The National Space Grant Office requires two annual reports, the Annual Performance Data Report (APD – this document) and the Office of Education Performance Measurement System (OEPM) report. The former is primarily narrative and the latter data intensive. Because the reporting timeline cycles are different, data in the two reports may not necessarily agree at the time of report submission. OEPM data are used for official reporting.

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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 Colorado Space Grant Consortium is a Designated Consortium funded at a level of $575,000 for fiscal year 2014.

PROGRAM GOALS

The Colorado Space Grant Consortium had four primary goals for the year as part of a five-year strategic plan developed to enhance the overall student experience and better equip the student for the workforce.

These four primary goals were:

1. Increase diverse student participation in hands-on space hardware programs.
2. Sustain four stages of hands-on programs for COSGC students.
3. Create and support opportunities for COSGC students to work with engineers and scientists form Colorado aerospace companies.
4. Partner COSGC students and program with faculty and industry experts and their research through space hardware missions, seed grants, and research grant opportunities.

PROGRAM/PROJECT BENEFIT TO OUTCOME (1,2, and 3)

Outcome 1:

- The student designed and built ALL-STAR CubeSat was launched and became the second Colorado Space Grant payload in Earth orbit.

- COSGC won funding through the Community College and Technical School Opportunity and was able to add four additional Colorado community colleges, thereby expanding the student population engaged in hands-on projects across the state. This same opportunity will add to the number of scholarships awarded and internships supported at NASA Centers.
- Amanda Williams (Pikes Peak Community College student) was selected to participate in the National Community College Aerospace Scholars program (NCAS) in the Fall 2014 semester. Her work won her a visit to participate in the program at Johnson Space Center.

PROGRAM ACCOMPLISHMENTS

Goals stated as SMART Goal Metrics from the COSGC 2010 Proposal are indicated in parenthesis at the end of each line item - including the page number from the proposal where each may be located.

NASA Outcome 1:

COSGC Goal 1 (Diversity)

- All COSGC students who received scholarships participated in hands-on, space hardware programs at their respective institutions, or with industry partners.
    - **32.5%** of scholarships were awarded to women (Goal: 33.7%, p. 9)
    - **18.4%** of scholarships were awarded to minority students underrepresented in STEM disciplines. (Goal: 19.5%, p. 9)

COSGC Goal 2 (Fellowship/Scholarship & Higher Education)

- All COSGC institutions awarded a minimum of **30%** of their FY 2014 funding directly to students in the form of scholarship awards. (Goal: 30%, p.10)
- **234** scholarships were awarded to COSGC undergraduate and graduate students in FY 2014. All awardees were engaged in hands-on space focused projects including laboratory research, observatory explorations, robotics projects, short and long duration balloon payloads, sounding rocket payloads, CubeSat payloads, and low Earth orbiting satellite missions. (Goal: 45, p.10)
- **237** undergraduate and graduate students engaged in hands-on space focused projects as credit students, volunteers or in project-focused courses. (Goal: 120, p.16)
- COSGC maintained all four stages of the SHOP (Staged Hands-On Program) approach to student experiences within the COSGC academic network.
    - In FY 2014 all COSGC institutions of higher education facilitated hands-on student projects that fall within the *Staged Hands-On Program* approach to student experiences outlined in the COSGC Strategic Plan: **17** facilitated at least one introductory (or "Walk) level student project (Goal: 17, p.16); **5** facilitated at least one beginning/intermediate (or "Run") level students project (Goal: 4, p.16); **3** facilitated one intermediate/advanced (or "Jump") level project (Goal: 2, p.16); and **2** facilitated an advanced (or "Fly") level project.

