Universities Space Research Association

ANNUAL REPORT 2022

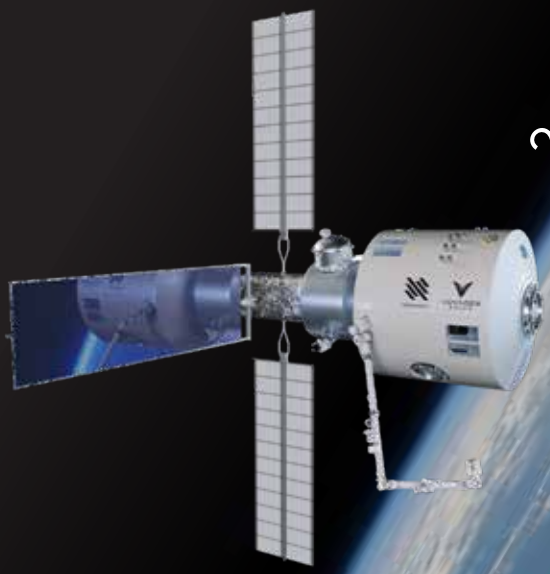

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Image from the Front Cover

Conceptual view of the Starlab Commercial Space Station. Image Courtesy: Nanoracks, Inc

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

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

Jeffrey A. Isaacson
President and
Chief Executive Officer

John A. Montgomery
Chair, Board of Trustees

Coming out of the pandemic in 2022, USRA made the strategic decision to relocate its corporate headquarters to Washington, D.C., where we reduced our footprint, cut costs, and leveraged the many lessons of remote work we've assimilated since 2020. The increased proximity to stakeholders is already reaping benefits for our nonprofit mission—to advance space- and aeronautics-related sciences and exploration; promote space and aeronautics policy; and operate premier facilities and programs involving universities, governments, and the private sector.

USRA achieved many noteworthy accomplishments in 2022, owing to the continued resilience, dedication, and innovation of our talented staff, whose expertise spans science, technology, and various mission-support specialties.

Among these many accomplishments:

- USRA welcomed the University of Zurich and Embry-Riddle Aeronautical University to membership, the 115th and 116th universities in our association, respectively.
- Across all programs, USRA executed research collaborations involving 263 different universities and 147 other research organizations.
- USRA staff published 281 peer-reviewed research products.
- Our programs managed or administered 2,694 internships, including 2,215 NASA Interns and 328 AFRL Scholars.
- USRA was a member of the winning Voyager/Nanoracks team on NASA's Commercial Low Earth Orbit (LEO) Destinations Program. USRA's scope is to design and operate the George Washington Carver Science Park, the laboratory module onboard the StarLab LEO spacecraft.
- The Stratospheric Observatory for Infrared Astronomy (SOFIA) ended its eight years of full-capability science flight operations on a high note, including 127 science flights from Palmdale, CA; Christchurch, New Zealand; and Santiago, Chile this year alone. To date, its scientific legacy includes 150 theses, 431 research publications, and more than 1,870 unique publication authors and coauthors.
- USRA's Lunar and Planetary Institute (LPI) was selected by the Japan Aerospace Exploration Agency (JAXA) to study samples returned by the Hayabusa2 Mission from asteroid Ryugu. In addition, four planetary science missions, each with an LPI co-investigator, were extended by NASA.
- Along with Japan's National Institute for Environmental Studies, USRA co-hosted a side event at the 2022 United Nations Climate Change Conference (COP27) focused on the use of Earth observations in support of climate-change mitigation.
- USRA's University Consortium Research Opportunity program delivered eight $350,000 awards to principal investigators at eight universities on behalf of the U.S. Space Force and the Air Force Research Laboratory.
- Our data scientists led work resulting in the addition of 301 newly validated exoplanets using a new deep neural network software product ("ExoMiner"). The results were published in *The Astrophysical Journal*.
- USRA added a fifth Distinguished Undergraduate Award—the Judith L. Pipher Memorial Scholarship Award—to honor the memory of Dr. Judith L. Pipher, who served USRA in various capacities including Vice Chair of the Board of Trustees.

In addition, USRA established the HBCU Science Council in 2022 to provide expert assistance in engaging and partnering with HBCUs in the furtherance of USRA's mission. The Council, chaired by Dr. Victor McCrary of the University of the District of Columbia, is also chartered to identify opportunities for institutional capacity building in space and aeronautics research.

These highlights, and those that follow, serve to summarize USRA's mission accomplishments in 2022. And while they can't tell the whole story of the institution, nor capture all the individual and team achievements undergirding our work, we do hope they reflect our collective passion for science, technology, and education, especially as it relates to space and aeronautics. This passion has driven our mission success since our founding in 1969.

Jeffrey A. Isaacson
President and Chief Executive Officer

John A. Montgomery
Chair, Board of Trustees

Aeronautics Research and Development

USRA's mission is to advance aeronautics technologies for the benefit of humanity.

Sustainable and Safe Airspace Operations

Engineers in USRA's NASA Academic Mission Services (NAMS) team collaborate with NASA's Ames Research Center, small business partners, universities, and other organizations to develop Next Generation Air Transportation System technologies. The purpose is to reduce air travel times and delays, to ensure greater safety in all weather conditions, and to reduce environmental impacts of aviation. This work supports goals of the U.S. Federal Aviation Administration (FAA).

During the past year, USRA's NAMS program supported NASA's Ames Research Center to develop a Digital Information Platform (DIP) and conduct sustainable aviation demonstrations with conventional airline flight operators, and to measure reductions in fuel use and emissions through improved air traffic decision making using a digital ecosystem including use of machine learning models.

This builds upon prior research with the Airspace Technology Demonstration 2 (ATD-2) project which resulted in the FAA Administrator announcing that the Integrated Arrival/Departure/Surface (IADS) technology developed as part of the NASA Airspace Technology Demonstration (ATD) project will be integrated with FAA systems and deployed for production use at 27 hub airports over the next decade. This followed the completion of the ATD project after nearly four years of demonstrated use at the Charlotte Douglas International Airport by American Airlines and the FAA, which demonstrated significant reductions in delays on taxiways and runways, use of aviation fuel, and aircraft emissions.

Reduced Emissions by 22.9M Pounds of CO_2 – The equivalent of 170 million urban trees

FUEL
Saved 1,088,888 gallons of fuel

TIME AND COST
Saving passengers approximately $4.3 million in time, and operators approximately $1.3 million in flight crew cost.

MAINTENANCE
Saved 5,948 of engine run time

ATD Benefits Measured at Charlotte Douglas International Airport (September 2017 – August 2021)

Wisk Aero electric Vertical Takeoff and Landing (eVTOL) aircraft. Image Courtesy: Wisk Aero

Unmanned Aircraft Systems (UAS)

USRA is continuing to collaborate with NASA's Ames Research Center to build upon the award-winning UAS Traffic Management (UTM) system, as well as other software tools, including an Airspace Operations Management (AOM) component to enable comprehensive situational awareness and improve coordinated decision making. Flight experiments for disaster preparedness, response and recovery use cases are being conducted in collaboration with multiple collaborators from academia, industry and government.

Advanced Air Mobility

The NAMS team is supporting NASA's Advanced Air Mobility (AAM) program to accelerate the realization of safe and scalable AAM capabilities through the development of transformative airspace-operations technologies and through integrated demonstrations of candidate operational concepts and scenarios. This effort involves collaboration with the growing industry that is producing advanced air vehicles, including electric Vertical Takeoff and Landing aircraft, high-altitude long endurance aircraft, and autonomous drones. The work also supports various missions including transporting people and cargo between places previously underserved by aviation and for remote sensing for disaster preparedness, response, and recovery.

This past year, the NAMS team collaborated with NASA Ames Research Center to deliver Urban Air Mobility (UAM) airspace software to the NASA Advanced Air Mobility (AAM) project. USRA supported Urban Air Mobility simulation (X4) that resulted in more than 20 consensus community based rules (CBRA) for strategic conflict management. USRA also supported NASA in leading seven airspace partners in developing the Provider of Services for Urban Air Mobility (PSU). Five of these partners continue to participate in airspace automation concept development with Wisk Aero as part of the National Campaign 1 (NC-1).

Digital Information Platform

Engineers in USRA's NAMS team collaborate with NASA's Ames Research Center to develop a Digital Information Platform (DIP) for advanced, data-driven, digital services for flight operators to promote efficient aviation operations in all airspaces. These include high-altitude autonomous vehicle operations including passenger and cargo transport. This effort builds upon the success of the ATD projects and the latest in cloud-based infrastructures and artificial intelligence technologies to realize the FAA and NASA vision for the digital transformation of Air Traffic Management from trajectory-based to collaborative and highly automated.

During this year, the DIP team released a cloud-based Catalog of aviation data services for improving data sharing and collaboration between airline operators, air traffic controllers, and other aviation users. The catalog provides an example for a marketplace for service providers and consumers to share data.

Roadmap for Digital Transformation of Air Traffic Management. Image Courtesy: NASA

Astrophysics and Heliophysics

USRA scientists, in collaboration with scientists around the world, are contributing to our understanding of a wide array of current astrophysical problems, using nearly the full range of the electromagnetic spectrum. Current work enabled by USRA includes 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, the origin of gravitational waves and high-energy cosmic rays, and the creation of the universe itself.

HAWC+ Observations Create a New Framework for Understanding Magnetic Fields in Galaxies

The magnetic fields of spiral (M51, M83, NGC 3627, NGC 7331), starburst (M82, NGC 2146), active galactic nuclei (NGC 1068 and Centaurus A), and merging (Antennae galaxies) galaxies obtained by SALSA Results are published in The Astrophysical Journal (SALSA IV: Lopez-Rodriguez et al.). Image Courstesy: USRA

Galactic evolution is controlled by an interplay between gravity, turbulence, feedback, dark matter, and magnetic fields.

The Survey of extra gALactic magnetism with SOFIA (SALSA) program aims to construct a picture of the magnetic field structure around different types of nearby galaxies by studying the effect of the gas dynamics on the magnetic fields from hundred-pc-to-kpc scales. SALSA has shown magnetic fields are always present in the cold, dense interstellar medium of all galaxies.

SALSA's data shapes refines and revolutionizes our understanding of extragalactic magnetism, and offers a statistical analysis of galaxies based on properties like galaxy type. These results allow us to understand the amplification and generation of magnetic fields in galaxy evolution, and can help elucidate how magnetic fields permeated the intergalactic medium in the early universe, the processes of star and galaxy formation, and giant molecular cloud assembly.

FORCAST Spectra Show the Chemical Evolution of a Dusty Star System in Real Time

Our understanding of how rocky planets, like Earth, form out of the gas and debris surrounding young stars hinges on our understanding of how hot gases condense into dust grains.

Eleven years after it was last observed and 17 years after a stellar merger occurred, SOFIA observed V838 Monocerotis, capturing a snapshot of its composition and watching its history unfold. These observations confirmed the dust chemistry of the system has changed significantly in the two decades following the merger from primarily comprising of alumina components in 2008 to now being dominated by silicates, as the alumina bond with their oxygen neighbors. SOFIA was the only observatory capable of observing V838 Monocerotis at infrared wavelengths required to monitor this dust process, so the data over the past decade have provided a unique archaeological view of its evolution.

SOFIA FORCAST measurements (orange) of the V838 Mon spectrum, and the best-fit composite model of SOFIA data with a silicate-to-alumina ratio of 50:50 (yellow), overlaid atop an image of V838 Mon obtained by the Hubble Space Telescope, which shows the light echo illuminating circumstellar material. Image Courtesy: V838 Mon: ESA/Hubble & NASA; Spectra: Woodward et al.

Background Image: A substantial coronal mass ejection, or CME, blew out from the side of the Sun, giving us a great view of the event in profile (June 17-18, 2015). NASA's Solar Dynamics Observatory caught the action in the 304 Angstrom wavelength of extreme ultraviolet light. The image covers about four hours of the event. While some of the plasma falls back into the Sun, a look at the coronagraph on SOHO shows a large cloud of particles heading into space. Image Courtesy: NASA/SDO

SOFIA Observation Maps Water Around the Moon's South Pole

Following the first ever detection of the water molecule on the sunlit surface of the Moon, researchers using SOFIA produced a regional map of the South Pole near the Moretus crater. This map enables tests of various water formation hypotheses and suggests that lunar surface water is created from pre-existing surface hydroxyl trapped in glass created during impacts.

Additional SOFIA observations have mapped water in various lunar regions, including interesting geologic features such as craters and pyroclastic flows. Observations at multiple latitudes and lunar times of day will constrain the origin, distribution, and evolution of lunar water. These observations will be critical for future NASA missions such as the VIPER lunar rover and the Artemis program that will return humans to the Moon by 2024.

Artist's impression of IXPE is space. Image Courtesy: Ball Aerospace

IXPE

IXPE is a Small Explorer Mission launched on December 9, 2021 into a low-Earth orbit with a two-year baseline mission to conduct precise imaging X-ray polarimetry of celestial targets. The IXPE mission is an international collaboration led by NASA Marshall Space Flight Center (MSFC).

In FY 2022 and prior to launch, the USRA IXPE team members supported several pre-launch reviews, including the Operations Readiness Review and Flight Readiness Review as well as numerous software quality assurance and testing processes. USRA personnel also supported calibration activities at MSFC's 100-meter beamline (formerly the Stray Light Test Facility) and computer hardware specification and procurement. In addition to software development tasks with the launch, USRA efforts have shifted to Science Operations. The Science Operations Center (SOC) is responsible for all science operations and formulates the long-term observing plan. The SOC then sends data to the High Energy Astrophysics Science Archive Research Center (HEASARC) for archiving and public access.

