

**MO\_FY18\_Year-4\_APD**

**Missouri Space Grant Consortium**

**Lead Institution: Missouri University of Science & Technology**

**Director: Dr. S. N. Balakrishnan**

**Telephone Number: 573-341-4675**

**Consortium URL: <http://www.mosgc.org/>**

**Grant Number: NNX15AK03H**

**LOB: NASA Internships, Fellowships, and Scholarships; Stem Engagement;  
Institutional Engagement; Educator Professional Development**

**A. PROGRAM DESCRIPTION**

The National Space Grant College and Fellowship Program consists of 52 state-based, university-led Space Grant Consortia in each of the 50 states plus the District of Columbia and the Commonwealth of Puerto Rico. Annually, each consortium receives funds to develop and implement student fellowships and scholarships programs; interdisciplinary space-related research infrastructure, education, and public service programs; and cooperative initiatives with industry, research laboratories, and state, local, and other governments. Space Grant operates at the intersection of NASA's interest as implemented by alignment with the Mission Directorates and the state's interests. Although it is primarily a higher education program, Space Grant programs encompass the entire length of the education pipeline, including elementary/secondary and informal education. The Missouri Space Grant Consortium is a Program Grant Consortium funded at a level of \$570,000 for fiscal year 2018.

**B. PROGRAM GOALS**

The mission of the Consortium is being accomplished through the following goals and objectives:

1. Maintain and expand a network of Missouri universities and corporate partners with interests and capabilities in aerospace and space related science, engineering, and technology.
2. Inspire, motivate, recruit, educate, and train students, especially women, underrepresented minorities, and persons with disabilities, for professional careers in all disciplines of interest to NASA.
3. Promote and enhance a strong science, technology, engineering, and mathematics (STEM) education base from elementary through university levels.
4. Support interdisciplinary education, research, and public service programs involving the STEM fields.

5. Encourage cooperative education and training programs in aerospace and space related science, engineering, and technology among universities, aerospace industry, and other federal, state, and local entities.

#### Metrics for Measuring Goal Achievement

The proposed efforts of mentoring, teaching, advising, nurturing, and associated scholarly activities will be assessed by the following set of outcomes as can be quantitatively related to NASA's Strategic Education Outcomes 1, 2, and 3:

- Number of Directly Supported Participants
- Number of Participants Entering into STEM-Field Disciplines upon Graduation
- Diversity of Directly Supported Participants
- Number of NASA Field Research Center and Corporate Internships
- Number of Journal Articles and Conference Papers Published
- Number of Student Research Groups and Engineering Design Teams
- Number of Teachers and Students Participating in Pre-College Programs
- Number of Persons Served in Informal Education Programs

#### C. PROGRAM/PROJECT BENEFITS TO PROGRAM AREAS

##### Outcome 1: Employ and Educate

The Missouri Consortium's Fellowship & Scholarship, Higher Education, and Research Infrastructure programs specifically address the objectives of NASA's Education Outcome 1. In FY2018 there were 97 directly supported students participating in independent research, course development, and laboratory development. There were an additional 498 indirectly supported students that participated in engineering design team and scientific research group Higher Education projects funded by the MOSGC.

##### Outcome 2: Educate and Engage

The Pre-College Education programs supported by the MOSGC in FY2018 involved a total of 86 events (6 Educator Professional Development, 72 interactive, 8 engagement) with 95 teachers and 2883 students participating.

##### Outcome 3: Engage and Inspire

The Informal Education projects supported in FY2018 involved a total of 8 informal educators, 24 additional direct participants, and 1,934 indirect participants. Projects meant to bring inspiration and informal education to the general public include telescope observation and night sky viewing programs, public lectures, and public flight demonstrations.

#### D. PROGRAM ACCOMPLISHMENTS

*Outcome 1: Contribute to the development of the STEM workforce in disciplines needed to achieve NASA's strategic goals:*

The Missouri Space Grant Consortium has been conducting highly successful Fellowship and Scholarship, Higher Education Internship, and Research Infrastructure Assistantship programs. The competitive selection of participants is

primarily based upon academic achievement and research project merit. This year, 24% the annual program participants were graduate students and 76% were undergraduate students. These students are supported to perform independent mentored research throughout the academic year and summer, including summer internships and academy student placement at NASA Field Research Centers. The ultimate goal is to provide graduate and undergraduate research training and contribute to the national workforce in the aerospace industry and in space science related fields as needed to achieve NASA's strategic goals to educate and employ.