COSGC Goal 3 (Research Infrastructure)

- **12** students participated in EduSourcing internships at Lockheed Martin and Digital Globe. (Goal 4, p.12)

COSGC Goal 4 (Research Infrastructure)

- **0** seed grants were awarded to junior faculty for research at Colorado State University (CSU). (Goal: 4, p.12) [CSU seed grant program was discontinued with the reorganization of CSU Space Grant programming.]
- **7** COSGC institutions facilitated research projects for students to work in collaboration with industry and/or academic mentors. (Goal: 4, p.12)
- **17** students participated in research projects for credit or as volunteers. (Goal: 10, p.12)

NASA Outcome 2: (Precollege)

- **95** teachers participated in **4** weeks of training at the Space Foundation's summer Space Across the Curriculum courses. (Goal: 170 teachers; 7 weeks, p.17) [This year, The Space Foundation focused partially on "training-the-trainers" with their Space Grant support. Space Foundation educators participated in professional development workshops with educators and industry representatives to make their workshops more innovative and in-line with new education guidelines.
- **0** pre-service teachers engaged in curriculum building activities. (Goal: 2, p.17) Note: There was a change of affiliate director at the proposing institution (Adams State College). The new AD changed the program accordingly, including shifting focus to undergraduate STEM students not pre-service educators. This was detailed in the 2011 Statement of Work accompanying the budget update that year.

NASA Outcome 3: (Informal Education)

- **59** COSGC undergraduate students facilitated **13** K-12 hands-on science and engineering activities, engaging **302** young students. These service-learning efforts support hands-on programs in order to promote well-rounded COSGC graduates by engaging young engineers with the wider community. (Goal: 1 activity with 30 K-12 participants, p.18)

PROGRAM CONTRIBUTIONS TO NASA EDUCATION PERFORMANCE MEASURES

- **Diversity:**
  - COSGC includes:
    - 8 Minority Serving Institutions (MSI)
    - 9 two-year colleges
    - 1 four-year baccalaureate colleges
    - 5 four-year baccalaureate through masters institutions
    - 5 universities through PhD
    - 1 non-profit organization
  - 32.5% of 234 scholarships were awarded to women
  - 18.4% of 234 scholarships were awarded to minority students underrepresented in STEM disciplines.
  - 97% of 234 scholarships were awarded to undergraduate students
  - Of the 237 students participating who did not receive fellowship/scholarship awards:
    - 30% were women

    - 21% were students from ethnic minority populations underrepresented in STEM disciplines
- Of 25 faculty involved:
    - 32% were women
    - 12% were underrepresented
- **Minority-Serving Institution Collaborations:** COSGC had **8** MSIs (or Hispanic Service Institutions) engaged as active members of the consortium:
    - Adams State University (ASU): Student teams participated in the Colorado Robotics Challenge, robotics workshops, and the Robotics Society. Provided content for summer high school robotics course.
    - Aims Community College (Aims): One of the new community colleges added to the consortium during this period of performance. Participated in the January balloon payload workshop. Currently facilitating a balloon payload project that will launch with the April 2015 DemoSat flight.
    - Colorado State University – Pueblo (CSU-Pueblo): Student teams are working on robotics projects and continuing work on a Sabatier Reactor.
    - Community College of Aurora (CCA): Facilitating a Experimental Design course, engaging students in robotics projects, and implementing a new program to work with students interested in engineering who do not have the math courses necessary to enter a 4-year institution. CCA students have submitted abstracts for the COSGC 2015 Undergraduate Space Research Symposium.
    - Community College of Denver (CCD): Student teams participated in the January 2015 balloon payload and robotics workshops; 3 teams were part of the DemoSat balloon payload program including 3 launches throughout the year; teams working on autonomous robots that will be demonstrated at the Colorado Robotics Challenge in April 2015; sent a student team to the 2014 RockOn! Workshop at Wallops Flight Facility (WFF). A team CCD students is now building a sounding rockets payload as a RockSat C team, scheduled to launch in July 2015 at WFF.
    - Otero Junior College (OJC): One of the new community colleges added to the consortium during this period of performance. Participated in the January balloon payload workshop. Currently facilitating a robotics program and building autonomous robots that will be demonstrated at the April 2015 Colorado Robotics Challenge
    - Pueblo Community College (PCC): Student teams working on robotics projects; Student teams participated in the Colorado Robotics Challenge and robotics workshops.
    - Trinidad State Junior College (TSJC): Student teams have been designing and building robots that will be demonstrated at the April 2015 Colorado Robotics Challenge. TSJC sent a student to participate in the January 2015 balloon payload workshop in Boulder and is now facilitating a team project that will launch with the April 2015 DemoSat flight. Three student papers will be submitted to the COSGC Undergraduate Space Research Symposium in April 2015. Finally, the TSJC Space Grant program has developed and implemented a 3D Printing and Design course. TSJC students have submitted 3 abstracts for paper and poster sessions at the 2015 Undergraduate Space Research Symposium.
    - All institutions participated in the 2014 annual meeting and contributed to the strategic plan process. All MSI institutions are collaborating with the consortium statewide on the COlorado Undergraduate Retention in Science and Engineering (COURSE) community college transfer initiative. All students are also eligible to apply for scholarships (transfer