MoonBEAM and LEAP

Artist's rendition of MoonBEAM mission concept. Image Courtesy: NASA/ Lockheed Martin

Members of the USRA's STI Gamma Ray Group (Adam Goldstein, Corinne Fletcher, Oliver Roberts, and William Cleveland) are supporting two NASA Mission of Opportunities —MoonBEAM and LEAP. MoonBEAM, led by Dr. Michelle Hui, Marshall Space Flight Center, to study the characteristics of relativistic jets and transients.

LEAP, led by March McConnell, University of New Hampshire, will study emission mechanisms, magnetic field, and jet composition of gamma-ray bursts. NASA's Marshall Space Flight Center will manage both Mission of Opportunities if they are selected.

Heliophysics

USRA's Science and Technology Center supported various space environments effects tests related to NASA's Artemis Gateway spacecraft and the Orion crew vehicle. The purpose of the testing was to advance the technology readiness level of subsystem design and materials to ensure proper performance on orbit.

In addition, the Partnership for Heliophysics and Space Environment Research (PHaSER) includes USRA and five university partners, which support scientific and technical aspects of the Heliophysics program at NASA Goddard. One of USRA's assignments has been to support internships for a diverse set of students who do not qualify for the NASA intern program. The research projects include exploring extreme magnetic field variations in the surface of the Earth using several MHD models at the Community Coordinated Modeling Center; refining techniques for estimating spatial gradients and temporal rates of change of atmospheric parameters for the GDC mission; identifying time periods where geomatic sub storms and steady magnetospheric convection events occur; and exploring the nature of the solar wind-magnetosphere interaction.

The Legacy of SOFIA

921 Flights of Observation

431 Published papers

60 Ph.D. Dissertations

Community of **3,500** researchers

The Legacy of the Stratospheric Observatory for Infrared Astronomy

NASA's and DLR's Stratospheric Observatory for Infrared Astronomy (SOFIA) was indeed an engineering and scientific marvel. It leaves behind a legacy of scientific discovery revealing the seen and unseeable parts of our universe. From discovering new water sources on the Moon and mapping magnetic fields deep in space, to detecting the first type of molecule in the universe, SOFIA explored a vast astronomical space revealing critical new information about our solar system, our galaxy, and beyond. SOFIA's Science Mission Operations, managed by USRA, enabled amazing scientific discoveries, and the operation of its telescope was an amazing engineering feat.

An airborne observatory with a 106-inch reflecting telescope mounted on a Boeing 747 airplane, SOFIA was one of a kind. By flying above 99.9 percent of the atmosphere's absorbing water, SOFIA was able to observe the infrared spectrum from 1 to 1000 micometers and tap into the wealth of astrophysical information accessible only at these wavelengths.

Among SOFIA's Science highlights are:

Discovery of Water on the Sunlit Portion of the Moon

Although SOFIA's telescope wasn't originally configured to look at the Moon, its lunar observations confirmed, for the first time, water on the sunlit surface of the Moon. This meant water may be distributed across the lunar surface, and not limited to cold, shadowed places.

NASA is eager to learn about water on the Moon in advance of sending humans to the lunar surface with the Artemis missions. SOFIA's data will be used for future Moon missions, such as NASA's water-hunting Volatiles Investigating Polar Exploration Rover.

The Moon was not SOFIA's only target in our solar system. The observatory also studied the circulation of gases within Jupiter's atmosphere, the possibility that comets delivered carbon to planets like Earth, and, just recently, the asteroid that will be explored by NASA's Psyche mission – to name a few.

Detection of the First Type of Molecule Ever to Form in the Universe

After decades of searching by astronomers, SOFIA detected, for the first time in space, the first type of molecule that ever formed in the universe. The discovery proved that the molecule, helium hydride, can indeed exist in space, confirming astronomers' basic understanding of the chemistry and evolution of the early universe.

SOFIA's work in astrochemistry also shed light on one way water gets distributed in the universe. The mission also explored the life cycle of materials in space, clouds of simple gases that form more complex gases, and ultimately stars and star systems.

Ultra-Time-Sensitive Observations

SOFIA's mobility allowed it to capture extremely fleeting celestial events over remote locations.

In 2015, Pluto passed directly between a distant star and the Earth, giving scientists a rare chance to analyze its atmosphere while backlit by the star. And SOFIA was the only observatory that could position itself over the open ocean, directly in the center of Pluto's shadow racing across Earth's surface.

SOFIA was nimble, which also helped it provide long-term monitoring – as for a surprisingly long, bright outburst by a protostar in the Cat's Paw Nebula – and respond quickly, when needed. This was the case in 2014 when an exploding star, a supernova, was spotted – the brightest and closest to Earth in decades.

A Star Is Born – or Not

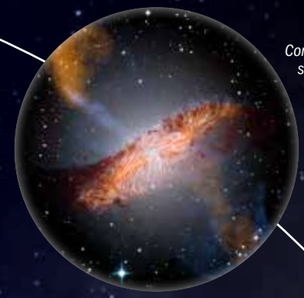
By observing in infrared light, SOFIA was able to reveal secrets of star formation that would otherwise have remained hidden inside massive clouds of gas and dust.

One major area of research for SOFIA involved an effect called "feedback," where stars either help or hinder the creation of more stars in their neighborhood. Using SOFIA's data, researchers found that a stellar wind in the Orion Nebula is clearing a bubble free of material needed to form new stars, while, in another nebula, the original star is triggering the birth of new generations.

New Way to Study Earth's Atmosphere

Flying at 38,000 to 45,000 feet, SOFIA soared above 99.9 percent of the water vapor in Earth's atmosphere that obscures infrared observations from the ground. But the telescope still had to peer through the upper reaches of our atmosphere.

After developing ways to work with SOFIA data on this hard-to-study region, researchers were able to make direct measurements of atomic oxygen in Earth's upper atmosphere.



Composite image of Centaurus A. Magnetic fields observed by SOFIA are shown as streamlines over an image of the galaxy taken at visible and submillimeter wavelengths by the European Southern Observatory and Atacama Pathfinder Experiment (orange), X-ray wavelengths from the Chandra X-Ray observatory (blue) and infrared from the Spitzer Space Telescope (dark red). Image Courtesy: Optical: European Southern Observatory (ESO) Wide Field Imager; Submillimeter: Max Planck Institute for Radio Astronomy/ESO/Atacama Pathfinder Experiment (APEX)/A.Weiss et al.; X-ray and Infrared: NASA/Chandra/R. Kraft; JPL-Caltech/J. Keene; SOFIA/L. Proudfit

Illustration of a comet from the Oort Cloud as it passes through the inner solar system with dust and gas evaporating into its tail. SOFIA's observations of Comet Catalina reveal that it's carbon-rich, suggesting that comets delivered carbon to the terrestrial planets like Earth and Mars as they formed in the early solar system. Image Courtesy: NASA/SOFIA/Lynette Cook

This illustration highlights the Moon's Clavius Crater with an image depicting water trapped in the lunar soil there, along with an image taken by NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) that found sunlit lunar water. Image Courtesy: NASA/Daniel Rutter

Mapping the Magnetic Universe

By mapping the polarization of light, SOFIA has studied magnetic fields in a wide range of celestial objects, illustrating this fundamental force's effects on the universe.

Using SOFIA, researchers have learned how galactic mergers can warp magnetic fields, that magnetic fields can either help feed a black hole or keep it quiet, and that magnetic fields have an impact on the evolution of galaxies, and stars and more.

Over the course of its life, SOFIA flew over 900 scientific flights, resulting in the publication of over 400 scientific papers.

SOFIA's instrument suite provided continuum, spectroscopic, and polarization imaging in the full mid-IR and far-IR wavelength range inaccessible from the ground. Its state-of-the-art instrument suite comprised of GREAT, FORCAST, FIFI-LS, HAWC+, and EXES complemented the wavelength ranges of other contemporary facilities.

USRA's Science Mission Operations selected and planned world-class science observations, provided user support and funding, delivered reliable, science-ready data, and expanded its user base to engage a diverse community.

Moving forward, SOFIA's data will be available in NASA's public archives for astronomers worldwide to use. NASA will continue to advance the future of scientific discovery in infrared astrophysics, starting with the recently launched James Webb Space Telescope, as well as further opportunities recommended by the Decadal Survey.

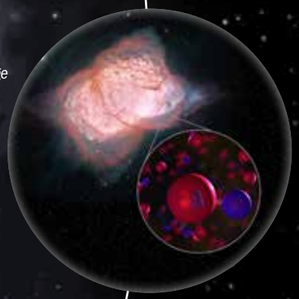
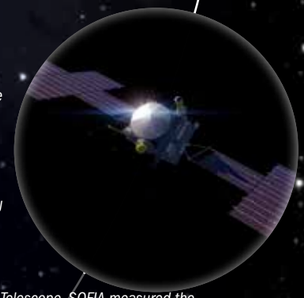


Image of planetary nebula NGC 7027 with image of helium hydride molecules. In this planetary nebula, SOFIA detected helium hydride, a combination of helium (red) and hydrogen (blue), which was the first type of molecule to ever form in the early universe. This is the first time helium hydride has been found in the modern universe. Image Courtesy: NASA/ESA/Hubble Processing: Judy Schmidt



This illustration depicts NASA's Psyche spacecraft. Set to launch in 2023, the Psyche mission will explore a metal-rich asteroid of the same name that lies in the main asteroid belt between Mars and Jupiter. Image Courtesy: NASA/JPL-Caltech/ASU

Background image of the nebula RCW 120. The ring-shaped clouds around the nebula were detected by the Spitzer Space Telescope. SOFIA measured the glowing gas shown in red and blue to study the nebula's expansion speed and determine its age. Image Courtesy: NASA/JPL-Caltech/SOFIA

Lunar and Planetary Sciences

USRA's mission is to advance our understanding of the solar system, from its formation, through its evolution, to its current state.

