FY 2019 Year 5 Extension Annual Performance Document

MO_FY19_Year5-Ext_APD

Missouri Space Grant Consortium Lead Institution
Director: S.N Balakrishnan
Telephone Number: 573-341-4675
Consortium URL: http://web.mst.edu/~spaceg
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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 $581,396 for fiscal year 2019.

A. 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 Employment 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 Projects and Persons Served in Informal Education Programs

B. PROGRAM/PROJECT BENEFITS TO PROGRAM AREAS

*Provide concise, significant, and meaningful **highlights or anecdotes** (no more than three) that are directly related to work completed in FY 2019, highlighting student and/or project accomplishments. Specify alignment to Space Grant program areas/ elements.*

Outcome 1: Employ and Educate

The Missouri Consortium's NASA Internship, Fellowship & Scholarship, Higher Education, and Research Infrastructure programs specifically address the objectives of NASA's Education Outcome 1. In FY2019 there were 87 directly supported students participating in independent mentored research, course development, and laboratory development. There were an additional 635 indirectly supported students that participated in engineering design team and scientific research group projects funded by the MOSGC.

Outcome 2: Educate and Engage

The Pre-College Education programs supported by the MOSGC in FY2019 involved 11 projects with a total of 45 events (7 Educator Professional Development, 31 Interactive K-12, 8 K-12 Engagement/Outreach) with 74 K-12 teachers and 1138 pre-college students participating.

Outcome 3: Engage and Inspire

The FY2019 Informal Education program supported a total of 8 projects with a total of 56 events (11 Demonstrations, 4 Exhibits, 13 Lectures, 25 Telescope/Night Sky Observing Sessions, 3 Satellite Tracking Sessions) involving 13 Informal Educators, 7 Higher Education Faculty Facilitators, 20 Higher Education Student Facilitators, 2 In-Service K-12 Teachers, 113 indirectly participating Pre-College Students, 175 indirectly participating K-12 Teachers, and 2190 General Public participants. Projects meant to bring inspiration and informal education to the general public include telescope observation and night sky viewing programs, satellite tracking events, public lectures, and public UAV flight demonstrations.

C. PROGRAM ACCOMPLISHMENTS

Refer directly to the specific consortium goals and SMART objectives in your base and augmentation proposals when describing your accomplishments. Describe the accomplishments as referenced to each of the five Space Grant Program Areas. The accomplishments should be a summary of the accomplishments rather than a specific description of each individual activity.

a) NASA Internships, Fellowships, and Scholarships:
b) Higher Education Projects:
c) Research Infrastructure Projects:
d) Precollege Projects:
e) Informal Education Projects:

a) NASA Internships, Fellowships, and Scholarships

i) 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 NASA Missouri Space Grant Consortium sponsored seven NASA Center Internships in FY2019 (four undergraduates and three graduate students) at the following facilities:

- Ames Research Center (2)
- Goddard Space Flight Center (1)
- Jet Propulsion Laboratory (1)
- Langley Research Center (2)
- Marshall Space Flight Center (1)

These students were selected by the MOSGC Director from the state-wide pool of applicants in the on-line NASA Internship Application System in cooperation with research mentor placements facilitated by NASA Center Internship Program Coordinators.

ii) The Consortium supports on-campus Fellowships and Scholarships to participate in faculty-mentored independent research activities and academic-based programs at most of its Affiliate and Associate Institutions. Programs of study must relate to STEM-field research projects that are aligned with the interests and objectives of one or more of NASA's Mission Directorates' priorities. In FY2019, there were 20 Graduate Fellowships and 13 Undergraduate Scholarships.

iii) At the University of Missouri – Kansas City, the 'Bridge to the Stars' STEM recruitment program is a creative high school-to-college pipeline designed to steadily increase the enrollment and success of historically underrepresented (ethnic and racial minorities, female, low-income, and first-generation college) majors in NASA-related STEM fields. This unique program offers extended engagement in astronomy, arguably the most accessible window to science, with a professional scientist and award-winning educator through a multi-tier STEM immersion program of innovative learning, research training, and mentoring. This is a hybrid F&S/HE program involving one Faculty Mentor, three Higher Education Undergraduate Student Mentors, and eight High School Student Scholarship recipients comprised of the following components:

STEM Mentoring (Bridge Mentors): UMKC undergraduates are provided a paid internship to assist Scholars to succeed in a university science course. Mentors gain a reinforced and deeper understanding of conceptual physics as well as experience as STEM educators.

STEM Learning (Bridge Scholars): High school students are provided scholarships to enroll in a learner-centered freshman astronomy course (ASTR 150) at UMKC for college credit. Students gain a strong conceptual understanding of physical laws and critical professional development in the form of communication skills, team work experience, and quantitative problem-solving.

b) Higher Education Projects

The Affiliates and Associates of the Consortium are involved in a wide range of programs that are designed to promote a strong science, mathematics, and technology base at the university level

through opportunities to engage students in authentic NASA-related mission-based research and development activities. These projects also have a significant potential to attract and retain students in STEM disciplines through a progression of educational and hands-on experiential learning.

i) On-Campus Internships
The Consortium supports on-campus faculty-mentored independent research programs at most of its Affiliate and Associate Institutions. In FY2019, there were 3 graduate and 43 undergraduate on-campus internships directly funded. These students are provided paid internships to pursue STEM-field research projects that are aligned with the interests and objectives of the NASA Mission Directorates.

ii) Engineering Design Teams
In FY2019, the Consortium provided indirect funding to 10 Student Engineering Design Teams involving 13 Projects with a total of 635 student and 15 faculty participants at three MOSGC Affiliate/Associate Institutions.

