USRA

Universities Space Research Association

2017 ANNUAL REPORT

USRA

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MISSION

- Advance the space- and aeronautics-related sciences exploration through innovative research, technology, and education programs
- Promote space and aeronautics policy
- Develop and operate premier facilities and programs by involving universities, governments and the private sector for the benefit of humanity

VALUES

- Passion—for science, technology, and education
- Partnerships—with universities, governments, and the private sector
- Professionalism—through excellence, accountability, and respect for others

Cover: Artist's conception of colliding neutron stars. Image courtesy: University of Warwick/ Mark Garlick

Inside cover: This artist's concept depicts the pulsar planet system discovered by Aleksander Wolszczan in 1992. Wolszczan used the Arecibo radio telescope in Puerto Rico to find three planets circling a pulsar called PSR B1257+12. Image courtesy: NASA

Message from the President and Chief Executive Officer and the Chair of the Board of Trustees

Jeffrey A. Isaacson
President and Chief Executive Officer

William Ballhaus, Jr.
Chair, Board of Trustees

Through our many programs last year, USRA fulfilled its fundamental role of serving the university and broader research community. From our operation of the Lunar and Planetary Institute, to our science operations for SOFIA, to our operation of the Quantum Artificial Intelligence Laboratory with NASA and Google, USRA is enabling some of most important discoveries of our time. USRA is also contributing substantially across the entire pipeline of workforce development, from K-12 STEM education activities, to student internship programs at federal laboratories and USRA facilities, to management of the NASA Postdoctoral Program. Among the notable scientific research and technology development achievements in 2017 in which USRA was involved were the following:

- Detecting gamma-ray bursts by NASA's Fermi Gamma-ray Space Telescope, coinciding with the detection of gravitational waves by the Laser Interferometer Gravitational-Wave Observatory, explained as a merger of binary neutron stars;
- Pinpointing the location of a repeating Fast Radio Burst, in a dwarf galaxy three billion light years away, through a collaboration between Arecibo Observatory and the European Very Long Baseline Interferometry Network;
- Examining the moon's giant Orientale impact basin using measurements taken by NASA's Gravity Recovery and Interior Laboratory mission, to help clarify how the formation of Orientale affected the moon's geology 3.8 billion years ago;
- Contributing to the development of NASA's Geostationary Lightning Mapper, which provides a quantum leap forward in lightning detection leading to improved forecasts and warnings of severe weather events; and
- Using the microgravity environment of the International Space Station to investigate fundamental questions about the behavior of colloids—knowledge of which may be applied to novel functional materials for applications ranging from photonics to drug delivery.

Among our many contributions to workforce development were:

- Supporting more than 1,600 paid internships, from high school to graduate level, at NASA Centers, Air Force Research Laboratory sites, and within USRA institutes and programs;
- Awarding six USRA Scholarships to undergraduate students, through a competitive process employing faculty from our member universities;
- Reviewing over 591 applications for postdoctoral opportunities at NASA; and
- Integrating STEMaction, Inc., a Maryland-based nonprofit supporting FIRST robotics competitions, with the USRA STEM Education Center. Last year alone, over 500 students from more than 100 teams used USRA's STEM facility.

USRA remains financially strong, growing revenue to $157 million in 2017 while keeping indirect costs relatively flat. Among the significant funding awards received last year was a new contract to continue science and mission operations support for SOFIA. The new contract is for a period of up to eighteen years, corresponding to SOFIA's maximum lifetime operation.

The following pages provide a brief outline of the breadth of our activities. Our achievements, in service to our nonprofit mission and purpose, reflect the professionalism of our employees, the support of the university community we serve, and the trust of our long-standing partners in the federal government.

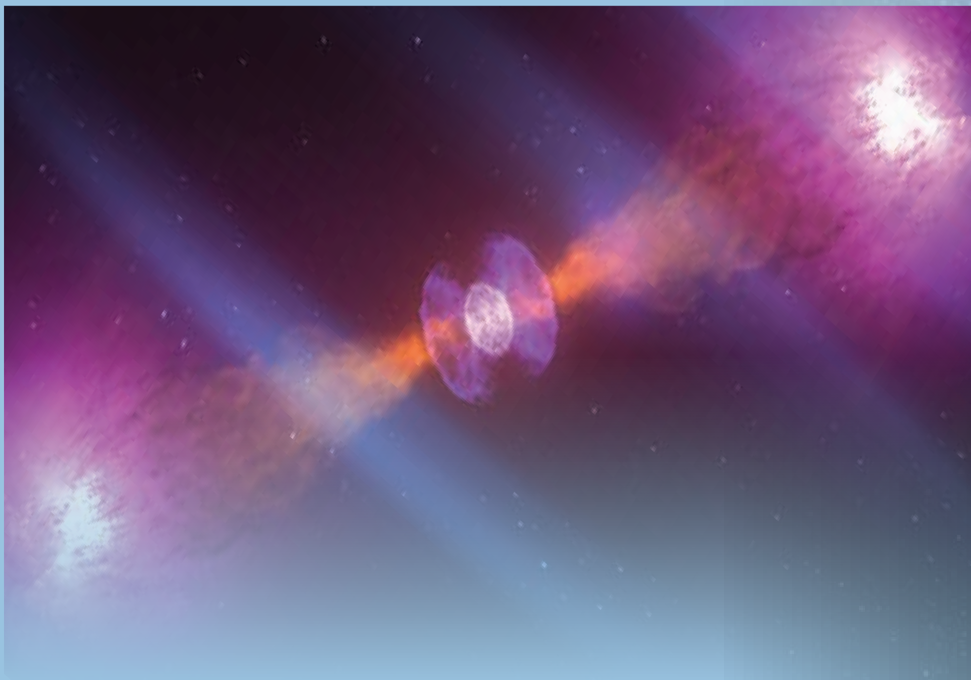
Jeffrey A. Isaacson
President and Chief Executive Officer

Wm F. Ballhaus, Jr.

William F. Ballhaus, Jr.
Chair, Board of Trustees

Astronomy and Astrophysics

USRA scientists working with the Stratospheric Observatory for Infrared Astronomy (SOFIA), the Science and Technology Institute, and Arecibo Observatory focus on understanding a wide array of current astrophysical problems, including the turbulent youth and explosive death of stars, the largest gravitationally-bound structures in the universe, the behavior of matter under the most extreme conditions and the origin of gravitational waves and high-energy cosmic rays.



When neutron stars collide, (left) the explosion blasts some of the debris away in particle jets moving at nearly the speed of light, as shown in this illustration. The jets produce a brief burst of gamma rays (magenta). For GW170817, the gamma rays reached Earth just 1.7 seconds after the merger's last gravitational wave (pale arc). Image courtesy: NASA

Stunning Discovery of Colliding Neutron Stars

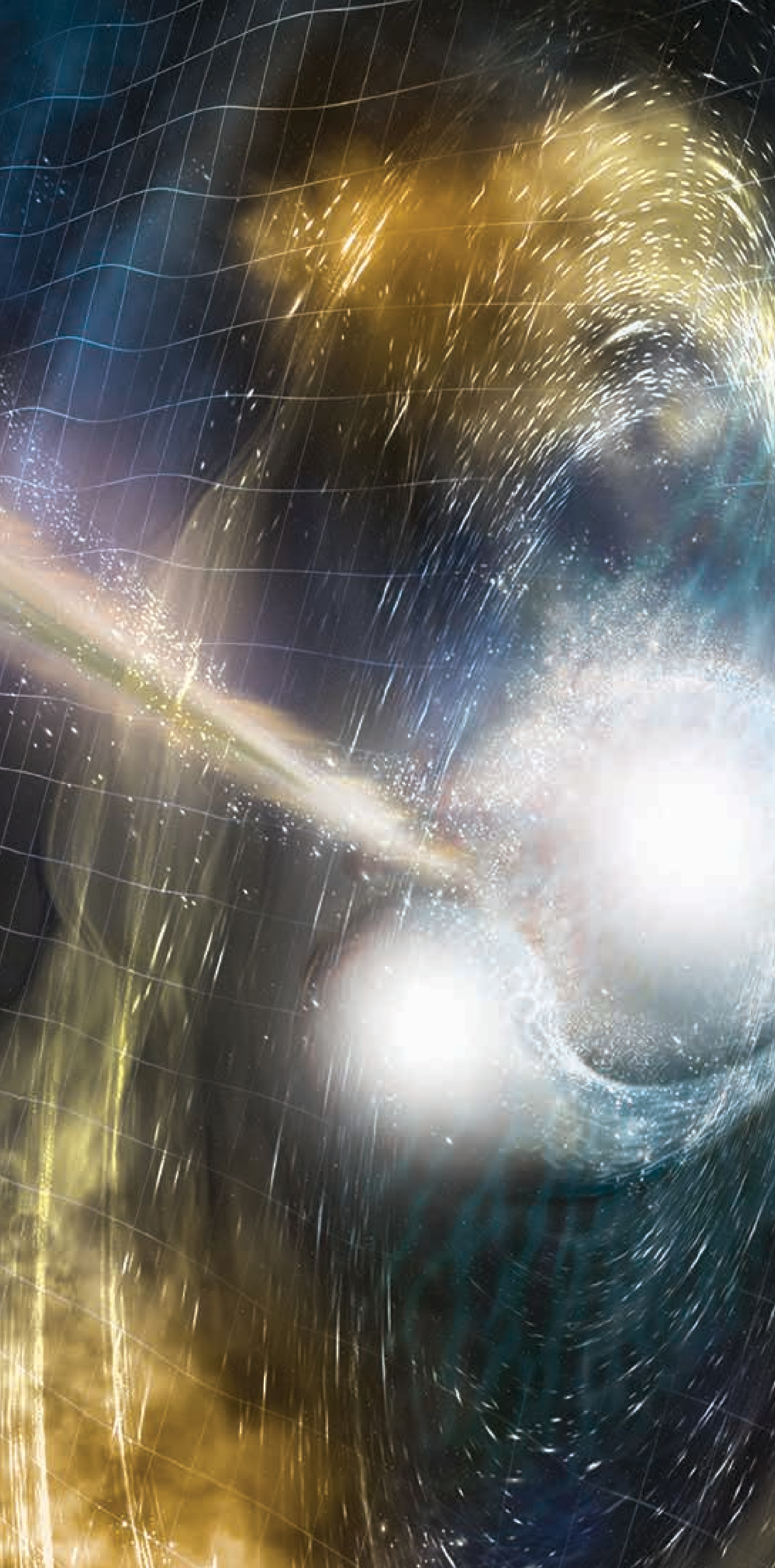
USRA scientists played a key role in a new gravitational-wave discovery—the first such detection by multiple space- and ground-based observatories.

This phenomenal event resulted from colliding neutron stars and was detected by NASA's Fermi Gamma-ray Burst Monitor (GBM) on August 17, 2017. Fermi's GBM instrument is operated by USRA for NASA.

The gravitational waves were picked up by the Laser Interferometer Gravitational Wave Observatory detectors at Hanford, Washington. This joint detection set in motion a series of observations across the electromagnetic spectrum from radio waves to very-high-energy gamma rays, resulting in multiple views of a fascinating phenomenon in our cosmological backyard, about 130 million light years from Earth.

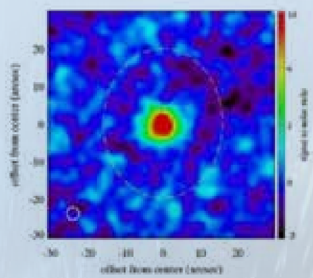
USRA scientists working on this observation soon realized the extraordinary nature of this event. As the observations of the gravitational waves unfolded, the impact of the discovery became evident. It confirmed a binary neutron stars merger as the origin of at least some short Gamma Ray Bursts (GRB). But just as importantly, the proximity in time of the Gravitational Wave and the Gamma Ray Burst detections showed that gravity waves travel at velocities that deviate from light speed by less than one part in one quadrillion.

Of the several published papers that have resulted from this major discovery, three appeared in Astrophysics Journal Letters, coauthored by USRA scientists Adam Goldstein and B.P. Abbott.



SOFIA Observes Solar System Analog

Using the mid-infrared camera FORCAST on SOFIA, University of Arizona's Kate Su and colleagues resolved the long-standing question of the nature of the dust surrounding the nearby star epsilon Eridani. The dust in the inner 25 AU of the epsilon Eridani debris disk system arises principally from collisions between planetesimals in a dust disk similar to Sun's asteroid belt, rather than by grains dragged in from a cold outer belt, like the Sun's Kuiper belt.