The students' research accomplishments were showcased at the 27<sup>th</sup> MOSGC Annual Spring Meeting, which was held on April 20-21, 2018, on the Missouri S&T campus. There were 22 faculty/staff and 80 students in attendance. This meeting featured 34 podium presentations and 22 poster presentations by students from all 11 Affiliate and Associate academic institutions.

- NASA Internships, Fellowships, and Scholarships:  
Both undergraduate and graduate students are competitively selected to participate in NASA Field Research Center Internships and Academies. These students travel to NASA Centers to perform independent research under the guidance and mentorship of professional engineers and scientists. The Missouri Consortium supported three summer interns at Marshal Space Flight Center in FY2018.

The Missouri Space Grant Consortium's undergraduate scholarships and graduate fellowships are competitively awarded to students pursuing independent faculty-mentored research in aerospace and space related science and engineering. Programs of study must relate to one or more of the NASA Mission Directorates. There were 33 undergraduate and 10 graduate students supported with fellowships and scholarships in FY2018.

- Higher Education Projects:  
The Affiliates and Associates of the Consortium are involved in a wide range of activities that are designed to promote a strong science, mathematics, and technology base at the university level. To greatly enhance the MOSGC's contribution to Outcome 1, indirect support was provided to eight design team and scientific research groups on the Affiliate and Associate campuses; thereby opening opportunities for 498 of post-secondary students to engage in authentic NASA-related mission-based R&D activities. These projects also have a significant potential to attract and retain students in STEM disciplines through a progression of educational and hands-on research and development opportunities for students, teachers, and faculty as desired in Outcome 2.
  - Student-Built Satellites  
The M-SAT Satellite Research Team from Missouri S&T is working on The Advanced Propulsion Experiment (APEX), which was accepted into the Air Force's Research Laboratory's University Nanosat 9. The APEX mission will serve as a Technology Demonstration Mission for a single, successfully

integrated multi-mode propulsion system that can operate in either chemical mode or electrical mode. This integrated propulsion system will use the same ionic liquid monopropellant for both modes. The benefit of this innovation is that it allows for wide flexibility in the mission by allowing a variable amount of propellant to be budgeted toward either mode as mission needs arise.

There are two Student CubeSat missions being pursued at Saint Louis University. The purpose of this project is to train students in the design, analysis, testing and operation of real-world spacecraft, adhering to NASA standards for quality and mission assurance. This is accomplished by developing and fielding CubeSats that are competitively launched through the NASA Educational Launch of Nanosatellites (ELaNa) program. To date, SLU has secured 4 NASA launch slots, and allowed them to leverage a fifth external opportunity.

- Student-Lead Flight Projects

Saint Louis University students are also involved in the annual *Student Unmanned Aerial System (SUAS) Competition* is hosted by the Seafarer Chapter of the Association for Unmanned Vehicle Systems International (AUVSI). This competition serves to stimulate and foster student interest in UAS and is designed to provide an ideal opportunity for students to gain valuable complementary, multi-disciplinary and systems engineering knowledge. The focus of this competition is to engage students in systems engineering and creating a total solution to complex, potentially real world problems. In order to address this, the student teams would have to design, develop, and fabricate an unmanned aerial system capable of completing specific autonomous operations, including takeoff, navigation, Sense, Detect and Avoid, among others, subject to several constraints on time and other mission parameters as well as analyze and validate its performance through flight test demonstration.

Another student design team at Saint Louis University is working to enhance educational and research use of remote sensing data from unmanned aircraft systems (UAS) to increase efficient data collection, fusion of data from multiple sensors and post-flight processing to simplify agricultural monitoring. Predictive monitoring of crop responses to abiotic stress using field and airborne remote sensing data are. This project includes field and airborne hyperspectral data, and crop phenotyping and physiological analysis.