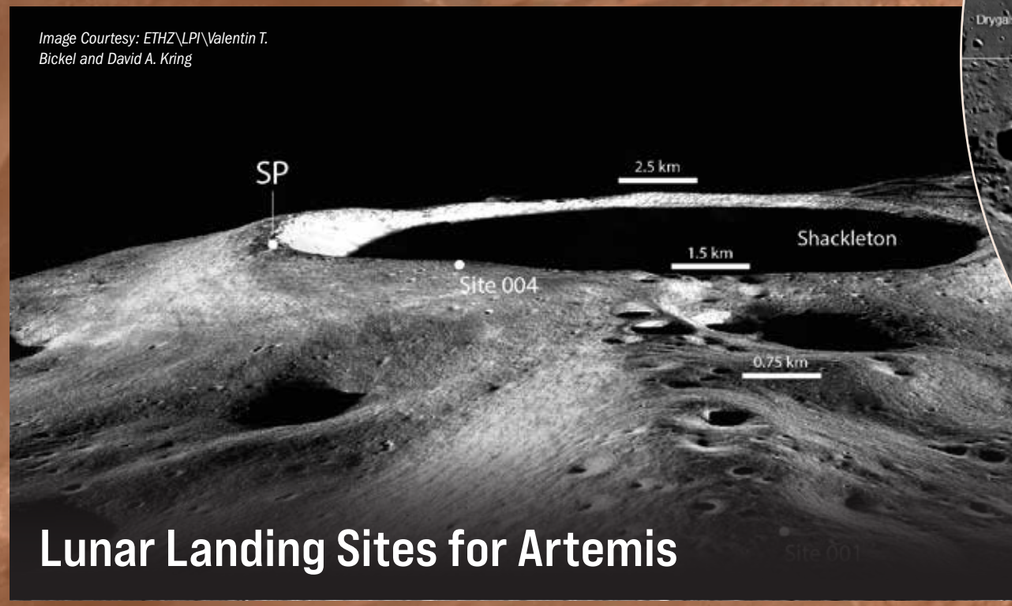


Image Courtesy: ETHZ\LPI\Valentin T. Bickel and David A. Kring

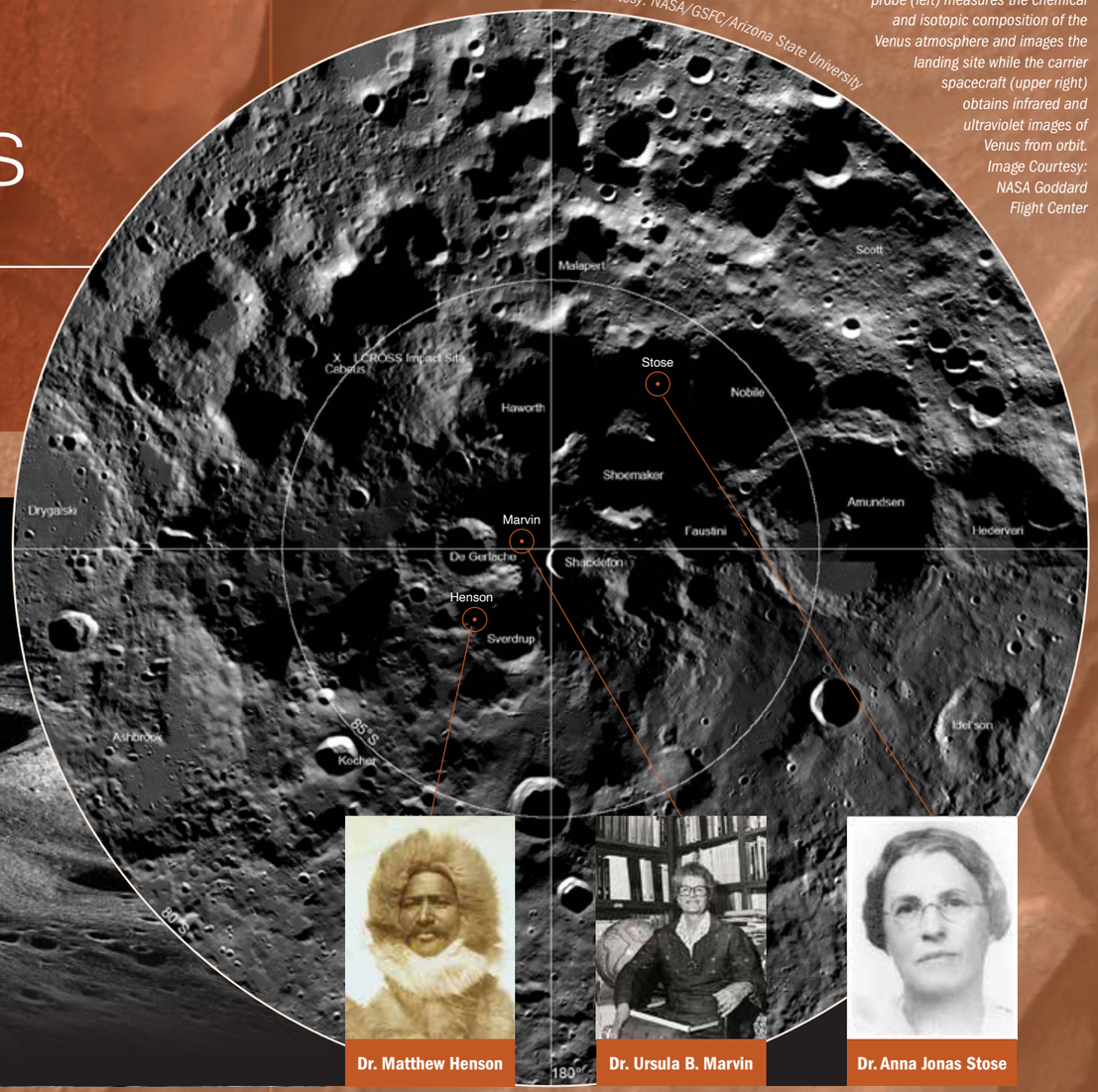


Image Courtesy: NASA/GSFC/Arizona State University

Lunar Landing Sites for Artemis

Dr. Matthew Henson

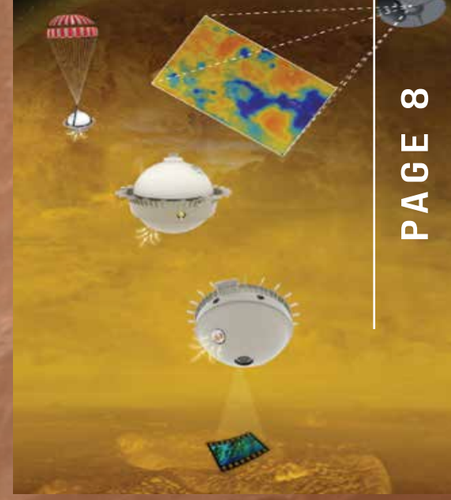
Dr. Ursula B. Marvin

Dr. Anna Jonas Stose

The Center for Lunar Science and Exploration (CLSE) team at the Lunar and Planetary Institute is investigating potential landing sites on the Moon for the Artemis III astronauts. The mission's goal is to land two astronauts in the lunar south polar region in 2025. NASA identified about a dozen candidates as landing regions on mountain summits and the rims of large craters. CLSE scientists are providing NASA with analyses of each of those regions, exploring scientific opportunities, assessing surface hazards, and identifying resources for a sustainable exploration program, so that the agency can select a final landing site. Astronauts will spend 6.5 days on the lunar surface and conduct at least two and possibly five EVAs during the Artemis III mission. Some of crew's excursions will take them to small permanently shadowed regions where volatile materials may have been deposited. To facilitate that exploration effort, CLSE and its partners developed a new imaging technique for seeing into those permanently shadowed regions with the Lunar Reconnaissance Orbiter spacecraft, greatly enhancing the agency's ability to plan traverses with reduced risk to crew. CLSE has published more lunar landing site and traverse analyses than any other group in the world. Those landing-sites studies and astronaut extravehicular activities' studies have engaged over one hundred (102) graduate students from over sixty (62) universities.

A related note about diversity

While mapping the geology of the lunar south polar region for the Artemis missions, the CLSE team found it necessary to name a few impact craters to facilitate discussion in the lunar science and exploration communities. This was an opportunity to celebrate diverse contributions to science, so the team proposed Henson, Stose, and Marvin as crater names to the International Astronomical Union, all of which were selected. Matthew Henson was a black explorer who (with Robert Peary) was the first person to reach the north pole. Anna Stose and Ursula Marvin were pioneering geologists in the United States. Their names now exist in the Artemis exploration zone and will become part of those missions' history. As USRA's David Kring at LPI notes, "Apollo demonstrated that lunar exploration can influence the dreams of the nation's children. I am among those who were motivated. It will be wonderful if the Artemis program generates the same result in an increasingly diverse way."



The DAVINCI atmospheric entry probe (left) measures the chemical and isotopic composition of the Venus atmosphere and images the landing site while the carrier spacecraft (upper right) obtains infrared and ultraviolet images of Venus from orbit. Image Courtesy: NASA Goddard Flight Center

New Spacecraft Missions to Venus

Dr. Walter Kiefer, LPI Associate Director, is a Co-Investigator for two missions to Venus that were recently selected for flight by NASA and the European Space Agency. The Deep Atmosphere Venus Investigation of Noble gases, Chemistry and Imaging (DAVINCI) is a NASA Discovery-class mission currently planned for launch in 2029. DAVINCI is an atmospheric entry probe whose chemistry measurements and imaging will address four key questions: (1) What is the origin and evolution of the dense atmosphere? (2) Did Venus ever have an ocean? (3) How has the rate of volcanic activity changed over time? (4) What is the geology and composition of the Alpha Regio landing site, which is the Venus equivalent of an ancient continent? EnVision is an ESA mission that will study the climate and geologic history of Venus, including possible present-day activity, with a planned launch in 2032. NASA is providing a radar whose imagery will offer the highest resolution global measurements ever made of the Venus surface. Other instruments will study the composition of the surface, look for evidence of actively erupting volcanoes, and use a ground-penetrating radar to study structure in the upper part of the crust. USRA's Walter Kiefer's role on both missions will be to study the tectonic and volcanic processes that have sculpted much of Venus' surface.

Background Image Courtesy: NASA/JPL-Caltech/Univ. of Arizona

Earth Sciences

Data visualization featuring volumetric carbon dioxide on a global scale for the period June 1, 2020 - April 23, 2021. Image Courtesy: NASA Scientific Visualization Studio

USRA scientists strive to understand the Earth's natural processes, their propensity to change, and the linkages between human and natural systems. They also work across sectors and disciplines to apply Earth Observations for broad societal benefit.

Studies on Greenhouse Gases

Greenhouse gases (GHG) emissions from human activities are the major contributor to ongoing climate change. Monitoring of GHG emissions level is critical for predicting the future climate and guiding our progress on climate mitigations. The The Earth from Space Institute (EfSI) has conducted GHG studies, especially CO_2 emission modeling in collaboration with world leading carbon research groups, such as NASA, Japan Aerospace Exploration Agency (JAXA); and the National Institute for Environmental Studies (NIES).

Dr. Tomohiro Oda, Senior Scientist at EfSI, maintains global emissions, the Open-source Data Inventory for Anthropogenic CO_2 (ODIAC), in collaboration with NASA, Japan's National Institute for Environmental Studies, and the Appalachian State University.

The ODIAC model produces a high-resolution global map of carbon dioxide (CO_2) emissions that indicates spatial patterns of the emissions at 1km resolution. The ODIAC data have been used for global, regional, and even local scale modeling and analysis of CO_2 in the atmosphere and the surface emissions. ODIAC has been used as a critical input for product development under NASA's Orbiting Carbon Observatory (OCO) mission and Carbon Monitoring System (CMS) program, as well as Japan's Greenhouse gas Observing SATellite (GOSAT) project. The ODIAC high-resolution map has become more critical as analyses at local levels, such as cities, need to be done in support of local climate actions by subnational actors. Dr. Oda's scientific contribution has been recognized and he was selected for the National Academies' consensus study committee. The report was released in Fall 2022.

Image Courtesy: Forge Branding

SERVIR

Members of the SERVIR GIT Team (Francisco Delgado, William Ashmall, Githika Tondapu, and Alexandre Goberna) continue to provide support to NASA in the joint NASA/USAID effort to support underdeveloped countries in areas of water and air quality analyses. During 2022, they developed and launched ClimateSERV 2.0, which includes significant performance improvements, higher stability and scalability, enhanced monitoring and logging mechanisms, all while retaining full compatibility with the previous API offered by ClimateSERV 1. They continued development of regional applications such as the Air Quality Explorer for SERVIR Mekong, and the RHEAS Viewer for SERVIR Eastern and Southern Africa, in collaboration with the regional science and GIT Teams. The SERVIR GIT Team developed applications to help disseminate alerts derived from the HIWAT system to users in Bangladesh and implemented mechanisms to maintain an inventory of SERVIR-developed applications (SCO, hubs, and AST), and manage technical information related to them. USRA employees managed the SOCRATES shared compute resources and provided support to users, prepared and promoted a strategy to expand the compute services available to the SERVIR network (also known as SOCRATES & Beyond), provided troubleshooting support and technical assistance to GIT Teams in the SERVIR network, and provided strategic advice and monitoring.

EfSI Delegation Attended UNFCC COP27

The Conference of the Parties (COP) is the decision-making body responsible for implementing the global climate convention, known as United Nations Framework Convention on Climate Change (UNFCCC). At COP meetings, signatory governments (the Parties) discuss how to address climate changes. The collective effort will be evaluated every five years beginning in 2023.

USRA has been admitted as an observer NGO since 2021, and it sent the first COP delegation to the 26th United Nations Climate Change Conference (COP26) held in Glasgow, Scotland, UK. USRA's delegation led by Dr. Oda, who also participated in a COP26 side event hosted by Japan's Ministry of the Environment at the Japan Pavilion and moderated the discussion of supporting the global stocktake (GST) through carbon science. The global stocktake of the Paris Agreement (GST) is a process for taking stock of the implementation of the Paris Agreement with the aim to assess the world's collective progress towards achieving the purpose of the agreement and its long-term goals.

Dr. Tomohiro Oda (Right) led the USRA delegation to the United Nations Climate Change Conference. Image Courtesy: USRA

This year USRA sent its COP delegation to the 2022 United Nations Climate Change Conference (COP27) which was in November 2022 in Sharm El Sheikh, Egypt. As an observer NGO, USRA continued monitoring the impactful discussions at COP27 and ensure their transparency. USRA/EfSI co-hosted a side event with Japan's National Institute for Environmental Studies (NIES). The USRA-NIES side event hosted leaders of carbon research and discussed the use of Earth Observations (EO) in support of climate mitigation. Following last year's discussion, the event further discussed the use of EO for generating actionable information for subnational actors.

Visualizations Aid Mission Planning for ARTEMIS III

USRA team member Ernie Wright worked closely with the ARTEMIS III team and served the mission with his scientific visualization and lunar expertise. One of the outcomes of this effort was to visualize 13 regions near the Moon's South Pole as candidate landing regions for Artemis III, the first crewed mission to the Moon's surface since 1972.

Located at the Scientific Visualization Studio (SVS) at NASA's Goddard Space Flight Center, Ernie Wright has created a visually rich and scientifically accurate and data-driven visualization body of work to support Lunar Science. Science visualizers at the SVS are typically not embedded in science and mission teams since visualizations are created to communicate research and scientific findings.

Ernie Wright, with his deep knowledge and expertise, succeeded in elevating the role of visualization for communication to visualization in service of mission planning for ARTEMIS III.

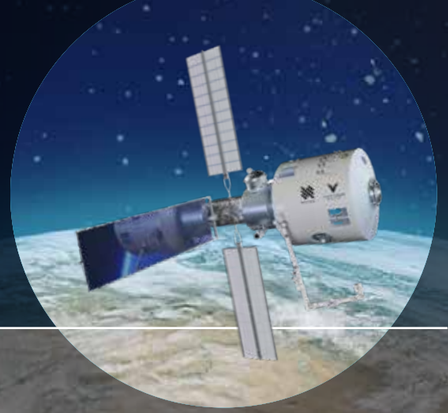
Data Visualization is Key in NASA's New Earth Information Center

Data visualization of observed and modeled data is a key component of understanding changes in climate science as they happen, and the Scientific Visualization Studio (SVS) at NASA's Goddard Space Flight Center has been delegated to lead the visualization effort for NASA's new Earth Information Center (EIC).

The EIC allows users to see how our planet is changing and provides easy-to-use information and resources to engage and inform the public and to support decision makers in developing the tools they need to mitigate, adapt, and respond to climate change. The USRA SVS team experience and expertise is uniquely qualified to support and lead the visualization effort for the entire EIC.

