RI_FY16_Year2_APD

Rhode Island Space Grant Consortium
Lead Institution: Brown University
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Lines of Business (LOBs): 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 **Rhode Island** Space Grant Consortium is **Program Grant** Consortium funded at a level of **$570,000** for fiscal year 2016.

B. PROGRAM GOALS

The ***goal*** of the Rhode Island Space Consortium is to provide fellowships and scholarships as well as fund research, education, and public-service projects and to broaden Rhode Island's role in space exploration. We accomplish our goals by the following objectives. *First*, we stimulate cooperative programs between universities, industry, federal, and state programs. *Second*, we encourage interdisciplinary training, research, and public service programs related to aerospace. *Third*, we engage and train U.S. citizens for careers in aerospace science and technology. And *fourth*, we promote a strong science, mathematics, and technology base from elementary through secondary levels.

C. PROGRAM/PROJECT BENEFITS TO PROGRAM AREAS

Stanford-Brown iGEM: The *Stanford-Brown iGEM* team conducted research at *NASA Ames Research Center* in order to experience and contribute to the burgeoning field of synthetic biology. The research emphasizes identifying, developing and presenting proof-of-concept projects that demonstrate the role of synthetic biology in advancing space research – human and robotic - into the coming decades. The experience is unique among internships in that the *iGEM* program emphasizes student teams that are to a large extent self-organized and motivated, and that the research is integrated into a common project which is presented at the *Giant Jamboree* at the Boston Hynes Convention Center at the end of October. This year the *iGEM* team developed microbes that were engineered to grow the components required for various tools and structures. One application was the development of balloon-membrane polymers with different properties of strength and elasiticity. This effort contributed to a sensing balloon made of biomaterials. Such a balloon could be used to traverse long distances on planets with an atmosphere. By bringing the materials, the bio-balloon could be "grown" and re-grown with the same bacteria. This year, the *iGEM* team won the *Gold Medal* for Best Measurement and was *Nominee* (runner up) for Best Manufacturing.

There have been multiple opportunities to learn oral and poster presentation skills at NASA, Stanford, local companies, Brown, the SF Bay Area and New York Maker Faires. Our support included materials, travel awards, and student support (included in our NIFS report above).

***RISD Mars Space Suit Simulator*:** Our Affiliate, the *Rhode Island School of Design* (RISD) invites guest critics to their studio design final. One of these guests came from the yearlong *HI-SEAS Analogue Mars Mission*, where participants live and work in a Mars analog habitat in Hawaii for an entire year. This guest recognized the need for a better spacesuit for proper simulations. From this came an independent study research course that challenged 9 students with backgrounds in *Industrial Design* and *Apparel Design* at RISD to design and fabricate a full-scale, wearable model of a NASA spacesuit that would be functional in a simulated Mars environment. Moreover, the suit had to be: adaptable to fit a wide range of people ranging in height from 5'2" to 6'3"; easily repaired and modified; maximize the fidelity of the sensation of wearing a suit; and do it all for a budget that is affordable for use by researchers conducting simulated Mars missions (<$10K). Over the last year, more than 1500 person-hours were spent to develop a unique suit largely from carbon fiber composites (with minimal steel parts) in order to reduce weight. The project partnered with a ship building company for fabrication. Weighing in at approximately 50 pounds, the suit feels a little bit lighter than what an actual (heavier) space suit would feel like on Mars, where the gravitational force is weaker than Earth's. It's also much easier to get in and out of than typical space suits now in use, taking about 15 minutes and requiring the help of just one person. The final design was presented to the *HI-SEAS* mission crew during an open house (with press) and resulted in press coverage (more than 270 news outlets) from around the world, including China, Great Britain, Germany and the US. This level of interest and coverage is unique for a RISD project - none have generated such wide spread coverage in so many major news outlets. We supported 1 student along with travel.

D. PROGRAM ACCOMPLISHMENTS

- NASA Internships, Fellowships, and Scholarships (NIFS):

The goal of our Fellowship/Scholarship (FS) Program is to engage, inspire, and motivate graduate and undergraduate students in the process of research and discovery, thereby providing relevance to their academic studies and preparing them for employment in STEM disciplines at NASA, industry, and higher education.