and 2-yr institution), NASA internships, and participating in the RockOn! Workshop at Wallops Flight Facility.

- **NASA Education Priorities:**

a. <u>Authentic hands-on student experiences in science and engineering.</u>

- <u>STATEWIDE EFFORTS:</u>

- **32** student teams representing **13** COSGC campuses are registered to participate in the Colorado Robotics Challenge on April 4, 2015 by designing and building autonomous robots.
- Student teams from **10** COSGC campuses have participated (summer/fall 2014) and will participate (spring 2015) in the statewide balloon payload program (7 in the DemoSat program which is extracurricular and 3 as courses) – building **37** short-duration balloon payloads that have and will launch on **3** flights in August/November 2014, and April 2015.
- Students from **11** COSGC campuses participated in robotics and balloon payload workshops facilitated by the COSGC Lead Institution in fall 2014 at Adams State University (Alamosa) and in spring 2015 at University of Colorado at Boulder.
- Students from **7** COSGC campuses have submitted abstracts to participate in the annual Colorado Space Grant Undergraduate Space Research Symposium. Students (either in teams or individually) submit research papers that are reviewed by judges from industry. Students then present their research. Students also participated by completing posters and/or hardware demonstrations for industry judges the day-of the Symposium.

- <u>WESTERN STATE COLORADO UNIVERSITY:</u>

The 2014-2015 year has been a banner year for the Western Space Grant program in many ways. The installation of a research-quality telescope at the Gunnison Valley Observatory has allowed for new avenues of astronomical research involving space grant students. The success of last year's robotics challenge team and active advertising has resulted in a considerable increase in the numbers of students participating in the 2015 Robotics Challenge. WSCU students attended the November 2014 COSGC robotics workshop in Alamosa. Students then helped build a team that is designing an autonomous robot that will be demonstrated at the Colorado Robotics Challenge on April 4, 2015. Astronomical research continues partnering students with WSCU faculty. The new telescope installed has enabled color imaging and exoplanet research – including the production of several quality exoplanet transit light curves which were submitted to the Exoplanet Transit Database and accepted.

- <u>UNIVERSITY OF NORTHERN COLORADO</u>

In summer 2014, five UNC undergraduates and two high school students developed a payload that used a Geiger counter to measure muon flux as a function of altitude. They reported on their findings at the COSGC annual fall meeting, and the high school students presented a poster at the Frontiers of Science Institute symposium ("Analysis of Muon Flux Across Elevation"). The experiment was successful in that the data displayed the expected behavior. Currently, four UNC undergraduates are designing a payload that will test the effect of high altitude radiation on carbon nanotubes. Their payload is scheduled to launch in April 2015. UNC Space Grant facilitates a robust robotics program that includes several foci including: **EEG Sensor:** This is an ongoing project involving one UNC undergraduate; **General Sensor Development:** This is an

