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Since its founding in 1947, Southwest Research Institute (SwRI) has contributed to the advancement of science and technology by working with clients in industry and government. Performing research for the benefit of humankind is a long-held tradition. The Institute comprises 10 divisions engaged in contract research spanning a wide range of technologies.

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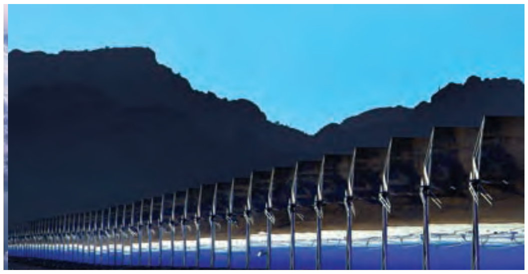
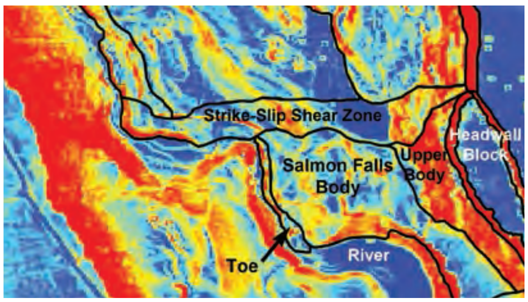
COVER

About the cover
Capsules containing phase-change materials store thermal energy for use at a solar concentrating power plant after sunset.

ARTICLES

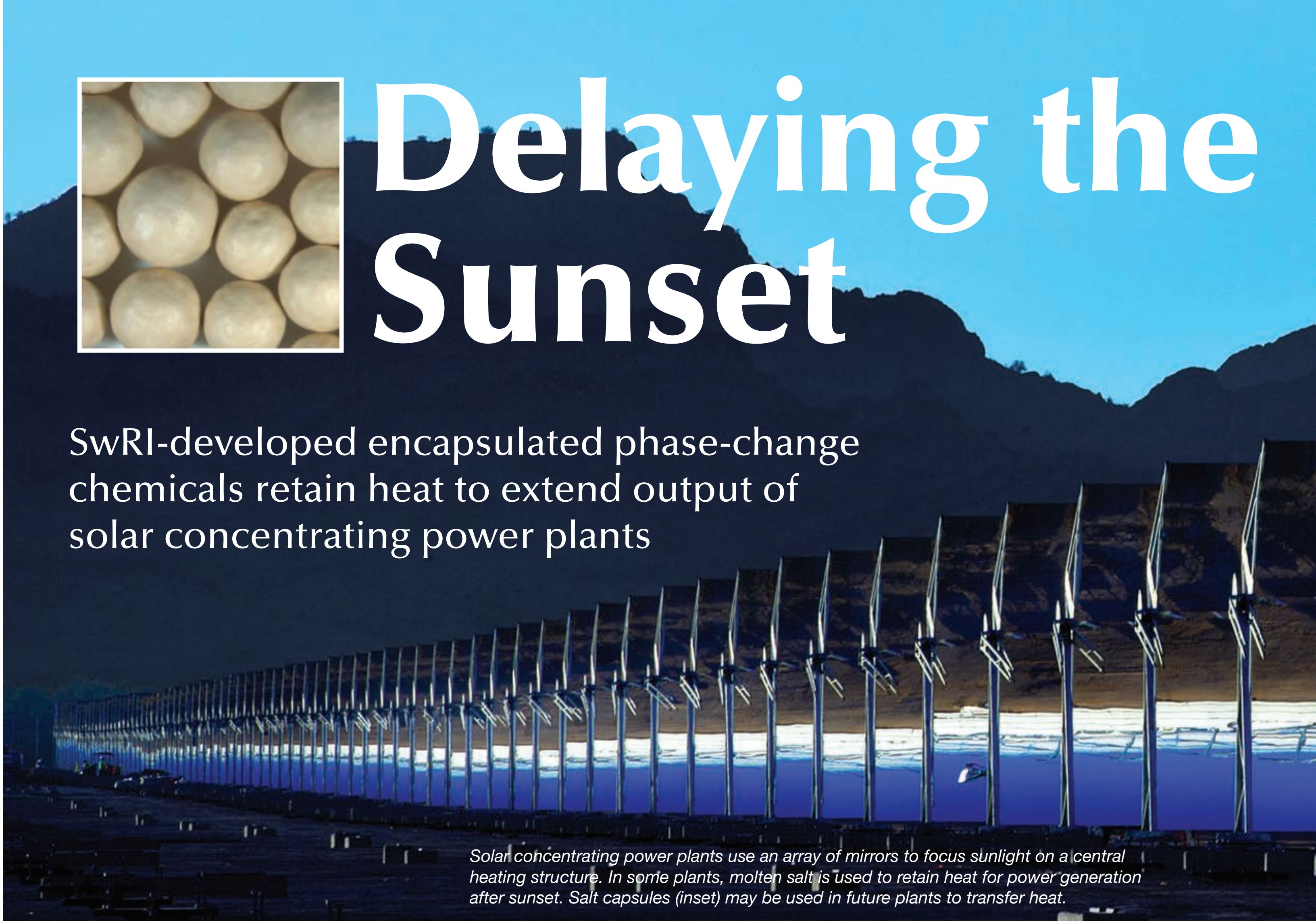




Departments

Delaying the Sunset

SwRI-developed encapsulated phase-change chemicals retain heat to extend output of solar concentrating power plants



Solar concentrating power plants use an array of mirrors to focus sunlight on a central heating structure. In some plants, molten salt is used to retain heat for power generation after sunset. Salt capsules (inset) may be used in future plants to transfer heat.

Photo courtesy of National Renewable Energy Laboratory

By James Oxley, Ph.D.

The alternative energy industry continues to grow in size and diversity as more countries invest and expand their use of wind, solar, hydroelectric, and geothermal power. Concentrated solar power (CSP) is one of many technologies experiencing growth in this area. It differs from conventional photovoltaic solar panels in that CSP systems use large arrays of mirrors or lenses to concentrate sunlight onto a small fixed point. The heat from this fixed point is then transferred to a conventional steam generator for conversion into electricity. The United States added 1,000 megawatts of CSP capacity to the electricity grid in the past year, bringing the total to about 1.4 gigawatts. (By comparison, the U.S. passed 16 gigawatts of photovoltaic solar power capacity in 2014.)

But a lack of adequate storage solutions for intermittent power sources is one of the most significant hurdles to integrating alternative energy systems. CSP relies upon sunlight for operation. For CSP to mature as a source of electricity and meet goals of uninterrupted supply, new energy storage systems must be developed and adapted for times when sunlight is not available.

Two modes of energy storage are applicable to CSP plants. Thermochemical systems use the energy storing capacity of a reversible chemical reaction, while thermophysical systems rely on the physical properties of a material. Both kinds of systems are under investigation, including latent (phase changing) and sensible (static phase) heat options. One of the newer plants uses high-temperature molten salts to provide up to six hours of energy storage after sunset. However, to make CSP systems competitive with conventional forms of electricity, energy storage systems need to be optimized.

Current commercial thermophysical energy storage systems use high-temperature molten salts in two large tanks, adding about $30 per thermal kilowatt-hour (kWh_t) to costs. One tank receives heated molten salt from the CSP receiver tower and supplies heat for the steam generator. The second tank receives the cooled molten salt from the steam generator and transfers it to the CSP receiver tower to be reheated.

A team of chemists from Southwest Research Institute (SwRI), under contract with a commercial client firm, recently sought to develop a single-tank solution to reduce the cost by half, to $15 per kWh_t. This approach uses latent heat and a novel encapsulation formulation for its high-temperature, phase-changing salt. The cost reduction is achieved through a 50-percent increase in energy density and a consequent reduction in the amount of salt required for thermal storage. The team of SwRI chemists and the commercial client developed a novel encapsulation formulation of a high-temperature phase change salt for use in a single tank CSP thermal storage system.

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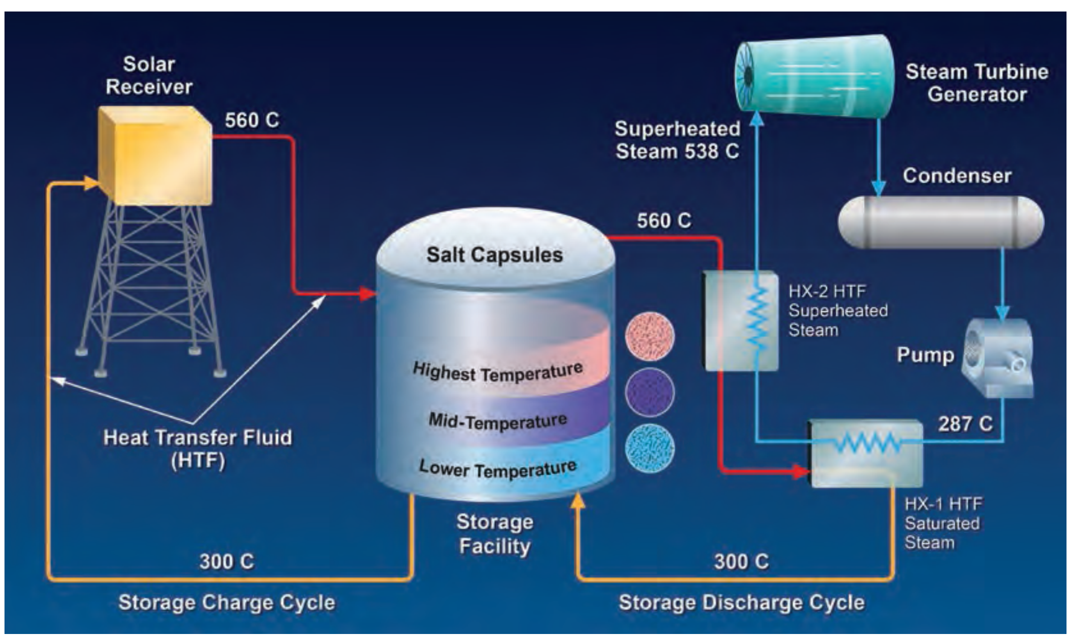
Dr. James D. Oxley is a principal scientist in the Chemistry and Chemical Engineering Division. He performs micro/nanoencapsulation and particle design research related to processes, chemistry, formulation development, and analytical methods. He has worked to develop encapsulated products and ingredients for applications including pharmaceuticals, nutraceuticals, consumer products, paints, coatings, energy storage, and other industrial products.

Phase-change microcapsules

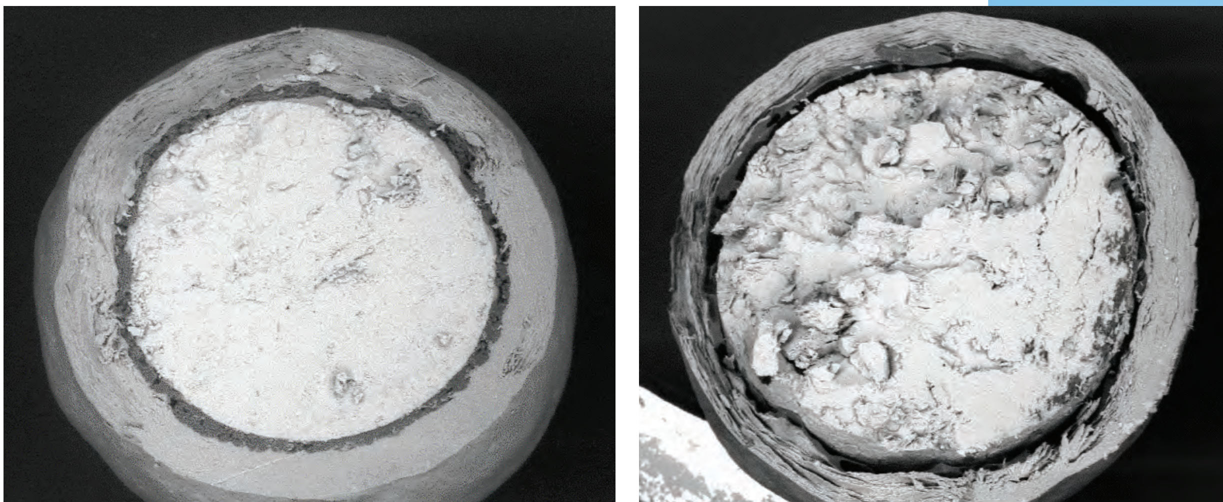
Microencapsulation is the process of containing an active ingredient within a protective shell, or matrix, to produce particles ranging from submicron to several millimeters in size. Microcapsules have applications in multiple fields, including pharmaceuticals, food, cosmetics, consumer products, agriculture, paints, coatings, construction, and defense. Encapsulated phase-change materials have been used for decades in applications ranging from thermal indication in forehead thermometers and coffee mugs, to temperature regulation in textiles and building materials. The traditional techniques for preparing capsules for low to moderate temperature applications use organic polymer shell materials and waxes, fats, or other organic materials as the phase-change media. In most cases, the upper temperature limit is 150 degrees Celsius. Encapsulating phase-change materials for solar thermal energy storage application requires a novel formulation to address the extreme environment and the unique properties of the payload.

Microcapsules used in conventional CSP systems must be stable at temperatures up to 600 degrees C, accommodate the volume expansion associated with inorganic salts as they melt or solidify, withstand the intergranular pressure associated with storage in a large tank, and survive 30 years of daily phase-change cycles. No conventional commercial encapsulation solutions meet this set of criteria, but many existing capsule formulations can meet individual objectives. For example, inorganic shell materials can withstand the high temperature but lack the flexibility to accommodate the core material's volume expansion of up to 20 percent when the inner salt melts.

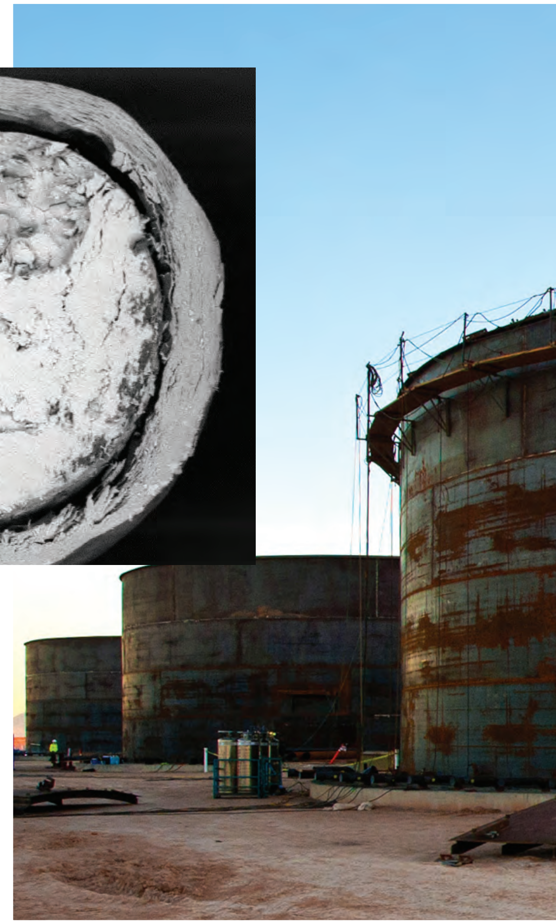
To meet the CSP requirements, SwRI scientists developed a novel



In this diagram, a single-tank concentrating solar plant stores energy using layers of encapsulated phase-change materials. Heat transfer fluid is pumped into the tank's top from the solar concentrator. Heat is transferred to the capsules and the cooled heat transfer fluid is pumped from the bottom of the tank, back to the concentrator for reheating.



Micrographs of phase-change salt tablets show their layered construction, before (left) and after (right) they are heat-treated to form an internal void that allows for expansion.



three-layer shell and a process to produce it. To withstand the high temperatures of a CSP system, the outer layer was formulated with a clay-based composite that is stable beyond 600 degrees C. A ceramic binder and polymeric film former were used to aid outer-layer deposition as well as subsequent heat tempering. The middle layer of the capsule shell was a sacrificial organic material that burned away to yield an inner void between the outer capsule wall and inner core material. This void provides space for core material to expand as the salt turns from solid to liquid. Finally, a third inner layer serves as a temporary protective barrier between the sacrificial polymer and the payload. The inorganic nitrates, such as potassium nitrate, commonly used as high-temperature phase change are typically strong oxidizing agents. To prevent rapid oxidation of the organic sacrificial layer during thermal evacuation at 250-300 degrees C, the inner layer isolates the salt until void formation is complete. As the salt melts and expands when temperatures reach 315-340 degrees C, it ruptures this temporary protective inner layer.