***SMART* Objectives**: *Specific*: All Fellowships /Scholarships will be judged on the proposed research (including NASA relevance), grades, letters of recommendation, and past responsiveness of their advisors (for repeat requests). Balance will be sought across different departments, advisors, young faculty, gender, ethnicity, and relevance. *Measurable*: Success will be measured by student engagement in our program, publications/presentations arising from this support (abstracts, papers, poster presentations, presentations at annual symposia), continued involvement with our (or other *SG*) program, and evidence that they stay within STEM areas, regardless of their specific path (e.g., science education, research, or industry). *Acceptable*: All awards will be made to US citizens and must be tied directly to one of NASA's strategic goals/objectives with diversity as one of the selection criteria. *Realistic*: The number of Fellowship awards is governed by the ability for each university to identify a match through tuition awards or other means. *Time Frame*: Fellows are eligible after their first but before their last year of study with awards limited to one year in order to engage more departments and faculty (excepting our Affiliates, the first and last-year requirement for Masters candidates is relaxed). Our targets were to track longitudinally at least **17** students in FY16 under this award (Lead & Affiliates), including: **4** *Full-Year (FY) Graduate Research Fellows*, **4** *Summer Graduate Fellows*, and **8** *Summer Undergraduate Research Scholarships*. We also proposed to support **1** *Targeted Scholarship*.

We exceeded our target for all awards with **26** (versus proposed 17) longitudinally tracked awards including distributed across the consortium (not including our targeted awards): **3** *FY-Graduate Research Fellows* (2 at Brown, 1 at our Affiliate, URI) vs. 4 proposed; **2** *Summer Graduate Fellows* (1 at Brown, 1 at our Affiliate) vs. 4 proposed; and **21** *Summer Undergraduate Research Scholarships* (11 at Brown, 10 at our Affiliates) vs. 8 proposed.

However, we had to adjust the distribution among categories due to the lateness of receiving the augmentation (affecting required sub-award funding) from graduate fellowships to undergraduate awards (easier to execute directly from Brown). The increase in the number of undergraduate scholarships was largely due to matching strategies. Awards were made across a wide range of NASA-related themes (physics, geoscience, astrophysics, engineering, math) at 9 different institutions of higher learning (out of the 11) in our RI. In addition, we made 3-targeted (and tracked) under-represented awards (as proposed): 1 award as part of our MSI program and 2 awards to Native American students. Because of their nature, these targeted awards are also listed under *Higher Education*. No NASA Center Interns were supported due to the difficulty in identifying the required non-federal match. ***In total*** (including targeted awards), we tracked **29 students** where **41%** were women (40% target) and **17%** from under-represented groups (10% target). While we exceeded the required minimum distribution ($161K), we did not meet our targeted amount ($217.5K versus $212.3K). Because this difference is more than $5K, we provide an explanation under "Improvements."

- Higher Education projects:

Goals and Purpose: Increase students in STEM fields through (a) postsecondary curricula (b) meaningful hands-on experiences and increase involvement of women and under-represented and underserved groups in STEM careers. We address 2 primary *Co- STEM* goals (*Enhance STEM experience* and *better serve historically under-represented groups in STEM fields*); NASA's *Strategic Plan and Relevance* (Objective 2.4) to increase NASA's pipeline by engaging students in NASA's mission and unique assets; and NASA Education's *Lines of Business* (Goals 1 through 4).

SMART Objectives: *Specific*: One-year awards will be based on clearly stated goals to develop, enhance, or integrate NASA-related programs into the undergraduate studies through new or revised curricula, hands-on use of NASA materials, NASA competitions, or development of new approaches relevant to NASA programs. *Measurable*: We measure success by a demonstration of student involvement, results (e.g., new class), connections with NASA Centers or programs, and demonstrated awareness within the university or department. Projects (class or individual) are reviewed at the end of the award (e.g., critical design reviews, written summaries, or presentations) and presented at the annual *RI-SG Symposium. Acceptable*: Selection requires that proposals document consistency with NASA themes/goals, hands-on experiences (e.g., field excursions, industry partnerships, and/or collaborations with NASA Centers), documented match, and potential for growth or self-sustainability. All travel grants have to demonstrate need (not just visits), specific goals, or participation (conferences or workshops). Interdisciplinary and collaborative approaches are encouraged, along with evidence for increasing diversity. *Realistic*: We require that proposed efforts can be completed within the proposed budget. *Time Frame*: We make our awards for one year in order to engage more departments and faculty. All requests are necessarily tied to the academic calendar (not grant cycle). Consequently, some programs extend over two grant cycles. We spent a total of $76.8K in this category versus our target of $85.8K (as explained in the budget discussions below under "Improvements").