Epsilon Eridani, the closest debris disk (outlined) around a star similar to the early Sun, was observed by SOFIA/FORCAST at 34.8μm. Image courtesy: NASA JPL/ K. Su

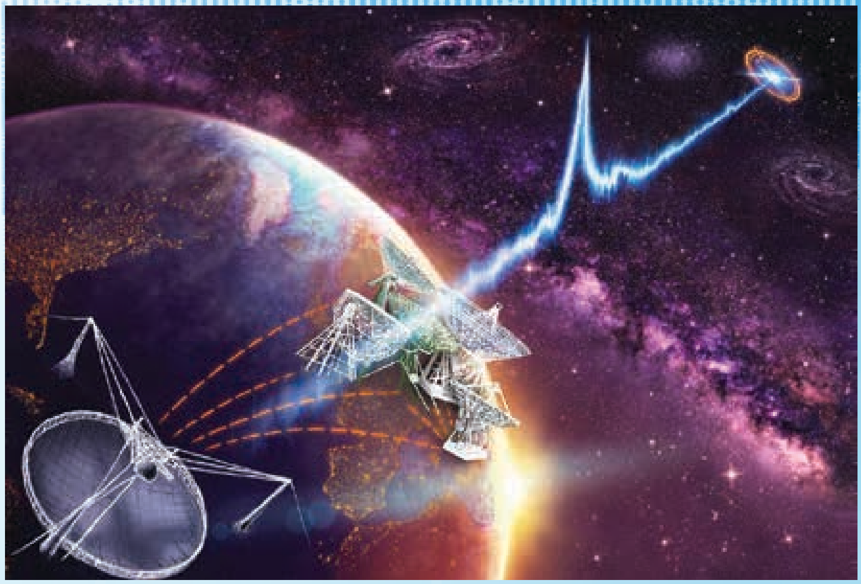
Illustration of two merging neutron stars. The rippling space-time grid represents gravitational waves that travel out from the collision, while the narrow beams show the burst of gamma rays that are shot out just seconds after the gravitational waves. Swirling clouds of material ejected from the merging stars are also depicted—these clouds glow with visible and other wavelengths of light. Image courtesy: National Science Foundation/ LIGO/Sonoma State University/A. Simonnet

Astronomy and Astrophysics *continued*

Fast Radio Bursts—Originating Long, Long Ago in a Galaxy Far, Far Away

For the first time, scientists have clearly established the host galaxy of a Fast Radio Burst (FRB) — one of astronomy's hottest topics. FRBs, which are very short, very intense pulses of radio waves, have puzzled astronomers since their discovery a decade ago. Twenty-three of these bursts have been recorded by telescopes around the world, but only one—discovered at Arecibo Observatory in Puerto Rico—has ever repeated. USRA scientists at Arecibo joined the European Very-Long-Baseline Interferometry Network to pinpoint the location of the FRB in a dwarf galaxy over 3 billion light-years away. These observations provide definitive proof that FRBs come from far outside our Milky Way.

Dwarf galaxies contain gas that is relatively pristine compared to that found in the more massive Milky Way. Conditions in this dwarf galaxy may make it possible to form much more massive stars than in the Milky Way, and the FRBs could be from the collapsed remnant of such a star. Alternately, FRBs could also be generated in the vicinity of a massive black hole that is swallowing the surrounding gas, a so-called active galactic nucleus. There is still a lot of work to be done to unravel the FRB mystery, but identifying the host galaxy for Arecibo's FRB marks a big step toward solving the puzzle.



Artist's conception of multi-site detection of FRBs. Image courtesy: Diane Fustelaar

Heliophysics

USRA has active efforts in Heliophysics, Solar Physics and Space Weather at the Science and Technology Institute (STI) in Huntsville, Alabama. Currently this group houses expertise in several basic and applied research efforts: particle acceleration in the heliosphere, modeling and assessment of charged particle environments and effects in near-Earth and interplanetary space, space weather assessments for NASA missions, space radiation and solar wind environment testing. It also conducts operational assessments for missions such as the Chandra X-ray Observatory and the Parker Solar Probe, and technology and operational development for multiple sounding rocket projects for solar investigations.

Parker Solar Probe. Image courtesy: Johns Hopkins University Applied Physics Laboratory

USRA Scientists and Marshall Space Flight Center get the Parker Solar Probe Instrument Ready to Fly

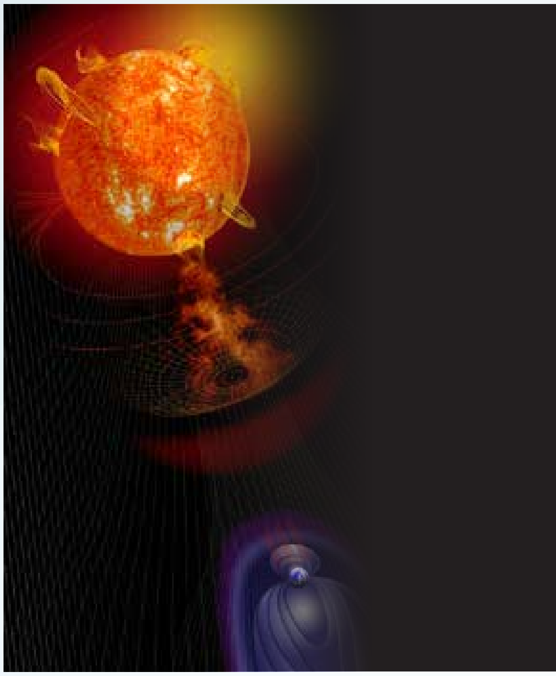
NASA's Parker Solar Probe mission will explore the sun's atmosphere by traveling closer to the sun than any other spacecraft before. This spacecraft will have to survive extreme environments encountered in proximity to the Sun, such as temperatures up 2500 ºF, and ionizing solar radiation that can affect both electronics and materials on-board the spacecraft. The Parker Solar Probe has an instrument suite that will measure magnetic fields and charged particles in the inner heliosphere, and will image the solar wind. USRA Research Scientist Dr. Ken Wright, a co-investigator for the Solar Wind Electrons, Alphas, and Protons (SWEAP) instrument on the Parker Solar Probe, was involved in the successful completion of solar wind and thermal testing for the Solar Probe Faraday Cup performed at Marshall Space Flight Center. Dr. Wright's efforts saw the testing through its complete lifecycle for development of test procedures, completion of Test Readiness Reviews, and thermal and charged particle testing for both engineering and flight models of the Faraday Cup.

Want to Build a Rocket?

USRA scientists at STI provided expert modeling, data analysis and design for the Marshall Grazing Incidence X-ray Spectrometer (MaGIXS) and the Chromospheric Lyman-Alpha Spectro-Polarimeter 2 (CLASP2) sounding rocket missions. MaGIXS will study the heating of active regions on the Sun to answer the question, "Are these regions heated via nanoflares or are they heated via waves?" USRA scientists hold integral roles in the mechanical design and analysis for the MaGIXS Telescope Mirror Assembly (TMA) and Spectrometer Optics Assembly (SOA) instrument structure for MaGIXS. USRA researchers are also active in performing the required analyses to determine the necessary performance parameters needed for MaGIXS to resolve and observe different heating mechanisms.

HERTZ Project

The USRA STI Heliophysics Group supports the Heliopause Electrostatic Rapid Transport Systems (HERTS) project—a development and testing effort for a system of electric wires that will exchange momentum with ions in the solar wind. The wires act as tethers for "solar sails" that will propel a probe to the edge of the Sun's Heliosphere.



Artist's rendering of the pressure of solar wind that streams out in all directions from the Sun against the Earth's magnetosphere (shown in purple). This pressure creates a bubble-like atmosphere that shields our planet from the majority of galactic cosmic rays. Image courtesy: NASA

Lunar and Planetary Sciences

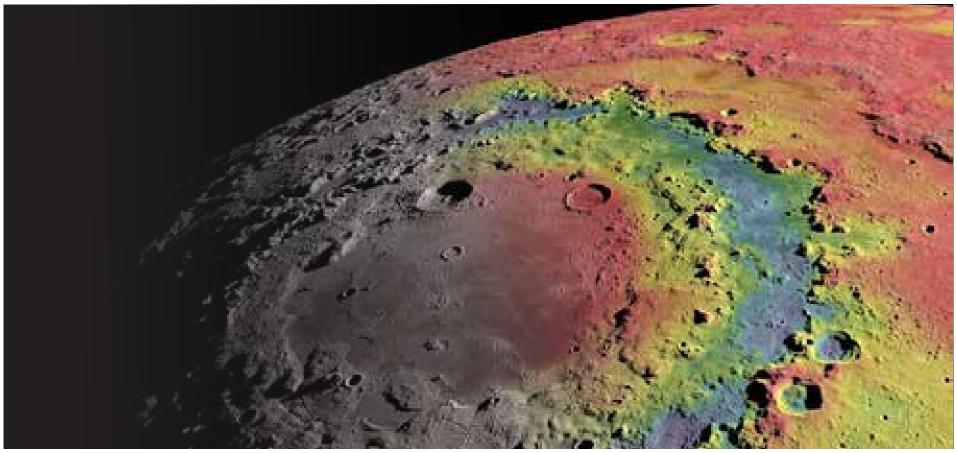
USRA conducts research on the formation, evolution, and current state of our solar system and shares these results with the science community, educators, and the public. In FY2017, USRA continued research at the cutting edge of lunar and planetary science at the Lunar and Planetary Institute, Arecibo Observatory and the Stratospheric Observatory for Infrared Astronomy.

GRAIL Observations Reveal Structure of Lunar Impact Basins

Results from NASA's Gravity Recovery and Interior Laboratory (GRAIL) mission are providing insights into the huge impacts that dominated the early history of Earth's moon and other solid worlds, like Earth, Mars, and the satellites of the outer solar system.

USRA's Walter Kiefer and Patrick McGovern at the Lunar and Planetary Institute and colleagues examined the origins of the Moon's giant Orientale impact basin to clarify the effect on the Moon's geology of the formation of the basin approximately 3.8 billion years ago. In their paper published in Science, the team showed that none of the rings in Orientale basin represent the initial, transient crater. Instead, it appears that in large impacts, like the one that formed Orientale, the surface violently rebounds, obliterating signs of the initial impact.

The powerful impacts that created basins like Orientale played an important role in the early geologic history of the Moon. They were disruptive events that caused substantial fracturing, melting, and shaking of the Moon's crust. They also blasted out material that fell back to the surface, coating older features that were already there. Analyzing the layering of ejected material helps scientists determine the age of lunar features as they work to unravel the Moon's complex history.



Orientale basin as rendered by Lunar Reconnaisance Orbiter with gravity data (color) from GRAIL superimposed. Image courtesy: NASA/E. Wright

Unearthing New Clues to the Dinosaur-Killing Impact

Dinosaurs and marine reptiles once dominated the world, but the impact of an asteroid and the series of catastrophic events that followed the impact caused the extinction of all large animals, leading to the rise of mammals and the eventual evolution of mankind. This finding was the result of the work of the International Ocean Discovery Program and International Continental Scientific Drilling Program (IODP-ICDP). Scientists on the expedition drilled an offshore borehole into the site of the asteroid impact, known as the Chicxulub Impact Crater, which is linked, famously, to the K-T or K-Pg mass extinction event. The crater is buried several hundred meters below the surface in the Yucatán region of Mexico.

The international team recovered nearly 14 tons of rock comprising a nearly complete set of rock cores from 506 to 1335 meters (1660 to 4380 feet) below the modern-day seafloor. The team, including USRA's David Kring of the Lunar and Planetary Institute, studied the rock cores for a first pass at understanding the effects of the impact on life and as a case study of how impacts affect planets.

In a paper published in Science, the scientists show how the basement of Earth's crust was uplifted over the surface to produce a shattered peak ring in the Chicxulub impact crater that was susceptible to hydrothermal alteration. The team found that the peak-ring is composed of granitic rock that once existed down to 8 to 10 kilometers (5 to 6 miles) beneath the surface. That rock was shattered and shocked, then uplifted above the Earth's surface before flowing outward over the floor of the Gulf of Mexico to form a ring of rock several hundred meters high during the formation of the crater.

The Chicxulub impact event, the environmental calamity it produced, and the paleobiological consequences are among the most captivating topics being discussed in the geologic community.

