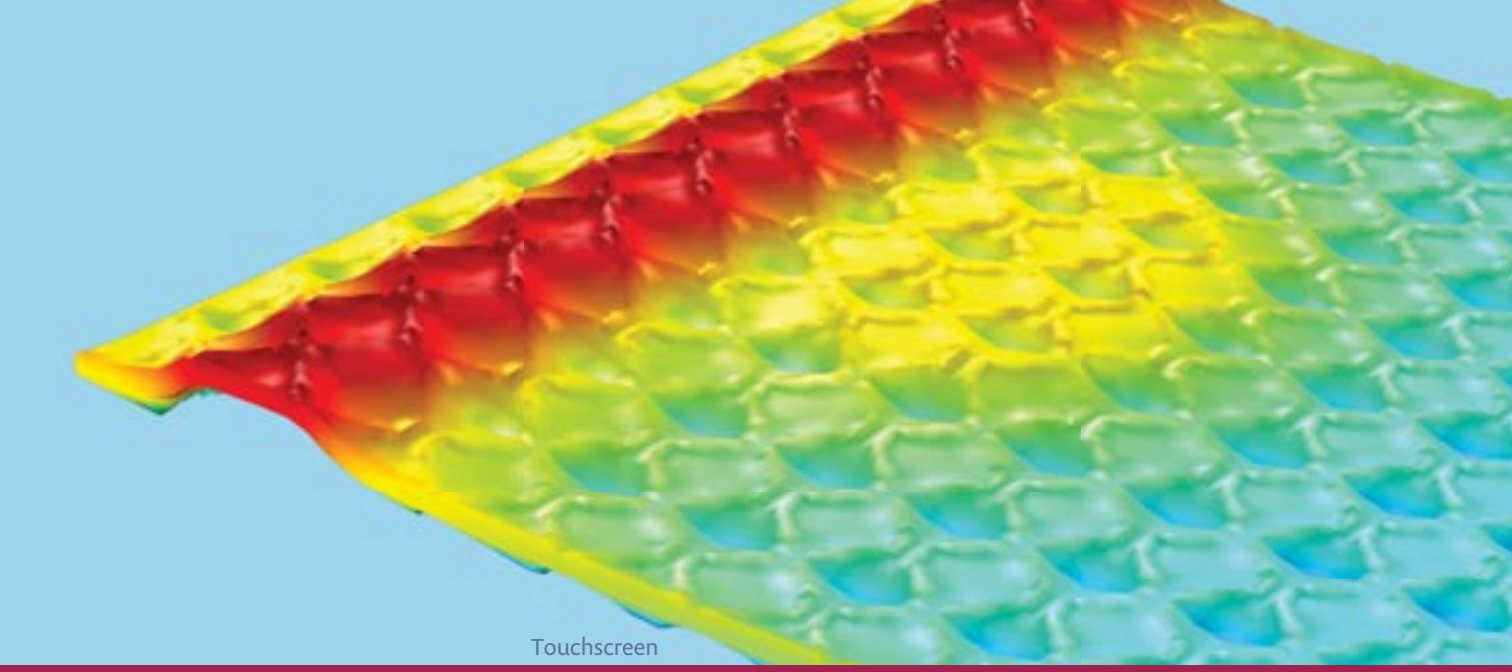
MARVEL (Multi Angle Rear Viewing Endoscopic tooL) features a camera that is 0.2" (4 millimeters) in diameter and about 0.6" (15 millimeters) long. It is attached to a bendable "neck" that can sweep left or right, looking around corners with up to a 120-degree arc. This allows for a highly maneuverable endoscope.

Operations with the small camera would not require the traditional open craniotomy, a procedure in which surgeons take out large parts of the skull. Craniotomies result in higher costs and longer stays in hospitals than surgery using an endoscope.

Stereo imaging endoscopes that employ traditional dual-camera systems are already in use for minimally invasive surgeries elsewhere in the body. But surgery on the brain requires even more miniaturization. That's why, instead of two, MARVEL has only one camera lens.

To generate 3D images, MARVEL's camera has two apertures — akin to the pupil of the eye — each with its own color filter. Each filter transmits distinct wavelengths of red, green, and blue light, while blocking the bands to which the other filter is sensitive. The system includes a light source that produces all six colors of light to which the filters are attuned. Images from each of the two sets are then merged to create the 3D effect.

Now that researchers have demonstrated a laboratory prototype, the next step is a clinical prototype that meets the requirements of the U.S. Food and Drug Administration. The researchers will refine the engineering of the tool to



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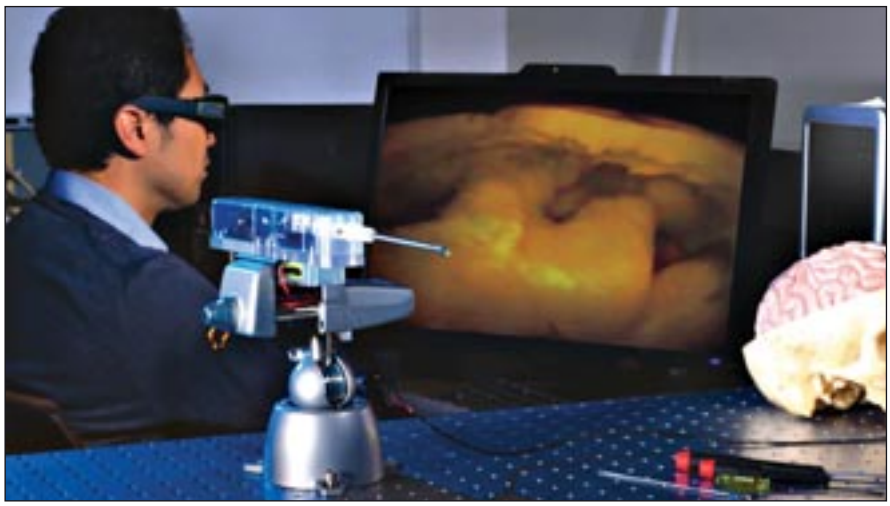
make it suitable for use in real-world medical settings. In the future, the MARVEL camera technology could also have applications for space exploration. A miniature camera such as this could be put on small robots that explore other worlds, delivering intricate 3D views of geological features of interest.

Dynamic Propulsion Data

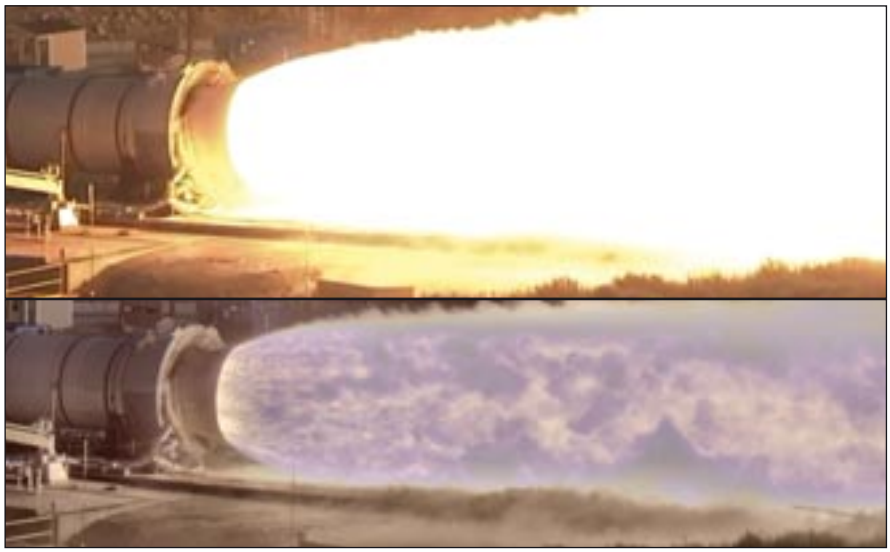
NASA's High Dynamic Range Stereo X (HiDyRS-X) high-speed, high-dynamic-range camera was used to film the full-scale test of the Space Launch System (SLS) booster, recording propulsion video data in detail never seen before.

The HiDyRS-X project originated from a problem that exists when trying to film rocket motor tests. Rocket motor plumes, in addition to being extremely loud, are also extremely bright, making them difficult to record without drastically cutting down the exposure settings on the camera. Doing so, however, darkens the rest of the image, obscuring other important components on the motor. Traditionally, video cameras record using one exposure at a time, but HiDyRS-X records multiple, slow-motion video exposures at once, combining them into a high dynamic range (HDR) video that perfectly exposes all areas of the video image.

The massive booster test served as a rare opportunity to test the HiDyRS-X hardware in a full-scale environment. Unlike smaller-scale rocket engine tests, boosters are extremely powerful and, once ignited, cannot be turned off or restarted. The HiDyRS-X team had one shot at getting good footage. When the team reviewed the camera footage, they saw a level of detail on par with the other successful HiDyRS-X tests. The team saw several elements never before caught on film in an engine test, including the exhaust plume, nozzle, and the nozzle fabric going through gimbaling patterns — an expected condition, but usually unobservable at slow motion or normal playback rates.



A laboratory prototype of MARVEL, one of the world's smallest 3D cameras. MARVEL is in the foreground. On the display is a 3D image taken by MARVEL of the interior of a walnut, which has characteristics similar to that of a brain. (NASA/JPL-Caltech/Skull Base Institute)



(Top) Image of the Space Launch System test without using the HiDyRS-X camera, and (bottom) with the HiDyRS-X camera.

A Jump in Resolution

It's an age-old astronomical truth: To resolve smaller and smaller physical details of distant celestial objects, scientists need larger and larger light-collecting mirrors. This challenge is not easily overcome given the high cost and impracticality of building and — in the case of space observatories — launching large-aperture telescopes.

However, a team of scientists and engineers at NASA's Goddard Space Flight Center in Greenbelt, MD has begun testing a potentially more affordable alternative called the photon sieve. This telescope optic could give scientists the resolution they need to see finer details still invisible with current observing tools — a jump in resolution that could help answer a 50-year-old question about the physical processes heating the Sun's million-degree corona.

Although potentially useful at all wavelengths, the team specifically is developing the photon sieve for studies of the Sun in the ultraviolet — the wavelength needed to disentangle the coronal heating mystery. The team has fabricated three sieves and plans to begin testing to see if they can withstand the rigors of operating in space.

The optic is a variant of a Fresnel zone plate. Rather than focusing light as most telescopes do through refraction or reflection, Fresnel plates cause light to diffract — a phenomenon that happens when light travels through a thin opening and then spreads out. This causes the light waves on the other side to reinforce or cancel each other out in precise patterns.

Fresnel plates consist of a tightly spaced set of rings, alternatingly trans-

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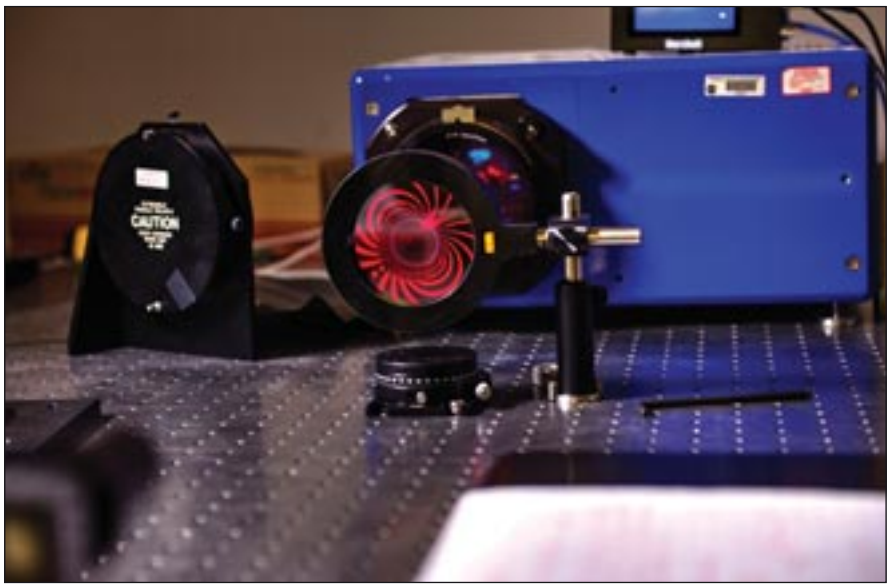

This image shows how the photon sieve brings red laser light to a pinpoint focus on its optical axis, but produces exotic diffraction patterns when viewed from the side. (NASA/W. Hrybyk)

parent or opaque. Light travels through the spaces between the opaque zones, which are precisely spaced so that the diffracted light overlaps and focuses at a specific point, creating an image that can be recorded by a solid-state sensor. The photon sieve operates largely the same. However, the sieve is dotted with millions of holes precisely placed on silicon in a circular pattern that takes the place of conventional Fresnel zones.

The team wants to build a photon sieve at least three feet in diameter — a size they think could achieve up to 100 times better angular resolution in the ultraviolet than NASA's high-resolution space telescope, the Solar Dynamics Observatory.

RESOURCES

www.nasa.gov/osiris-rex

www.asteroidmission.org

http://microdevices.jpl.nasa.gov

www.nasa.gov/exploration/systems/sls

gsfctechnology.gsfc.nasa.gov/newsletter/Current.pdf

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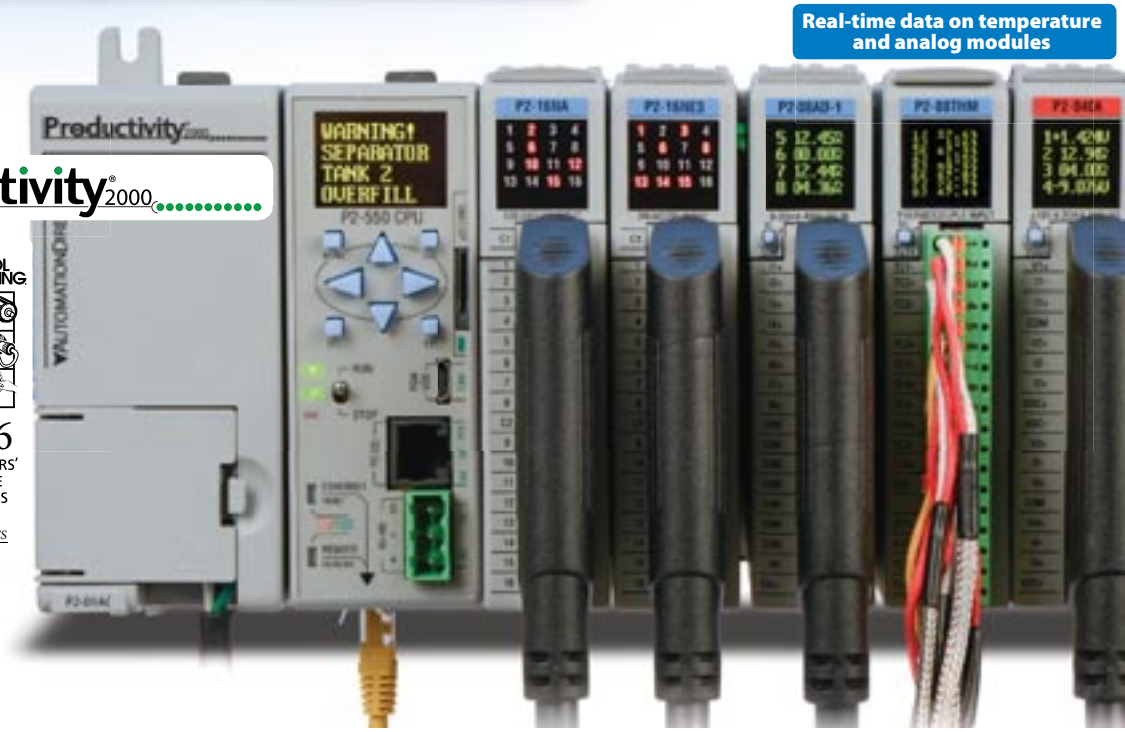

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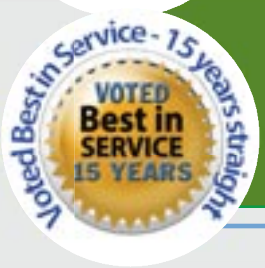

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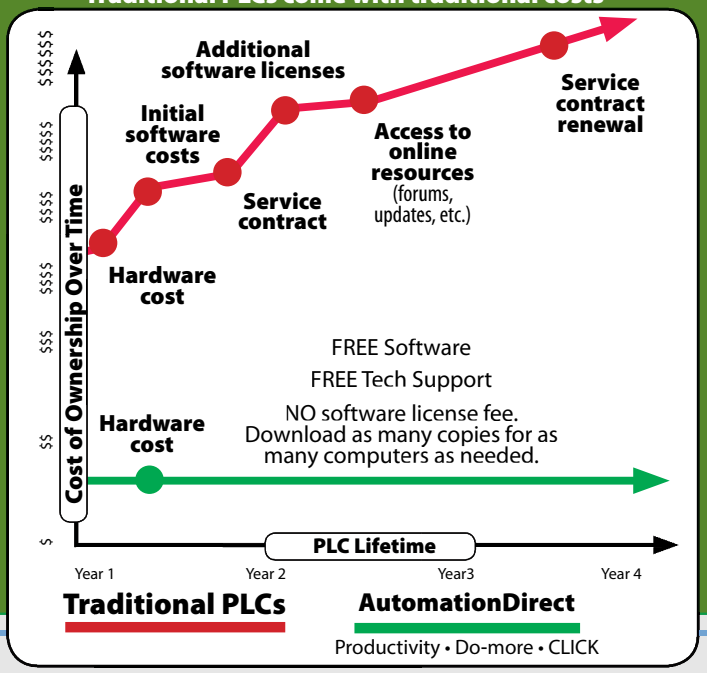

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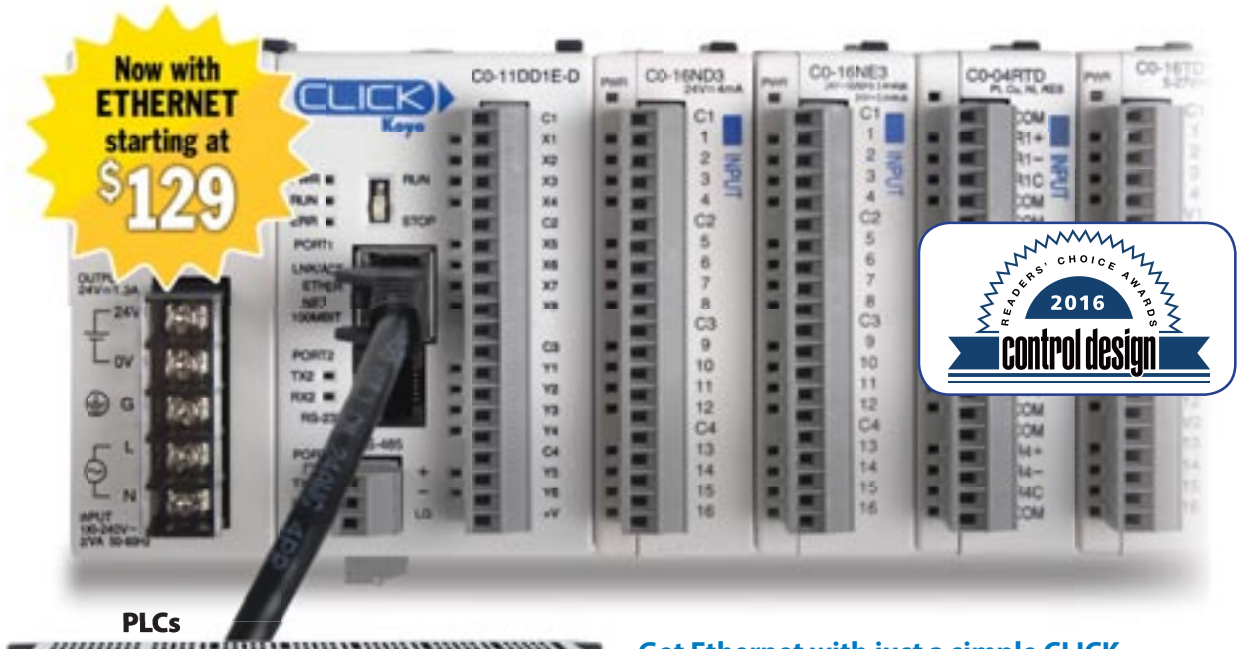

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Photogrammetry System and Method for Determining Relative Motion Between Two Bodies

Highly accurate, flexible system measures relative dynamics in six degrees of freedom.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed a novel method to calculate the relative position and orientation between two rigid objects using a simplified photogrammetric technique. The system quantitatively captures the relative orientation of objects in six degrees of freedom (6-DOF), using one or more cameras with non-overlapping fields of view (FOV) that record strategically placed photogrammetric targets.

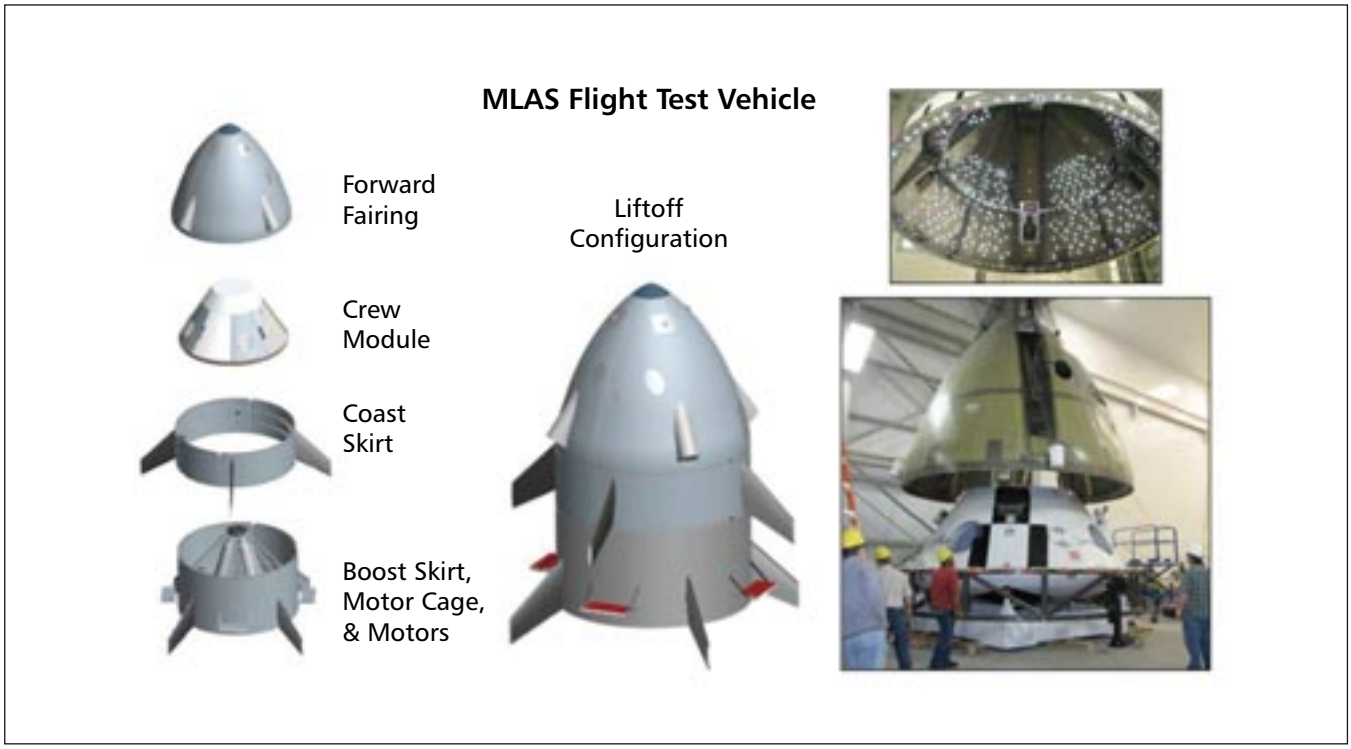
This high-speed camera system provides an algorithmic foundation for various photogrammetry applications where detecting relative positioning is important. Originally developed to evaluate the separation stage of NASA's Max Launch Abort System (MLAS) spacecraft crew module, this technology has also been used to evaluate the effect of water impact on the MLAS crew module and for trajectory analysis of military aircraft.

The NASA technology uses a photogrammetry algorithm to calculate the relative orientation between two rigid bodies. The software, written in LabVIEW and MATLAB, quantitatively analyzes the photogrammetric data collected from the camera system to determine the 6-DOF position and rotation of the observed object.

The system comprises an arrangement of arbitrarily placed cameras rigidly fixed on one body, and a collection of photogrammetric targets rigidly fixed on the second body. The cameras can be either placed on rigidly fixed objects surrounding the second body (facing inwards), or can be placed on an object directed towards the surrounding environment (facing outwards). At any given point in time, the cameras must capture at least five non-collinear targets. The 6-DOF accuracy increases as additional cameras and targets are used. The equipment requirements include a set of heterogeneous cameras, a collection of photogrammetric targets, a data storage device, and a processing PC. Camera calibration and initial target measurements are required prior to image capture.

A nonprovisional patent application on this technology has been filed. This technology has potential applications in satellite-based star tracking, car crash dynamics, vehicle separation tests, computer-assisted surgery, ballistics testing, terrestrial surveying, and wind tunnel testing.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-38.



This photogrammetry technique was used to evaluate the crew module separation stage of NASA's MLAS flight vehicle.

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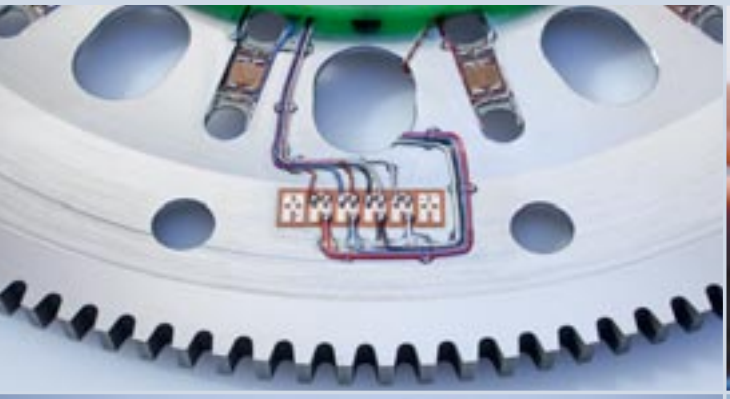

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Directed Design of Experiments for Validating Probability of Detection Capability of a Testing System

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed new software that enables users of critical inspection systems to validate the capability of the inspection system. Traditionally, inspection systems are validated using various methodologies to determine probability of detection (POD). One widely accepted metric of an adequate inspection system is that there is 95% confidence that the POD is greater than 90% (90/95 POD). Directed Design of Experiments for Probability of Detection (DOEPOD) is a user-friendly software package that enables detailed analysis of 90/95 POD or at any specified confidence level. Although it was designed to validate the capability of inspection systems to find fracture-critical flaws in materials, DOEPOD can be applied to systems to locate any type of flaw as well as to validate the detection capability of personnel. DOEPOD can also be employed as the core of an NDE (nondestructive evaluation) system, and provide accurate on-demand validation of the inspection system.

The DOEPOD software package can validate the capability of inspection systems to find fracture-critical flaws in materials, components, and systems, and can be used for qualifying personnel. DOEPOD provides an accurate methodology that yields observed POD and confidence bounds for both Hit/Miss and signal amplitude testing. The software uses the concept of Point Estimate Probability of a Hit (POH) at any flaw size. POH defines the number of hits observed per set of specimens exhibiting flaws of similar characteristics. The estimated POH determined by DOEPOD at any selected flaw size is a measured or observed quantitative value between zero and one, and knowledge of the estimated POH yields a quantitative measure of the lower confidence bound. In DOEPOD, flaw size is referred to as class length. Flaws are defined as digital, analog, diameter, volume, length, depth, color intensity, grey scale, or by a combination of criteria such as total mass.

DOEPOD incorporates these features into a user-friendly software that can easily be integrated into any NDE. Today, almost universally, NDE systems are validated by predictive methods, which do not follow a single standard and vary widely in their results. DOEPOD provides an advance in inspection system validation because the software can prove that an inspection system is capable of finding flaws without relying on predictive math models. The software is not limited to inspection data, and may be applied to determine Probability of Success (POS) for commercial and military logistics, industrial engineering, consumer product acceptance, education testing levels, and more.

The DOEPOD software is appropriate for validation of any inspection system, including industrial inspection, materials inspection, medical imaging, qualification of personnel conducting inspections, and probability of success in supply logistics, education, and consumer products.

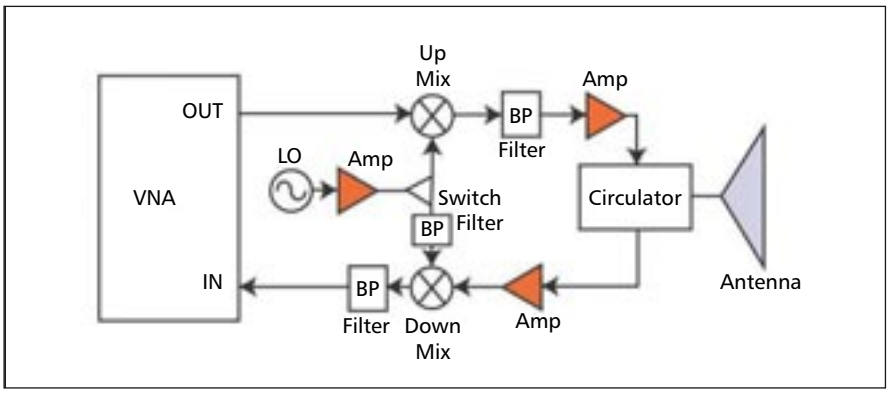
NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-82.

Method and Apparatus for Measuring Surface Air Pressure

This technology enhances the predictive capabilities of weather forecasting models.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed a novel method for long-range atmospheric pressure sensing. Based on known properties involving oxygen density, the technology is able to measure small pressure changes over a wide area. NASA developed the technology to address known gaps in the area of weather forecasting as a result of the inability to accurately detect atmospheric pressure above the ocean. Oxygen band reading can be performed remotely, most likely from a satellite-based system. The technology is particularly applicable in the area of storm forecasting.



A diagram of the front end of the baseline radar system.

Understanding the characteristics of a weather system is vital to predicting the path and severity of storms such as hurricanes and typhoons. The surface air pressure over the ocean is one of the key characteristics that can be used in making those predictions. Current long-range technologies can perform only loose estimations of the surface air pressure based on wind speed and direction. Direct measurements of the air pressure require costly and risky plane missions through the storm to collect periodic data. The oxygen band radar system developed by NASA Langley allows for the continuous remote monitoring of atmospheric pressure over the world's oceans.

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The technology incorporates the use of a low-power laser frequency specific to the known oxygen band. By using this narrow band, the researchers are able to measure surface level oxygen density and subsequently, air pressure. The increased knowledge of localized air pressure will significantly enhance the predictive power of weather forecasting models and allow for the development of new models.

Possible uses for this technology include increased forecasting ability for weather applications, short-range secret communications for military applications, and improved flight ops planning for Navy applications.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-102.

HEIST Ironbird to Test Cutting-Edge Hybrid Electric Propulsion Technologies

Testbed will study the system complexities of powering an aircraft with two different power sources.

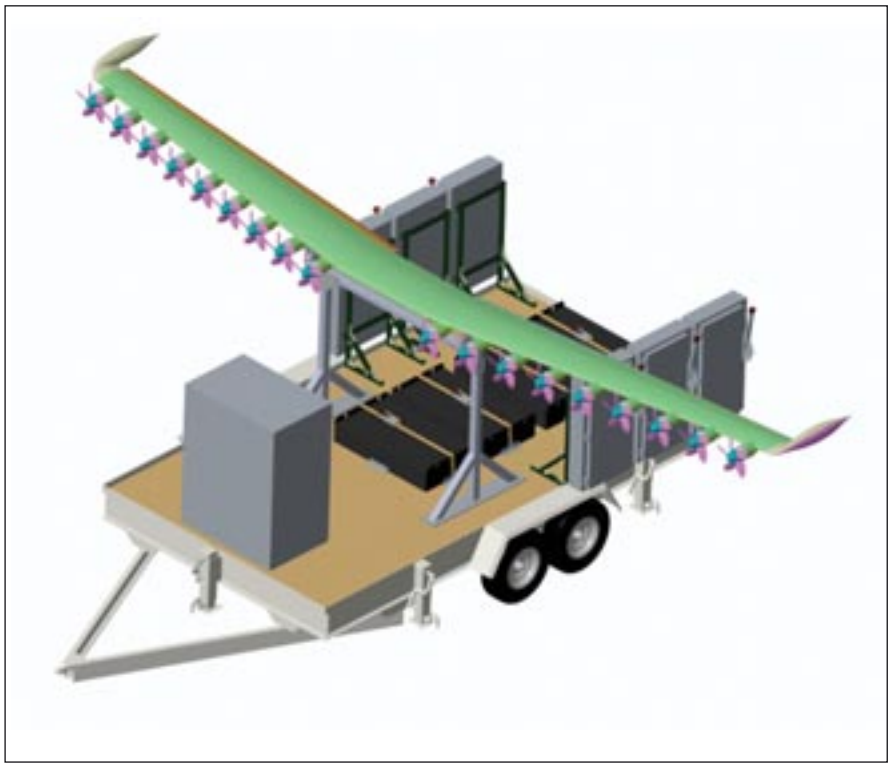
Armstrong Flight Research Center, Edwards, California

A key goal of NASA's aeronautics research is to help the aircraft industry transition to low-carbon propulsion. Many potential power architectures for electric propulsion have been proposed, and design considerations for turbo-electric distributed propulsion have been studied. However, few mid- to full-scale testbeds have been built to validate these different architectures.