New and Revised Curriculum Development: *RISG* supported the development or implementation of 4 new or revised courses over the report period, thereby exceeding our target of 2. Metrics for success included Final Critical Reviews, student written responses, and post-graduate career paths. Faculty and/or students presented reviews at the annual RISG Symposium.

RISD Studio courses: *RISG* supported 3 courses at RISD. First, a studio course focused on living in extreme environments that ended in May of 2016 ("*Mars Ascent Vehicle*"). Objects created by students was used as the foundation for a new exhibit at the *Museum of Natural History* in Roger Williams Park, Providence RI. This exhibit called, "*The Red Planet: Going to Mars*" shows the work students accomplished designing innovative solutions for NASA. The students worked with a NASA astronaut and a person from the *EVA Physiology Laboratory* on designs for two different versions of an innovative *Mars Ascent Vehicle* (*MAV*). The class had a critical design review throughout the semester with the final critique held at the end of the semester (including personnel from NASA Johnson).

The RISG is also supported an innovative design studio beginning in February 2017. This studio course works with the *NASA-JSC Habitability Design Center* (*HDC*) at *NASA Johnson Space Center*. It engages 17 students (including 3 graduate students) in the very current and important *HDC* project of designing fabrication and repair workstations for future analogue Mars missions slated to be conducted in *Human Exploration Spacecraft Testbed for Integration and Advancement* (*HESTIA*) at *NASA-JSC*. These novel approaches to repairing and building equipment or habitats in space or on the surface of Mars will be tested in the analog habitat constructed in *HESTIA*.

Finally, we supported an independent study on designing and making an innovative new analog space suit simulator. The course (led by M. Lye) engaged and 9 students (2 graduate students included). Industry (*Wyle Laboratories*, Inc) was the source of the technical advisor for the project, which also worked with some of the crew of the NASA-funded *HI-SEAS Analogue Mars Mission*. The project also forged relationships with local marine industry suppliers to assist in making parts through a novel Direct-to-Mold (DTM) process and providing materials for the project. The *MS1 Suit* analog was unveiled during a final 2-day critique at RISD and involved visitors from *HI-SEAS*. The first day demonstration invited the press, which resulted in incredible news coverage worldwide: picked up by more than 270 news outlets from around the world, including China, Great Britain, Germany and the US -- along with local, national and international print, TV and radio (including most recently in India). This level of interest and coverage is unique for a RISD project - none have generated such wide spread coverage in so many major news outlets. It gave RISD and the *Space Grant* a platform for outreach and engaged readers and viewers worldwide in an exciting and inspiring view of the efforts that go into NASA's efforts to explore. The project also was favorably reviewed by industry, when the president of *Final Frontier Design* (a NASA contractor and prize winner of a *NASA Centennial Challenge*) visited RISD to discuss the possibility of future collaborations and support.

***Rhode Island College*:** Our Affiliate *Rhode Island College* is establishing a new physics laboratory course on optics in order to raise the level of instruction at this college that is a primary source for teachers in RI (and a 30% underrepresented student population). The course would include lectures and demonstrations illustrating NASA's use of optics from space telescopes to planetary missions. Seed funding enabled the purchase of supplies and basic course development, with the course to be offered in the fall next year.

Other Higher Education (HE) Opportunities: We offered a variety of HE opportunities and evaluated each subtask by evidence for hands-on student involvement (written assessments by both students and faculty), results (e.g., new class), connections with NASA Centers or programs, and awareness within the university or department. Projects were reviewed through written summaries, and presentations at the annual *RI-SG Symposium*. ✪ ***NASA Rover Challenge*** (*RISD*)**:** In the April 2016 Rover Challenge competition at *NASA-Marshall SFC*, with support from RISG, the RISD Rover team brought home *second place*, college division. The team also *won* the *Flyweight Award* for the lightest rover to successfully complete the course. After April a new team began designing an entirely new rover to compete in the March 2017 Rover Challenge. The new team is official student led RISD club sponsored by the *Center for Student Involvement*, engaged ~15 students from across the college, including 3 first-year students, a first for the club. The new rover features a brand new chassis design, an innovative transverse, carbon fiber, leaf spring-front suspension, a novel, new and thoroughly custom power train and essentially all new parts throughout rover. The entire rover, with the exception of a few small bicycle parts has been made in-house