During the last year team members have been actively preparing for and creating visualizations on greenhouse gases, and developing a gallery of visualizations called "Climate Essentials" to engage the public and to support NASA leadership and policy makers in their international communication efforts. USRA's Helen-Nicole Kostis is leading the production visualization effort for EIC, along with SVS Team Lead Mark SubbaRao. As part of this effort, they also organized and led the workshop called *"High-Impact Visual Climate Science Communication"* at VIS 2022, with the goal to further develop the climate visualization community and establish a community of practice, and in so doing address one of the grand challenges of our time.

Low-Gravity Sciences



Conceptual view of Starlab Space Station. Image Courtesy: Nanoracks, LLC

A Deeper Understanding of Fire in Space and on Earth

NASA astronaut and Expedition 66 Flight Engineer Thomas Marshburn configures the Combustion Integrated Rack to begin SoFIE operations. Image Courtesy: NASA

The Solid Fuel Ignition and Extinction (SoFIE) project is a set of experiments launched aboard Northrop Grumman's 17th cargo resupply mission to the International Space Station in February 2022. SoFIE, which will run in the station's Combustion Integrated Rack, promises to light the way to a deeper understanding of fire in space. According to USRA's Dr. Paul Ferkul (SoFIE Project Scientist), "With NASA planning outposts on other planetary bodies like the Moon and Mars, we need to be able to live there with minimal risk. Understanding how flames spread and how materials burn in different environments is crucial for the safety of future explorers." SoFIE consists of five investigations to study the flammability of plexiglass, cotton-based fabrics, and other materials commonly used in spaceflight.

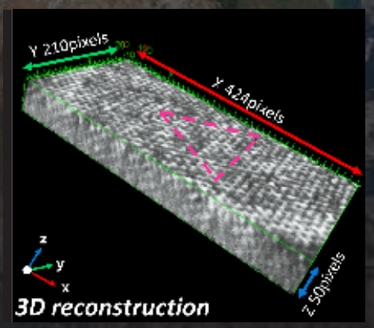
The results of SoFIE will aid NASA and other commercial entities to select materials and designs for spacesuits, cabins, and habitats. The experiments also will help identify the best ways to put out fires or smoldering materials in space as we prepare to go farther and stay longer. "On Earth, gravity has a profound influence on flames. In lower gravity environments, fire can behave unexpectedly and could be more hazardous," Ferkul said.

SoFIE's main purpose is to study spacecraft fire safety. However, data from the experiments could help improve fire safety on Earth by adding to the existing body of knowledge that could improve screening tests to evaluate fire-safe materials for everyday applications.

Advanced Colloids Experiments (ACE) Growing Large Single Defect Free Colloidal Crystals in Space

USRA's Dr. William Meyer is the Project Scientist for the Advanced Colloids Experiments (ACE) family of investigations that were flown on the ISS over the last decade. When removing the sedimentation and gravitational jamming seen on Earth, these experiments can use a 3D microscope to capture images that bridge the understanding of colloidal particle behaviors and colloidal engineering. Recent experiments include ACE-T11, ACE Temperature Control -12-2 (ACE T-12-2) [Nanoparticle Haloing], ACE Temperature Control -11 (ACE-T11) [Hard spheres], ACE Temperature Control-Ellipsoids (ACE-TR [Ellipsoids]), ACE Temperature 4-1 (ACE T4-1), ACE Temperature 4-2 (ACE T4-2), ACE Temperature control (ACE-T-2-3), ACE Temperature control (ACE T1), and ACE Advanced Imaging, Folding, and Assembly of Colloidal Molecules (ACE-T9-3).

As a result of the ACE-T11 flight experiment, USRA and partners Nanoracks, New Jersey Institute of Technology, and New York University filed a provisional patent (#63365667) for growing large single defect free colloidal crystals in space. The invention relates to the fabrication of large three-dimensional Bragg gratings operating at infrared wavelengths. Due to the unique properties of these Bragg gratings, these photonic crystals are expected to be crucial for applications in remote sensing, fiber optic communication, materials processing, chemical analysis, biomedical diagnostics, optical computing, security and defense.



3D confocal slices from a 27 mm crystal grown on International Space Station Increment 65 during ACE-T11 [Hard Spheres]. Image Courtesy: NASA

Commercial Low-Earth Orbit (LEO) Destination (CLD)

USRA has been selected by Nanoracks and Voyager Space—along with ZIN Technologies, The Ohio State University, and the International Association of Science Parks (IASP) and Areas of Innovation—to join the founding leadership team in charge of supporting the development and operations of the Starlab George Washington Carver (GWC) Science Park. The GWC Science Park will leverage a successful terrestrial business model where scientists and industry experts share findings, collaborate, and use new technologies to advance both scientific and commercial endeavors. The GWC Science Park goals will be accomplished within its four main operational components, which will include a biology lab, plant habitation lab, physical science and materials research lab, and an open workbench area. The program also stands up a terrestrial twin located in Columbus, Ohio.

USRA, as a trusted NASA research partner with among the largest collection of space-specialized principal investigators, will manage the GWC and drive use within its existing network.

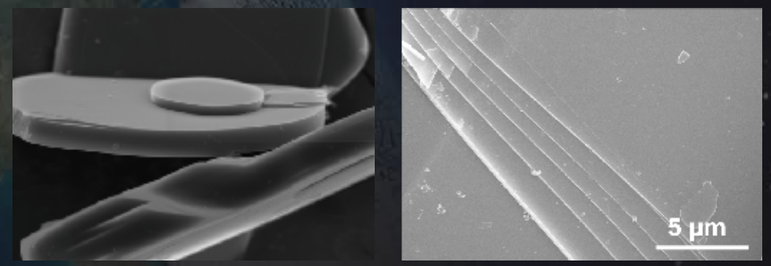
To maintain an uninterrupted U.S. presence in Low-Earth Orbit (LEO) by transitioning from the International Space Station to commercial platforms, NASA signed an agreement with Nanoracks and their partners at Voyager Space. This agreement helps enable Nanoracks to begin designing its Starlab commercial space station as part of NASA's Commercial LEO Development program. The GWC Science Park, established by Nanoracks, is the world's first-ever science park in space, active today on the International Space Station, and will be the core science element of Starlab once it achieves initial operational capability in 2028.

Advances in Materials for Aerospace Applications

Materials research stretches across several areas in support of Glenn Engineering and Research Support (GEARS) including:

1) Radioisotope Power Systems (RPS)- Dynamic Radioisotope Power Systems (DRPS) Dynamic Power Conversion (DPC) technology development project for new generation DPC convertor development.

2) Transformational Tools and Technology (TTT)- Electric Aircraft Propulsion (EAP) Advanced multifunctional materials project to improve/optimize, scale up, and commercialize the newly invented high voltage, lightweight micro-multilayer multifunctional electrical insulation (MMEI) system (U.S. Pat. No. 10,546,666). Support includes development and modification of new and current materials for power cable improvements where different boron nitride types with different particle sizes are exfoliated using chemical reaction method.



SEM images of a pristine boron nitride (left) and exfoliated boron nitride after the chemical reaction (right). Image Courtesy: NASA

3) Advanced Air Transport Technologies (AATT)- Electrified Aircraft PowerTrain (EAPT) Electric machine insulation project focused on improving potting qualities of Litz wires for better thermal management and structural integrity of the stator winding of high efficiency and high power density electric motors for the future electrified aircraft applications. This includes an extrusion of different flexible polymer composites to study their properties applicable for wire coating, slot liners and high voltage separators.

4) Convergent Aeronautics Solution (CAS) executive project to develop novel polymer electrolytes and cathodes for batteries for Urban Air Mobility (UAM) and all electric aero-vehicles.

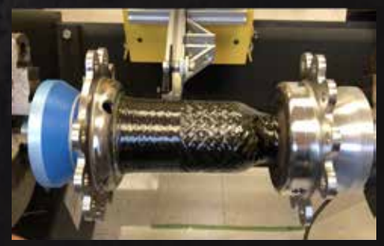
5) Rapid Analysis and Manufacturing Propulsion Technology (RAMPT) studying composite overwrap for additively manufactured metallic thrust chambers as well as obtaining boundary and shear data from composite overwrapped tubes.

6) Revolutionary Vertical Lift Technology (RVLT) evaluating carbon fiber/epoxy composite panels which incorporate a pitch-based fiber to assess thermal conductivity and damage tolerance.

7) Thermoplastic Development for Exploration Applications (TDEA) / Hi-Rate Composite Aircraft Manufacturing (HiCAM) evaluating process and property relationships for thermoplastic matrix composites.

8) Aerogels including cross-linked polymer /organic aerogels, and ceramic aerogels, which have multiple aerospace applications because of their low density, high porosity, high surface area, low thermal conductivity, and low dielectric constant.

USRA also serves as lead for multiple materials laboratories.



Filament winding of composite overwrap for additively manufactured thrust chamber. Image Courtesy: NASA

Quantum Computing and Artificial Intelligence

Data Sciences using machine learning is enabling computers and other automated systems to perform tasks that have historically required human cognition and human decision-making abilities. USRA scientists and engineers have made significant contributions through foundational and use-inspired research and collaborative education projects in application domains that include Aviation Data Sciences and Environmental Data Sciences among others.

Quantum Artificial Intelligence Laboratory (QuAIL)

USRA's Research Institute for Advanced Computer Science (RIACS) conducts research in quantum computing as part of the Quantum Artificial Intelligence Lab at NASA's Ames Research Center. This research supports NASA's missions and involves collaboration with two Department of Energy (DOE) National Quantum Initiative Centers. It also involves collaborations with other federal programs including multiple Defense Advanced Research Projects (DARPA) programs. The team performs a wide range of research, which includes development and analysis of quantum machine learning and optimization methods in applications such as wildfire research and advanced air mobility. This year the team published 23 research papers in peer-reviewed journals and conference proceedings, including high-impact journals *Nature* and *Science*.

DARPA, NSF, and SCB Research Programs

The quantum team also collaborates with academia and industry in projects funded by DARPA, the National Science Foundation (NSF), and Standard Chartered Bank (SCB). During the past year, the team began Phase II of the DARPA ONISQ program with Rigetti Computing and NASA, developing new quantum processors to run the Quantum Approximate Optimization Algorithm (QAOA) method to solve real-world scheduling and asset allocation problems. The team also studied optical coherent Ising machines under the NSF Expeditions project in collaboration with Stanford University, and several others. Finally, the team began working in collaboration with SCB to develop and evaluate quantum machine learning approaches for solving problems in environmental sustainability and governance applications such as in forecasting rainfall, floods and tropical cyclones.

Feynman Quantum Academy Internship Program

Since its inception in 2016, USRA's Feynman Quantum Academy has hosted over 50 students from top international universities to receive hands-on training and undertake individualized research projects utilizing a wide array of quantum architectures. In 2022, the USRA Feynman Quantum Academy had another excellent cohort of student interns, who worked on research topics that included: quantum optimization methods, large-scale tensor-network simulations, quantum machine learning methods, noise modeling and error mitigation analysis, benchmarking methods and several others.

Artificial Intelligence for Natural Hazards

USRA's Research Institute for Advanced Computer Science (RIACS) conducts foundational and use-inspired research in artificial intelligence and data science for disaster preparedness, response and recovery operations in collaboration with multiple federal sponsors including NASA's Ames Research Center, the USGS National Innovation Center, and the DHS Science & Technology Directorate among others. Projects include use of data science for wildfire operations, rapid flood mapping, hurricane operations, earthquake early warning, and landslide risk monitoring to help reduce the impact of such hazards on the lives and livelihoods of people. This research builds upon the decades of research in artificial intelligence that has been done in RIACS since its founding in 1983.

As one example, RIACS scientists collaborated with the USGS Water Mission Area, the NASA Ames Intelligent Systems Division, and other agencies on the DELTA-IRONFIST project. The project utilized neural networks with satellite imagery and other data, to classify whether an area is flooded. Topography-based predictions are incorporated where there are high error rates. The resulting model is in the process of being deployed for operational use.

Artificial Intelligence for Sustainable Aviation

Scientists in USRA's Research Institute for Advanced Computer Science (RIACS) are collaborating with NASA's Ames Research Center, small business partners, and other organizations to develop machine learning approaches to model and predict aircraft movements on the surface of airports and in the national airspace system managed by the Federal Aviation Administration (FAA). This work supports the United Nations' International Civil Aviation Organization (ICAO) member state resolution to strive to achieve a goal of keeping the global net carbon emissions from international aviation from 2020 at the same level by enabling reduced fuel use and emissions.

During this past year, RIACS scientists supporting the NAMS program collaborated with NASA and small business partners to develop machine-learning models to help reduce fuel use and emissions for ground and airspace operations. This included models to predict arrival and departure runways, surface taxi times to and from the gate to the runway, and arrival and departure times at the gate. During an eight and a half month field demonstration, machine learning algorithms aided in reducing emissions by 76 thousand pounds of carbon dioxide (CO_2) for 41 flights.

Artificial Intelligence for Advanced Air Mobility

RIACS scientists are collaborating with NASA's Ames Research Center and other organizations including the Civil Air Patrol as part of the NASA Academic Mission Services program to develop a Data and Reasoning Fabric (DRF) for Advanced Air Mobility. The DRF enables integrating streams of data from multiple sources (e.g., satellite and ground data), analyzing data using machine learning algorithms for prioritizing allocation of airborne resources, developing optimal flight plans for autonomous air vehicles, and presenting analysis of airborne remote sensing data to decision makers. The digital marketplace enabled by DRF is being developed to serve the demands for new services that support applications requiring airborne remote sensing and air transportation that utilizes advanced air mobility vehicles, including electric Vertical and Takeoff and Landing aircraft.