Now, thanks to an important NASA research effort, the hardware testbed required to enable informed decision-making is forthcoming. The Hybrid Electric Integrated System Testbed (HEIST) will study the major aspects of combined gas-electric distributed propulsion.

The HEIST Ironbird is centered on a research wing used in the Leading-Edge Asynchronous Propeller Technology (LEAPTech) Project. LEAPTech was designed with 18 independent battery-powered electric motors mounted on a 31-foot carbon composite wing. After testing the LEAPTech wing on the back of a modified flatbed truck at speeds simulating takeoff and landing for validation of aerodynamic and propulsive performance, researchers began constructing the HEIST Ironbird to integrate the wing with a configurable piloted simulation system.

The 200-kW testbed will accommodate representative hybrid gas-electric aircraft configurations as well as missions for flight controls, propulsive, and power transfer research. It will also be designed to scale up to a 2-MW system and accommodate a flight research computer. Dynamometers will simulate aerodynamic loading.



The 31-foot LEAPTech wing was tested on the back of a modified flatbed truck at speeds simulating takeoff and landing for validation of aerodynamic and propulsive performance.

With its combination of representative hardware and piloted simulations, the HEIST Ironbird will investigate flight control algorithms, power management, and transition issues of hybrid electric propulsion. It will enable users to test different mission profiles, control systems, power configurations, and failure modes in a hardware-in-the-loop simulated flight environment. Various bus configurations will be tested to determine weight, size, electromagnetic interference (EMI), and thermal and energy transmission efficiency.

Researchers will use the information gleaned from HEIST Ironbird to develop new technologies and additional capabilities that will allow them to assess the flight readiness — and safely carry out testing — of hybrid electric/distributed electric flight. Such developments will include:

- Flight test vehicle design
- Evaluation of concept aircraft

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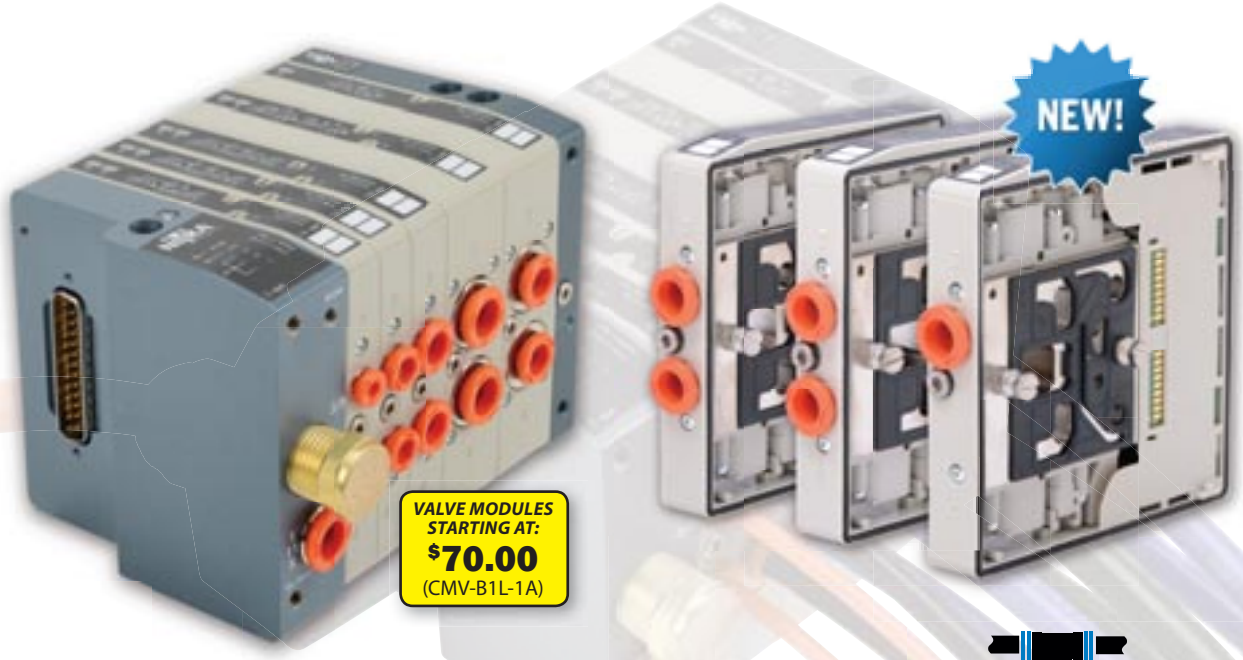

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The HEIST Ironbird research effort will enable the design of more advanced electric propulsion system testbeds. By providing informed assessments of key technology drivers and methodologies, HEIST will help NASA shape the upcoming low-carbon X-plane.

This work was done by Kurt Kloesel, Yohan Lin, Starr Ginn, Sean Clarke, Kurt Papathakis, and Jacob Ediger of Armstrong Flight Research Center. ***NASA is seeking partners to further develop this technology through joint cooperative research and development. For more information about this technology and to explore opportunities, please contact NASA Armstrong Technology Transfer Office at 661-276-3368 or by e-mail at AFRC-TTO@mail.nasa.gov.***
DRC-016-006

Small-Body Testbed

The system can simulate a microgravity environment with a wide range of terrain types and topographies.

NASA's Jet Propulsion Laboratory, Pasadena, California

This technology allows one to test small-body surface mobility and sampling systems in the laboratory. It is capable of simulating a microgravity environment with relevant terrain. The magnitude of the gravity, the terrain properties, and the surface system being tested are all easily modified to allow for a broad range of experimental setups.

The small body testbed consists of two major components: a 6-DOF (degrees of freedom) microgravity gantry and terrain simulant. The 6-DOF microgravity gantry consists of three active linear DOFs and a passive 3-DOF gimbal. The active DOFs consist of three brushless motors with 500 count encoders and planetary gear heads. Three absolute encoders on the gimbal provide an angular measurement resolution of 1.53 mrad. It should be noted that these resolutions are not the absolute accuracy of the gantry pose estimate, which will also be affected by backlash and deflections of the mechanisms and structures of the gantry. An F/T (force/torque) sensor located at the end of the third stage (but before the gimbal) measures the interaction forces between the robot and the environment. Measurement of the three orthogonal forces can then be used to determine the linear accelerations of the gantry axes in such a way as to simulate a robot of arbitrary mass with a gravity vector of arbitrary magnitude and direction.

The passive gimbal was designed as a compact passive spherical joint that uses ballast masses above the robot in order to make the center of mass (CM) of the robot/ballast system coincide with the intersection of the three gimbal axes. This results in a balanced system that floats freely and responds to external forces with appropriate rotational accelerations at all angles. Some sacrifices are made with this passive gimbal system for the three rotational DOFs as compared with an active system, including the inability to simulate arbitrary rotational inertia, the inability to accommodate changes in the CM due to limb motion, and the relocation of the CM of the robot, which affects the interaction dynamics with the environment. These sacrifices were made to greatly simplify the system.

The terrain simulant resides in a sandbox below the gantry that can be raised and lowered to accommodate a wide range of terrain types and topographies.

The advantage that this small-body testbed has over other existing technologies is the combination of the relatively large workspace, the sensitivity of the interaction force measurement, the accuracy of the ground truth measurement, the high rate of loop closure resulting in smooth and precise motion, and the full 6-DOF simulation.

This work was done by Daniel M. Helmick of Caltech for NASA's Jet Propulsion Laboratory. ***NASA is seeking partners to further develop this technology through joint cooperative research and development. For more information about this technology and to explore opportunities, please contact Dan Broderick at Daniel.F.Broderick@jpl.nasa.gov.*** *NPO-49705*

Saturn Net Flux Radiometer (SNFR)

Goddard Space Flight Center, Greenbelt, Maryland

A Saturn Net Flux Radiometer (SNFR) is being developed as part of a payload for a future NASA-led Saturn Probe Mission. The current design has two spectral channels i.e., a solar channel (0.4-to-5 μm) and a thermal channel (4-to-50 μm). The SNFR is capable of viewing five distinct viewing angles during the descent. Non-imaging Winston cones with window and filter combinations define the spectral channels, each with a 5° field-of-view. Uncooled thermopile detectors are used in each spectral channel and are read out using a custom-designed Application Specific Integrated Circuit (ASIC). The SNFR measures the radiative energy anisotropies with altitude. In the solar channel, the downward flux will determine the solar energy deposition profile and the upward flux will yield information about cloud particle absorption and scattering. In the thermal channel, the net flux will define sources and sinks of planetary radiation. In conjunction with calculated gas and particulate opacities, these observations will determine the atmosphere's radiative balance.

Presently, the focal plane array, ASIC front-end electronics, and software are being integrated. Comprehensive radiometric performance testing will follow.

This work was done by Shahid Aslam, Gerard Quilligan, Donald Jennings, and Edward Wollack of Goddard Space Flight Center. ***NASA is seeking partners to further develop this technology through joint cooperative research and development. For more information about this technology and to explore opportunities, please contact Scott Leonardi at Robert.S.Leonardi@nasa.gov.***
GSC-17204-1

Applying the Dynamic Inertia Measurement Method to Full-Scale Aerospace Vehicles

Researchers have begun testing on large articles in conjunction with ground vibration tests.

Armstrong Flight Research Center, Edwards, California

Researchers at NASA's Armstrong Flight Research Center have been interested in using the Dynamic Inertia Measurement (DIM) method on full-scale aerospace test vehicles, given its advantages over traditional methods for determining the mass properties of such vehicles. Developed at the University of Cincinnati, the DIM method uses a ground vibration test setup to determine mass properties using data from frequency-response functions. The method has been successfully tested on a number of small-scale test articles — including automobile brake rotors, steel blocks, and custom fixtures — but until now, has had limited success being tested in larger applications. Armstrong's recent efforts, in conjunction with ground vibration tests, represent a step forward in applying the DIM method successfully to full-scale aerospace vehicles.

Mass properties of an aerospace vehicle are necessary to obtain in order to understand the flight dynamics of the vehicle. These properties include mass, center of gravity, moments of inertia, and products of inertia. While mass and center of gravity can typically be determined with a weight-and-balance procedure, determining moments/products of inertia requires dynamic testing. Traditional methods include spin tables or pendulum-based swing tests. However, these methods are time-consuming and expensive for large aerospace vehicles. They also require significant amounts of labor, materials, and time, putting project timetables and budgets at risk.

Armstrong researchers have conducted DIM method testing to determine the mass properties on an iron bird test article composed of two I-beams that were comparable in mass and geometry to a fighter jet, similar to that shown here. (NASA image)

Because of the testing needs of full-scale aerospace vehicles and the shortcomings of traditional methods, the DIM method has become an attractive option to researchers. Armstrong researchers conducted mass properties testing on an iron bird test article composed of two I-beams that were comparable in mass and

geometry to a fighter jet. They conducted traditional swing testing in conjunction with the DIM testing to compare the level of effort needed for each testing type as well as to validate the quality of data obtained by the DIM method. The DIM testing showed favorable results for the center of gravity and moments of inertia; products of inertia showed disagreements with analytical predictions (compared to the larger moment of inertia values, the smaller product of inertia values are more sensitive to uncertainties using the DIM test set-up and algorithm).

This work was done by Alexander W. Chin of Armstrong Flight Research Center. ***NASA is seeking partners to further develop this technology through joint cooperative research and development. For more information about this technology and to explore opportunities, please contact NASA Armstrong Technology Transfer Office at 661-276-3368 or by e-mail at AFRC-TTO@mail.nasa.gov.***
DRC-014-034

Modules for Inspection, Qualification, and Verification of Pressure Vessels

This automated, modular, standardized system features interchangeable probes.

Lyndon B. Johnson Space Center, Houston, Texas

After decades of composite overwrapped pressure vessel (COPV) development, manufacturing variance is still high, and has necessitated higher safety factors and additional mass to be flown on spacecraft, reducing overall performance. When liners are used in COPVs, they need to be carefully screened before wrapping. These flaws can go undetected and later grow through the thickness of the liner, causing the liner to fail, resulting in a massive leakage of the liner and subsequent mission loss.

To address these concerns, modular manufacturer-grade pressure vessel nondestructive evaluation (NDE) scanners were designed and produced. This automated scanning system is designed to be modular, and currently includes interior and exterior profilometry probes for mapping and measuring dimensions, and producing boroscope-like images. A developmental system has been produced to refine laser profilometry probes and scan techniques in a laboratory setting.

The laboratory unit is capable of providing interior and exterior profilometry and eddy current scans of 6.5 × 22 in. (≈17 × 56 cm) COPVs commonly used aboard the International Space Station (ISS). A manufacturing-grade interior profilometry demonstration unit was developed to support the development and qualification of 16.7 × 30.5 in. (≈42 × 77 cm), 20-gallon (≈75 L), Type IV COPVs that will supply ISS with cryogenic oxygen and nitrogen as part of the Nitrogen Oxygen Recharge System (NORS). These highly sensitive NDE systems have been demonstrated capable of measuring simulated composite disbonds as thin as 0.01 in. (≈0.03 cm) thick near the liner, weld irregularities, and ripples resulting from inadequate wrapping processes, and collect data that can be used to refine models. Insight into the behavior of pressure vessels through historical measurement data was referenced to identify inadequate wrapping processes in one case (high internal pressure) that resulted in a COPV that grew after it was wrapped, counter to previous observations. Laser intensity maps surface reflection strength, and has been demonstrated capable of producing images identifying 0.003 × 0.125 in. (≈0.008 × 0.32 cm) cracks, foreign objects and debris (FOD), metal discoloration, and other features related to surface finish quality.

This modular system features standardized, interchangeable probes. The external laser profilometry probe simultaneously measures the interior radius and surface reflectivity of pressure vessels. An exterior eddy current probe assesses cracks in metallic pressure vessels from the outside in; an interior eddy current probe assesses cracks in metallic pressure vessels from the inside out.

A graphical user interface provides an intuitive view of flaws with sensitivity enhanced well above visual detection limits. Laser profilometry scans are traceable to a NIST-qualified standard, and provide radial measurements with ±0.001 in. (≈±0.003 cm) precision. Laser intensity maps taken during profilometry scans provide images similar to boroscopes mapped to a precise and user-defined coordinate axis.

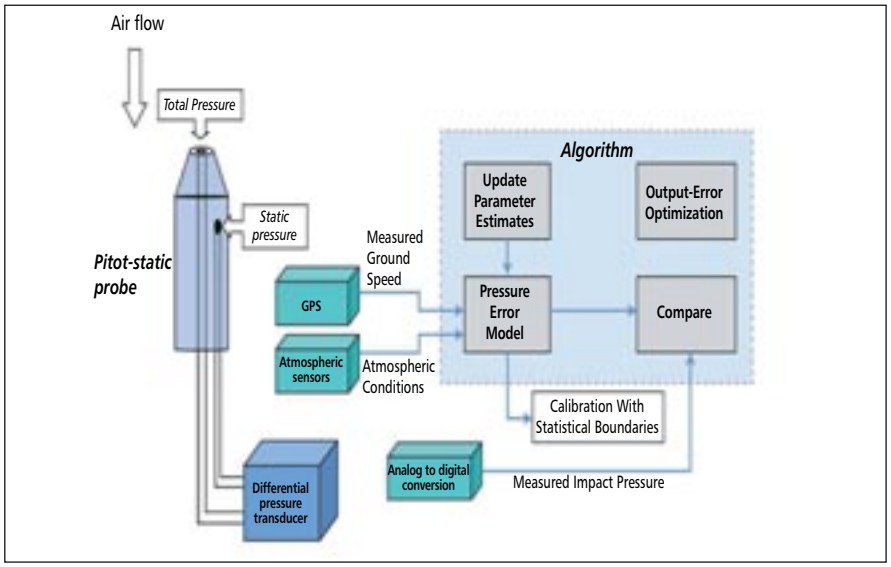
This work was done by Regor L. Saulsberry, Charles Nichols, Daniel Wentzel, Ralph Lucero, Kyle Carver, and Paul Spencer of NASA White Sands Test Facility; James Doyle and Mike Brinkman of Laser Techniques Company, LLC; and Russell Wincheski of Langley Research Center for Johnson Space Center. ***NASA is seeking partners to further develop this technology through joint cooperative research and development. For more information about this technology and to explore opportunities, please contact jsc-techtran@mail.nasa.gov.*** *MSC-25533/4/5/6/7/8-1*

In-Flight Pitot-Static Calibration

This precise yet time- and cost-effective method is based on GPS technology using output error optimization.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed a new method for calibrating pitot-static air data systems used in aircraft. Pitot-static systems are pressure-based instruments that measure the aircraft's airspeed. These systems must be calibrated in flight to minimize potential error. Current methods — including trailing cone, tower fly-by, and pacer airplane — are time- and cost-intensive, requiring extensive flight time per calibration. NASA's method can reduce this calibration time by up to an order of magnitude, cutting a significant fraction of the cost. In addition, NASA's calibration method enables near-real-time



The output-error method for measuring airspeed error in air-data systems.

monitoring of error in airspeed measurements, which can be used to alert pilots when airspeed instruments are inaccurate or failing. Because of this feature, the technology also has applications in the health usage and monitoring (HUMS) industry. Flight test engineers can be trained to use this method proficiently in 12 days without costly specialized hardware.

The method for pitot-static calibration is a novel application of modern system identification methods for in-flight airspeed calibration. True airspeed is calculated using measurements from a global positioning system (GPS) by vector summing ground speed and estimated wind speed. This value is used to estimate actual impact pressure, which is compared with the impact pressure measured by the flight instrumentation for a range of airspeeds. The difference between these values is the error in impact pressure measurements. The optimization process calculates a mathematical model of the pressure error as a function of calibrated airspeed and an estimate of the wind speed and direction. A statistically based maximum likelihood method known as output-error is used to estimate the parameters describing the pressure error model and the wind vector values. This method can work with any airplane with a digital flight data system.

The technology can be used in aerospace applications replacing current legacy pitot-static calibration methods, and in aerospace health usage and monitoring systems measuring error in airspeed instruments in near-real-time to improve air safety.

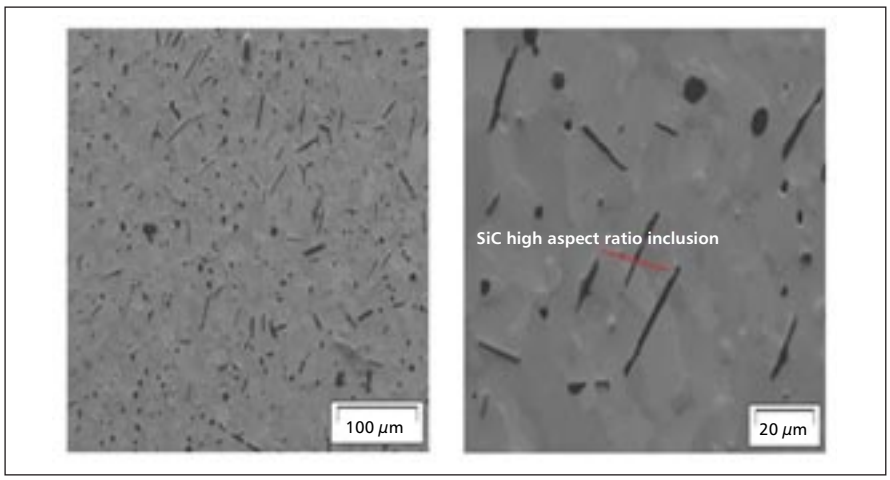
NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-89.

In-Situ Formation of Reinforcement Phases in Ultra-High-Temperature Ceramic Composites

This technology could be used in re-entry vehicles, reusable launch vehicles, hypersonic vehicle leading edges, and commercial spacecraft.

Ames Research Center, Moffett Field, California

Future-generation materials for use on space transportation vehicles require substantial improvements in material properties leading to increased reliability and safety, as well as intelligent design to allow for current materials to meet future needs. Ultra-high-temperature ceramics (UHTC), composed primarily of metal diborides, are candidate materials for sharp leading edges on hypersonic re-entry vehicles. NASA has demonstrated that it is possible to form high-aspect-ratio reinforcement phases in-situ during the processing step for both ceramic composites and UHTCs. Initial characterization of these systems has demonstrated that crack deflection along the matrix-reinforcement interface is observed yielding a system of improved toughness over the baseline system, leading to improved mechanical performance. The reinforced composites should therefore reduce the risk of catastrophic failure over current UHTC systems.



A UHTC engineered microstructure with high-aspect-ratio SiC inclusions.

UHTCs are a family of ceramic materials with very high melting temperatures and reasonable oxidation resistance in re-entry environments. Ground-based arc-jet testing has demonstrated their potential for applications at temperatures approaching 4000 °F, or 2200 °C. This invention generally relates to ceramic compositions and processes for obtaining a ceramic product, especially UHTCs. It specifically targets consolidated ceramic composites comprising a microstructure of a ceramic matrix that incorporates a reinforcing ceramic phase with a uniform distribution of the reinforcing phase, and controlling the growth of these phases.

A tough UHTC composite comprises grains of UHTC matrix material, such as HfB_2 or other metal boride, carbide, or nitride. These are surrounded by a uniform distribution of acicular high-aspect-ratio reinforcement ceramic rods or whiskers, such as SiC, that are formed from uniformly mixing a powder of the UHTC material and a pre-ceramic polymer selected to form the desired reinforcement species. The mixture is then thermally consolidated by hot pressing.

This technology could potentially be used in re-entry vehicles for aerospace and defense applications, reusable launch vehicles, hypersonic vehicle leading edges, and commercial spacecraft for enhanced aerodynamic performance.

NASA is actively seeking licensees to commercialize this technology. Please contact the Technology Partnerships Office at ARC-TechTransfer@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/TOP2-181.

Multi-Phase Ceramic System

John H. Glenn Research Center, Cleveland, Ohio

Bearing surfaces are typically either metal-on-metal (MOM), ceramic-on-ceramic (COC), or metal-on-polyethylene (MOP). MOM and MOP couplings have the drawback that metallic or polyethylene particles can sometimes separate from the couplings, which can cause significant problems, particularly in a hip or joint replacement. COC couplings are less likely to lose particles due to wear, which makes them more biocompatible, but they are more susceptible to fracture. COC couplings also have a tendency to squeak as they move. Innovators at NASA's Glenn Research Center have developed a technique using rare earth elements to fabricate a dual-phase ceramic composite that combines a wear-resistant phase and a solid-state lubricant phase. The result is a coupling material that, compared to currently used materials, exhibits a tenfold reduction in the friction coefficient, a sixfold reduction in wear, and a significant reduction in debris caused by wear. Glenn's groundbreaking rare-earth aluminate composite has considerable potential, not only in biomed-

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ical applications, but also in commercial and industrial sectors.

Glenn's approach utilizes a combination of alumina (Al_2O_3) and specially defined ratios of rare earth oxides. These rare earth elements are typically either yttrium or gadolinium, although other rare earths may be substituted to produce different targeted effects, including generating a multiphase composition instead of a dual-phase one. Glenn's method of adding rare earths to the alumina material produces a two-phase composite system that is optimized for the targeted mechanical properties of wear resistance and coefficient of friction.

These composites can be formed by either casting from a melt with directional solidification or solid-state sintering of isostatically pressed powder preforms. In the latter process, the hot isostatic pressing both reduces the porosity of the ceramic material and increases its density prior to the sintering process. Glenn's technique yields a composite with significant advantages over single-phase ceramics. Single-phase ceramics, although they display high strength and wear resistance compared to other materials and high-performance alloys like CoCr, also have a relatively high friction coefficient. The incorporation of rare earths allows the fabrication process to introduce a continuous second ceramic phase and create tertiary phases at the interfaces, which greatly improves the material's friction properties without sacrificing the wear characteristics. This combination of sturdiness and reduced friction gives these materials great potential for use in a wide range of applications.

Potential applications include use in biomedical (e.g., hip and joint replacements), ball bearings and hard face seals, oil drilling, automotive and marine engines, and industrial machines.

NASA is actively seeking licensees to commercialize this technology. Please contact the Technology Transfer Office at ttp@grc.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LEW-TOPS-62.

Minimally Machined HoneySiC Panels and T300 HoneySiC

The materials are intended for low areal density and near-zero CTE optomechanical structures.

Marshall Space Flight Center, Alabama

The primary purpose of this work is to develop and demonstrate technologies to manufacture ultra-low-cost precision optical systems for very large x-ray, UV/optical, or infrared telescopes.

Starfire® RD-730 is a polycarbosilane precursor material that can be converted to a thermally stable silicon carbide by direct pyrolysis. RD-730 is a melt-processable polymer, meaning that it is a solid at room temperature, but can be melted to produce a viscous liquid polymer that can be flowed at temperatures to 100 °C. Using melt processing, T-300 cloth fabrics can be infiltrated with RD-730, which then solidifies and becomes a hard, machinable thermoplastic. T-300 cloth layups with RD-730 in the thermoplastic form will be the new prepreg material. The prepreg in block form can be machined to near-net shape, put in a mold, and re-flowed (re-melted). The molded parts can then be cured (curable above 150 °C) to render a thermoset, which is machinable. The cured polymer matrix composite can then be fired to form a high-temperature, oxidation-resistant, amorphous silicon carbide material.

A 12 × 12 × 0.5 in. (≈30 × 30 × 1.3 cm) vented, lightweight, H-SiC panel was developed that had a density relative to bulk silicon carbide of 11% (89% lightweighting). The H-SiC panel and facesheet stock material were fabricated into ASTM standard coupons and tested at SoRI to obtain basic materials properties data. The materials properties data showed a near-zero coefficient of thermal expansion [CTE, from –320 to +75 °F (≈ –196 to 24 °C) is –0.22 ppm/°C] ceramic matrix composite (CMC) C/SiC material with good strength.

This work was done by Bill Goodman of Trex Enterprises Corporation for Marshall Space Flight Center. ***NASA is seeking partners to further develop this technology through joint cooperative research and development. For more information about this technology and to explore opportunities, please contact Ronald C. Darty at Ronald.C.Darty@nasa.gov.***

MFS-33282 -1/90-1

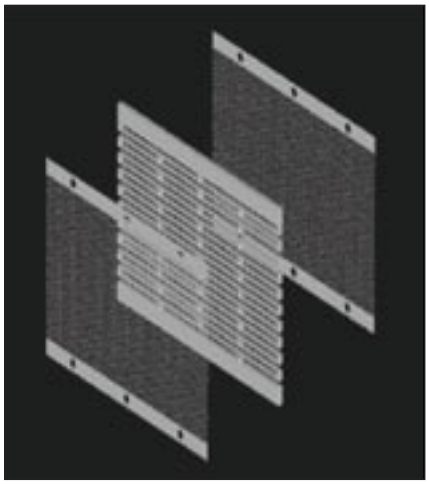
Flexible Volumetric Structure

These composite elastic skins can be tailored for specific applications.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed composite elastic skins for covering shape-changing (morphable) structures. These skins are intended especially for use on advanced aircraft that change shapes in order to assume different aerodynamic properties. Examples of aircraft shape changes include growth or shrinkage of bumps, conformal changes in wing planforms, cambers, twists, and bending of integrated leading and trailing-edge flaps. Prior to this invention, there was no way of providing smooth aerodynamic surfaces capable of large deflections while maintaining smoothness and sufficient rigidity.

The composite elastic skin can include one or more internal skeletal layer(s) made of a metal or a suitably stiff composite. By use of water-jet cutting, laser cutting, photolithography, or some other suitable technique, regular patterns of holes are cut into the skeletal layers (see figure). The skeletal layers are thereby made into planar springs. The skeletal layers are embedded in a castable elastomer. The anisotropic stiffness of the skin can be tailored through choice of the materials, the thicknesses of the skeletal and elastomeric layers, and the sizes and shapes of the cutouts. Moreover, by introducing local variations of thicknesses and/or cutout geometry, one can obtain local variations in the



The skins' skeletal layers are embedded in an elastomeric sheet.

anisotropic stiffness. Threaded fasteners for attachment to actuators and/or the underlying structure are inserted in the internal skeleton at required locations.

The skin can be stretched up to 20%, and can be stretched or otherwise warped with low actuation force in one or both in-plane direction(s). This technology has potential applications in the aerospace and automotive industries.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-139.

Aeroplastic Composites

John F. Kennedy Space Center, Florida

Aeroplastic refers to a family of polymeric composites with properties that provide a significant reduction in heat transfer. These composites reduce the thermal conductivity of the base polymer resin between 20%-50% without changing its mechanical properties or modifying the original techniques for processing those polymers. The composites can be made into fibers, molded, or otherwise processed into usable articles. Aeroplastic composites are superior alternatives to prior composite materials with respect to both their thermal conductivity and physical properties.

Researchers at NASA's Kennedy Space Center have developed a new series of polymer composite materials. A material of this type can be made from a blend of thermoplastics — elastomers with appropriate aerogel and non-halogenated flame-retardant additives — and processed on normal polymer processing equipment. These materials are useful as substitutes for metals in cryogenic and other low-temperature applications with increased ductility, which are important terrestrially and in space exploration. One specific application of the polymeric composition is for use in tanks, pipes, valves, structural supports, and components for hot or cold fluid process systems where heat flow is not desired. Another use is in thermal barrier products for the construction industry, such as use in wood plastics. Sports equipment and performance apparel could be developed to take advantage of the temperature stability of the new material.

Potential applications include residential and commercial construction, automotive parts, refrigeration and refrigerated transport, chemical processing and fluid systems, aerospace vehicles, textiles, electronics, and military hardware.

NASA is actively seeking licensees to commercialize this technology. Please contact Jeffrey Kohler at Jeffrey.A.Kohler@nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nsa.gov/patent/TB2016/KSC-TOPS-34.

An Apparatus and Method for Communication Over Power Lines

John H. Glenn Research Center, Cleveland, Ohio

NASA's Glenn Research Center is offering a sensor and actuator networking innovation applicable to smart vehicle or component control. This innovation requires no additional connectivity beyond the wiring providing power. This results in lower system weight, increased ease and flexibility for system modifications and retrofits, and improved reliability and robustness. The technology was specifically designed for harsh, high-heat environments, but has applications in multiple arenas. The device is compatible with most communication protocols.

The innovation consists of both a device and a technique. The device is radiation hard, and capable of withstanding temperatures up to 225 °C using available silicon-on-insulator semiconductor components. The technique is a method of modulating a signal to be placed on a DC power bus.

The signal is modulated by on-off keying, and uses capacitive coupling. The demodulation is accomplished using an asynchronous quadrature detection technique. The technique relies on a quasi-discrete Fourier transform that occurs by using the quadrature components of the carrier frequency as generated by the microcontroller, and as a function of the selected crystal frequencies driving its oscillator. The detected signal is changed into a direct current using an absolute value circuit containing no diodes (diodes can't operate at high temperatures). The local power for the circuit is derived from a 5-volt regulator whose input is the supply rail. The data imposed upon the supply rail does not substantially present itself upon the local power rail of the circuit, because the lower excursions are above the dropout voltage of the regulator and also within the regulator's power supply rejection specifications.

The device can draw power for itself and associated sensors and actuators from an existing power bus, communicate with similar devices or a central processor by placing a signal on the same power bus, make smart decisions within its operational loop, and affect control outputs to associated sensors and actuators. There is no limit to the number of sensors/actuators that could be placed in the network. All of this can be accomplished in a high-heat (up to 225 °C) environment with a bandwidth range of 1500 bps, ideal for environments such as jet engines, smelting operations, or deep drilling.