by the students, giving them an incredible first-hand experience of turning design concepts into real world systems and then testing the results to understand the strengths and weaknesses. Throughout this process the students are actively engaged in STEM activities and learning. ✪***EquiSAT*** **(**Brown**):** *EQUiSat* is a student-led effort (8 students) at Brown University as an outgrowth of the Capstone Engineering course (above) to design, build, and launch a *CubeSat*. The *EQUiSat* team is manufacturing and testing their satellite for launch. Over the last year, the team has put the satellite through a suite of tests that simulate conditions during launch and during orbit that our spacecraft must survive in order to function. In keeping with the mission goals, they are using simple equipment and methods to achieve as near as possible conditions to the launch and space environments. *EQUiSat* is scheduled for launch in the summer of 2018.
✪***Community College of RI*****:** We proposed a focused opportunity for out Community College system in RI and made 4 awards. (a) *Bringing Experiential Learning About Serpentinization in a Mars-analog Setting to a Community College* (CCRI): This is a joint Community College and University effort to engage 4 CCRI undergraduates for five days in a NASA Astrobiology Institute-sponsored field locale to learn about planetary geology, astrobiology, and data collection and interpretation in a Mars-analog setting dominated by serpentinization. Student participants will collect original data, interpret data in a planetary geology context, and create a scientific research poster for presentation. (b) *Curriculum Enhancements*: This effort focused on incorporating new tools in *ArcGIS* and geology classes through digital mapping and combining field GPS data with remote-sensing data. The overall goal is to introduce the scientific method to students through the use of use tools comparable to mapping boulders on Mars along a rover trek. (c) *Student Travel Awards*: We supported travel for students to participate in field studies, an experience known to stimulate careers in STEM. (d) *CCRI Astronomy Club*: A physics professor proposed to develop informal STEM experiences through hands-on operations with "astro-imaging", which would introduce modern digital light detectors and learn the basics of signal processing. ✪***Student Hands-on Experiences*** (Brown): We proposed to provide partial support for various hands-on experiences to Brown students focusing on NASA themes including planetary analog field trips, NASA Center trips, and/or Conference/Workshop trips. We supported one planetary analog field trip to Death Valley, California. The trip includes 20 undergraduates and 2 graduate students. We supported 6 travel grants: two RIC students to participate in *Materials Research Society* meeting; one URI student collecting data in the Coast Range Ophiolite Microbial Observatory in Lower Lake, CA; three students attending ACS Northeast Regional Meeting in Binghamton, NY as well as ACS National Meeting in San Francisco. ✪***3D Modeling Workshop*** (Brown)**:** 3D printing is now widely available to faculty and students. However, most of the source data are not provided in an easy-to-use form and many 3D printers develop mechanical or software issues that result in abandoned printers. A two-day workshop (successive weekends) was offered across the consortium designed to develop or enhance the use of 3D printing for teaching and research. In addition to nuts/bolts of 3D printing, various products were provided including: special software, useful websites, problem websites, trouble-shooting techniques, and examples of using 3D printing in the classroom.
Targeted Awards: These awards targeted (and tracked) under-represented groups and a minority-serving institution through leveraging with existing programs. We met our total target of supporting 3 students in this category but report them under NIFS (above). ✪***RISG/Brown/Tougaloo Research Partnership*****:** RISG leveraged an existing program (bringing under-represented students from *Tougaloo* to Brown for summer classes) in order to introduce a *Tougaloo* student to research on the Brown campus over the summer. Selection was based on letters of recommendation, CV, and phone interview with a Brown faculty mentor. This year we supported 1 student (biology major) Working with faculty mentor on research entitled *Cell Mechanics in Response to Simulated Microgravity.* Resulting in the submission of a poster *" Investigating the Effects of Microgravity on 3D Cortical Micro-Tissues"*. ✪***Narragansett Tribal Student NASA-RISG Scholars*****:** We partnered with the URI/GSO and the Narragansett Indian Tribal Historic Preservation Office in order to provide 2 Narragansett tribal members the opportunity to engage in hands-on research "Exploring Deep Time and Space: An Examination of Tribal Oral History and Ceremonial Stone Landscapes and their Relationship with the Sun and its Interactions and Impacts on Ancient Native American Peoples". Native-American students participating in this effort gave their first oral presentation at the RISG Symposium last year, with their parents in attendance.

- Research Infrastructure projects:

Goals and Objectives: Our goal is to encourage research that not only develops new directions and opportunities relevant to NASA's goals and missions but also can be integrated into student training, thereby advancing the Nation's STEM workforce pipeline by engaging faculty in NASA's mission (*NASA Strategic Objective 2.4*).