The capsules were prepared using a fluid bed coating encapsulating process. Fluid bed coating, also known as air suspension coating, is the second most-common encapsulation process and is used across multiple industries. With contract manufacturing capacities available up to 1 ton per hour, it is an attractive process for short-term scale-up potential.

Spherical pellets, or prills, of inorganic salt, approximately 3-5 millimeters in diameter, were loaded into a fluid bed coater and fluidized on a bed of air. While suspended in warm air, coating solution was sprayed onto the particles, resulting in the incremental formation of a coating. The inner, middle, and outer capsule layers were coated in succession, using coating timing and solution flow rates to control the thickness of each layer. The coated salt prills were then subjected to a controlled heat treatment to remove residual coating solvent, ameliorate the film-forming polymer in the outer layer, and eliminate the middle sacrificial layer. For potassium nitrate capsules, the heat treatment reaches 320 degrees C. Once the sacrificial layer was removed, the capsules were then heated to 400 degrees C to melt the inner core. The SwRI team used optical and electron microscopy to confirm capsule morphology during the preparation and heat-treatment process.

Testing and evaluation

Once the capsules were prepared, the team evaluated the capsules' mechanical stability and phase-change performance, including simulating performance over a 30-year service life or approximately 10,000 heat/cool cycles. Mechanical testing reported a 40 percent decrease in capsule strength compared to the uncoated salt prill. To compensate for reduced mechanical strength, final storage tank designs may require baffles to reduce intergranular pressure on the capsules.

Thermogravimetric analysis confirmed that the phase change activity of encapsulated potassium nitrate over a 20-cycle period created no evidence of decreasing intensity or reduced capsule integrity. To accelerate the testing process for 10,000 cycles, the SwRI chemists hosted a rapid thermal cycling apparatus designed and built by the client. The device submerges batches of phase-change capsules between a "cold" tank at 250 degrees C and a "hot" tank at 425 degrees C for two to five minutes per cycle, with each tank containing a lower-melting heat-transferring liquid salt. The capsules remained intact after being cycled 5,000 times, although they did show some signs of salt diffusion through the capsule walls.

Microcapsules designed with a sacrificial layer normally have some porosity in their outer shell so gases can escape.

Large, insulated tanks like these, shown under construction at a solar concentrating power plant site, store molten salt for use to create steam after sunset.

Photo courtesy of National Renewable Energy Laboratory

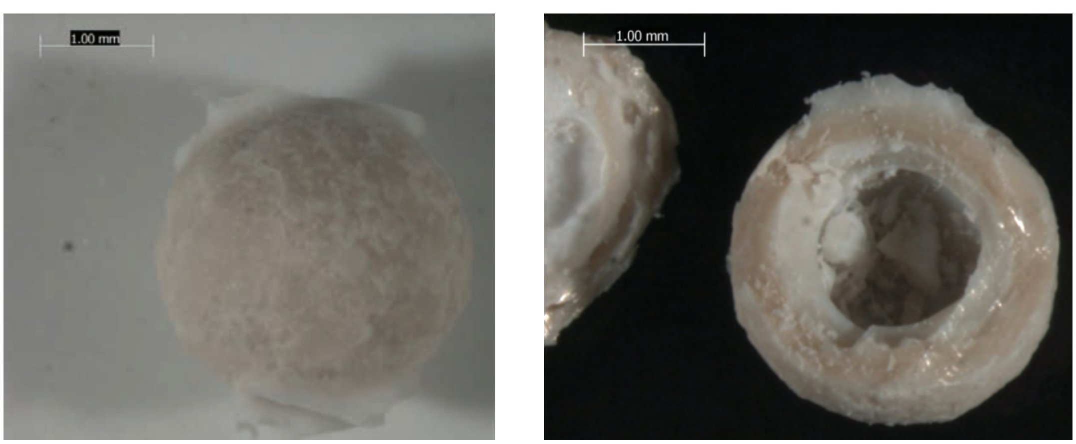
The initial capsule design did not include a step to seal the capsules. Although the initial allotted project achieved 5,000 cycles, the team has proposed subsequent experiments and formulations to deposit a nickel coating onto the surface of the capsule to reduce porosity and enhance its mechanical strength.

Conclusion

The client's initial vision and the SwRI team's encapsulation expertise combined to develop a novel, high-temperature phase-change microcapsule. The capsules are stable up to 600 degrees C, possess moderate mechanical strength, withstand the thermal expansion of the encapsulated salt as it transitions between phases, and have been demonstrated to survive 5,000 thermal transfer cycles. This work was conducted on a laboratory scale, preparing fifty 200-gram batches of capsules, and using 10-gram quantities for the cycling studies with a potassium nitrate salt core.

Future projects could address further optimizing of the capsules and investigating their performance on a pilot scale. Additional enhancements could include a nickel coating to seal the capsules, as well as encapsulating other salts. Pilot-scale research would involve preparing 25-kilogram (55-pound) batches of capsules and supplying them for larger thermal cycling studies to demonstrate their use in a thermal energy storage system.

Questions about this article? Contact Oxley at (210) 522-2913 or james.oxley@swri.org.



This micrograph shows the condition of phase-change capsules after 250 cycles from 250 degrees C to 425 degrees C.

A Sliding Scale

Satellite image analysis measures up as a landslide risk assessment tool

The Salmon Falls Creek Canyon, near Twin Falls, Idaho, is a well-studied locale by researchers investigating the evolution of landslides dating back to 1937. The creekbed is visible in the lower right-hand quarter of this photograph, with the headwall of the landslide forming a bluff in the background.

By Marius Necsoiu, Ph.D., Ronald N. McGinnis and Donald M. Hooper, Ph.D.

Landslides and related events are a worldwide threat to human life and property, affecting all 50 states. In the U.S., they cause up to $2 billion in damage and more than 25 deaths each year, according to the U.S. Geological Survey. The annual worldwide death toll from landslides is in the thousands.

Preventing, predicting, or mitigating landslides is complicated, requiring extensive knowledge about the myriad factors involved. A team of Southwest Research Institute (SwRI) scientists set out to find ways to improve monitoring and risk-assessment technologies for these often devastating natural disasters.

For many years, geoscientists have used inclinometers and other on-site, ground-based instrumentation to detect and track slope instability. These instruments, inserted into boreholes or placed on the ground surface, map earth movements by linking to high-resolution global positioning system (GPS) data. More recently, wireless sensor arrays have been deployed to monitor landslides.

Using airborne or satellite-based remote-sensing systems can reduce costs of monitoring landslides and also provide rapid, up-to-date digital data over large swaths of terrain. Early remote-sensing methods compared a succession of images to map landslide progression over time. More recently, satellite-based Interferometric Synthetic Aperture Radar (InSAR) has used sophisticated processing techniques to recognize and map identifiable, pixel-sized features that appear in pairs of radar images over time. Although InSAR can distinguish spatial relationships and provide information on landslide movement patterns, slow-moving landslides and particularly rugged terrain challenge conventional InSAR techniques. Variable time spans between radar images can also affect accuracy.

To address these problems, scientists are applying new processing algorithms for InSAR data that can identify pixels that are said to be coherent, or recognizable across multiple radar images. By applying two of these techniques, Persistent Scatterer (PS) and Small Baseline Subset (SBAS) interferometry, scientists can measure minuscule movements of natural features, such as rocky outcrops and boulders, and man-made structures, such as roads and homes.

A team of geoscientists from Southwest Research Institute evaluated the PS

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Marius Necsoiu, Ph.D., left, is a principal scientist in the Earth, Material and Planetary Sciences Department. He is an environmental scientist and electrical/electronic engineer with broad national and international experience and expertise in remote sensing systems. Ronald N. McGinnis, center, is a structural geologist and a senior research scientist. His expertise includes quantitative and qualitative analyses of the origins of structural geologic and tectonic features. Donald M. Hooper, Ph.D., right, is a geologist with expertise in volcanology and geomorphology. His research experience includes landscape evolution and terrain analysis. All are in the Geosciences and Engineering Division.

and SBAS radar interferometric techniques as a landslide risk assessment tool. The team applied the techniques to archived InSAR images to create accurate motion rate estimates for a landslide area in Idaho. This process also gave insight into the strengths and weaknesses of the two techniques.

Physical setting and local geology

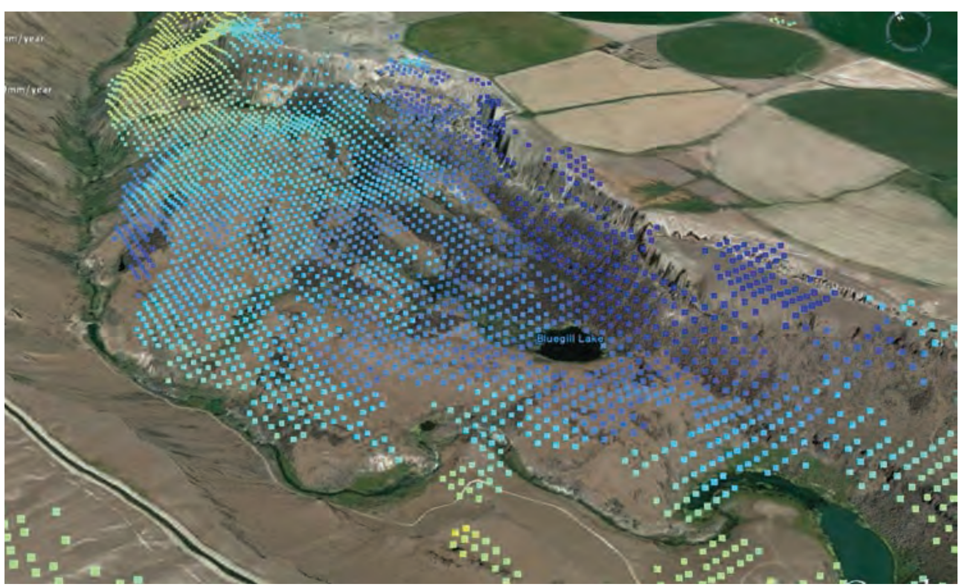
The SwRI team focused on a landslide complex in Salmon Falls Creek Canyon near Twin Falls, Idaho, because the site is well-studied and the team has field experience in the area. In southern Idaho, the Snake River has cut valleys through hard surface basalt and the softer sedimentary strata below, a natural process that has destabilized valley walls, causing landslides. Salmon Falls Creek, a tributary of the Snake River, flows through a narrow canyon that is about 130 meters (427 feet) deep and 375 meters (1,230) feet wide. Ten kilometers (6.2 miles) downstream, landslides have widened the canyon to 1.3 kilometers (0.8 mile).

The Salmon Falls landslide's headwall, or the point from which the landslide broke away, shows vertical slippage down onto horizontal basalt pavements. Farther down the slope, large basalt blocks dot an area where an earlier slide disrupted and rotated the basalt pavement. Still farther down, a zone of mixed basalt and clay-rich sediment indicates where the landslide probably initiated. The uplifted creek flood-sediment lying atop intermixed basalt and clay shows evidence of repeated landslides.

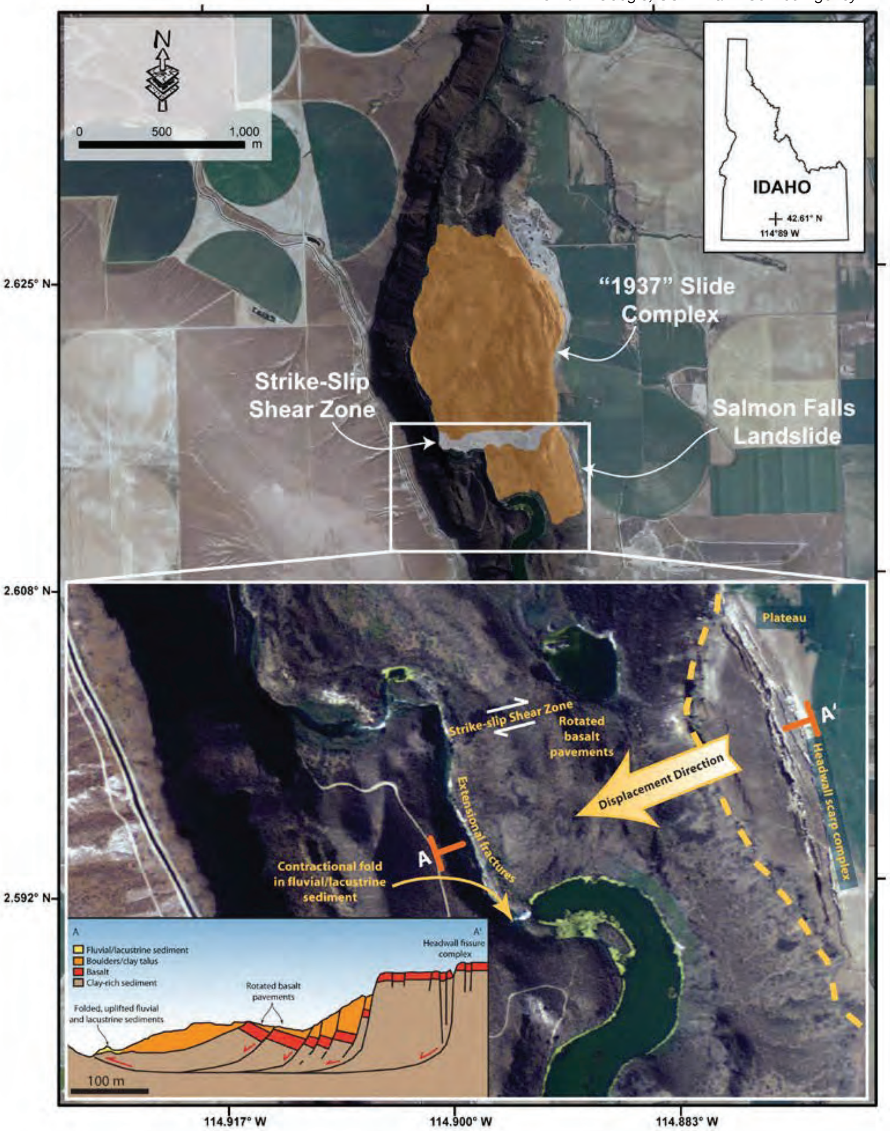
Landslides periodically dam the creek, leading to concerns about catastrophic flooding downstream if the landslide-formed dam were to unexpectedly give way. The landslide's fastest recorded movement (45–200 centimeters, or 18–79 inches) per year occurred between 1998 and 2003. As of 2008, the rate of movement on the landslide had significantly decreased to less than 10 cm/yr (4 in/yr). The earliest recorded event in the area was a 1937 landslide about 0.8 km (0.5 mi) north of the later 1998-2003 event. Although much larger than the Salmon Falls landslide, the 1937 landslide is similar in both shape and deformation pattern. The boundary between the two slides is defined by an east-west shear zone, which provided a basis for differentiating between the movements within the two slides.

Remote-sensing data and analysis

The ability to monitor surface movement rates on landslides over time in an inexpensive and efficient manner allows scientists to (i) characterize unique movement patterns within a slide complex, (ii) quickly assess potential hazards associated with the slide, and (iii) monitor regularly in order to provide a baseline of movement rate data that may help to predict large slide events.



A three-dimensional effect is produced by superimposing a series of dots representing SBAS reference points atop an orthophoto image of the 1937 landslide complex at Salmon Falls Creek, Idaho. (Background image © 2014 Google, USDA Farm Service Agency.)



Located 30 miles west of Twin Falls, Idaho, the landslide study area includes the entire Salmon Falls Creek Canyon landslide complex. The white rectangle represents the area shown in the inset at bottom, which in turn shows a roughly east-west cross section of the Salmon Creek Gorge.

To provide a basis for evaluating the adequacy of alternative techniques, the SwRI team found a large set of historical satellite images of the Salmon Falls Creek area previously acquired by the European Space Agency. The team examined data quantity and type, image time frames, and other factors that affect accuracy, eliminating images obscured by snow, rain, and overcast conditions. They selected two datasets, 39 images from 1995–2002 and 20 images from 2005–2009.

Next, they gathered field data to compare to the 2005–2009 dataset. Between November 2006 and September 2008, an SwRI-led team conducted seven GPS field surveys at the study site. An autonomous base station achieved survey-grade accuracies, recording 10 locations (nodes) over seven survey campaigns. For each node, the elevation was re-projected in the line-of-sight of the InSAR sensor. The team confirmed displacement values with SBAS-recognized locations within 20 meters of each GPS node.