The ability to draw power and communicate over a power bus reduces weight and mass. With less wiring, the risk of interconnection breakdown and failure diminishes. In addition, the system is less susceptible to noise because it operates in a lower, unused frequency spectrum — it can withstand a noise-to-signal ratio of 20 dB. This innovation's simplicity and off-the-shelf components make it suitable for multiple applications.

Potential applications include use in jet engines, oil field services, power turbines, biomedical devices, nuclear power plants, factory automation, and solar power collectors.

NASA is actively seeking licensees to commercialize this technology. Please contact the Technology Transfer Office at ttp@grc.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LEW-TOPS-18.

A High-Efficiency Power Module

John H. Glenn Research Center, Cleveland, Ohio

Innovators at NASA's Glenn Research Center have developed a microwave power module to power radar, communications, and/or navigation interchangeably. This high-efficiency, all-solid-state microwave power module (MPM) is based on a multi-stage distributed-amplifier design, which is capable of very wideband operation. This MPM is extremely durable and can last a decade or longer. Already more compact and lightweight than conventional designs, Glenn's patented technique offers further size reduction by eliminating the need for either a traveling-wave tube amplifier or its accompanying kV-class electronic power conditioner. The performance of this MPM is exceptional, with much higher cut-off frequency and maximum frequency of oscillation than metal-semiconductor field-effect transistors offer, and the distributed amplifier's wide bandwidth also results in much faster pulse rise times. Finally, Glenn's design allows the module to operate in both pulsed and continuous wave modes, so it can single-handedly drive exceptional performance for radar, navigation, and communications.

Typically, MPMs are useful only for radar and navigation purposes because they lack the linearity and efficiency required for communications. In standard configurations, conventional MPMs require both a solid-state amplifier at the front end and a microwave vacuum electronics amplifier at the back end. By contrast, Glenn's design features a wideband multi-stage distributed amplifier system. The low-power stage is a high-efficiency, gallium arsenide (GaAs) pseudomorphic high-electron-mobility transistor (pHEMT)-based monolithic microwave integrated circuit (MMIC) distributed amplifier. The medium-power stage is configured to pick up and amplify the low-power signal. This stage can be either another high-efficiency GaAs pHEMT or a gallium nitride (GaN) HEMT-based MMIC distributed amplifier, depending on the need. The high-power

stage, configured to pick up the signal from the second amplifier, is a high-efficiency GaN HEMT-based MMIC distributed amplifier that supplants the traveling-wave tube amplifier found in most microwave power modules.

In Glenn's MPM, the radar functions as a scatterometer, radiometer, and synthetic aperture imager. The high-speed communications system downlinks science data acquired by Earth-observing instruments. The navigation system functions like a transponder for autonomous rendezvous and docking, and estimates the range information.

Potential applications include commercial and military satellite communications, military radar systems, phased-array antenna systems, and aerospace (radar, communications, navigation).

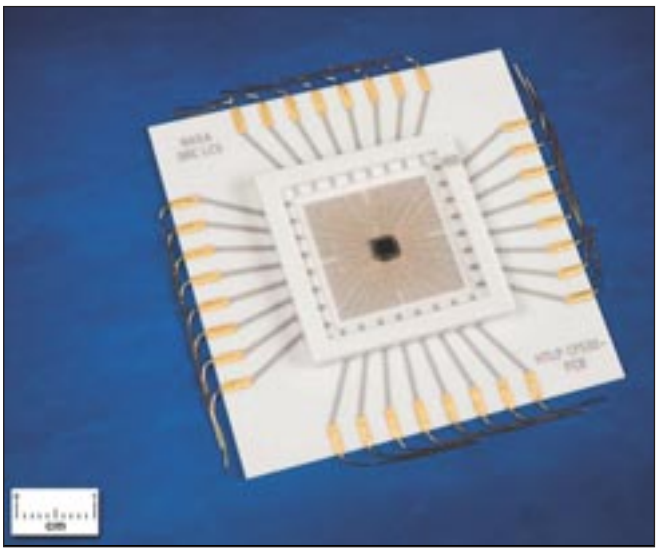
NASA is actively seeking licensees to commercialize this technology. Please contact the Technology Transfer Office at ttp@grc.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LEW-TOPS-70.

Addendum of Self-Aligned Ion Implant to Design and Processing of SiC High-Temperature Transistors for Durable Operation Above 400 °C

Applications include aerospace, oil and gas combustion, well drilling, transportation, and computers.

John H. Glenn Research Center, Cleveland, Ohio

Researchers at NASA's Glenn Research Center have developed a revolutionary new generation of silicon carbide (SiC) integrated circuit (IC) chips, setting an unprecedented benchmark in the field of high-temperature electronics. In the past, SiC ICs could not withstand more than a few hours of 500 °C temperatures before degrading or failing. Now, Glenn has successfully fabricated prototype chips that can exceed 10,000 hours of continuous operation at 500 °C. The advanced performance stems in part from the development of Glenn's patented iridium interfacial stack (IrIS), a bondable metallization stack that prevents diffusion of oxygen and gold into silicon carbide (SiC) integrated circuits operating above 500 °C. The enhanced reliability of these components (and the transistors and logic



The IrIS acts as both a bond metal and a diffusion barrier within the IC chip.

boards they support) will enable important improvements in the control and operation of combustion engines, well-drilling, and other harsh environment systems, thereby greatly impacting operational efficiency and environmental quality. This advance in the manufacture of SiC-based electronics also fundamentally revolutionizes the opportunities for intelligent systems operating in high-temperature environments.

The IrIS acts as both a bond metal and a diffusion barrier within the IC chip. SiC integrated circuits designed for operation in air at 500 °C or above need this barrier to prevent gold or oxygen from diffusing to the ohmic contact interface that transports electrical signals into and out of the SiC semiconductor. These elements interfere with the performance of the interface once they diffuse in sufficient quantities. Because the IrIS also acts as a bond metal, the diffusion barrier bonds more easily for electrical connection to off-chip circuitry. Glenn's patented innovation thus allows the bond metal to be used directly on ohmic contact metal, or on top of dielectric insulating layer(s) as an interconnect metal. In addition, the fabrication of the IrIS stack does not require extra anneals or masking steps, so the stack is both time-efficient and cost-effective to produce.

Additional technology from Glenn includes the fabrication of a self-aligned nitrogen-implant that works especially well with junction field effect transistors (JFETs), which are composed of silicon carbide. These JFETs are capable of being electrically operated continuously for 10,000 hours at 500 °C while undergoing less than 10 percent change in operational transistor parameters. Furthermore, the same methods have produced semiconductor devices for aerospace combustion applications that operate in temperatures up to 600 °C. This technology is a game-changer for high-temperature, harsh-environment applications of all types.

Potential applications include aerospace, oil and gas combustion (lower pollution and improved fuel economy), well drilling (deeper wells drilled faster for enhanced oil production), transportation (personal, commercial, military), and computers.

NASA is actively seeking licensees to commercialize this technology. Please contact the Technology Transfer Office at ttp@grc.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LEW-TOPS-33.

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Method and Apparatus to Detect Wire Pathologies Near Crimped Connector

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has created a collection of innovations for rapid, precise, and verified crimps. Wiring crimp failures can be a threat to safety and may lead to a loss of critical functions in high-risk applications, such as aerospace. In addition to the safety concerns, diagnosing and repairing poor crimp connections can be costly. Langley's crimping innovations increase quality and reduce risk by using ultrasound to provide real-time, nondestructive verification of wire-crimp integrity while the crimp is being formed. This technology can be applied to electromechanical crimping machines, where the appropriate force required to form a crimped connection is determined in real time. Such an application prevents over- or under-crimping, and prevents excessive tool wear. Langley has also created a means and method to calibrate and verify the mechanical and electrical settings for an ultrasonically enhanced crimp tool.

The crimping innovations are based on traditional, ultrasonic, nondestructive evaluation methods. The quality of the contact between the connector and wire is determined by sending an acoustic wave through the crimp assembly. As the applied pressure increases and the crimp terminal deforms around the wire, the ultrasonic signature passing through the crimp is altered. The system analyzes the changes in the signal, including the amplitude and frequency content, as an indication of the quality of both the electrical and mechanical connection between the wire and terminal.

Various crimp quality issues such as under-crimping, missing wire strands, incomplete wire insertion, partial insulation removal, and incorrect wire gauge have been tested using this technique, and results show that the instrumented crimp tool consistently discriminates between good and poor crimps for all of these potential quality issues. This information can be used to provide a pass or fail indication for instant verification of the crimp quality, and to give a better prediction for the service life of the crimp.

This technology can improve safety and reduce costs related to installing and/or overhauling crimp/wire connections in applications with critical wire terminations, such as marine and automotive systems, industrial plants, nuclear power plants, and medical devices.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-52.

Jet Engine Exhaust Nozzle Flow Effector

Shape memory alloy provides variable shape control of aircraft structure through actively deformable surfaces.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has created novel flow effector technology for separation control and enhanced mixing. The technology allows for variable shape control of aircraft structure through actively deformable surfaces. The flow effectors are made by embedding shape memory alloy actuator material in a composite structure. When thermally actuated, the flow effector deflects into or out of the flow in a prescribed manner to enhance mixing or induce separation for a variety of applications, including aeroacoustic noise reduction, drag reduction, and flight control. NASA developed the active flow effectors for noise reduction as an alternative to fixed-configuration effectors, such as static chevrons, that cannot be optimized for airframe installation effects or variable operating conditions, and cannot be retracted for off-design or fail-safe conditions.

The technology involves embedding pre-strained SMA actuators on one side of the chevron neutral axis in order to generate a thermal moment and deflect the structure out of plane when heated. The force developed in the host structure during deflection and the aerodynamic load are used for returning the structure to the retracted position. The NASA chevron design is highly scalable and versatile, and easily affords active and/or autonomous (environmental) control.

Prototype chevrons at 1:9 scale have been built and tested at NASA Langley. This included thermal cycling tests, repeatability tests, and tests with representative flow conditions. All aspects of the chevron performance were found to be very repeatable, including closed-loop performance of the chevron tip to prescribed positions while immersing into and retracting from the flow.

This technology can be used in aerospace applications for distributed spoilers, jet noise control, airframe noise control, and flow separation control over high lift devices; in defense weapons bays for an adjustable flow to reduce damaging noise and reduce the thermal footprint due to flow when opening the bay; and in automotive applications for flow control and aerodynamic flow optimization.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-23.

Chevron flow effectors are part of this engine nozzle chevron design that uses asymmetrical scallops around the engine to reduce noise. (Credit: The Boeing Company/Bob Ferguson)

A Structural Joint with Multi-Axis Load Carrying Capacity

The technology can be used in aerospace and automotive applications, outdoor structures, and sporting goods.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed a composite joint connector that is more structurally efficient than joints currently on the market. Traditionally, composite joints can bear heavy loads along their length but tend to fail when stress is applied along multiple axes. This joint is designed to minimize stress concentrations, leading to overall increased structural efficiency when compared to traditional joints.

The joint connector is for application between two or more tubular parts, or to connect one or more tubular parts to a fixed structure. This attachment technology is more structurally efficient and reduces failure characteristics due to the uniformity of composite material across the joint. In comparison to a typical joint, this technology reduces weight while minimizing stress variations that lead to structural failure. Moreover, typical joints must be bonded or screwed together, which further reduces efficiency. This joint, however, is designed so that it is both bonded and mechanically locked by design rather than relying on separate mechanical fasteners. The result is a design that mitigates failure of a structural joint.

The technology can be formulated to fit a variety of joint shapes, and is corrosion resistant, lightweight, and electrically insulated. Potential applications include use in aerospace and automotive designs, outdoor structures, and sporting goods.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-198.

The joint assembly showing a four-lobed connector and single tube element.

Eddy-Current-Minimizing Flow Plug for Use in Flow Conditioning and Flow Metering

Marshall Space Flight Center, Alabama

Innovators at NASA's Marshall Space Flight Center have developed a suite of prototype fluid plug technologies with an array of capabilities for fluid flow metering, mixing, and conditioning. Each innovation within this suite is based upon a core technology that has no moving parts, is simple to manufacture, and provides high reliability and efficiency. Also, the base fluid plug technology can be modified with very few or no hardware changes to achieve the desired effect or combination of mixing, metering, and conditioning capabilities depending on the application.

The suite of innovations includes: a fluid-mixing plug with metering capabilities; an unbalanced-flow, fluid-mixing plug with metering capabilities; a flow meter plug with length-to-hole size uniformity; and an eddy-current-minimized flow plug for use in flow conditioning and flow metering. The suite consists of variations of the same base innovation — a fluid plate or plug of varying thickness that is simple to install and can be mounted between two flanges in a fluid-flow conduit, or can be threaded or welded into the conduit. In some curved-pipe applications, the device can be integrated into a pipe fitting, bend, elbow, or tee.

The face of the plug features several ports through which fluid flows. The orientation and position of these ports vary, depending on the needs of a specific application. The design balances fluid flow and kinetic energy across the plug face to create the desired flow effect. The device can smooth the fluid flow for superior conditioning, decrease turbulence for highly accurate metering, or increase turbulence to enhance fluid mixing. For example, discrete openings parallel to the fluid flow will decrease turbulence for accurate metering and conditioning. Other shapes of fluid openings can be introduced to change flow velocity or energy. The openings can also contain tapers and/or be directed along an unparallel path to the flow conduit to induce fluid mixing. In addition, the open flow area of the plug can be more heavily weighted on one side to amplify or offset the fluid effects around bends.

This technology can be used in chemical processing facilities, manufacturing facilities, ground test facilities, industrial processing, petro-chemical processing, mechanical operations, mining, water analysis, liquid rocket engines, space propulsion, spray nozzles, variable orifice stream jets, Venturi applications, density measurements, flow conditioners, and pump inlets.

NASA is actively seeking licensees to commercialize this technology. Please contact Sammy A. Nabors at sammy.nabors@nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/MFS-TOPS-51.

Process for Forming a High-Temperature Single Crystal Preloader

Non-contacting, acoustic pressure seals and preloader superalloys prevent fluid leakage.

John H. Glenn Research Center, Cleveland, Ohio

Friction has long been a thorny problem for sealing-device designers. Traditional sealing devices rely on a contacting relationship between surfaces and sealing elements to prevent fluid leakage, but in the case of moving elements, this contact produces friction that causes wearing and eventual failure of the sealing system. Friction also consumes energy and produces harmful debris. In a new breakthrough, however, researchers at NASA's Glenn Research Center have patented an acoustic seal that generates a pressure barrier to prevent fluid leakage from a high-pressure area. Instead of using contacting components as a seal, the patented seal employs acoustic technology to generate pressure waves that control, mitigate, or prevent fluid leakage. The result is a very low-leakage, non-contact seal that eliminates problems associated with friction. In addition, when traditional seals are needed in extremely high-temperature environments, Glenn innovators have developed new processes to enable the fabrication of single-crystal superalloys that can increase the upper limit of thermal seals to greater than 2000 °F.

The first of Glenn's innovative sealing technologies features an acoustic resonator, which creates acoustic waveforms that generate a sealing pressure barrier blocking fluid flow from an area of high pressure to an area of low pressure. Through the use of resonant macrosonic synthesis (RMS), the device permits non-contacting sealing operation. To increase the effect, Glenn researchers discovered that an oscillating driver can be coupled with the resonator to achieve an RMS pressure-multiplying effect. In this way, the combination of the oscillating driver and the resonator cavity can create four to ten times greater pressure at the seal, thereby enabling optimal sealing.

These sealing devices are also very versatile for practical applications. The resonators can be selected from several different shapes to produce the desired RMS effect. Moreover, the high- and low-pressure areas in the application can be in contact with a structure while the resonator is not in contact, allowing a wide array of design strategies to integrate the sealing device.

For extremely-high-temperature sealing applications, Glenn researchers have devised novel methods for using nickel-based, single-crystal superalloys. One process involves fabricating a

rapid prototype spring "pattern" to create the required cavity in a ceramic mold, and then casting a coiled spring to form at least one coil spring configuration based on the ceramic mold. The second process comprises determining the orientation of the single crystal in a single crystal slab to "harvest" a single crystal spring with optimal properties. In this way, the single crystal preloader can be manufactured in a variety of configurations to meet the requirements of particular applications.

This technology can be used in aerospace systems, gas turbine engines, compressors, computer disk drives (preventing particles from reaching components), microelectromechanical systems (MEMS), and medical materials (preventing contamination).

NASA is actively seeking licensees to commercialize this technology. Please contact the Technology Transfer Office at ttp@grc.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LEW-TOPS-38.

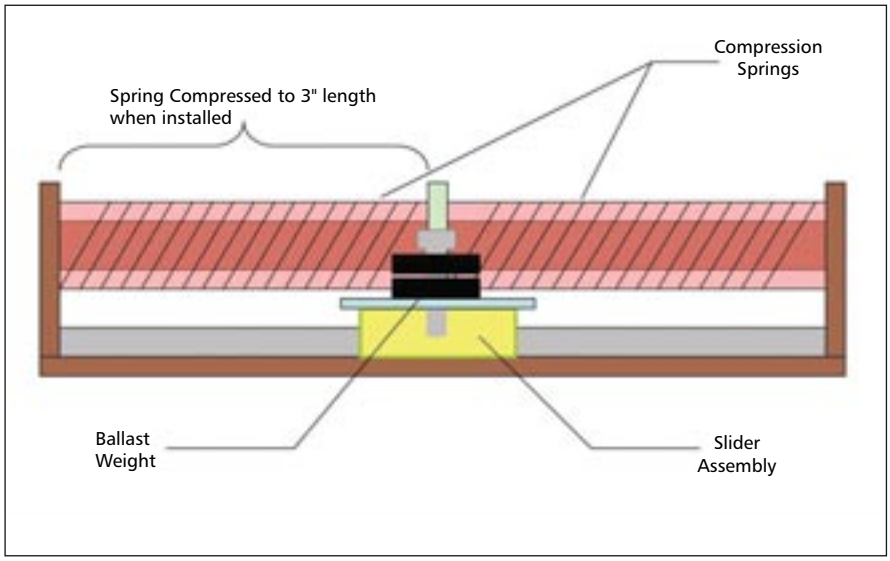
Compact Vibration Damper

Applications include wind tunnel models, launch vehicles, smokestacks, helicopters, wind turbines, and skyscrapers.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed a compact tuned damper to reduce vibration occurring at a fixed frequency. Tuned dampers reduce vibration of the base structure by the dissipation of energy. The magnitude of the dissipated energy is proportional to the square of the displacement or velocity of the tuned mass, which in turn is proportional to the range of motion. The NASA damper design allows the slider mass to achieve 2× to 3× greater range of motion than that found in conventional devices. This enables 4× to 9× more effectiveness for the same size and weight; or the same effectiveness for a 4× to 9× decrease in weight. The damper is also tunable and can be adjusted in effectiveness. The damper can be made small enough for use in wind tunnel tests, or scaled up to large sizes like those used in helicopters, wind turbines, or skyscrapers.

Structural vibrations frequently need to be damped to prevent damage to a structure. To accomplish this, a standard linear damper or elastomeric-suspended masses are used. The problem associated with a linear damper is the space required for its construction. For example, if the damper's piston is capable of three inches



The side view of the vibration damper.

of movement in either direction, the connecting shaft and cylinder each need to be six inches long. Assuming infinitesimally thin walls, connections, and piston head, the linear damper is at least 12 inches long to achieve ±3 inches of movement. Typical components require 18+ inches of linear space. Further, tuning this type of damper typically involves fluid changes, which can be tedious and messy. Masses suspended by elastomeric connections enable even less range of motion than linear dampers.

The NASA invention is a compact and easily tunable structural vibration damper. The damper includes a rigid base with a slider mass for linear movement. Springs coupled to the mass compress in response to the linear movement along either of two opposing directions. A rack-and-pinion gear coupled to the mass converts the linear movement to a corresponding rotational movement. A rotary damper coupled to the converter damps the rotational movement. To achieve ±3 inches of movement, this design requires slightly more than six inches of space.

Potential applications include wind tunnel models, launch vehicles, smokestacks, helicopters, wind turbines, and skyscrapers.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-189.

Fluidic Oscillator Array for Synchronized Oscillating Jet Generation

This technology can be used in aerospace applications, shipbuilding, gas turbines, and commercial spa equipment.

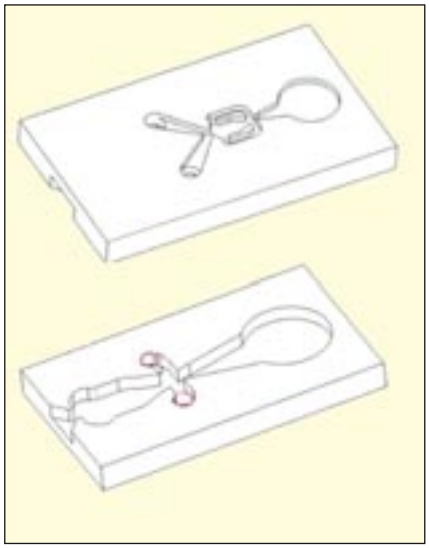
Langley Research Center, Hampton, Virginia

NASA's Langley Research Center develops innovative technologies to control fluid flow in ways that will ultimately result in improved performance and fuel efficiency. Often called fluidic oscillators, sweeping jet actuators, or flip flop oscillators, these flow-control devices work based on the Coanda effect. They can be embedded directly into a control surface (such as a wing or a turbine blade) and generate spatially oscillating bursts (or jets) of fluid to improve flow characteristics by enhancing lift, reducing drag, or enhancing heat transfer. Recent studies show up to a 60% performance enhancement with oscillators. NASA offers two new fluidic oscillator designs that address two key limitations of these oscillators: coupled frequency-amplitude and random oscil-

lations. One oscillator effectively decouples the oscillation frequency from the amplitude. The other design enables synchronization of an entire array. The new oscillators have no moving parts — oscillation, decoupling, and synchronization are achieved entirely via internal flow dynamics.

The first design decouples frequency and amplitude. Existing oscillators are limited in that the frequency of oscillation is controlled by input pressure or mass flow rate. The frequency and amplitude (mass flow rate) are coupled, limiting control authority over the oscillators. The new oscillator design decouples the frequency from the amplitude by employing a novel design featuring a main oscillator that controls the amplitude and a small oscillator that controls the frequency of the oscillations. The decoupled oscillator delivers high (or low) mass flow rates without changing the frequency and vice versa.

The second design synchronizes the entire oscillator jet array. Existing oscillators in an array oscillate randomly. While this is useful for mixing enhancement, synchronized flow may be more beneficial for active flow-control applications. The simple design of the new Langley synchronized oscillator achieves synchronization without having electro/mechanical or any other moving parts. The new oscillator enables synchronization of an entire array by properly designing the feedback loops to have one unique feedback signal to each actuator. Once each actuator has the same feedback signal, each main jet attaches to one side of the Coanda surface at the same time, allowing synchronized oscillation.



A 3D isometric view of the oscillator. The main oscillator is on the top, and the control oscillator is on the bottom.

These fluidic oscillator designs are rugged and can be used in harsh environments. In addition, they are scalable from micro to macro size, and can be machined as embedded arrays. This technology can be used in aerospace applications for boundary layer control, separation control, lift enhancement, drag reduction, and mixing; in shipbuilding for flow control; in gas turbines for heat transfer enhancement and separation control; and in commercial spa equipment for improved nozzle performance.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-36.

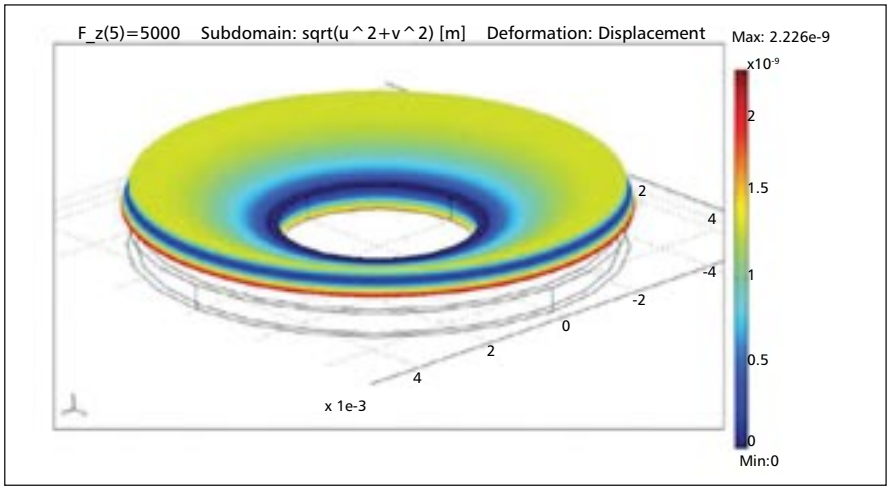
Neutral Mounting of Whispering Gallery Mode Resonators for Suppression of Mechanical Frequency Fluctuations

This technology can be used in laser devices, chemical sensing, navigation, aerospace, and scientific instrumentation.

NASA's Jet Propulsion Laboratory, Pasadena, California

NASA's Jet Propulsion Laboratory has developed a neutral mounting scheme that eliminates the acceleration sensitivity of whispering gallery mode resonators (WGMRs), making them suitable for use in high-precision portable instruments such as optical atomic clocks and high-resolution laser ranging systems. With state-of-the-art WGMR mounting schemes, accelerations induce deformations in the resonator structure, changing its resonant frequency and limiting their usefulness in precision devices. JPL's novel coaxial mounting scheme is capable of reducing and even eliminating these vibration- and acceleration-induced frequency fluctuations, yielding a WGMR with superior frequency stability that can be used for creating ultra-compact, highly stabilized lasers that are ideally suited for use in spectroscopy, sensing, and frequency metrology applications.

With a neutral mounting architecture, the mounting forces are distributed such that the deformation of the optical cavity is null in a given direction, regardless of their amplitudes. This can guarantee that mechanical fluctuations are not transferred to a cavity-length deformation (i.e., to the resonance frequency). Whispering gallery mode disc resonators can only be loaded through normal stresses exerted on the top and bottom surfaces of the disc by clamping the disc between two cylinders with different radii. This neutral mounting scheme creates a radial displacement field that is null at the rim of the disc, regardless of the mounting force intensity.



The finite element numerical results show the disc-resonator deformed from the neutral coaxial mounting scheme. Colors represent the magnitude of radial deformation, and a band where this deformation is zero can be seen along the perimeter of the disc.

Finite element method simulations of a coaxially clamped WGMR have been performed using the following disc dimensions and geometries: inner radius a = 2 mm, outer radius b = 5 mm, thickness = 0.5 mm, and disc symmetry plane aligned on the z axis. The material properties of the disc were based on those of calcium fluoride. The simulations show that optimal mounting configurations are quite robust and can significantly improve frequency stability under a wide range of loading forces.

Potential applications include a small and robust frequency reference for portable and practical devices, laser devices, chemical sensing, navigation, aerospace, frequency metrology, data transfer, and scientific instrumentation.

NASA is actively seeking licensees to commercialize this technology. Please contact Mark W. Homer at Mark.W.Homer@jpl.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/NPO-TOPS-23.

Magnetostrictive Pressure Regulating System

The regulator system offers precise operation with response times up to an order of magnitude faster than current technologies.

Marshall Space Flight Center, Alabama

NASA's Marshall Space Flight Center has developed a set of unique magnetostrictive (MS) technologies for utilization in pressure regulation and valve systems. By combining MS-based sensors with a newly designed MS-based valve, Marshall has developed an advanced MS regulator. This innovative approach provides both a regulator and a valve with rapid response times. In addition, the components are lightweight, compact, highly precise, and can operate over a wide range of temperatures and pressures. A prototype of the MS valve has been developed and NASA is seeking partners for licensure of this novel technology.

Magnetostrictive materials used in valves developed at Marshall allow the

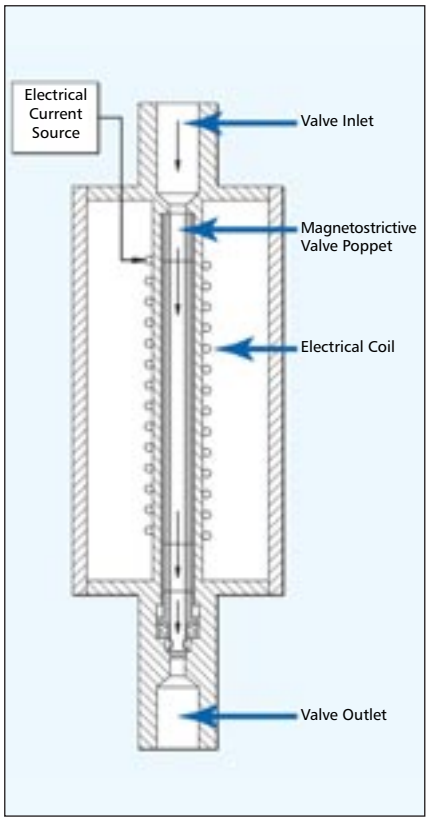
valve to be opened and closed via application of a magnetic field to the outside of the valve envelope. This process contains all moving parts inside the pressure shell, eliminating the need for feedthroughs or mechanical seals. Marshall's valve concept moves the valve coil outside a fluid boundary, keeping the coil from contacting the fluid under flow. This concept features a small valve design no greater than 1/16 OD, and accommodates a digital design whereby multiple elements are used to accommodate larger throughput needs. This results in a highly effective, redundant valve system.

Building on this concept, Marshall's MS regulator is comprised of the MS valve element, an MS-based pressure transducer, and a servo-circuit to control the current to the valve coil. 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.

The regulator system offers precise operation with response times up to an order of magnitude faster than current technologies. By using fewer moving parts and no external or dynamic seals, friction, wear, and leaks are reduced and reliability is increased. The novel design allows alternate parallel pathways to be implemented for increased redundancy, and is also self-adjusting, continuously sensing conditions to maintain precise control and reduce setpoint drift.

Potential applications include use in pressure-fed rocket propulsion systems, aircraft engines, automotive fuel systems, oil-flow control in industrial systems, air and gas compressors, steam turbines, power recovery, power-generating equipment, biomedical device implants requiring pressure/flow control, and drug metering systems.

NASA is actively seeking licensees to commercialize this technology. Please contact Sammy A. Nabors at sammy.nabors@nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/TOP8-108.



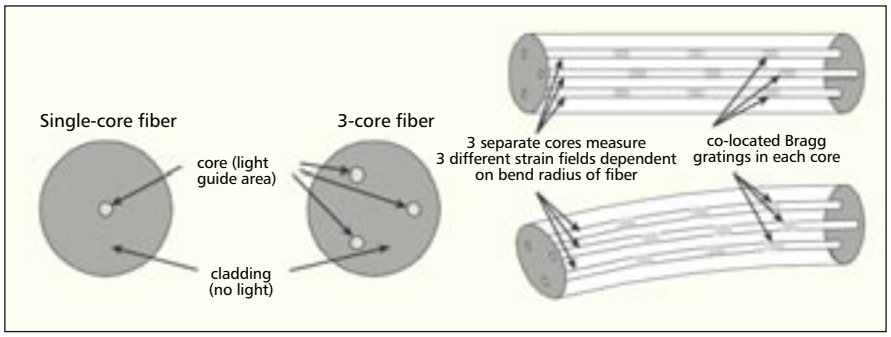
An example of vibration mitigation in a harmonic absorber application.

Shape Sensing Using a Multi-Core Optical Fiber Having an Arbitrary Initial Shape in the Presence of Extrinsic Forces

This technology can be used for aerospace safety, medical applications, robotics, and space exploration.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has demonstrated a patent-pending method and apparatus for determining the position, in three dimensions, of any point on an optical fiber. The new method uses low-reflectance Fiber Bragg Grating (FBG) strain sensors in a multi-core fiber to determine how any point along that fiber is positioned in space. The characteristics of optical fibers and the FBGs vary with curvature, and by sensing the relative change of FBGs in each of three or more fiber cores, the three-dimensional change in position can be determined. By using this method in monitoring applications where optical fibers can be deployed — such as in structures, medical devices, or robotics — precise deflection, end position, and location can be determined in near real time. This innovative position detection method offers 10 times greater positional accuracy than comparable optical techniques.



This diagram shows axial views of single-core and multi-core fiber (left), and bend measurements in multicore fiber with fiber Bragg gratings.

Multi-core optical fibers contain multiple light-guiding cores arranged symmetrically. Sensors, such as FBGs, are embedded into each of the cores (see figure, left). Such an arrangement allows for the measurement of strain in each core of the fiber at specific axial locations along the fiber. When a multi-core fiber is subjected to bending, the strain imposed in each core relative to one another is used to provide position information (see figure, right).