SMART Objectives: *Specific*: All research awards will be for one year and based on relevance to NASA themes and goals and effective use of the budget for the proposed tasks, absence of existing NASA funding for the proposed tasks, and relevance. *Measurable*: Our metrics for success include any or all of the following: increased young faculty involvement in NASA research as well as written outcomes, publications, proposals to NASA, and/or papers presented at meetings or our annual symposium. *Acceptable*: Each proposed award was based on: (i) relevance to NASA goals/objectives; (ii) potential for seeding new grant opportunities; (iii) involvement of new participants and students in the effort and; (iv) demonstration of a collaborative or cooperative interdisciplinary theme. We add merit for increased diversity. *Realistic*: Proposals are ranked according to likelihood for results evidenced by a new proposal to NASA or graduate student after the award period. *Time Frame*: We limited awards for one year in order to broaden engagement.

Program Description: In our prior reduced award, we severely cut back research awards, in deference to student opportunities. The combined core and augmentation awards this year allowed supporting 8 very different research seed grant categories to 6 different members of our consortium. We exceeded our target (2 Lead awards; 4 Affiliate awards). All research grants were seed grants (typically less than $12K/project) and most engaged students. Success metrics included reports, publications, and presentations at meetings (including the RISG Symposium). We made a total of $47.5K awards in this category, which exceeds our target of $31K (as discussed in the "Improvements" section below).

✪***Research Seed Grants*:** We had **8** categories of research seed grants (12 total awards) to our Affiliates in response to a brief (2 page) proposal that demonstrated feasibility, cost reasonableness, relevance to NASA's goals and mission, and documented the required match. ✪***Travel Grants*:** 6 travel awards were made during the report period including national conference trips reporting on results from prior Space Grant funding. ✪***Space Horizons 2016*** ("Destination Alpha Centauri"): *Space Grant* & *Brown University School of Engineering* hosted a workshop in February focusing on the expansion of space capabilities that are not yet realized. This student-led effort explored one of the approaches suggested by Stephen Hawkins. ✪***Auditory Countermeasures to Nauseogenic Motion Sickness*** (*Brown*)**:** Motion sickness is shaping up to be a defining technology limitation for the 21st century, from space-mission simulators to gaming. Motion sickness and vertigo are debilitating conditions that emerge based on failures of the brain to coordinate output of different sensory systems, typically the vestibular and visual systems. Until recently, only those at elevated risk for vertigo and falls, such as the elderly, those suffering from inner ear pathology, and those sensitive to vehicular induced accelerations were at particular risk. With the expanded use of immersive visual 3D systems in movies and VR (Virtual Reality) gaming, sensory immersion for data manipulation, and the emergence of autonomous road vehicles which provide no cues about movement planning, the number of individuals subject to motion sickness has increased tremendously and has been identified as a limiting factor in the expansion of many of these current technologies. As a result, this RISG seed-research effort (joint project with a non-profit institute) developed a prototype wearable hardware/software solution for reducing motion sickness that relies on psychophysical principles of sensory remapping rather than increased computational and engineering demands. This audio-based system can be used as a platform independent wearable device to use with head mounted displays, an integratable software patch for existing VR systems. The effort has attracted considerable attention by industry engaged in spaceflight and VR gaming. ***Biomimetic CFC's degradation in Insight to Biotic Halogen Cycling*** (*Roger*