Missouri S&T (5 Teams, 8 Projects, 472 Students, 7 Faculty Research Advisors/Mentors)
Mars Rover Design Team (159 Students, 2 Faculty Mentors)
The MRDT participates in the University Rover Challenge (URC). URC is hosted by the Mars Society at the Mars Desert Research Station in Hanksville, UT. The site is selected to simulate as accurately as possible the terrain of Mars. The competition is broken into five tasks. Systems Acceptance Review is a detailed technical document demonstrating the designs, decisions, and theories that MRDT is planning to physically use at competition. Autonomous Traversal asks the team to input GPS coordinates and then allow the Rover to maneuver itself. The Rover must then approach the coordinate while avoiding obstacles, locate an AR tag, and signal to judges when the tag is found. Equipment Servicing is a task in which the dexterity of the robotic arm is demonstrated. The team is asked to control the Rover by servicing a faux lander and initiating a launch sequence. Science Analysis Task requires team to analyze previously identified soil samples and determine the presence of life. Students are then required to prepare a presentation within fifteen minutes of receiving data to defend their decision of life vs. no life. Finally the team participates in Extreme Retrieval and Delivery. This task forces students to drive the Rover across difficult terrain, locate items, and deliver them to designated locations. This final tasks is very much a test of suspension, vision systems, and control station coordination. Unfortunately, the University Rover Challenge and Mars Society have made the decision to cancel the URC2020 Finals due to the COVID-19 pandemic.

Miner Aviation (90 Members, 1 Faculty Mentor)
The goal of the 2019 AIAA Design Build Fly competition (April 16-19, Witchita KS) is to create a banner-towing, charter bush plane. The competition is split into 3 flight missions, a ground mission, and a design report. The ground mission demonstrates the planes ability to complete its flight missions and is a time trial. The design report is multiplied to the team's final score. Details of each flight mission are listed below:

- Mission 1 (Test Flight): The aircraft will take off in 20 feet and complete 3 laps. This mission must be completed before proceeding with other flight missions and receives a flat score upon completion.
- Mission 2 (Charter Flight): The aircraft will be loaded with 4 oz "passengers" with corresponding 1 oz "luggage". The passengers must be restrained in a way that keeps them in place for the entire flight while not touching any other passengers. The aircraft has a 200ft

runway and will complete 3 laps. This mission is scored based on the number of passengers and flight time.

- Mission 3 (Banner Flight) requires the team to deploy a banner with a maximum aspect ratio of 5. The aircraft will take off in 20ft and complete as many laps as it can in 10 minutes. This mission is scored based on the length of the banner and the number of laps completed. The competition is sponsored by Textron, Raytheon, and the American Institute of Aeronautics and Astronautics (AIAA). Unfortunately, due to the COVID-19 pandemic, this year's competition that was originally scheduled for April 16-19, 2020 in Wichita, KS, has been cancelled.

M-SAT (3 Projects, 69 Members, 3 Faculty Research Advisors/Mentors)
The M-SAT team is currently pursuing three separate satellite projects:
MR & MRS SAT
The first mission, MR & MRS SAT, is nearing completion. The purpose of this satellite project is to perform circumnavigation of a non-cooperative (or unfamiliar) resident space object (RSO) in order to capture images of the RSO. Once pictures have been taken, the images will be downlinked to the ground station, located on campus, so that a 3-D model may be constructed to get an idea of what the RSO's purpose and capabilities may be. For this mission, M-SAT will integrate a single microsatellite (~50 kg mass) composed of the two smaller spacecraft MR SAT (Missouri-Rolla Satellite) and MRS SAT (Missouri-Rolla Second Satellite). MR SAT is the active imaging satellite while MRS SAT represents the non-cooperative RSO. Using "his" cold-gas propulsion system, MR SAT will perform maneuvers about MRS SAT, taking multiple images with the imaging system at various angles. After the images are downlinked to the M-SAT ground station, the team can then deduce the capabilities and purpose of the RSO. Because most of the team's funding is provided by the Air Force, this mission profile was developed in collaboration with personnel at Kirtland AFB and satisfies several areas of technical investigation that they are currently pursuing.

M-SAT is currently focused on achieving a critical milestone early in 2020 that requires the team to perform four major tests to demonstrate the capabilities of the prototype MR & MRS SAT satellite pair as its Pre-Integration Review (PIR) with the Air Force. After successful completion of PIR, M-SAT will build the final space-grade satellites that will be shipped to Kirtland AFB for final testing before being launched to the International Space Station for deployment. As such, M-SAT is currently purchasing space-rated components and equipment for the lab to facilitate the detailed integration procedures required for satellite assembly. In parallel to spacecraft integration, the Department of Defense and the Air Force are responsible for assigning priority for providing launches to government sponsored satellites requiring M-SAT students to present to the DoD Space Experiments Review Board (SERB). The team has consistently ranked higher compared to other universities, and recently made a presentation again this year.