InSAR analyses generated results over these two time intervals representing estimated total displacement, mean displacement velocities, and displacement history. Finally, the team analyzed specific surface features as persistent scatterers/coherent pixels, recognizable in multiple images over time, for both the 1937 and the more recent Salmon Falls landslides.

Results and interpretation

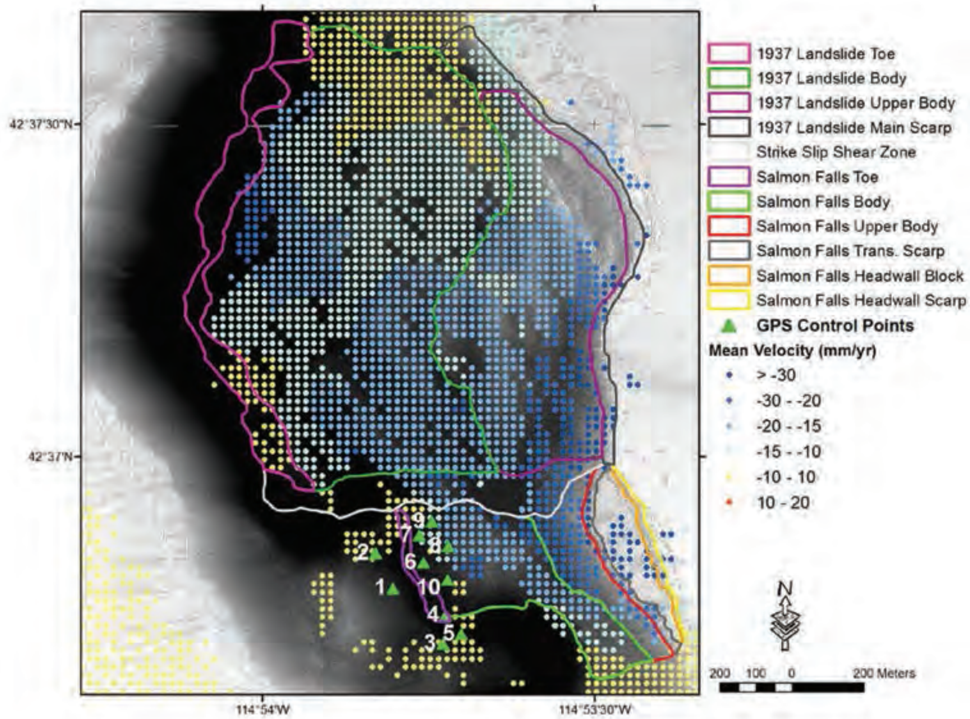
Both PS and SBAS techniques identified pixels that contain earth movement information along the valley in the unstable area and amid sparse vegetation. The SBAS techniques produced the greatest number of pixels showing movement. However, farming activity around the canyon rim areas disguised any movement pixels in that region. The team saw large variation in movement pixels in the southeastern area, where the canyon drains into the gorge. Due to the arid environment, there were few changes to the drainage system over time, producing correspondingly small variations over time in the radar image. A large number of coherent, or unchanged, pixels recognized in the zone by the PS and SBAS InSAR analyses confirmed this finding.

The spatial distribution of movement detected using InSAR techniques matched the boundaries of the two landslide complexes, as defined by the shear zone between the two. The SwRI team noted that the PS results match the SBAS results in the upper and lower boundaries of the test area. However, they detected almost no PS points in the active zone, probably because PS InSAR is more sensitive to linear displacement that occurs at a uniform rate.

Neither the main scarp, or cliff, from the 1937 landslide nor the headwall scarp from the Salmon Falls landslide showed many pixels from stationary objects. Areas affected by landslides typically have very steep slopes, so any subsequent movement would be most noticeable on the leading scarps of the landslide complex, leaving only a few persistent reference points in such areas.

Comparison with field data

A 2003 aerial photograph and a digital elevation model based on Light Detection and Ranging (LiDAR) were used to examine the topography of the landslides and to identify displacement values corresponding to changes in local surface characteristics. Coherent-pixel estimates corresponded to different types of displacement measurements. For example, SAR techniques rely on line-of-sight surface displacement, whereas GPS measures horizontal and vertical displacement. Although dates of field measurements and the satellite images did not match perfectly, qualitative comparisons between the two were still valid. Between November 2006 and September 2008, the cumulative displacement data correlated both in the direction and rates of ground deformation. Interestingly, the Salmon Falls landslide had areas near the bottom where displacement data showed upward, as well as the expected



SBAS reference points were detected over the 1937 and Salmon Falls landslide complexes. GPS control locations are shown as green triangles. Negative velocity values on the table beside the graphic indicate motion away from the satellite.

downward, movement of the landslide. This occurred as some blocks rolled down the slide, while others slid down as a large, intact package and pushed against the earlier slide debris, sometimes piling it upward. Looking at 11 representative locations in the two landslides, the team focused on two key parameters: topographic texture, or surface roughness, and average slope.

The texture of the Salmon Falls headwall block varied by only an average 2.60 m, lowest for any unit measured, indicating a relatively smooth surface. The mean slope angle also was low, indicating that the block slid downslope en masse without much rotation or tilt. However, as the Salmon Falls landslide continues to advance in the future, the blocks will likely rotate and fracture. The toe, or end point, of the Salmon Falls landslide also is smoother than the toe of the older 1937 landslide complex. The difference in surface roughness could reflect greater upward thrusting by later landslides, or more erosion. The top of the 1937 landslide complex has the greatest roughness, 27.46 m. This landslide may have tumbled rather than simply sliding downward, or perhaps it involved a coarser type of rock.

The Salmon Falls landslide headwall, or breakaway area, had the highest average annual velocity. Movement at the toe of each landslide was slower, signifying that movement is more active in the upper reaches. Also, motion at the toe end tends to slow as it becomes more horizontal, while headwall motion is mostly vertical and therefore more rapid.

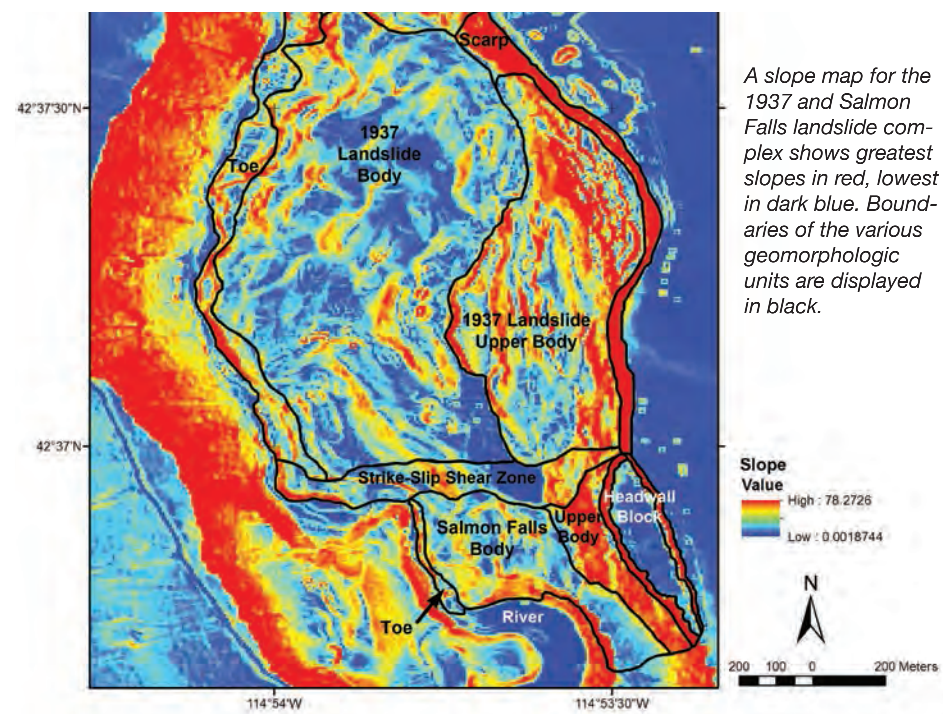
Conclusion

This study improved the understanding of the rate and extent of landslide movement in Salmon Falls Creek Canyon. The SwRI team proved the ability to estimate annual displacement rates accurately by analyzing a collection of archived radar satellite imagery using both SBAS and PS techniques, although between the two, SBAS techniques appeared to perform better than PS techniques when it came to estimating nonlinear displacement rates. Overall, the displacements measured using InSAR-derived techniques showed agreement with on-site GPS field measurements. Thus the research shows that radar imagery analysis is a reliable, low-cost alternative for monitoring earth movement and predicting landslides in high-risk areas.

Questions about this article? Contact Necsoiu at (210) 522-5541 or marius.necsoiu@swri.org.

Source: Information contained in this story can be found in "New Insights on the Salmon Falls Creek Canyon Landslide Complex Based on Geomorphological Analysis and Multitemporal Satellite InSAR techniques," Necsoiu M., R.N. McGinnis, and D.M. Hooper. DOI: 10.1007/s10346-014-0523-8, Landslides, Springer Berlin Heidelberg, Vol. 11, No. 6, pp. 1141–1153, 12/2014.

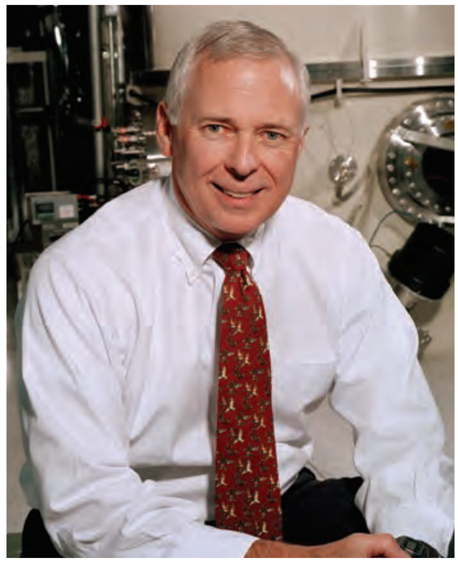
Acknowledgment: Satellite SAR data was provided by the WInSAR consortium; LiDAR data was provided by the courtesy of N. Glenn, Boise State University.



A slope map for the 1937 and Salmon Falls landslide complex shows greatest slopes in red, lowest in dark blue. Boundaries of the various geomorphologic units are displayed in black.

Solving Magnetic Reconnection

Photo courtsey of NASA



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Dr. James L. Burch is vice president of the Space Science and Engineering Division. He is an experimental space physicist investigating various aspects of the interaction of the solar wind with the magnetospheres of the Earth and Saturn and with comets. He has been principal investigator for several NASA space instruments and missions.

A new space mission will study a powerful, puzzling force of nature

By James L. Burch, Ph.D.

On March 12, NASA's Magnetospheric Multiscale (MMS) spacecraft was launched from the Kennedy Space Center aboard an Atlas V rocket to study a fundamental physical process that occurs throughout the Universe — magnetic reconnection. Four identical spacecraft flying in a unique pyramid formation will use Earth's magnetosphere as a laboratory to discover how energy stored in astrophysical magnetic fields is explosively converted into kinetic energy and heat. Southwest Research Institute (SwRI) leads the MMS science investigation and was responsible for developing and integrating the science payload.

Why magnetic reconnection matters

Magnetism is a universal force. In the Sun's million-degree atmosphere, or corona, magnetic fields create spectacular loops and arcades. As field lines converge, they break and reconnect, producing explosive solar flares and coronal mass ejections (CMEs). These solar events accelerate particles to extremely high energies and expel hot plasmas (electrically charged gases) that carry the Sun's magnetic field into interplanetary space.

Earth is protected from the supersonic outflow of plasma from the Sun by a magnetic bubble known as the magnetosphere. When CMEs reach the Earth, the Sun's magnetic field and Earth's magnetic field can merge at the dayside, or Sun-facing, boundary of the magnetosphere. As the fields merge, magnetic field lines break and reconnect, leading to a buildup of magnetic energy on the night side, in the stretched field lines that form Earth's comet-like magnetotail that extends away from the Sun.

At some point, the buildup becomes unsustainable. The energy is released explosively through reconnection on the night side, accelerating plasma particles along Earth's magnetic fields. Particles spiral down Earth's magnetic field lines at the north and south poles, creating auroras or the Northern and Southern Lights. During especially severe disturbances, powerful electrical currents in the upper atmosphere can disrupt power grids, causing blackouts.

Solar and magnetospheric storms, referred to as space weather, impact technologies such as communications, navigation, and power grids, as well as astronaut health and safety. MMS will improve scientists' understanding of the fundamental physics that drive space weather.

Magnetic reconnection is not limited to the Sun and Earth, but likely also plays a role in energetic phenomena observed elsewhere in the universe. Insights obtained by MMS may help guide efforts to understand the role of reconnection in more exotic settings.

Scientists also study magnetic reconnection in laboratory experiments and fusion research. The MMS team is collaborating with researchers at Princeton to share insights on this fundamental process.

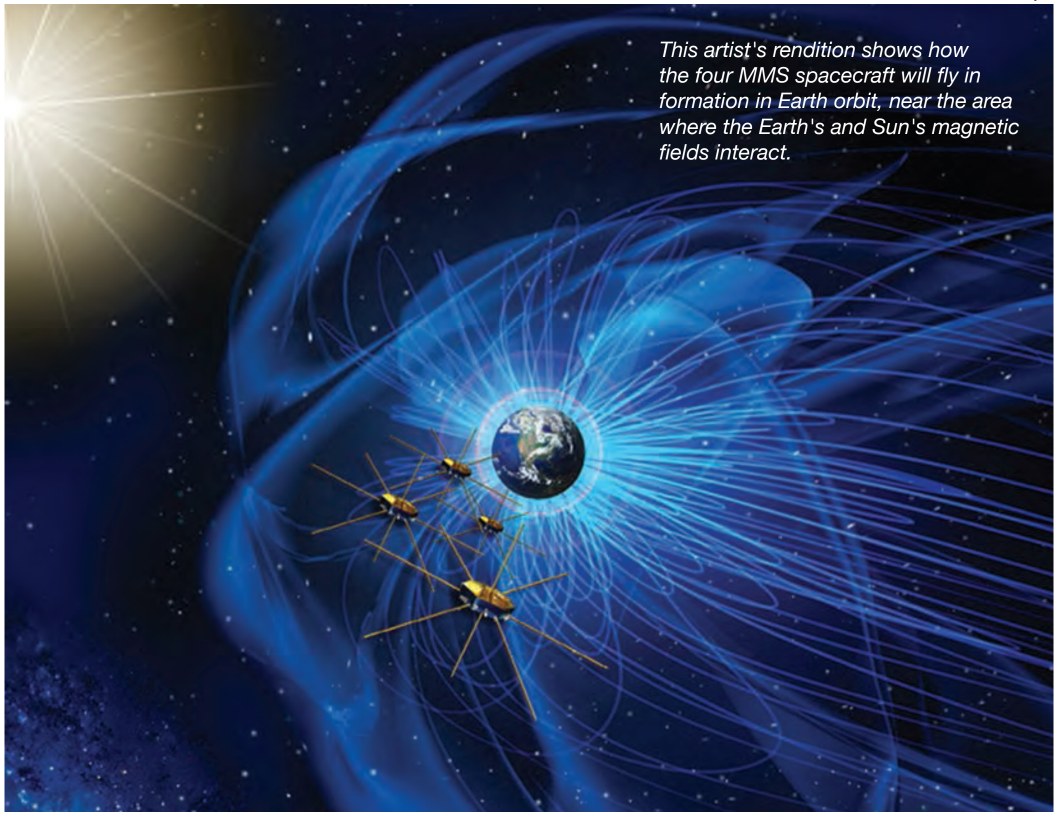
The devil is in the microphysical details

While scientists know where reconnection occurs and what its effects are, how it occurs is still unknown. That is the puzzle that the MMS team hopes to solve. The key to this puzzle lies in the diffusion region, where the plasma decouples from the magnetic field, allowing the field lines to break and reconnect. These narrow regions where magnetic fields merge are the target of the MMS science investigation.

For the first five and a half months, scientists are checking and commissioning the science payload; science operations begin this September. The two-year science investigation has two phases. In the first phase, MMS will sample reconnection sites on the day side of Earth's magnetosphere. In the second phase, the four spacecraft will reconfigure to explore reconnection sites in the Earth's magnetotail on the night side.

