MA Space Grant Consortium
Lead Institution: MA Space Grant Consortium
Director: Jeffrey Hoffman
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Consortium URL: www.maspacegrant.org
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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 MA Space Grant Consortium is a Designated Consortium funded at a level of $760,000 for fiscal year 2018.

B. PROGRAM GOALS

The following are MA Space Grant Consortium's (MASGC) goals:

1. Provide research fellowships to as many Massachusetts college and university students as possible, to enable them to work on cutting-edge NASA–related research.
2. Support NASA–related higher education activities across campuses in the state.
3. Support Pre-College programs to utilize unique NASA resources in order to train teachers and increase the STEM pipeline in the state
4. Support informal education to inform and educate the general public about NASA.

C. PROGRAM/PROJECT BENEFITS TO PROGRAM AREAS

Below is one of many testimonials received by MASGC describing the impact of Space Grant funding on students in the state:

My summer fellowship at MIT was an important addition to my life as a student as and as a person. I was able to work with some amazing faculty who was always available if I had a question or comment, and I was also able to work with some amazing students from all over the

world. As a non-traditional student (a bit older than most), they made me feel welcome and I had no problems coexisting with them in the lab.

From the day I walked into the lab, Dr. Consi kept me busy with all kinds of different and exciting projects. They kept me challenged and for the most part, I think I was quite successful with everything that was given to me.

My main project for the summer was how to utilize and construct payloads and apply them to the operation of drones. MIT Sea Grant has a couple of excellent drones that I was able to spend a lot of time with all summer (I think I flew most days I was there, sometimes twice per day, weather permitting of course). I worked with Arduino's and Raspberry Pi's, where I had to connect sensors, like temperature, humidity, orientation, and gas sensors, apply power to the apparatus using available connectors on the drone, mount the device and fly the vehicle while gathering data.

I had to create my own custom prototyping boards for use on the drones, that involved soldering headers to connect the sensors, applying resisters and wiring the devices so they would work with the processing boards. It was awesome that I had all the available tools and devices to accomplish my project goals, and if I ever needed anything, my request was granted and I received whatever it was that I needed.

I also got to spend some time with a LIDAR (Light, Imaging, Detecting and Ranging) device, which is a high speed revolving laser that has the capabilities of mapping out a room or space. The signal from the device is sent back to a computer and will print out a map of the space being observed by it. It takes high speed measurements so it can be used for vehicle obstacle avoidance and navigation. Mapping is its most common use.

I got some experience working with 3D printing software and actually printed parts that I used for my final project with my partner, where we mounted two cameras and a couple of Raspberry Pi's, and attached it to a drone and was able to take IR and normal photos of an area that was solely for my partners project. I was responsible for attaching the payload and flying the drone to get that data she needed. The project worked perfectly!

My favorite part of my summer was flying of course. Coming to MIT, I had already had experience flying drones (I actually have built and flown several of them). The main craft that I spent most of my time with, the DJI Matrice 100, is an excellent machine. It was my first out-of-the-box drone, so there was no programming involved. Just charge the batteries and fly. It was so easy to operate, that I took a couple of my colleagues in the lab out to learn how to fly. I enjoyed teaching the art of flying, and I think they enjoyed learning as well.

In closing, I'd like to thank everyone who made it possible for me to attend the most prestigious research school in the world, something that so many only dream of and never get the chance. It was an experience that I will never forget. I'm glad that I got the opportunity to spend my summer at MIT, and if given the chance, I'd do it all over again.

Mark P Pasquantonio, Bridgewater State University

D. PROGRAM ACCOMPLISHMENTS

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

MASGC Objective: Offer at least 20 student fellowships for cutting-edge aerospace research actively recruiting women and minorities.

Outcome: Awarded 88 student fellowships for higher education & research across 16 academic affiliates statewide.