APEX
The Advanced Propulsion Experiment (APEX) was accepted into the Air Force's Research Laboratory's University Nanosat-10 program, with the competition officially kicking off January 2019. 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 electric 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. Conventional satellites typically use a single mode thruster, limiting maneuvers to either high-thrust/low-Isp or high-Isp/low-thrust. Two separate propulsion systems, chemical and electric, could be used to bridge the gap between these types of maneuvers, but at increased hardware cost (i.e. mass and volume), which is challenging for small satellites. The multi-mode thruster payload in this mission is a single thruster capable of two modes, and thus has a hardware footprint similar to existing single-mode propulsion systems.

NASA-USIP

M-SAT was accepted in January 2016 to the NASA Undergraduate Student Instrumentation Project (USIP), which provides undergraduate students the opportunity to design, test, build and deliver a satellite. M-SAT is developing its "Multi-Mode Mission" (M3) 3U CubeSat that complements the APEX mission. This simplified version of the APEX CubeSat is designed to identify and address high risk aspects of the multi-mode thruster. The M3 mission integrates a single-strand multi-mode thruster with the primary focus to obtain pressure, voltage and temperature values of the thruster and its custom propellant in the unique testing environment of space.

Currently, both prototype and flight versions of M3 are being fabricated/integrated. Plans are underway to conduct environmental testing of the flight version this spring semester. Manifesting a launch has been approved by NASA, and NASA/Kennedy Space Center personnel are actively seeking a launch opportunity for M3 (possibly using an Antares launch vehicle).

Multirotor Robot Design Team (81 Members, 1 Faculty Mentor)

The Multirotor Robot Design Team (MRR) is comprised of a group of Missouri S&T students interested in multirotor flight 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 possibilities that a career in engineering offers. Through collaboration, members will work together to design and build autonomous flying robots that will represent S&T at the International Aerial Robotics Competition (IARC). To complete our mission the team is comprised of two divisions, a hardware and software division. The hardware division goes through the entire design process, including picking components, 3D modeling, and manufacturing the drones. Then the software division does all the coding for autonomous flight, vision and collision avoidance. This process will include researching, designing, and testing. Through hands on experience, members will learn skills that will help them in mathematical programming and a plethora of engineering tasks. Note that the 2020 IARC Mission 9 competition has been postponed until 2021 due to the COVID-19 pandemic. However, the organizers of the IARC have created an on-line challenge to all registered Mission 9 teams to develop simulations of Mission 9 showing how their aerial robot will conduct the mission from beginning to end.

Rocket Design Team (2 Projects, 73 Members, 2 Faculty Research Mentors)

Liquid Fuel Rocket

The liquid fuel division of the rocket design team has the long-term goal of launching a liquid fueled rocket to an altitude of 10,000 ft. To accomplish this, the team has been working on three key projects throughout the year: the engine, igniter, and the water flow stand.

The most prominent of these projects is the engine. A prototype CAD model of the engine has been completed and analyzed, and the team has sent the files to be printed so that they can be water flow tested in the spring of 2020. The team plans to adjust the model based on the data collected by the water flow tests and proceed with hot fire testing in the fall of 2020.

Solid Fuel Rocket
The Solid Fuel Rocket Design Team attends the Experimental Sounding Rocket Association's (ESRA) Spaceport America Cup competition in New Mexico every year. The challenge that the teams must meet is designing and manufacturing a rocket that reaches a target altitude between 10,000 and 30,000 feet while carrying a 10-pound scientific payload. All propulsion systems and airframes must be student made. The scoring is based on accuracy of the rocket's apogee proximity to the specified altitude, readiness/operations, recovery, student design and manufacturing, deliverables provided throughout the design phase, and a technical presentation given by the chief engineer and team leads at competition. This year's competition, which was to be held from June 16-20, 2020, has been cancelled due to the COVID-19 pandemic.

Saint Louis University (3 Projects, 105 Students, 4 Faculty Mentors)
Student CubeSat Missions (45 Members, 2 Faculty Mentors)
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. The 2019-2020 objectives were to:
1. Deliver, launch and operate Argus-02
2. Submit a proposal to NASA for a fourth SLU CubeSat mission (DORRE)
3. Build and test the DORRE engineering unit

Student Unmanned Aerial System Competition Team (15 Members, 1 Faculty Mentor)
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 comprehensive solution to complex, potentially real-world problems. The 2020 AUVSI-SUAS Competition has been cancelled due to the COVID-19 pandemic.

Student Rocket Competition Team (45 Members, 2 Faculty Research Mentors)
The SLU student rocket club was formed in 2015 and took 13th place (out of 70 teams) in its first Experimental Sounding Rocket Competition; the club has sent a team to the competition every summer since then. This year's ESRA Spaceport America Cup competition, which was to be held from June 16-20, 2020, has been cancelled due to the COVID-19 pandemic.

University of Missouri - Columbia
(2 Projects, 58 Student Members, 2 Faculty Research Advisors)
Mizzou's Students' Underwater Robotics Foundation (SURF)
(22 Members, 1 Faculty Research Advisor)

SURF students at UMC 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 SURF team plans to enter into AUV competitions in the future.