The four observatories fly in a three-dimensional tetrahedral formation, 10 kilometers to 400 kilometers (~6 to ~250 miles) apart. This configuration allows MMS to probe the diffusion regions in three dimensions. By varying the separation distance among the spacecraft, MMS collects measurements at different scales. The diffusion regions are so thin that the spacecraft will fly through them in less than a second. However, the MMS sensors are designed to make measurements as much as 100 times faster than ever before.

Photo courtsey of NASA



This artist's rendition shows how the four MMS spacecraft will fly in formation in Earth orbit, near the area where the Earth's and Sun's magnetic fields interact.

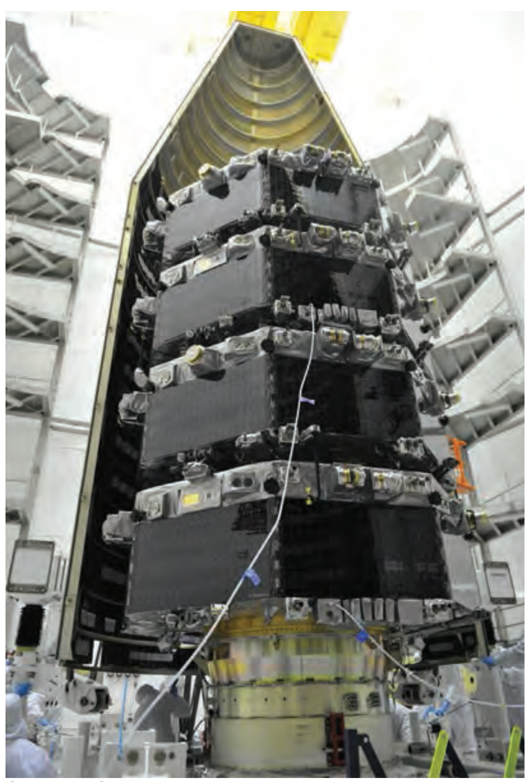
Four spacecraft, one mission

The MMS instruments measure the plasma, energetic particles, and electric and magnetic fields in and around the diffusion region. Each octagonal, 12-foot-diameter spacecraft carries 25 instruments, for a fleet total of 100 instruments. SwRI's space scientists and engineers also built the mission's hot plasma composition analyzers (HPCA). These spectrometers use a novel radio frequency technique to measure important minor ions, such as oxygen and helium, in areas of high flux. These ions are difficult to measure in plasmas dominated by protons. SwRI scientists and engineers also built the central instrument data processor for each observatory, providing the interface between the instrument suite and the spacecraft's command and data handling system.

Other scientific instruments onboard the MMS spacecraft were provided by the University of New Hampshire, the University of Colorado, the University of California Los Angeles, the University of Iowa, NASA's Goddard Space Flight Center, the Johns Hopkins University Applied Physics Laboratory, the Aerospace Corporation, the Institut für Weltraumforschung (Austria), Labotoire de Physique des Plasmas (France), L'Institut de Recherche en Astrophysique et Planétologie (France), the Japanese Aerospace Exploration Agency, the Royal Institute of Technology (Sweden), the Swedish Institute of Space Physics, and the University of Oulu (Finland).

MMS is the fourth NASA Solar Terrestrial Probes Program mission. Goddard Space Flight Center built, integrated, and tested the four MMS spacecraft and is responsible for overall mission management and mission operations. Science operations planning and instrument commanding are performed at the MMS Science Operations Center at the University of Colorado's Laboratory for Atmospheric and Space Physics in Boulder.

Questions about this article? Contact Burch at (210) 522-2526 or jim.burch@swri.org.



Courtsey NASA

The four MMS spacecraft are shown in "stacked" position in a NASA facility, shortly before being enclosed within the protective fairing of the rocket that launched them into space.

Delivering Power

Where Wires Can't Go

Dr. Monica Rivera Garcia, a research engineer in the Applied Physics Division, has more than 10 years of experience in mechanical engineering and materials science research. Her recent experience involves energy transfer and storage systems for small UAS applications.

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SwRI-developed mobile technology charges inaccessible electronic devices

By Monica Rivera Garcia, Ph.D.

Unattended sensors are ubiquitous in today's society, providing critical information to consumers, businesses and military personnel regarding their equipment or their environment. While the majority of these sensing systems have access to the power grid, a number of mission-critical sensors are positioned in remote locations, such as along a gas pipeline or on an active volcano. Typically, such systems rely on battery power. But even long-life batteries must be replaced or replenished eventually, and difficulties arise if they are located in areas that are inaccessible due to work-force limitations, difficult terrain, adverse weather, hazardous environmental conditions0, or the presence of hostile adversaries.

Many manufacturers address this issue by incorporating energy-harvesting systems, such as solar panels, to extend operational battery life. However, the output and consistency of these systems remain major concerns when precipitation, cloud cover, high temperatures, or pollution are prevalent. In such areas, the amount of energy collected via traditional photovoltaic (PV) methods may be insufficient to adequately extend the run time of the device. Thermoelectric, wind, and piezoelectric energy harvesting systems, which convert vibrations into electric current, also are vulnerable to problems with output, consistency,and placement.

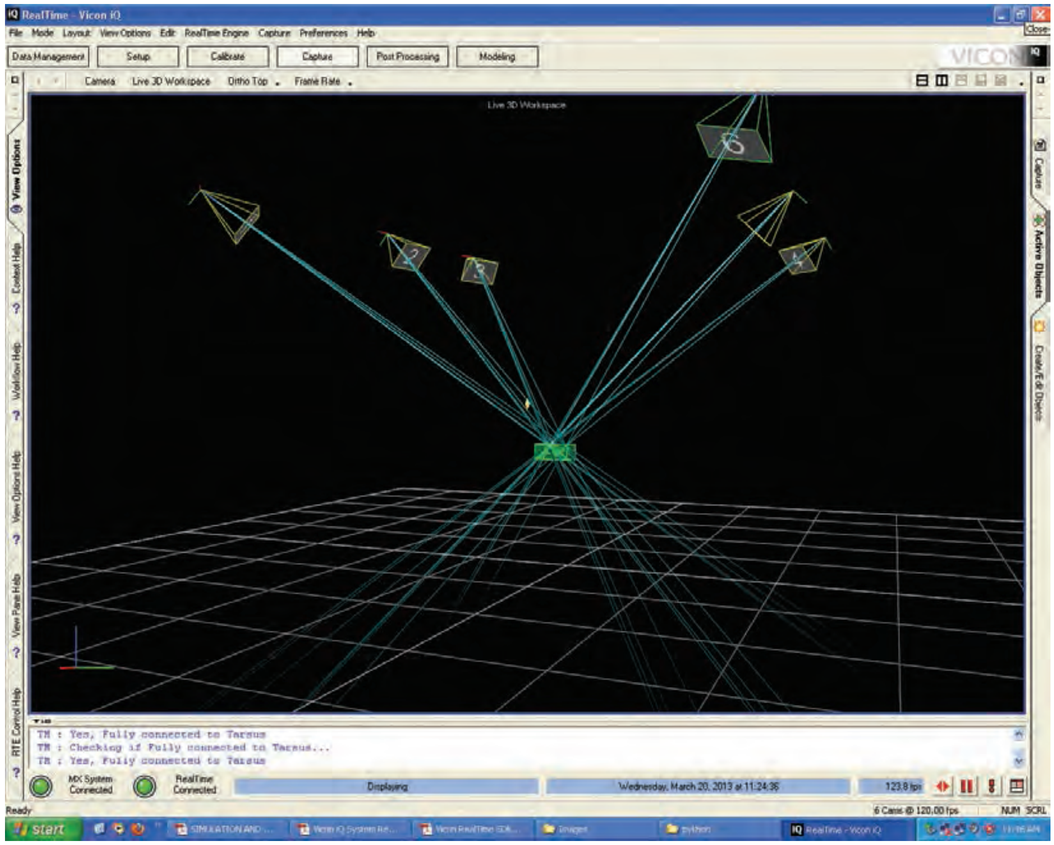
An alternative, on-demand charging modality is needed to address unexpected or premature sensor failure and cases in which a device's location precludes quick and easy replacement of its energy storage unit.

Using internal research funding, a multi-divisional team of engineers at Southwest Research Institute (SwRI) developed an alternative charging methodology for on-demand power transfer to inaccessible electronic devices. Using a small unmanned aerial system (UAS) as a mobile delivery platform, along with commercial off-the-shelf lasers, PV devices, supercapacitors and electronics as the wireless power-transfer system, the SwRI team developed a process to transfer power to electronic devices without wires or any other physical connection.

Wireless power transfer

Although a number of wireless power-transfer techniques exist, the SwRI team elected to focus research efforts on an optical-based methodology, because the technique is compatible with the solar energy harvesting systems found on many of today's unattended sensors. This method converts energy into a light beam that can be transmitted through free space, collected with a PV receiver, and then converted back into usable electrical energy. While an everyday flashlight could serve as the light source in this technique, using a laser can increase the amount of energy transferred and converted in the wireless system. For instance, by selecting a wavelength of light that is tuned to the bandgap of a PV cell's own semiconductor material, the photon conversion efficiency of a silicon-based cell can increase from approximately 15 percent to 40 percent.

Based on these principles, SwRI identified a laser with a wavelength compatible with single-junction, silicon-based solar cells (commonly used in consumer-grade PV-enhanced electronics) that also matched the size, weight, and power (SWaP) constraints imposed by a small UAS. Once the laser arrived, the research team focused on identifying key design variables and determining the relationship between those variables and energy conversion efficiency.



A six-camera motion-capture system tracks the UAS (green box) as it maneuvers in three dimensions during a laboratory flight test.

Energy storage

Although batteries are the primary energy storage units in most electronic devices, the research team elected to use a supercapacitor in its ground-based receiver because it would facilitate rapid transfer of energy to the unattended sensor.

The SwRI team designed and constructed a custom, two-phase charging circuit to prevent the supercapacitor from discharging back into the PV cells when the light striking the cells is reduced. The circuit also reduced electrical losses in the receiver system, minimized the charge time of the supercapacitor, and boosted the charge voltage to enable complete charging of the supercapacitor. Once the charge circuit was constructed, the researchers set about characterizing the relationships among the wireless power transfer system, the charging circuit configuration, and the charge time.

Mobile delivery

To facilitate charging of remote, hard-to-access sensors, the SwRI team chose a small UAS to bring the power transmitter to the sensor's location. The purpose for this was threefold. First, relocating the transmitter facilitated more efficient power transfer by reducing the beam degradation effects associated with propagating energy over large distances. Second, by controlling the separation distance between the power transmitter and receiver by using a UAS, the transmitter's optics were simplified and the size of the beam illuminating the PV cells was tuned to maximize energy transfer. The simplified optics system also had the benefit of keeping the transmitter payload mass to a minimum. Third, using a UAS allowed devices to be charged beyond the user's line of sight, a key factor in potential field applications.

The SwRI team selected a specific commercial six-propellered "hexacopter" UAS based on its cost, payload capacity, and use of open-source autopilot software. The open-source software was critical to the research because it allowed the team to focus on developing specific UAS capabilities without spending time, money, and resources to design a new UAS and get it up and flying. The team concentrated instead on tuning the system as well as designing and constructing a wireless power transfer payload.

Flight tests

The final phase of the project focused on flight testing the complete mobile wireless power transfer system. To comply with Federal Aviation Administration regulations that limit the use of UASs in the National Airspace System, the research team conducted its flight tests in an indoor test facility on the SwRI campus in San Antonio. Anticipating that indoor testing would degrade the UAS autopilot's ability to receive satellite navigation signals from the global positioning

The hovering UAS maneuvers above its target during indoor laboratory flight testing that was conducted using an eye-safe light-emitting payload.

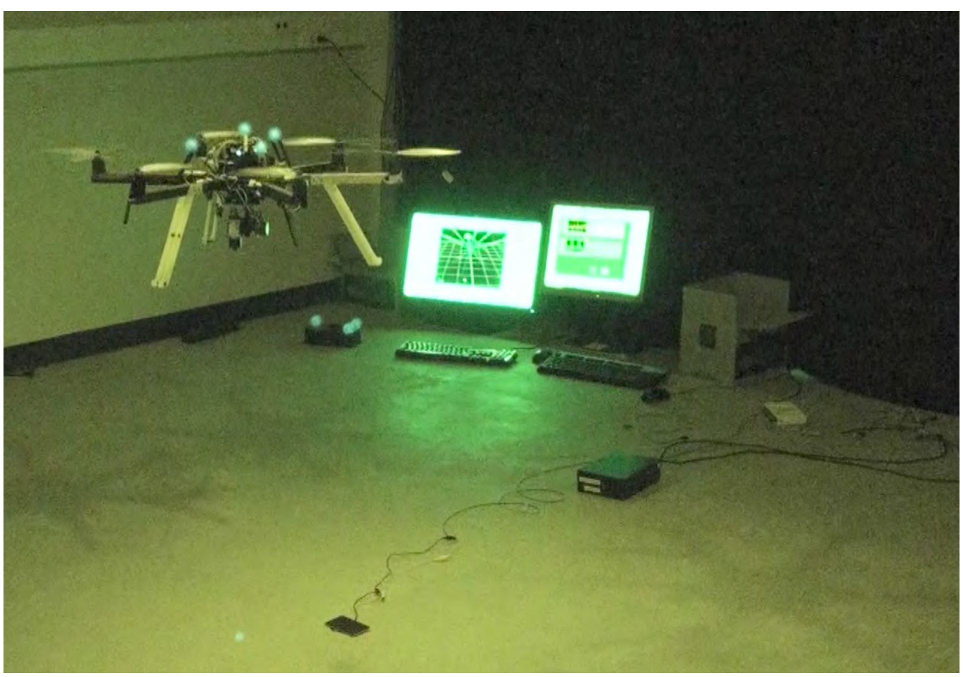
system (GPS), the team modified the craft to accept positioning data from a motion capture system.

During initial flight tests using a flashlight as a surrogate payload for a light-transmitting laser, the vehicle's drift was found to be too great to allow adequately precise laser targeting of the PV receiver. The SwRI team made a number of modifications to improve both the vehicle's hovering stability and the light source's pointing accuracy. Once those modifications were completed, the project culminated with an indoor flight test of the complete mobile wireless power transfer system. Further system modifications and enhancements will be needed before such a system is ready to be fielded, but the tests demonstrated the feasibility of UAS-based wireless power transfer.

Conclusion

There is a strong need for on-demand charging techniques for mission-critical electronic devices located off the electrical grid. The results achieved by the SwRI research team demonstrated that wireless power transfer from a mobile platform is feasible. During the project, the team was able to identify key design variables, and determine the relationships between these variables and the efficiency of the wireless power transfer system. Research also focused on developing tools to align the UAS and its laser transmitter payload with the ground-based receiver during flight. In doing so, the SwRI researchers established an effective process to transfer power to an inaccessible electronic device, rapidly and wirelessly.

Questions about this article? Contact Monica Rivera Garcia at (210) 522-5210 or monica.garcia@swri.org.



During tests to demonstrate payload functionality, a laser spot can be seen on the floor as the UAS approaches a hovering position directly above a photovoltaic panel. The laser dot to the left of the PV cell on the floor is visible due to the "Night-Shot" camera mode.

TECHNICS

Brief notes about the world of science and technology at Southwest Research Institute

SwRI receives $9.9 million from U.S. DOE to improve solar plant efficiency

Southwest Research Institute (SwRI) has been awarded $4.9 million by the U.S. Department of Energy (DOE) as part of a $9.9 million continuation contract to manufacture and test a high-efficiency supercritical CO2 (sCO2) hot gas turbo-expander and compact heat exchangers for concentrating solar power (CSP) plants.

The award was given through DOE's SunShot Initiative, a collaborative national effort to make the cost of solar energy competitive with other forms of energy by the end of the decade. This award continues a previous DOE project to design the sCO2 expander. SwRI will lead a team of industry collaborators that includes Aramco Services Company, Bechtel Marine Propulsion Corporation, Electric Power Research Institute (EPRI), General Electric, and Thar Energy.

"Over the last two years, SwRI and its industry collaborators have developed a highly efficient, multi-stage axial flow sCO2 hot gas turbo-expander that advances the state of the art from laboratory size to a full mega-watt scale prototype," said Dr. Jeff Moore, manager of the Rotating Machinery Dynamics Section in SwRI's Mechanical Engineering Division, and principal investigator of the project.