There were four student-lead flight projects supported at Missouri S&T:

*Miner Aviation* designs, builds, and operates a heavy lift aircraft to compete in the annual SAE Aero Design Competition. Missouri S&T competes in the Advanced class of the competition which focuses on the practical application of heavy lift aircraft. Teams must carry a fixed payload on the aircraft along with a humanitarian aid payload (sandbags) which must be accurately dropped on a target from a minimum altitude of 100 feet. The class also

allows the use of composite materials and requires competitors to stream live video and telemetry data from the aircraft. Miner Aviation works to optimize every design based on performance analysis from previous designs. This competition provides Missouri S&T students with a unique opportunity to get firsthand experience in the design, manufacturing, testing, and practical application of aerospace vehicles.

The *Solid-Fuel Rocket Design Team* provides its members a chance to apply concepts learned in class to real world situations through national competitions. The team operates as a small Aerospace company which does its own design, manufacturing, marketing, and budgeting; and also provides students with an opportunity for interdisciplinary cooperation in advancing quality designs of competitive aerospace vehicles. This year, the Rocket Design Team competed in the Spaceport America Cup hosted by the Experimental Sounding Rocket Association (ESRA). This competition draws universities from all over the world to design, test, and build a rocket to meet the competition's specifications, where the final scores are based largely on the rocket's final flight performance. Before the teams are allowed to launch, each participant goes through an event cycle that involves rigorous research and testing, technical reports, and presentations. As part of the competition, teams must also integrate a scientific payload. The payload may be experiments that researchers on campus need to test or an experiment created by elementary through high school students.

The *Liquid-Fuel Rocket Design Team's* current main project is designing and building a rocket engine test stand that will serve the team for many years. Structural design, instrumentation, control, and fluid flow of both gases and liquids all come together in the project. The test stand has been designed to accommodate a large range of possible future engines, with the largest producing 2,000 lbf of thrust. Once the test stand is built, the team will perform cold flow tests using water and inert liquid nitrogen (instead of fuel and oxygen) to verify its functionality of its first engine.

The *Multirotor Robot Design Team* (MRR) is comprised of a group of Missouri S&T students interested in multirotor flight, robotics, and competition. MRR exists to provide students an opportunity to learn more about engineering and teamwork. Team members will take advantage of the resources at Missouri S&T and explore the many possibilities that a career in engineering offers. Through interdisciplinary collaboration, members will work together to design and build an autonomous flying robot that will represent S&T at the International Aerial Robotics Competition (IARC). This process will include researching, designing, building, and testing of aerial robots.

- Mizzou Students' Underwater Robotics Foundation (SURF) at UMC has designed and built an autonomous underwater vehicle (AUV) capable of performing a variety of underwater tasks. AUV's have many real-life

applications from marine biology studies to oceanography to space exploration.

- The Mars Rover Design Team improved upon their previous University Rover Challenge entry to stay ahead of the technical curve and lead the cutting edge with regard to their drivetrain design, making the suspension more durable and reliable, while also maintaining its terrain dominance and maneuverability. Additionally, they improved upon their science capabilities: an advanced collection mechanism that allows for rapid and accurate sample retrieval. A core drill allowed them to analyze undisturbed layers of soil and evaluate geological phenomena spanning thousands of years. The most notable advancement this year was the rover's autonomous capabilities. An on board autonomous system allowed the rover to utilize on-board cameras and LIDAR system to map encountered terrain and aid in decision making in order to avoid hazardous obstacles.
- The Multidisciplinary Astrobiology Research Community at Truman State University – continues to capitalize on the momentum created by the prior funding and the creation of the Center for Astrobiology to continue the activities of the multidisciplinary astrobiology research community. Following the highly successful model from previous years, teams will pursue astrobiology research projects, participate in weekly community-building events, and take a field trip to an astrobiology-related research site. This project will support the activities of the vigorous and productive astrobiology research program at Truman, strengthen the new Center for Astrobiology, and inspire students from a range of science disciplines to consider careers in astrobiology.
- The Consortium also invested in the curriculum development of NASA-related course resources for integration into STEM disciplines at the university level. The “Astrobiology Seminar Course” is a one-credit-hour course that meets once per week. This course is discussion-based and focuses on current topics relevant to astrobiology. These discussions are based on recently published papers and books.
- Metropolitan Community College of Kansas City (MCKC) enhanced its connections with a local informal education provider (Kansas City FIRST Tech Challenge), inspiring and educating students at both the high school and community college level through expanded participation in local and regional robotics competitions.