Rock cores recovered from the Chicxulub impact crater. Image courtesy: MARUM/MMowat@ECORD/IODP

SOFIA Catches the Shadow of Neptune's Moon Triton

NASA's flying telescope, the Stratospheric Observatory for Infrared Astronomy, SOFIA, set out from its home base in Palmdale, California, to Daytona Beach, Florida, in early October to observe Neptune's moon Triton as it passed in front of a distant star.

As Triton blocked light from the star, it cast a shadow that raced across Earth's surface at more than 37,000 mph. Catching Triton's shadow as it races across Earth's surface while the aircraft is traveling at Mach 0.83 (approximately 636 mph), is no small feat. If a telescope can be positioned in the direct center of the shadow, researchers can make precise measurements of Triton's atmosphere.

Triton has strong tides because it is close to Neptune, much closer than our moon is to Earth. These powerful tides combined with its strong winds, change the shape of its atmosphere. To measure the overall shape of Triton's atmosphere, researchers using SOFIA also teamed with more than 30 ground-based telescopes across the Eastern United States and Europe. Most of these telescopes were not located where the center of the shadow fell, but they made simultaneous observations of different areas of Triton's atmosphere to get a global view of its shape.

The data from ground-based telescopes, combined with that collected by SOFIA's 100-inch (2.5-meter) on-board telescope and three powerful instruments, helps USRA/NASA researchers understand how Neptune's gravitational forces influence Triton's atmosphere, including its temperature, pressure and density.

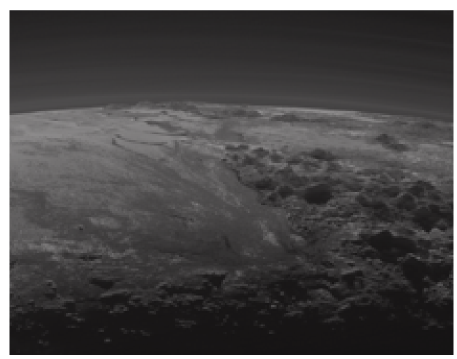
The borders of Triton's shadow across Earth's surface are indicated by black lines on this map, while the orange line is the path of the shadow's center. SOFIA's flight path is represented by the red line; the point of the crucial, two-minute observation of Triton as it aligns with a distant star is marked by the airplane. Image courtesy: German SOFIA Institute/Karsten Schindler; map data courtesy Google

Soaring Over Pluto's Majestic Mountains and Icy Plains

On July 14, 2015, NASA's New Horizons spacecraft made its historic flight through the Pluto system and sent home the first close-up pictures of Pluto and its moons—amazing imagery that inspired many to wonder what a flight over the distant worlds' icy terrain might be like.

Scientists are still analyzing and uncovering data that New Horizons recorded and sent home after the encounter. On the two-year anniversary of the fly-by, the team is also unveiling a set of detailed, high-quality global maps of Pluto and its largest moon, Charon. USRA's Paul Schenk of the Lunar and Planetary Institute is a Co-Investigator on the New Horizons mission to Pluto and beyond.

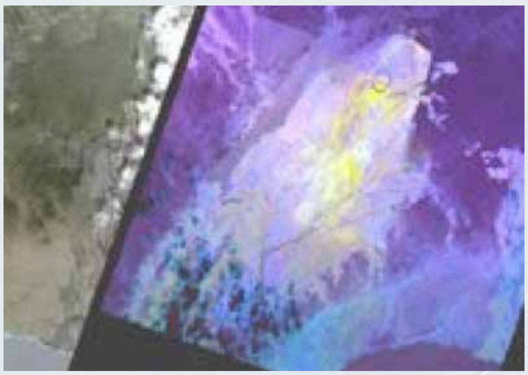
Schenk is an expert in the area of stereo topographic mapping, and led the creation of flyover movies using actual New Horizons data and digital elevation models of Pluto and its largest moon Charon. The movies take the viewer on flyover tours of their incredible landscapes offering spectacular new perspectives of the many unusual features that were discovered and which have reshaped our views of the Pluto system, all from a vantage point even closer than the spacecraft itself.



View of Pluto taken during New Horizons mission fly-by. Image courtesy: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute/Lunar and Planetary Institute

Earth Science

Along with their counterparts at different agencies, USRA scientists contributed significantly to the Earth Science communities. During 2017, USRA researchers and staff affiliated with the Science and Technology Institute (STI) at NASA Marshall Space Flight Center in Alabama, the NASA Academic Mission Services (NAMS) group at NASA Ames Research Center at Moffett Field in California, and the Goddard Earth Sciences, Technology, and Research (GESTAR) program at NASA's Goddard Space Flight Center in Greenbelt, Maryland, all made impressive contributions to NASA's Earth Science goals. Collectively, USRA personnel worked on nearly 200 individual projects from among the three programs.



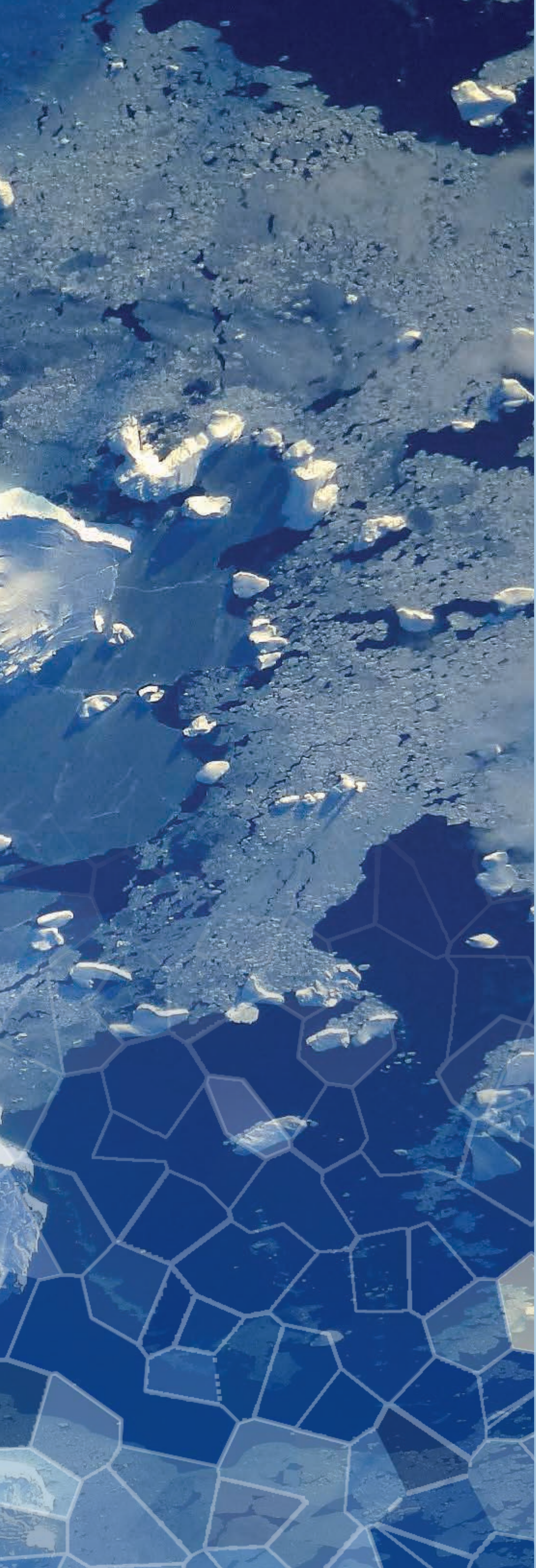
Images of the Kilauea caldera in Hawaii. The Hyperspectral Infrared Imager—a proposed satellite system to study the world's ecosystems—provides information on natural disasters using the MASTER instrument to collect data. Here sulfur dioxide gas plumes appear in yellow in this image taken by MASTER in Hawaii. Image courtesy: NASA

Airborne Test of Instrument to Monitor World's Ecosystems

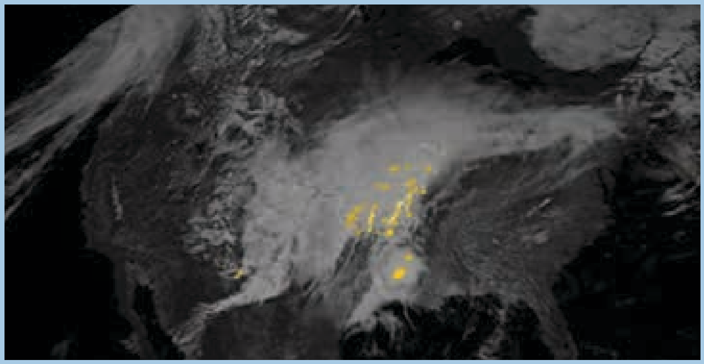
At NASA Ames Research Center, USRA operates Ames Airborne Sensor Facility (ASF) to support the airborne science research activities of the NASA Earth Science Division with sensor development, data collection and instrument engineering services. It operates a suite of facility remote sensing instruments that are used for earth science process studies, satellite calibration and validation and algorithm development.

Data acquired by the ASF are used by a variety of scientific programs to monitor variation in environmental conditions, assess global change and respond to natural disasters. Recent and ongoing activities include validation of the Hyperspectral Infrared Imager concept, which is a proposed satellite mission that will study the world's ecosystems and provide critical information on natural disasters such as volcanoes, wildfires and drought. The mission will provide a benchmark on the state of the world's ecosystems against which future changes can be assessed. In order to validate the concept, a multi-year airborne data collection campaign is underway using the JPL AVIRIS and Ames MASTER instruments to provide precursor data sets over carefully selected test sites. USRA's NAMS/ASF contribution is the operation of the MASTER instrument, which provides multi-spectral thermal infrared imagery for the study.

Edge of an ice shelf in Adelaide island, off the Antarctic Peninsula. Image courtesy: NASA/ Maria-Jose Vinas



Early Warning of Severe Weather



Lightning observed by GLM (yellow dots), overlaid on the GOES visible image, for 29 April 2017. Image courtesy: NASA, NOAA, Lockheed Martin

USRA researchers, Doug Mach, Monte Bateman and Bill McCaul contributed to algorithm development, calibration and validation of NASA's Geostationary Lightning Mapper (GLM), which was launched on GOES-16 in November 2016. One of the major features of GLM is that it is able to detect lightning against the bright background of clouds. This new capability provided by GLM represents a quantum leap forward in our ability to detect lightning and to use that detection to forecast and warn people of severe weather events.

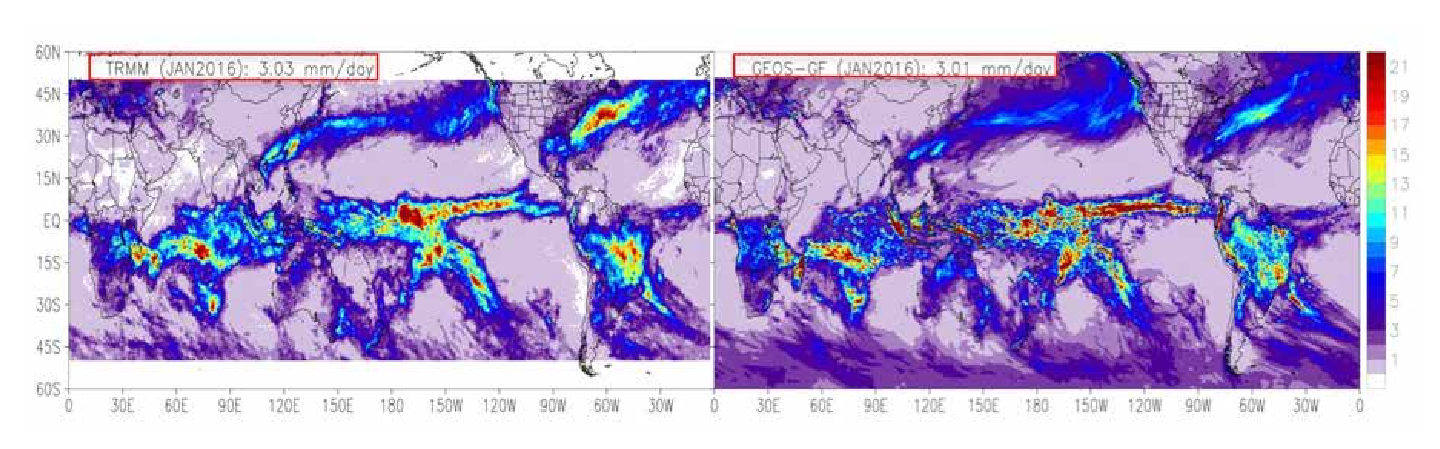
Operation IceBridge

Operation IceBridge imagery of a glacier on the edge of the Penny Ice Sheet, Baffin Island, Nunavit, Canada. Image courtesy: NASA

Operation IceBridge is an ongoing airborne mission to assess the state of the Arctic and Antarctic ice sheets. It includes annual missions to both polar areas, staging out of Greenland, Alaska, and southern Chile. USRA contributed to the operation of the Digital Mapping System cameras and precision altitude reference systems. The resulting data was then processed by the Alaska Satellite Facility (ASF) into Digital Ortho-Photos which are used to document the changing conditions of sea and land ice. In 2017, the ASF collected and processed 795,459 frames of calibrated DMS imagery with a total data volume of 17.09 Terabytes, all of which are archived at the National Snow and Ice Data Center in Boulder, Colorado.