A second objective of the project is to optimize novel compact heat exchangers for sCO2 applications to drastically reduce manufacturing costs. The scalable sCO2 expander design and improved heat exchanger will close two critical technology gaps and potentially provide a major pathway to achieve power at 6 cents per kilowatt hour, increasing energy conversion efficiency to more than 50 percent, and potentially reducing total power block cost to below $1,200 per kilowatt installed. The project, which will be conducted in two phases, began in late December 2014 and will continue through mid-2016.

Contact Moore at (210) 522-5812 or jeff.moore@swri.org

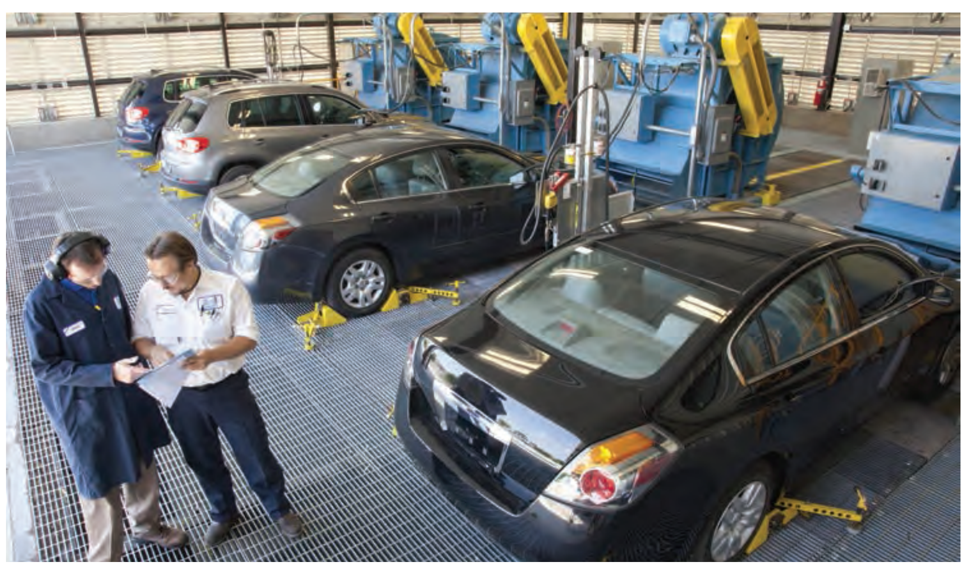
SwRI wins EPA contract for emissions testing, analytical services

Southwest Research Institute (SwRI) has been awarded a five-year, $20.16 million contract by the U.S. Environmental Protection Agency (EPA) to provide testing and analytical services related to vehicle emissions and fuel consumption.

Key areas of support include emissions characterization and technology assessment. SwRI can develop test procedures and equipment for regulated and unregulated emissions in light- and heavy-duty vehicles and components as well as marine, railway, aircraft, small engine, and other non-highway propulsion systems.

"The scope of this contract is quite broad," said Patrick Merritt, principal scientist in the Engine, Emissions, and Vehicle Research Division. "It encompasses 25 areas, from fuels and lubricants to engine and emissions characterizations, as well as economic studies, general rule-making support, and coordinating peer review meetings."

The contract also calls for evaluating vehicles to ensure compliance with current emissions and other regulatory requirements and safety testing powertrains, batteries, and emission control systems. Technical services include evaluating prototype vehicle propulsion systems and related control, data acquisition, and sampling systems.



The contract through the EPA's Office of Transportation and Air Quality (OTAQ) Assessment and Standards Division (ASD) uses SwRI's expertise in its Office of Automotive Engineering, which comprises the Engine, Emissions, and Vehicle Research Division and the Fuels and Lubricants Research Division.

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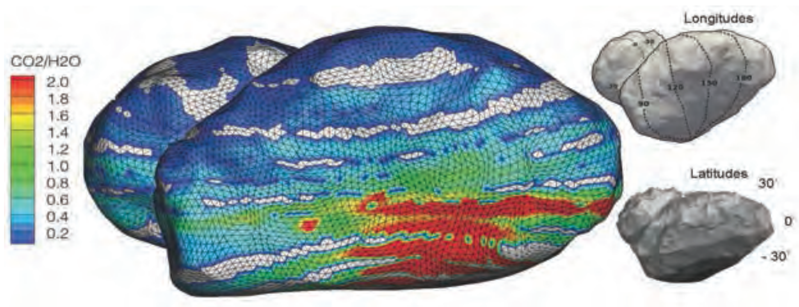
Rosetta data reveals more surprises about comet 67P



As the Rosetta spacecraft orbits comet 67P/Churyumov-Gerasimenko, an international team of scientists have discovered that the comet's atmosphere, or coma, is much less homogenous than expected and comet outgassing varies significantly over time, as reported in a paper published in the Jan. 23, 2015, issue of Science.

"If we would have just seen a steady increase of gases as we closed in on the comet, there would be no question about heterogeneity of the nucleus," says Dr. Myrtha Hässig, lead author of the paper titled "Time Variability and Heterogeneity in the Coma of 67P/Churyumov-Gerasimenko" and a postdoctoral researcher at Southwest Research Institute (SwRI)in San Antonio. "Instead we saw spikes in water readings, and a few hours later, a spike in carbon dioxide readings. This variation could be a temperature effect or a seasonal effect, or it could point to the possibility of comet migrations in the early solar system."

Rosetta scientists measuring the composition of comet 67P's atmosphere or coma discovered that it varies greatly over time. Large fluctuations in composition in a heterogeneous coma indicate day-night and possibly seasonal variations in the major outgassing species: H_2O, CO, and CO_2. After the European Space Agency Rosetta spacecraft rendezvoused with 67P in August 2014, it made headlines around the world landing a space probe on the comet's surface in November. The lander is now in hibernation, but the Rosetta orbiter continues conducting 11 experiments vital to understanding comets in general and comet 67P specifically, as it approaches the Sun.

"These large fluctuations in composition in a heterogeneous coma indicate diurnal or day-night and possibly seasonal variations in the major outgassing species," says Hässig. "When I first saw this behavior, I thought something may have been wrong, but after triple-checking the data, we believe 67P has a complex coma-nucleus relationship, with seasonal variations possibly driven by temperature differences just below the comet surface."

Rosetta is an ESA mission with contributions from its member states and NASA. Airbus Defense and Space built the Rosetta spacecraft. NASA's Jet Propulsion Laboratory (JPL) manages the U.S. contribution of the Rosetta mission for NASA's Science Mission Directorate in Washington, under a contract with the California Institute of Technology. JPL also built the microwave instrument for the Rosetta Orbiter and hosts its principal investigator, Dr. Samuel Gulkis. SwRI (San Antonio and Boulder, Colo.) developed the Rosetta orbiter's Ion and Electron Sensor (IES) and Alice instrument and hosts their principal investigators, Vice President Dr. James Burch for IES and Associate Vice President Dr. Alan Stern for Alice.

Contact Hässig at (210) 522-2449 or myrtha.haessig@swri.org.

SwRI's Walker named Fellow of American Institute of Aeronautics and Astronautics

Dr. James D. Walker, an Institute scientist in the Mechanical Engineering Division at Southwest Research Institute (SwRI), has been elected a Fellow of the American Institute of Aeronautics and Astronautics (AIAA).

According to AIAA, Fellows are "persons of distinction in aeronautics or astronautics, who have made notable and valuable contributions to the arts, sciences, or technology thereof." Walker's Fellow citation reads "for his pioneering analysis, development, and modeling of impact dynamics, penetration mechanics, and materials characterization in response to dynamic loading, with applications in defense and space." He will be formally recognized at the AIAA Aerospace Spotlight Awards Gala May 6 in Washington, D.C.

Walker's research efforts have focused on the mechanical response of a variety of systems and materials to impact loads. Much of his research centers on personnel protection ranging from vests worn by soldiers and police officers, to designs for ground vehicles, the International Space Station, and satellites.

The author of more than 100 papers and publications, Walker holds bachelor's, master's and doctoral degrees in mathematics from the University of Utah. Walker is an adjoint faculty member at The University of Texas at San Antonio, where he teaches graduate courses in mechanical engineering and mathematics.

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Technical Staff Activities

Publications

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Technical Staff Activities

Broerman, E.L., **S.B. Simons** and **R.G. Durke**. "Effective Noise and Vibration Solution for a PD Pump System." Paper presented at the GMRC Gas Machinery Conference 2014, Nashville, Tenn., October 2014.

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Brown, T. "Retrofit Safety Devices for Cooperative Commercial Vehicles." Presented at the 2014 Intelligent Transportation Society Three Chapters (ITS 3C)-(Gulf Region Intelligent Transportation Society, The Intelligent Transportation Society of Florida and The Intelligent Transportation Society of Georgia) Summit, Mobile, Ala., September 2014.

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Brown, T. and P. Vega. "Integrating Arterial System Operations into TMC Operations." Presented at the 2014 ITS 3C Summit, Mobile, Ala., September 2014.

Bzowski, M., M. Kubiak, J. Sokol, P. Swaczyna, E. Möbius, T. Leonard, D. Heirtzler, M. Hlond, M. Banaszkiewicz, M. Witte, P. Wurz, D. Rodriguez, N. Schwadron, **S.A. Fuselier**, **D.J. McComas** and H. Kucharek. "Interstellar He Parameters in Front of the Heliosphere: View from IBEX and Ulysses." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Campbell, B.A., G.A. Morgan, **N.E. Putzig**, J.L. Whitten, J.W. Holt and R.J. Phillips. "Enhanced Radar Visualization of Structure in the South Polar Deposits of Mars." Presented at the 46th Lunar and Planetary Science (LPS) Conference, The Woodlands, Texas, March 2015.

Casey-Snyder, J. "Fighting Back GPS Attacks: Clock Security for Phasor Measurement Units." Presented at the 2014 ASME Dynamic Systems and Control Conference, San Antonio, October 2014.

Caspi, A., J. McTiernan, H. Warren and T. Woods. "The Multi-instrument, Comprehensive Differential Emission Measure (DEM) of the Solar Corona During Flares and Quiescent Periods." Presented at the 224th American Astronomical Society (AAS) Meeting, Boston, June 2014.

Caspi, A., J. McTiernan, H. Warren and T. Woods. "New Soft X-ray Observations from the X123 Spectrometer." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Chan, K.S., **M.P. Enright**, **J. Moody** and S. Fitch. "Modeling Variability of Time-dependent Fatigue Crack Growth in Ni-base Superalloy Disks." Presented at the Propulsion-Safety and Affordable Readiness (P-SAR) 2015 Conference, Baltimore, March/April 2015.

Chirathadam, T.A. and **G.O. Musgrove**. "Centrifugal Compression Machinery for Wet Natural Gas Applications: Preliminary Performance Measurements and a Scheme to Recover Lost Performance." Presented at the GMRC Gas Machinery Conference 2014, Nashville, Tenn., October 2014.

Chou, Y. and **R. Mason**. "Determination of Variables Affecting Multivariate Process Variability in Phase I." Presented at the 174th Annual Meeting of the American Statistical Association (ASA) Joint Statistical Meeting (JSM), Boston, August 2014.

Christian, E., H. Funsten, **D.J. McComas** and N. Schwadron. "Parallax Measurements of the Ribbon of ENA Emission, Current Results and Future Prospects." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Coogan, J., **T. Eliason**, **D. Nicolella** and N. Hibri. "Finite Element Modeling of a Disc Nucleus Replacement Device." Presented at the Society of Interventional Radiology, Atlanta, February/March 2015.

Cook, J.C., **S.A. Stern**, P.D. Feldman, **G.R. Gladstone**, **K.D. Retherford**, **T.K. Greathouse**, **C. Grava** and the Lyman Alpha Orbiter (LRO)/Lyman Alpha Mapping Project (LAMP) Team. "The Search for Ar in the Lunar Atmosphere Using the Lunar Reconnaissance Orbiter's LAMP Instrument." Presented at the 2014 AGU Fall Meeting, San Francisco, 2014.

Dannemann, K.A., **A.J. Carpenter**, **N.L. Scott** and **I.S. Chocron**. "A Comparison of the Mechanical Response of Weld Regions in Friction Stir Welded Aluminum Alloy 7085." Presented at Materials Science & Technology 2014, Pittsburgh, October 2014.

DeForest, C. "The Future of Heliospheric Imaging." Presented at the 40th COSPAR Scientific Assembly, Moscow, Russia, August 2014.

DeForest, C. and **T.A. Howard**. "Understanding CME Propagation through Combined Imaging and *In-Situ* Measurements." Presented at the 40th COSPAR Scientific Assembly, Moscow, Russia, August 2014.

DeForest, C., **T. Howard**, **G. Laurent** and **J. Diller**. " Demonstration LEO Polarizing Heliospheric Imager (DELPHI): A Pathfinder to Low-cost Access to Space (LCAS) Onboard the International Space Station." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

DeForest, C., and J. Klimchuk. "Hi-C Observations and the Structure of Coronal Loops." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

De Pater, I., **D. Santos-Costa**, R.J. Sault, M.A. Janssen, S.M. Levin, **T.W. Broiles** and **S.J. Bolton**. "Changes in the Spatial Distribution of Jupiter's Synchrotron Radiation in Response to External Influences during the *Cassini* Flyby of Jupiter." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Dellenback, S. "Autonomous Vehicles: Commercial Examples and Military Automated Vehicles." Presented at ITS Alaska, Anchorage, Alaska, September 2014.

Dellenback, S. "Autonomy Now: Developing Autonomous and Connected Vehicles." Presented at the Florida Department of Transportation Automated Vehicle Summit, Orlando, November 2014.

Dellenback, S. "Connected Vehicles (CV): State-of-the-art of Connected Vehicles and Highlights of Deployments." Presented at ITS Alaska, Anchorage, Alaska, September 2014.

Dellenback, S. "Moving at Lightning Speed: The Future of Transportation and Technology." Presented at the International Bridge, Tunnel and Turnpike Association (IBTTA) Annual Meeting, Austin, Texas, September 2014.

Dellenback, S. "State-of-the-art in Self-driving Vehicle." Presented at the Intelligent Transport Systems (ITS) 21st World Congress, Detroit, September 2014.

Desai, M.I., **M. Al-Dayeh**, **R.W. Ebert**, **D.J. McComas**, G.M. Mason, C.M.S. Cohen, G. Li, R.A. Mewaldt and C.W. Smith. "Spectral Properties of Large Gradual SEP Events." Presented at the 40th COSPAR Scientific Assembly, Moscow, Russia, August 2014.

Desai, M.I., **M. Al-Dayeh**, **R. Ebert**, **D.J. McComas**, G.M. Mason, R. Mewaldt, C. Cohen and G. Li. "Spectral Properties of Large Gradual Solar Energetic Particle Events." Presented at the 40th COSPAR Scientific Assembly 2014, Moscow, Russia, August 2014.

Desai, M.I., **F. Allegrini**, **M. Al-Dayeh**, H. Funsten, J. Heerikhuisen, **D.J. McComas**, N. Pogorelov, N.A. Schwadron, **S.A. Fuselier**, G.P. Zank and **E. Zirnstein**. "Global Properties of the Heliospheric Termination Shock as Inferred from Energetic Neutral Atoms Measured by the Interstellar Boundary Explorer (IBEX)." Presented at the 40th COSPAR Scientific Assembly, Moscow, Russia, August 2014.

Desai, M.I., **D.J. McComas**, **F. Allegrini**, **S. Livi**, **K. Ogasawara**, **R.W. Ebert**, **S. Bolton**, **S.A. Fuselier**, **N. Alexander**, **S.E. Weidner** and **S. Persyn**. "CoDICE: A Compact, Dual Ion Composition Experiment for Planetary Missions." Presented at the International Workshop on Instrumentation for Planetary Missions, Greenbelt, Md., November 2014.

Technical Staff Activities

Desai, M.I., **D.J. McComas**, E.R. Christian, R.A. Mewaldt and N.A. Schwadron. "Suprathermal and Solar Energetic Particles – Key Questions for the Interstellar Mapping and Acceleration Probe (IMAP)." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Duncan, T. "Universal Electronic Identifier for Commercial Vehicles." Presented at the Commercial Vehicle Safety Alliance (CVSA) Annual Conference, Buffalo, N.Y., September 2014.