Women participation: **40.9%**
Underrepresented Minority participation: **20.5%**

- Higher Education projects:

1. Worcester Polytechnic Institute – (SPAce)

The Summer Program in Aerospace Engineering (SPAce) is a two-year program lead by Professor Gatsonis and funded through direct fellowships to WPI AE students by the NASA Mass Space Grant Consortium. SPAcE combines graduate and undergraduate research, and Outreach in a unique way.

The 2018 Summer Program in Aerospace Engineering (SPAcE) at WPI combined research with outreach activities. SPAcE was led by Professor Gatsonis and along with other WPI Professors who engaged eight (8) WPI Student Fellows in research. The WPI faculty and Student Fellows students provided educational activities to rising seniors from the Mass Academy of Math and Science.

Eight SPAcE Student Fellows funded through fellowships performed research under the supervision of SPAcE Faculty Advisors on various aerospace topics such as Spacecraft Propulsion, Aerospace Vehicle Dynamics. Bio fluids in Microgravity.

From June 4 to June 29, sixteen High School Fellows from Mass Academy of Math and Science (MAMS) were immersed in daily classroom and laboratory activities relevant to aerospace engineering. This four-week, non-residential outreach program was provided free of charge to the High School Fellows and was delivered by SPAcE Faculty Advisors and SPAcE Student Fellows. The goal of SPAcE was to increase awareness in Aerospace Engineering to rising seniors from MAMS who are considering Engineering as their possible major.

2. BEAR Team at Bridgewater State College

Supported the undergraduate astronomy research group called the BEAR Team, or the BSU Experimental Astrophysics Research Team (note - our university mascot is a Bear). Students who were part of the BEAR Team from Fall 2017 through Summer 2018 engaged in mentored research in that involved gathering images for photometry or making spectroscopic observations. During every clear night, student team members are given an observing plan to make observations that support any ongoing research activities. On cloudy nights (and some daytime

hours), team members have engaged in other research activities like image processing and analysis.

As a result, students who are part of the BEAR team develop advanced skills in observational astronomy (including instrumentation), get significant experience in observational astronomy to add to their resumes, provide support (and data) for students enrolled in classes that require observational astronomy projects and benefit from collaboration with other students and they get paid while doing it.

Students were mostly physics majors, but several students from other departments were involved as well. BSU has benefitted from the BEAR team because we now have a structure in place to support and encourage students who are interested in astronomy and this helps support our new Astrophysics concentration. We have a repository of data available to any students (even those not yet part of the team) who want to engage research at a variety of levels. We make maximum use of our research grade telescope and CCD camera, and through BEAR teamwork were able to identify and justify the need and purchase of another CCD camera and a new echelle spectrograph. We are building a strong base of students familiar with equipment and observational techniques and even the students who do not stay with astrophysics are well prepared to transition into other research labs or projects within the department.

3. University of Massachusetts/Dartmouth – Proactive Mentoring of Talented Undergraduate Students (PROMOTUS)

This second year of a two-year augmentation award enabled undergraduate students to conduct research under the auspices of the NASA Space Grant. By enabling a population of underserved students to participate in paid research during the academic year, this funded activity will help boost student retention and STEM degree completion rates. Students will participate in cutting-edge research activity in relativity and astrophysics, as well as work in other NASA-related STEM fields.

4. Wellesley College – High-precision tests of gravity with the APOLLO Lunar Laser Ranging Project

This work is in support of the APOLLO project (Apache Point Observatory Lunar Laser-ranging Operation, jointly funded by NASA & NSF), which measures the Earth-Moon distance with millimeter precision to test General Relativity and other fundamental physics. APOLLO uses a pulsed laser to range to retro-reflectors on the lunar surface placed by Apollo 11, 14 and 15 astronauts, as well as two unmanned Russian rovers. With archival observations dating back to 1970, lunar laser ranging affords high-precision constraints on fundamental physics, including long-period phenomena.