In the past, shape-sensing measurements using optical fibers estimated bending at sequential points along the fiber, and the resulting measurement had many discontinuities and errors. The combination of these errors resulted in a very poor indication of actual fiber position in three-dimensional space.

NASA's patent-pending algorithms and apparatus incorporate not only fiber bending measurements, but fiber twisting measurements, to eliminate previous sources of error. The uniqueness of the algorithm is in how the curvature, bend direction, and twisting information of the fiber are all brought together to obtain a highly accurate 3D location and shape characterization. The new methods have been demonstrated to significantly improve the accuracy of multi-core fiber optic shape sensors.

This technology provides high spatial resolution for fibers up to 10 meters in length, and can be extended to other forms of cable. Potential uses include aerospace safety systems, medical applications, cabled remote vehicles, and space exploration.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-79.

Magnetic and Raman-Based Method for Process Control During Fabrication of Carbon-Nanotube-Based Structures

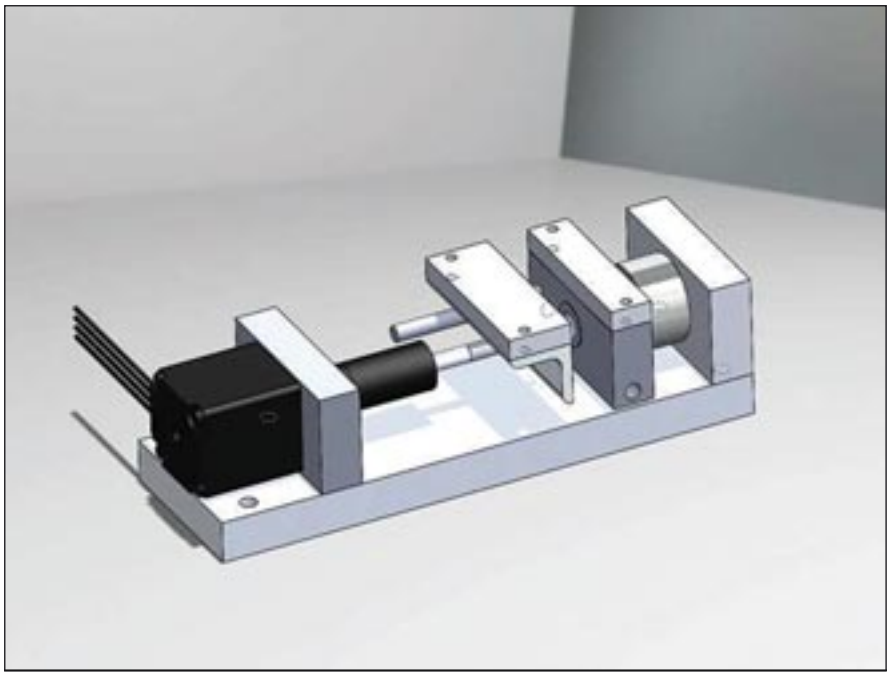
The methodology enables high quality and high yield with about 30% weight reduction over carbon composite materials.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed an innovative magnetic and Raman-based method for macroscopic process control during fabrication of carbon-nanotube-based structures. The development of super-strong, lightweight materials based on carbon nanotubes promises new materials with the strength of current carbon composite materials, but at substantially less weight. The development of these new materials is dependent upon nanotube quality, alignment, and load transfer between individual nanotubes in the structure. However, current fabrication process controls are limited to time-consuming microscopy testing at intermittent stages during processing. NASA's innovative method can be applied during nanotube structure fabrication to obtain real-time feedback on critical processing parameters during fabrication. Moreover, the method is compatible with in-line fabrication processes.

A combination of magnetic and optical methods is applied to characterize the residual catalyst content, nanotube alignment, and load transfer between individual nanotubes during the fabrication process. The techniques used in this method, which have been proven at the micro level, are applied so that scanning and mapping occurs at the macro level. These methods have been successfully used for nondestructive evaluation of large-format carbon nanotube-based structures, primarily yarns and sheets from several inches square to as large as 4 ft. by 8 ft. The new methodology promises to enable high quality and high yields of carbon nanotube-based structural materials for mission critical applications, with an approximately 30% weight reduction over carbon composite materials in applications such as pressure vessels.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-133.



The apparatus for in-situ Raman measurements of materials. (Image credit: NASA)

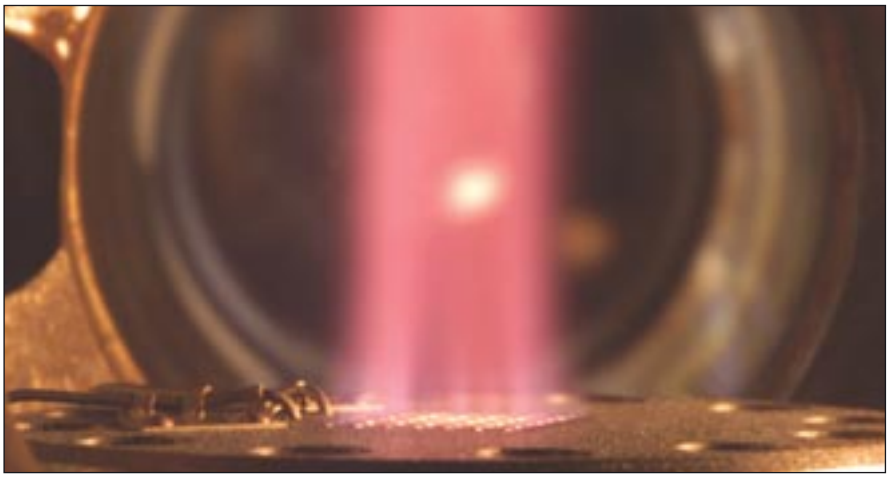
Fully Premixed, Low-Emission, High-Pressure, Multi-Fuel Burner

Applications include use in aircraft, spacecraft, and heating and boilers for commercial and residential systems.

John H. Glenn Research Center, Cleveland, Ohio

NASA's Glenn Research Center has developed a novel design for a fully premixed, high-pressure burner capable of operating on a variety of gaseous fuels and oxidizers, including hydrogen-air mixtures, with a low pressure drop. The burner provides a rapidly and uniformly mixed fuel-oxidizer mixture that is suitable for use in a fully premixed combustion regime that has the benefits of low pollutant emissions (when operated at fuel lean conditions) and freedom from harmful flashback effects, combustion instabilities, and thermal meltdown problems that are normally associated with premixed combustion systems operating at high pressures.

The novel burner technology has been demonstrated to operate on hydrogen-air mixtures at pressures up to 30 bar and at equivalence ratios (Phi) ranging from 0.15 to 5.0, but typically at equivalence ratios below 0.6 or above 2.0 for extended periods of time. It has also been demonstrated to work well with hydrogen-carbon monoxide fuel mixtures in a 1:1 mixture (by volume). The design provides a uniform zone of combustion products and temperatures, and is able to achieve complete and rapid mixing of the reactant gases over a distance as short as 5 mm, with the combustion products reaching a fully reacted state within about 10 mm downstream of the burner face. Furthermore, the design of the burner, which utilizes high-speed jets to prevent flashback, is simple and straightforward to manufacture using conventional techniques. The modular design of the burner lends itself to scalability for larger power output applications. Finally, the burner is simple to operate and is robust for use in an industrial setting, such as a low-emissions stationary gas turbine engine, or for aircraft gas turbine engines.



A photograph of the technology operating at 10 atm inside an optically accessible high-pressure burner facility with premixed stoichiometric hydrogen-air reactants.

NASA is actively seeking licensees to commercialize this technology. Please contact the Technology Transfer Office at ttp@grc.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/TOP3-406.

Selenium Interlayer for High-Efficiency Multi-Junction Solar Cell

This technology can be commercialized for terrestrial applications such as power plants and smart grid systems.

John H. Glenn Research Center, Cleveland, Ohio

Innovators at NASA's Glenn Research Center have developed a low-cost, high-efficiency solar cell that uses a thin layer of selenium as the bonding material between wafers. Selenium is a semiconductor, and it is also transparent to light at photon energies below the band gap. The innovation allows a multi-junction solar cell to be developed without the constraint of lattice matching, and uses a low-cost, robust silicon wafer as the supporting bottom substrate and bottom cell. This enables a cell that is simultaneously lower in cost, more rugged, and more efficient than existing space solar cell designs. This technology has the potential to be used in next-generation solar cells in space, and it can be commercialized for terrestrial applications such as power plants and smart grid systems.

This innovation is a novel method for manufacturing a multi-junction photovoltaic (PV) cell using selenium as a bonding material sandwiched between two multi-junction wafers, enabling higher efficiencies. A multi-junction PV cell differs from a single junction cell in that it has multiple sub-cells (p-n junctions). A multi-junction cell can convert more of the Sun's energy into electricity as the light passes through each layer. Glenn Research Center's multi-junction PV cell has three junctions to improve efficien-

cies further, where the top wafer is comprised of high solar-energy absorbing materials forming a two-junction cell, and the bottom wafer would remain a simple silicon wafer substrate. The three-junction solar cell manufactured using selenium as the transparent interlayer has a higher efficiency than traditional multi-junction cells.

The technology has a 40% expected conversion efficiency. PV cells can be manufactured on a large scale, and have a low environmental impact (zero greenhouse gasses emitted). In addition, the rugged design can be used for both space and terrestrial applications.

This is an early-stage technology requiring additional development. Glenn welcomes co-development opportunities. Potential applications include utility-scale PV power plants, PV distributed generation (PV-DG) for smart grid systems, building-integrated photovoltaics (BIPV), building-applied photovoltaics (BAPV), government communications systems, military and space-based power systems, solar-powered aircraft, unmanned aerial vehicles (UAVs), and satellites.

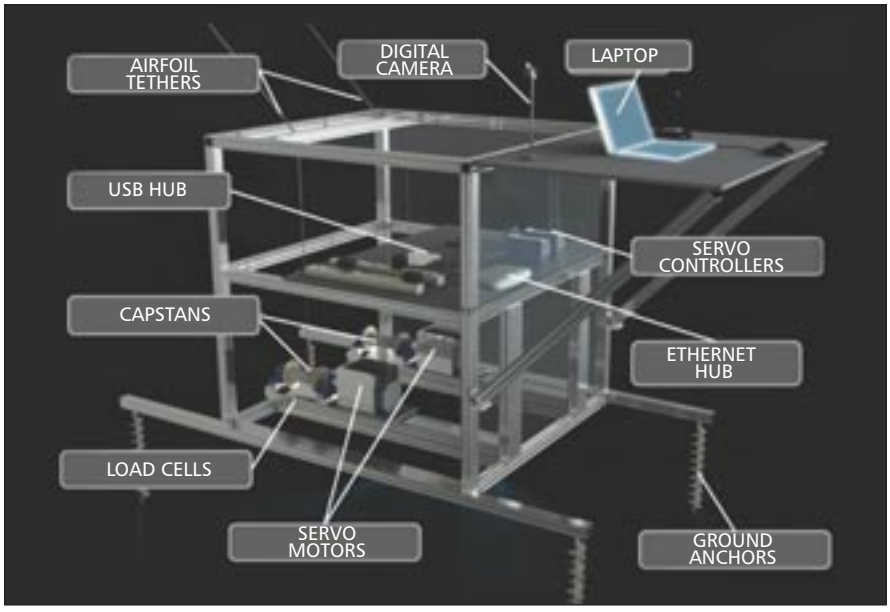
NASA is actively seeking licensees to commercialize this technology. Please contact the Technology Transfer Office at ttp@grc.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LEW-TOPS-50.

Tethered Vehicle Control and Tracking System

The system enables effective operation of airborne wind energy (AWE) generation systems.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed hardware and software to track the flight of tethered vehicles, including kite-like, airborne wind energy (AWE) generation systems. The control system consists of a pan-tilt platform and a visible-spectrum digital camera, combined with tracking control software running on a standard PC. The system controls the flight of the vehicle to keep its position on a power-producing trajectory, maximizing velocity (but within limits). This trajectory produces tension, which turns the ground-based generator, producing the energy. The NASA system enables effective operation of groundgen or flygen types of AWE systems. NASA has a working prototype and pre-beta soft-



The ground station for NASA Langley's wind energy prototype.

ware, and is seeking development partners to make it more robust and user-friendly by testing it in real-world systems.

Comprised of a camera, load cells, encoders, an anemometer, and software, the tracking system is based on digital photo analysis. The system tracks where the kite is 30 times every second. The controller makes an adjustment to the tether winch to keep the kite in the controlled trajectory to maximize power at high velocities without exceeding the limits of the hardware. Langley has built and generated power with a 2-kW demonstrator with two tethers (each with its own servomotor), and a pan-tilt unit to extend the field of view of the camera. NASA has flown the system many times and has collected an abundance of flight data. A video of the demo is available at ***http://www.youtube.com/watch?v=DCfw1B2XGQc.***

The system uses low-cost components, and provides tracking and control for both groundgen and flygen systems (allowing the designer to move the control system from the kite end to the ground). The technology can potentially scale to enable groups of hundreds of kites to fly in flock formation for scalable power. It can be utilized as either a primary or backup system, and can be used in both land-based and offshore applications.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-40.

Method of Forming Textured Silicon Substrate by Maskless Cryogenic Etching

NASA's Jet Propulsion Laboratory, Pasadena, California

NASA's Jet Propulsion Laboratory has developed an advanced energy-storage device to accommodate portable devices, minimize emissions from automobiles, and enable more challenging space missions. The use of silicon for the anode of lithium ion (Li-ion) batteries is attractive because silicon has the highest theoretical charge capacity of any material when used as an anode in a Li-ion battery. Conventional silicon anodes undergo large-volume expansions and contractions with the absorption and desorption of Li ions, however, and this results in pulverization of the anode after several charge and discharge cycles. JPL's innovative Li-ion battery anodes are made of micro-textured silicon, which is able to

accommodate the stress of expansion and contraction during the charging cycle. These robust silicon anodes make high-capacity, rapid-charge-rate Li-ion batteries practical.

JPL's method of cryogenic etching using inductively coupled plasma rapidly and repeatedly produces a micro-scale and/or nano-scale textured silicon substrate known as black silicon over a relatively large area and in a cost-effective manner. Texturing the surface greatly increases the surface area, which increases the kinetic rates and therefore the charging rates of Li-ion batteries. The black silicon needle-like structures are able to accommodate the stresses of charging due to radial expansion and contraction of Li ions during the absorption and desorption of the charging cycle, and the micro-scale texturing avoids the generation of excess solid electrolyte interphase, which until now has inhibited the production of a practical (>2.5 V) battery employing silicon anodes.

A textured silicon anode has been demonstrated having needle-like structures with a depth of about 120 microns and a width of about 10 microns at the widest part. The textured substrate was produced using a two-step etch. The first step created a high-density stubble of black silicon across the surface, while the second step employed a higher forward power, a greater percentage of SF_6, and less O_2 to increase the depth of the etch. Textured silicon anodes allow for Li-ion batteries capable of over 200 Wh/kg.

Potential applications include use in Li-ion batteries, high specific energy batteries for portable electronic devices, plug-in hybrid and electric vehicles, and spacecraft.

NASA is actively seeking licensees to commercialize this technology. Please contact Mark W. Homer at Mark.W.Homer@jpl.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/NPO-TOPS-44.

Preventing Cell-to-Cell Thermal Runaway in Lithium-Ion Battery Modules

Lyndon B. Johnson Space Center, Houston, Texas

Lithium-ion (Li-ion) cells are increasingly used in high-voltage and high-capacity modules. The Li-ion chemistry has the highest energy density of all rechargeable battery chemistries, but associated with that energy is the issue of catastrophic thermal runaway with a fire. With recent incidents in the commercial aerospace and electronics sectors, it was necessary to find methods to prevent cell-to-cell thermal runaway propagation.

The work carried out here is not specific to any existing battery design, and was started with the goal of achieving a common method to trigger a cell into thermal runaway and determine if one can consistently obtain this thermal runaway event. The second goal was to determine if cell-to-cell thermal runaway can be prevented.

Li-ion cell-to-cell thermal runaway propagation was studied using a heat-to-vent/thermal runaway method. The trigger method was a commercial heater tape. Different cell designs of various Li-ion chemistries, as well as physical formats, were studied. Testing consisted of designing the cell modules with just spacing between the cells, introduction of a radiant barrier, and placing the cells in a module manufactured using intumescent materials. It was determined that at least 2-mm spacing was required for cylindrical cell designs. For cell formats that had vents on the side, a physical separation between neighboring cells was required. This was achieved by using intumescent materials as well as the radiant barrier.

The methods and designs used to prevent cell-to-cell thermal runaway in Li-ion modules consisted of increased cell-to-cell spacing, introduction of a radiant barrier between the cells, the use of intumescent cell modules that provide physical separation between the cells, and a method to absorb the heat from the cells, preventing the heat from directly affecting the neighboring cells by lowering the heat spread to the neighboring cells.

This work was done by Judith Jeevarajan and Joseph Orieukwu of Johnson Space Center, and Carlos Lopez of Texas A&M University. ***NASA is seeking partners to further develop this technology through joint cooperative research and development. For more information about this technology and to explore opportunities, please contact jsc-techtran@mail.nasa.gov.*** *MSC-25942-1*

System and Method for Space Utilization Optimization and Visualization

The program uses a standard Web browser to allow for visualization of an entire organization down to individual rooms.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed a space-allocation and planning software system to allow for more effective and efficient facility usage. It also provides a customizable strategy for organizing personnel and project teams to maximize productivity and synergies among employees. Cost-reduction solutions are suggested based on organizational input constraints related to the facility. The program uses a standard Web browser to allow for visualization of an entire organization down to individual rooms. The planning tool is based on algorithms that were developed using ArcGIS software and Visual Basic codes, which enable evaluation of different space-management scenarios in real time.

A screenshot of NASA's space utilization tool.

The robust and highly flexible software package was developed in response to an internal need for more efficient and effective facilities management. Available software did not allow for the customization needed in a large, robust organization. A GIS visualization technique combined with optimization techniques was designed. The software provides visual representation of not only physical space, but also of color-coded employee teams through a Web-based portal.

The software has the capability of retrieving data from multiple, dynamic data sources and automatically resolves any consistency issues. Rules for mapping the source data have been defined by an XML model, so the user can access the program via any Web browser. The system will model the desired space, and display it according to user-generated constraints and metrics. This visualization can be expanded to the entire organization, or detailed down to the room level. Constraint and metric inputs might include, but are not limited to, personnel resource requirements, space compatibility, move costs, and synergies among employees. Finally, the software identifies fragmented personnel organizations and inadequate space utilization, and suggests where there might be opportunities for efficiencies. This allows the user to evaluate and compare different scenarios with cost savings (annual efficiencies) tracking. Inevitably, the software will be able to suggest solutions that are optimal for that facility.

The software can be used for optimizing, coordinating, and/or preparing large, complex government and corporate facilities, technical and laboratory space, and multi-national or multi-building office space.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-107.

Reducing Sensor and Readout Circuitry Noise in Digital Domain Using Reference Pixels

Goddard Space Flight Center, Greenbelt, Maryland

One of the main heritage tools used in scientific and engineering data spectrum analysis is the Fourier Integral Transform and its high-performance digital equivalent — the Fast Fourier Transform (FFT). The Fourier view of nonlinear mechanics that has existed for a long time and the associated FFT carry strong a-priori assumptions about the source data, such as linearity and being stationary. Natural phenomena measurements are essentially nonlinear and nonstationary.

A recent development at the NASA Goddard Space Flight Center (GSFC),

known as the Hilbert-Huang Transform (HHT), proposes a novel approach to the solution for the nonlinear class of spectrum analysis problems.

The present innovation is an engineering tool known as the HHT Data Processing System (HHTDPS). The HHTDPS allows applying the Transform, or "T," to a data vector in a fashion similar to the heritage FFT. It is a generic, low-cost, high-performance personal computer (PC)-based system that implements the HHT computational algorithms in a user friendly, file driven environment. Unlike other signal processing techniques such as the Fast Fourier Transform (FFT1 and FFT2) that assume signal linearity and stationarity, the Hilbert-Huang Transform (HHT) utilizes relationships between arbitrary signals and local extrema to find the signal instantaneous spectral representation.

Using the Empirical Mode Decomposition (EMD) followed by the Hilbert Transform of the empirical decomposition data, the HHT allows spectrum analysis of nonlinear and nonstationary data by using an engineering a-posteriori data processing, based on the EMD algorithm. This results in a non-constrained decomposition of a source real value data vector into a finite set of Intrinsic Mode Functions (IMF) that can be further analyzed for spectrum interpretation by the classical Hilbert Transform.

The HHTDPS has a large variety of applications and has been used in several NASA science missions. NASA cosmology science missions, such as the Joint Dark Energy Mission (JDEM/WFIRST), carry instruments with multiple focal planes populated with many large sensor detector arrays. The sensor-readout electronics circuitry must perform at extremely low noise levels.

A new methodology and implementation platform using the HHTDPS for readout noise reduction in large IR/CMOS hybrid sensors was developed at GSFC. The GSFC scientists have also used the algorithm to produce the first known Hilbert-Transform-based wide-field broadband data cube constructed from actual interferometric data. Furthermore, HHT has been used to improve signal reception capability in radio frequency (RF) communications.

This NASA technology is currently available to the medical community to help in the diagnosis and prediction of syndromes that affect the brain, such as stroke, dementia, and traumatic brain injury. The HHTDPS is available for non-exclusive and partial field of use licenses.

The HHT Data Processing System is broadly applicable to analyzing nonlinear and nonstationary signals while improving the accuracy of linear- and stationary-signal analysis. Potential applications include structural damage detection, analyzing dynamic and earthquake motion recordings in studies of seismology and engineering, pitch determination in speech recognition, geometrical signal processing, biological signal processing, geophysical signal processing, and analyzing nonstationary financial time series.

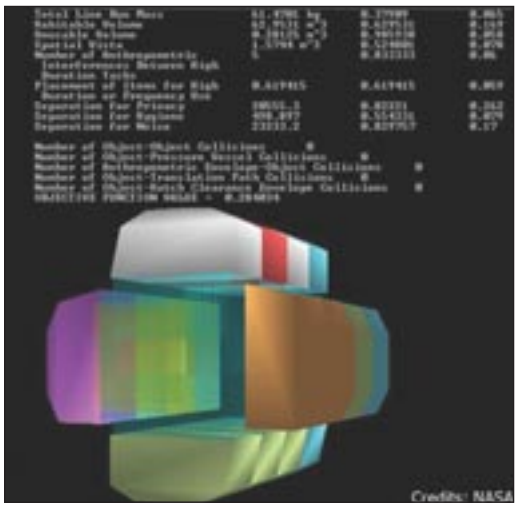
NASA is actively seeking licensees to commercialize this technology. Please contact the Strategic Partnerships Office at techtransfer@gsfc.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/GSC-TOPS-63.

Method and Software Tool for Evaluation and Automated Generation of Space Habitat Interior Layouts

The software can help design space habitats, submarines, ships, aircraft, recreational vehicles, and small residences.

Langley Research Center, Hampton, Virginia

NASA has developed a new software tool for optimizing interior layout designs of highly constrained, highly integrated, and/or confined spaces, such as space habitats. This tool will automatically generate or evaluate interior layout options while taking into account multiple end-user objectives. Development and evaluation of interior layouts are often ignored during conceptual design because of the subjectivity and long times required using current evaluation methods (e.g., human-in-the-loop mockup tests and in-depth CAD evaluations). The NASA tool will allow for early, more objective assessment that will prevent expensive design changes, which can increase vehicle mass and compromise functionality.



An OpenGL output of the layout evaluation tool.

After evaluating interior layouts against multiple objectives and constraints, the software will automatically generate feasible layout alternatives that perform well across these objectives. The method uses geometric modeling and a multi-criteria objective function to assess layout alternatives in seconds, enabling optimization of layouts based on designer preferences. For spacecraft or similar designs, this innovation will allow for the early determination (in the conceptual phase) of the adequacy of habitat size and the identification of potential design issues related to layouts. The tool will generate higher-fidelity conceptual designs, leading to mass and cost savings. Although the technology has been implemented for conceptual space habitat applications, it is also relevant to other highly constrained human systems, such as submarines, naval vessels, aircraft, recreational vehicles, small terrestrial residences, some factories, and workstation design.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-217.

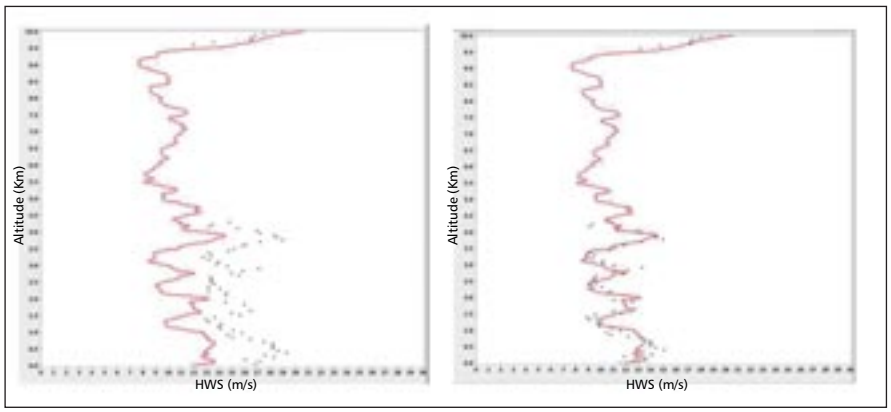
Airborne Wind Profiling Algorithm for Doppler Wind Lidar

This novel method enables accurate, real-time parameter estimation in noisy environments.

Langley Research Center, Hampton, Virginia

NASA's Langley Research Center has developed an algorithm, Airborne Wind Profiling Algorithm for Doppler Wind Lidar (APOLO), that offers highly accurate, real-time measurement of wind parameters (i.e., direction and speed) by airborne wind lidar sensors. APOLO enables the extraction of accurate wind speed and direction from noisy flight environments, and provides correction for instrument installation biases. The algorithm has been incorporated into a supporting software package that displays accurate airborne Doppler wind lidar data, and offers several data post-processing and display functionalities. The offset compensation and parameter extraction technology could be used in a variety of applications where the motion and orientation of a lidar sensor may result in data inaccuracy. NASA is seeking licensees that may benefit from integration of the compensation algorithm and data post-processing software into existing or developing systems.

APOLO and its supporting data processing package were developed for NASA's Doppler Aerosol Wind (DAWN) lidar to compile three-dimensional wind profiles for improved hurricane forecasting models. The data acquisition and processing software displays wind profile parameters that include Doppler shift, power distribution, wind direction, and wind velocity. Doppler shift created by aircraft motion is measured by the internal navigation and GPS system, and is fed to a signal processing system that utilizes APOLO for real-time removal of aircraft effects from wind measurements. APOLO also corrects instrument offsets that arise from GPS/INS unit misalignment, lidar telescope misalignment, and scanner installation bias. Offset compensation routines, based on the minimum mean square error principle, estimate offset angles using ground-return lidar data to compensate for their adverse effect to wind parameter estimation. APOLO utilizes two perpendicular lines-of-sight Doppler shift observations, compensation for aircraft motion along each line of site, then a vector sum to determine wind parameters.



An offset compensation comparison for headwind speed using APOLO. The data was collected on September 1, 2010, during NASA's Genesis and Rapid Intensification Processes (GRIP) hurricane mission at an altitude of 10,608 meters. The left graph is without offset compensation, and the right graph is with offset compensation. The red line represents dropsonde data; black dots are lidar-collected data.

The technology has been utilized in a flight environment, and wind vectors have been measured from altitudes as high as 10 km. Plots of wind speed data produced by the lidar data analysis package are provided in the figure. Similar plots of wind direction as a function of altitude are also generated from the lidar measurements.

This technology has applications in the following areas: clear air turbulence and aircraft wake detection systems for aircraft safety, 3D wind mapping for offshore turbine placement optimization and economic analysis, upward-looking buoy-mounted lidar for offshore turbine placement optimization and economic analysis, study of weather and wind patterns in meteorology, aircraft-mounted imaging and mapping lidar for aerial geographic surveys, and shipborne mapping and navigation lidar for oceanographic surveys.

NASA is actively seeking licensees to commercialize this technology. Please contact The Technology Gateway at LARC-DL-technologygateway@mail.nasa.gov to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TB2016/LAR-TOPS-42.

NETMARK Fast Search

Applications include enterprise knowledge management, and document and content management systems.

Ames Research Center, Moffett Field, California

The problem that motivated this work was one of analyzing hundreds of thousands of records of historical problem failure reports (aka, problem reports and corrective actions — PRACA) for improved mission safety. Whenever there is an anomaly in mission design or operations, the anomaly gets entered into a problem failure reporting database for tracking purposes. The objective of the research was to make this data queryable and analyzable using the NETMARK XML database.

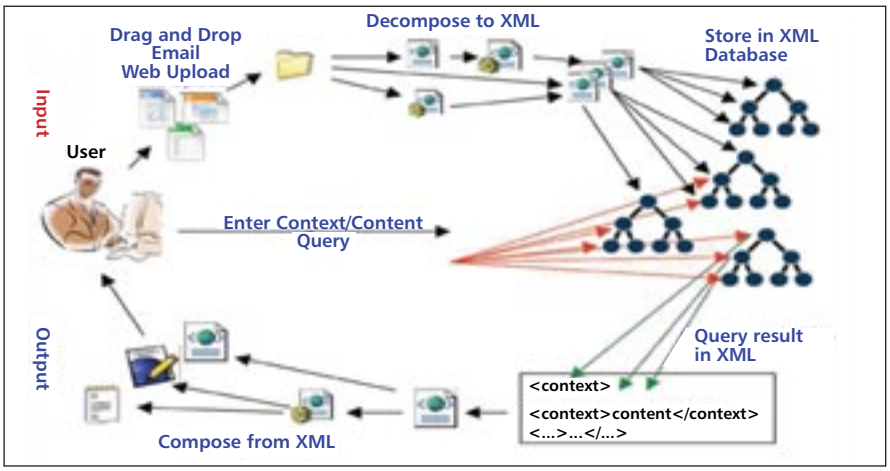
NETMARK software is a unique innovation designed to seamlessly integrate structured, semi-structured, and unstructured

data and documents across enterprise organizations. Originally developed to integrate the vast quantities of complex, heterogeneous documents existing within NASA, this schema-less integration technique and framework offers a highly scalable, open enterprise database architecture that eliminates or reduces the need for database design and administration, and converts information from a wide range of data types into a single, universal data type for storage, retrieval, and content and context-sensitive query and search. A production-ready, enterprise-level application, NETMARK rapidly assimilates and retrieves gigabytes of disparate information, and can be easily integrated with existing applications as well as accommodate new data formats fitting into the legacy data network, while growing with evolving technologies and business practices.

NETMARK takes advantage of an object-relational model and the eXtensible Markup Language (XML) standard, along with an open, extensible database framework to dynamically generate arbitrary schema stored within relational databases and an object relational database management system. NETMARK maps XML-encoded information into a true data model by employing a customizable data type definition structure, defined by an SGML parser to model the hierarchical structure of XML data regardless of any particular XML document schema representation.

By achieving a true XML data model, NETMARK can help enterprise organizations make better use of the information they need to make business decisions by converting Web pages, text documents, PDF files, spreadsheets, presentations, and other document types into a single, universal data type, then storing it in an object-relational database. Users can query this database with searches that are based on content or contextual associations. Query results then can be composed into different data types, including presentations, spreadsheets, and text documents, enabling rapid reuse of information and broadening the scope of data from which users can gain knowledge and make decisions.

Most traditional document management systems do not provide an easy and efficient mechanism to store, manage, and query relevant information from heterogeneous and complex data types. To do so, database management systems need a standard for common data and exchange. The industry standard, XML, places structure within documents. The traditional mapping model is limited because the hierarchy is different for each set of XML documents. In contrast, NETMARK's SGML parser models the documents themselves and its structure is the same for all XML documents, providing independence of any particular XML document schemas.



NETMARK's schema-less integration technique converts information from many different data types into a universal data type for unprecedented information assimilation and retrieval across the enterprise.