Durda D.D., **C.C.C. Tsang**, S.A. Stern, **C.B. Olkin**, K. Ennico Smith and E.R. Schindhem. "Validation of Suborbital Spaceflight Experiments Through Zero-G Flight Demonstration of Flight-ready Hardware." Presented at the 45th LPS Conference, The Woodlands, Texas, March 2014.

Ebert, R., F. Bagenal, **D.J. McComas**, C. Fowler and **H. Elliott**. "A Survey of Solar Wind Conditions at 5 AU: A Tool for Interpreting Solar Wind-Magnetosphere Interactions at Jupiter During Juno." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Elaydi, S., L. Assas, B. Dennis, E. Kwessi and **G. Livadiotis**. "A Nonautonomous Hierarchical Model with the Strong Allee Effect." Presented at the 2015 JMM/AMS, San Antonio, January 2015.

Elliott, H., **D.J. McComas**, **P. Valek**, G. Nicolaou, F. Bagenal, P. Delameere and **G. Livadiotis**. "Solar Wind Observations from 10 to 30 AU Measured with the New Horizons Solar Wind Around Pluto (SWAP) Instrument." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Emberley, N., I.K. Sinclair, A. Newell, **A.P. Morris**, **R.N. McGinnis** and **D.A. Ferrill**. "History, Character, and Implications of Fault Growth in the Terra Nova Oilfield, Jeanne d'Arc Basin." Presentation at the 4th Atlantic Conjugate Margins Conference, St. John's, Newfoundland, Canada, August 2014.

Eriksson, S., B. Peng, S. Markidis, J. Gosling, **D.J. McComas**, G. Lapenta and D. Newman. "Ulysses Observations of Tripolar Guide-Magnetic Field Perturbations Across Solar Wind Reconnection Exhausts." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Estabrook, R., D. Graves, **D. George** and J. Harvey. "Wet Natural Gas Sampling Panel Discussion." Presented at the 2014 Midwest Measurement Society (MMS) Standards Roundtable, Oklahoma City, August 2014.

Evans, N.D. "Measurement of High Amplitude Relief Valve Noise for Acoustically Induced Vibration and Comparison to Predictive Methods." Presented at the ASME Pressure Vessels & Piping Division Conference, Anaheim, Calif., July 2014.

Evans, N.D. and **M. Al-Dayeh**. "Nearfield Acoustic Measurements of Triggered Lightning Using a One-Dimensional Microphone Array." Presented at the 2014 Acoustical Society of America (ASA) Fall Meeting, Indianapolis, October 2014.

Evans, P. "A Community Approach Guiding the Future of Robotics in Advanced Manufacturing." Presented at the Accelerate Colorado Symposium and Showcase, Loveland, Colo., October 2014.

Evans, P. "Enabling Manufacturing Innovation in America." Baylor Research and Innovation Collaborative (BRIC) Foundations Series Event, Waco, Texas, November 2014.

Evans, P. "Technical Advancements Guiding the Future of Robotics in Manufacturing." Electrical and Computer – Baylor Engineering and Research Seminars, Baylor University, Waco, Texas, November 2014.

Fanick, E.R. and A. Cahana. "Novel Renewable Oxygenated Additive for SI Engines." Presented at the 2014 ITS World Congress, Detroit, April 2014.

Fanick, E.R., **C.A. Sharp**, **S. Quarderer** and **C. Gourley**. "Dilute Measurement of SVOC From Heavy-Duty Diesel Engines." Presented at the 24th CRC Real World Emissions Workshop, San Diego, March/April 2014.

Ferrill, D.A., A.P. Morris, K.J. Smart and **R.N. McGinnis**. "Mechanical Stratigraphy and Normal Faulting." Presented at the Geological Society of London Conference: Geometry and Growth of Normal Faults, Burlington House, London, June 2014.

Fichtner, H., K. Scherer, F. Effenberger, J. Zoennchen, **D.J. McComas** and N. Schwadron. "The Interstellar Boundary Explorer (IBEX) Energetic Neutral Atom (ENA) Ribbon and an Inhomogeneous Local Interstellar Medium (LISM)." Presented at the 40th COSPAR Scientific Assembly 2014, Moscow, Russia, August 2014.

Fox, N., M. Velli, J. Kasper, **D.J. McComas**, R. Howard, S. Bale and R. Decker. "Solar Probe Plus: A NASA Mission to Touch the Sun." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Freitas, C.J. and **M.V. Grimm**. "Solution Verification and Simulation Validation for Ballistic Impact." Proceedings of the 2014 ASME Verification & Validation Symposium, Las Vegas, May 2014.

Frisch, P., **M. Al-Dayeh**, **M.I. Desai**, H.O. Funsten, J. Heerikhuisen, P. Janzen, **D.J. McComas**, **G. Livadiotis**, **K. Ogasawara**, N. Pogorelov, D. Reisenfeld, N.A. Schwadron, J. Slavin and G.P. Zank. "Charging of Interstellar Dust Grains in the Out-of-Equilibrium Plasma of the Inner and Outer Heliosheath Regions." Presented at the 2014 AGU Fall Meeting, San Francisco, December, 2014.

Frisch, P., B.-G. Andersson, A. Berdyugin, H. Funsten, A. Magalhaes, **D.J. McComas**, V. Piirola, N. Schwadron, D. Seriacopi, J. Slavin and S. Wiktorowicz. "Charting the Interstellar Magnetic Field Behind the IBEX Ribbon." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Funsten, H., R. Demajistre, P. Frisch, **S.A. Fuselier**, P. Janzen, **G. Livadiotis**, **D.J. McComas**, K. Pittman, D. Reisenfeld and N.A. Schwadron. "Profiles of the Ribbon: Systematic ENA Flux Features Within and Beyond the Central Ribbon." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Fuselier, S.A., **F. Allegrini**, M. Bzowski, **M. Al-Dayeh**, **M.I. Desai**, H.O. Funsten, A. Galli, D. Heirtzler, P. Janzen, M. Kubiak, H. Kucharek, **W.J. Lewis**, **G. Livadiotis**, **D.J. McComas**, E. Möbius, S. Petrinec, M. Quinn, N.A. Schwadron, J. Sokol and K.J. Trattner. "Low Energy Neutral Atoms and Kappa Ion Distributions in the Heliosheath." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Garcia, R.D. "Implementing Unmanned Aerial Surveillance Best Practices and Processes: From Technology Selection to Operating Procedures." Presented at the 2014 Maritime Security Conference, Nassau, Bahamas, October 2014.

Garcia-Hernandez, A. and **J.A. Bennett**. "Evaluation of a Pumping System to Aid Machine Performance Testing." Presented at the 2014 Pipeline Simulation Interest Group (PSIG), Baltimore, May 2014.

Garcia-Hernandez, A., **H. Delgado-Garibay**, R. Rivera Reyes, J.L. Martinez and L. Martinez Gomez. "A New Risk and Reliability Model for Compressor and Pump Installations." Presented at the 2014 ASME Turbo Expo, Dusseldorf, Germany, June 2014.

Garcia-Hernandez, A. and **K.R. Supak**. "Multiphase Assessment of an Offshore Production System." Presented at the 2014 PSIG, Baltimore, May 2014.

George, D. "Review of Methods for Hydrocarbon Dew Point Prediction." Presented at the American Gas Association (AGA) Workshop on Gas Quality — Challenges and Changes, Brooklyn, New York, November 2014.

George, D. "Survey of Fuel Quality for CNG Vehicles." Presented at the AGA Workshop on Gas Quality — Challenges and Changes, Brooklyn, New York, November 2014.

Girard, J.N., P. Zarka, I. de Pater, S. Hess, C. Tasse, R. Courtin, M. Hofstadter, **D. Santos-Costa**, N. Nettelmann and L. Lorenzato. "Exploring Jupiter's and Saturn's Radiation Belts with Low-Frequency Array (LOFAR)." Presented at the

European Geosciences Union (EGU) General Assembly 2014, Vienna, Austria, April/May 2014.

Glenar, D.A., T.J. Stubbs, D. Richard, P.D. Feldman and **K.D. Retherford**. "Reexamination of Lunar Exospheric Dust Estimates Using Discrete Dipole Scattering Simulations." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Goldstein, J. "Solar System Space Physics." Presented at Colloquia at Texas Lutheran University, Seguin, Texas, October 2014 and at Trinity University, San Antonio, Texas, October 2014.

Goldstein, J. "Space Weather: What Do We Learn from Plasmaspheric Imaging?" Presented to Young Engineers and Scientists (YES), SwRI, San Antonio, July 2014.

Goldstein, J., **J.-M. Jahn**, S. De Pascuale, C. Kletzing, W.S. Kurth, K.J. Genestreti, R.M. Skoug, B.A. Larsen, L.M. Kistler, C. Mouikis, H. Spence, G.D. Reeves, D.N. Baker and J.B. Blake. "Van Allen Probes Observations of the Plasmasphere and Radiation Belts." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Goldstein, J., **J.H. Waite**, **J.L. Burch** and T.W. Hill. "A Theoretical Model for the Origin of Saturn's Plasma Cam: Analytical Model of Rotating, 2-Cell Convection at Saturn." Presented at SwRI Space Science Seminar, San Antonio, July 2014.

Gorby, M., N.A. Schwadron, T. Torok, C. Downs, R. Lionello, J. Linker, V. Titov, Z. Mikic, P. Riley, **M.I. Desai** and **M. Al-Dayeh**. "Particle Acceleration in the Low Corona Over Broad Longitudes: Coupling Magnetohydrodynamics (MHD) and 3D Particle Simulations." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Grava, C., **K.D. Retherford**, **T.K. Greathouse**, **G.R. Gladstone**, D. M. Hurley, **J.C. Cook**, **S.A. Stern**, **P.D. Feldman**, **D.E. Kaufmann**, **P.F. Miles**, W.R. Pryor, J.S. Halekas and the LRO/LAMP Team. "LRO-LAMP Observations of the Lunar Exosphere Coordinated with Lunar Atmospheric and Dust Environment Explorer (LADEE)." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Guerra, C. "Enterprise MROadmap for Maintenance, Modernization, and Sustainment." Presented at the 2014 C-130 Hercules Operators Council (HOC), Atlanta, October 2014.

Hedrick, J. "Partial Flow DPF System for Large Bore or High Power Applications." Presented at the ASME Internal Combustion Engine Division 2014 Fall Technical Conference, Columbus, Ind., October 2014.

Henden, A.A., S. Levine, **D. Terrell** and D.L. Welch. "APASS/AAVSO — The Latest Data Release." Presented at the 225th AAS Meeting, Seattle, January 2015.

Holmquist, T.J. and F.C. Rickert. "An Experimental and Computational Study Investigating the Ballistic Response of Seams that Connect Steel Targets." Presented at the 28th International Symposium on Ballistics (ISB), Atlanta, September 2014.

Howard, T., and **C. DeForest**. "The Pre- and Post-Launch Configuation of a CME Flux Rope." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Hurley, D., **K.D. Retherford**, **J.C. Cook**, **C. Grava**, **T.K. Greathouse**, **G.R. Gladstone** and **S.A. Stern**. "Distribution of H_2 in the Lunar Exosphere from LAMP Observations." Presented at the 46th Annual Meeting of the AAS/Division Planetary Sciences (DPS), Tucson, Ariz., November 2014.

Janssens, M. "Challenges in Predicting the Pyrolysis Rate of Solid Materials." Presented at the 14th International Conference on Fire and Materials 2015, San Francisco, February 2015.

Janssens, M. "Estimating Convective Heat Losses for Analysis of Ignition Data." Presented at the 11th International Symposium on Fire Safety Science, Christchurch, New Zealand, February 2014.

Janssens, M. "North American Fire Performance Criteria of Sandwich Panels Used Inside Buildings." Presented at the 11th International Symposium on Fire Safety Evaluation of Sandwich Panels Used as Interior Components, Tokyo, August 2014.

Janssens, M. "Performance-based Fire Protection of Nuclear Plants." Presented at the Continuing Professional Development Lecture, Hong Kong Polytechnic University, Hong Kong, August 2014.

Janssens, M., **K. Carpenter** and S. Turner. " Experimental Program to Obtain Characteristics of Electrical Cables for Performance-based Fire Protection of Nuclear Facilities in Japan." Presented at the 10th International Conference on Performance-based Codes and Fire Safety Design Methods, Gold Coast, Australia, November 2014.

Janssens, M., **K. Carpenter**, S. Turner and S. Tsuchino. "Opposed-flow Flame Spread in Electrical Cable Trays." Presented at the 11th International Symposium on Fire Safety Science, Christchurch, New Zealand, February 2014.

Jensema, R., **M.I. Desai**, **M. Al-Dayeh** and G.M. Mason. "The Sources and Acceleration of Suprathermal Particle Populations." Presented at the Solar Heliospheric & Interplanetary Environment (SHINE) workshop in Telluride, Colo., June 2014.

Jensema, R., **M.I. Desai**, **T.W. Broiles** and G.M. Mason. "Properties of Suprathermal Ions in Solar Wind Compression Regions." Presented at 2014 AGU Fall Meeting, San Francisco, December 2014.

Johnson, G.R., **S.R. Beissel** and **C.A. Gerlach**. "A New Combined Particle-element Method for Ballistics Computations Involving High-velocity Impact." Presented at the 28th ISB, Atlanta, September 2014.

Johnson, G.R., **S.R. Beissel** and **C.A. Gerlach**. "Some Progress in the Utilization of Meshless Particle Methods for High-velocity Impacts Involving Severe Distortions." Presented at the U.S. Association for Computational Mechanics (USACM) Workshop on Meshfree Methods for Large-scale Computational Science and Engineering, Tampa, Fla., October 2014.

Johnson, J. "Big Data and Connected Vehicles." Presented at the Intelligent Transportation Society of America (ITSA) Leadership Circle Meeting, San Diego, December 2014.

Kilpatrick, S. and **T. Newton**. "The Unique Challenges of Testing Specialized Network-based Data Acquisition Systems." Presented at the Institute of Electrical and Electronics Engineers (IEEE) AUTOTEST 2014, St. Louis, September 2014.

Kirchoff, M.R. "Impact Crater Saturation of Outer Solar System Satellites: Results from Spatial Statistics." Presented at the Geological Society of America (GSA) Meeting, Vancouver, Canada, October 2014.

Koets, M. "Solid State Recorder Data Organization Software and Functional Emulator for Mission Planning and Early Integration." Presented at the 2014 Workshop on Spacecraft Flight Software (FSW), Pasadena, Calif., December 2014.

Kurth, W., J. Connerney, **D.J. McComas**, B. Mauk, **R. Gladstone**, A. Adriani, F. Bagenal and **S. Bolton**. "Jupiter's Polar Magnetosphere: Outstanding Issues to be Addressed by Juno." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Kurth, W., D. Gurnett, **D.J. McComas** and **H. Elliott**. "Solar Activity Associated with Electron Plasma Oscillations in the Interstellar Medium Observed by Voyager 1." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Kurz, R., R.C. White and **K. Brun**. "Transient Operation in Pipeline Compressor Stations." Presented at the 2014 ASME Turbo Expo, Dusseldorf, Germany, June 2014.

Kwessi, E., L. Assas, B. Dennis, S. Elaydi and **G. Livadiotis**. "Multispecies Hierarchical Competition Models with the Allee Effect." Presented at the 2015 JMM/AMS, San Antonio, January 2015.

Lamb, D., **C. DeForest** and S. Van Kooten. "Magnetic Feature Tracking in the SDO Era: Past Sacrifices, Recent Advances, and Future Possibilities." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Technical Staff Activities

Lamm, R. "Challenges of Unmanned Systems Integration: Integration of Autonomy into the Force Structure." Presented at the 1st Naval Surface Warfare Center Dahlgren Division (NSWCDD) Unmanned Systems Integration Workshop and Technical Exchange Meeting, Dahlgren, Va., August 2014.

Lamm, R. "Technical Challenges for the Adoption of Self-driving Vehicles." Presented at the 21st ITS World Congress, Detroit, September 2014.

Lavraud, B., Y. Liu, R. Harrison, W. Liu, F. Auchere, W. Gan, P. Lamy, L. Xia, J. Eastwood, R. Wimmer-Schweingruber, Q. Zong, P. Rochus, M. Maksimovic, M. Temmer, C.P. Escoubet, E. Kilpua, A. Rouillard, J. Davies, J.-C. Vial, N. Gopalswamy, S. Bale. L. Gang, **T. Howard** and **C. DeForest**. "Instant: An Innovative L5 Small Mission Concept for Coordinated Science with Solar Orbiter and Solar Probe Plus." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Lecocke, M. "Formal Modeling for Verifiable, Efficient Fault Detection and Response." Presented at the Workshop on Spacecraft Flight Software, Pasadena, Calif., December 2014.