Mizzou Space Program (36 Members, 1 Faculty Research Advisor)
The Mizzou rocket competition teams work year-round to compete against other top R1 Universities in international competitions such as the Global Space Balloon Challenge, the University Student Rocketry Competition, and the Spaceport America Cup. Unfortunately, all of these 2020 competitions have been cancelled due to the COVID-19 pandemic.

iii) Scientific Research Groups
In FY2019, the Consortium provided indirect funding to four Student Scientific Research Groups involving five Projects with a total of 15 student and 4 faculty participants at two MOSGC Affiliate/Associate Institutions.

Lincoln University of Missouri (2 Projects, 8 Students, 1 Faculty Research Advisor)
Purification of Wastewater from Research Facilities Using Graphene Nanoparticles
(1 Faculty Research Advisor, 1 Graduate Student, 3 Undergraduate Students)
A novel nanomaterial based filter for use in the treatment and effective purification of water using graphene nanoparticles is being developed. Grapheme nanoparticles offer the possibility of more effective remediation due to their higher surface-to-volume ratios and the possibility of novel collection and separation protocols. Graphene was prepared successfully and the leaching level was evaluated. The standardized graphene-gel matrix was used to examine absorbance of dichloromethane. Columns packed with graphene will be examined for their capacity to adsorb other carcinogenic organic solvents such as methanol and chloroform. The performance of the matrix will be monitored using NMR techniques and the ability of matrix to filter and remove these toxic materials would indicate the success of the project.

Fabrication of a Microfluidic Platform for Optical Detection
(1 Faculty Research Advisor, 1 Graduate Student, 3 Undergraduate Students)
This project involved the micro-fabrication and study of the mechanisms for optical sensing functions as well as nanotechnology and nanomaterials that could be used to improve detection sensitivity. Microfabrication has been shown to improve the performance of detection. By using small volumes of samples to test, this will increase sensitivity of the detection platform when compared to the testing in aqueous solution. The use of micro channels and fiber optics could lead to more sensitive and efficient sensing platforms.

Truman State University (3 Projects, 7 Students, 3 Faculty Research Mentors)
The Multidisciplinary Astrobiology Research Community (2 Projects, 4 Students, 2 Faculty Research Mentors) at TSU pursued two projects in FY2019:
1. Negative Feedback Mechanisms & Habitability of Tidally-locked Planets
   This project investigated the possibility of biology-driven environmental transformation on the entire tidally locked planet, as microbial evolution due to random genetic mutations leads to the gradual spreading of life from this thin sliver to neighboring, progressively more hostile

environments.

2. Exoplanet Detection and Analysis using the Transit Method
   This project involved collecting data over several nights using the recently automated and upgraded 17-inch Planewave telescope at the Truman State Observatory and the 31-inch NURO telescope at Lowell Observatory to confirm transits of known candidate planets, then processing the images followed by analyzing and interpreting them. The data through different filters were analyzed for similarities and differences in the resulting light curves. The target stars were selected from the Kepler and TESS missions.

Light Pollution Research Group
(3 Students, 2 Faculty Research Advisors (one each from Truman State University (TSU) and the Moberly Area Community College (MACC)).
Students used light sensors and an all-sky-camera to monitor the levels of light pollution at different locations around Kirksville, Missouri, and near Flagstaff, Arizona. Some of these light sensors were controlled by Raspberry-pi microcomputers and some are fully automatic sensors which are ideal for remote observations when power-outlets and a wireless networks are unavailable.

iv) Curriculum Development
In FY2019, the Consortium two Curriculum Development projects with a total of 45 student and 3 faculty participants at two MOSGC Affiliate/Associate Institutions.

Saint Louis University (35 Students, 1 Faculty Instructor)
Orbital Mechanics
The PI taught a junior-level Orbital Mechanics course in Spring 2020. Modules in the course made, use of the Argus-2 spacecraft to calculate items like viewing times, orbit propagation, Keplerian elements and decay.

Truman State University (10 Students, 2 Faculty Instructors)
Astrobiology Seminar
This course was a discussion-based, one-credit-hour course that met once per week. Class discussions were based on recently published papers and books. Students worked in pairs on specific topics of interest, reviewed research papers, and gave oral presentations during and at the end of the semester. Each group produced a formal written report on their topic. Students from a variety of STEM and non-STEM disciplines were recruited to attend this course; resulting in a free interplay of scientific, philosophical, historical, ethical, and moral issues related to astrobiology.

c) Research Infrastructure Projects

- Research Infrastructure Development -
Students work directly with faculty to develop, maintain, and enhance the capability to perform cutting-edge research at the Consortium's Affiliate and Associate Institutions.

Missouri State University
Development of Mixed Reality Visualization Platform for NanoMaterials

(1 Undergraduate Student, 1 Faculty Research Mentor)
This project developed an interactive multiuser mixed reality visualization platform to visualize large-scale atomic structures and dynamics in nanomaterials. This is a continuation of a project from the previous year whereby the virtual reality platform designed for a smaller size atomic model was developed. The goal was to enable a multi-user environment of a mixed (virtual and or augmented) reality visualization tool (e.g. through the use of HoloLens) to elucidate the intricate and complex atomic structures and dynamics involved in nanomaterials. This can potentially also be used as an educational tool to introduce nanomaterials and nanotechnology in general.