Earth Science *continued*

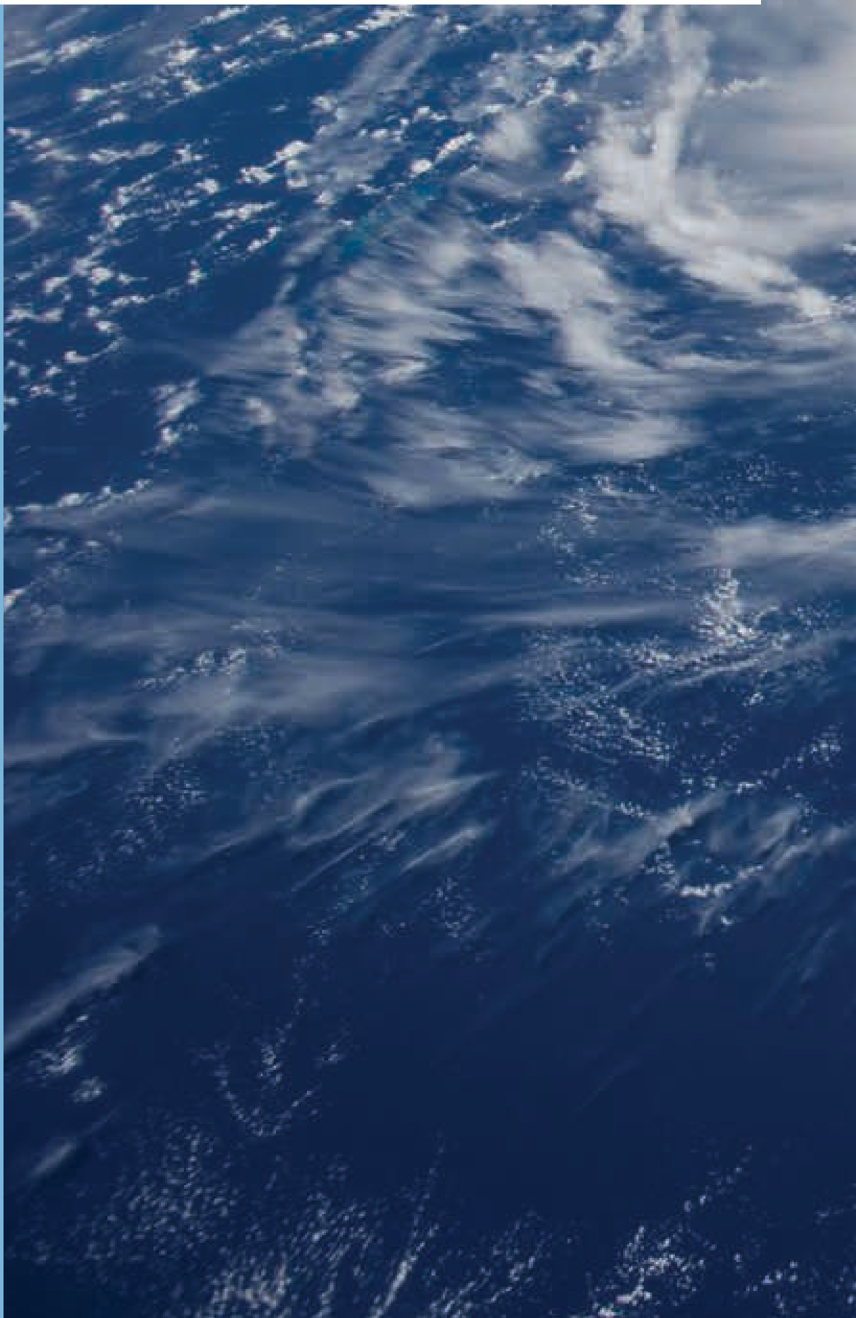
USRA scientist Saulo Freitas worked on a variation of convective parameterization in the NASA GEOS-5 model (right), and test results show that the data from the model is very accurate when compared to the standard Tropical Rainfall Measuring Mission (TRMM) (left). Image courtesy: NASA/USRA



Improved Model of Global Precipitation

Most people check the weather each day, and those forecasts come from informational models that simulate data from many systems and predict future results. To increase the reliability of models of statistical and global weather, USRA scientist Saulo Freitas has worked at NASA Goddard Research Center to develop, implement, and evaluate an alternative convection parameterization in the NASA Goddard Earth Observing System (GEOS-5) global model. Convection parameterization (CP) is a sub-model component of an atmospheric model, and aims to represent the role of convective clouds on the evolution of the weather.

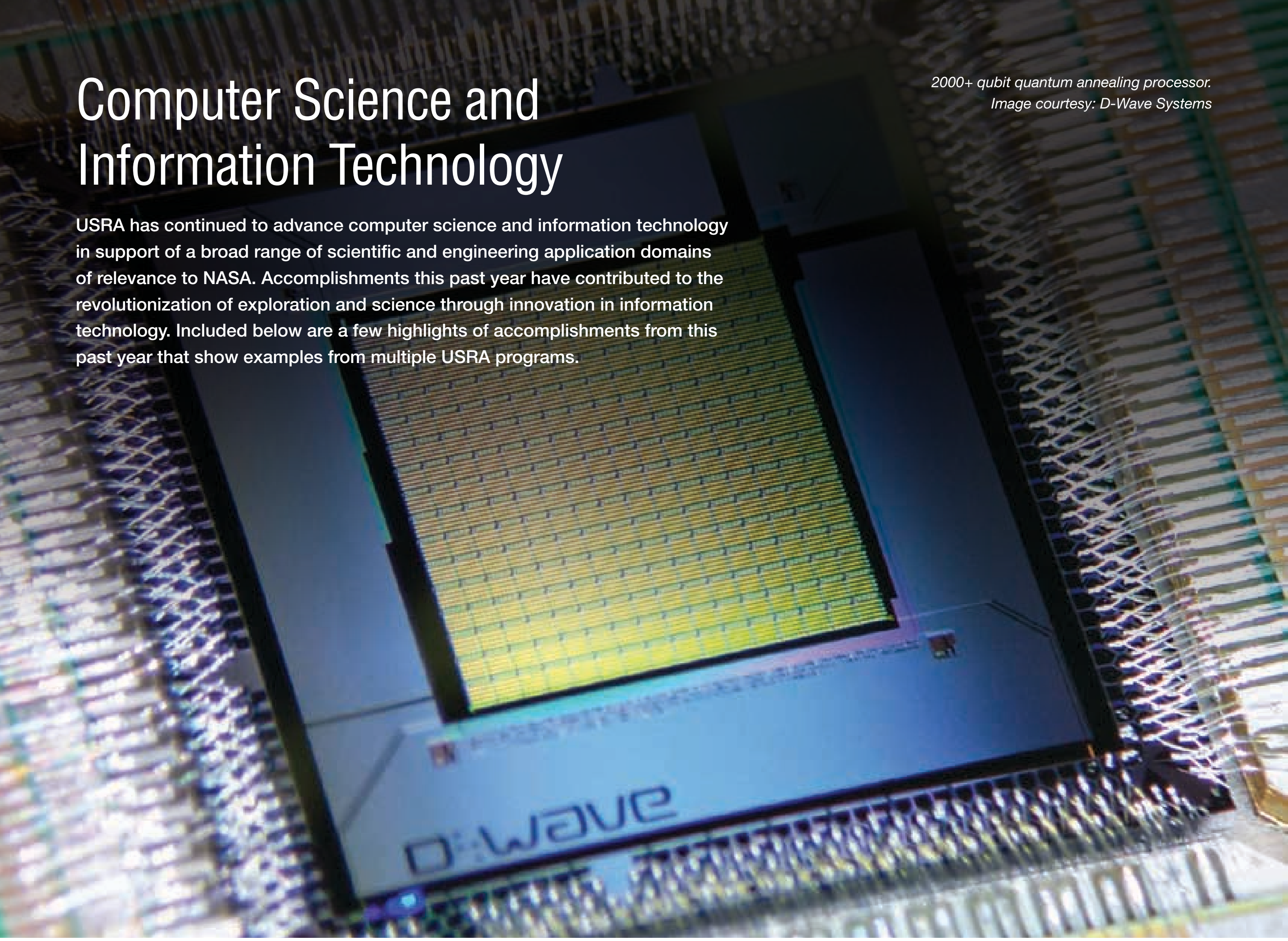
Most atmospheric models, even on a global scale, come close to the spatial resolution where convective clouds are being explicitly resolved. After being tested on several model configurations and spatial resolutions, the alternative convection parametrization provided a stable and reliable solution. Its reliability compared to other models makes it applicable on a large range of scales, from planetary waves down to cloud scale circulations. It can be used in studies of weather and air pollution forecasting, and seasonal climate prediction and atmospheric chemistry processes. Depending on the factors being studied, utilization of this CP scheme, alone or with others, could provide scientists with additional information to improve the accuracy of local and global forecasts.



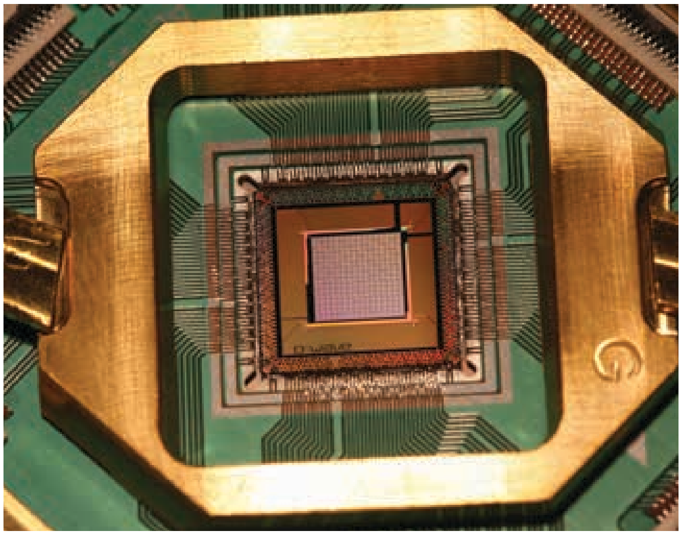
View of Hurricane Edouard taken during Expedition 41. Image courtesy: NASA

Computer Science and Information Technology

2000+ qubit quantum annealing processor. Image courtesy: D-Wave Systems



USRA has continued to advance computer science and information technology in support of a broad range of scientific and engineering application domains of relevance to NASA. Accomplishments this past year have contributed to the revolutionization of exploration and science through innovation in information technology. Included below are a few highlights of accomplishments from this past year that show examples from multiple USRA programs.