The Kansas City FIRST Tech Challenge (FIRST Robotics) regional planning committee supervised a mini-competition at the MCKC Business & Technology campus. Competitors included local high school FTC teams and two college-age teams. The competition used FTC equipment based on previous FIRST Robotics Competition games scaled down to an appropriate field size.

MCC students were encouraged to network with the high school FTC coaches at the event, with the goal that MCC students sign up in the VIMS volunteer management system on the FIRST website, and then volunteer with a local high school FTC team that is in need of mentors.

- Research Infrastructure Projects:  
Research Infrastructure Assistantships: Both undergraduate and graduate students are competitively selected to assist in the support of Research Infrastructure Development projects at the Affiliate Institutions. Students work directly with faculty to develop, maintain, and enhance the capability to perform cutting-edge research at the Consortium's affiliate institutions. There were seven Research Infrastructure Assistantships awarded this year.
  - Robotic Autonomous Telescope: Astronomy researchers at Missouri State University are in the process of commissioning a telescope to be used for remote and automated operations, chiefly for a sky survey project, but also for enhancing astronomy laboratories. This project includes the installation of a telescope, dome, weather station, and various webcams for remote and automated operation.
- Pre-College Projects:  
The primary goal of the Consortium's Pre-college Education Program is to expose aerospace and space related science, technology, and engineering topics to young students in such a way as to be an enjoyable learning experience; leaving students, parents, and teachers with a better appreciation for and understanding of these disciplines. The Consortium's approach to many of these activities is to assist pre-college educators with developing and presenting programs and activities. The assistance may include use of technical/scientific staff and facilities, logistical support, and modest amounts of funding for program materials. The following K-12 Projects involved a total of 72 Interactive Events with 79 teachers and 2592 students directly participating along with 8 Engagement Events with a total of 307 indirect participants:
  - Classroom Visits - Missouri State University supported visits by faculty, researchers, and/or advanced students to K-12 school classes in the Southwest Missouri area to present illustrated talks on astronomy, space research and other NASA related activities.
  - The Introduction to Aerospace Engineering program at Missouri S&T provides hands-on aerospace laboratory experience to secondary students in research fields of aeronautics, structures, propulsion, and flight simulation. High school students attend short lectures, observe demonstrations, and conduct experiments in on-campus aerospace engineering laboratories under the guidance and direction of higher education faculty, staff, and students. The objective of this project is to increase enrollment in STEM disciplines and inspire interest in pursuing aerospace-related STEM careers.

- The Challenger Learning Center's *Educator Scholarship Program* provided elementary and middle-school educators with the knowledge, resources, and tools to help their students be innovative, successful, and lifelong learners by increasing students' knowledge of and interest in science and engineering. The professional development workshops are designed to enhance educators' capabilities of utilizing NASA's scientific and technical expertise through exposure to NASA resources provided to them during professional development workshops. In addition, the Challenger Learning Center's newest mission, *Earth Odyssey*, which is available for student groups to participate in, directly connects to NASA's Area of Emphasis of Environmental Science and Global Climate Change.
- The *5th Grade Planetarium Program* at the University of Missouri in St. Louis works with the Saint Louis City and County schools to bring students to their campus for demonstrations and a planetarium show. In May of 2015, UMSL began a new program utilizing a Spitz SciDome planetarium projector, located in the Research building on the UMSL campus.
- Informal Education Projects:  
The Consortium's Informal Education programs included Telescope Observing Sessions being held at MSU, UMKC, and UMSL; along with SLU-facilitated UAV demonstration flights at The Saint Louis Science Center, involving a total of 32 direct participants and 1,934 indirect participants.
  - The Warkoczewski Public Observatory (the 'Warko', WPO), located on the UMKC campus and the Powell Observatory Complex (POC) owned and operated by the Astronomical Society of Kansas City (ASKC) has been a key focal point of astronomy education and public outreach (EPO) efforts in the Greater Kansas City Metropolitan Area for over 44 years. Such public events are an effective tool for communicating the joy and impact of NASA-related science to interested citizens.