This work was done by David Maluf and Chris Knight of Ames Research Center; and David Bell of USRA-RIACS. ***NASA is actively seeking licensees to commercialize this technology. Please contact Trupti Sanghani at trupti.d.sanghani@nasa.gov or 650-604-6889 to initiate licensing discussions. Follow this link for more information: http://technology.nasa.gov/patent/TOP2-119.*** *ARC-15722-1*

Python Interface to T-Matrix Scattering Computations (PyTMatrix)

NASA's Jet Propulsion Laboratory, Pasadena, California

PyTMatrix is a Python interface to a T-matrix numerical scattering computation code originally developed at NASA GISS (Goddard Institute for Space Studies). It integrates into the NumPy/SciPy scientific framework. The software provides streamlined access to numerical T-matrix computations directly from the Python programming language. It retains the original numerical core written in Fortran 77, thus combining the flexibility of Python and the numerical performance of Fortran. It also provides tools for post-processing the output by integrating over various particle size and orientation distributions.

The PyTMatrix package was designed with the objective of providing a simple, extensible interface to T-Matrix electromagnetic scattering calculations performed using an extensively validated numerical core. The interface, implemented in the Python programming language, facilitates automation of the calculations and further analysis of the results through direct integration of both the inputs and the outputs of the calculations to numerical analysis software.

The software enables rapid specification of inputs (e.g., particle size, wavelength) and the integration of the outputs into further numerical analysis. These features are lacking in most comparable codes. For example, the original Fortran code used as part of the software needs to be recompiled for new input parameters.

The software is used to compute the electromagnetic scattering properties of spherical, spheroidal, and cylindrical particles. The focus is on microwave and light scattering by particles in the atmosphere, but these computations have many applications in optics and radio science.

This work was done by Jussi S. Leinonen of Caltech for NASA's Jet Propulsion Laboratory. ***This software is available for license through the Jet Propulsion Laboratory, and you may request a license at: https://download.jpl.nasa.gov/ops/request/request_introduction.cfm.*** *NPO-49724*

New on the MARKET

Product of the Month

National Instruments, Austin, TX, announced LabVIEW 2016 system design software that introduces new channel wires to simplify complex communication between parallel sections of code. Available on both desktop and real-time versions of LabVIEW, the channel wire method helps improve code readability and reduces development time. The software features enhanced interoperability with Python and third-party devices. Five add-ons are now supported with LabVIEW 64-bit that enable users to harness all the memory of an operating system when developing and debugging applications. The software offers an Instrument Driver Network that supports 500 new instrument control drivers, as well as increased integration with open-source platforms such as Linux and Eclipse.

For Free Info Visit http://info.hotims.com/61066-120

Product Focus: Power Management

Power Converters

Schaefer, Hopkinton, MA, introduced the C/B 4800 Series 6U DC/DC and AC/DC converter modules ranging in output power up to 5kW. Nine DC input ranges are standard, and AC input options are 1-Phase 115VAC or 230VAC, as well as 3-Phase inputs of 3 × 200VAC, 3 × 400VAC, or 3 × 480VAC. Battery charging models are also available. All modules feature a standard operating temperature of -20 to +75 °C.

For Free Info Visit http://info.hotims.com/61066-100

Energy Device

Murata Americas, Smyrna, GA, released UMAL, a low-profile energy device that delivers a slim, high-capacity energy source with a nominal voltage of 2.3 VDC. It can supply 12 mAh with a maximum discharge current of 120 mA, and withstands load fluctuations. It has a low internal resistance of 200 mOhm, and operates over the temperature range of -20 to 70 °C.

For Free Info Visit http://info.hotims.com/61066-103

Power System

North Atlantic Industries, Bohemia, NY, announced the VPX56H-6 6U rugged VPX power product that provides up to 1,000 Watts of power (CC4 temperature range, full load) with five outputs, and is compliant with MIL-STD-704F. Other features include current share, remote error sensing, and a built-in EMI filter compliant with MIL-STD-461F. It has VITA 62 compatible keying, outputs and signaling, user programmability, I2C communication, geographical addressing, programmable over-temperature monitor, and a status LED.

For Free Info Visit http://info.hotims.com/61066-101

Power Distribution Boxes

Phoenix Contact, Harrisburg, PA, offers M12 power distribution boxes designed for field-based power supply voltages of 24V. The boxes, in combination with standard M12 power cables of 4 ×10 AWG conductors, can eliminate voltage drop that occurs across long cable runs. The boxes have four T-coded M12 receptacles with a current load of up to 10 A per channel.

For Free Info Visit http://info.hotims.com/61066-104

Power Supplies

The PS5R-V DIN-rail power supplies from IDEC Corp., Sunnyvale, CA, includes 7.5W, 10W, 15W, 30W, 60W, 90W, 120W, and 240W versions. Operating temperature ranges from -25 to +75 °C, enabling the supplies to be used in control panels without the need for air conditioning or other cooling devices. Other features are spring-up screw terminals that accept ring and fork terminals, as well as stripped wire.

For Free Info Visit http://info.hotims.com/61066-102

Power Modules

TDK-Lambda Americas, National City, CA, introduced the TDK-Lambda PFE1000FA series of AC-DC power modules that enables designers to utilize a single device containing power factor correction, regulation, and input-output isolation. The modules operate from a universal input of 85-265Vac, and are available with nominal outputs of 12, 28, and 48Vdc. They deliver full power with an operating baseplate temperature range of -40 to +100 °C.

For Free Info Visit http://info.hotims.com/61066-105

The U.S. Government does not endorse any commercial product or service identified in this section.

New on the Market

Electronics Enclosures

Intermas US, Alpharetta, GA, offers cabinets, housings, sub-racks, and accessories for 19" rack systems and small form factors used in PCI, VME/VME64x, cPCI, IEEE, and communication applications with EMI- and RFI-shielded protection. InterShell aluminum housing enclosures are composed of a top and bottom, two front panels, and four screws, and are used for the packaging of small electronic units such as Eurocard formats with 100 × 160 mm, universal formats, or as mITX formats.

For Free Info Visit http://info.hotims.com/61066-106

Smart Graphics Displays

The OMEGA® OM-SGD Series panel meters from OMEGA Engineering, Stamford, CT, are bright color TFT smart graphics displays available in three screen sizes. They offer an operating power supply voltage range of 4 to 30 Vdc and two alarm outputs. Waterproof NEMA 6 (IP67) versions are also available. Customized colors, text labels, input scaling, and units can be specified before uploading the selected display configuration to the meter via USB interface to the PC.

For Free Info Visit http://info.hotims.com/61066-107

Digital Storage Oscilloscope

The Global Specialties DSC-5300 digital storage oscilloscope from Global Specialties, Yorba Linda, CA, is a portable benchtop instrument used for making measurements of signals and waveforms. The oscilloscope offers two channels with a bandwidth of up to 50 MHz. With a real-time sampling rate of up to 500 MSa/s and 32 kpts of deep memory, it provides analysis on a 7" color LCD display. Users can save or load to and from the scope using 10 internal locations for waveforms and 20 locations for scope settings.

For Free Info Visit http://info.hotims.com/61066-108

Coin Cell Batteries

llinois Capacitor, a subsidiary of Cornell Dubilier Electronics, Lincolnwood, IL, offers RJD Series lithium-ion coin cell batteries that feature encapsulation technology that increases storage capacity by completely utilizing the space within the cell case. The batteries are available in eight capacity levels, leaded or with conventional flat terminals. Each is rated at 3.7VDC. Operating temperature range is -20 to +60 °C.

For Free Info Visit http://info.hotims.com/61066-109

3D Printer

Rize, Inc., Woburn, MA, announced the Rize One zero-post-processing desktop 3D printer that features a patented Augmented Polymer Deposition (APD™) process and Rizium™ One engineering and medical-grade thermoplastic filament. Users release a 3D printed part from its support structure cleanly, safely, and in seconds with bare hands. No filing or sanding are required. The system 3D prints photorealistic color on thermoplastic parts, and prints multiple parts simultaneously.

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Fluid Metering, Inc.

Free Info at http://info.hotims.com/61066-752

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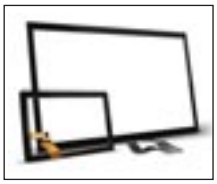

Elo announces the expansion of the TouchPro™ PCAP line, adding to their all-glass Pro-G line to include sizes up to 70" with the mesh Pro-M line. Elo's robust standard and custom PCAP screens are designed to provide high performance and cost effective solutions for demanding commercial and industrial applications. EloComponents.com

Elo Touch Solutions, Inc.

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New Evanscap TDDs are energy-dense supercapacitors with more than 2x peak discharge of similar capacitors. The patent-pending design significantly increases power, reduces ESR, and reduces heat. Pulse currents, duty cycles, and durability all increase. Voltage droop is minimal. TDDs often eliminate external cooling requirements, saving system space, weight, and cost. 10V to 125V at 85°C. For more information visit Evans Capacitor Company at www.evanscap.com.

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NASA's Technology Transfer Program

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of laboratories and business support entities. The network includes ten NASA field centers, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. To explore technology transfer, development, and collaboration opportunities with NASA, visit **technology.nasa.gov**.

NASA's Technology Sources

Ames Research Center
Selected technological strengths: Information Technology; Biotechnology; Nanotechnology; Aerospace Operations Systems; Rotorcraft; Thermal Protection Systems.
David Morse
(650) 604-4724
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Armstrong Flight Research Center
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Unmanned Research Aircraft Test Cutting-Edge Innovations

NASA-funded aircraft tests parameters that can't be modeled in simulations.

Born out of a desire for aircraft to be able to take off and land capably at airports with shorter runways to alleviate congestion at the major hubs, the circulation control wing concept has been floated by the aeronautical community as a possible solution for decades. The technology calls for increased amounts of high-pressure air, derived from either the jet engines or separate compressors, to flow over the leading and trailing edges of the wings, creating greater lift. Given extra lift, an aircraft can take off and land at a lower speed, thus reducing the length of runway needed. Extra lift also enables increased weight-carrying capacity.

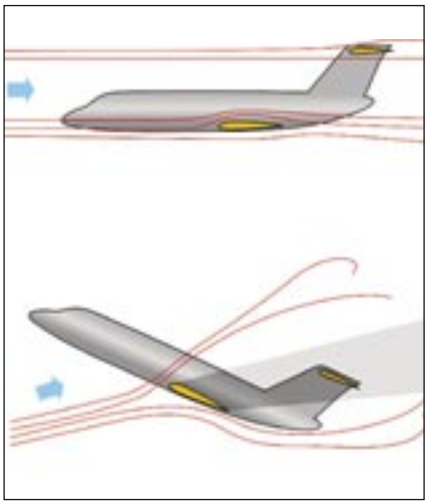
To test an idea that had yet to see flight time, NASA's Dryden Flight Research Center (now Armstrong Flight Research Center) put out a call in 2006 through the Small Business Innovation Research (SBIR) program for the design and manufacture of an unmanned, sub-scale test aircraft outfitted with circulation control wings that could fly with or without the technology.

"The goal would be, you fly the baseline aircraft and see how long it takes to take off and land, and then compare it to the new technology," said Armstrong aeronautical engineer Bruce Cogan. A host of other parameters would also be tested, including how the circulation control wing responded to aerodynamic stalling, whereby an aircraft simultaneously loses lift and altitude. "And since stalling cannot be modeled well in a wind tunnel or in a simulation, it's one of those areas where you have to get flight test data, and because this is a risky maneuver, unmanned testing is always better."

Area-I Inc. of Kennesaw, GA garnered Phase I and II SBIR funding primarily for developing the aircraft's design, and the company used grants from the state of Georgia, along with its own money, to build a prototype. Nick Alley, Area-I's CEO, oversaw the circulation control wing project and finished constructing the aircraft in 2011.

In the intervening years, however, NASA had begun to focus on other aeronautical research, and two of the Agency's centers were soliciting SBIR proposals for the development of different research aircraft. Armstrong was looking for an economical, sub-scale baseline model akin to a medium-range, narrow-body, twinjet airliner for aerodynamics investigations, and Langley Research Center, through the Aviation Safety Program, needed a regional-type, sub-scale airplane with a T-tail empennage and a rear engine mount. T-tail aircraft can have more severe stall characteristics, so Langley researchers wanted to fly a small-scale facsimile into extreme conditions and experiment with recovery maneuvers. The data gathered from those tests would be used to develop a model for a pilot-training simulator.

The aircraft Area-I had constructed to test the circulation control wing technology was highly adaptable. "The unforeseen genius of the aircraft was that we inadvertently designed a platform that was reconfigurable in the way we designed the molds and the tooling," Alley said. "We could, for a minimal amount of effort relative to designing a whole new airplane from the ground up, reconfigure it and put a different type of wing on it or do a whole bunch of other things as needed." Banking on its versatility, he named his baseline aircraft PTERA — Prototype-Technology Evaluation Research Aircraft — and applied for and received Phase I SBIR funding from both Armstrong and Langley to develop the pair of what Alley calls his "flying laboratories" in 2011. He received Phase II funding from both centers to continue work the following year.



An aircraft with a T-tail empennage in normal flight (top) versus when it's in a deep stall condition, whereby the wake created by the stalled wings blankets the T-tail, preventing normal recovery.

In 2014, Area-I completed construction of both aircraft, in addition to another model similar to Armstrong's medium-range twinjet airplane that the company is keeping for commercial use. Armstrong's model is 10 percent the size of its commercial counterpart, while Langley's plane — which the center named PTERA GMA-TT, for Generic Modular Aircraft T-Tail — is about 16 percent of full-scale, and represents the flight dynamics of a mid-sized regional jet transport.

With their respective aircraft at hand, both centers see a lot of potential. In addition to improving pilot performance during stall, a secondary goal for GMA-TT would be to test related alerting and automation technologies, said David Cox, who is element lead for sub-scale testing at Langley.

Armstrong's interest in aerodynamics opens up numerous research possibilities using PTERA. Plans are in place to test wing tips made of shape-memory alloys, which can change their shape at certain temperatures to reduce drag or maximize control at various stages of the flight envelope. "We could test a number of other wing innovations as well, along with assorted sensors and promising algorithms," said Cogan. "The baseline PTERA is designed for experimenting on a range of technologies, so it's certainly capable."

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Wednesday, October 12, 2016 at 2:00 pm U.S. EDT

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Speaker:

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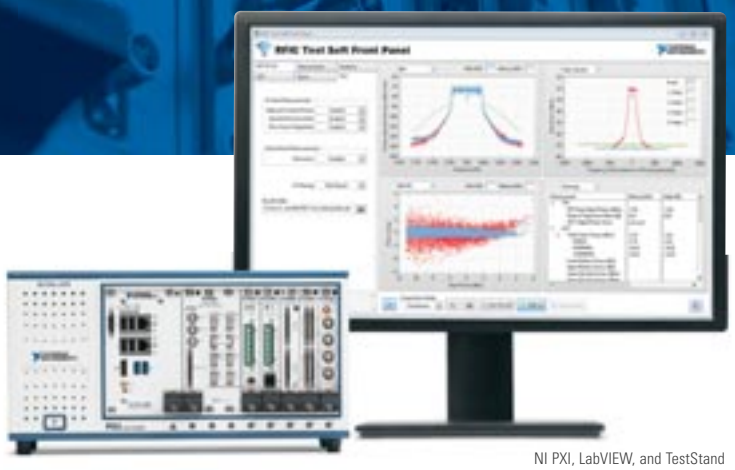

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MOTION CONTROL and Automation Technology

Hexapods help users test image stabilization systems by providing precise, repeatable motion simulation. See page IIa.

Supplement to *NASA Tech Briefs*

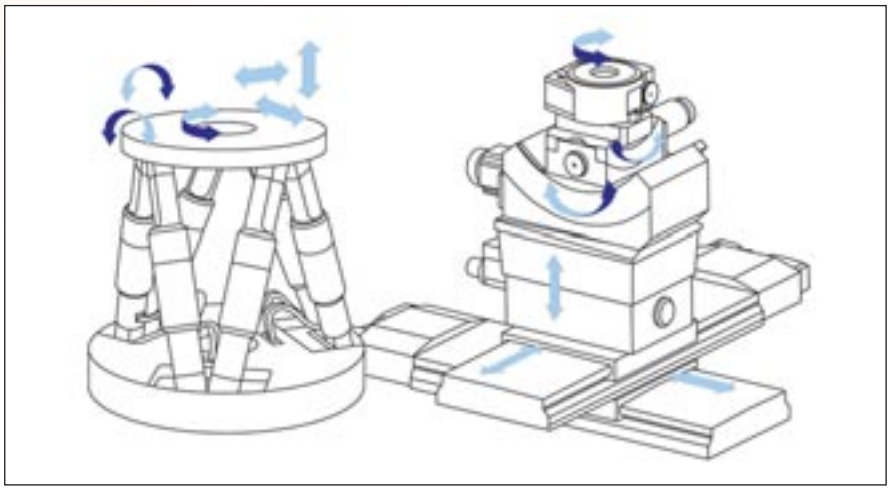
www.techbriefs.com/motion

PRECISION ROBOTICS AND AUTOMATION:

Hexapods Advance Production Processes

Hexapods — six-legged parallel-kinematic machines — are quickly gaining ground in a broad range of industrial automation applications after "learning" how to directly communicate with PLC or CNC controllers via Fieldbus interfaces. As far as the semiconductor and electronics industry, automobile industry, and precision assembly are concerned, many production processes have become inconceivable without them. Today, the six-axis positioning systems are available with load capacity from 2 kg to 2000 kg, and travel from 10 to hundreds of millimeters while maintaining sub-micron precision. Hexapods are used for aligning the smallest optical components in the latest silicon photonics production processes, for controlling automated labeling machines, and positioning entire body parts for automotive production. The intrinsic hexapod features contribute to a wealth of new possibilities in robotics.

There are two methods of constructing multi-axis positioning systems: serial kinematics and parallel kinematics. Stacked serial kinematic systems are easy to design and control; however, there are a number of drawbacks compared to the more powerful and elegant group of parallel kinematic machines.



Comparison of serial- and parallel-kinematics 6-axis motion mechanics. (PI)

Hexapod in a labeling robot prototype. (Tirelli/PI)

Parallel Kinematics and Their Advantages

Each actuator in a serial-kinematic multi-axis system is assigned to exactly one degree of freedom. When position sensors are integrated, they are also each assigned to one drive, and only measure the motion on the corresponding positioning axis. Any undesirable motion in the other five degrees of freedom that occur, for example, as a result of guiding errors of the individual axes, cannot be detected or compensated. In a hexapod, however, all actuators directly drive the same platform. The accumulation of drive train and guiding errors — common with stacked systems — does not occur with well-designed parallel kinematics.

Hexapods also have no dragged cables, reducing friction or torque on the motion platform while increasing lifetime. In addition, hexapods are stiffer, more compact, and together with a significantly reduced inertia (moving mass), can provide faster response and settling resulting in higher dynamics, repeatability, and accuracy.

Mechanics, Controls, and Software

The mechanical design is critical for stiffness, accuracy, repeatability, and lifetime. Many details (such as spherical rolling joints) that seem like a good idea at first glance turn out to be a dead end. The flexibility and versatility depends on the controller and software.

Hexapod six-axis positioning systems are available with load ratings from 2 to 2000 kg and travel ranges from just a few to several hundred millimeters, providing precision in the sub-micrometer realm. (PI)

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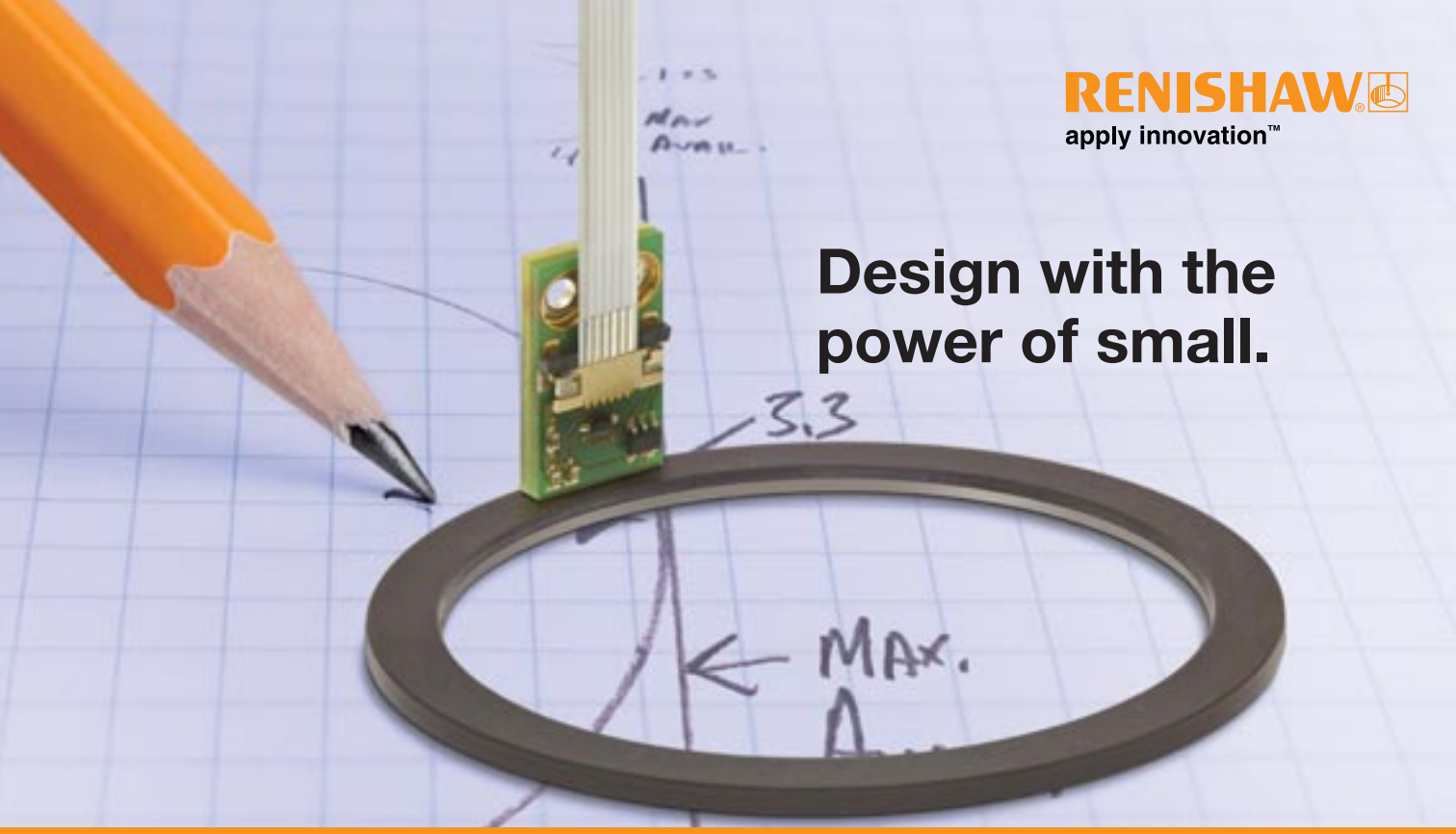

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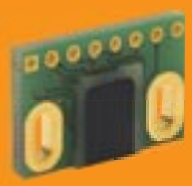

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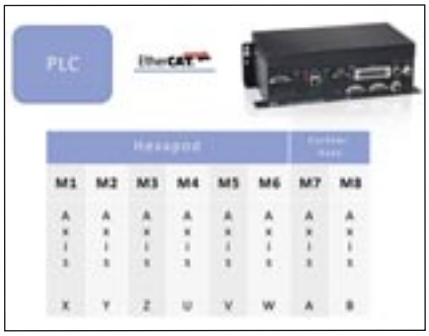
For example, unlike with serial kinematics, if you want to move a platform in just one axis, the controller has to change the individual lengths of each strut — some will extend and some will contract. The required coordinate transformations and path calculations need a powerful controller capable of running hundreds of thousands of operations per second, because there is no linear dependence on the current coordinates. The stiffest mechanical designs are based on cardanic joints with an offset between the axes, making the math even more complex.

Generally, there is no analytical solution, and CPU-intensive, iterative algorithms are required to recalculate the complex hexapod kinematics for each step. All of this is transparent to the user, who does not need to worry about implementing the hexapod kinematics on the PLC. A dedicated digital hexapod controller serves motion with sub-micron precision by tightly controlling each actuator in real time. Linear and rotary motion of the platform is simply commanded in Cartesian coordinates.

An essential feature of the hexapod system allows the adaptation of both the position and the alignment of the reference coordinate system and the pivot point by simple software commands. To adapt the trajectory perfectly to the requirements of the application, work and tool coordinate systems can be defined referring to the position of the workpiece or tool. This function saves valuable time in industrial automation and photonics alignment tasks.

Robust hexapod joints. Cardanic joints (top) with Z-offset provide the highest stiffness and best orientation-independent performance, but require more advanced algorithms. Spherical bearings (bottom) are not recommended due to their lower stiffness and directional dependency. (PI)



The controller communicates with the hexapod via a standard protocol such as EtherCAT. (PI)

All PLC standard language functions are available for controlling the hexapod systems; the controller communicates with the hexapod via a standard protocol. Established Fieldbus protocols, such as EtherCAT or ProfiNET, are available for this purpose; additional RS-232 and TCP/IP interfaces are integrated as well. With the help of these interfaces, it is possible to exchange time-synchronized data, such as target and actual positions or status information, in real time both with the hexapod system and any other components in the network.

In a typical automation application, the corresponding Cartesian target positions, or trajectories, are generated by a master controller (e.g., a standard software PLC with TwinCAT) and transmitted to the hexapod system via the EtherCAT protocol or similar, and in return, the actual positions and status information can be polled. System parameters such as the center of rotation and the coordinate systems can also be conveniently configured. The hexapod system behaves as an intelligent multi-axis drive on the bus.

PI hexapods can work with multiple coordinate systems and allow the user to change the center of rotation or cast/rotate a coordinate system with a simple software command — an important feature when using the hexapod in precision machining applications. (PI)

Examples in Manufacturing and Quality Assurance

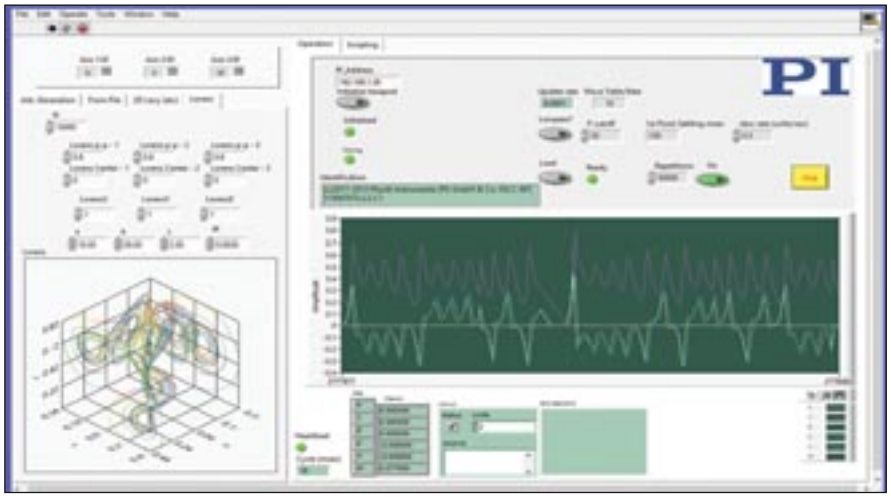
The areas of application for the versatile hexapods are broad because there is no difference between precision positioning of semiconductor components, or mechatronic components or heavy loads.

For example, automated 6D alignment systems take care of important tasks during testing and manufacturing of accessories for MEMS (microelectromechanical systems) camera sensors and photonics components, including the alignment of optical fibers and fiber arrays, and the production of optical lenses.

Further applications can be found in the "classical" industrial environment, such as material processing, when several axes are required, or inspection systems in the automobile industry. Precision alignment on several axes can also be important for heavy objects, such as mirrors and reflectors in large telescopes, precisely positioning and aligning patients to a radiation source for tumor diagnosis and thera-

py, or inspection systems for large-format flat panels.

Hexapods can carry loads up to 2 tons at any orientation and if required, be mounted upside down. Because the maximum permissible load of a hexapod system depends on various parameters, such as the mounting position, the center of gravity of the load, and the current position, suitable simulation programs are supplied that enable convenient setup. They also allow easy determination of workspace and motion limits, depending on the selected center of rotation or the current position.



Complex patterned motion generation is becoming increasingly important for applications such as vehicular simulation and airborne platform simulation and test. Hexapods with advanced controllers and software can perform complex profiles in 6 degrees of freedom. (PI)

Fast Motion and Scanning

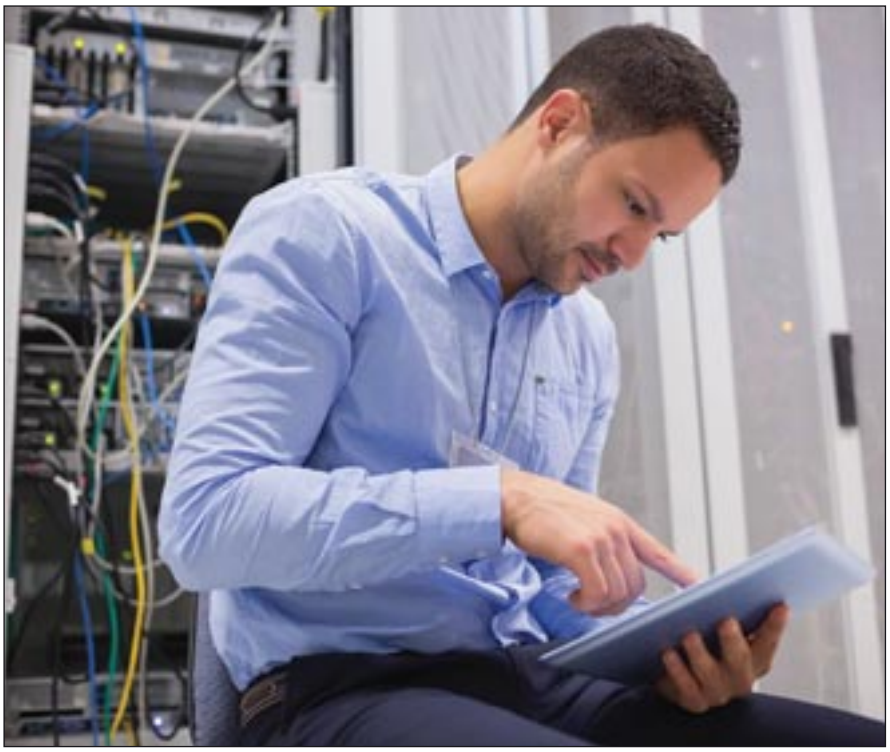
Motion simulators make high demands on motion dynamics. They repeatedly perform defined motion cycles; for example, for quality assurance and function monitoring of products in mobile use. Typical examples of this include inspection systems for acceleration or gyroscopic sensors like those used in smartphones, cellphones, and cameras for detecting changes in position. They are tested by means of a specified motion pattern.

Similarly, this applies during testing of image stabilization systems in cameras when the algorithms and mechanics are tested for effectiveness. For this, precise, repeatable, natural, and artificial motion must be simulated with the same dynamics and accuracy on all linear and rotary axes. Hexapods are predestined for these tasks.

This article was written by Dr. Markus Frietsch, R&D Department, Software & Applications at PI (Physik Instrumente), Auburn, MA. For more information, visit ***http://info.hotims.com/61066-320****.*

Motor Controller Provides Custom Electronic Control Solution

A Fortune 200 company needed a turnkey, DC voltage, agency-compliant electronic control solution capable of providing motion control with memory position capabilities and auto run/sense features for a multi-motor application involving four motors. Particularly important to the design criteria was the development of an interactive system of wireless remote control capabilities and other user interface devices, including iPhone and iPad interconnect devices. It was a complicated job, and the company would need to partner with experts who could deliver a time- and cost-effective solution.



Challenges

This project required creation of high-reliability designs operating in an environment of multi-media devices while avoiding RF interference issues and providing for the highest reliability for home and commercial applications.

The project quickly grew to more than just a motor control design project. The company chose Buse Industries (Bridgeton, MO) to assist in the development of the look and feel of new remotes so they were cost-effective to manufacture. Buse helped determine the type of backlighting, how text was applied, the look and feel of buttons, and overall appearance of the remotes.

As this controls package was geared for the consumer market, cost and features had to balance. There were many rounds of concept designs needed in order to determine the best cost structure for the type of electronics used. The final product would need to meet a globally competitive cost base.

Applications would need to be developed to run on both iOS and Android devices. The general communication method chosen was Zigbee to allow for the possibility of operating multiple systems in close proximity. Using this communication method eased the burden on communication programming and agency submittals. Buse also used this to reduce the possibility of interference in the consumers' home from other communication items such as Wi-Fi, Bluetooth, and cellphones. For the secondary communication, Buse used Bluetooth modules to provide connectivity for Android and iOS systems.