- Workshops -

Saint Louis University/Harris-Stowe State University
(4 Higher Education Student Facilitators, 10 Higher Education Workshop Participants, 2 Faculty Instructors/Advisors)
Unmanned Arial System (UAS) Remote Sensing Workshops
Undergraduates from Harris-Stowe State University in St. Louis participated in two half-day UAS workshops hosted by Saint Louis University, Department of Earth and Atmospheric Sciences, that provided opportunities for underrepresented groups to engage in authentic NASA-related research and development. Students were introduced remote sensing concepts and data from satellites and UAS sources and explored the possibilities for 360-degree visualization of UAS datasets for agricultural and environmental studies using a low-cost wearable AR platform. An agricultural field site on HSSU's campus was established to provide minority students with opportunities for undergraduate hands-on research activities and increase student engagement in research projects centered on STEM education challenges.

- Conferences -

Missouri University of Science & Technology
The 28th NASA-Missouri Space Grant Consortium Annual Spring Meeting was held on April 26-27, 2019, at the Missouri University of Science and Technology in Rolla, MO. There were 23 faculty/staff and 97 students (21 Graduates, 69 Undergraduates, and 7 High School) in attendance, making this our largest meeting to date. This meeting featured 36 podium presentations and 25 poster presentations by students from 10 Affiliate and Associate academic institutions. The 2019 Annual Spring Executive Board Meeting was also held on April 26, 2019.

The 29th NASA-Missouri Space Grant Consortium Annual Spring Meeting was scheduled to be held on April 24-25, 2020, at the Missouri University of Science and Technology in Rolla, MO; but was cancelled due to the COVID-19 pandemic and will be re-scheduled when conditions permit. However, the 2020 MOSGC Annual Spring Executive Board Meeting will take place by teleconference on April 24, 2020.

d) Precollege 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 NASA-Missouri Space Grant Consortium pursues three different categories of Pre-College Education Programs as follows:

Educator Professional Development
<2 Projects, 7 Events, 60 In-Service Teachers, 5 Informal Educators, 10 Higher Education Student Facililtators, and 2 Administrators/Staff>

Interactive Pre-College Programs
<7 Projects, 47 Events, 1076 Directly Participating K-12 Students, 8 Parents/Guardians, 6 In-Service Teachers, 36 Higher Education Student Facilitators, 5 Higher Education Faculty, and 9 Administrators/Staff>

Pre-College Student Engagement Programs
<3 Projects, 7 Events, 160 Indirectly Participating K-12 Students, 8 In-Service Teachers, 1 Informal Educator, 14 Higher Education Student Facilitators, 2 Higher Education Faculty, and 2 Administrators/Staff>

Challenger Learning Center of St. Louis
(2 Projects, 16 Events, 5 Informal Educators, 5 Administrators/Staff, 40 In-Service Teachers, and 700 Pre-College Students)
Challenger Educator Scholarship Program / 'Earth Odyssey' Interactive Student Missions
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.

Additionally, the Challenger Learning Center's newest interactive K-12 student mission, *Earth Odyssey*, directly connects to NASA's Area of Emphasis of Environmental Science and Global Climate Change through interactive hands-on mission-based activities.

Metropolitan Community College of Kansas City
(2 Projects, 8 Events, 26 Higher Education Students, 8 High School Students, 20 Middle School Students, 3 Faculty Research Mentors, 3 Staff Members)
MCCKC continued its connections with the Kansas City FIRST Tech Challenge, inspiring and educating students at both the high school and community college level through participation in local and regional robotics competitions.

The Kansas City FIRST Tech Challenge (FIRST Robotics) regional planning committee supervised a mini-competition at the MCCKC 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.

Missouri University of Science & Technology

Introduction to Aerospace Engineering

(16 Interactive Events, 98 High School Students, 3 Higher Education Student Facilitators, 1 Staff Facilitator, and 1 Faculty Advisor/Mentor)

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

University of Missouri – St. Louis

Planetarium Outreach Program

(4 Engagement Events, 1 Higher Education Faculty Facilitator, 2 Higher Education Student Facilitators, 140 Indirectly Participating Pre-College Students, 8 In-Service Teachers, 5 Parents/Guardians)

The UMSL planetarium provides free programs to elementary and middle school groups in the St. Louis area. Most of the students and teachers are from St. Louis City and North St. Louis County (Normandy, Jennings, and Ferguson-Florissant school districts) and are from under-represented groups. Groups have the option of adding a classroom presentation where we discuss NASA goals and missions, and ice in the solar system from Mars to Pluto to comets. This includes a comet simulation demonstration with dry ice, soil, and liquid nitrogen.

Collaboration with the Challenger Learning Center

(3 Interactive Events, 1 Informal Educator, 2 Higher Education Faculty Facilitators, 6 In-Service Middle School-Teachers, 60 Directly Participating Middle-School Students)

Collaborations with the Challenger Learning Center of St. Louis enable hosting 5 middle school classes each year from the Normandy, Ferguson-Florissant, and Jennings School Districts to UMSL for planetarium and classroom demonstrations and then to the Challenger Learning Center for a simulated space mission. UMSL pays for transportation costs and the CLC missions that these schools could not otherwise afford. The focus was on middle school students from under-represented groups.

e) Informal Education Projects

The Consortium's Informal Education programs are intended to engage, inspire, and inform members the general public in NASA-related science, engineering, and mission events.