View of the D-Wave 2000Q chip processor. Image courtesy: D-Wave Systems

Quantum Computer Advances with Each Generation Processor

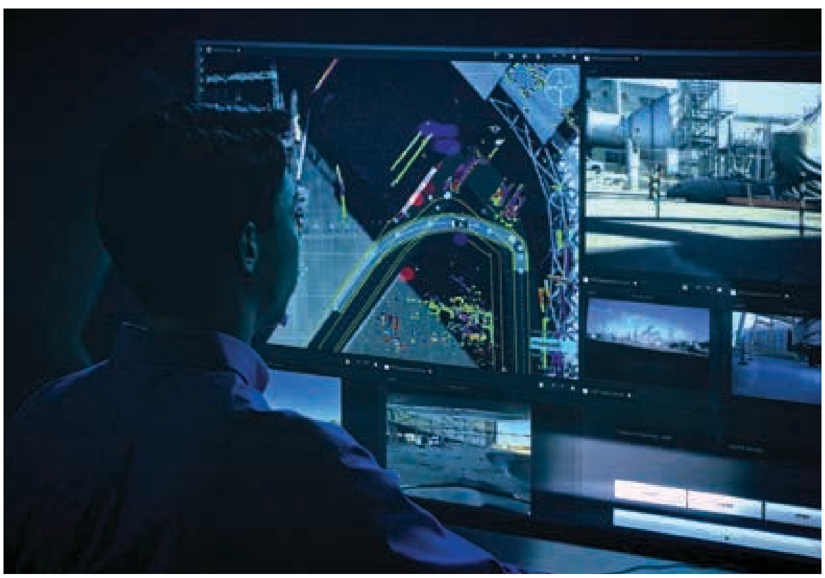
USRA operates a Quantum Artificial Intelligence Lab with NASA and Google, resulting in a number of research papers by USRA, NASA, Google and the university community. Use of the lab continues to grow with thirteen proposals received to date for the third Request for Proposal Cycle that was announced after the lab's quantum annealing computer upgrade to a D-Wave 2000 Q processor with 2048 qubits and other system enhancements. Improvements include reduction of the minimum annealing time from 5 to 1 microseconds, and ability to offset the annealing cycle with a global pause and quench cycle on a per-qubit basis. The 2000Q represents the third processor that will have been installed in the lab, which started with a 512-qubit processor in 2013 and was upgraded to an 1152-qubit processor in 2015.

Autonomous Systems

Research and development on autonomous systems greatly expanded this past year at USRA through the RIACS and NAMS programs, including achievement of a major milestone in our collaborative research agreement with Nissan Research Center – Silicon Valley.

Nissan Leaf driven autonomously at NASA's Ames Research Center. Image courtesy: NASA

USRA's continued collaboration with Nissan resulted in a live demonstration at the Consumer Electronics Show (CES). In January 2017, thousands of visitors to the Nissan CES exhibit watched live televised demonstrations of Nissan Leaf cars being driven autonomously at NASA Ames Research Center. A Nissan "mobility manager" at CES demonstrated capability for humans to remotely assist autonomous vehicles in unpredictable and difficult situations where the vehicle cannot solve the problem itself. The software that enables this remote assistance was developed with significant support from USRA/RIACS technical staff working onsite at Nissan, and was built on NASA's open-source VERVE software that was developed for human-robot teaming in space exploration. In the live demonstration, the mobility managers were able to remotely help the self-driving cars navigate around construction machinery and other difficult road obstacles. Current research is focused on enhanced support for use of Artificial Intelligence and Human-Autonomy teaming, as well as field operation trials for driverless vehicles in the U.S. and other countries related to operating fleets of autonomous taxis and shuttle buses.



To accelerate the time it will take for autonomous vehicles to get on the road safely, at CES 2017 Carlos Ghosn announced a breakthrough technology called "Seamless Autonomous Mobility," or SAM. Developed from NASA technology, SAM partners in-vehicle artificial intelligence (AI) with human support to help autonomous vehicles make decisions in unpredictable situations and build the knowledge of in-vehicle AI. This technology could potentially enable millions of driverless cars to co-exist with human drivers in an accelerated timeline. It is part of Nissan Intelligent Integration. Image courtesy: Nissan

Bioinformatics

Planned exploration missions will take human beings to distances further from Earth and for longer durations than any previous mission, during which, returning to Earth or communicating with Earth may not be an available option for crew members. In some deep-space situations, the exploration crew may have to manage their medical care without assistance from group support. To enable crew autonomy when far from Earth, the seamless management of medical data provided by a self-contained medical system will be necessary to support these missions.

This paradigm for medical care is a shift from current care provided on the International Space Station (ISS), where astronauts may be returned home in an emergency, or may readily contact ground control if a situation arises. In addition, ISS medical data management includes a combination of data collection and distribution methods that are minimally integrated with on-board medical devices and systems. For deep-space missions, having an integrated solution for data collection, storage and distribution will alleviate the crew from time-consuming tasks associated with data management, and will prevent errors in storing medical data that may occur when entered manually.

An interdisciplinary team at NASA Ames Research, which included Dr. Michael Krihak of USRA, initiated the development of a medical system that was designed to ingest data from various data sources. The integrated system also included the beginnings of a data architecture that will ultimately support more sophisticated capabilities such as data analytics, image analysis and decision support. Capabilities of the system were further expanded to send Astroskin biometric data via telemetry to a Core Flight Software system. Simultaneously, the medical system, using Consultative Committee for Space Data Systems protocol, also received and stored vehicle environmental data from an Environmental Control and Life Support System simulator. As part of the Next Space Technologies for Exploration Partnerships ground test, this capability was demonstrated in a live integrated test at the NASA Johnson Space Center Integrated Power, Avionics and Software facility.

Aeronautics Research

USRA leads a wide range of cutting edge research and technology development in aeronautics on the Advanced Research and Technology Support (ARTS) contract at NASA Glenn Research Center in Cleveland, Ohio, and on the NASA Academic Mission Services (NAMS) contract at NASA Ames Research Center in Mountain View, California.

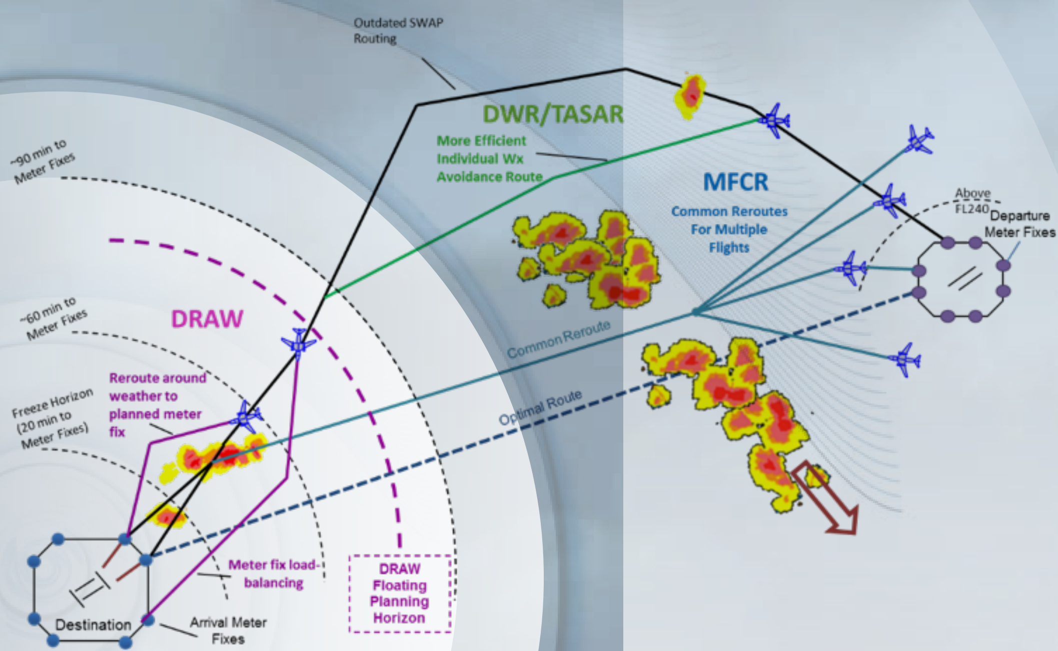
Brownout flight testing for the Army DVE-M Program at Yuma Proving Ground, Arizona, assesses how integrated cueing, sensor technologies and advanced flight control can be applied to improve helicopter operations in a visually degraded situation. Image courtesy: U.S. Army

Whiteout flight testing at Älggialp from Militärflugplatz Alpnach, Switzerland. Image courtesy: U.S. Army

Helping Pilots "See" Through the Storm

Helicopters often provide crucial access to tough, remote locations, and pilots currently take-off and land safely using visual cues of the terrain around them. Such procedures are challenged when the terrain is obscured by a storm, or sand and dust kicked up by the helicopter rotor.

USRA engineers are helping design and test new human-machine interfaces for both helicopters and unmanned aerial system ground stations to provide greatly improved performance and safety in these degraded visual environments. Recent test flights of an integrated cueing environment providing landing guidance symbology and an associated audio cueing system showed significant improvement in landing performance accuracy and safety through greater crew situational awareness. The tests were conducted on the JUH-60A RASCAL and EH-60L Black Hawk research helicopters in support of the Army Degraded Visual Environment Mitigation (DVE-M) Program as part of USRA's NASA Academic Mission Services contract with NASA providing support to the U.S. Army Aviation Development Directorate at Moffett Field, California.



Complex air traffic environment integrating weather reroutes. Image courtesy: NASA

Decreasing the Impact of Bad Weather on the Travelling Public

A frequent issue for on-time arrivals in airline travel occurs due to a long reroutes around storm systems. Such issues can result in significant numbers of travelers missing a connecting flight and arriving late at their final destinations. Currently air traffic controllers rely on pre-planned large route deviations to ensure safe flight around bad weather, but these often add significantly more delay.

USRA scientists and engineers have helped develop and demonstrate optimization decision support tools (DST) for En Route air traffic controllers that automatically generate improved routing around bad weather. Such DST provide significantly shorter routes with corresponding savings in time and fuel. This system was developed under the Airspace Technology Demonstration 3 project on USRA's NAMS contract at NASA Ames Research Center. A variation of this system has been successfully used by American Airlines, where it presented potential savings of over 1000 minutes nationwide in weather-induced re-routes over one month.

This system will help the FAA and industry to improve the air travel experience and reduce the environmental impact of aviation.

Microgravity Sciences

NASA Glenn Research Center (GRC) manages an internationally recognized program of scientific research in the microgravity environment in the areas of Combustion, Fluid Physics, and Complex Fluids. These three areas of research are integral to the future of the exploration and commercialization of space.

NASA astronaut Kjell Lindgren replaces items inside the Multi-user Droplet Combustion Apparatus found inside the station's Combustion Integrated Rack (CIR). The CIR houses hardware capable of performing combustion experiments to further research of combustion in microgravity. Image courtesy: NASA

The USRA members of the Microgravity Research Team with USRA President and Chief Executive Officer Jeff Isaacson at the NASA GRC drop tower. Image courtesy: USRA

USRA Continues to Make Key Contributions to Microgravity Research at NASA Glenn Research Center

USRA along with its subcontractor Case Western Reserve University (CWRU), continues to make key contributions to microgravity research at NASA GRC, on the Advanced Research and Development Support (ARTS) contract. The USRA/CWRU Microgravity Research Team on ARTS had another outstanding year in FY2017, achieving mission success on numerous flight experiments on the International Space Station (ISS) while also supporting ground-based R&D that is the precursor of future ISS flight experiments. The following are a few highlights of the many scientific and technical accomplishments made by the team.

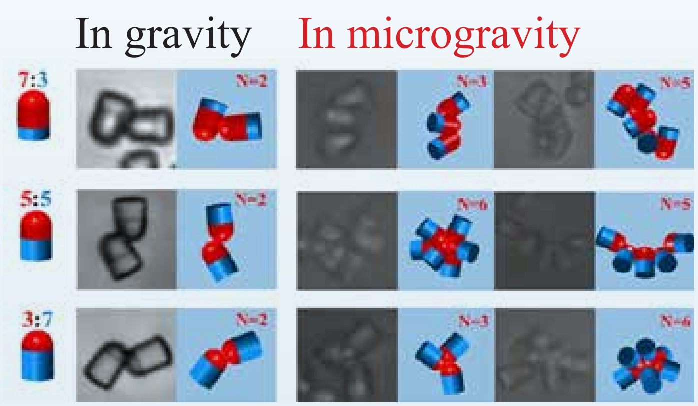
Cool Flames in Space

In September 2017, the Multi-User Droplet Combustion Apparatus (MDCA) culminated 8 1/2 years of operations in the Combustion Integrated Rack (CIR) onboard the ISS with the completion of the final in-space operations of the Flame Extinguishment Experiment (FLEX) series of investigations. FLEX was a program of five separate experiment campaigns in droplet combustion that accomplished nearly 1,500 successful test points for investigators from five countries and three space agencies. USRA and Case Western Reserve University have been integral members of the FLEX investigations, with our employees serving in a range of critical science roles for the family of experiments.

FLEX led to a 2012 ISS Research Discovery of the Year with the detection of a new "cool flame" mode of non-premixed combustion observed during the second stage burning of an alkane droplet. This discovery paved the way for the Cool Flames Investigation experiment and has significantly improved models of low-temperature chemical kinetics. The data from FLEX experiments will lead to better fuel efficiency and improved fire safety for applications on Earth and in space.