Williams University): The objective of this research was to discern the scope and mechanism for the oxidation and reduction of iron porphyrins by volatile halo-carbons (HCs) HCs as biomimetic models of marine heme systems. Detecting bio signatures such as HCs at terrestrial concentration in the atmospheres of Earth type planets will be feasible with next-generation technology NASA's James Webb Space Telescope. Thus, detection of a short-life HC's will signal bioactive reactions, whereas the detection of a long-lived CFC 10^5 yrs will be more probable of an industrialized civilization. This effort engaged students in practical hands-on laboratory experiences during the academic year. ✪ ***Spectroscopic studies*** (*Providence College*): A seed grant was made to a new young professor to study the energy level structure of atoms (like rubidium and cesium) and simple molecules with high-resolution in order to study various interactions and perturbations that complicate the regular progression of spectral lines. Using various techniques (e.g., polarization, absorption, and fluorescence spectroscopy of atomic rubidium and cesium) he investigated the Zeeman shift under varying magnetic field strengths (relevant to stellar astronomy) and Doppler-free absorption spectroscopy. The effort is designed to not only enhance his research (e.g., studies of Zeeman but to provide a range of opportunities for undergraduate students to work in the field of atomic and molecular spectroscopy, to operate a high-resolution laser, to utilize precision optics, and to record data with detection equipment like photodiodes and PMTs. Such analysis ranges from simple fitting techniques to quantum calculations that can be run on a desktop computer. ✪***Lacustrine deposits as an analog for future Earth and surface sediments on Mars*** (*Bryant University*): This research seed grant enabled field and laboratory studies to study Middle Miocene deposits in Idaho in order to study ways to extract various biomarkers and bio-molecules from these well studied lacustrine sediments and a better understanding of preservation and recovery methods are important for treating samples from future Mars explorations for life on Mars. This effort provided sufficient data for a proposal to NSF. ***Improving Dye-Sensitized Solar Cells*** (*Roger Williams University*): This research synthesized a series of derivatized bipyridyl ligands that are used to produce a series of chromophoric dyes in order to determine whether or not applying a potential (voltage bias) during the fabrication of a dye-sensitized solar cells (DSSC) increases or decreases the ability to operate effectively. The study found that photo-conversion efficiency improved by adding a bias potential during dye deposition. The effort engaged 3 students in hands-on experience in the laboratory.

- Precollege projects:

Goals and Purpose: (1) Inspire and motivate educators to incorporate aerospace themes into their classrooms; (2) Engage undergraduates and graduate students in formal and informal education in order to sustain their future involvement, whether as faculty researchers or educators; and (3) Engage graduate students in the excitement of their research through communicating their NASA-related results.

SMART Objectives: *Specific*: Three programs were proposed for FY16: (a) 1 *Educator Workshop* structured around a new NASA-themed exhibit and the new *Earth Room* (*Seismic Shifts*) reaching ~90 educators at the *MNH*. (b) 1professional development travel awards for informal education providers (MNH) to NASA-relevant workshops and NASA Center activities that provide meaningful resources for distribution. (c) 10 workshops (>80 educators, grades 4-8) through our partner with the *Krupowicz Planetarium* (at *Gaudet School* in Middletown RI) through the *MNH*. *Measurable*: We will measure success through the following metrics. (1) *Educator workshops*: educator responses to questionnaires, repeat participants, and solicited feedback on the use of material in the classroom, and whether in the classroom or through informal settings (e.g., clubs). (2) Success of travel support by documentation of implementation of materials into workshops or programs at the museum and *Gaudet*. *Acceptable*: (1) Our in-service professional development program incorporates hands-on activities consistent with *NASA's Education Strategic Coordination Framework*. The *MNH* has 3 full-time professional educators trained in STEM-based education programming. (2) All workshops will involve NASA themes and resources. (3) Programs at the *Krupowicz Planetarium* (*KP*) work with the *MNH* and *Science Curriculum Coordinator, Middletown Assistant Superintendent* and educators, thereby ensuring integration of our programs into their curriculum. *Realistic*: In FY 16, our target under this award was to engage at least 110 educators through

11 workshops through the MNH or *Krupowicz Planetarium*. *Time Frame*: Each educator workshop series is re-defined each year in order to maximize their impact and relevance. We made awards totaling $9.3K in this category, thereby meeting our target of $9.4K.