Leonard, T., E. Möbius, M. Bzowski, **S. Fuselier**, D. Heirtzler, M. Kubiak, H. Kucharek, M. Lee, **D.J. McComas**, N. Schwadron and P. Wurz. "Observing the Interstellar Medium Flow Over the Past 6 Years with IBEX-Lo." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Lepri, S., **S. Livi**, A. Galvin, L. Kistler, J. Raines, **F. Allegrini**, M. Collier and T. Zurbuchen. "Heavy Ion Composition in the Inner Heliosphere: Predictions for Solar Orbiter." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Li, G., L. Zhao, **R.W. Ebert**, **M.I. Desai**, **M. Al-Dayeh**, G.M. Mason, Y. Chen and Z. Wu. "Modeling Particle Acceleration and Transport at CIRs." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Light, G.M. "Inspection and Monitoring of Piping, Tubing, Plate Structure, and Vessels Using Guided Waves Generated Using Magnetostriction." Presented at the American Society for Testing and Materials (ASTM) Winter Meeting, Ft. Lauderdale, Fla., January 2014.

Light, G.M. and **C.J. Thwing**. "Guided Wave Sensor Technology for Monitoring Aircraft Structure for Fatigue Failure." Presented at the 2nd International Conference and Exhibition on Mechanical and Aerospace Engineering, Philadelphia, September 2014.

Light, G.M. and **S.A. Vinogradov**. "Using Guided Waves to Monitor for Fatigue Damage on Electrical Transmission Tower Line Hangers." Presented at the ASNT 2014 Fall Conference, Charleston, S.C., October 2014.

Liu, Y. "Megawatts on Wheels — Bi-Directional Grid Support through DC Fast Charge Electric Vehicles." Presented at the ASME 2014 Dynamic Systems and Control Conference (DSCC), San Antonio, October 2014.

Livadiotis, G. "Application of the Large-scale Quantization to the Inner Heliosheath Plasma." Presented at the 13th Annual International Astrophysics Conference, Myrtle Beach, S.C., April 2014.

Livadiotis, G. "Evidence of a New Quantization Constant in Collisionless Plasmas." Presented at the 56th Annual Meeting of American Physical Society (APS) Division of Plasma Physics, New Orleans, October 2014.

Livadiotis, G. "Foundations of Statistical Mechanics in Space Plasmas." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Livadiotis, G. "Implications and Applications of Kappa Distributions in Space Plasma Physics — Introduction/Discussion." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Livadiotis, G. "Kappa Distributions: Founding Statistical Mechanics in Space Plasmas." Presented at the 56th APS Plasma Physics, New Orleans, October 2014.

Livadiotis, G. "Understanding Kappa Distributions in Space Plasmas." Presented at the 6th International Conference on Statistical Physics "SigmaPhi," Rhodes, Greece, July 2014.

Livadiotis, G., L. Assas, B. Dennis, S. Elaydi and E. Kwessi. "Host-parasitoid Discrete Models with Strong Allee Effect." Presented at the 2015 JMM/AMS Meeting, San Antonio, January 2015.

Livadiotis, G., J. Heerikhuisen and Y. Kourakis. "Implications and Applications of Kappa Distributions in Space Plasma Physics." Presented at the 2014 AGU, San Francisco, December 2014.

Llera, K., **J. Goldstein**, **D.J. McComas** and **P. Valek**. "Energy Spectral Evolution of Precipitating Ring Current Ions Using Two Wide-angle Imaging Neutral-atom Spectometers TWINS Low-Altitude Emissions (LAEs) and *In-Situ* NOAA Observations." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Marshall, A., **N. Evans**, K. Oelschlaeger and C. Hackert. "Source Parameters for the Numerical Simulation of Lightning as a Nonlinear Acoustic Source." Presented at the 2014 Acoustical Society of America (ASA) Fall Meeting, Indianapolis, October 2014.

Mason, G.M., **M.I. Desai**, **M. Al-Dayeh**, **R.W. Ebert**, **D.J. McComas**, G. Li, C.M.S. Cohen, R.A. Mewaldt and C.W. Smith. "Spectral Properties of Large Gradual Solar Energetic Particle Events." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Mason, R. and J. McKenzie. "A Brief History of the American Statistical Association: 1839-2014." Presented at the 174th 2014 Joint Statistical Meeting of the American Statistical Association (ASA), Boston, August 2014.

McClung, R.C., **C.F. Popelar**, **J.M. McFarland**, **V. Bhamidipati**, M.A. James, J.D. Watton, M.R. Hill, A. DeWald and D.L. Ball. "Predicting Fatigue Crack Growth in Forgings with Bulk Residual Stress." Presented at the 2014 United States Air Force (USAF) Aircraft Structural Integrity Program (ASIP) Conference, San Antonio, December 2014.

McClung, R.C., **C.F. Popelar**, **J. McFarland**, **V. Bhamidipati**, M.A. James, J.D. Watton, M.R. Hill, A.T. DeWald and D.L. Ball. "Predictive Models for Fatigue Crack Growth in Forgings with Bulk Residual Stress." Presented at the International Committee on Aeronautical Fatigue (ICAF) Symposium, Helsinki, Finland, June 2015.

McClung, R.C., **B.H. Thacker** and **V. Bhamidipati**. "A Framework for Verification and Validation of Models for Laser Peening." Presented the 5th International Conference on Laser Peening and Related Phenomena, Cincinnati, May 2015.

McComas, D.J. "Investigating Pickup Ions Out to 28 AU with New Horizons." Presented at the 40th COSPAR Scientific Assembly 2014, Moscow, Russia, August 2014.

McComas, D.J. "Recent IBEX Discoveries and Five Years of Observing the Outer Heliosphere." Presented at the 40th COSPAR Scientific Assembly 2014, Moscow, Russia, August 2014.

McComas, D.J. "Revealing Ribbon Riddles: From IBEX's Discovery to What We Know Now." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

McComas, D.J., M. Bzowski, P. Frisch, **S. Fuselier**, M. Kubiak, H. Kucharek, T. Leonard, E. Möbius, N. Schwadron, J. Sokol, P. Swaczyna and M. Witte. "Warmer Local Interstellar Medium: Resolving the Ulysses-IBEX Enigma and the Promise of IMAP." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

McFarland, J.M., **V. Bhamidipati**, **R.C. McClung**, M.A. James, J.D. Watton, M.R. Hill and D.L. Ball. "Probabilistic Modeling of Bulk Residual Stress." Presented at the 56th AIAA/American Society of Civil Engineers (ASCE)/American Helicopter Society (AHS)/American Society for Composites (ASC) Structures, Structural Dynamics, and Materials Conference, Kissimmee, Fla., January 2015.

Mentzer, C. and **E. Johnson.** "Dismounted Soldier Autonomy Tools (DSAT) – from Conception to Deployment." Presented at the 6th Annual National Defense Industrial Association (NDIA) Ground Vehicle Systems Engineering and Technology Symposium (GVSETS) 2014 and Advance

Planning Briefing for Industry, Autonomous Ground Systems (AGS) Technical Session, Novi, Mich., August 2014.

Mitchem, S. "Charged for Change: Your Electric Vehicle Can Do More Than Drive." Invited Lecture, Trinity University, San Antonio, December 2014.

Mitchem, S. "Electric Vehicles and the Grid." Presented at the Border Energy Forum XXI, Monterrey, Mexico, October 2014.

Mitchem, S. "Providing Fast Response Regulation Services using an Electric Vehicle Fleet and Relevance to Microgrids and Grids Using Electric Vehicles to Support a Microgrid in the Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) Program." Presented at the 2nd National Microgrids Conference, Chicago, September 2014.

Mitchem, S. "Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) - One Year Later: The Web Grows." Presented at the Defense Energy Summit and Innovation Showcase, Austin, Texas, November 2014.

Mitchem, S. "Technology Development in Smart Energy, Cyber Security, and Advanced Manufacturing at Southwest Research Institute." Presented at the ASME 2014 Dynamic Systems and Control Conference, San Antonio, October 2014.

Möbius, E., M. Bzowski, P. Frisch, H. Funsten, **S. Fuselier**, H. Kucharek, **D.J. McComas**, N. Schwadron, R. Wimmer-Schweingruber, P. Wurz and G. Zank. "The ENA Ribbon and the ISN Flow as Key Tools for the ISM-Heliosphere Interaction — Open Questions, the Need for Future Observations with IBEX and IMAP." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Möbius, E., M. Bzowski, P. Frisch, **S. Fuselier**, D. Heirtzler, M. Kubiak, H. Kucharek, M. Lee, T. Leonard, **D.J. McComas**, N. Schwadron, J. Sokol, P. Swaczyna and P. Wurz. "Local Interstellar Cloud Temperatures as Observed with IBEX." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Mohanty, S., **S. Stothoff**, **M. Muller**, M. Bourgeois, A. De Hoyos, G. Mathieu and D. Pellegrini. "Probabilistic Modelling of Radionuclide Transport Evaluation for Geological Disposal in Meuse/Haute-Marne, France." Presented at the 12th International Probabilistic Workshop, Weimar, Germany, November 2014.

Moody, J., J. Barnes, **P. Roming**, D. Durfee, B. Campbell, S. Turley and P. Eastman. "Mentoring Undergraduate Students through the Space Shuttle Hitchhiker GoldHELOX Project." Presented at the 225th AAS Meeting, Seattle, January 2015.

Moore, J.J. "Tutorial on Turbomachinery for SCO_2 Applications." Presented at the 2014 ASME Turbo Expo, Dusseldorf, Germany, June 2014.

Musacchio, F., J. Saur, **L. Roth**, P.D. Feldman, D.F. Strobel, **K.D. Retherford** and M.A. McGrath. "Observations of Ganymede's Variable Auroral Ovals on Leading Side Derived from HST/STIS." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Musgrove, G.O., C. Pittaway and E. Vollnogle. "Tutorial: Heat Exchangers for Supercritical CO_2 Power Cycle Applications." Presented at the International Gas Turbine and Aeroengine Congress and Exposition, Dusseldorf, Germany, June 2014.

Musgrove, G.O. and **M.A. Poerner**. "Tutorial: Wet Gas Compression for the Oil and Gas Industry." Presented at the International Gas Turbine and Aeroengine Congress and Exposition, Dusseldorf, Germany, June 2014.

Musgrove, G.O., **M.A. Poerner**, M. Cirri and M. Bertoneri. "Overview of Important Considerations in Wet Gas Compression Testing and Analysis." Presented at the 43rd Turbomachinery Symposium, Houston, September 2014.

Musgrove, G.O., **A.M. Rimpel** and **J.C. Wilkes**. "Tutorial: Applications of Supercritical CO_2 Power Cycles: Fundamentals and Design Considerations." Presented at the International Gas Turbine and Aeroengine Congress and Exposition, Dusseldorf, Germany, June 2014.

Necsoiu, M. "Rock Glaciers Dynamics and Permafrost Degradation Using Optical and SAR Satellite Imagery. Case Study: Retezat Mountains, Romania." Presented at The Mountain Research Initiative Key Contact Workshop, San Francisco, December 2014.

Necsoiu, M., **D. Hooper** and **R. McGinnis**. "Landslide Investigations at Salmon Falls Creek Canyon in Idaho Using Satellite-Based Multitemporal Interferometric Synthetic Aperture Radar Techniques." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Nesvorny, D., D. Kipping and **D. Terrell**. "Detection and Characterization of Non-Transiting Planets from Transit Timing Variations." Presented at the 46th Annual Meeting of the AAS/DPS, Tucson, Ariz., November 2014.

Newton, T., **M. Timme**, **B. Abbott**, T. Grace and W. Malatesta. "Initial Integrated Network Enhanced Telmetry (iNET) Test Article (TA) Network Testing." Presented at the International Telemetering Conference 2014, San Diego, October 2014.

Nicolaou, G., **D.J. McComas**, F. Bagenal and **H. Elliott**. "Derivation of Ions Bulk Properties in the Deep Jovian Magnetotail beyond $200R_J$." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Nicolella, D.P., **T.L. Bredbenner**, L.M. Havill, J.G. Tamez-Pena, P.C. Gonzalez, E. Schreyer, S. Totterman and C.K. Kwoh. "Variation in Knee Shape Predicts the Future Onset of Radiographic Knee Osteoarthritis (RKOA) and This Variation is Different in Males Compared to Females." Presented at the Orthopaedic Research Society Meeting, Las Vegas, March 2015.

Nicolella, D.P., **A.E. Nicholls**, **D.E. Moravits**, J.A.K. Harris, S.M. Levine, **T.D. Eliason**, M. Allen, J.S. Nyman, **T.L. Bredbenner** and L.M. Havill. "Females and Males Achieve Equivalent Cortical Bone Mechanical Properties through Different Combinations of Bone Traits." Presented at the Orthopaedic Research Society Meeting, Las Vegas, March 2015.

Noonan, P., **T. Newton**, **G. Willden**, T. Grace and W. Malatesta. "iNET System Manager." Presented at the International Telemetering Conference 2014, San Diego, October 2014.

Ogasawara, K., J. Bonnell, E.R. Christian, **M.I. Desai**, G. Grubbs, **J-M. Jahn**, **S.A. Livi**, K. Llera, **D.J. McComas**, R. Michell, M. Samara and S. Vines. "In-flight Verification of Avalanche Photodiodes: Avenue to a Low-cost Solution to Measure Suprathermal Particles for Future Missions." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Oxley, J. "Challenges and Future of Microencapsulation." Presented at the Avant Institute Symposium, Bridgewater, N.J., December 2014.

Oxley, J. "Contract R&D Services at SwRI." Presented at Partnerships in Drug Delivery, Boston, October 2014.

Parnell, C., **D. Lamb** and **C. DeForest**. "The Distribution and Behavior of Photospheric Magnetic Features." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Parra, J.O., U. Iturraran-Viveros, J.S. Parra and P.C. Xu. "Neural Network and Rock Physics for Predicting and Modeling Attenuation Logs." Presented at the Society of Exploration Geophysicists (SEG) International Exposition and 84th Annual Meeting, Denver, October 2014.

Peleikis, T., M. Kruse, L. Berger, C. Drews, R. Wimmer-Schweingruber, **D.J. McComas** and G. Gloeckler. "Investigation of Solar Wind Source Regions by Using Ulysses/Solar Wind Ion Composition Spectrometer (SWICS)/Solar Wind Observations Over the Poles of the Sun (SWOOPS) Composition Data and a Potential Field Source Surface Model to Map *in-situ* Measurements Back Onto the Photosphere." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Perez, J., N. Buzulukova, M.-C. Fok, **J. Goldstein**, **D.J. McComas**, **P. Valek** and K. Wood. "TWINS Geomagnetic Storm Catalog." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Technical Staff Activities

Poenitzsch, V.Z., **R. Wei**, **K.E. Coulter** and **M.A. Miller**. "High Power Impulse Plasma Source (HiPIPS) for Diamond-Like Carbon and Low Temperature Diamond Growth." Presented at the 2014 New Diamond and Nano Carbons Conference, Chicago, May 2014.

Poenitzsch, V.Z., **R. Wei**, **J. Lin** and **K.E. Coulter**. "Plasma Characteristics of High Power Impulse Plasma Source (HiPIPS) for Low Temperature Diamond Growth." Presented at the International Conference on Metallurgical Coatings and Thin Films (ICMCTF), San Diego, May 2014.

Pryor, W.R., K.Simmons, J. Ajello, W.K. Tobiska, **K.D. Retherford**, **S.A. Stern,** P.D. Feldman, P. Frisch, M. Bzowski and C. Grava. "Testing the Interstellar Wind Helium Flow Direction with Galileo EUVS Data," Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Putzig, N.E. "Subsurface Imaging with SHAllow subsurface RADar (SHARAD) and Implications for the Recent Climate History of Mars." Presented at the University of Colorado, Laboratory for Atmospheric and Space Physics Seminar Series, Colorado, January 2015.

Putzig, N.E., **R.J. Phillips**, **I.B. Smith**, C.J. Thomason, M.T. Mellon, B.A. Campbell and S.E. Wood. "Low Radar Reflectivity in Planum Australe Points to Past Episodes of Martian Atmospheric Collapse." Presented at the 46th LPSC, The Woodlands, Texas, March 2015.