Fluid Physics and Complex Fluids

The Advanced Colloids Experiment with Temperature Control (ACE-T1) using the Fluids and Combustion Facility (FCF) on-board the International Space Station was a success. During ISS Increments 49-51, the ACE-T1 experiment investigated the particle behavior of 3 x 5-micron anisotropic colloidal Janus particles, as well as their self-assembly, in microgravity. Microgravity provides a promising environment for acquiring a novel scientific understanding of these behaviors, something that is not observable on Earth where they are inhibited by gravitational sedimentation.



The ACE-T1 investigation showed the structural differences of self-assembled clusters formed by using anisotropic (convex-top) Janus particles in gravity and in microgravity. Limited 2D small dimers (N=2) are formed in gravity while various 3D clusters (spherical and linear forms) are formed in microgravity. Image courtesy: NASA

On Earth, it is hard to observe a structural difference of the assembled clusters expected from controlling the ratios of the hydrophobic and hydrophilic parts of the Janus particles. Only small-size dimers (N=2) are formed by each of the three types of the Janus particles, and no significant grown structures exist.

In contrast, microgravity allows the formation of various 3D clusters, and their structural differences are observed depending on the ratio of the hydrophobic and hydrophilic parts. The 3:7 convex-top Janus particles dominantly self-assemble into spherical morphology and the 5:5 convex-top Janus particles self-assemble into both 3D spherical and 3D linearly grown clusters. In the case of 7:3 Janus particles, formation of 3D linearly grown clusters are observed (see figure above).

USRA's Dr. William Meyer – the ACE Project Scientist - worked with Professor Chang-Soo Lee, the Principal Investigator, and his student research team from Chungnam National University in South Korea.

The ACE-T1 investigation seeks to answer fundamental questions about behaviors of colloids, helping scientists to understand how to control, change, and even reverse interactions between tiny particles. This knowledge is crucial for developing self-assembling, self-moving, and self-replicating technologies for use on Earth. This novel fabrication approach may be applied to produce novel functional material in various applications such as self-assembly, photonics, diagnostics, and drug delivery.

Saffire-3 flame spread from bottom to top is shown in this composite series of time lapsed photos. The fuel is a cotton/fiberglass fabric measuring 40 cm wide by 94 cm long and the airflow direction is up. As the flame spreads it leaves some fuel behind which continues to smolder, evident as small orange dots. Data from Saffire-1, -2, and -3 are being used to verify theories on flame spread in microgravity. Image courtesy: NASA

Combustion Science

Two highly successful experiments in the Spacecraft Fire Experiment (Saffire) family of investigations occurred in FY2017. The Saffire investigations were performed on the Cygnus Resupply Vehicle after it undocked from the ISS but prior to its destructive re-entry into the Earth's atmosphere.

Saffire conducts the largest scale fire experiments ever performed in space, returning critical data on material flammability and flame spreading in a spacecraft environment. Both experiments achieved 100% mission success, with more than 100,000 images collected. Dr. Paul Ferkul (USRA) and John Easton (CWRU) are members of the Saffire science team.

Space Technology

USRA leads a wide range of cutting edge research and technology development in space-based technology on the Advanced Research and Technology Support (ARTS) contract at NASA Glenn Research Center in Cleveland, Ohio, and on the NASA Academic Mission Services (NAMS) contract at NASA Ames Research Center in Mountain View, California.

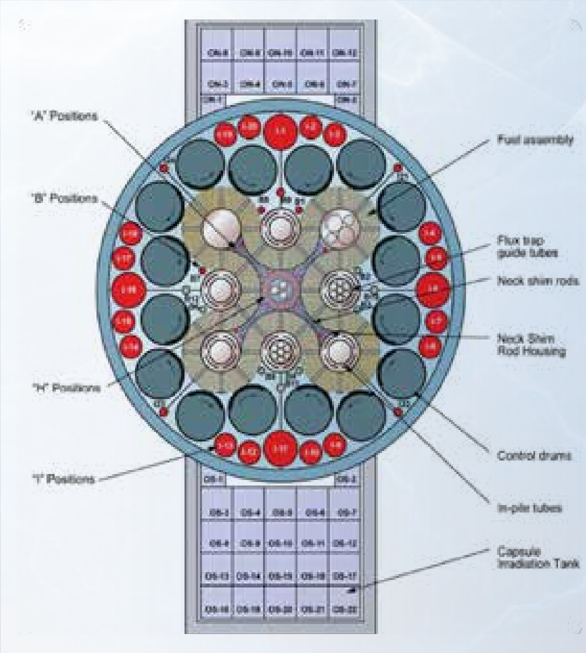
At Space Launch Complex-41 on Cape Canaveral Air Force Station, spacecraft technicians in the Vertical Integration Facility prepare to install the multi-mission radioisotope thermoelectric generator (MMRTG) for NASA's Mars Science Laboratory mission on the Curiosity rover. The MMRTG is enclosed in a protective mesh container, known as the "gorilla cage," which protects it during transport and allows any excess heat generated to dissipate into the air. Image courtesy: NASA

Electricity and Heat for Planetary Exploration

A Radioisotope Thermoelectric Generator (RTG) uses the heat of long-lived isotopes to produce 100 to 300 W of electricity and heat to keep electronic circuits and mechanical joints functional.

RTGs are an enabling technology for many planetary missions, including the New Horizons mission to Pluto, the Curiosity Rover on Mars and to the Cassini Mission to Saturn, which completed its 20-year mission in 2017. Earlier RTGs continue to power the Voyager 1 and 2 more than 40 years after launch.

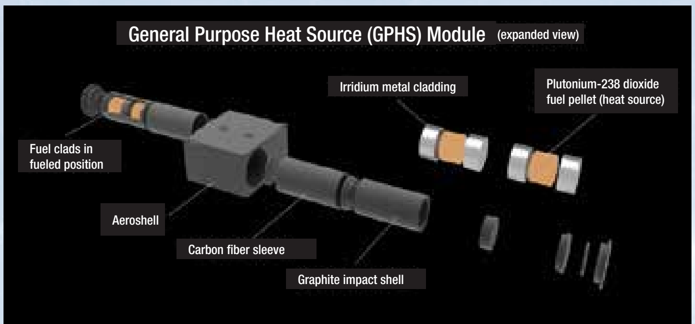
USRA hosted three teams of students from ten U.S. universities, led by USRA's Steve Herring and mentored by Jorge Navarro, Brian Gross, Eric Clarke and Ken Wahlquist (from Idaho National Laboratory-INL) who worked on three projects during the 2017 USRA/CSNR Summer Program in Idaho.



Advanced Test Reactor, showing the "I-Positions" in red. Image courtesy: US DOE, INL 07-GA50705-06

Pellet of $^{238}PuO_2$, glowing due to decay. Image courtesy: NASA

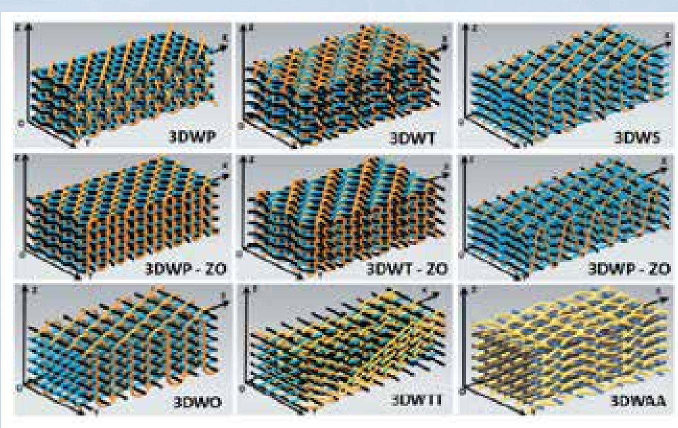
The first team explored the irradiation of Np-237 in the Advanced Test Reactor at the INL since older reactors that produced Pu-238 for earlier missions are no longer operating. Using neutron transport codes, the team found that the use of twenty seldom-used "I-Positions" around the periphery produced high-purity Pu-238 because of the low-energy neutron flux in those locations. Because of the number and size of the I-Positions, the ATR could be a significant source of future Pu-238.



General Purpose Heat Source (GPHS), showing its internal components. The CSNR team focused on substitute materials for the aeroshell and the graphite impact shell. Image courtesy: NASA

The second team developed software to model the fueling and testing of the General Purpose Heat Source (GPHS) module at the Idaho National Lab to account for combinations of events such as simultaneous work on two or three units, for late deliveries of components and for breakdowns in test facilities.

The third team explored substitutes for the currently used Fine Weave Pierced Fabric (FWPF), which is a critical material used by NASA in their MMRTGs. FWPF is a carbon-carbon composite, which is very labor-intensive and expensive. The team presented a table of 10 currently available substitutes for FWPF.



Nine distinct weave patterns were analyzed for a new material to replace FWPF. Image courtesy: K. Bilisik, N.S. Karaduman, N.E. Bilisik & H.E. Bilisik

Cryogenic Fluid Management in Space

Integral to all phases of NASA's projected space and planetary expeditions is affordable and reliable cryogenic fluid storage for use in propellant or life support systems. Cryogen vaporization due to heat leaks into the tank from its surroundings and support structure can cause self-pressurization that can be relieved through venting. During long-duration on-orbit or on-surface storage, however, repeated venting of the vapor will result in significant propellant loss rendering the cost of long distance human space expeditions prohibitive. This has led to a significant impetus for developing innovative pressure control designs based on mixing of the bulk tank fluid together with some form of active or passive cooling to allow storage of the cryogenic fluid with zero or reduced boil-off.

The Zero-Boil-Off Tank (ZBOT) Experiments being performed and led by PI Dr. Mohammed Kassemi of CWRU, on the ARTS contract at NASA GRC are a series of small scale tank pressurization and pressure control experiments aboard the ISS.

Located in the Microgravity Science Glovebox, ZBOT uses a transparent volatile simulant fluid in a transparent sealed tank to delineate various fluid flow, heat and mass transport, and phase change phenomena that control storage tank pressurization and pressure control in microgravity. The hardware for ZBOT-1, the first of three hierarchical flight experiments, flew to the ISS in April 2017.

Experiments began in September 2017. The ZBOT-1 experiment consists of approximately 90 tests, which are being conducted over a 3- to 6-month period. These investigations are quantifying fluid flow and thermal stratification during self-pressurization and mixing, thermal destratification, depressurization, and jet ullage penetration during the pressure control intervals. The digital imaging and machine readable textual/numerical data from the experiments are being continuously downloaded. The raw experimental data and a set of reduced data analyzed and processed by the ZBOT science team together, with the CFD simulations results, are being stored on the ISS Physical Sciences Open System Repository Server operated and maintained by NASA. Approximately one year after the end of ZBOT's on-orbit operations, this data will be released for use to the scientific and engineering communities at large.

Science Facility Management and Operations

USRA is recognized for its expertise in managing ground, airborne, and spaceborne research through the operation of laboratories, observatories and other facilities.

At Arecibo Observatory, USRA manages the astronomy, planetary science, electronics and Information Technology activities. The Observatory is a national research center operated by SRI International, USRA and UMET, under a cooperative agreement with the National Science Foundation (NSF). Above: Arecibo Observatory. Image Courtesy: New Scientist/Louie Psihoyos/Corbis

The USRA Management Approach

USRA often draws upon the technical competencies of its member universities and programs to leverage existing external and internal technical resources to operate facilities. This specialization in coordinating multiple institutional teams allows USRA to serve government sponsors by coordinating the work of industrial partners and contributions of research universities. USRA's disciplined approach to contract, project and facility management employs industry-standard practices and tools that include business systems using accepted government contracting software.

The Stratospheric Airborne Observatory for Infrared Astronomy (SOFIA) at its airfield in New Zealand. Image courtesy: NASA

NASA Postdoctoral Program researcher James O'Donoughue makes observations from the JUNO mission at the USRA Remote Observing Center connected to the Keck Observatory in Hawaii. Image courtesy: USRA

Science Facility Management

USRA participates in the management of various facilities, including the Stratospheric Observatory for Infrared Astronomy (SOFIA) at NASA's Ames Research Center in California, Arecibo Observatory in Puerto Rico, the Quantum Artificial Intelligence Laboratory at Ames, and the Ames Airborne Sensor Facility (ASF) in support of airborne science research for the NASA Earth Science Division. USRA also manages the Remote Observing Center in Columbia, Maryland, currently supporting the Keck telescope in Hawaii.