ongoing effort by students to develop a variety of sensors. More generally, the students are acquiring electronics skills and are learning how to customize sensors for specific applications. **Rapid Part Fabrication with 3D Printing:** Students continue to collect several CAD designs for various basic parts needed to build robots. They experiment with the strength of the material, thickness, and mass in an effort to optimize the designs. The 3D printer is also used to generate prototypes that will eventually be manufactured out of materials other than plastic. **Investigating the Process of Balance:** Two students and Dr. Matthew Semak are fine-tuning a stochastic model for motion of the center of pressure of the foot occurring as the body tries to maintain its balance. They tested their model by using it to fit actual data generated in experiments performed by researchers in UNC's School of Sport and Exercise Science. The results show promise; the essential features of the data were reproduced. Currently, they are using time series analysis to assess the linearity of the behavior and the extent to which past events affect future ones. This research has applications to robotics. The students will present their results at the College of Natural and Health Sciences Student Research Celebration and at the COSGC Symposium in April, 2015. **Preparation for the Robotics Challenge:** Students are working to improve the communications between the robot and the beacon. In summer 2014, two UNC students and four high school students were able to make good progress. The high school students presented a poster at the Frontiers of Science Institute symposium ("Beacon and Obstacle Navigation for an Autonomous Rover"). **Investigating Swarm Behavior in Interacting Arduinos:** This project investigates swarm behavior using a collection of selectively coupled microprocessors (Arduinos). A UNC student has been able to establish communication among five Arduinos using XBee wireless communication modules. Currently, he is adapting a mathematical model that is used for multi-robot search processes for invoking swarm behavior. The goal is to have the group of Arduinos synchronize and perform the same task and indicate success.

- UNIVERSITY OF COLORADO AT COLORADO SPRINGS

A student mechanical team worked with a disabled athlete to develop a more adjustable back rest and wheel chair lift. The design was used at the World Championship in Germany where the athlete earned a slot for the 2016 Paralympic Games. A student biomechanics team has been working on a system that can identify tightness and weakness in the human body. Autonomy was an important attribute of the system, so students developed a custom marker and have been working on processing and video output done with student developed MATLAB software.

- UNIVERSITY OF COLORADO AT BOULDER

CU Space Grant supported a student team working on the PolarCube CubeSat. The mission is a collaboration with Center for Environmental Technology and National Snow and Ice Data Center. A new project was begun in support of the PolarCube effort, called Earth Station. This is an effort to develop a mobile ground station. Work on the Earth Station effort has involved Space Grant students in addition to an electrical engineering senior design team. The PropSat CubeSat mission continued development of a propulsion system for CubeSat use. CU Space Grant has been mentoring a senior design team in aerospace engineering developing a CubeSat called Phoenix. The RocketSat 10 mission worked toward an August 2014 launch out of Wallops Flight Facility. Launch was postponed, allowing the team to continue sample generation and testing through the year. Launch is currently scheduled for March 26, 2015. The team is attempting to combine aluminum and indium in microgravity during a sounding rocket flight. Three long-duration high altitude duration payload teams were engaged during the period of performance. HELIOS III completed their mission with launch in August 2014 and final

analysis. The team was encouraged to re-fly the payload and the HELIOS IV team is working toward an August 2015 launch where they will fly an improved payload. A new team called SIMBA is developing a payload that will collect microbes from the stratosphere. SIMBA will also launch in August 2015. Mission operations took place for the ALL-STAR mission at the mission operations and control center on the CU campus in the COSGC facility. Ten students attended the Conference on Small Satellites at Utah State University in August, 2015. Students hosted a booth highlighting the PolarCube mission and two students presented an accepted paper on the DANDE satellite mission. CU Space Grant continues to develop and operate a mission operations control center with a dedicated student team. CU Space Grant facilitated Arduino workshops in collaboration with student societies including Society for Hispanic Professional Engineers/Mexican American Engineering Society, Society of Women Engineers, and National Society of Black Engineers. CU Space Grant students are working on autonomous robots for demonstration at the 2015 Colorado Robotics Challenge. The lead institution facilitated two robotics workshops for statewide COSGC students and faculty and will lead the Challenge on April 4, 2015. A student team called "the A-Team" was engaged to provide general support for COSGC efforts – including research and development of projects to support statewide efforts and CU student programs, such as re-design of the beacon system for the Challenge and design and launch of a camera module for use on high altitude balloon projects. The Gateway to Space class was expanded to be taught in both fall and spring semesters in order to reach a wider range of students and disciplines. The COSGC leadership facilitated a balloon payload workshop in January 2015. The workshop was primarily for new community college partners. However, base funding allowed established COSGC community college programs to send teams in order to expand student projects to include balloon payloads.