Space Biosciences

USRA scientists, in collaboration with the Space Biosciences Division at Ames, perform biological research and develop technology needed to enable NASA's long-term human exploration mission. In addition to designing and conducting ground and spaceflight experiments and developing spaceflight-relevant omic datasets and information sharing portals, we help to develop advanced research portals and platforms for the ISS to enable the broader scientific community to conduct life-science experiments in microgravity.

Mitigating Effects of Long-Term Space Exposure on Humans

During FY 2022, Dr. Raj Prabhu (USRA) supported the Cross-cutting Computational Modeling Project's (CCMP) computational modeling efforts to investigate human physiological responses to space stressors and provided modeling and simulation-based support to mitigate HRP-related risks.

CCMP presented the final demo on the Extravehicular activity (EVA) injury Modeling and Simulation (M&S) credibility assessment to NASA Johnson Space Center (JSC) Human Physiology, Performance, Protection, and Operations (H-3PO) stakeholders. This demonstration reported findings of M&S Scenario/Injury risk assessments for Elemance (or Global Human Body Models Consortium) and Total Human Model for Safety (THUMS) human body finite element (FE), and Open Simulator (OpenSim) musculoskeletal models.

In February 2022, GEARS CCMP team members showcased their work at the virtual Human Research program (HRP) Investigators' Workshop (IWS) as coauthors on seven technical presentations. This year's theme was Enabling the Future: The Pathway to the Moon and Mars. These presentations highlighted the latest mathematical and computational modeling findings, addressing problems that astronauts may face during deep space missions. Some of their work included machine learning models to predict space effects on the central nervous, cardiovascular, and ocular systems, and modeling and simulation credibility assessment as per NASA-STD-7009A. Deputy Project Scientist, Dr. Raj Prabhu (USRA), and team members also participated in several cross-disciplinary technical interactions regarding human responses to the space environment and engaged in risk mitigation discussions to ensure astronauts' safety when traveling to the Moon and Mars.

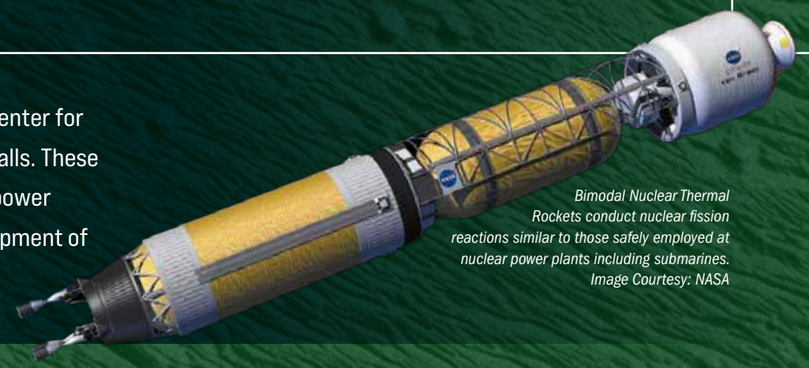
Supporting Space Life Sciences with the NASA Life Science Portal (NLSP)

USRA staff in the NASA Academic Mission Services (NAMS) program were instrumental in developing and launching the new NASA Life Sciences Portal (NLSP), which replaces the legacy NASA Life Science Data Archive (LSDA). The NLSP provides information and data on life science studies involving human, plant and animal subjects from 1961 (Mercury Project) through current flight and flight analog studies (International Space Station). The portal includes data from over 300 missions, with more than 2,500 experiments by 1,300 principal investigators from over 700 organizations including 300 universities. It also includes studies in 30 or more research areas that include 300 neuroscience experiments. In addition it includes 250 experiments in cell and molecular biology, 250 experiments in cardiovascular physiology, 250 plus experiments in skeletal physiology, 250 experiments in behavior and performance and more than 240 experiments in radiation biology.

A crew member on a simulated Mars mission at NASA's Human Exploration Research Analog (HERA) inspects rock samples inside a glovebox. Image Courtesy: NASA

Advanced Technologies for Space Exploration

USRA performs advanced studies at the Center for Space Nuclear Research (CSNR) in Idaho Falls. These studies support radioisotope and fission power systems for space exploration and development of advanced propulsion.



Bimodal Nuclear Thermal Rockets conduct nuclear fission reactions similar to those safely employed at nuclear power plants including submarines. Image Courtesy: NASA

A Bimodal Reactor for Long-term Propulsion and Power

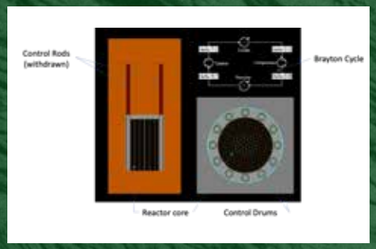
The USRA Center for Space Nuclear Research has focused on bimodal operation producing either thrust or electricity during different stages of a crewed Mars mission. We showed that the reactor could be used for five 1560-day missions if the hydrogen propellent could be replenished upon returning to Low Earth Orbit (LEO). In addition, the reactor could provide 2.5 megawatts for 25 years on the martian or lunar suface after the completion of its flight missions.

Our Mars missions included four interplanetary transfers or orbital insertions. Between the 500 Megawatt thermal (MWth) burns, the spacecraft and crew need about 2.5 electrical megawatts (MWe) for communications, atmospheric control, cryogenic refrigeration, and attitude control. In the propulsion mode, liquid hydrogen is introduced into ducts surrounding the structural components of the reactor and is then heated to about 1100 K before flowing through the reactor and exiting through the nozzle at 2,700 K.

In the generating mode the liquid hydrogen flow is shut off and the ducts surrounding the structural components carry a He-8.67% Xe gas mixture to the turbine-generator and radiator of a Brayton cycle.

After five Mars missions the reactor could still achieve criticality in the electric power mode, so we explored ways to use it as a planetary surface power source. The core was buried in the regolith for shielding and the control drums were replaced with control rods as shown in the figure below. The regolith reflected neutrons back into the core, but that scattering made the control drums less effective because their angular position was less important. The control rods are a greater distance from the core when withdrawn. Making use of the reflection from the regolith allowed the reactor to operate for an additional 25 years at 2.5 MWe.

Thus the Bimodal Reactor is neutronically capable of providing propulsion, heat, and electricity over a 45-year lifetime. Obviously, the reliability of the overall system is then a key determinant of the achievable lifetime.



Configuration of the Bimodal Reactor for Planetary Surface Power. Image Courtesy: USRA

Mission Equity

The Advancing IDEA in Planetary Science conference was held virtually on April 25–29, 2022. A key outcome of this conference was to identify community-led actionable and tangible recommendations to advance IDEA (Inclusion, Diversity, Equity, and Accessibility) principles within the planetary science and astrobiology community. Image Courtesy: USRA/Lunar and Planetary Institute

Equity Action

USRA is embedding equity as a core component in every program and project, with emphasis on two major classes of equity actions:

- Equity in mission, program and project work that advance opportunities, access and representation of underserved communities through employment and participation in contracts, grants and cooperative agreements, and
- Equity in benefits from mission, program and project achievements such as mitigating environmental challenges in underserved communities where challenges are particularly acute.

As one example, with the NASA Academic Mission Services (NAMS) contract, USRA is engaging students and faculty from minority serving institutions (e.g., HBCUs, HSIs, and TCUs) in support of NASA missions, programs and projects to build capacity within universities and colleges to educate students using NASA open-source technologies, open data and published research results in areas that include artificial intelligence/machine learning, autonomous operations, quantum information science, and advanced air mobility. Metrics include:

- Over 500 minority serving institutions' (MSI) students have taken courses enabled by the NAMS Collaborative Curriculum Program that incorporate results from research at NASA's Ames Research Center.
- More than 50 MSI student internships were completed to date as part of the NAMS Student R&D Program that align with and support research projects at NASA's Ames Research Center.
- Overall USRA enabled 2,200 student internships this past fiscal year with over 40 percent being from MSIs.

LPI Engages with NASA's Mission Equity

In 2022, LPI was actively engaged in supporting underrepresented communities within the NASA ecosystem. NASA and other planetary science stakeholders have committed to fostering IDEA (Inclusion, Diversity, Equity, and Accessibility) principles throughout their agencies and funded programs. NASA has added language to standard Announcements of Opportunity, requested information and feedback from the community on agency practices, and added inclusion as a core value. As one example of a major accomplishment in supporting these values, LPI hosted the Advancing IDEA (#IDEAcon) workshop (see https://www.hou.usra.edu/meetings/advancingidea2022/) in April 2022 to bring together members of the planetary science community to discuss current practices and needed improvements to ensure that we support underrepresented community members. The goal of the workshop was to bring together the planetary, astrobiological, and social science communities to (1) lean into lessons learned, (2) identify opportunities for improvement by listening to those most impacted in our community, and (3) make recommendations for actionable and tangible measures for advancing IDEA principles within planetary science. Following this event, Drs. Edgard Rivera-Valentín and Kennda Lynch of the LPI published a report (https://zenodo.org/record/6656887) of findings and recommendations and presented them to the NASA Planetary Science Advisory Committee (https://science.nasa.gov/science-pink/s3fs-public/atoms/files/10-Rivera-Valentin-Lynch-IDEACon_TAGGED.pdf). LPI has been leading the way in supporting NASA in IDEA values and actions.

Image Courtesy: Forge Branding

Leadership in Projects

Green House Gas Emissions for Decision Making

Monitoring of greenhouse gas (GHG) emissions and providing actionable information for climate mitigation is an urgent task to achieve the Paris Climate goal. The National Academies' fast-track consensus study team conducted a study over the past summer to develop a system for evaluating global anthropogenic GHG information in support of decision making and completed a report. The report examines emerging approaches used to generate GHG information at different scales from global to local scales. The study was done in an accelerated time to inform discussions at COP27 in November 2022.

Dr. Tomohiro Oda, Senior Scientist at Universities Space Research Association, and contributor to the report stated, "While it was no easy task for the committee members to develop a report in a little over two months, it was such an honor to work with this prestigious committee and NAS staff. The team is looking forward to upcoming opportunities for discussion, especially at COP27 in November 2022."

The OSIRIS-APEX Rendezvous with Asteroids

LPI was selected in 2022 to be the Planetary Defense Lead on NASA's OSIRIS-APEX mission to explore the asteroid Apophis. In April 2029, the OSIRIS-APEX spacecraft will begin an 18-month campaign of investigation and discovery at S-complex ("stony") asteroid Apophis.

LPI Cooperation with the International Space Institute in Bern

Since 2020, LPI has been working with the International Space Science Institute in Bern, Switzerland (https://www.issibern.ch) to support international planetary science collaborations between U.S. and international scientists. The purpose of the collaboration is to achieve a deeper understanding of the results from different space missions' ground-based observations and laboratory experiments and add value to those results through multidisciplinary research.

LPI's Role in the Planetary and Astrobiology Decadal Survey

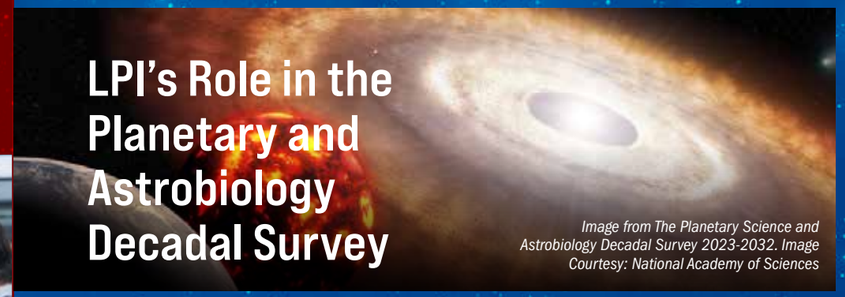


Image from The Planetary Science and Astrobiology Decadal Survey 2023-2032. Image Courtesy: National Academy of Sciences

In April 2022, the Planetary and Astrobiology Decadal Survey 2023–2032 (see https://www.nationalacademies.org/our-work/planetary-science-and-astrobiology-decadal-survey-2023-2032) was released. This report consolidated community input to address scientific questions in planetary science and astrobiology, identify priorities for missions, and present a research strategy for 2023–2032. LPI scientists Edgard Rivera-Valentín and Paul Schenk provided essential input to this report on the topics of outer planets, small bodies and asteroids, planetary defense, and the state of the profession.

USRA's Earth from Space Institute's Carbon Product, ODIAC, Used for Key Carbon Research Projects

USRA's Earth from Space Institute's (EfSI) carbon research has been uniquely funded by multiple sponsors. It offers tailored carbon emission information and associated research products to sponsors, such as NASA, JAXA and NIES. Because of that, EfSI's carbon product, such as Open-Source Data Inventory for Antrhopogenic CO_2 (ODIAC), has been used as a key information for a wide variety of carbon research projects. EfSI has been a key interface among different international agencies and facilitates collaborations with researchers in the U.S. and abroad. The team is led by USRA's Dr. Tomohiro Oda.

Science Facility Management and Operations

USRA manages various facilities including the Science Mission Operations for the Stratospheric Observatory for Infrared Astronomy (SOFIA). Summarized below are the other facilities it operates.