Electronics needed to last ten years, making component selection critical. For months, there were cycle tests running to simulate five years of operating time. Balancing performance and cost without effecting overall quality was crucial.

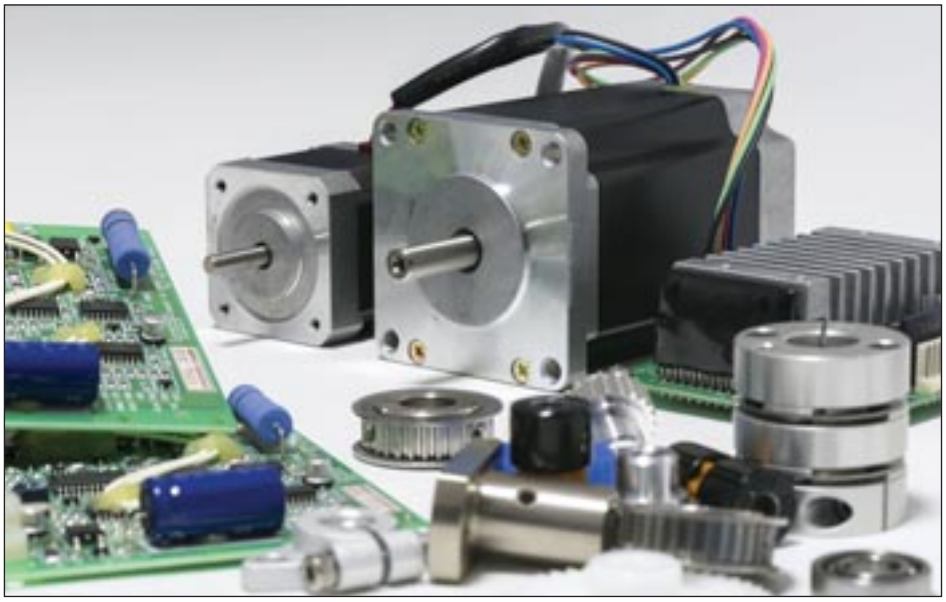
Solution

There are many elements to consider when deciding what type of motor is optimal for creating the motion to be controlled and the type of feedback used for position sensing.

Historically, AC induction motors have been a workhorse for this industry, providing high-torque, relatively quiet operation and long life. However, AC motors tend to be difficult and more expensive to incorporate speed control.

In contrast, permanent magnet DC motors offer a quiet, low-cost solution. Additionally, brush, commutator, and magnet technology have allowed DC motors to meet life specifications. Advances in electronic filtering systems on DC motors have eliminated electrostatic discharge (ESD) and other electrical noise issues that have plagued both home appliances and control software designers. More efficient designs are available to reduce current draw (and ultimately lower-cost power supplies), and DC motors offer simpler and lower-cost speed control options, giving the designer the options of slow start, stops, and position controls.

The different feedback options considered are timer-based systems, potentiometers, Hall effect sensors, and reed switches. Timers are not generally the best option with DC motors, as the full load speed of the motor can vary depending on load. Potentiometer feedback can be expensive and provide challenges to mechanically incorporate. Hall effect sensing (with magnets) may be most accurate, but generally is more expensive than reed switch (with mag-



net) designs. The end goal is a reliable system with quiet operation and maximum life at the best value-cost position.

Based on the needs of the customer, Buse began work on control PCB development, PCB layout, schematics, embedded logic software development, integration, validation, and design and development of the base control system and enclosure designs for the project. Additionally, all accessory enclosure designs would need to be designed and developed, including the development of multiple plastic injection molds and the submittal of these systems for FCC testing and approval, along with agency compliance design, testing, and approval.

Buse championed the overall program plan, and managed timelines and critical milestone achievement dates for program launch, including UL agency listing and approval of the product. The Buse solution included battery backup features along with multi-interface designs and supplemental control design variations in order to meet good, better, and best product line offerings. Additionally, Buse provided for multi-customer application rendition varieties of the system package, offering niche market and alternative branding opportunities.

This article was contributed by Buse Industries. For more information, visit ***http://info.hotims.com/61066-321****.*

NEW Products

Electro-Hydraulic Motion Controller

Delta Computer Systems (Battle Ground, WA) has announced the RMC200 closed-loop electro-hydraulic motion controller that has the capacity to handle closed-loop control of up to 32 motion axes. The controller can synchronize the motion of multiple axes, enabling the construction of machines with scalable performance and quick production changeovers. It provides built-in support for controlling pressure/force as well as position/velocity/acceleration. Through use of a programmable feature key, the controller will enable only the number of control loops that a customer's application needs. Other features include a display screen on the CPU, I/O modules with push-in wire connectors, and fully encased, user-installable modules that "rock-in" to provide power-sequencing capability. The unit's modular expandability enables it to support expanded control and I/O interfacing compatibility as new modules are developed.

For Free Information Visit http://info.hotims.com/61066-300

Grippers

Airpot® Corp. (Norwalk, CT) announced GramForce™ Accurate Force Pneumatic grippers that generate no measurable friction and provide a gentle grip for delicate operations.

They operate at pressures from 0.02 MPa to 0.7 MPa, and offer holding pressures as low as 0.25 N (0.056 pounds) and up to 8.6 N (1.9 pounds). With synchronous and counterbalanced parallel design that allows unchanging gripping force in any mounting orientation, the grippers are internally driven by two 5.6-mm-bore pneumatic actuators. The carriage blocks are mounted on a stainless steel rail. They have operating ranges from -20 to 80 °C. The design accommodates finger lengths up to 75 mm. Assembled, the gripper is less than 50 mm high, less than 79 mm long, and 26 mm wide. The grippers are suited for precision assembly equipment, test and measurement devices, robotic end-effectors, small parts handling, and machining operations.

For Free Information Visit http://info.hotims.com/61066-301

Servo Drives

Advanced Motion Controls® (Camarillo, CA) announced AxCent™ servo drives for centralized motion control schemes. The Models AB15A100, AB25A100, and AB20A200 are panel-mount servo drives that operate with brushless permanent magnet motors as well as brushed motors and inductive loads. The drives are controlled with ±10V analog command signals, and use trapezoidal commutation when driving brushless motors. The AB15A100 outputs 15A peak and 7.5A continuous with up to an 80VDC bus; the AB25A100 outputs 25A peak and 12.5A continuous with up to an 80VDC bus; and the AB20A200 outputs 20A peak and 10A continuous with up to a 175VDC bus.

For Free Information Visit http://info.hotims.com/61066-302

Hollow Shaft Encoder

Kübler (Charlotte, NC) released the Sendix F5883 Motor-Line optical hollow shaft encoder with a mounting depth of 43 mm. The encoder is based on the Sendix platform, and features Intelligent-Scan Technology . It is insensitive to magnetic fields, offers EMC characteristics, and supports interfaces such as SSI, BiSS, SinCos, RS422, and Push-Pull for connection to frequency converters. The encoder is resistant to installation errors, shock, and vibration. It is available with a through hollow shaft of up to 15 mm, and clamping on the A and B side for all usual geared motor drive shafts. With a tangential cable outlet, the encoder can be installed in tight mounting spaces.

For Free Information Visit http://info.hotims.com/61066-303

AC Drive

Danfoss Drives (Milwaukee, WI) introduced the VACON 20 AC drive that features built-in PLC functionality. It is available in all common voltages (110-600V), and a power range up to 18.5 kW/25 HP. The built-in RS-485 interface offers a serial control interface for the drive. With optional modules, the drive can be connected to almost any communication system including CANOpen, Fieldbus, DeviceNet, and Profibus DP. Features include accessible terminals, built-in DIN rail mounting, and the MCA parameter-copying tool that can clone settings without main power in the drive. Users can build their own control logic in the drive, and utilize unused I/O of the drive for performing other machine-related tasks. In addition, the parameter list can be freely modified, and application-specific parameter sets and default settings can be created.

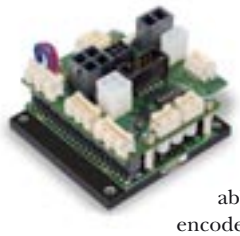
For Free Information Visit http://info.hotims.com/61066-304

Brush DC Mini Motors

Portescap (West Chester, PA) introduced the 16DCP Athlonix™ high-power-density brush DC mini motors. Available in a 16-mm diameter, the 16DCP motors feature a coreless design with an optimized self-supporting coil and magnetic circuit. The motors are available in two variations — precious metal commutation and graphite commutation — both featuring an Alnico magnet inside. The motors feature a constant force spring design for carbon brush, and an REE (Restriction of Electro Erosion) coil is an available option. With maximum continuous torque up to 2.63 mNm, the motors are suited for medical and industrial pumps, gas analyzers, security and access, and power tools. They are available with encoders and gearheads of various sizes and ratios.

For Free Information Visit http://info.hotims.com/61066-308

Positioning Controllers



maxon motor (Fall River, MA) offers the EPOS4 controller module with detachable pin headers and two different power ratings. With a connector board, the modules can be combined into a ready-to-install solution. The position controllers are suitable for control of brushed DC motors and brushless BLDC motors (EC motors) with Hall sensors and encoders up to 750W continuous power and 1500W peak power. The CANopen positioning motor controllers are available with Ethernet-based interfaces such as EtherCAT, or absolute rotary encoders. Features include Field Oriented Control (FOC) with multiple analog and digital I/O, along with various command options. Start-up and parameterization are performed with the EPOS Studio intuitive graphical user interface and user-friendly, menu-controlled wizards.

For Free Information Visit http://info.hotims.com/61066-306

Fan Controller

Orion Fans (Dallas, TX) offers the OA11/22 fan speed control unit that provides precise airflow control. The field-adjustable, dual-channel phase control unit allows the user to control fan speed for single or multiple fan assemblies. The control units are designed for use with any AC fan or fan tray. The 120/220 VAC speed control unit allows users to specify and control fan noise, speed, and air delivery according to specific application requirements. Four user-adjustable speeds (off, low, medium, and high) allow for maximum control and flexibility with minimum setup time. The unit is designed with fan trays and equipment racks in mind, where noise versus airflow needs to be controlled according to immediate needs.

For Free Information Visit http://info.hotims.com/61066-307

Brake

SEPAC (Elmira, NY) announced the Thin Spring Engaged Brake, a thin-body, spring-engaged, power-off brake. The brake offers reversible mounting with the shaft extending past the brake or within the brake body. The friction disc/rotor and hub are manufactured from lightweight metal, allowing for lower

inertia. A splined hub for shaft connections typically provides less than 1.5° backlash. The brake is suited for servo motors/systems, medical apparatus, robotics and imaging equipment, material handling, semiconductors (wafer handling equipment), energy-related (wind, petroleum, etc.) actuators, and security-related actuators for doors, gates, and curtains.

For Free Information Visit http://info.hotims.com/61066-311

Position Sensors

TE Connectivity (Pennsauken, NJ) announced the HLIR 750 intrinsically safe, 4-20 mA LVDT position sensors that are CSA listed for use in hazardous locations and where an intrinsically safe sensor is required. With stainless steel construction and a hermetically sealed sensor body, these LVDT position sensors provide contactless position measurement for critical applications in gas turbines for fuel valve position feedback, vane pitch servo controls, governor controls, and generator shell expansion measurement.

Available in measuring ranges from ±2" to ±20", the sensors feature low hysteresis and maximum linearity error of ±0.25% of full range output. Constructed entirely of stainless steel, they feature a through-bore design that makes the core accessible from both ends. Sensor lead wires exit through a radially mounted 1/2-14 NPT male threaded conduit fitting for attachment to an explosion-proof junction box as well as rigid or flexible conduit.

For Free Information Visit http://info.hotims.com/61066-309

Feedback Cylinder

The Series 6PF positioning feedback cylinder from Camozzi Pneumatics (McKinney, TX) is equipped with a potentiometric transducer of a linear position integrated inside the rod. This type of cylinder, when used with the LRXA4 proportional servo valve, makes it possible along the entire stroke to constantly control the position of the rod. The pistons are equipped with specific seals for increased accuracy, and a permanent magnet in order to use external end-stroke sensors. The cylinder is suited for use in tensioning cylinders, positioning cylinders, and filling/cutting/measuring systems. Features include bores from 50 to 125 mm, standard strokes from 50 to 500 mm (50-mm intervals), ISO 15552 compliance, protection class IP67, and assembly with standard ISO accessories.

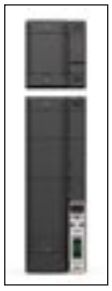
For Free Information Visit http://info.hotims.com/61066-313

Variable-Speed Systems

Nidec Motor Corp. (St. Louis, MO) launched NMC's ACCU-Series™ family of variable-speed products. Users can match a U.S. MOTORS® brand inverter duty motor with an NMC drive or panel, or purchase integrated motors and controls. The products are designed to be used together as a system. The family includes variable frequency drive pump panels for agricultural irrigation, 3-10HP electronically commutated (EC) motors with an IE4 rating integrated with tuned VFDs, individual AD700 and AD1000 drives, and the Totally Enclosed Fan Cooled (TEFC) motor.

For Free Information Visit http://info.hotims.com/61066-314

Modular Drives

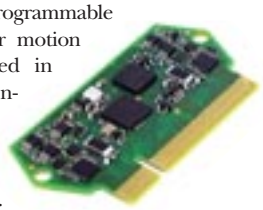


Control Techniques, a business of Emerson Industrial Automation USA LLC (Eden Prairie, MN), offers Unidrive M and Powerdrive F300 variable-speed, high-power modular drives. Both are available in frame size 11, providing a flexible method of building compact, high-power solutions. Paralleled together, Unidrive M can control asynchronous and permanent magnet motors in systems up to 2.8 MW (4,200 hp). The frame 11 is a 250-kW (400 hp) module that allows system builders to create high-power solutions with a small number of components. Unidrive M's Active Front End (AFE) solutions provide torque precision and power quality.

For Free Information Visit http://info.hotims.com/61066-310

Motion Controller

The Lexium Motion Module (LMM) from Schneider Electric Motion USA (Marlborough, CT) is a compact, programmable motion controller for motion applications measured in millimeters. The controller is programmed via MCode, and can validate motion with a turning motor shaft. MCode programs are transferrable to LMM and longer-lead PCBs. One- or four-axis development boards include isolated I/O, locking pluggable connectors, and serial RS-422/485 programmable motion or CANopen. Motors, accessories, and starter kits are available.



For Free Information Visit http://info.hotims.com/61066-305

Permanent Magnet Motors

NovaTorque (Fremont, CA) introduced 600 RPM versions of its PremiumPlus+® Electronically Commutated Permanent Magnet (ECPM) motors. The new versions are available from 0.75 HP to 3 HP, and are suited for directly driving larger-diameter fans at low speeds. The motors offer lower current requirements (FLA) than AC induction motor alternatives. A patented geometry allows for the use of readily available ferrite (versus rare earth) magnets. The motors are produced in standard NEMA frame sizes.

For Free Information Visit http://info.hotims.com/61066-312

Clutch-Brake

Nexen Group (Vadnais Heights, MN) introduced the Flange Mounted Clutch-Brake Enclosed (FMCBE) for any environment where cleanliness is a primary concern. A single, double-acting piston prevents simultaneous clutch and brake engagement. It features a nickel-plated finish to resist corrosion, and stainless steel, hex-head bolts with no exposed threads or sockets. All machined mating surfaces are sealed with O-rings to prevent ingress of fluids. The clutch-brake has no indentations, allowing easy cleaning and eliminating areas of possible build-up and contamination.

For Free Info Visit http://info.hotims.com/61066-315

Variable Frequency Drive

American Control Electronics (South Beloit, IL) introduced the ACF Series of open chassis microprocessor-based variable frequency drives that offers the simplicity of a DC drive. ACF700 drives are designed for setup without any programming. The drives are equipped with user-adjustable trim pots to set Max/Min Speeds, Slip Comp, Boost, Torque Limit, Accel, and Decel/Injection Braking parameters. The 115V/230V single-phase input can provide single- or three-phase outputs of 115V or 230V for sub-fractional HP motors and gearmotors. An onboard microprocessor allows custom programming for a variety of OEM applications. Other features include 1/60 to 1 HP, carrier frequency of 1.6 or 16 kHz, adjustable base frequency, DC injection braking, and protection against overheating as a result of frequent overload.

For Free Info Visit http://info.hotims.com/61066-317

Servomotors

Siemens Industry (Elk Grove Village, IL) offers Simotics 1FK7 Generation II servomotors with seven shaft heights, quick-connect power connectors, and 20- and 24-bit field-replaceable encoders. The series offers three inertia versions — standard, high-dynamic for rapid acceleration jobs, and high-inertia for maximum smooth running. The motors are designed for operation without external cooling; heat is dissipated through the motor surface. The encoders are mechanically and thermally decoupled from the motor, making them more resistant to vibration conditions on the machine. The servomotors provide cross-profiling for mounting, Drive-Cliq interface for field commissioning and unit recognition with the Siemens Sinamics S120 drive family, plain shaft or keyway design, and three IP ratings.

For Free Info Visit http://info.hotims.com/61066-318

Linear Actuator

Midwest Motion Products (Howard Lake, MN) offers the Model MMP LA3-12V-5-A-SP-100 linear actuator that utilizes an all-steel drive pinion while maintaining a 5:1 reduction ratio that allows the unit to maintain a 2"-per-second stroke speed. The stroke length for the design is 4" overall, but the same design is available with 2, 6, 8, 10, and 12" stroke lengths. The actuator features 8-mm-diameter clevis mounts on both ends, and built-in limit switches for both (full extend and full retract) ends of travel. The operating temperature rating range is from –26 °C to +65 °C. An acme screw drive allows for 517 pounds of static load.

For Free Info Visit http://info.hotims.com/61066-323

Pneumatic Grippers

Fabco-Air (Gainesville, FL) announced the FKHS Series 3 Jaw Parallel Motion Pneumatic Gripper line for handling small parts in tight spaces. The design is available in six different bore sizes: 25, 32, 40, 50, 63, and 80 mm. A magnetic piston is a standard feature on all grippers. Other features include polarity protection and LED indication. Mounting is via direct body (top and bottom) mounting holes.

For Free Info Visit http://info.hotims.com/61066-316

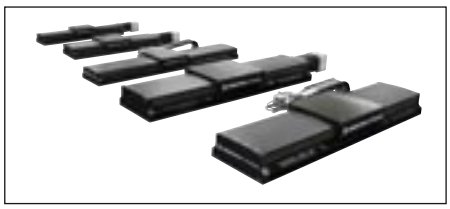
Positioning Tables and Stages

Positioning tables and nano-precision stages from Primatics (Vaughan, ON, Canada) are used in applications where high accuracy and repeatability and/or smoothness are critical. The PCL50 and PCL65 linear stages offer micron-level repeatability and integrate a precision ball-screw drive with recirculating ball linear bearings. PCR32/43 Series positioning stages are designed for applications such as high-precision alignment, attachment, and inspection. They utilize anti-cage creep precision cross roller bearings and a center-driven brushless linear motor. PLG stages are flexible, all-purpose compact linear positioning stages featuring strokes to 800 mm for payloads up to 100 Kg. Available with aluminum or cast iron base, the stages also offer a Class 10 cleanroom option. PO Series stages are two-axis, large-travel center-aperture positioning stages featuring single or dual linear motors per axis and high-resolution linear encoders. PXL stages are low-profile, small-footprint linear motor stages with cross roller bearings offering < 2 nm incremental motion. Models are directly stackable in XY configurations.

For Free Info Visit http://info.hotims.com/61066-319

Stages

Aerotech (Pittsburgh, PA) offers the PRO series industrial linear motor and ball-screw positioning stages, including two new sizes of the PRO-LM (linear motor) series stage line: the PRO115LM and PRO190LM. New features include a linear encoder option on PRO-SLE ball-screw stages, absolute encoder options on both the linear motor and ball-screw stages, and direct mounting to English and metric optical tables. All stages employ a recirculating linear guide bearing system and a low-friction sealing solution. The design provides protection from debris while side seals prevent dirt and particulates from entering the stage.



The base mounting holes are accessible from the outside of the stage, allowing for easy mounting. Standard mounting holes for both English and metric optical tables are present in all travels. The tabletop is available with both English and metric mounting patterns, and can be ordered with brush attachments to clear any debris that may collect on the stage hard cover. Incremental and absolute encoders are available as standard options, and enable minimum incremental motion down to 5 nm and sub-micrometer repeatability.

For Free Info Visit http://info.hotims.com/61066-324

Slides

NB Corporation of America (Hanover Park, IL) released TOPBALL® slide products that self-align. The floating wiper seal makes unrestricted self-alignment possible. A floating load plate adjusts clearance, and tolerances are achieved by grinding the raceways and load plates. Applications include automation equipment, machinery, and optical and measuring instruments. They also are suited for new designs and are interchangeable for retrofitting. The slide products are available as total systems or as individual components such as slide bushings, housings, slide shafts, and supports in metric or inch.

For Free Info Visit http://info.hotims.com/61066-325

NEW Products

Press Brake

The GOFORM portable electric press brake from Cincinnati Incorporated (Harrison, OH), is designed for parts up to 1/4" thick and less than 50 pounds. It features a large touchscreen control, PC-based 3D graphics, and bend simulation. The unit guides the operator though setup and part handling sequences. Additional features include 0.0002" ram repeatability, Dynamic Thickness Compensation (DTC), 6-axis backgage, quick-clamp system, and 22" gage depth.

For Free Info Visit http://info.hotims.com/61066-326

Encoder Modules

Heidenhain (Schaumburg, IL) launched MRP 2000, 5000, and 8000 encoder modules that contain bearing sets not conventionally available that can be integrated with various encoder types. These angle encoder modules merge requirements for precision rotary axes used in metrology, calibration devices, automation technology, micro machining, and the semiconductor industry. The modules offer low starting torque and a constant continuous torque. Bearing loads up to 300 Newtons are possible while still maintaining the system accuracy. Incremental or absolute encoders can be used as required, with resolutions up to 29 bits.

For Free Info Visit http://info.hotims.com/61066-328

Couplings

R+W America, Coupling Technology (Bensenville, IL) offers maintenance-free disc pack couplings in seven new sizes from 350 Nm to 24,000 Nm. Additional connection methods allow for easier installation and maintenance. The spacers are customizable, and can be designed for any length.

The LP series is a backlash-free coupling driven through pure friction force. The connecting flanges are pressed to the disc pack faces using high-strength bolts. When properly assembled, the torque is transmitted purely through the disc pack, and no additional stress is placed on the bolt shanks.

For Free Info Visit http://info.hotims.com/61066-332

Block Spindle

Suhner Industrial Products Corp., Automation Division (Rome, GA) introduced the BEX8 high-speed machining block spindle for extremely high-speed operations up to 25,000 rpm. The spindle weighs 33 pounds and mounts directly onto robotic arms for fully automated machining operations in high-speed, high-production departments in automotive, appliance, off-highway, and other industries.

The standard motor supplied is seither 0.37 kW or 0.75 kW, and the standard toolholder supplied is ER20. Spindle concentricity is better than 0.01 mm.

For Free Info Visit http://info.hotims.com/61066-333

Automated Measurement Cell

Hexagon Manufacturing Intelligence (North Kingstown, RI) announced the 360 Flexible Measurement Cell, an automated measurement work cell suited for automotive and aerospace structure applications including powertrain and closure panel fabrication. The cell is built on commercial-off-the-shelf (COTS) work cell systems integrated with the company's measurement solutions. The cell combines external devices, products, processes, and systems in a COTS format to enable them to be easily customized. The cell is scalable, portable, and modular, and is offered in three configurations: in-line, near-line, or off-line. Solutions are scalable as required by specific part size and measurement tasks.

For Free Info Visit http://info.hotims.com/61066-330

Accelerometers

The Model 356A43, 356A44, and 356A45A miniature triaxial ICP® accelerometers were introduced by PCB Piezotronics (Depew, NY). They measure 0.4 × 0.4 × 0.75", weigh 4.2 grams, and are TEDS IEEE 1451.4 enabled. The TEDS feature self-identifies the accelerometer and describes type, operation, and attributes. Data contained in the TEDS programming includes manufacturer, model number, serial number, calibration date, sensitivity, frequency response, and measurement ID. Models are available with three sensitivities: 10 mV/g, 50 mV/g, or 100 mV/g. They are packaged in a hermetically sealed titanium cube. Common applications include modal and structural analysis, automotive NVH, and package testing.

For Free Info Visit http://info.hotims.com/61066-331

Weldable Couplings and Collars

A line of weldable shaft collars, couplings, and mounts is available from Stafford Manufacturing Corp. (North Reading, MA). The components are made from ANSI 1018 steel and stainless steel to allow users to modify parts and create assemblies without fasteners. Typical modifications include brackets, cams, lever arms, mounts, pins, and rods. They are suited for the design and repair of special machinery, conveyors, packaging systems, and racks. The weldable shaft collars are available in one- and two-pieced, and hinged styles. Flange mounts are offered in ¼" to 6" bore sizes, and weldable shaft couplings are available in ¼" to 2" bore sizes. Smooth-, hex-, and square-bores for shafts, pipe, and tube can be supplied.

For Free Info Visit http://info.hotims.com/61066-327

Linear Guide Kit

To simplify product selection of self-lubricating linear guides, igus (East Providence, RI) has developed a modular construction kit for belt-driven DryLin ZLW linear axes. The ZLW toolkit enables users to customize their solutions, including rail widths, system length, etc., even for small installation spaces. Cross beams, rails, and/or carriages are available in either aluminum or stainless steel to suit a wider range of application requirements. The ZLW system enables loads up to 165 lbf. to be lifted with stroke lengths of up to 3 meters (118"). Wide drive belts can also permit speeds of more than 5 m/s (16 ft./s), depending on the load. Underwater applications are possible via a special toothed belt.

For Free Info Visit http://info.hotims.com/61066-329

Actuators

Curtiss-Wright Sensors & Controls Division (Gilbert, AZ) announced Exlar® brand FTX Series actuators. The high-force electric rod style actuators replace hydraulics in high-force, high-duty-cycle applications in harsh environments. Based on planetary roller screw technology, the actuators offer a compact form factor. With continuous force rating to 178 kN (40,000 lbf), speed to 875 mm/sec (34 in/sec), and stroke lengths from 150 mm (6 inches) to 900 mm (3 feet), the actuators can be applied across a range of linear motion applications.

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What's On TECH BRIEFS TV

MOTION CONTROL CHANNEL

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Featured Sponsor Video: H-Bot Robotic Automation

Learn how Pac Tec Packaging of Janesville, WI, put H-Bot robotic automation to work in a new machine that manufactures single serve beverage brewing cups. Yaskawa servos and machine controller combine with three H-bots to deliver precision and productivity for a complex packaging application.

www.techbriefs.com/tv/H-Bot

Super-Efficient Robot Strolls like a Human, Wears Sneakers

Georgia Tech researchers have created what they say is the most efficient-walking humanoid robot ever created. Their DURUS robot has springs between its ankles and feet, similar to tendons, allowing for a gait that stores mechanical energy from a heel strike to be reclaimed as the foot lifts off the ground.

www.techbriefs.com/tv/DURUS

Morphing Wing for Lighter Weight, More Agile Aircraft

When the Wright Brothers first flew over 100 years ago, they used a twisting wing to stabilize their plane. University of Michigan aerospace engineers are revisiting the idea of the morphing wing, using a multifunctional system of composite lightweight materials and integrated actuators.

www.techbriefs.com/tv/morphing-wing

SpotMini: Agile, All-Electric Robot Dog Does the Dishes

SpotMini is a new, smaller version of Boston Dynamics' Spot robot. The bot is all-electric (no hydraulics) and runs for about 90 minutes on a charge, depending on what it's doing. SpotMini is very quiet and has a variety of sensors, including depth cameras, a solid-state gyro, and proprioception sensors in the limbs.

www.techbriefs.com/tv/SpotMini-bot

www.techbriefs.tv

NEW Products

Automation Cables

Molex, LLC (Lisle, IL) offers Flamar industrial automation cables for signal and control equipment and servomotors. The cables are available in multiple jacket materials (PVC, WSOR, PUR, TPE). The standard cables range from 26 AWG to 10 AWG for applications in food and beverage, material handling, automotive lines, and other manufacturing operations. The cables are rated for temperature ranges down to -40 °C (-40 °F) and up to 105 °C (221 °F). They are compatible with all standard industrial connectors, including RJ45, the Brad® range of circular connectors (M8, M12, M23) for servomotors, and mPm® DIN valve and Molex Heavy Duty connectors.

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Precision Ball Screws

Thomson Industries (Radford, VA) has introduced miniature metric precision ball screws in three interface styles: flanged, threaded, and rounded. The FSI metric ball screws are flanged, and the RSI style is rounded. Both feature a multi-liner ball return system that provides smooth operation and increased load capacity. The miniature ball screws are available in a range of standardized diameters from Ø6 mm – Ø14 mm. Flexible ball nut mounting configurations and rapid prototyping are options for the ball screws.

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Servo Drives

The MR-J4-TM multi-network servo drives from Mitsubishi Electric Automation (Vernon Hills, IL) are available with EtherNet/IP™ and EtherCAT® interfaces. The drives feature dual 100BASE-TX Ethernet ports in line, tree, and star topologies; One-Touch Auto-Tuning; 2.5 kHz speed frequency response for short settling time; high-resolution 4,194,304 pulse/revolution absolute encoders; and Advanced Vibration Suppression Control II for vibration suppression on both the load and the machine base. The drives also come with add-on instructions for EtherNet/IP networks using ControlLogix® or CompactLogix® controllers.

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Translation Stages

Thorlabs (Newton, NJ) announced XR-Series cross roller bearing, aluminum-bodied translation stages. The series includes rear- and side-actuated 1" travel stages and all components needed for left- or right-handed X, XY, XZ, YZ, and XYZ configurations. A dovetail feature is incorporated into the design for stacking; it could also be used to provide custom mounting options. When stacking two stages, coarse positional alignment in the axis perpendicular to stage travel is achieved by sliding the dovetail along the mating dovetail prior to lockdown. Features include less than 150 rad of angular deviation in pitch and yaw, side or end actuation with conversion between the two options, and deep and blind ¼"-20 (M6) tapped holes on the moving world.

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October 2016

SENSOR TECHNOLOGY

NASA Sensor Supports Flexible Aircraft Design

Encryption Basics: Learn the 'Keys' of IoT Security

CryoFOSS Optical Sensor Offers Next-Level Liquid Measurement

Special Section:
OEM Sensors Supplier Guide

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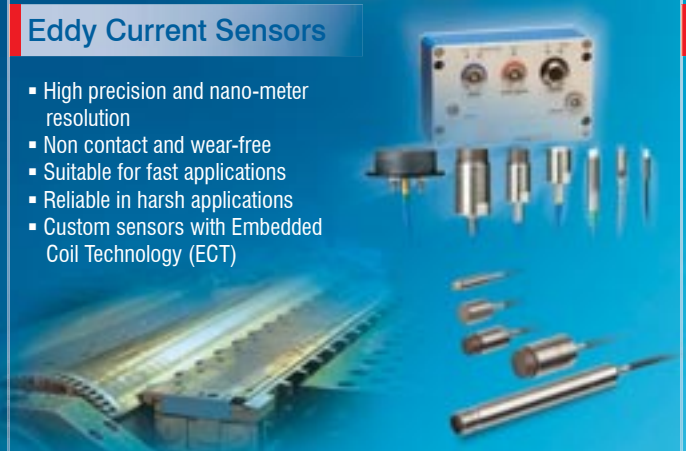

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*Which Website Offers the Easiest Checkout Process?**

*AspenCore's 11th Design Engineer and Supplier Interface Study gathered information from engineers regarding their need for product information and other services, as well as how and when they interface with suppliers and how they see the quality and value of that interface. 1,750 U.S. engineers participated in this year's web-based survey. The results represent those surveys completed by April 2016.

When asked "When purchasing electronic components online, which website offers the easiest checkout process?" The chart above shows the results among the industry's electronic component distributors.

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ON THE COVER

In 2014, NASA Armstrong's G-III took to the air with a pair of experimental morphing flaps. The flight was part of the Adaptive Compliant Trailing Edge (ACTE) project. An optical sensing system from Langley Research Center supports the development and implementation of these advanced kinds of flexible wings. For more information, read the story on page 13.