#### E. PROGRAM CONTRIBUTIONS TO NASA EDUCATION PERFORMANCE GOALS

- **Diversity:**  
The Affiliates, Associates, and other partners are geographically distributed relatively uniformly throughout the state, yielding a wide range of demographic diversity. The most recently published NASA-targeted minority participation from the National Center of Education Statistics for all postsecondary institutions in Missouri for Fall 2016 was 18.7% (please see NCES Table dt17\_306.60). The 97 directly supported MOSGC students in FY2018 were comprised of 43.3% females and 29.9% NASA-targeted minorities. For the 56 students with significant awards there were 32.1% female and 21.4% minority participants.
- **Minority Serving Institution Collaborations:**  
The Missouri Consortium continues to support activities at Lincoln University of Missouri in Jefferson City (HBCU). This year's independent research program at

LU involved one graduate and eight undergraduate directly supported students. Research topics included investigations into the 'Rapid Detection of Pathogens'.

The Consortium is also continuing to support a partnership between Saint Louis University and Harris-Stowe State University. This project involves training underrepresented students with data visualization tools. Students will be introduced to remote sensing concepts and data from satellites and UAS systems, and explore the possibilities for 360-degree visualization of UAS datasets for agricultural and environmental studies using a low-cost wearable Virtual Reality (VR) platform.

- **Office of Education Annual Performance Indicators:**

- API 3.3.3: STEM-18-1 56 Directly Funded Students with Significant Awards
- API 3.3.5: STEM-18-5 106 Paper Presentations and Peer-Reviewed Research Publications

F. IMPROVEMENTS MADE IN THE PAST YEAR

A major operational improvement was achieved in the most important event run by the Missouri Space Grant Consortium. The Consortium's website was revised to accommodate the creation of a new online annual state meeting registration and report upload process. Considering that there were 22 faculty, 80 students, and 17 guests for a total of 119 attendees from 11 institutions, this process proved to be quite helpful.

G. CURRENT AND PROJECTED CHALLENGES

We are encouraging more competitiveness in the funds handled by the affiliate members. It is now better than last year. We will continue to encourage more dissemination and competition.

We will be looking at new strategies to involve community and technical college (CTC) participation in the Space Grant Consortium activities. This problem seems to have been faced by many other states also; we are getting some advice from Space grant consortia as to how they improved on the CTC participation in this respect.

H. PROGRAM PARTNERS AND ROLE OF PARTNERS IN PROJECT EXECUTION

The Missouri Space Grant Consortium is composed of the Lead Institution, six Affiliates, four Associates, and two Community Colleges with a fairly even balance of science and engineering disciplines that have specialization in research areas of interest to NASA. Each member institution pursues projects that best suit their unique capability and contribute the overall success of the Consortium, as summarized in the Outcomes section above. The Affiliates have been highly effective in promoting and executing NASA related opportunities on their campuses and in their local communities, which is considered one of the Consortium's greatest strengths. Some of the Affiliates collaborate in Space Grant activities with Associate Members of the Consortium. Furthermore, the Affiliates are being encouraged to seek out and join with organizations of common interest to increase the number of

Associates and thereby extend the scope and reach of the Consortium. The list of current MOSGC Affiliate and Associate Members along with their core departments is as follows:

**Affiliate Members**

- Missouri University of Science & Technology (MS&T - Lead Institution)  
Department of Mechanical and Aerospace Engineering
- Missouri State University (MSU)  
Department of Physics, Astronomy, and Materials Science
- University of Missouri – Columbia (UMC)  
Department of Mechanical and Aerospace Engineering  
Nuclear Science and Engineering Institute
- University of Missouri – Kansas City (UMKC)  
Department of Physics and Astronomy
- University of Missouri - St. Louis (UMSL)  
Department of Physics and Astronomy
- Washington University in St. Louis (WashU)  
Department of Mechanical Engineering and Material Science
- Lincoln University of Missouri (HBCU)  
Department of Life and Physical Sciences

**Associate Members**

- Challenger Learning Center of St. Louis
- St. Louis University  
Parks College of Engineering, Aviation, and Technology  
Center for Sustainability
- Truman State University  
Department of Physics  
Department of Chemistry  
Department of Biology
- Astronomical Society of Kansas City

**Community and Technical Colleges**

- Moberly Area Community College
- Metropolitan Community College – Kansas City