Aeronautics R&D Testbed for Airspace Operations

Engineers in USRA's NAMS team are developing and operating an aeronautics R&D Testbed for airspace operations with engineers at NASA's Ames Research Center. The core purpose of the Testbed is to enable realistic simulations of current and proposed future air traffic concepts for use by government, industry, and academia. The USRA team was involved with key simulations such as origin-to-destination, trajectory-based operations, widespread integration of novel vehicles and operations such as unmanned vehicles, and real-time safety assurance technologies to enable autonomous operations. As part of this work, the team supports industry partners, who provide real-world use cases and challenges to the team. During this past year, NAMS personnel released enhanced Aviation Systems TestBed capabilities and improved usability in support of NASA projects to integrate domestic and international partner software with NASA systems for upcoming simulations and flight demonstrations.

North Texas Research Station

Engineers in USRA's NAMS Team develop and operate the North Texas (NTX) Research Station in collaboration with NASA's Ames Research Center. NTX is a 5000 square-foot dedicated, air traffic management research facility. NTX has a dedicated radio tower and a reconfigurable computer lab, with access to live data including Air Route Traffic Control Center and Terminal Radar Approach Control Facilities data from Dallas/Fort Worth and Dallas Love Field airports. The NTX team collaborates with the airline operation centers for American Airlines, Southwest Airlines, and Envoy Airlines. During the past year, benefits of the NASA Digital Information Platform (DIP) project were tested as part of a sustainable aviation demonstration at Dallas/Fort Worth airport with American Airlines, Southwest Airlines, and Envoy Airlines.

Image Courtesy: Forge Branding

A primitive chondritic meteorite. This image is about 10 cm across. Chondritic meteorites are fragments of asteroids. Like interplanetary dust particles, the abundances of rock forming elements in these meteorites are similar to that of the Sun. They also contain carbon in the form of organics and carbonate, but less than IDPs. Image Courtesy: NASA

XSPACE at LPI

Led by Dr. Cyrena Goodrich of the LPI, the XSPACE (eXterrestrial SamPle, Analyses, Curation, and Exploration) Laboratory (see https://www.lpi.usra.edu/science/science-labs-equipment/xspace/) is a new facility dedicated to the classification and curation of meteorites. The Nomenclature Committee of the Meteoritical Society recognized XSPACE as an official meteorite repository in 2022. Meteorite classification is led by scientists at the Astromaterials Research and Exploration Science Division (ARES) of Johnson Space Center in partnership with scientists at the LPI.

The primary source of these meteorites is Africa, but other non-Antarctic sources will be considered for the collection as well. New meteorites submitted to XSPACE will first be examined and documented in hand sample at LPI (USRA-Houston) using optical microscopy and/or the LPI Phenom XL Scanning Electron Microscope. Those deemed worthy of further study will be transferred to ARES for additional preparation and analyses needed for classification. The XSPACE meteorite collection currently consists of a small number of donated meteorite samples, with additional donations anticipated. Several new meteorites are currently being classified and will become part of the collection.

Artificial Intelligence R&D Testbed

USRA's RIACS developed a new computational testbed for Artificial Intelligence R&D in collaboration with the University of California, San Diego. The testbed provides access to the high-performance Graphic Processing Unit (GPU) and storage nodes for select university research projects aligned with USRA activities. The testbed was used with Jupyter Labs to support a new 12-week Advanced Aviation Data Sciences course that RIACS staff taught this year for USRA and NASA personnel.

Diversity, Equity, and Inclusion

2022 was a year of unprecedented program shifts for USRA. Through the headwinds we remain committed to our values and diversity goals, which include increasing the number of women and underrepresented minorities in leadership, science and technical roles, and ensuring inclusive leadership practices are embedded in our culture.

At USRA, we strive to provide a workplace where everyone has access and opportunity to achieve their best. Inclusion is one of USRA's core values and it is at the heart of our culture. We believe that whenever an employee has a voice and a sense of belonging, USRA can be more innovative, agile and responsive to our sponsor needs. We also know today's greatest challenges require a shared commitment to development of a more diverse science and technology workforce, which includes collaboration with our sponsors and university members.

At the Institutes and Programs of USRA, DEI continues to play an important role. In January 2022, the Lunar and Planetary Institute's (LPI) inclusion, diversity, equity and accessibility (IDEA) initiative began working with USRA Information Technology Systems to make improvements to the USRA Meeting Portal to support greater inclusion, diversity, equity and importantly – accessibility. Increasing the percentage of employees who self-identify as having a disability within our workforce is a key objective.

Additionally, we continue to expand our relationships with HBCUs and MSIs. As an example, the NASA Advanced Supercomputing (NAS) Center at NASA Ames began funding a year-long project with Hampton University on High-Performance Computing (HPC) for Distributed Training of Machine Learning Models for Flood Inundation Mapping.

Diversity and inclusion are instrumental in driving innovation and delivering strong program growth. We are committed to creating a more inclusive environment for our programs and our partnerships with governments, academia, and communities to make space-related research and technology more fully inclusive.

Reviews of our diversity data show areas of success, while still recognizing there is more work to do:

- Regarding our U.S. pay data, salaries for women trended at or slightly higher than men within almost every pay band showing improvement from the previous year
- Salaries for minorities trended slightly lower than non-minority counterparts
- Minority representation held steady at 38 percent
- Females in Program Science/Engineering Professionals increased from 28 percent to 30 percent
- Minorities in Program Science/Engineering Professionals increased from 38 percent to 39 percent;
- In 2022, 77 percent of employees reported, "I feel included at USRA," a 2 percent decrease year over year

Over the next year, we will continue to invest in our functions and programs with initiatives that advance our inclusion goals and create greater positive change.

Image Courtesy: Forge Branding

STEM Workforce Development Internships, Fellowships and Scholarships

USRA's extensive workforce development pipeline provides immersive and experiential learning opportunities for K-12 students, undergraduate, and graduate students, as well as postdoctoral fellows and early career professionals.

AFRL Programs

In conjunction with the Air Force Research Laboratory (AFRL) and the United States Space Force (USSF), USRA spearheads a portfolio of programs aimed at increasing preparedness of the next generation of high-tech workers focused on science, technology, engineering, and mathematics (STEM), with an emphasis on the recruitment of underrepresented populations.

During FY 2022, more than 300 participants in the AFRL Scholars Program were placed among ten Technical Directorates (TDs) across multiple sites in the AFRL Scholars Program.

Another program in the portfolio of the Workforce Development Pipeline is Scholars Professionals (SPs) that allows recent bachelor's, master's, juris doctorate, and doctorate degree recipients to pursue research conducted under the supervision of an AFRL mentor. The program seeks to develop highly skilled talent from a variety of educational backgrounds. SPs will be selected for a one-year, full-time appointment with the opportunity to renew for up to three years.

Finally, the University Consortium Research Opportunity (UCRO) is administered by USRA to connect the USSF and AFRL with academic research. During FY 2022, USRA issued a solicitation in coordination with AFRL management and government Core Technical Competency (CTC) Lead(s) to encourage interest from accredited U.S. colleges and universities. The solicitation requested proposals that addressed one of six pre-determined critical research topic areas. A total of 46 proposals were submitted, with 41 percent representing minority serving institutions (MSIs).

NASA Internships

With "inclusion" as one of its core values, NASA seeks talented interns to strengthen tomorrow's science, technology, engineering, and mathematics (STEM) workforce—both on-site and virtually. Virtual internships have continued to provide valuable work-based learning experiences to students across the United States in the wake of the COVID-19 pandemic.

USRA continues to create strategies to target a diverse population of students and bring awareness to opportunities within NASA by attending events targeted to MSI students, identify barriers that preclude them from applying for an internship, connecting with students using Handshake and LinkedIn, and supporting students through the application process.

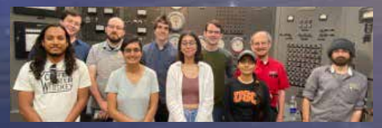
Collaboratively, USRA and NASA reached and unified students by breaking down barriers that inhibit participation in STEM learning opportunities and NASA's future workforce.

Background Image. Image Courtesy: Forge Branding

STEM Workforce Development Continued

Interns at the Center for Space Nuclear Research (CSNR)

CSNR held its first in-person Summer Program since 2019 with nine students at Idaho National Laboratory (INL) and one attending virtually from Ann Arbor, MI. The Summer Fellows participated in a multi-facetted design study of a bimodal reactor to provide both nuclear thermal propulsion (NTP) and electrical power to a series of round-trip missions to Mars. The neutronics analysis of the reactor indicated that it could complete five NTP missions and provide 2.5 MWe for on-board electrical needs over the course of 20 years. Afterwards, the reactor could be imbedded in the lunar or Martian regolith and provide 2.5 MWe of fission surface power for about 25 years.



2022 CSNR Summer Fellows in the EBR-1 Control Room at the Idaho National Laboratory. (l to r): Arnold Pradhan, U of Idaho; Zyed Ansary, U of Denver; Daniel Watson, Texas A&M; Aanchal Gupta, UIUC; Kean Martinic, Idaho State; Berenice Sosa Aispuro, Idaho State; Daniel Black, BYU-Idaho; Kasturi Khatun, USC; Steve Herring, CSNR; Teyen Widdicombe, U of Idaho; (not shown) Manikandan Pandiyan, UMich; Brad Kirkwood, CSNR

Image Courtesy: Forge Branding

USRA STEM Education Center

USRA's STEM Education Center provides experiential learning opportunities for K-12 students, with a specific focus on engaging underrepresented students. Programming offers critical insight relating to STEM academic and career fields to attract and retain the next generation of scientists, technologists, engineers, and mathematicians, Throughout FY 2022, USRA worked collaboratively to develop a series of student and educator workshops to ignite STEM interest with Luxrobo Education Technology Corporation located in South Korea.

Luxrobo, a technology and education software development corporation based in Seoul, South Korea, visited USRA Houston during July 2022 to discuss future opportunities for international collaboration with USRA's STEM Education Center. Image Courtesy: USRA

STEM Education Programs

USRA develops curriculum collaboratively with universities, incorporating research results from federal sponsor research. In the past year, USRA scientists taught/co-taught courses at NASA's Ames Research Center (Advanced Aviation Data Science), at UC Berkeley (Data Science in Aviation), and at Carnegie Mellon University (Quantum Integer Programming and Machine Learning); and helped develop a four-course Post-Baccalaureate Certificate of Professional Studies in Quantum Computing in collaboration with the University of Maryland, College Park and staff at the National Institute of Standards and Technology NIST. This builds on prior courses co-developed with faculty that are continuing in universities and which have reached over 500 participants to date.

Immersive Experiences for University Students

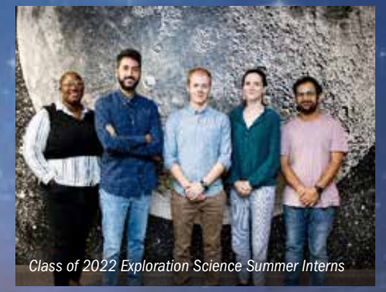
Lunar and Planetary Institute Summer Intern Program in Planetary Science

The Summer Undergraduate Program for Planetary Research (SUPPR) invites undergraduate students who are interested in learning about research in planetary geoscience to participate. We pair undergraduates with NASA-sponsored planetary geology and geophysics investigators at locations around the country for eight weeks during the summer. In 2022, 12 SUPPR interns were competitively selected from over 97 qualified college undergraduate applicants and paired up to work one-on-one virtually with NASA-sponsored planetary science investigators from various scientific institutions.

Exploration Science Summer Intern Program (Graduate)

The Exploration Science Summer Intern program, led by USRA's Dr. David Kring at LPI, is motivated by Space Policy Directive – 1, which directs NASA to deliver humans to the Moon for long-term exploration and resource utilization. This year's 10-week intern program evaluated changes in elevation and slope around potential landing sites and developed a method for designing traverses to permanently shadowed craters.

Hybrid planetary science seminar, June 2022



Class of 2022 Exploration Science Summer Interns

Interns on a tour of NASA JSC Lunar Receiving Laboratory, July 2022

Interns and mentors after the Final Intern Conference, August 2022

2022 SUPPR Meet and Greet, June 15, 2022

Quantum Workforce Development Programs

In Fall 2022 semester, USRA scientists taught a course at Carnegie Mellon University Quantum Integer Programming and Machine Learning (QuIPML). This course is primarily designed for graduate and advanced undergraduate students. It covers recent developments in Quantum Computing for solution of combinatorial optimization problems and machine learning.

USRA scientists also participated in the Summer School on Quantum Simulation of Field Theories at the Galileo Galilei Institute for Theoretical Physics, organized in collaboration with the Department of Energy, National Quantum Information Science Research Centers, Superconducting Quantum Materials and Systems Center (SQMS).

Student R&D Programs

The NASA Academic Mission Services (NAMS) Student R&D Program engages a diverse set of students from universities, including minority serving institutions. Internship projects focus on artificial intelligence, quantum information science, autonomous air vehicles, and high-performance computing. This program serves as a workforce pipeline, with a significant number of students converting to full-time staff to support technical projects with federal sponsors.

As one highlight from this past year, USRA collaborated with students and faculty from Howard University, Hampton University, Morgan State University, Navajo Technical University and Foothill College on an integrated portfolio of projects applying emerging technologies (e.g., artificial intelligence/machine learning and advanced air mobility) to disaster use cases (e.g., wildfires and floods).