(*Image Credit: NASA/Ken Ulbrich)*

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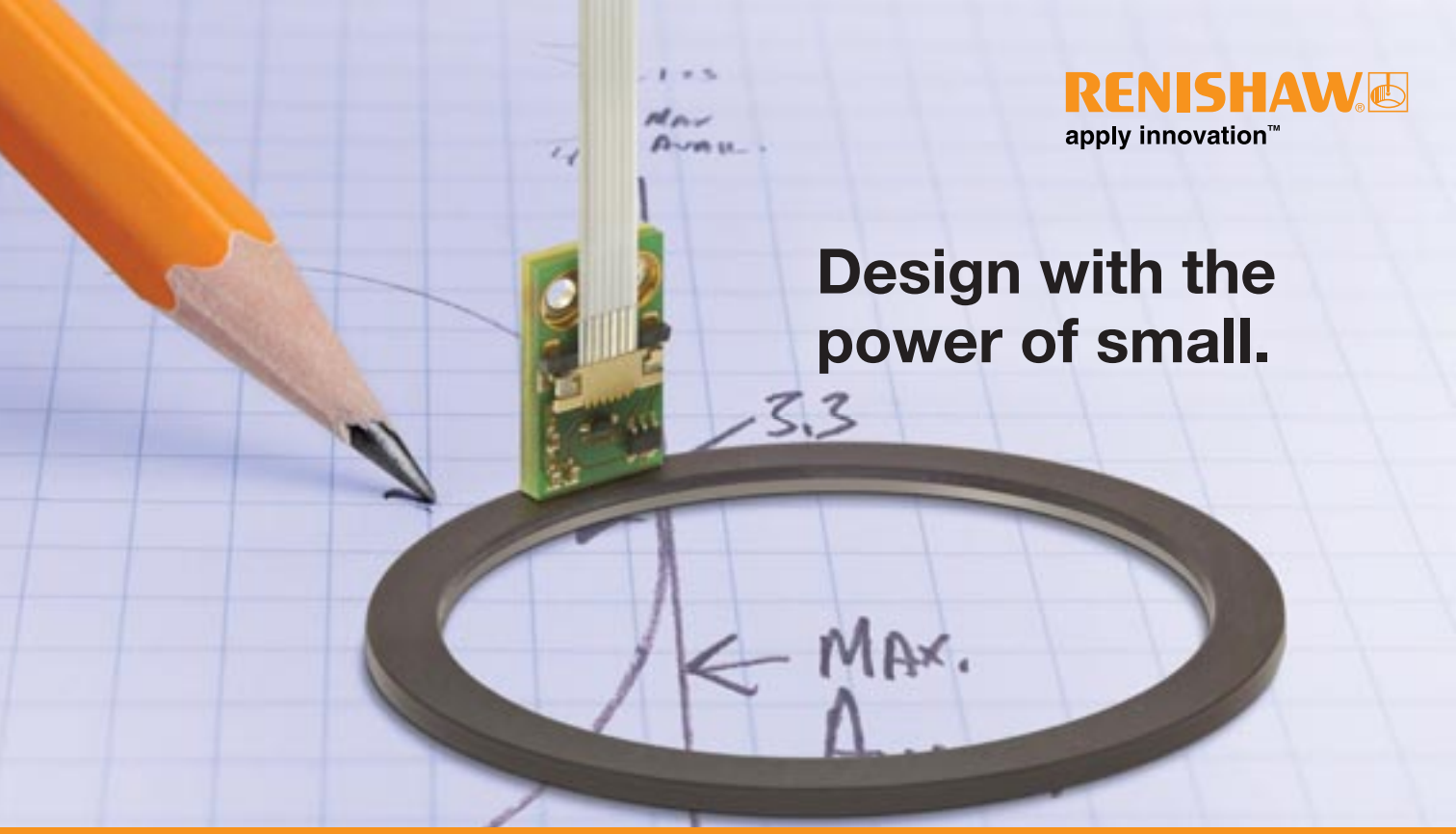

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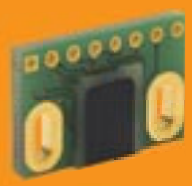

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RLB—A PCB-level magnetic encoder designed for high volume low cost OEM integrations with added flex cable option

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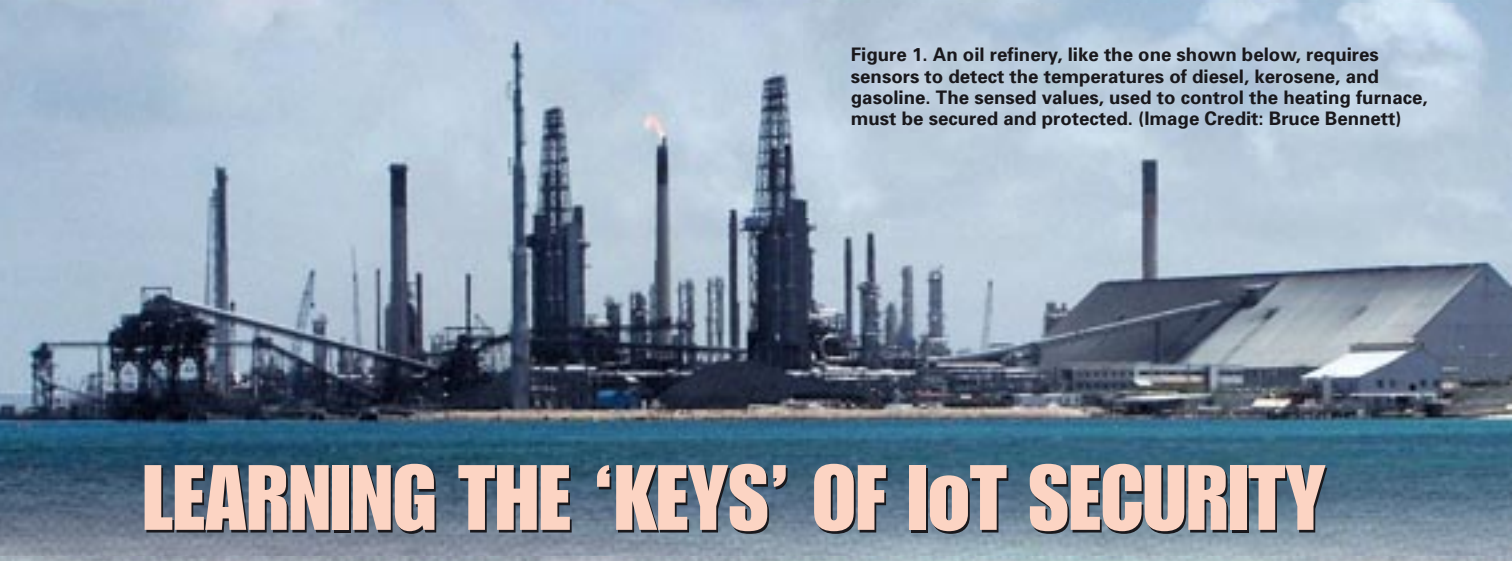


Figure 1. An oil refinery, like the one shown below, requires sensors to detect the temperatures of diesel, kerosene, and gasoline. The sensed values, used to control the heating furnace, must be secured and protected. (Image Credit: Bruce Bennett)

LEARNING THE 'KEYS' OF IoT SECURITY

Network-connected devices provide many opportunities to improve and enrich people's lives, but the "Internet of Things" has a range of definitions. A consumer's experience with the "IoT" may be a wearable computer for fitness tracking. A physician may place a connected heartbeat monitor on a patient. An industrial engineer may see the Internet of Things as thousands of sensor points that provide measurements of temperatures, pressures, or valve states.

Unfortunately, these connected devices also represent individual targets for would-be cybercriminals. The question is: "How do we secure the IoT?"

Refining Security

We are talking about connected things. But the nature of the "thing," its connection to the sensor network, and the use of the collected data all vary widely from application to application.

In an oil refinery, for example, the crude oil must be heated to specific temperatures in order to separate the different products — diesel, kerosene, and gasoline — through the distillation process. Sensors detect the current temperature, and the sensed values are used to control the heating furnace.

Since this process includes extremely flammable liquids, the ability to alter the reported temperature could result in either a failed cycle (because the crude oil fails to reach the proper temperature for distillation) or an explosion if the furnace temperature gets too high. Without a means to ensure the sensor's integrity, as well as the reported temperatures, the refinery would need to resort to manual ways of measuring the temperatures, with the resulting delays potentially crippling the refinery's production capability (see Figure 1).

If a potential interloper could alter the boot cycle of the sensor, modify the algorithm used to measure the temperature, or simply alter the reported value as the sensor's message transmits, then the refinery could experience a catastrophic failure. Users not only need a method to confirm the sensor's integrity, but also a means of ensuring that the message traffic from the sensor travels across the communications link unmodified. Additionally, the sensor unit's software must be able to receive authorized updates, and outsiders must be precluded from manipulating the sensor code.

Sensor connectivity often leads to conflicting goals. On the one hand, a refinery worker may want to ensure that all of the raw sensor data is available for analysis, potentially in the cloud, in order to verify the efficiency of refinery operations. On the other hand, revealing that data to outsiders may allow them to compromise refinery safety, or derive the techniques used for the refining operation's key processes, thereby resulting in potential lost revenues. Two sensor connectivity models are possible: the cloud model and the fog model (see Figure 2).

The Cloud Model

In the cloud model, each individual sensor is directly connected to the Internet, and directly reports to a centralized service that collects the data. Analytical algorithms, or a data analyst, then collate and filter the raw information to spot trends and determine potential efficiencies for a given process. By accessing all of the collected data, the

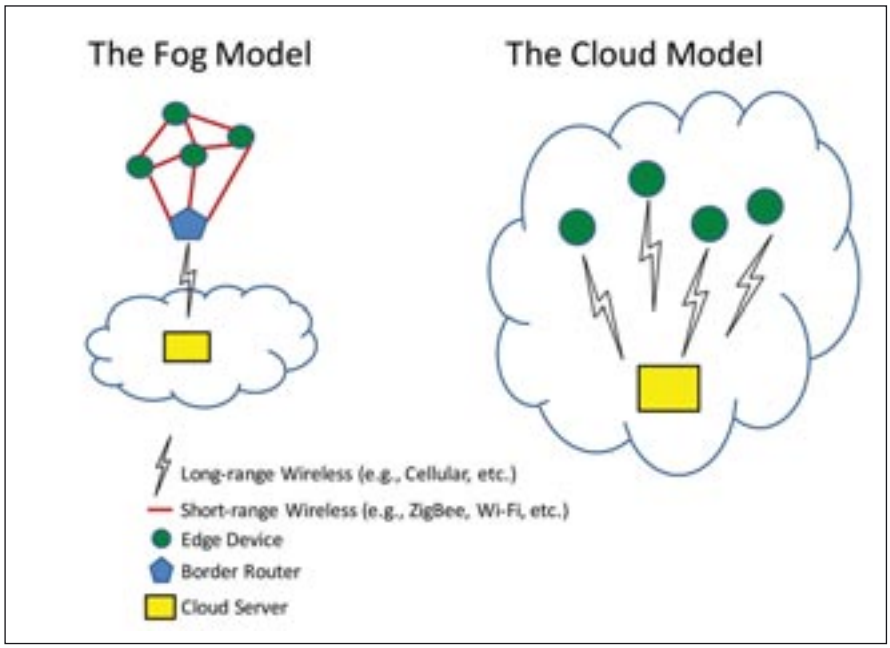


Figure 2. The above diagrams show a fog model and cloud model. The fog model significantly reduces the attack surface by preventing the sensor network from being directly accessed from anywhere on the Internet.

thought is that subtle features that may not be immediately apparent to a human can be discovered through clever data-analytic techniques. In this model, however, potentially thousands of sensors are exposed to the Internet, creating an enormous cyberattack surface.

The Fog Model

With the fog model, an alternate model for IoT systems, the sensors do not report raw data to the cloud servers. Instead, the sensors send the information to an intermediate device known as a border router or border gateway. The border gateway then collects, filters out bad samples, and collates the data for periodic transfer to the cloud-based servers. In this model, the sensors are not directly connected to the Internet, only the border gateway. The arrangement potentially reduces costs of communications and of storage of noisy, unfiltered data. From a security standpoint, however, the fog model significantly reduces the attack surface by preventing the sensor network from being directly accessed from anywhere on the Internet.

Figure 3. SignalFire Wireless Telemetry, a Hudson, MA-based company that offers remote asset monitoring and control services, now implements the Advanced Encryption Standard (AES) with a 128-bit key size to protect its wireless data. A SignalFire wireless node is shown in the above image.

The CIA of the IoT

Many in the cybersecurity business view security as including elements of confidentiality, integrity, and authentication, collectively referred to as "CIA."

Confidentiality, a guarantee that data is restricted from general access, is often accomplished using technical means such as encryption. Integrity has many dimensions, ranging from proper system

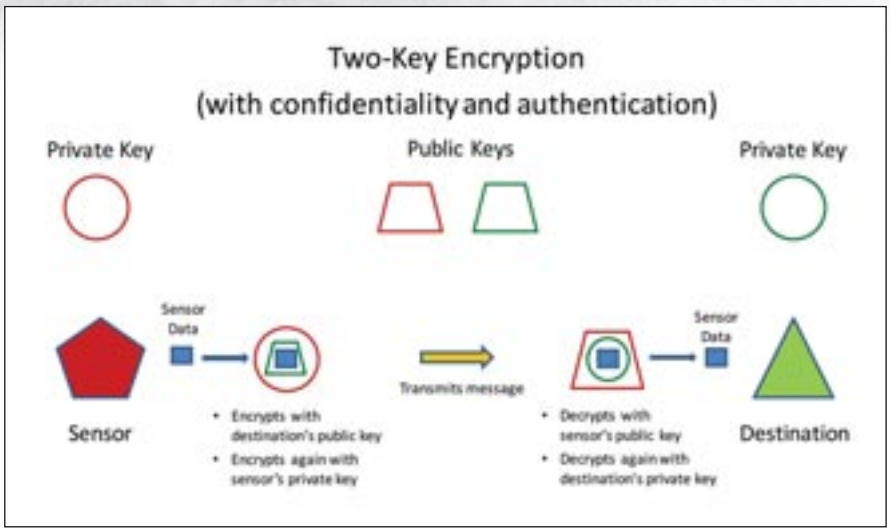


Figure 4. The above diagram reviews two-key encryption. Public and private keys are used to encrypt and decrypt data, both at the sensor point and its destination.

booting to ensuring that messages are delivered intact and unmodified. Authentication verifies the identity of the person, device, or process that is attempting to access the data or update device software.

Many of the "CIA" elements of a system can be addressed through the use of encryption technology. Encryption is simply a technique, sometimes referred to as a cipher, which obscures a message or data in some way to prevent access to the contents. Encryption techniques date back to early Roman times, and can range from simple techniques such as substitution ciphers to techniques based on sophisticated mathematical concepts.

Decoding Encryption: The Basics

Without getting into the complicated mathematics of encryption algorithms, encryption is generally divided into either symmetric (private-key) or asymmetric (public-key/two-key) techniques. In the case of a symmetric approach, both the sender and the receiver of the message must have knowledge of the encryption algorithm and the key used to generate the encrypted message (also called the cipher text). The problem with symmetric algorithms: how to communicate the key to both parties, also known as the key exchange problem.

Key exchange is typically accomplished by relaying the key through a separate channel. For example, you might send the key through the mail while delivering the cipher text electronically. Naturally, if the key is somehow compromised or easily guessed, then a third party could obtain the cipher text and decrypt the message. Requiring an out-of-band communications channel for the key exchange adds complexity and potential delays in the message exchange.

Unfortunately, many of the higher-grade symmetric encryption algorithms are quite computationally intensive. The typical, small 8- or 16-bit microcontroller used in many sensor applications often does not have the computational horsepower to perform the encryption while maintaining the line speed and sampling rates of many application scenarios. All hope is not lost, however.

Many silicon manufacturers now incorporate hardware-based encryption engines into their wireless interface circuitry. The encryption, possibly AES-128, is then used as link encryption between the sensors and the data collection facilities (see Figure 3). Given the cost and delay of trying to create a wireless radio (and getting it through the government certification process), it is often the path of least resistance to simply use an off-the-shelf wireless interface that supports link encryption and uses a symmetric crypto-algorithm.

With link encryption, however, only the data traffic is encrypted. The data and applications code running in the sensor itself is unencrypted. If a cyberattacker gains physical access to the sensor, then the data can still be compromised. End-to-end encryption has the application itself perform the encryption operation. The data is encrypted from application-to-application between the sensor and the data collection facility.

Performing real-time end-to-end encryption still requires sufficient CPU capability. Nonetheless, the designer could use a block cipher approach. A hardware-encryption processor could receive the data and encrypt it as a block message rather than a continuous stream. The application could then transmit the data as a packet across the link (via the sockets interface, for example). If the encryption engine is on the same silicon die as the microcontroller, then the potential for compromise of the data — even if the attacker has physical access to the sensor — is somewhat lessened because it is more difficult to tap into the communications between the encryption engine and the microcontroller.

The Keys to Asymmetric Encryption

Asymmetric encryption techniques are designed to address the key exchange problem. In an asymmetric approach, each user generates a pair of keys, known as the public and the private key. These keys are cryptographically related in such a way that anyone with knowledge of the encryption algorithm can encrypt the message with the recipient's public key; only the holder of the private key, however, can decrypt the message.

Therefore, no symmetric keys need to be exchanged ahead of time. The encryption algorithm is publicly known as is the recipient's public key, ensuring message confidentiality but not message integrity. Because encryption/decryption is a mathematical operation, the modified cipher text will still decrypt even though it may not make sense. In order to ensure message integrity, designers can use a cryptographic-based message authentication code (MAC) or hashed MAC (HMAC), such as SHA-256, on the message and send the resulting signature to the recipient separately. If even a single byte of the cipher text is modified, the HMAC computation result will not correspond to the hash provided by the sender.

Unfortunately, asymmetric algorithms are often even more computationally intensive than many symmetric algorithms. Additionally, the delays associated with the double encryption/decryption make asymmetric algorithms problematic for resource-constrained platforms. Asymmetric techniques, however, can be extended to apply in certain authentication approaches.

One such extension of the asymmetric concept is embodied in the Diffie-Hellman (D-H) key exchange protocol. In this protocol, two parties (we'll call them "Bob" and "Alice") that have no prior knowledge of each other can use an insecure channel to jointly establish a secure link. Through a series of exchanges, using publicly known values and combining them mathematically with their own private values, Bob and Alice simultaneously generate an identical symmetric key on their respective ends of the connection. Then, the resulting key secures the communications channel via a symmetric encryption algorithm. The same concept can be extended to IoT devices, establishing a secure link with the cloud destination machine or the border gateway.

The advantage of the D-H approach is that no predefined secret keys need to be exchanged. The public keys are known to everyone, and may actually be stored in public key servers located around the Internet. Only the respective private keys are stored on the opposite ends of the connection. Since the symmetric key is simultaneously generated on both sides of the link, the key never transits the link. This significantly increases the security of the link, and the use of a symmetric algorithm reduces the computational complexity of the encryption.

As an example, let's say that the sensor needs to send a set of collected temperatures of the refinery furnace over the past five minutes. The set of values may be from several temperature sensors located in the furnace and throughout the distillation vessel. Rather than setting up a virtual private network (VPN) for a continuous link, perhaps the company opts for periodic transfer of the data to keep communication costs down.

Using an asymmetric approach, the transmitting sensor needs only its own private key and the destination's public key. Then, using the approach outlined earlier, the sensor performs a double encryption with the destination's public key and the sensor's private key. The encrypted block of data can now be communicated to the destination using whatever method is appropriate. The destination then does the double decryption using the sensor's public key and the destination's private key. The temperature data is now available as a block of data at the destination, and confidentiality, authentication, and non-repudiation characteristics of the message can be assured (see Figure 4).

Asymmetric encryption techniques can also address authentication via software certificates and secure software updates using code signing approaches. Both practices are significant challenges in today's world of IoT-connected devices, where cybercriminals could add their own devices to a sensor network or arbitrarily update a sensor's software. Encryption is only one part of a "CIA" solution, but the encoding technology is at the heart of ensuring security for the IoT in any of its forms.

This article was written by Mike Anderson, CTO and Chief Scientist for The PTR Group, Inc. (Ashburn, VA). With over 35 years in the embedded and real-time computing industry, Mike works with a number of applications ranging from satellites and robotics to SCADA platforms. His recent focus has been the use of Linux and Android in embedded sensor applications and the deployment of the Internet of Things. For more information, visit ***http://info.hotims.com/61066-140****.*

CryoFOSS Optical Sensor Offers Next-Level Liquid Measurement


Allen Parker

NASA engineer Allen Parker and a team at Armstrong Flight Research Center have developed a fiber-optic-based sensing technology that accurately pinpoints and measures liquid levels. The CryoFOSS, or Cryogenic Fiber Optic Sensing System, uses fiber optic Bragg sensors, located along a single cable, to actively discern between liquid and gas states. The technology can be employed in a variety of applications, from NASA's rockets to a winery's storage tanks.

Sensor Technology: What is the CryoFOSS sensor?

Allen Parker: The CryoFOSS sensor was developed in an attempt to do liquid-level measurement or mass gauging in a cryogenic tank environment, for a rocket application like a fuel tank. The actual sensor itself is made of a fiber optic strand. The strand of fiber has gratings, or little sensors, that measure stress at every quarter inch along the length of the fiber. This fiber is placed within a small polyimide or PTFE tube. Inside the tube, with the fiber, we have a small heating element, roughly about the same diameter as the actual fiber itself. That heating element, along with the fiber, allows you to make a liquid-level measurement along the length of that structure.

ST: How is the sensor used to monitor a rocket's cryogenic fuel levels?

Allen Parker: We have a couple modes of operation. One is more of a continuous mode, while another is more of a "one-shot" mode. Basically, you energize the heating element. You apply a current, and that will heat up the local area around that heating element, which also contains the fiber. The fiber will tell you how the environment is absorbing that heat. You use the gratings inside the fiber as temperature devices. You simply monitor how the environment will suck away the heat that you're injecting through the heating element.

For the portion of the sensing structure that is located in the liquid, the thermal conductivity of the liquid would be higher than in the gas region. You would see in your data that the temperature would be transferred into the liquid a lot faster than it would be in the gas region. You would see that by way of a significantly lower temperature reading in that particular portion of the fiber data set.

ST: How is the CryoFOSS sensor better than current liquid-level gauges?

Allen Parker: The CryoFOSS sensor is better (in my view) because we are making a continuous liquid-level measurement. The sensors that I have seen demonstrated, whether they use a silicon diode or a thermocouple rake, are very discrete in nature. So you maybe have a sensor at the 75-percent fuel point, the 50-percent fuel point, or at the 25-percent fuel point. Once the liquid reaches that level, then you would have in your data set either an "on" or "off" to indicate if you were in liquid or in the gas region.

This particular CryoFOSS sensor gives you a continuous indication of liquid level throughout the length of the fiber optic sensor itself. So if you take this CryoFOSS sensor and install it in your tank from the top to the bottom, you can get a quarter-inch spatial resolution of liquid-level indication from the top to the bottom.

ST: Why are these measurements so important?

Allen Parker: Being able to get a real indication of liquid level, especially for rockets, is important — both on the fueling part of the process, and knowing when your tank is full or coming to a point where it's full. Also, what's probably more important: When you're expelling the fluid through a burn process, you want to be able to monitor that in real time and feed that back into the computer that controls the burning of that process. Being able to have an accurate indication of where the liquid level is is very important for that whole burn process.

ST: How is accuracy ensured, and how accurate are these measurements?

Allen Parker: It really is on a per-application basis. We've seen that it can vary a little based upon whether you're purging with a hot gas, not purging with a hot gas, or using liquid hydrogen or liquid nitrogen. In terms of an ideal situation, we are able to resolve it to within a half of an inch, or a quarter of an inch, based upon how we have the system set up — within at least one percent of accuracy.

ST: In what other applications could this be used?

Allen Parker: Another potential area is in the oil and gas industry. For instance, you may have a storage tank that has crude oil with water mixed in, or maybe even some sediment, based upon the type of processing being done in extracting the oil from the ground. We believe that this technology could be used to tell you how much oil, water, or gas that you have in a storage tank.

Of course, there are industries like wine and beer, where you have these large storage tanks, and they want to know exactly what the liquid levels are. This sensor is not limited to just cryogenic environments. It can be used in normal environments — wherever you have an application where you need to know liquid level.

ST: What was your role in the development of the CryoFOSS sensor?

Allen Parker: NASA Kennedy, along with Marshall, came to us because we were developing systems using this FOSS technology. They asked a question: Could we use this measurement technology, based on fiber optics, to give us a continuous indication of cryogenic liquid level? Our first response was: "Well, we don't know, but we can

The CryoFOSS system includes a fiber optic connector and sensor. (Image Credit: NASA)

definitely go out and do some crude measurements at Marshall [Space Flight Center, located in Huntsville, AL]," where they were conducting these experiments.

We took our system out and put it in an environment where we had some liquid nitrogen and did our first liquid-level measurement attempt. We found that the fiber in and of itself was not able to make that measurement. That's when we came up with the idea — this was my direct part — to couple that fiber with a heating element, to excite the local area around the fiber to see how the environment would absorb the heat, and use the fiber as an indication of that. It was really a team effort. My part was coming up with using a heating wire to help us make that liquid-level measurement.

ST: What's next with the development of CryoFOSS?

Allen Parker: We're continuing to do testing at NASA Marshall. We've been testing liquid hydrogen in a large tank that's symbolic of a fuel tank. Then, the thought is that we would move to liquid-oxygen-type applications and additional tank applications with different configurations. We're continuing to test, and continuing to partner with the rocket manufacturers out here to try and have this technology adopted.

ST: What do you think is most exciting about the sensor and its capabilities?

Allen Parker: What's really exciting is that the sensor itself is fairly simple. You have a tube, you have a fiber, and you have a heating element. It's relatively inexpensive. The egress inside the tank is, I believe, one of the simplest solutions: You have two metallic conductors and an optical fiber that passes through the barrier of the tank. That's pretty simple in comparison to some of the other tanks being used.

It's also a part of the fiber optic sensing family; you have a sensor that can give you liquid-level measurement, but that sensor plugs into a system as just another fiber that could make additional strain or temperature measurements. That's the versatility of the technology. One system could do liquid-level measurement, strain measurement, temperature measurement, shape measurement — all simultaneously on one system. So for a rocket, which is a very complex structure made up of multiple different types of systems that require different types of parameter measurements, the FOSS technology really has a lot of potential.

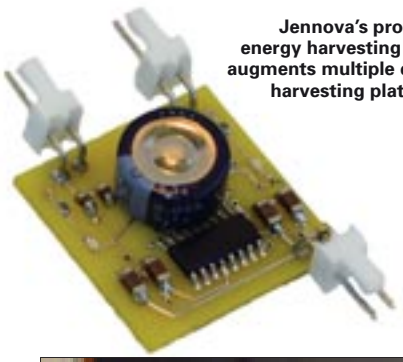
The CryoFOSS sensor is available for licensing. Through partnerships and licensing agreements with industry, NASA's Technology Transfer Program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life. For more information, visit ***www.technology.nasa.gov****.*

ENERGY HARVESTING'S EMERGING ROLE IN A 'SMARTER' WORLD

When most individuals hear "energy harvesting," they often think of alternative energy sources like wind and solar power. There is a distinct difference, however, between alternative energy and energy harvesting, or EH, approaches, based on the amount of power each can generate.

Alternative energy commonly focuses on grid off-set methodologies aimed at reducing fossil fuel usage. For example, wind turbines are capable of producing up to three megawatts per hour, enough to power almost 500 homes. Energy harvesting, on the other hand, typically produces energy in the microwatt range and is not considered a viable candidate for grid use.

So, why even bother with energy harvesting? Although there are many obstacles to its mainstream use, energy harvesting has an opportunity to support a growing number of devices and objects as they become connected to the Internet.



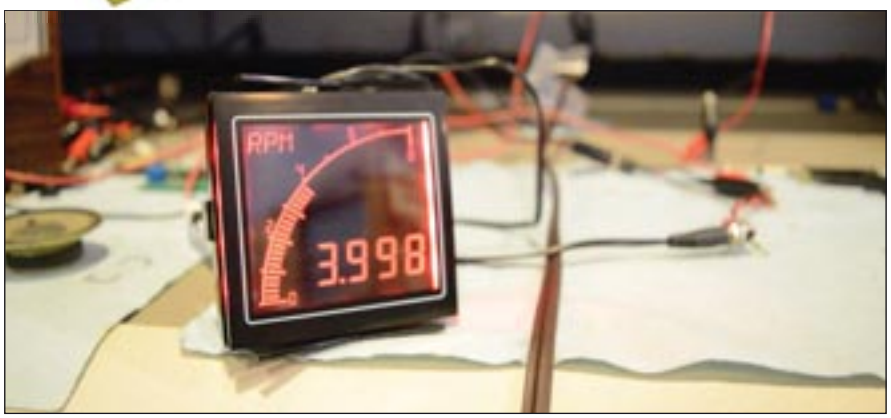
Jennova's prototype energy harvesting circuit augments multiple energy harvesting platforms.

As an example, let's consider a kitchen wall clock. Sure, two AA batteries will keep a traditional clock running for a few years. Now, think about the benefits of a clock that provides digital weather alerts in real-time and connects with mobile devices via Wi-Fi to offer texts, calls, and other push notifications. Suddenly, those two AAs cannot be expected to power the clock for extended periods of time, given the constant battery drain posed by the new "smart" clock features.

ENTER ENERGY HARVESTING

Instead of powering clocks with batteries that need continual changing, that new clock can now run non-stop for decades by combining a thermal gradient harvester with small solar cells. A thermoelectric energy harvester uses two dissimilar materials to convert a temperature difference into energy.

The same general concept surrounds the Internet of Things (IoT), which connects vast numbers of inanimate objects extrapolating copious amounts of real-time data to create increased operational efficiencies, in-depth insights, and human-free automation.



Lab testing of an energy-harvesting-powered wireless sensor and display, demonstrating how EH can simplify the integration of added measurement and HMI. (Image Credit: Jennova)

Imagine vital signs monitored with the accuracy needed to notify medical staff days in advance of a pending heart attack, or fully automated manufacturing plants operating with machines that repair themselves with no unplanned downtime.

IoT ideas perhaps sound complicated. In reality, however, these scenarios actually include a very simple process chain: data is collected by sensors; that data is transferred to either a fog or cloud network; the information is processed; and either extrapolated information or actuation commands are dispersed.

Where does energy harvesting fit into the mix? Go back to the clock example. In order to provide digitally-aware insights 24/7, the clock needs three components: the right software, the right hardware, and a steady, consistent power source. The same is true for widespread IoT implementations. Some updates would only require the latest software, with other applications needing new hardware integrated into the operational environment.

Opting for energy harvesting as a power source drastically reduces the initial and ongoing maintenance and cost of modular IoT upgrades, as well as offers a quicker and more simplified installation method. It may not seem too troublesome to change out the batteries of one clock, but imagine the effort involved in replacing and maintaining the batteries on tens of thousands of sensors and nodes installed throughout a manufacturing plant. The process would take months, if not longer, to complete the seemingly innocuous task.

In addition to time-saving benefits, energy harvesting also provides increased data rates for IoT applications. Real-time data is often the goal of many operations, and in some scenarios an absolute necessity. The energy cost for real-time, non-stop data collection and transmission is extremely high. Battery-powered sensors or transmitters operating in real-time, as opposed to

A prototype multi-sensor, powered by energy harvesting and capable of wireless transmission up to 1 mile. (Image Credit: Jennova)

delayed iterations, require more frequent battery replacements. As a result, efficient energy harvesting power sources would be needed at the data collection point, with wireless transmission and increased security features integrated into the sensor itself.

Finally, another energy harvesting benefit is mobility. A clock can be simply plugged into an outlet, provided an outlet is nearby. When the clock is self-powered, however, it can be placed virtually anywhere. This is a very important advantage in the IoT realm, where sensors or nodes are many times placed in remote, mobile, or hazardous locations, making hard-wiring or the regular replacement of batteries extremely cumbersome.

THE OBSTACLES

Why hasn't implementation happened already? There are successful energy harvesting IoT technologies that exist currently, but they are largely focused on very specific applications. In order for energy harvesting to reach its widespread implementation potential, there are a few barriers that still have to be breached.

Power Generation

Energy harvesting is generally talked about in terms of power creation relative to size, with the standard being cm^2. Most energy harvesting products within the landscape typically generate energy in microwatt range (μW). The amount of power can be valuable for MEMS sensors and a few other potential niches, but not for realizing the full

potential of energy harvesting in the IoT marketplace.

The current ideal power range for operating sensors and nodes is around 10 milliwatts (mW). Unfortunately, such a capacity is still a stretch for most energy harvesting platforms. The most prevalent energy harvesting platforms include thermoelectric, piezoelectric, RF harvesting, photovoltaic, and electrodynamic devices.