Program Description: Most of our Pre-College activity is done through partnership with the *Museum of Natural History* (*MNH*, City of Providence). *MNH* staff members are skilled educators, familiar with state/national standards. Our pre-college programs focus on educators from primary to secondary schools. We partner with professional education providers at the *Museum of Natural History* (*MNH)* and *Krupowicz Planetarium* (*KP*) in order to ensure use of appropriate themes and materials consistent with state educational reforms. For FY16, we **proposed** to host 1 workshop at the *MNH* (30 teachers) and 10 workshops in Middletown (10 middle school teachers) .We assessed these programs through educator response to questionnaires, repeat involvement, feedback, and evidence for use of materials in the classroom. Programs sponsored in FY16 include: ✪***MNH Internship*:** We provided support for an undergraduate to work with the *MNH* for exhibit development and programming related to NASA themes. ✪ ***Krupowicz Planetarium*:** The *MNH* Director developed new STEM-based (and NASA-themed) programs (Gaudet Middle School) and also supported workshops for 60 educators and reached 2750 students. ✪***Professional Development*:** We supported travel for *MNH* Director to participate in an *Astronaut Training Experience at Kennedy Spaceflight Center*, a program that immersed participants in the world of astronaut training. In addition to authentic mission simulators trainees performed a real space shuttle mission simulation within a full-scale, realistically outfitted mission control mock-up. This RISG-sponsored trip contributed to programming at the Museum, including *Living and Working in Space*. We also supported the Museum Directors attendance at a *Climate Workshop* focusing on Earth's Systems and NASA's supported satellite systems and research about Earth's dynamics; and *Searching for Habitable Environments on Mars with Curiosity*, which provided experience-based learning in the context of gravitational forces of Earth. All trips introduced better content for MNH educator workshops. ✪***Museum Workshops*:** The Science Educator Workshop Series at the MNH supported one workshop on *Global Precipitation Measurement* (GPM) for 30 teachers. We did not meet our targets through the *MNH* in part because this report does not cover the full year and because of the need to coordinate Professional Development Days with different school systems in the state. The Museum Director is working on this issue. ✪***Woonsocket/NASA-Goddard/MNH Partnership*:** Through a joint project between the MNH, NASA-Goddard, and the Woonsocket, RI school system, a new effort developed and provided STEM curriculum support for grades 4-8, working with all the teachers and schools in the district. The effort included 4-5 day Professional Development days using on-line NASA resources (e.g., *NASA-BEST* and *NASA Wavelength*).

- Informal Education projects:

Goals and Purpose: To inspire, engage, promote, and educate the public in NASA's mission through informal education at museums, observatories, and other STEM resources.

***SMART Objectives*:** *Specific*: 5 tasks are proposed: (a) one NASA-themed exhibit; (b) updated exhibit in the Earth Room; (c) new full-dome programming development support; (d) *Krupowicz Planetarium* NASA-themed "Family Fun Nights" (Middletown, RI); and (d) jointly sponsored NASA-themed events with our Consortium Partners. *Measurable*: Measured results including increase in MNH attendance, feedback from visitors, press coverage, and web hits. *Appropriate*: All *RISG*-sponsored exhibits, public events & open houses, and programming that align with NASA goals, missions, and themes. *Realistic*: Exhibits not only involve the MNH staff but also engage Affiliate faculty, students, and staff for planning and implementation. Hence, our objectives are realistic through a heavily leveraged partnership. *Time Frame*: (a) We proposed to support 1 new exhibit/year in the *Space Room* (highlighting NASA exploration). (b) *MNH* staff will work with NASA resources to update content that highlight NASA's role in monitoring our

planet for the new *Earth Room*. We made $11.7K in awards, thereby meeting our target of $11.3K (within $5K).

We achieved most of our *SMART* objectives. ✪***Planetarium and Terra Dome*** (***MNH***): Over the last year, the full dome was used for more public and student programming. A new Mars full dome program, using a NASA Mars full dome video, is being developed and will be launched in the spring of 2017. Because more NASA full-dome programming is now available, the museum will produce shows using both the full dome and traditional star projector system. The museum also hosted special afterschool *STEAM* programming for 4-5 grade students, serving over 100 students. ✪***Krupowicz Planetarium***, ***KP*** (Gaudet School, Middletown, RI): We supported 16 Educator workshops supporting Middletown Public Schools Krupowicz Planetarium Programming, grades 4-8 for a total of 60 educators, a reduction in the previous year as the Museum has formulated a new partnership with Woonsocket Public schools. Family fun nights continued with (8) Family Fun Planetarium Nights that reached over 320 visitors focusing on different themes: 2 Solar System themed (2); Mars themes (2); Life Cycle of Stars (2); and telescope use/instruction (2). The family fun nights reached over 320 visitors. The MNH also hosted 2 special home-school programming days focused on the solar system, for local home-school families. In total 60 children and families attended. ✪***Northeast Planetary Data Center (NEPDC) and Ladd Observatory***: The RISG Director gave a guest lecture in celebration of the 125th Anniversary of Ladd Observatory. The NEPDC co-hosted the *3D Printing Workshop* by providing computers, 3D printers, and space. ✪***MNH Exhibits: The Red Planet: Going to Mars*:** This new exhibit focused on the engineering challenges of a Martian mission and opened in the summer 2016. A crucial element of NASA's plans is the *Mars Ascent Vehicle* (MAV), the spacecraft that will return the astronauts to Earth. In the spring of 2016, RI School of Design's *Design for Extreme Environments* (Industrial Design Studio), worked with NASA-JSC to design two different concepts for the *MAV*. The mock-up models resulting from the class became the centerpiece of the exhibit by providing visible evidence that we will be going to Mars. In conjunction with the exhibit, 3D models of future landing sites (currently under review) were produced. The exhibit partnered with the *Northeast Planetary Data Center*. ✪***Earth Room***: The earth rooms exhibit about the earth and climate change is updated and provides information about current NASA missions including SMAP and upcoming ICE-Sat 2, launching in late 2017