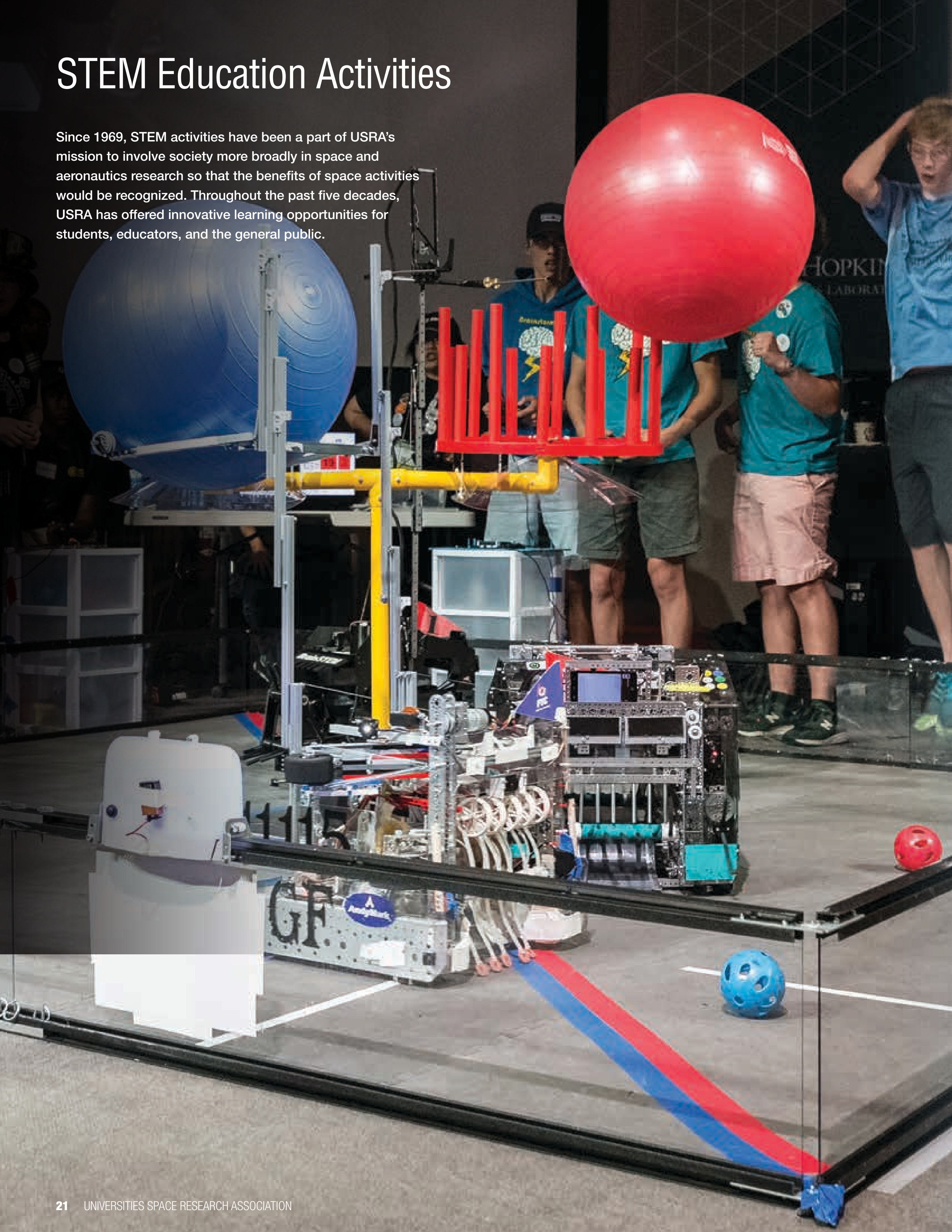
SOFIA is a heavily modified Boeing 747 jetliner that carries a 100-inch (2.5-meter) telescope to altitudes between 39,000 to 45,000 feet (12-14km) above more than 99% of Earth's atmospheric water vapor. This gives astronomers the ability to study celestial objects at infrared wavelengths that cannot be seen from ground–based observatories.

USRA also operates the Quantum Artificial Intelligence laboratory by collaborating with Google and NASA's Ames Research Center. The lab hosts a D-Wave Quantum Computing System which was upgraded to a D-Wave 2000Q system. The computer offers the promise for solving challenging problems in a variety of applications including machine learning, scheduling, diagnostics, medicine and biology among others. The newly upgraded system, which resides at the NASA Advanced Supercomputing Facility at NASA's Ames Research Center, has 2031 quantum bits (qubits) in its working graph—nearly double the number of qubits compared to the previous processor.

USRA Headquarters also operates the Remote Observing Center, which provides two observation rooms for users to connect with remote telescopes such as the Keck telescope in Hawaii.

STEM Education Activities

Since 1969, STEM activities have been a part of USRA's mission to involve society more broadly in space and aeronautics research so that the benefits of space activities would be recognized. Throughout the past five decades, USRA has offered innovative learning opportunities for students, educators, and the general public.



STEM

The USRA STEM Education Center, established through the integration of STEMaction, a Maryland based non-profit, and Universities Space Research Association (USRA), is committed to continuing STEMaction's legacy.

The USRA STEMaction Center is now the Maryland Affiliate Partner for the FIRST LEGO League Junior program, in which kindergarten through third-grade students engage in a science project of discovery. It is also an affiliate partner of the FIRST Tech Challenge, an annual competitive robotics program, in which middle- and high-school student teams compete with and against one another.

The Center enjoys active use by FIRST teams. More than 550 students from 100 teams utilized the facility during the 2017 competition season. Due in part to the use of the facility and the students' hard work, three of the teams that used the USRA STEMaction Center were recognized as Division Champions at the FIRST World Championship event for their respective programs.

The USRA STEMaction Center also hosted the first annual Maryland Tech Invitational, the premiere off-season competition for the FIRST Tech Challenge program, at Johns Hopkins Applied Physics Lab (APL). Twenty-six teams from nine states competed for grant awards provided by local sponsors. Former NASA Administrator Major General Charles Frank Bolden, Jr. (USMC-Ret.), and APL Director Dr. Ralph Semmel were keynote speakers during the Opening Ceremonies. Students, coaches, and volunteers were also invited to a presentation on the Parker Solar Probe being developed at Johns Hopkins APL before the competition.

The Center hosted an ACT test preparation program for underserved students from the Howard County Public School System. Eleven high school juniors participated in a 15-week Saturday program held at USRA headquarters. The prep program resulted in most students scoring higher on the second round of ACT testing. USRA participants scored, on average, four points more than Maryland averages. The ACT program was deemed a success based on the overall outcome.

Additionally, USRA is serving as the Presenting Institution for the Maryland STEM Festival for 2017. This year's Festival has more than four hundred events taking place in every county of Maryland over a two-week period. The Maryland STEM Festival is celebrating the use of STEM in agriculture over the course of the 2017 festival.

USRA STEMaction Center programs would not be possible without the support of sponsoring organizations such as the University of Maryland School of Agriculture, Rockwell Collins, the Howard County Community Foundation, Tenable, Best Buy, and many others that helped to make this year a success.

Internships, Fellowships and Scholarship Awards

As an association of universities, USRA recognizes a fundamental responsibility to facilitate the education and career development of children and young adults. With its focus on the science and technology of space, USRA is uniquely situated to utilize the pervasive fascination with space exploration to engage young people and attract them into careers in the science and technology fields, advancing the Nation's technical prowess. This engagement includes programs that span from elementary and middle school to high school to university and beyond, and are supported by NASA, NSF, DOD and USRA's own corporate resources. A cornerstone of USRA's commitment to developing the STEM workforce of the future resides in support of intern programs, which supported hands-on experiences for over 1700 students from high school to graduate school in FY2017. In addition, the USRA Scholarship Award Program supports undergraduates who will be future leaders in the fields of space science and aerospace engineering.

2017 SCHOLARSHIP AWARDS

The USRA Scholarship Awards were established to honor the service and memory of individuals who made significant contributions to their fields and to USRA.

Frederick A. Tarantino Memorial Scholarship Award

Honors Tarantino's contributions to USRA and his commitment to education

John R. Sevier Memorial Scholarship Award

Honors Sevier's contributions to aerospace technology.

Thomas A. McGetchin Memorial Scholarship Award

Honors McGetchin's contributions to planetary science.

James B. Willett Education Memorial Scholarship Award

Honors Willett's contributions to astronomy and astrophysics.

2017 Scholarship Award Winners

USRA is pleased to recognize and support the careers of these winners of the 2017 USRA Scholarship Awards. These students have made contributions to their fields of study and have given back to their communities through outreach and education efforts.

- Joseph Breeden, University of Maryland
- Shannon Gatta, University of Washington
- Emily Jewell, University of Wisconsin – Madison
- Kristine Khieu, University of California San Diego
- Joanna Rivero, University of Pittsburgh
- Tyler Valentine, University of Washington

Emily Jewell (Univ. Wisconsin – Madison) receives a USRA Scholarship Award. She is pictured here with her advisors from the Department of Aerospace Engineering, Prof. Matt Allen (far left) and Prof. Robert Witt (far right), and with the USRA Council of Institutions Representative, Prof. Steve Ackerman.

Joseph Breeden at University of Maryland is also a scholarship recipient. In this photo (from left to right), Prof. Mary Bowden, Visiting Assistant Professor, Department of Aerospace Engineering, Joseph Breeden, Prof. Norman Wereley, Chair of Department of Aerospace Engineering.

NASA Internships Rising to Meet the Nation's STEM Needs

Vital to achieving NASA's objective to "Inspire, Educate, Engage, and Employ", the NASA Internship program seeks to increase the capabilities, diversity, and size of the science, technology, engineering, and mathematics (STEM) workforce through participatory, immersive educational experiences.

NASA Internships allow students to apply knowledge acquired in the classroom to advanced scientific research, under the guidance of a NASA mentor. Interns not only gain technical skills, but also the soft skills necessary to secure post-graduation employment in the high-tech workforce. To ensure students receive a well-rounded internship, USRA Coordinators provide on-site experiences, networking events, and professional development opportunities. Through these unique internships, a new generation of scientists, engineers, technologists, physicians, and astronauts are cultivated and retained to advance NASA's future endeavors.
In FY2017, 1,395 students participated in the NASA Internship program. Since program inception in 2013, USRA has managed 4,632 interns, representing 716 high schools, colleges, and universities.

Interns at NASA's Armstrong Flight Research Center were participants in the summer 2017 #InternEclipse photo challenge. Here, they don solar eclipse glasses and pose with the PRANDT-L glider, a cutting edge project to which a student contributed. Image courtesy: NASA

Internships, Fellowships and Scholarship Awards *continued*

Internships in Other USRA Programs and Institutes

The Lunar and Planetary Institute's (LPI) Summer Intern Program in Planetary Science hosted four male and 10 female undergraduate students from the United States, United Kingdom, Australia, and Ukraine. During the 11-week program, each intern worked one-on-one with a scientific advisor, either at the LPI or at NASA Johnson Space Center. In addition to their individual projects, the interns participated in special activities including visits to NASA facilities.

The NASA Academic Mission Services (NAMS) Student R&D Program supported 22 students in FY2017 (six undergraduate students and 16 graduate students) from U.S. and international universities. Student internships spanned a diversity of research topics including research on small satellites, quantum computing, synthetic biology, machine learning, intelligent robotics, and air traffic management.

NASA Postdoctoral Program

USRA operates the NASA Postdoctoral Program (NPP) that offers U.S. and international scientists the opportunity to advance their research while contributing to NASA's scientific goals. The NPP supports fundamental science, explores the undiscovered, promotes intellectual growth, and encourages scientific connections. For the three application cycles during FY2017, more than 4,000 students demonstrated interest in the program, and USRA received 591 applications. Of those who completed their applications, approximately 13.5% were selected for the NPP (a total applicant pool acceptance rate of around 2%). These numbers indicate a high level of awareness of the NPP, and also reflect the competitiveness of the program. USRA strives to ensure a high quality of submitted applications, application reviews, and delivery of the highest caliber of applicants to NASA for selection into the Program.

Other Representative Career Development Activities at USRA

The Arecibo Observatory Space Academy (AOSA) is a semester-long, pre-college program for high school students in Puerto Rico with ten on-site contact days. The program promotes STEM education and research among Puerto Rican students by way of hands-on investigations in the broad field of space science conducted at the observatory. The mission of AOSA is to prepare students for careers in STEM related fields via a student-centric, immersive research experience. The AOSA Spring 2017 semester ran from February to May with 33 students selected from a total of 87 applicants.