Several efforts took place in conjunction with NASA's Wallops Flight Facility. COSGC Director, Chris Koehler, and a student support team, organized and facilitated the 2014 RockOn! Workshop in June 2014. Student program manager, Becca Lidvall, coordinated the RockSat C program culminating in a launch in June 2014. Student program manager, Jesse Austin, coordinated the RockSat X program throughout the year. The X launch slipped from the July date, extending the program through the new launch date set for March 2015. Both the C and X program are going strong and working toward launches in summer 2015. The RockSat X program has enabled a mechanical engineering senior design project to develop a payload to capture video of future RockSat X flights.

- TRINIDAD STATE JUNIOR COLLEGE

TSJC students are involved in two projects – design and build of an autonomous robot that will be demonstrated at the April 4 Colorado Robotics Challenge; and desing and build of a balloon payload that will launch with the DemoSat flight on April 11 in Eaton, CO. One student participated in COSGC's 3-day Colorado Community College Expansion balloon satellite workshop in Boulder, CO in January 2015. TSJC Space Grant is developing a 3D Printing and Design course. 10 students are enrolled in the spring semester pilot course. Both the robotics and balloon payload teams submitted abstracts to the COSGC Undergraduate Space Research Symposium. In addition, one student submitted an abstract for a single-author paper to the Symposium. TSJC Space Grant sponsored three internships on the TSJC campus. These included lab and teaching assistants for the Intro to Electronics and 3D Printing and Design courses in addition to one position designing and printing circuit boards.

- PIKES PEAK COMMUNITY COLLEGE

PPCC fulfilled the goal of having a five student DemoSat team during the Summer 2014 semester. All the students participated in a basic soldering and Arduino workshop on the first meeting of the semester. All five students stayed actively engaged throughout the semester and participated in design reviews, launch and recovery, and the writing of a final paper. Two of the five Summer students are also participating in DemoSat in the Spring 2015 semester. PPCC has two payloads in development for the April 11 DemoSat launch, engaging new students and incorporating the continuing students. Students have submitted an abstract for the Undergraduate Space Research Symposium in April 2015.

- PUEBLO COMMUNITY COLLEGE

PCC students worked on two projects. A team built a beacon system with a yagi antenna to help the robotics teams with testing of their designs. Students have designed and built a wheeled, autonomous robot that will be demonstrated at the Colorado Robotics Challenge on April 4, 2015.

- COLORADO STATE UNIVERSITY – PUEBLO

CSU – Pueblo students continue work on two main projects – autonomous rover design and Sabatier Reactor (Mars return fuel project). One of the rover students applied for a summer 2015 internship with Lockheed Martin. The interviewer expressed great interest in her rover experience and she was offered the position.

- COLORADO STATE UNIVERSITY – FORT COLLINS

The Robotics Challenge serves as an entry-level project after which students can continue on to more advanced projects. During the summer of 2014 two teams of summer interns (4 students on each team) worked on hands-on projects – one on a Laboratory Research project and one on a balloon payload project with the DemoSat program. The DemoSat team explored the variation of CO_2 concentration as a function of height in the atmosphere. The Laboratory Research team supported ongoing laser sensor work in Prof. Yalin's laboratory. The students' specific focus was on hardware and methods to maintain high mirror reflectivity, in the presence of ambient particles and vapors, as is needed for high sensor sensitivity. The student team was very successful in developing hardware designs and testing them, and the research group continues to use approaches that they first developed. Finally, a Senior Design project was supported during the 2014-2015 academic year. The team is, for the first time at CSU, developing a rocket for the Intercollegiate Rocket Engineering Competition (IREC) to be held in Utah in June 2015. The rocket team has successfully engaged support from Sierra Nevada Corporation (SNC). SNC is impressed with their effort and is supporting in the following ways: cash donation of $1000, lending a test-stand (with thrust meters etc.), and holding weekly telecons for technical guidance. All CSU Space Grant students are encouraged to submit entries to the Undergraduate Space Research Symposium.