E. PROGRAM CONTRIBUTIONS TO NASA EDUCATION PERFORMANCE GOALS

Include summary data for the bulleted list below:

- **Diversity**: Supported 5 underrepresented students
- **Minority Serving Institution Collaborations**: 1 (Tougaloo)
- **Office of Education Annual Performance Indicators**:
    - API 2.4.1: ED-16-1 29 total (tracked): 5 underrepresented; 12 women; 0 veterans
    - API 2.4.2: ED-16-2 60
    - API 2.4.4: ED-16-4

Museum of Natural History (*MNH*, Providence): Affiliate member which provides most of our K12 educational activities, informal education, and public outreach (through RISG-produced exhibits).

Ladd Observatory (Brown): Co-sponsor open houses and special events; provide speakers for special events.

Northeast Planetary Data Center (Brown): Co-sponsor NASA events; develop special exhibits with the *MNH*.

Gaudet Krupowicz Planetarium (Middletown School): Work with the planetarium through the *MNH* for various NASA-content Open Houses and Educator Workshops.

- API 2.4.5: ED-16-5 8840

F. IMPROVEMENTS MADE IN THE PAST YEAR

Due to the lateness of implementing the award augmentation, we had to reduce the number of Summer Graduate Fellowship awards and unexpectedly lost one Affiliate Fellowship at our Affiliate. As a result we focused on undergraduate awards but still missed our target expenditure by $6K. We also under spent by $9K (out of our target of $85.K) in Higher Education. But we received more requests for research this year. Because these requests involved hands-on engagement by students, we increased this category slightly. None of our categories missed our targets by more than $35K.

G. CURRENT AND PROJECTED CHALLENGES

We continue to face challenges with achieving the required institutional matches and must rely on tuition (lead), reduction in indirect costs (sub-awards), in-kind time, and/or faculty release time. This limits participation in any *NASA Center Internships* or national programs, such as *Rock-On*, which do not provide a mechanism for achieving the necessary non-federal match.

H. PROGRAM PARTNERS AND ROLE OF PARTNERS IN PROJECT EXECUTION

Brown University (Lead Institution) has an active research and graduate program in several NASA programs, with leadership roles in fundamental research, NASA missions and national committees related to planetary exploration and astronomy- astrophysics. The ***University of Rhode Island*** (*URI*) has two campuses, each treated separately. The main campus of *URI* in Kingston is the primary state-supported undergraduate/graduate institution (identified here as "*URI*") and a *Land Grant* institution. The ***Graduate School of Oceanography*** ("*GSO*"), at the Narragansett campus of URI, has a highly respected graduate program in oceanography (also the lead for *Sea Grant*) with a strong interest in deep-sea life (relevant for astrobiology). ***Bryant University*** (*Bryant*) in Smithfield is a highly respected private university with emphasis on business and an active program in climate change, along with 6 graduate degrees including environmental science, business administration, accounting, and taxation. ***Roger Williams University*** (*RWU*) in Bristol is a private institution (MAT, Masters of Public Administration, Architecture, Law, Criminal Justice, School of Engineering) with growing programs in environmental and international studies. The ***Rhode Island School of Design*** (*RISD*) is a nationally ranked private college in the arts and design, with competitive academics. ***Rhode Island College*** (*RIC*) is the primary training institution for teachers in the state and houses the NASA's *Educator Resource Center*. The ***Community College of Rhode Island*** (*CCRI*) is Rhode Island's two-year state-supported community college, which provides opportunities for re-training and a stepping-stone to a four-year institution. ***Wheaton College*** is a private liberal arts college (just over the border in Norton, MA) with several faculty members who are involved in NASA-related research. ***Providence College*** (*PC*) and ***Salve Regina University*** are primarily undergraduate catholic institutions. *PC* is a Roman Catholic four-year liberal arts institution (under the auspices of the Dominican Friars). *Salve Regina* was founded under sponsorship of the Sisters of Mercy) became a university in 1991, offering PhD in the humanities. Through RISG, the ***Museum of Natural History*** (City of Providence, RI) developed a special "Space Room" that brings NASA exhibits and programming throughout southern New England.