Two NASA Academic Mission Services (NAMS) STEM Video Production Boot Camps were conducted in the summer of 2017, one with the Boy Scouts of America (Silicon Valley Monterey Bay Council) and one with the Girl Scouts of Northern California. Each STEM Camp was two weeks long, and provided an opportunity for Scouts to learn about science and engineering activities taking place on the NAMS contract at NASA's Ames Research Center as well as learn various video production techniques.

AFRL-Eglin scholars attend a program-coordinated tour at the Joint Strike Fighter facility, exposing them to unique Air Force technology and the F-35 Lightning II airframe. Image courtesy: USRA

AFRL-Eglin scholars tour Explosive Ordnance Disposal facilities. Image courtesy: USRA.

USRA Reflects Air Force Core Value of Excellence in AFRL Scholars Program

USRA administers the Air Force Research Laboratory (AFRL) Scholars Program, acting as the key to unlocking the potential of our Nation's future by offering outstanding intern experiences and superior customer service.

Since program inception in 2013, more than 990 high school, undergraduate, and graduate students have participated in the AFRL Scholars Program. In FY2017, 267 students participated in technical research projects in advanced manufacturing, biologically-inspired flight and navigation systems, aero-optics, microwave interactions, lasers, space applications, and other cutting-edge research opportunities.

USRA's on-site program coordinators deliver a uniquely tailored experience to Scholars by organizing informal and professional networking events, such as "social scholar" groups and Career Forums with industry-leading employers; educational seminars from AFRL mentors and prominent speakers; and opportunities to develop and sharpen presentation skills.

University Engagement

USRA institutes and programs engage the university community in a variety of ways: through research collaborations with scientists and engineers; maintaining the active involvement of member universities in our governance and oversight; and advocating in Washington on issues identified by our members as important to university space-related research.

Featured USRA Institute and Program Engagements

In FY2017, USRA institutes and programs engaged in 1,720 research activities across 488 universities and other research organizations. Among the most prominent:

NASA Academic Mission Services (NAMS) supports on-going research across directorates at Ames Research Center. NAMS provides collaborations as a unique key aspect of fostering long-term growth at ARC and to engage academia, other government agencies, research laboratories and/or commercial entities on R&D projects. These collaborations provide cutting edge research and development to advance technology in existing and new areas.

During NAMS' first year of operations USRA has put in motion numerous collaboration activities including Autonomous Systems, Small Satellites, Research Laboratory Capabilities, Quantum Computing, and Human-Machine Interfaces. These collaborations involve nine universities and nearly 20 students.

As part of the Advanced Research and Technology Support (ARTS) contract at NASA Glenn Research Center (GRC), USRA contributes significantly to NASA's Microgravity Research Program. This program is comprised of a robust portfolio of fundamental, applied, and translational research projects in the areas of combustion science, fluid physics, and complex fluids that address the current and future science and technology needs of NASA and the Nation. Flight experiments are performed on the ISS, while ground-based experiments utilize the 5.2-second drop tower at NASA GRC. In support of the Microgravity Research Program, USRA's science team on ARTS was actively engaged in FY2017 with more than 50 investigators from the 41 universities on a wide range of flight and ground-based experiments.

Participation of Member Universities in USRA Governance and Oversight

USRA holds an annual meeting of its member universities, comprising the Council of Institutions (COI), each spring in Washington D.C. The USRA President and Chief Executive Officer, as well as the Chair of the Board of Trustees, update the Council on USRA activities. The Council votes on new members to the Board and other matters of importance to the Association. In 2017, 85% of the members cast their votes. In addition, at its 2017 Annual Meeting, the Council welcomed Columbia University as the 106th member of USRA.

Public Policy Advocacy

USRA provides a voice on public policy issues important to the university community through the COI Issues and Program Committee (IPC). Comprised of members of the COI drawn from each Region, the IPC formulates public policy positions, meets with members of Congress and their staffs, provides testimony, as requested, and also organizes the program for the symposium, held in conjunction with the COI Annual Meeting.

The topic of the 2017 symposium was "Space Situational Awareness: How Can Evolving SSA Capabilities Contribute to Science, Commerce, and Security". The keynote speaker was Maj. Gen. Roger Teague, Director of Space Programs in the Department of Defense Office of the Assistant Secretary for Acquisition. The symposium was successful in bringing together scientists from academia, agencies, and the commercial sector. In attendance were key stakeholders, congressional staff, the press, and university representatives from the COI.

As a follow-up to USRA's successful efforts to obtain legislative reform of space-related export controls, enacted in 2013, and its work on the regulatory implementation, USRA invited Mr. David Brady, Director of the Office of Export and Secure Research Compliance at Virginia Tech, to address the COI at its 2017 Annual Meeting. He spoke on the results and benefit of the new regulations to universities in their research and education efforts.

Governance

A consortium of 106 doctoral-degree granting universities oversees USRA to ensure that it meets its public purpose as a nonprofit. A primary role of these universities is to elect the USRA Board of Trustees. This broadly-based membership ensures accountability and oversight of USRA as it serves its tax-exempt purpose and assures equal access to USRA facilities and programs by researchers and students from all institutions, both member and nonmember.

The Board has 15 members including nine regional trustees, one for each of nine regional groups of the member universities, and four at-large trustees. The Trustees appoint the President. The President and the Chair of the COI serve on the board, ex-officio. Each Trustee serves a three-year term, limited to re-election to a second term.

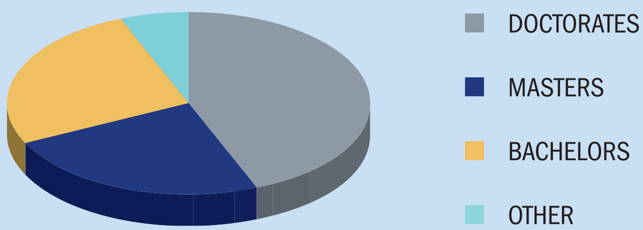
Board of Trustees

Member Universities

Alabama A&M University
The University of Alabama in Huntsville
University of Alaska - Fairbanks
The University of Arizona
Arizona State University
University of Arkansas
Auburn University
Baylor University
Boston College
Boston University
Brandeis University
The University of British Columbia
Brown University
University at Buffalo, SUNY
University of California - Berkeley
California Institute of Technology
University of California, Los Angeles
University of California, San Diego
University of California, Santa Barbara
Case Western Reserve University
University of Central Florida
University of Chicago
The College of William & Mary
The Chinese University of Hong Kong
University of Cologne
University of Colorado Boulder
Colorado School of Mines
Columbia University
University of Connecticut
Cornell University
University of Delaware
University of Denver
University of Florida - Gainesville
Florida State University
George Mason University
The George Washington University
Georgetown University
Georgia Institute of Technology
Hampton University
Harvard University
University of Hawaii
University of Houston
Howard University
University of Illinois at Urbana-Champaign
Indiana University
University of Iowa
Iowa State University
Johns Hopkins University
The University of Kansas
Lehigh University
University of Leicester
Louisiana State University
University of Maryland
Massachusetts Institute of Technology
University of Michigan
Michigan Technological University
University of Minnesota
Mississippi State University
University of Nebraska - Lincoln
University of New Hampshire
New Jersey Institute of Technology
The University of New Mexico
New Mexico State University
New York University
North Carolina A&T State University
North Carolina State University
Northwestern University
Ohio University
The Ohio State University
The University of Oklahoma
Oklahoma State University
Old Dominion University
The Pennsylvania State University
University of Pittsburgh
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Rice University
University of Rochester
Rochester Institute of Technology
The Rockefeller University
The University of Sheffield
University of Southern California
Stanford University
Stony Brook University, SUNY
University of Stuttgart
The University of Sydney
Technion - Israel Institute of Technology
Tel Aviv University
University of Tennessee, Knoxville
Texas A&M University
Texas Tech University
University of Texas at Arlington
University of Texas at Austin
University of Texas at Dallas
University of Texas Medical Branch at Galveston
University of Toronto
Tufts University
Utah State University
Vanderbilt University
University of Virginia
Virginia Polytechnic Institute & State University
Washington University in St. Louis
University of Washington
University of Wisconsin - Madison
Yale University

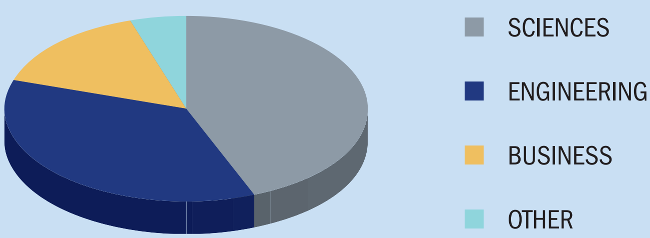
USRA's Workforce: Growing and Diversified

Employee Distribution by Degree



Approximately 40 percent of USRA's workforce hold Doctoral degrees, and another 23 percent hold Masters

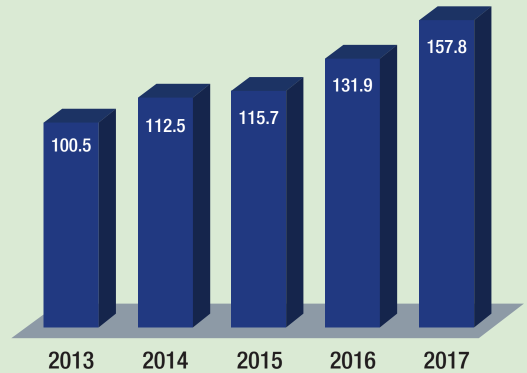
Employee Distribution by Areas of Study



Approximately 75 percent of USRA's workforce comprises physical scientists and engineers

Financial Highlights

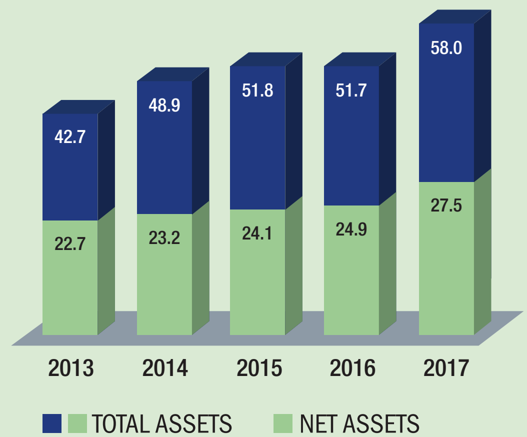
FY2013-2017 Revenue in Millions



For FY2017, USRA's annual revenue from contracts and grants totaled more than $157 million.

Roughly 20 percent of USRA's revenue is devoted to education programs including STEM workforce development that included more than 1600 internships, and the NASA Postdoctoral Programs.

FY2013-2017 Assets & Net Assets in Millions



USRA continues to maintain a healthy ratio of total assets versus liabilities. Net assets are defined as total assets minus liabilities.

A beautiful new image of two colliding galaxies has been released by NASA's Great Observatories. The Antennae galaxies, located about 62 million light years from Earth, are shown in this composite image from the Chandra X-ray Observatory (blue), the Hubble Space Telescope (gold and brown), and the Spitzer Space Telescope (red). The Antennae galaxies take their name from the long antenna-like arms seen in wide-angle views of the system. Image courtesy: NASA

SEND CORRESPONDENCE AND QUESTIONS TO:

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Columbia, MD 21046

Or email: sfarukhi@usra.edu

About USRA

Founded in 1969, under the auspices of the National Academy of Sciences at the request of the U.S. Government, the Universities Space Research Association (USRA) is a nonprofit corporation chartered to advance space-related science, technology and engineering. USRA operates scientific institutes and facilities, and conducts other major research and educational programs, under Federal funding. USRA engages the university community and employs in-house scientific leadership, innovative research and development, and project management expertise. More information about USRA is available at www.usra.edu.

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European Southern Observatory's fleet of telescopes in Chile detected the first visible counterpart to a gravitational wave source. These historic observations suggest that this unique object is the result of the merger of two neutron stars which was detected by several observatories in the U.S. including NASA's Fermi Gamma Ray Burst Monitor operated by USRA for NASA. Here is screen shot of the ESOcast 133 in which ESO Telescopes observe first light from the Gravitational Wave Source. Image courtesy: ESO/L. Calcada/M.Kornmesser