<8 Projects, 56 Events (11 Demonstrations, 4 Exhibits, 13 Lectures, 25 Telescope/Night Sky Observing Sessions, 3 Satellite Tracking Sessions), 13 Press Releases, 2 In-Service K-12 Teachers, 13 Informal Educators, 7 Higher Education Faculty Facilitators, 20 Higher Education Student Facilitators, 113 Indirectly Participating Pre-College Students, 175 indirectly Participating K-12 Teachers, 2190 General Public)

Missouri State University

Public Observing Nights at Baker Observatory
(3 Observing Sessions, 4 Student Facilitators, 2 Faculty Facilitators, 1000 General Public)
Project Description: Three times per semester (fall and spring), Baker Observatory is opened to the public and staffed by astronomers and astronomy students. This allows the public to enjoy the facilities and allows students to demonstrate the science of astronomy.

Saint Louis University
Satellite Tracking
(2 Demonstrations, 3 Observing Sessions; 1 Faculty, 4 Undergraduate Students, 60 Indirect Participants)
Tracking and listening to the Argus-02 Spacecraft: As part of the launch activities for Argus-2, SLU partnered with a local Amateur radio club to develop an Informal Education project to build "do-it-yourself" antenna and listening radio. For less than $50 in materials for each kit, participants were be able to listen to the Argus-2 beacon transmitter using 10 kits at Amateur Radio outreach events after the launch.

Truman State University
Astronomy/Astrobiology Public Outreach
(7 Events, 4 Higher Education Student Facillitators, 2 Higher Education Faculty Mentors, 200 Indirect Participants)
Public Observing Sessions and Outreach at the Truman State Observatory and the Dell & Norma Robison Planetarium engaged members of the public in astrobiology related topics. Participating students designed astrobiology-themed posters, gave short presentations about the possibility of life elsewhere in our Galaxy, and distributed flyers at the planetarium, local schools, and the county library.

Truman State University/Moberly Area Community College
Light Pollution Awareness
(17 events, 3 Higher Education Student Facilitators, 2 Higher Education Faculty Mentors, 2 Pre-College In-Service Teachers, 805 Indirect Participants)
TSU Students continued to strengthen contacts with local businesses, local government agencies, as well as administrators at local institutions and public schools to increase awareness and affect change in outdoor lighting to mitigate the problem of light pollution. The outreach and engagement activities included:

a) Students collaborated with the recently established Missouri chapter of the International Dark Sky Association (IDA-Missouri) to engage the public by giving talks and presentations based on our results and shared the accumulated expertise to help and encourage members of the IDA-Missouri to install SQMs in their communities.
b) Formalized relationships with Mo-state parks with the help of already established contacts and with the help of the contacts through IDA-Missouri to set up SQMs in several state parks across Missouri.
c) Participating students shared their expertise with willing partners at universities across Missouri and neighboring states including students and professors at MACC, Lincoln University, UMKC, the University of Iowa and Benedictine College in Kansas.

University of Missouri – Kansas City / Astronomical Society of Kansas City

EPO with the UMKC Warkoczewski Public Observatory
(12 Events, 1 Faculty Facilitator, 9 Informal Educators, 800 Observers)
Informal Education and Public Outreach (EPO) using telescopic observations is conducted weekly, March through November and weather permitting, at the Warkoczewski Public Observatory located on the UMKC campus. Additional events are held in the event of interesting astronomical occurrences, such as bright comets. The observatory is maintained and sta?ed by members of the Astronomical Society of Kansas City (ASKC), with oversight by Dr. Daniel McIntosh, director of the observatory.

University of Missouri – St. Louis
UMSL Observatory Open Houses
(12 Events, 2 Higher Education Student Facilitators, 75 Pre-College Students, 40 Higher Education Students, 15 Parents/Guardians, 100 General Public)
From March through October, UMSL holds public open houses at the Richard D. Schwartz Observatory on the UMSL campus. In the early spring the schedule for the year is posted and distributed to local newspapers and radio outlets. Students from the UMSL astronomy classes and special groups such as scouts and home school groups also attend these events.

D. MILESTONES

Refer directly to the Milestones chart included in your 5th year funding extension proposal.

a. Include a summary of your proposed milestones, and describe the extent to which each milestone has been met. If there have been significant deviations from your proposed milestones that will affect your initial period of performance, please provide a justification for those deviations.

b. If there have been significant deviations from your proposed milestones that will affect your initial period of, please provide a revised list of milestones.

Key:
Milestone
=> Result

#1 Review, Select, and Establish Funding for 2019 NASA Center Summer Internships (January - April, 2019)

=> 7 of the 139 SS2019 NIAMS applicants were selected for funding.

#2 Review, Select, and Establish Funding for 2019 NASA Center Fall Internships (June-August, 2019)

=> There were no FS2019 NIAMS candidates selected for funding.

#3 Review, Select, and Establish Funding for 2020 NASA Center Spring Internships (September-December, 2019)

=> There were no Spring 2020 NIAMS candidates selected for funding.

#4 Release RFP for Affiliate/Associate Award Competitions (April-June, 2019)

=> The solicitations for the Affiliate and Associate Award Competitions were released on May 21, 2019.