CSU Space Grant also supports graduate student Laurie McHale. Laurie serves as the Graduate Student Manager while also performing laser sensor research in Yalin's research group. Laurie has been tasked with mentoring the undergraduate student teams (DemoSat and Robot Challenge) both administratively, i.e. coordinating meetings, travel, and purchases, as well as technically, i.e. providing guidance on designs, technical analysis etc. Laurie's research concerns the development of laser based sensors for air quality measurements. In particular, she is focused on measuring emissions from oil and gas systems, particularly methane as is important for radiative forcing (global warming and climate change). She is making strong research progress and is currently preparing a manuscript on her sensor work.

- COLORADO SCHOOL OF MINES

The Space Grant program at the Colorado School of Mines (CSM) underwent a significant change this year by expanding its objectives and reach from a sophomore-level design course to projects involving all levels of students, from freshman to senior, and also including new hands-on opportunities and research activities. As a result, projects now include participation in COSGC sponsored activities, such as the Robotics Challenge, the Robotics Workshops, and DemoSat, as well as senior engineering-design teams working along with freshmen, sophomores, and juniors from the CSM Space Society, Rocket Club, and Astronomy Club on space-related activities including a NASA-sponsored robotic mining competition and CSM's first CubeSat initiative. In addition, last year students participated along with faculty on summer research projects at the Center for Space Resources and made technical presentations at the Space Grant Undergraduate Space Research Symposium, as well as at the AIAA-Rocky Mountain Section Technical Symposium.

A student team composed of 5 sophomore students developed a conceptual design for an ROV spacecraft as part of their Space Design Class (EPICS II). The Assistive, Independent Maintenance and Observation Vehicle (ASIMOV) was designed to be operated from the safety of a spacecraft cabin and to perform tasks such as routine spacecraft maintenance and collect samples from the surface of an asteroid. The team submitted their design proposal to NASA's Revolutionary Aerospace Concepts-Academic Linkage (RASC-AL) program, which was accepted for presentation at its annual student forum in Cocoa Beach, Florida on June 17-19, 2014. A student team composed of 2 sophomore students built a working prototype of a NTP as part of their Space Design Class (EPICS II). The NTP housing was designed to protect the instrumentation during a free-fall landing, with a landing gear that "rights" the NTP to vertical upon landing, readying it for proper positioning of antennas for operation. The team (called *Blasterbotica*) is composed of students in the Capstone Senior Design course in the CSM College of Engineering and Computational Sciences. New this year was the inclusion of juniors from the CSM Space Society who will become part of next year's *Blasterbotica* team. This approach was adopted to smooth the transition of juniors to their senior-design project and to provide continuity of ideas, hardware design, and general experience in the construction of future rover designs. A team of 3 students from the CSM Robotics Club are designing and building an autonomous rover to participate in the COSGC Robotics Challenge on April 4, 2015. Their objective is to come up with a Mars-like rover to autonomously navigate courses of varying complexity and ruggedness with the possibility of unexpected obstacles, high and low temperature extremes, and blowing sand. Two teams composed of 3 students each participated in an all-day workshop at COSGC headquarters in CU Boulder on January 31 to learn about electronics, robots, soldering, and programming. These students were part of the CSM Space Society and CSM Rocket Club and were sent to this workshop to gather as much information on the design and assembly of robotic systems in order to share this knowledge with all members of their respective clubs.

- COLORADO MESA UNIVERSITY

Work in the DARPA robotics challenge continues. The team is now among the ~20 teams (internationally) invited to the world finals. CMU Space Grant has a robust robotics program and supports the Embedded Systems Lab on the CMU campus. Student projects in the lab in include autonomous robots of various design and quadcopters.

- ADAMS STATE UNIVERSITY

The ASU Robotics Society has been doing well and experienced good attendance through the period of performance. The scope of the program has broadened into other space related

technology. It is expected that the name of the program may change as a result over the next year. The society engages students of various demographics and disciplines including a few high school students, one high school teacher, and ASU faculty members and staff. ASU will have several robotics society student teams participating in the Colorado Robotics Challenge in April 2015. ASU Space Grant also hosted the fall 2014 robotics workshop on the ASU campus and is looking for a space on campus to host a Makerspace the day before the Robotics Challenge on April 3, 2015.