Thermoelectric harvesters convert a temperature difference into energy, but the devices only reach significant outputs when coupled together.

Piezoelectric crystals, used as vibrational energy harvesters, generate energy when their physical state is altered. In order to maximize the amount of created energy, however, the harvester must be tuned to the vibration of the desired installation site, which becomes a drawback for the goal of widespread implementation.

An expo display of rotation-based energy harvesters, gathering energy from standard fans. In this example, up to 18 mW is possible from a single energy harvester. (Image Credit: Jennova)

RF energy harvesting converts ambient radio frequency waves into energy. While wireless energy is the most ideal scenario, RF harvesters tend to generate the lowest amount of usable energy.

Currently photovoltaic and electrodynamic technologies have the highest power generation. Photovoltaic devices are capable of harvesting 100 mW/cm^2 with outdoor light, but only 100 μW/cm^2 with indoor light. Additionally, most energy harvesting technologies need to act as embedded components within enclosures that do not easily enable the collection of light for power.

Electrodynamic energy harvesting uses the basic principle of magnetic induction to harvest energy from motion and generate power in the mW range. While there are models that harvest from a wide variety of motion sources, however, many of the variations are bulky, again drawing concerns as embedded solutions.

Intermittency

Intermittency is also a challenge for users implementing energy harvesting platforms. Just like with alternative energy, the consistency of freely harvested energy can be difficult to guarantee. Think of solar panels. As long as the sun is shining brightly, there is plenty of available energy.

Similarly, every energy harvesting method faces the same threat of intermittency. There is no way to guarantee the consistency of power output, since consistency from the harvesting source is also not guaranteed.

ROI

Finally, and possibly the biggest hurdle yet for mainstream energy harvesting use, is the ability to present data-backed ROI projections. Energy harvesting benefits must be clearly demonstrated. Of course, there are and will be unique scenarios in which EH proves to be the best solution. To beat out alternate power sources, it will take real data from pioneering companies who want to implement energy harvesting into the early stage development of their overall platforms.

A PATHWAY FOR ENERGY HARVESTING

Collectively, the hurdles point in the direction of one best-case option overall: a small, low-cost, battery-coupled, vibration-based, electrodynamic energy harvesting platform. The smaller the device, the more easily it can be integrated. In addition, low cost is absolutely necessary for widespread implementation.

With this form of energy harvesting, the issue of intermittency is overcome by coupling a battery and energy harvester together. The battery acts as a primary power source, while the energy harvester keeps the battery charged to provide an elongated lifespan. With current battery developments, 20+ years of operation is not unreasonable.

Finally, vibration and electrodynamics go hand-in-hand. Whereas piezoelectric vibrational harvesting requires a "tuning" element, it is theoretically possible that an electrodynamic vibration model could operate without the need for major individual adjustments.

Essentially, the only current factor preventing the technology from reaching further into the IoT space is scale. For the many energy harvesting devices that meet the necessary size requirements, power density is often a challenge. So, either we wait for a smaller vibrational source with a high enough energy density, or a combined energy-harvesting, battery-powered technology that collectively meets both power needs and necessary lifespan.

As a result, an electrodynamic, vibrational energy harvester with battery power management could prove an extremely important pathway to the widespread implementation of Internet-of-Things technologies, regardless of industry. In such a world, software updates on open platform systems will be the norm (with modular hardware upgrades). Energy harvesting could provide cost-effective methods for scaling up the physical side of IoT systems worldwide.

This article was written by Christian Pennisi, COO of Jennova Inc. (Nashville, TN), a specialist in smart energy management solutions. For more information on Jennova and its new Electrodynamic Energy Harvesting (EH) technologies and products, visit ***http://info.hotims.com/61066-141****.*

Applications

NASA Sensor Supports Flexible Aircraft Design

A NASA-developed fiber optic sensor provides the kind of detailed feedback that could guide the direction of flexible wings and other next-generation aerospace parts. The multi-core fiber (MCF) contains light reflectors, known as fiber Bragg gratings, that reveal shape and position in three dimensions.

For analysis of stiff, long-established aircraft structures, NASA traditionally relied upon surface-bonded fiber optic strain sensors. As today's airframes move to lighter, more flexible configurations, new structures like morphing aircraft wing flaps and adaptable control surfaces provide too much unpredictable behavior for a traditional strain gauge to manage.

Jason Moore, a fiber optics sensor engineer at NASA Langley Research Center, currently tests and develops fiber optic technologies, including a multi-core fiber that senses in-flight structural shape change in the more advanced and flexible aircraft technology.

Moore focuses his research on how to use the fiber Bragg grating measurements to deduce the shape of the multi-core fiber.

"We're trying to get these shape sensors into or onto these flexible flaps, to feed back to the control system what these flaps are actually doing," said Moore.

The modified Gulfstream III (shown) is the testbed aircraft for the ACTE flexible-flap research project. (Image Credit: NASA)

Changing the Shape of Flight

NASA's Adaptive Compliant Trailing Edge project, a collaboration begun in 2014 between NASA, the Air Force Research Laboratory (AFRL), and the Ann Arbor, MI-based aerospace manufacturer FlexSys, is an effort to create shape-changing flaps that bridge the wing's gaps to create a seamless, bendable surface. The trailing-edge wing flaps aim to improve aircraft aerodynamic efficiency and reduce takeoff and landing noise.

Fiber optic sensors, previously employed to sense environmental characteristics like temperature and pressure, now provide an important understanding of an advanced aircraft's structural shape. The multicore fiber developed by Moore, once bonded, bends along with the moving surface. By measuring the bending and twisting of the MCF, using the embedded gratings, Moore can determine the shape of the multi-core fiber.

"You basically track the bending and the changing shape of the fiber, and that will directly tell what the shape of the structure is that it is secured to," said Moore.

The fiber Bragg grating sensors, contained in each core of the fiber, are embedded wavelength-specific reflectors.

By tracking the specific wavelength reflected from each "FBG" strain sensor, the effect on the fiber can be determined. If the fiber is stretched, for example, the wavelength reflected from the sensor increases, demonstrating strain.

The many cores are spaced equally throughout the fiber, both in an angular and radial sense. Even a small bend in the fiber will compress some of the cores, while stretching some of the others.

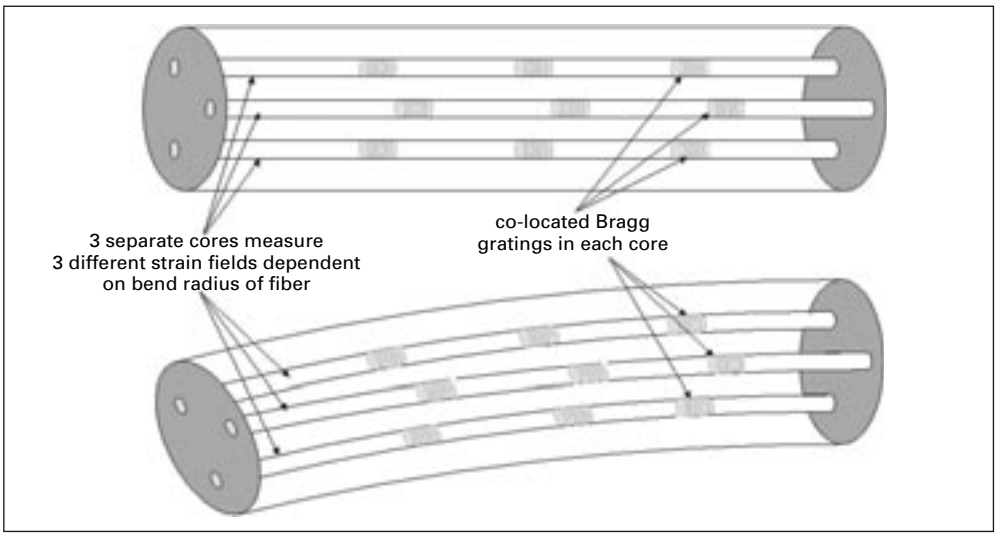
Think of a garden hose. If a fiber were run on the inside of a bend, the fiber would be compressed, showing a negative strain. If the fiber were on the outside of the bend, positive strain measurement would occur as the hose stretches.

"With many cores, we take up the measurements from all the gratings at each individual section down the fiber and get bend measurements," said Moore. "From those bend measurements, there's more math that can kick out an actual three-dimensional shape of the fiber."

When optical fibers were first used to provide shape-sensing measurements, bending had to be estimated at sequential points along the fiber, leading to errors and a poor indication of actual fiber position in three-dimensional space.

Jason Moore

NASA's patent-pending algorithms and apparatus incorporate the curvature, bend direction, and twisting information of the fiber to obtain an accurate 3D location and shape characterization.



The MCF (with fiber Bragg gratings) measures various strain fields as the radius of the device bends.

Achieving a Location, in Three Dimensions

The MCF's fiber Bragg grating strain sensors determine how any point along the fiber is positioned in space. The characteristics of optical fibers and the fiber Bragg gratings vary with curvature. By sensing the relative change of the fiber sensors in each of three or more fiber cores, the three-dimensional change in position can be determined.

Measurement of each core's strain occurs at specific axial locations along the fiber. When a multi-core fiber is bent, the strain imposed in each core, relative to one another, provides position information.

The sensing system also includes an interrogator, a measurement instrument that contains a zero-point reference of the fiber shape after installation. The lightweight fiber optic cables lead from the interrogator out to the shape-sensing fiber, which is taped down or bonded at locations of interest.

The interrogator measures the stretch or compression in each core's grating along the fiber. A laser sweeps over each core of the multi-core fiber, recording individual back-reflections. Through some signal processing, the measurements of each fiber Bragg grating are produced.

Next-Generation Sensing

Beyond flexible aircraft flaps, NASA's fiber optic sensor could also be used to monitor the deflection of NASA's inflatable re-entry shields and the agency's tethered satellites, which feature long cables that sweep through magnetic fields to generate electricity. The bonded sensors could measure the shape and behavior of the cable while it is being deployed.

Additionally, the fiber optic shape sensors could also be used inside catheters for very precise surgical maneuvers. Fiber-optic-based, shape-sensing catheters, placed in the human body, could be located without the use of X-ray technology.

Moore's primary application for the sensor, however, is to support new flexible aircraft and provide a measurement that might not otherwise be possible.

"These fiber optic shape sensors are just about the only way to get so much feedback in so much detail into what these control surfaces are doing that could ultimately steer the direction of these next-gen control surfaces," said Moore.

Moore is presently coordinating the installation of some multi-core fibers on wing models for wind tunnel testing. In a future flight test, the Langley team also plans to test the sensors' ability to monitor the effects of flutter, an unstable oscillation of an aircraft caused by aerodynamic forces.

In addition to creating equipment to test accuracy and refine the shape-sensing algorithms, Moore is also looking for more cost-effective ways of producing a multi-core fiber that contains more densely populated fiber Bragg gratings.

This article was written by Billy Hurley, Associate Editor, NASA Tech Briefs. *To submit questions or comments, email feedback@abpi.net. Visit* ***http://technology.nasa.gov for more information.***

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Company Description

HBM develops and manufactures its products at its seven locations in Europe, China and the United States. For over 65 years, HBM has earned itself a global reputation in its three key competencies: flexibility, precision and innovation.

As a leader in the measurement technology market, HBM is synonymous with quality, and offers all of the components in the measurement chain. Our clients rely on our solutions to guide their design, development, production and maintenance, to optimize their product life cycles.

In North America, HBM has provided exceptional test and measurement products used in a variety of testing applications for over 40 years.

In addition to the US headquarters in Marlborough, MA, there are facilities in Champaign, IL and Southfield, MI. Regional sales and application engineers are available throughout the country to offer the local support you need, whether it be for data acquisition, strain gauges, sensors, analysis software and more!

Target Markets

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- Agriculture
- Automotive
- Chemical
- Civil Engineering
- Construction
- Electricity
- Energy
- Food
- Gas
- Marine
- Medical
- Metalworking
- Military
- Off-Highway
- Packaging
- Petrochemical
- Petroleum
- Pharmaceutical
- Railway
- Steel

Products/Services Offered

Sensors: Strain gauges, load cells, transducers/sensors (torque, force, optical, displacement, pressure, piezo), OEM sensors.

Instruments: Data acquisition systems for a number of applications and specific requirements, including lab and general purpose, harsh environments, high speed, high channel, high precision and high voltage. Other products include amplifiers for production control and industrial use, optical interrogators, weighing electronics and indicators.

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Company Description

Micro-Epsilon is a medium-sized family-run company, which plays a leading role in measurement technology. For more than 40 years we have continuously offered reliable, high performance, unique solutions particularly when high precision measurement or inspection is required. Our product range covers sensors for the measurement of distance and displacement, sensors for IR temperature measurement and color detection, as well as systems for dimensional measurement and defect detection.

Innovative products that provide the very highest levels of precision are created through intensive research and development processes, unique know-how and a broad network of collaborative operations, which are essential for such high performance measurement systems. We understand that our customers are our business partners, which creates a win-win situation for both parties. Our products often provide customers with a genuine competitive advantage. However, this is only the case if the products are higher precision and so provide a clear, decisive competitive edge – with more precision.

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Aerospace, Conveying, Automation, Building, Chemical, Electronics, Energy, Precision Mechanics, Glass, Household Appliances, Academic Institutes, Hydraulics, Plastics, Food Industry, Machine Building, Medical Engineering, Metal Processing, Military, Paper, Shipbuilding, Railway

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Micro-Epsilon designs and manufactures high-precision sensors, instruments and systems for displacement, position, dimension, color and temperature measurement. An innovative multi-technology company that is dedicated to solve basic and extraordinary applications with an unrivalled range of standard or customized products. Customers throughout the entire world trust the state-of-the-art measuring technology from Micro-Epsilon.

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- Speed and length sensor ASCOspeed 5500
- Color sensors for various objects and surfaces
- Displays and signal processing units
- Inspection systems for in-line quality control

www.micro-epsilon.com

Free Info at http://info.hotims.com/61066-826

Renishaw Inc.
5277 Trillium Blvd.
Hoffman Estates, IL 60192
Phone: 847-286-9953
Fax: 847-286-9974
Email: usa@renishaw.com
www.renishaw.com

Company Description

Renishaw is one of the world's leading engineering and scientific technology companies, with expertise in precision measurement and healthcare. The company supplies products and services used in applications as diverse as jet engine and wind turbine manufacture, through to dentistry and brain surgery. It is also a world leader in the field of additive manufacturing.

We have a comprehensive range of encoders used by OEMs globally for exact positioning, reliability, and superior performance-to-cost value. Three encoder technologies – optical, magnetic and laser interferometer – all are engineered to deliver non-contact, friction-free operation, exceptional ease of installation, space savings, and application flexibility.

Target Markets

The Automotive Industries, Aerospace Industries/Defense (Munitions), Oil and Gas Industries, High Precision Manufacturers, Low to High Volume Manufacturers, the Medical Industry

Products/Services Offered

Renishaw is a global company with core skills in measurement, additive manufacturing, motion control, and precision machining. We develop innovative products that significantly advance our customers' operational performance – from improving manufacturing efficiencies and raising product quality. Our products are used for applications as diverse as machine tool automation, co-ordinate measurement, prototyping, gauging, machine calibration, and position feedback.

Our product offerings will enhance positioning, reliability, and productivity while striving for total customer satisfaction through superior customer service. Our aim is to provide leading-edge technology by encouraging innovation to address our customers' needs. Our key products include: VIONiC™ encoder systems, The ATOM™ miniature encoder, The RenAM 500M industrial additive machine, Equator™, The versatile gauge™, Revo-2, a 5-axis measurement system and RVP optical probe, the wireless QC20-W ballbar calibration system, RENGAGE™ machine tool probes and Inspection Plus with SupaTouch machine tool software.

www.renishaw.com

Free Info at http://info.hotims.com/61066-827

.steute Wireless

Creating Switch Solutions Without Cables

Steute Industrial Controls, Inc.
901 Ethan Allen Highway, Suite 102
Ridgefield, CT 06877
Phone: 203-244-6304
Fax: 203-894-8065
Email: leonard.patti@steutewireless.com
www.steutewireless.com

Company Description

STEUTE offers a broad range of wireless, industrial-grade, digital (on-off) control components and related accessories for control and automation applications.

Typical applications include product/machine element presence detection, machine on-off control, valve position monitoring, cut-to-length control, door/flap/hatch monitoring, mobile door control, assembly station inventory monitoring, security systems, emergency eye wash station alarms, production counting, and remote crane/motor control.

Target Markets

Automation and control applications for:

- Process Industries
- General Manufacturing
- Machinery Manufacturers
- Equipment Manufacturers
- Automotive Assembly
- Security Systems
- Packaging
- Food Processing

Benefits:

- Lower installation costs
- Elimination of cables that fail due to flexing or bending
- Elimination of long cable runs
- Handheld/mobile wireless control

Products/Services Offered

Products include limit switches, miniature position switches, pull-wire switches, non-contact magnet switches, non-contact inductive sensors, pushbuttons, selector switches, key-operated switches, foot switches, remote handheld controls, door handles with integrated pushbuttons, universal wireless transmitters, receivers, range extenders and antennas. All have the required FCC, IC and cCSAus certifications. ATEX and IECEx explosion-rated models are also available.

STEUTE would be pleased to discuss your application and recommend suitable components for addressing your control needs.

www.steutewireless.com

Free Info at http://info.hotims.com/61066-828

Photron
High-Speed Cameras for Slow Motion Analysis

Photron USA, Inc.
9520 Padgett Street Suite 110
San Diego, CA 92126
Phone: 858-684-3555
Fax: 858-684-3558
Email: image@photron.com
www.photron.com

Company Description

Photron is the world's leading manufacturer of high-speed digital imaging systems. Our high-speed cameras record at frame rate speeds of 60 to over two million frames per second (fps) perfectly freezing any action; providing reliability and high performance in the most challenging imaging applications, from scientific research to bio-analysis to manufacturing problem solving.

Target Markets

- Military
- Automotive
- Ballistics Testing
- Microscopy
- Particle Image Velocimetry (PIV)
- Digital Image Correlation (DIC)
- Broadcast

Products/Services Offered

Photron's varied product range makes it the first choice for designers, manufacturers, R&D and test engineers to solve their most challenging motion problems. Whether it's testing a new product design or piece of equipment, or trouble-shooting a high-speed production line, Photron's digital camera systems can capture thousands of high resolution images for playback and analysis. Products include the highest light sensitive cameras available with mega pixel resolution to 21,000 frames per second (fps), high definition (both 180HD and 720 HD), tiny high-G remote camera heads for easy access to difficult or hazardous locations.

www.photron.com

Free Info at http://info.hotims.com/61066-831

TE connectivity

TE Connectivity
2900 Fulling Mill Road
Middletown, PA 17057
Phone: 1-800-522-6752
te.com/gosensors

Company Description

TE Connectivity (TE) is a $12 billion global technology leader. Our connectivity and sensor solutions are essential in today's increasingly connected world. We collaborate with engineers to transform their concepts into creations – redefining what's possible using intelligent, efficient and high-performing TE products and solutions proven in harsh environments. Our 72,000 people, including over 7,000 engineers, partner with customers in close to 150 countries across a wide range of industries.

Target Markets

- Automotive
- Industrial
- Medical
- Appliance
- Aerospace & Defense
- Industrial and Commercial Transportation

Products/Services Offered

P900 HEAVY INDUSTRIAL PRESSURE TRANSDUCER: TE Connectivity's P900 Series Strain Gauge Pressure Transducers are premium grade sensors that provide highly precise measurement of absolute, vented gauge, or sealed gauge pressures over wide temperature ranges.

www.te.com/gosensors

Free Info at http://info.hotims.com/61066-832

MERIT SENSOR™

Merit Sensor Systems
1600 West Merit Parkway
South Jordan, UT 84095
Phone: 801-208-4722
Fax: 801-208-4700
Email: michael.daily@merit.com
www.meritsensor.com

Company Description

Merit Sensor Systems, Inc. has partnered with customers for more than 20 years to design, fabricate, assemble and package reliable, cost-effective piezoresistive pressure sensor solutions for automotive, medical, industrial, aviation, defense and consumer applications. Merit Sensor is able to provide unparalleled flexibility to customize pressure sensing solutions to fit into our customers' applications.

Target Markets

- Automotive
- Industrial
- Medical
- Aerospace
- Consumer Applications

Products/Services Offered

Merit Sensor provides customers with completely customized pressure sensor designs with large or smaller/limited production runs. Our customers range from pressure sensor transducer manufacturers who are experts in pressure sensing technology and rely on Merit Sensor for highly stable and sensitive MEMS sensing elements (bare die), to customers who have little to no experience in the pressure sensing world and look to Merit Sensor to assist with a completely custom design and implementation of a pressure sensor that best fits their application. At Merit Sensor our engineers are application experts. We are ready to help customers design applications to work with a pressure sensor or design a customized pressure sensing solution that works for any application.

www.meritsensor.com

Free Info at http://info.hotims.com/61066-893

New Products

Solid State Relays

The TS13102 and TS13103 solid state relays from Semtech Corp. (Camarillo, CA) support the company's Neo-Iso™ Platform, an isolated power/switch management technology. The TS13102 autonomously harvests energy, without the assistance of a microcontroller (and while the switch is closed). The harvested energy, stored in a system capacitor (Csys), can be shared across a system's multiple channels, driving several loads simultaneously. The TS13103, outfitted with a Power Transfer Output pin (PTO), transfers the harvested energy on the other side of the isolation barrier to the system's controller. Specific commands are sent through the control line (CLK) to perform a variety of functions, including receiving diagnostic information such as status, fault information, and voltage detection. The control and feedback lines can also be shared across multiple channels. Three address pins allow for up to eight switches on the same control line (CLK).

For Free Info Visit: http://info.hotims.com/61066-148

Pressure Gauge

The MAN-R pressure gauge from KOBOLD (Pittsburgh, PA) uses an elastic measuring element to generate a precise, reproducible deflection when subjected to pressure. The pressure is converted into rotary motion of a pointer. The subsequent pressure measurement can then be read on the scale of the dial. Available in ranges from 30" Hg to 15,000 PSIG, the MAN-R offers a choice of up to four magnetic, sliding, or highly reliable inductive switches. Bottom or rear process connections are available in 1/4" or 1/2" NPT.

The housing is a rugged stainless steel, and the bourdon tube sensing element and internal movement features either a rugged copper alloy or chemically resistive stainless steel. Rear mount fittings are offered with a panel mounting front flange. Dial size is available in 4 or 6 inches. Glycerin oil filling dampens excessive pointer movement caused by machine vibrations, and paraffin oil is specified when higher temperature conditions or optional switches are required.

For Free Info Visit: http://info.hotims.com/61066-149

Regulator

STMicroelectronics (Coppell, TX) has introduced the LDBL20, a 200mA Low-Dropout (LDO) regulator in a 0.47 × 0.47 × 0.2 mm chip-scale package. The LDBL20 features a 200mA output. Input voltage ranges from 1.5V to 5.5V, with 200mV typical dropout. Rejection (PSRR) of 80dB at 100Hz and 50dB at 100kHz simplifies filtering over a wide frequency range. The device has a quiescent current of 20µA no-load, 100µA full-load, and 0.3µA in standby. Output voltages are available on request, from 0.8V up to 5.0V in 50mV increments. Built-in features include logic-controlled electronic shutdown, internal soft-start, and support for active output-voltage discharge if required.

An evaluation board supports the design of fitness and blood-pressure monitors, glucose meters, hearing aids, wearable sensors, smart headphones, portable audio devices, smart plugs, and smart watches.

For Free Info Visit: http://info.hotims.com/61066-153

Position Sensors

The Alliance Sensors Group (Moorestown, NJ) has introduced the PG Series of linear variable differential transformer (LVDT) position sensors. The products are designed specifically for valve position sensing applications, such as steam turbine control systems in electric power generation plants. Installation features include standard body clamps, flange mounts, ball joint couplings, and rod eye ends. Two double-contact shaft seals keep contaminants from the LVDT's bore. With no connector, the sensor has screw clamping terminals that accept No. 24-14 AWG wire. Continuous sensor operation is possible in ambient temperature up to 350 °F (175 °C).

A PG series LVDT's 3/8-inch diameter operating rod, offered with either a rigid coupling or a ball joint coupling, captivates the LVDT's core so that it can never come out or vibrate loose. Alliance Sensors Group PG Series LVDTs are available in five full scale ranges from 0–3 to 0–15 inches (75 to 380 mm).

For Free Info Visit: http://info.hotims.com/61066-150

New Products

Wireless Temperature Sensing System

Chromalox (Pittsburgh, PA) offers the IntelliTrace® Wireless system for heat trace applications in both ordinary and hazardous areas. The Chromalox temperature sensing system includes the IntelliTrace® ITAS or ITLS Series Heat Trace Control Panel and specific industrial wireless transmitters, which are paired with appropriate temperature sensors. The panel facilitates both wired and wireless temperature sensor inputs, and the touchscreen computer HMI distinguishes wireless circuits from wired ones. The IntelliTrace® Wireless system utilizes the Rosemount® 248 Wireless Temperature Transmitter, which may be pipe- or structure-mounted. The 248 transmitter is offered with either aluminum or polymer housing, and is available with or without a matching universal mounting bracket.

For Free Info Visit: http://info.hotims.com/61066-151

Sensor Diagnostics

The IP67-rated Allen-Bradley ArmorBlock IO-Link master from Rockwell Automation (Milwaukee, WI) allows manufacturers and industrial operators to access detailed sensor diagnostics in harsh operating environments. The device features event and process time-stamping capabilities for on-machine applications. The IO-Link master stores up to 40 timestamps of sensor events on each channel. Input timestamps of all sensor data also can be sent to the controller upon a change of state. The on-machine option requires only a single cable from the cabinet. The ArmorBlock IO-Link master includes connectivity for up to eight IO-Link sensors.

For Free Info Visit: http://info.hotims.com/61066-152

Transceiver

Mountain RF Sensors (Fort Lauderdale, FL) has announced the MtRF-7501 VHF/UHF Ground-to-Air Transceiver. The model supports Single Side Band (SSB), LSB, and USB modes. Featuring frequency ranges of 116–152 MHz (VHF) and 225–400 MHz (UHF), the Model MtRF-7501 provides RF output of 25 Watts AM, 50 Watts FM, and 100 Watts on SSB. Housed in a 4U, 19-inch rackmount enclosure, the transceiver includes serial, USB, Ethernet, and remote display ports. The unit features a color touch screen standard, plus dedicated front panel controls for power, volume, squelch, tuning, and high/low power. The MtRF-7501 operates from 90–250 VAC line power or 24–32 VDC.

For Free Info Visit: http://info.hotims.com/61066-154

Lidar Sensor

Velodyne LiDAR (Morgan Hill, CA) has announced the Puck Hi-Res™ sensor. Expanding on the company's VLP-16 Puck, a 16-channel, real-time 3D lidar sensor, Puck Hi-Res provides greater resolution in the captured 3D image. Puck Hi-Res retains the VLP-16 Puck's 360° horizontal field-of-view (FoV) and 100-meter range, but offers a 20° vertical field of view for a tighter channel distribution — 1.33° between channels instead of 2.00°. The real-time LiDAR sensor supports autonomous-vehicle, 3D-mapping, and surveillance industries and applications.

For Free Info Visit: http://info.hotims.com/61066-155

Pressure Sensor

SignalFire Wireless Telemetry (Hudson, MA) has introduced the Pressure Scout, a wireless pressure sensor that supports pressure monitoring and alarm reporting as part of the SignalFire Remote Sensing System. The first in a line of wireless integrated sensors, the Pressure Scout consists of a pressure sensor (integrated with a wireless node) and internal battery. Ideal applications for the device include well tubing and casing pressure monitoring, tank level monitoring, and compressor station status monitoring.

The Pressure Scout provides up to a ½-mile transmission to the Signal Fire Gateway, where pressure data becomes available via a Modbus RTU or TCP interface. Sold in standard pressure ranges, the Pressure Scout performs five-second pressure sampling with configurable alarm reporting. Units offer local push-button zeroing. The technology operates in temperature ranges from -40 °C (104 °F) to 80 °C (176 °F). The Pressure Scout utilizes an internal battery that powers the integrated pressure sensor and radio for up to 10 years.

For Free Info Visit: http://info.hotims.com/61066-570

Magnetic Sensors

Wireless, non-contact magnetic sensors from Steute Industrial Controls (Ridgefield, CT), in the presence of their actuating magnet, send a unique, coded telegram to one or more compatible, easily-programmed receivers. The receiver accepts up to 10 discrete telegrams per channel. The magnetic devices, powered by a field-replaceable lithium battery, operate at 915 MHz (USA/Canada/Australia) or 868 MHz (Europe). Other features include sensing range of up to 30 mm; bidirectional communications with receiver; IP67 ingress protection rating; operating temperature range of -20 to + 65 °C; and a stainless-steel or glass-fiber reinforced plastic housing.

For Free Info Visit: http://info.hotims.com/61066-569

Pressure Sensors

All Sensors Corporation (Morgan Hill, CA) now offers the DLHR pressure sensor series. The new devices feature lower pressure ranges of 0.5 to 60 inH_2O. All error compensation is performed internally by an advanced ASIC; no external calculation is required.

The DLHR products include I^2C or SPI output interfaces with 16/17/18-bit resolution. With the ability to operate at a low, variable supply voltage (from 1.68V to 3.6V), the DLHR Series supports portable applications, including medical devices associated with low pressure, remote sensing, spirometry, and industrial controls. Devices are available in 0.5, 1, 2, 5, 10, 20, 30, and 60 inH2O pressure.

For Free Info Visit: http://info.hotims.com/61066-568

Humidity Sensor

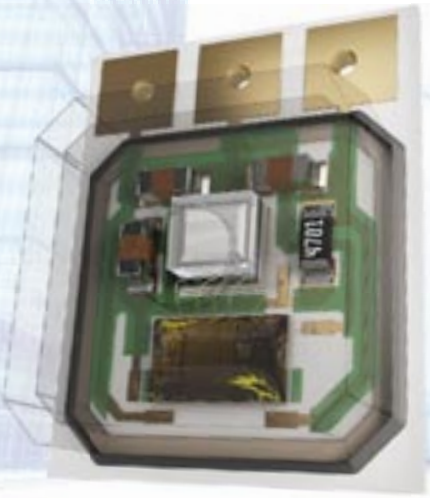
The Humidity Sensor from Develco Products (Aarhus, Denmark) allows end-users to track indoor climate. Regular readings can be sent from the sensor to an app. Users control the humidity level and temperature from a distance; several households or institutions can be monitored from one central point. Equipped with the wireless technology ZigBee, Develco's new sensor is easily connected with other existing devices in "smart home" applications. A ventilation system, thermostat, or air-conditioner can automatically be activated by the humidity sensor.

For Free Info Visit: http://info.hotims.com/61066-567

MERIT SENSOR SYSTEMS

MEMS SENSORS & PRESSURE TRANSDUCERS

- Wide temp range -40 .. +150°C
- Harsh-Environment (Backside pressure)
- Eutectic soldered HM-Series (media compatible)
- Gage and absolute
- Moisture resistant
- Pressure range : 1 .. 35 bar
- Vacuum capability



TR Series

- Burst pressure : 3x (min. 105bar)
- Analog Ratiometric output (0,5 .. 4,5Vdc)
- Accuracy 2.5%FS (total error band)
- RoHS-Compatible
- AEC-Q100 certified
- Axial / radial sealing
- Short circuit, overvoltage, ESD protected

Automotive • Medical • Industrial • Consumer • Aerospace

LP-Series:
Low pressure range: 1.0 .. 7 kPa
Uncompensated/compensated (full calibrated) with analog/digital (I2C) output. Evaluation kit available for testing.

MEMS sensors:
Wide pressure range: 1kPa .. 100 MPa
High stability with superior thermal hysteresis and non-linearity features.

Pressure transducers:
Uncompensated/analog/I²C SMD gage/differential. Excellent media compatibility with wide pressure ranges.

See the TR Series in Detailed 3D. No App Required. ▶

ABOUT MERIT SENSOR

Merit Sensor Systems offers the broadest range of MEMS pressure sensors and pressure transducers on the market.

Our 25 years of supplying our customers with highly accurate and reliable pressure sensors make us a partner you can trust.

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MEMS Pressure Sensors

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Our field-proven range of FCC-, IC- and $_{C}CSA_{US}$-certified wireless switches and receivers include limit, pushbutton, selector, key-operated, foot, magnetic, inductive, pull-wire, and integrated door handle switches. Available for battery-less (energy harvesting) or long-life battery operation.

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