#5 Receive/Review Proposals and Select Affiliate/Associate Competitive Awards (June-September, 2019)

=> The Affiliate/Associate Award Competition Proposals were received by June 24, 2019, and were selected by mid-September. Award letters were issued on September 27, 2019.

#6 Issue Affiliate/Associate Award Competiton Subcontracts (September-November, 2019)

=> All FY2019 Affiliate/Associate Award Competiton Subcontracts were in place and finalized by November 7, 2019.

#7 Fall Executive Board Meeting (September, 2019)

=> The FY2019 Fall Executive Board Meeting was held by teleconference on October 18, 2019.

#8 "Reverse" Site Visit to DC (July-September, 2019)

=> The "Reverse" Site Visit to DC was replaced by a "Mega PI" meeting held at Glen Research Center in Cleveland, OH, on August 8-9, 2019. Both the MOSGC Director and Program Manager were in attendance.

#9 Regional SG Meeting in MN (October-December, 2019)

=> The Fall 2019 Great Midwestern Space Grant Meeting was replaced by a "Fall 2019 Space Grant Midwest Region "Short Talks" videoconference on Thursday, November 14, 2019. Dr. Hank Pernika, from Missouri S&T, was one of three presenters for this event.

#10 Request 2019 OEPM Report Data from Affiliates/Associates (July-September, 2019)

=> 2019 OEPM Report Data requests and forms were distributed on June 25, 2019, with a due date of September 30, 2019.

#11 Receive/Review 2019 OEPM Report Data from Affiliates/Associates (September-October, 2019)

=> 2019 Affiliate/Associate OEPM Data was received between September 30 and December 31, 2019.

#12 2019 OEPM Data Entry (October, 2019 - January, 2020)

=> 2019 OEPM Data Entry was completed and verified on January 27, 2020.

#13 2019 APD Report (January-March, 2020)

=> 2019 APD Report compilation is currently in progress.

#14 Winter 2020 National SG Meeting in Washington DC (February 27-28, 2020)

=> Due to illnesses, neither the Director nor the Program Manager were able to attend the Winter 2020 National SG Meeting in Washington DC

#15 2019 MOSGC Annual Spring Meeting (April 26-27, 2019)

=> The 28th NASA-Missouri Space Grant Consortium Annual Spring Meeting was held on April 26-27, 2019, at the Missouri University of Science and Technology in Rolla, MO.

#1B Review, Select, and Establish Funding for 2020 NASA Center Summer Internships (January - April, 2020)

=> The review and selection process for SS2020 NASA Center Internships and Academies is currently under way.

#4B Release RFP for Affiliate/Associate Award Competitions (April-June, 2020)

=> Pending Implementation, tentatively in May, 2020

#5B Receive/Review Proposals and Select Affiliate/Associate Competitive Awards (June-September, 2020)

=> Pending Implementation, tentatively in July-August, 2020

#15B 2020 MOSGC Annual Spring Meeting (April 24-25, 2020)

=> Due to the COVID-19 pandemic, the 2020 MOSGC Annual Spring Meeting has been cancelled and will be re-scheduled when conditions permit. However, the 2020 MOSGC Annual Spring Executive Board Meeting will take place by teleconference on April 24, 2020.

E. PROGRAM CONTRIBUTIONS TO NASA EDUCATION PERFORMANCE GOALS

Include summary data for the bulleted list below:

- **Diversity**: Describe the diversity of institutions, faculty, and student participants (gender, underrepresented, underserved)
- **Minority Serving Institution Collaborations**: Summarize interactions with MSIs within the consortium, and describe projects/activities.
- **Office of Education Annual Performance Indicators (APIs)**: Provide numerical values for consortium contributions to API's. Refer to Table 1: *Annual Performance Plan:FY19 Performance Goals and Annual Performance Indicators* on page 6. Note the explanation above the table.

    - API 3.3.3: STEM 19-1
    - API 3.3.5: STEM 19-5

Diversity

The institutional demographics for the NASA-MOSGC participating universities, as given by the

National Center for Education Statistics - College Navigator (Fall 2018) are:

Institution	% Female	% Minority
Missouri S&T (Lead Institution)	24%	14%
Lincoln University of Missouri	58%	53%
Metropolitan Community College - Kansas City	59%	37%
Missouri State University	58%	14%
Rockhurst University	60%	23%
Saint Louis University	60%	23%
Truman State University	59%	14%
University of Missouri - Columbia	52%	19%
University of Missouri - Kansas City	57%	31%
University of Missouri - St. Louis	56%	24%
Washington University in St. Louis	53%	39%

The student population weighted averages for the MOSGC are: 53% Female and 23% Minority.

The state-wide demographic statistics for all accredited colleges and universities in Missouri (NCES Fall 2017) are: 57.1% Female and 25.5% Minority.

The 2019 OEPM directly supported student data table demographics for the MOSGC were: 40% Female and 27.3% Minority.

The MOSGC Executive Board is 0% Female and 50% Minority (Asian American).

Minority Serving Institution Collaborations

Lincoln University of Missouri

The Missouri Consortium continues to support activities at Lincoln University of Missouri in Jefferson City (HBCU) as a fully-funded Affiliate. This year's independent research program at LU involved two graduate and six undergraduate directly supported students. Research topics included investigations into the 'Purification of Wastewater from Research Facilities using Graphene Nanoparticles' and 'Fabrication of a Microfluidic Platform for Optical Detection'.