Already, APOLLO has demonstrated millimeter-precision range measurements (data steadily accumulating since 2006), and has recently begun a funded effort (NASA & NSF) to develop and deploy an advanced absolute timing calibration system for the instrument. Under this funding Wellesley College students were able to play a larger role in this endeavor, through both

on-campus hands-on research (hardware development of opto-electronics systems, as well as software development for system control and data analysis), and off-campus research (site visits to the APOLLO instrument at the Apache Point Observatory 3.5m telescope near Sunspot, NM for both observations and system installation/shakedown).

5. MIT Gelb Project: Einstein's Playground

The project is developing Einstein's Playground, a digital visualization of Special Relativity that allows audiences to suggest experiments and see them play out in real time. The software illustrates Einstein's thought experiment about riding the streetcar in Bern and watching the clock tower, as a way to connect his theory of relativity to the physical environment he lived in and wrote about.

6. Conference and Competition Travel for students

The Consortium supported 12 students to attend and present their research at various conferences and competitions, NASA RASC-AL Mars Ice Competition; SEDS satellite Competition and the NASA Suits Competition.

7. Maria Mitchell Observatory - "Women in Science Symposium"

Supported students to attend the symposium. The Symposium was designed to serve as an inspiration and support for women working and teaching in the sciences, technology, mathematics, and engineering fields (STEM). Supported 27 students (100% female, 11.1% underrepresented).

8. MIT Space Seminar

Supported the MIT Space Seminar, which was a seminar series organized by the Students for the Exploration of Space and Development of Space (SEDS). It gave the attendees a general understanding of current developments in space. Speakers included professors from academia, employees from the private sector.

9. Astropreneurship & Space Industry Club Conference (ASIC)

2019 Speakers will discuss new technologies and services being implemented to close the business case for the emerging space economy. Topics will cover the drivers for astropreneurship: space accelerators, the role of public organizations and policy makers, development of new generations of satellites, new methods of utilizing spacecraft and much more. This year's event will also be part of MIT Space Week including a celebration of the Apollo Moon Landing 50th anniversary and beyond the cradle: envisioning a new space age. Supported 50 students (36% female; 48% underrepresented)

Hands-on experiences in science and engineering disciplines:

MASGC Objective: Conduct the MIT-KSC Internship program for at least 6 students to introduce students to the design and operational aspects of space flight and developments in our space program. Gaining this operational perspective at KSC and commercial companies such as Space X, as well as other NASA contractors, helped participating students become better engineers and attract them to space-related careers, in line with NASA's work force development goals.

For over ten years, MASGC had conducted this program under the mentorship of MASGC Co-Director Raji Patel. This year, however, we did not receive the POC support from KSC and therefore were forced to end the program.

Outcome: We are looking into supporting the SEDS (Students for the Exploration and Development of Space)

CubeSat Project

The CubeSat project is a joint collaboration involving the Tufts, MIT and Northeastern SEDS. The group has completed an exhaustive systems requirement review and trade studies on each subsystem and is attempting to demonstrate the capabilities of Electrospray Thrusters made by the MIT Space Propulsion Laboratory for orbit raising and fine-tuning.

Research Infrastructure projects:

MASGC supports students to work on faculty-initiated research projects individually or as a team. The main objective is to give students an authentic research experience through hands-on training in the research process. A targeted deliverable is to have the students present their work at a professional conference (e.g., AIAA) or publish their work in a technical journal. MASGC supports student travel to conferences to present research papers.

1. Wellesley College/Boston University – Enhancing dark matter detectors using FPGA-based readout electronics

Identifying the new physics of dark matter is a primary scientific target for the 21st century. In our proposed work we will address the nature of dark matter by enhancing the sensitivity of direction-sensitive dark matter detectors by a factor of 100 per unit volume by developing a data acquisition system built around a Field-Programmable Gate Array (FPGA). This collaborative, interdisciplinary, work unites the particle physics expertise of Dr. James Battat at Wellesley College with the digital electronics expertise of Dr. Martin Herbordt at Boston University.

2. OLIN College for Engineering Summer Research Program

The students work on faculty-initiated research projects individually or as a team. The main objective is to give students an authentic research experience through hands-on training in the research process. A targeted deliverable is to have the students present their work at a professional conference (e.g., ASME, AIAA) or publish their work in a technical journal.