Reisenfeld, D., P. Janzen, M. Bzowski, **M. Al-Dayeh**, H. Funsten, **S. Fuselier**, M. Kubiak, **D.J. McComas**, N. Schwadron and J. Sokol. "ENA Time Variation in the IBEX Skymaps and at the Poles." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Retherford, K.D., **M.W. Davis**, **T.K. Greathouse**, **G.R. Gladstone**, **A.J. Steffl,** D. Grodent and O.H.W. Siegmund. "Response of Microchannel Plate (MCP) Detectors to MeV Electrons: Beamline Tests in Support of Juno, Jupiter Icy Moon Explorer Mission (JUICE), and Europa Mission Ultra-violet Spectrometer (UVS) Instrument Investigations." Presented at the 46th Annual Meeting of the AAS/DPS, Tucson, Ariz., November 2014.

Retherford, K.D., **A.J. Steffl**, **J.R. Spencer**, **G.R. Gladstone**, **L. Roth,** J. Saur, D.F. Strobel, **S.A. Stern**, **J.W. Parker**, **M.H. Versteeg**, **M.W. Davis**, N.J. Cunningham and M.A. McGrath. "Far-UV Eclipse Observations of Ganymede's Atmosphere with New Horizons Alice: New Constraints to the Atomic Oxygen Component." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Rhoden, A. R., T. Hurford, L. Roth and **K.D. Retherford**. "Linking Europa's Plume Activity to Tides, Tectonics, and Liquid Water." Presented at the 46th Annual Meeting of the AAS/DPS, Tucson, Ariz., November 2014.

Ridens, B.L. and **I.A. Sandoval**. "High Pressure Thermophysical Gas Property Testing, Uncertainty Analysis, and Equation of State Comparison for Supercritical CO_2 Compression Applications." Presented at the 2014 Gas Processors Association (GPA) Convention, Dallas, April 2014.

Rodway, K., **C. DeForest**, **J. Diller**, F. Vilas, L. Sollitt, M. Reyes, A. Filo and E. Anderson. "New Platforms for Suborbital Astronomical Observations and *In-situ* Atmospheric Measurements: Spacecraft, Instruments, and Facilities." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Roth, L., **K.D. Retherford**, J. Saur, D.F. Strobel, P.D. Feldman, M.A. McGrath, F. Nimmo, **J. Spencer**, **C. Grava** and A. Bloecker. "Following up on the Discovery of Water Vapor at Europa's South Pole with HST." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Roth, L., J. Saur, **K.D. Retherford**, D.F. Strobel, P.D. Feldman, A. Blocker, N. Ivchenko and A. Kullen. "New Hubble Space Telescope (HST) Observations of Io's Time-variable UV Aurora: Probing Io's Magma Ocean and Neutral and Plasma Environment." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Rutherford, J., K. Harrison and G. White. "The Honey Community: Use of Combined Organizational Data for Community Protection." Presented at the 48th Annual Hawaii International Conference on System Sciences (HICSS), Hawaii, January 2015.

Santos-Costa, D., G. Clark, C. Paranicas, J.D. Menieti and W.-L. Tseng. "A Data-model Comparison Approach to Understand the Source and Transport Mechanisms of keV-Energy Electrons at Saturn." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Schultz, R., R. Youngblood III and **C.J. Freitas**. "Defining and Using Risk-significant Events as the Basis to Design Validation Experiments and Validation Matrices for Advanced Reactor Systems — A V&V 30 Methodology." Presented at the ASME 2014 Small Modular Reactors Symposium (SMR2014), Washington, April 2014.

Schwadron, N., F. Adams, E. Christian, P. Desiati, P. Frisch, H. Funsten, J. Jokipii, **D.J. McComas**, E. Möbius and G. Zank. "Global Anisotropies in TeV Cosmic Rays Related to the Sun's Local Galactic Environment and Heliotail from IBEX." Presented at the 40th COSPAR Scientific Assembly 2014, Moscow, Russia, August 2014.

Schwadron, N. and **D.J. McComas**. "Spatial Retention of Pickup Ions Beyond the Heliopause to Form the IBEX Ribbon." Presented at the 40th COSPAR Scientific Assembly 2014, Moscow, Russia, August 2014.

Seifert, C.M., **K.E. Mandt**, **K.D. Retherford**, **T.K. Greathouse**, A.R. Hendrix, **A.F. Egan**, **G.R. Gladstone**, P.D. Feldman, **C. Grava** and P.F. Miles. "LRO/LAMP Investigation of the Lunar Albedo Far-UV Spectral Inversion." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Simons, S.B., **T.C. Allison** and **B.A. White**. "Acoustic Induced Vibration (AIV)/Flow Induced Turbulence (FIT)/Flow Induced Vibration (FIV)/Small Bore Piping Analysis." Presented at the GMRC Gas Machinery Conference 2014, Nashville, Tenn., October 2014.

Simons, S.B. and **E.L. Broerman**. "Predicting Vortex-shedding Induced Pulsation Amplitudes in Piping Systems." Presented at the GMRC Gas Machinery Conference 2014, Nashville, Tenn., October 2014.

Simons, S.B., M. Johnson and **E.L. Broerman**. "A Case Study: Best Practices for Pulsation Bottle Design to Reduce Horsepower Losses." Presented at the GMRC Gas Machinery Conference 2014, Nashville, Tenn., October 2014.

Smith, I.B. "Stratospheric Airship Design and HiSentinel." Presented at the 2nd International Conference and Exhibition on Mechanical and Aerospace Engineering, Philadelphia, September 2014.

Smith, I.B., **N.E. Putzig**, **R.J. Phillips** and J.W. Holt. "Recent Climate Change Detected on Mars: Implications for the Planetary Ice Budget." Presented at the 46th LPSC, The Woodlands, Texas, March 2015.

Suman, A., R. Kurz, N. Aldi, M. Morini, **K. Brun**, M. Pinelli and P. Spina. "Quantitative CFD Analyses of Particle Deposition on a Transonic Axial Compressor Blade, Part I: Particle Zones Impact." Presented at the 2014 ASME Turbo Expo, Dusseldorf, Germany, June 2014.

Suman, A., R. Kurz, N. Aldi, M. Morini, **K. Brun**, M. Pinelli and P. Spina. "Quantitative CFD Analyses of Particle Deposition on a Transonic Axial Compressor Blade, Part II: Impact Kinematics and Particle Sticking Analysis." Presented at the 2014 ASME Turbo Expo, Dusseldorf, Germany, June 2014.

Teolis, B.D. "A Global Plume Fed European Exosphere: Structure, Composition, Temporal Variability, and Surface Interactions." Presented at the Europa Clipper Science Definition Team Meeting, Invited Advisory Session on Potential Plume Measurements, The Johns Hopkins University Applied Physics Laboratory, Laurel, Md., June 2014.

Teolis, B.D. "Maintenance of Surface Current Balance by Field-aligned Thermoelectric Currents at Astronomical Bodies: Cassini at Rhea." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Thacker, B.H. "Application of UQ in Engine Life Management – from Preliminary Design to Retirement." Presented at the 2014 ASME Turbo Expo, Dusseldorf, Germany, June 2014.

Technical Staff Activities

Thacker. B.H. "Uncertainty in Modeling and Measurement – Converging the Methodologies and Insight." Presented at the 2014 ASME Turbo Expo, Dusseldorf, Germany, June 2014.

Thacker, B.H., **T.D. Eliason**, **J.S. Coogan** and **D.P. Nicolella**. "Validation of Probabilistic Models of the Anterior and Posterior Longitudinal Ligaments of the Cervical Spine." Presented at the ASME Verification and Validation Symposium, Las Vegas, May 2014.

Thorp, J., F. Khan, **K. Brun**, M. Strobel and M. Khalifa. "Risk-based Assessment of Gas Turbines in Pipeline Service." Presented at the 2014 ASME Turbo Expo, Dusseldorf, Germany, June 2014.

Timme, M., **T. Newton**, **M. Moodie**, **B. Abbott** and T. Grace. "Initial iNET RF Network Testing." Presented at the 50th Annual International Telemetering Conference (ITC) USA 2014, San Diego, October 2014.

Trevino, G. "Using Electric Vehicles for Fast Response Regulation Services." Presented at the ASME 2014 DSCC, San Antonio, October 2014.

Tsang, C.C.C., J.A. Rathbun, **J.R. Spencer**, B.E. Hesman and O. Abramov. "Io's Hotspots in the Near-infrared Detected by LEISA during the New Horizons Flyby." Presented at the 45th LPS Conference, The Woodlands, Texas, March 2014.

Tsang, C.C.C., **J.R. Spencer**, M. Richter, E. Lellouch and M. Lopez-Valverde. "Io's Primary Atmosphere In Eclipse: First Observations from Gemini — Texas Echelon Cross Echelle Spectrograph (TEXES)." Presented at the 46th Annual Meeting of AAS/DPS, Tucson, Ariz., November 2014.

Valek, P., **J. Goldstein**, **J. Jahn**, **D.J. McComas** and H. Spence. "Global Observations of the O^+/H^+ Ratio During Large Geomagnetic Storms." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Valek, P., **D.J. McComas**, **M. Al-Dayeh**, **J. Goldstein** and **K. Ogasawara**. "TWINS and IBEX Observations of Shock-associated Storms and Substorms." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Vines, S.K., **M.I. Desai**, **K. Ogasawara**, K. Leera, S.G. Kanekal, **S.A. Livi** and E.R. Christian. "Characterizing SEP electrons with the Compact Radiation Belt Explorer (CeREs)." Presented at the SHINE Workshop in Telluride, Colo., June 2014.

Vinogradov, S.A., **C.E. Duffer** and **G.M. Light**. "Review of Magnetostrictive Sensors for Guided Wave Screening of Heat Exchanger Tubing." Presented at the ASNT 2014 Fall Conference, Charleston, S.C., October 2014.

Webb, D. and **T. Howard.** "Tracking Coronal Mass Ejections through the Space Environment." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

White, B.A., **B.J. Bichon**, **D.L. Ransom** and **E.L. Broerman**. "Optimized Robust Compressor Station Design Methodology." Presented at the 9th EFRC, Vienna, Austria, September 2014.

Zhao, L., G. Li, **R. Ebert**, **M. Desai**, Z. Wu, Y. Chen and G. Mason. "Particle Acceleration and Transport in CIR." Presented at the SHINE Workshop, Telluride, Colorado, June 2013.

Zhao, L., G. Li, G.M. Mason, C.M.S. Cohen, **R.W. Ebert**, R.A. Mewaldt and I.G. Richardson." Q/A Dependence on Shock Geometry Using Multi-Spacecraft Observations." Presented at the AGU Fall Meeting, San Francisco, December 2014.

Zirnstein, E., J. Heerikhuisen, N. Pogorelov, **D.J. McComas** and **M. Al-Dayeh**. "Simulating a Dynamic Solar Cycle and Its Effects on the Interstellar Boundary Explorer Ribbon." Presented at the 2014 AGU Fall Meeting, San Francisco, December 2014.

Internal Research

Funded January 1, 2015

Al-Dayeh, M. and N. Evans. "Acoustic Measurements of a High Mass-Flow Cold Jet."

Anderson, B. "LTE System Security."

Bartley, G. and R. Hill. "Radiative Excitation of Methane for Reduced Temperature Catalyst Activity."

Downs, R. "Feasibility of Low Resolution Video Streams for Wrong Way Driver Detection."

Feng, M., J. Erwin and D. Daruwalla. "Rapid Catalyst Lifetime Determination and Deactivation Sensitivity Assay."

Ferrill, D., K. Smart, R. McGinnis and A. Morris. "Mechanical Stratigraphy and Natural Deformation in the Permian Strata of West and Central Texas and New Mexico."

Florea, R. and G. Neely. "Experimental Investigation of Co-direct Injection of Natural Gas and Diesel in a Heavy-duty Engine."

Fratesi, B., P. Bertetti and R. Green. "Investigation of Drought Intensity and Periodicity in South Texas Using Chemical Records in Bat Guano Cores."

Helffrich, J., W. Roberds and J. Harrison. "A Microcontroller Study."

Jaeckle, T. and O. Granados. "Feasibility of a Flexible Receiver Architecture and Algorithm to Detect Spoofing of Global Navigation Satellite Signals."

Jahn, J.-M., G. Miller and R. Ebert. "HighRISE — High Resolution Ion Spectrometer Experiment."

Lecocke, M. "Efficient Execution of High-capacity Data Organization Software on a Radiation-hardened Embedded Platform."

Lee, P., G. Hansen, S. Westbrook and G. Wilson. "Tribological Fuel Study."

Murray, D. and P. Keller. "Evaluating the Capability of an Open-source Software-defined Radio Platform as a Reactive Signal Jammer."

Ogasawara, K., F. Allegrini, M. Al-Dayeh, M. Desai, R. Ebert and S. Livi. "Development of a Low-cost and Robust Particle Counter for General Time-of-flight Applications under Planetary, Geospace, and Heliosphere Environment."

Peri, G. "Optimized Multi-channel Communications."

Poerner, M. and D. Ransom. "Methodology for Qualifying Flow Regime of Two-phase Flow within a Pressurized Compressor."

Reinhard, R. and R. Fenske. "Evaluation of Theater Netcentric Geolocation (TNG) 2.0 Silkwave Technology with SwRI Frontier Systems over Disadvantages Links."

Signorotti, J. and D. Van Rheeden. "Precision HF Signal Geolocation Using a Two Aircraft T/FDOA Technique."

Winters, G., M. Davis, T. Greathouse, K. Mandt and P. Roming. "Fast Acquisition Multi-band High Resolution Spectrometer Development."

Funded October 1, 2014

Bartley, G. "Development of New Ruthenium Catalysts for the Low-Temperature Reduction of NOx Emissions from Vehicle Exhaust — Connect Program."

Bayless, A., P. Roming, R. Thorpe and C. Fryer. "Capability Development of Supernova Models."

Edwards, S. "Investigation of Robotic Production Singulation Methods."

Technical Staff Activities

Fanick, R., S. Kroll and S. Quarderer. "Light-duty Vehicles Sample Collection for Air Toxic Pollutants."

Gutierrez, G. "Evaluation of Anti-bacterial Effects of Novel Formulations that Target an Essential Metabolic Pathway of the Agent of Lyme Disease — Connect Program."

Hoag, K. and A. Megel. "Methodology Development for IC Engine Tumble Port Evaluation."

Khalek, I. and N. Jeyashekar. "Effect of Jet Fuel Properties on Soot Mass and Solid Particle Number Emissions from Aircraft Engines: Development of a Fuel Particulate Matter (PM) Index Concept."

Kroll, S., K. Spreen, R. Fanick and W. Barclay. "Real-time Automatic GC-MS Gas Sampling System for Detailed Characterization of Advanced Combustion Engine Emissions."

Lillywhite, M. "Energy Efficient GPS Processing Methods."

Morgan, P. and M. Amann. "Lubricant Impact on Fuel Economy — Correlation Between Measured Engine Component Friction and Vehicle Fuel Economy."

Mott, C., R. Garcia and P. Avery. "Cooperative Framework for Negotiated System Integration Among Heterogeneous Vehicle Systems."

Myers, S. "Technology Development for the High Energy Polarimeter (HEP) Instrument Detector."

Nowicki, K., S. Rafkin and A. Soto. "Coupled Laser Anemometer and Trace Gas Detector."

Price, W. and D. Slimpin. "Data Collection Using Android Smart Phones."

Rigney, M. "Automated Perception and Robotic Targeting of Fluorescent Markers."

Roberts, J. and T. Brockwell. "Development of a Dust-tolerant, All-metal, Molecular Flow Seal for Space Flight and Other Vacuum Applications."

Rutherford, J. "Community Based Cybersecurity with UTSA/Center for Infrastructure Assurance and Security."

Van Horn, A., D. Vickers and M. Brown. "Detecting Distracted Drivers Using Vehicle Data."

Van Rheeden, D. and W. Music. "Utilizing Frequency Diversity to Enhance Indoor Geolocation."

Wellinghoff, S., J. Ling, M. Rubal, H. Chen and R. Rawls. "Rh-BMP2 Activated Mineralized Bone Scaffold for Cranio-maxillofacial Repair."

Wray, C. "Single Cylinder Engine for Advanced Combustion Development."

Young, E., S. Smith and Z. Dischner. "Demonstration of Infrasound Detection of Explosive Events from Balloon-Borne Platforms."

Patents

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