Saint Louis University

Undergraduates from Harris-Stowe State University in St. Louis participated in two half-day remote sensing UAS workshops hosted by Saint Louis University, Department of Earth and Atmospheric Sciences, that provided opportunities for underrepresented groups to engage in authentic NASA-related research and development. Students were introduced remote sensing concepts and data from satellites and UAS sources and explored the possibilities for 360-degree visualization of UAS datasets for agricultural and environmental studies using a low-cost wearable AR platform. An agricultural field site on HSSU's campus was established to provide minority students with opportunities for undergraduate hands-on research activities and increase student engagement in research projects centered on STEM education challenges.

Office of Education Annual Performance Indicators:

- API 3.3.3: STEM-18-1 _63_ Directly Funded Students with Significant Awards
- API 3.3.5: STEM-18-5 _82_ Technical Reports and Peer-Reviewed Research Publications

F. IMPROVEMENTS MADE IN THE PAST YEAR

Succinctly *describe improvements and/or adjustments made last year that demonstrate significant change(s) within the consortium. The improvements and/or adjustments that brought about change may have been in management, resource allocation, project design, project evaluation, etc.*

Programmatic Improvements

The Consortium increased its number of participating Associate Institutions by recruiting Rockhurst University in Kansas City through the 2019 Associates Award Competition.

The MOSGC Executive Board voted to promote Saint Louis University from Associate to full permanent Affiliate status beginning in FY2020.

Administrative Improvement

The Annual Consortium Assessment forms were converted from paper to on-line digital format.

G. CURRENT AND PROJECTED CHALLENGES

Identify any current or projected challenges in the implementation or execution of activities. Explain how the management team is working to address the challenges identified and/or how National Program Staff can assist. ***If this is your close-our report, please skip this section.***

The Consortium continues to have a low response rate to recruiting Community and Technical Colleges to participate in its programs. A more direct method of reaching out to these institutions is under consideration.

The 29th NASA-Missouri Space Grant Consortium Annual Spring Meeting was scheduled to be held on April 24-25, 2020, at the Missouri University of Science and Technology in Rolla, MO; but was cancelled due to the COVID-19 pandemic and will be re-scheduled when conditions permit. However, the 2020 MOSGC Annual Spring Executive Board Meeting will take place by teleconference on April 24, 2020.

H. PROGRAM PARTNERS AND ROLE OF PARTNERS INPROJECT EXECUTION

List the institutions that comprise the consortium; include the name, type of institution, key characteristics, and role in consortium activities/operations. A listing of affiliates with no description of characteristics or roles is not sufficient.

The Missouri Space Grant Consortium is composed of the Lead Institution, six Affiliates, five 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 and Associates 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. One of the primary roles of the Affiliate members is to serve as Executive Board Members in guiding the priorities of the Consortium. The list of current MOSGC Affiliate and Associate Members along with their core departments and roles in Consortium operations is as follows:

Affiliate Members

- Missouri University of Science & Technology (MS&T - *Lead Institution*)
  Department of Mechanical and Aerospace Engineering
  ⇨ *Fellowships, Internships, Engineering Design Teams, and Interactive Pre-College Programs*
- Lincoln University of Missouri (LU-HBCU)
  Department of Life and Physical Sciences
  ⇨ *Fellowship & Scholarships s , Internships, and Scientific Research Groups*
- Missouri State University (MSU)
  Department of Physics, Astronomy, and Materials Science
  Department of Geography, Geology, and Planning
  ⇨ *Fellowships, Internships, and Informal Education Programs*
- University of Missouri – Columbia (UMC)
  Department of Mechanical and Aerospace Engineering
  Nuclear Science and Engineering Institute
  ⇨ *Fellowships, Internships, and Engineering Design Teams*
- University of Missouri – Kansas City (UMKC)
  Department of Physics and Astronomy
  Astronomical Society of Kansas City
  ⇨ *Fellowship & Scholarships, Internships, Interactive Pre-College and Informal Education Programs*
- University of Missouri - St. Louis (UMSL)
  Department of Physics and Astronomy
  ⇨ *Fellowship & Scholarships s , Internships, Interactive Pre-College and Informal Education Programs*
- Washington University in St. Louis (WashU)
  Department of Mechanical Engineering and Material Science
  ⇨ *Fellowships and Internships*

Associate Members

- Challenger Learning Center of St. Louis
  ⇨ *Pre-College Teacher Professional Development and Interactive Pre-College Student Programs*
  Rockhurst University
  ⇨ *Pre-College Teacher Professional Development and Interactive Pre-College Student Programs*
- St. Louis University
  Parks College of Engineering, Aviation, and Technology
  Department of Earth and Atmospheric Sciences
  ⇨ *Fellowships, Internships, Engineering Design Teams, Pre-College Student Engagement Programs, Higher Education Workshops, and Informal Education Programs*
- Truman State University (TSU)
  Department of Physics
  Department of Chemistry

Department of Biology
- ⇨ *Internships, Scientific Research Groups, and Informal Education Programs*

Community and Technical Colleges

- Moberly Area Community College
  - ⇨ *Scientific Research Group collaboration with TSU*
- Metropolitan Community College – Kansas City
  - ⇨ *Engineering Design Teams and Interactive Pre-College Student Programs*