President's Award Recipients and Other Award Winners

The USRA President's Awards recognize outstanding achievements by all USRA staff, reflecting performance well above normal expectations for a given job assignment. The awards come in three categories, and include monetary prizes:

- USRA Distinguished Service Award: For sustained, exceptional contributions to USRA's mission and purpose by an individual, which reflect great credit upon USRA or its partner organizations in academe, government, and industry
- USRA Individual Excellence Award: For excellence by an individual in research, development, or other areas, consistent with USRA's mission and purpose, that demonstrates USRA's values of Passion, Partnerships, and Professionalism
- USRA Team Excellence Award: For excellence by a team in research, development, or other areas, consistent with USRA's mission and purpose, that demonstrates USRA's values of Passion, Partnerships, and Professionalism

This Years' Award Winners Are:

USRA Distinguished Service Award: Dr. Allan Treiman, Lunar and Planetary Institute (LPI) for his consistent and important contributions to the field of planetary science

USRA Individual Excellence Award: Dr. Elizabeth (Liz) Moore, Stratospheric Observatory for Infrared Astronomy (SOFIA) for making SOFIA a high functioning astronomical observatory

USRA Individual Excellence Award: Ms. Denisse Garza, Air Force Research Laboratory (AFRL) Scholars for her relentless efforts to assure "Scholars" achieves not only AFRL's objectives for the program, but a rewarding and fulfilling experience for the student participants

USRA Team Excellence Award: SOFIA High-resolution Airborne Wideband Camera Plus (HAWC+) Team

Peter Ashton, Reid Contente, Simon Coude, Sarah Eftekharzadeh, Murali Kandlagunta, Justin Lott, William Vacca, and Caesar (Jesse) Wirth make up the SOFIA HAWC+ team, which ensured this state-of-the-art instrument was functioning nominally and available to SOFIA participating scientists worldwide

USRA Fellow Award

Dr. Davide Venturelli

Dr. Davide Venturelli was recently appointed to the eminent position of a USRA Fellow, a position held by only one other USRA scientist, Dr. Bill Meyer. The Fellows program recognizes USRA's most distinguished scientific and technical staff for their accomplishments over a sustained period and the recipients must be internationally recognized experts in their fields and have made significant, lasting contributions.

Davide is currently Associate Director for Quantum Computing at USRA's Research Institute of Advanced Computer Science (RIACS). He has authored more than 30 publications in international journals and 15 juried conference papers. He also holds five patents spanning artificial intelligence, theoretical physics, quantum computing, and robotics.

Other Awards

Dr. Paul Schenk

Paul Schenk

Senior Scientist at the Lunar and Planetary Institute, received the 2021 Fred Whipple Award, the highest honor given by the Planetary Sciences section of the American Geophysical Union (AGU) for significant contributions to the field of planetary science from a mid-career or senior scientist.

Dr. Lisa Gaddis

Lisa Gaddis

Director of the Lunar and Planetary Institute, was honored with the prestigious Eugene Shoemaker Distinguished Scientist Medal by NASA's Solar System Research Virtual Institute (SSERVI) for her significant contributions throughout her career to understanding the Moon and other small bodies in our solar system.

Dr. Allan Treiman

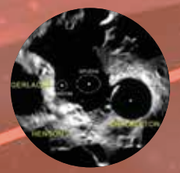
Allan Treiman

Principal Scientist at the Lunar and Planetary Institute, is the recipient of the 2022 G.K. Gilbert Award presented by The Geological Society of America (GSA) Planetary Geology Division (PGD) for his outstanding contributions to the field of planetary geology. Additionally, Treiman was awarded the 2021 USRA Distinguished Service Award in recognition of his outstanding career and his 29 years at the LPI.

Andrew Shaner

Andrew Shaner

Senior Education Specialist at the Lunar and Planetary Institute, is the recipient of the 2022 Ronald Greeley Award for Distinguished Service, presented by The Geological Society of America Planetary Geology Division for his contributions to the planetary community and engagement of the younger generation in planetary sciences.



Paul Spudis

(1952–2018) of the Lunar and Planetary Institute has a place on the Moon named in his honor for his outstanding and fundamental contributions to the field. Spudis crater is located near the Moon's south pole and is 13 kilometers in diameter.

William Cleveland

William Cleveland

William Cleveland at USRA's Science and Technology Institute received the NASA Silver Achievement Medal for exemplary support and commitment to NASA and the Gamma-ray Burst Monitor Mission.

Douglas Swartz (far right)

Douglas Swartz

Douglas Swartz received the NASA Exceptional Public Service Medal for unceasing support of critical NASA X-ray missions, including the Chandra X-ray Observatory and the Lynx X-ray Observatory concept, and the mentoring of future scientists.

Community Leadership

Lunar and Planetary Institute

Senior Scientist Paul Schenk is a member of the Planetary Science and Astrobiology Decadal Survey 2023–2032 of the U.S. National Academies for Science, Engineering and Medicine.

Senior Scientist and Associate Director Walter Kiefer serves as editor of the *Journal of Geophysical Research:* Planets. LPI Director Staff Scientist Julie Stopar is Vice-Chair of the Mapping and Planetary Spatial Infrastructure Team (MAPSIT) and serves on various "special action teams" for the Lunar Exploration Analysis Group (LEAG). LPI Director Lisa Gaddis also serves (Ex Officio) on LEAG. Senior Scientist Pat McGovern is a member of the Venus Exploration Analysis Group (VEXAG) Steering Committee. Staff Scientist Kennda Lynch is a member of the Outer Planets Assessment Group (OPAG) Steering Committee and the Mars Exploration Program Analysis Group (MEPAG) Steering Committee. Principal Scientist David Kring leads the LPI-JSC Center for Lunar Science and Exploration (CLSE) team, part of NASA's Solar System Exploration Research Virtual Institute.

Silver Snoopy Award From NASA

The Silver Snoopy award is a special honor awarded by NASA to NASA employees and contractors for outstanding achievements related to human flight safety and mission success. This year, it was awarded to USRA's Gordon Berger and to Chris Pestak, formerly of USRA. Gordon Berger received the award "in recognition of commitment to ground safety and ingenuity in addressing these issues to enable safe conduct of a variety of investigations designed to ensure crew safety in the event of fire in future spacecraft".

Gordon Berger (center) receives NASA's Silver Snoopy Award for Space Flight Awareness

USRA Distinguished Undergraduate Awards

Established to honor the service and memory of individuals who made significant contributions to their fields and to USRA, these awards are made possible by financial contributions, including those made by USRA Employees.

In 2022, USRA added a new award – The Judith L . Pipher Memorial Scholarship Award – to honor the memory of Dr. Judith L. Pipher. With the establishment of this new award, USRA will now routinely offer five Distinguished Undergraduate Award Scholarships. Dr. Pipher served USRA in various capacities including Vice Chair of the USRA Board.

Judith L. Pipher Memorial Scholarship

Theo O'Neill
Astronomy-Physics and Applied Statistics
University of Virginia

In keeping with its goal to recognize and develop promising future scientists and engineers in space-related disciplines, USRA bestows these awards to honor outstanding undergraduate students in a variety of majors through a competitive process. In 2022, we established the Judith L. Pipher Memorial Scholarship in honor of the former Representative from the University of Rochester who had played an important role in the field of infrared astronomy and in USRA.

In 2022, USRA received 85 eligible applications from 57 different universities (including 31 member universities) and 23.5 percent of the applicants were underrepresented students. Eleven applicants were from minority serving institutions, nearly double from previous years.

John R. Sevier Memorial Scholarship

Sabrina NoorAhmad-Yarzada
Electrical Engineering and Computer Engineering.
University of California, Davis

The Following Students were the Winners of the USRA 2022 Distinguished Undergraduate Awards:

Frederick A. Tarantino Memorial Scholarship

Jennifer Berry
Mechanical Engineering
University of Canterbury

Thomas R. McGetchin Memorial Scholarship

Claire Blaske
Astrophysics
Arizona State University

James B. Willett Education Memorial Scholarship

Brooke Carruthers
Molecular and Cellular Biology
University of Arizona

Madison VanWyngarden
Astronomy & Physics
Boston University

Shane Riley
Mechanical Engineering & Computer Science, University of Pittsburgh

Isabella Macias
Astrophysics
University of Florida

Honorable Mentions:

Amelia Korveziroska
Physics Engineering
Illinois State University

Kevin Boes
Mechanical Engineering
Purdue University

Partnerships and Cooperative Agreements

USRA was established in 1969 by the National Academy of Sciences at the request of NASA, with a purpose to "provide a means through which universities and other research organizations may cooperate with one another, with the Government of the United States and with other organizations." The fulfillment of this purpose is enabled through partnerships, both big and small, with academia and industry, in support of government initiatives to advance science and technology through research and workforce development initiatives.

Industry Partnerships

USRA has pivoted along with key sponsors, most notably NASA, towards substantial partnerships with the commercial space industry. Evidence of this shift includes the series of partnerships just within the GEARS Program for work supporting human landing systems (HLS), NASA's Gateway, and the Commercial Lunar Payload Services (CLPS) Program. GEARS scientists also joined with industry colleagues to submit a Research Campaign white paper to the Biological and Physical Sciences Research in Space Decadal Survey for 2023-2032 to establish a Soft Matter Institute.

The LPI science staff are teaming with Intuitive Machines in the Houston area on novel lunar lander concepts in support of a variety of new NASA Discovery mission concepts. USRA's Commercial LEO Destinations (CLD) team continue to engage with Zin Technologies in the conceptual design and concept of operations for the Starlab LEO commercial space station to eventually replace the ISS National Laboratory after its deorbit at the end of the current decade.

New Partnership Supports Student Research Opportunities

Universities Space Research Association (USRA) launched a unique partnership between the U.S. Space Force (USSF) and the Air Force Research Laboratory (AFRL) to advance scientific and technical research at eight selected universities. The University Consortium Research Opportunity (UCRO) announcement signifies the beginning of a critical partnership between USSF and AFRL that connects government with academic research.

UCRO provides undergraduate, graduate, and postdoctoral fellows with authentic research opportunities, in collaboration with USSF and AFRL, that increase interest in science, technology, engineering, and mathematics (STEM) careers of the future.

AFRL Future Scholars and STEM Workforce Development Programs

USRA was awarded a new cooperative agreement entitled "Air Force Research Laboratory (AFRL) Future Scholars and STEM Workforce Development Programs". This program is designed to strengthen the scientific and technical workforce pipeline on behalf of the Department of Defense (DOD) by offering immersive and project-based learning opportunities for students, postdoctoral fellows and K-12 STEM professional educators.

Background Image Courtesy: Forge Branding

University Engagement

USRA's university engagement includes engagement with member and non-member universities in research collaborations; maintaining the active involvement of universities in our governance and oversight; and advocating, in Washington, D.C. on key issues identified by our members as important to university space-related research and education.

University Engagement at LPI

The Lunar and Planetary Institute (LPI) is involved in active collaborations with numerous university faculty and students throughout the world, primarily through NASA-funded mission teams and PI-led science investigations.

The NASA SSERVI program's Center for Lunar Science and Exploration (CLSE) led by USRA's David Kring at LPI has partnerships with research teams at several universities including Johns Hopkins University/APL, University Hawaii, Open University (UK), Sherbrooke University (Quebec, Canada), University Texas El Paso, and the University Muenster (Germany). Candice Bedford, a USRA Scientist at LPI, traveled to Iceland in summer 2022 to conduct field exercises for the NASA-funded Semi-Autonomous Navigation for Detrital Environments (SAND-E) science team, working with Johnson Space Center scientists and members from various universities.

USRA's Kennda Lynch at LPI also visited Iceland in summer 2022 to support the Digging Iceland Geology for Mars Analog Research Science (DIGMARS) collaboration to investigate Mars analogs, working with teams from NASA Johnson Space Center, and several universities.

The LPI Science Council, chaired by Prof. Jessica Sunshine, University of Maryland, met virtually on June 1, 2022 to discuss recommendations from June 2021 Science Council meeting, the LPI recompete strategy, and the LPI strategic plans for joint astromaterials research with JSC/ARES.

The USRA CEO and LPI Director attended the NASA "HBCU/MSI Technology Infusion Road Tour" at Texas Southern University in Houston, Texas. The program offered attending universities access to unique internships for their students and summarized for them many current and future Science, Technology, Engineering, and Mathematics (STEM) and research-focused partnership opportunities with NASA and other affiliated institutions.

Governance & Member Universities

Universities Space Research Association Board of Trustees 2022 – 2023

Standing (L to R): Daniel E. Hastings, Massachusetts Institute of Technology (Region I); Kathleen C. Howell, Purdue University (Region VI); Wayne A. Scales, Virginia Polytechnic Institute and State University (Region III); Alfred Krabbe, University of Stuttgart (Region V); Robert P. McCoy, University of Alaska Fairbanks (Region IX); Louis Lanzerotti, New Jersey Institute of Technology (Region II); Truell W. Hyde, Baylor University (Region VII)

Seated (L to R): Kim P. Williams, Lawrence Berkeley National Laboratory (ret.) (At-Large, Financial); Jeffrey Issacson, President & CEO; John Montgomery, Naval Research Laboratory (ret.), Board Chair (At-Large); Berrien Moore III, University of Oklahoma, Board Vice Chair (Region VIII); Gen. Lester L. Lyles, U.S.Air Force (ret.) (Atl-Large),

Not present: Brian Gilchrist, COI Chair; Elizabeth A. Lada, University of Florida (Region IV); Natalie W. Crawford, RAND Corporation (At-large)

USRA is an association of 116 doctoral degree-granting universities engaged in space and aeronautics related research and education. University membership ensures broad public oversight of the corporation, as it engages in activities to fulfill its nonprofit purpose of "development and application of space-related science, technology, and engineering."