Students were funded to conduct research on the following projects:

1) ThinSat mission for an orbital debris experiment. Olin is designing, fabricating, and testing three ThinSat (small satellites) that will be used to conduct calibration experiments related to orbital debris. The mission comes from NASA JSC Orbital Debris Program Office. During the summer, a student team developed a mission plan, system diagrams, and began fabricating and testing prototype mechanisms.
2) Creating CAD models for 3D printing based upon two-dimensional images. Previously developed techniques and processes for creating and printing 3D models based on a series of 2D images were updated and improved.
3) FEA simulation of a broadband vibration energy harvester. Finite element analysis simulations (using ANSYS) were performed to validate experimental measurements from a prototype vibration energy harvester.

Project goals were accomplished successfully. The first and second projects are continuing. The third has been completed and we are currently working on a journal article for submission this spring.

3. University of Massachusetts/Lowell - SPACE HAUC CubeSat Mission

Science Program Around Communications Engineering with High Achieving Undergraduate Cadres (SPACE HAUC) is a CubeSat mission being developed by a team of undergraduates at UMass Lowell. It will demonstrate the suitability of high data rate X-band communications on CubeSat. SPACE HAUC is designed to leverage our on-going efforts and provide an opportunity for undergraduate and graduate students to develop and flight demonstrate a state-of-the-art, low-cost phased array antenna and phase shifter electronics manufactured by 2-D Printing aboard a CubeSat platform. The project is a multidisciplinary research effort that will involve the design, construction, integration, test, and launch of UMass Lowell's first satellite. During the two years of this project, undergraduate students will gain hands-on experience in a broad range of spaceflight technology topics, such as, spacecraft and instrument design, hardware fabrication, control theory, integration and tests, and spacecraft operations, as well as data analysis. Support from MASGC allows the students to participate in SPACE HAUC in a meaningful way. The students supported by MASGC are members of various subsystem teams for the project, each contributing crucial research and design to make the mission a success. Graduate students supporting the SPACE HAUC team - Glenn Howe and George Geddes support the undergraduate students. Glenn provided space flight hardware expertise to members of the space HAUC team. George provided space environmental information and data processing approaches using an instrument on the international space station.

- Pre-college and Informal Education projects:

1. Supported the SSEP (Student Spaceflight Experiments Program) at Montachusett Regional Vocational Technical School. The entire student body was offered the opportunity to participate in a school wide scientific experimental design competition to place an experiment aboard the International Space Station in the spring of 2019.

2. Supported the Woodland Elementary School in Milford, MA to visit the Christa McCauliffe Center at Framingham State University. Approximately 340 students were guided through a launch and landing simulation, experiencing a shuttle mission. Each student, as part of the mission, was assigned roles. These roles are real and true to actual launch missions. Students had to work together as a team in order to have a successful mission. Lastly, students were carefully placed in these roles with a focus on putting at-risk students in leadership roles along with a focus of identifying female students for these leadership roles in this scientific field.

E. PROGRAM CONTRIBUTIONS TO NASA EDUCATION PERFORMANCE GOALS

- **Student data and Longitudinal Tracking**:

Starting in 2006, MASGC has carried out longitudinal tracking of students who have participated in the Consortium's programs. The impressive **STEM retention results (89%)** are as follows:

Over 10 years, of the **691 students have graduated with the initial degree** they were pursuing when supported by MASGC:

- **319** are pursuing advanced STEM-related degrees
- **49** were actively seeking STEM employment when last contacted
- **98** are employed by aerospace contractors
- **92** are employed in non-aerospace STEM positions
- **14** are employed by NASA/JPL
- **13** are employed in K-12 STEM
- **31** are employed in "other" STEM academic fields
- 75 are employed in non-STEM fields.

- **Diversity**:

  Women participation: **40.9%**
  Underrepresented Minority participation: **20.5%.**

- **Minority Serving Institution Collaborations**:

The Consortium's members include Roxbury Community College, the Commonwealth's only designated "minority-serving institution". Attracting community college students to aerospace-related activities is challenging, because aerospace is a field of endeavor most of the students have not thought about. Therefore, MASGC offers fellowships to community college students, to encourage them to enter the aerospace workforce pipeline.

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

  - API 3.3.3: ED-18-1 64 awards; 20.3% underrepresented; 42.2% women
  - API 3.3.5: ED-18-5 7 papers presented/published

F. IMPROVEMENTS MADE IN THE PAST YEAR

1. MASGC has made an effort to maximize the benefits from reduced funding by increasing student travel opportunities. In keeping with MASGC's guiding principle of using Space Grant funding to enable students to engage in NASA-relevant activities they would otherwise not have access to, the consortium provided funding for students to attend conferences in which they presented a research paper or poster, or attended aerospace-related competitions.

2. As described in NASA education priorities above, the consortium has extended its reach to community colleges by providing student funding to community college students as a part of its higher education portfolio.

G. CURRENT AND PROJECTED CHALLENGES

As shown below, currently MASGC has 18 academic members. Given that some of them are the largest research institutions in the world, there is a very large demand for student support within the state. Therefore, it is a challenge to meet this demand with the SG reduced level of funding, which is then further divided into base and augmentation funding.

Further, while we give priority to our members for student support, we do not preclude other education institutions from space grant funding when we feel that the support makes most impact. For e.g. we have in the past, supported fellowships at the Holyoke Community College and the Quinsigamond Community College (QCC) even though neither college is officially a consortium member. We are also looking to support students at the Bunker Hill Community College.

We have been forced to end our flagship program at the Kennedy Space center after almost 15 years because of lack of support from KSC. We are now looking into supporting hand-on projects for our students especially in the areas of developing and testing CubeSats.

H. PROGRAM PARTNERS AND ROLE OF PARTNERS IN PROJECT EXECUTION

Currently, the Massachusetts Space Grant Consortium has 18 academic affiliates and 3 institutional (outreach) affiliates, covering the entire state from Cape Cod and the Islands to the Berkshires. Members are listed below, together with the name of each affiliate's representative to MASGC. MASGC affiliates play an important role in execution of the consortium's goals and programs. Each affiliate is responsible for selecting the most competitive and deserving programs and students for space grant funding to assist NASA's education mission.

Academic Affiliates

Massachusetts Institute of Technology, Lead	Professor Jeffrey Hoffman
Boston University (Boston)	Professor John Clarke

Bridgewater State University (Bridgewater)	Professor Martina Arndt
Framingham State University (Framingham)	Dr. Irene Porro
Five College Astronomy Department (Amherst)	Dr. Alexandra Pope*
Harvard University (Cambridge)	Professor Jonathan Grindlay
Mount Holyoke College (South Hadley)	Professor Darby Dyar
Northeastern University (Boston)	Professor Alain Karma
Olin College (Needham)	Professor Christopher Lee
Roxbury Community College (Boston)	Dr. Javad Moulai
Tufts University (Somerville)	Prof. Danilo Marchesini
University of Massachusetts (Amherst)	Prof. Daniella Calzetti
University of Massachusetts (Dartmouth)	Professor Robert Fisher
University of Massachusetts (Lowell)	Prof. Supriya Chakrabarti
Wellesley College (Wellesley)	Professor Kim McLeod
Williams College (Williamstown)	Professor Jay Pasachoff
Worcester Polytechnic Institute (Worcester)	Professor Nikolaos Gatsonis
Worcester State University (Worcester)	Professor Nabin Malakar

* Five-College Astronomy Department, which in addition to Amherst, Mount Holyoke and UMass, also includes Hampshire and Smith Colleges.

Institutional Affiliates (Outreach)

Museum of Science (Boston)	Ms. Dani Leblanc
Christa McAuliffe Center (Framingham)	Dr. Irene Porro
Maria Mitchell Observatory (Nantucket)	Dr. Regina Jorgenson