The university members comprise a Council of Institutions. Because of the ongoing pandemic, the 2022 Annual Meeting of the Council was held virtually. Nonetheless, the USRA President and Chief Executive Officer, and the Chair of the Board of Trustees reported on USRA activities. The Council voted to approve the membership of University of Zurich. Later in the year the Council voted to approve the membership of Embry-Riddle Aeronautical University.

The members elect a Board of Trustees, which govern USRA and appoint the USRA President and CEO.

Image Courtesy: Forge Branding

USRA Member Universities

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

Public Policy and Advocacy

USRA provides a voice on public policy issues important to the university community through the Issues and Program Committee (IPC). Comprised of representatives from USRA member universities in nine geographic regions, the IPC formulates public policy positions, meets with members of Congress and their staffs, provides testimony as requested, and organizes the program for a symposium held in conjunction with the Annual Meeting of the member universities in Washington.

On Friday, April 1, 2022, the IPC visited Capitol Hill in Washington, D.C. to advocate for space research at our Nation's universities. IPC members thanked Members of Congress and their staff for their support and reported on the status of university-based space research. The committee met with Congressional offices, including Rep. Don Beyer (D-VA), Rep. Ed Perlmutter (D-CO), Rep. Grace Meng (D-NY), Rep. Brian Babin (R-TX), and Rep. Matt Cartwright (D-PA).

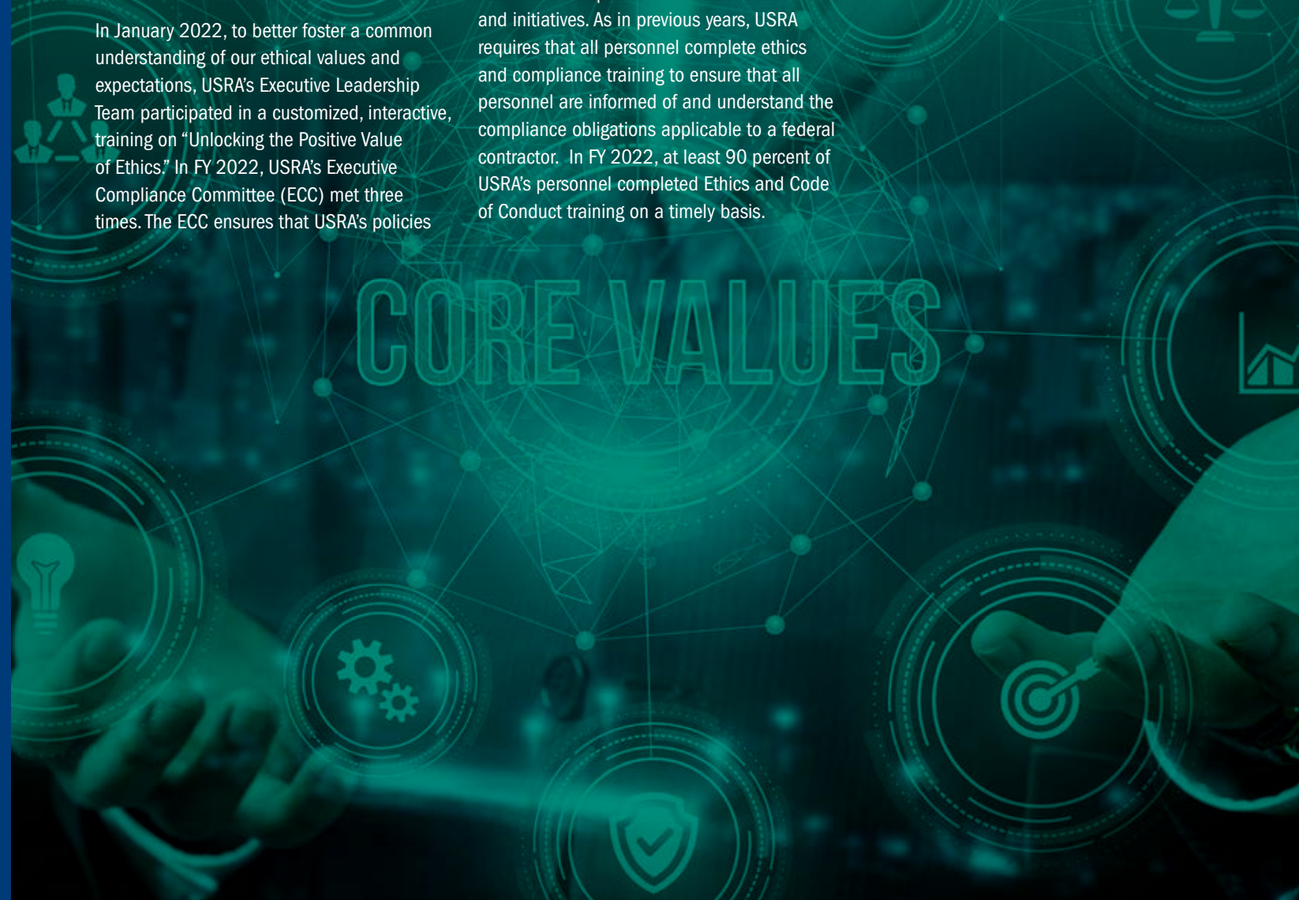
For the fourth consecutive year, Congress has decided to include language in annual Appropriations legislation encouraging the funding of 'University Small Missions.' The IPC successfully advocated for the inclusion of $30 million in the House-passed NASA Fiscal Year 2022 Commerce, Justice, Science appropriations bill for university-led small satellite missions. Such SmallSat and CubeSat missions provide research opportunities for universities and training for the next generation of scientists and engineers.

Ethics and Compliance

USRA remains committed to fostering an organizational culture of excellence and integrity. USRA personnel, consultants, and vendors are directed to comply with all applicable policies, regulations, and laws and are expected to conduct USRA's business in an ethical manner, by acting not merely within the letter but also the spirit of the law. USRA personnel, consultants, and vendors are also expected and encouraged to report any conduct or circumstances that they believe may violate USRA's values.

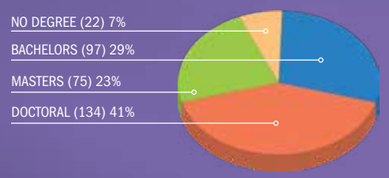
Program Developments

In January 2022, to better foster a common understanding of our ethical values and expectations, USRA's Executive Leadership Team participated in a customized, interactive, training on "Unlocking the Positive Value of Ethics." In FY 2022, USRA's Executive Compliance Committee (ECC) met three times. The ECC ensures that USRA's policies and procedures are reasonably designed, communicated, implemented, enforced, and generally effective at preventing and detecting legal or ethical misconduct. USRA's Chief Ethics and Compliance Officer (CECO) continued to advise senior management on ethics and compliance-related policies and issues; updated internal ethics and compliance resources for employees; provided advisory ethics opinions to personnel; and received, investigated, and addressed -ethics complaints. The CECO regularly informed the Board and USRA senior management about ethics and compliance-related incidents and initiatives. As in previous years, USRA requires that all personnel complete ethics and compliance training to ensure that all personnel are informed of and understand the compliance obligations applicable to a federal contractor. In FY 2022, at least 90 percent of USRA's personnel completed Ethics and Code of Conduct training on a timely basis.



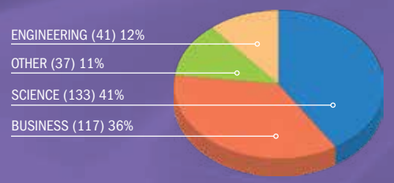
USRA's Diversified Workforce

Employee Distribution by Degree



Approximately 41 percent of USRA's workforce hold Doctoral degrees, and another 23 percent hold Masters.

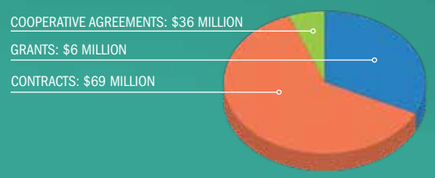
Employee Distribution by Areas of Study



Approximately 63 percent of USRA's workforce comprises scientists and engineers.

Financial Highlights

FY 2022 Revenue Distribution



For FY 2022, USRA's annual revenue was $111 million. USRA's portfolio of programs weathered COVID-19 with modest impact to revenue.

FY 2022 Assets

Total Assets: $60.6 million
Net Assets: $37.3 million

USRA's Total Assets for FY 2022 were $60.6 million and Net Assets were $37.3 million.

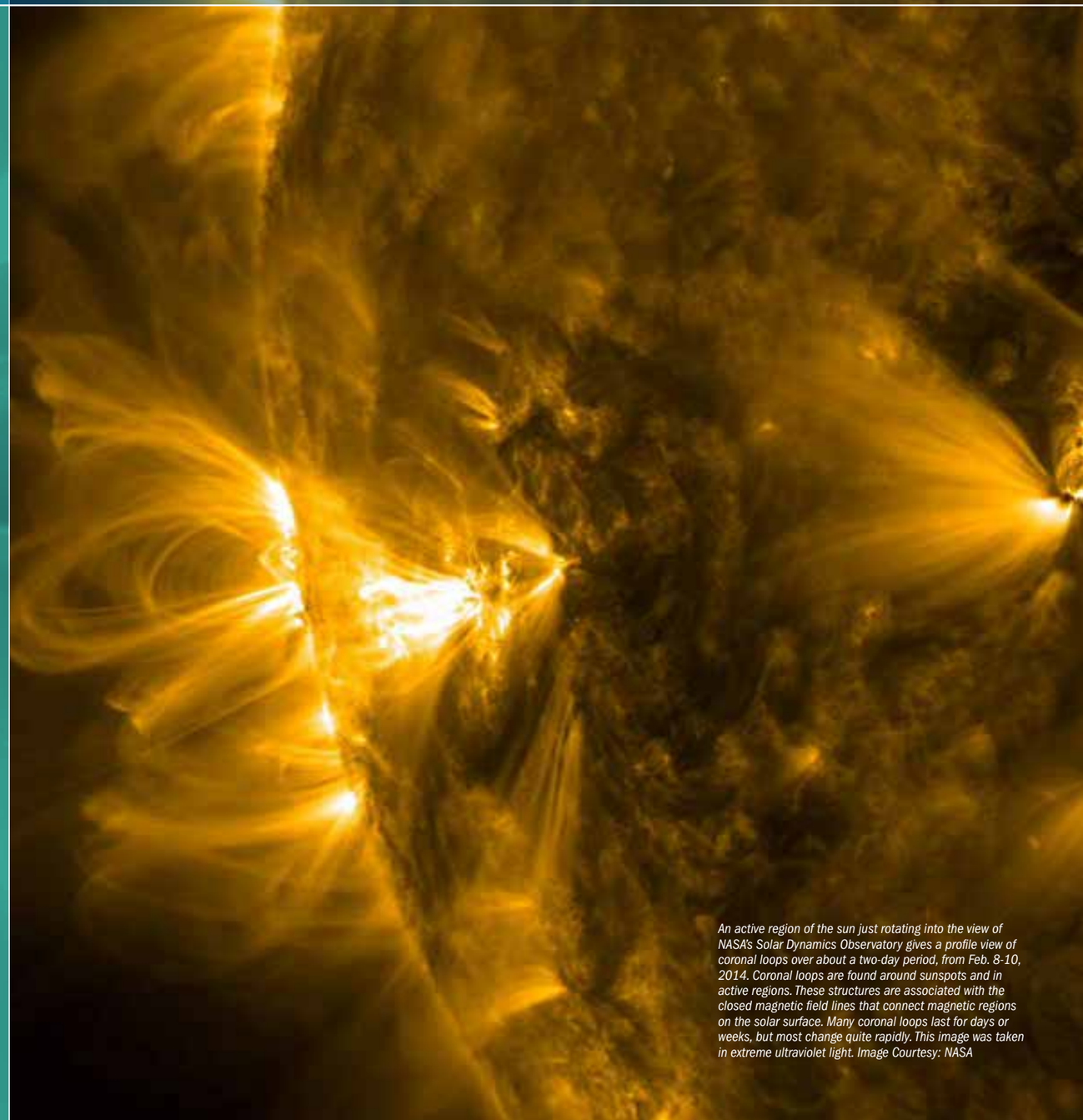
Net assets are defined as total assets minus liabilities.

USRA Annual Report Editorial Board
Suraiya Farukhi
Dennis Feerick
Rochelle Ford
Bernie Seery

ART and DESIGN
Forge Branding

Copy Editing
Suraiya Farukhi
Erin Senoz

Send Correspondence to:
Director, Communications
University Space Research Association
425 3rd Street SW, Suite 905
Washington D.C. 20024
www.usra.edu



An active region of the sun just rotating into the view of NASA's Solar Dynamics Observatory gives a profile view of coronal loops over about a two-day period, from Feb. 8-10, 2014. Coronal loops are found around sunspots and in active regions. These structures are associated with the closed magnetic field lines that connect magnetic regions on the solar surface. Many coronal loops last for days or weeks, but most change quite rapidly. This image was taken in extreme ultraviolet light. Image Courtesy: NASA

Universities Space Research Association

USRA CORPORATE OFFICES

Headquarters
425 3rd Street, SW,
Suite 950
Washington D.C., 20024
410-730-2656

3600 Bay Area Blvd
Houston, TX 77058

Image Courtesy: ETHZ\LPI\Valentin T. Bickel and David A. Kring