- METROPOLITAN STATE UNIVERSITY OF DENVER

MSUD Space Grant facilitated several hands-on projects to engage students. These included a thermal analysis project; Two student teams designed and built autonomous robots to be demonstrated at the Colorado Robotics Challenge; Six MSUD students also participated in a national robotics competition. Students continued work on the design of an electric vehicle. A new project was started that engaged four students working with a dynamometer. Finally, the balloon payload course was facilitated in both the fall and spring semesters. A total of 9 payloads were built and flew with the COSGC DemoSat launches.

- COMMUNITY COLLEGE OF AURORA

The Space Grant program at CCA focused primarily on the Experimental Design course. Students work in teams to design, build, and launch balloon payloads. CCA Space Grant also encourages students to submit applications to COSGC statewide opportunities (transfer to 4-year institutions. Finally, all balloon payload teams have submitted abstracts to the COSGC Undergraduate Space Research Symposium.

- COMMUNITY COLLEGE OF DENVER

The CCD Space Grant program expanded to include two additional student projects joining the established balloon payload program. Expanded programs were possible with the additional of two more CCD faculty mentors. CCD students build payloads for the 2014 summer and fall DemoSat launches and are building a payload to fly with the April 2015 flight as well. In summer 2014, two CCD Space Grant students and the affiliate director participated in the RockOn! Workshop at NASA's Wallops Flight Facility (WFF). They came home and established a sounding rocket payload program for CCD Space Grant students. The team is building a payload in conjunction with the RockSat C program scheduled to launch in June 2015 at WFF. CCD Space Grant is sponsoring two teams designing autonomous robots for demonstration at the 2015 Colorado Robotics Challenge.

- FORT LEWIS COLLEGE

FLC Space Grant students participated in an introductory robotics workshop in October 2014 at Adams State University in Alamosa. During the academic year, students worked on several robot designs, including one with legs. At least two teams will participate in the Colorado Robotics Challenge on April 4, 2015. Two students worked during the summer on observatory projects - specifically to design and build a remote stage for the guide scope. Software and procedural upgrades continue to improve the capabilities of the observatory. Students flew a payload on the summer balloon launch in 2014. Several gas sensors and an electric field mill were included as payloads. A payload monitoring system that was previously used was modified and included. It was intended to provide power and heating to multiple attached payloads. Battery usage is monitored and regulated. The 3-D Reprap printer built in previous years was updated, and printed parts were used in the balloonsat payload structure. Several former Space Grant students have reported benefiting from their Space Grant projects as they do senior design projects.

b. Engage middle school teachers

- The Space Foundation's Summer Space Across the Curriculum courses were held in Colorado Springs, Colorado. **Four** courses focusing on science technology, engineering and math were offered as graduate courses for teachers seeking a graduate degree or continuing professional development through university partners that included University of Colorado – Colorado Springs, Regis University, and Colorado State University - Pueblo. **95** teachers participated in the 2014 courses.

c. Summer opportunities for secondary students on college campuses with the objective of increased enrollment in STEM disciplines or interest in STEM careers.

- University of Colorado at Boulder taught the Earth to Space course as part of the CU PreCollegiate Development Program (PCDP) for rising high school seniors June – July 2014.
- Adams State University facilitated a one-week STEM academy for high school students in July 2014.
- 3 high school students participated in the RockOn 2013 workshop.

d. Community Colleges – develop new relationships as well as sustain and strengthen existing institutional relationships with community colleges.

- COSGC completed the first year of the transfer program funded through the Innovative Pilot opportunity. The team presented finding of the effort at the Western Regional Space Grant meeting in October 2014. Transfer students participated in campus visits and connected with Space Grant faculty and students on their transfer campuses. The 2nd year of the program is underway with a committee reviewing applications and preparing to make 13 awards during year 2.
- COSGC proposed for and won funding through the Community College and Technical School opportunity to add 4 more Colorado community colleges to the consortium – Aims CC, Arapahoe CC, Otero JC, and Red Rocks CC. Faculty and students from these institutions participated in a kick-off workshop in January 2015. All four institutions are facilitating hands-on Space Grant programs on their. Teams are engaged in either the DemoSat program or Colorado Robotics Challenge. In addition, the deadline has just passed for scholarship and internship applications. The application for the RockOn! Workshop is due on March 31. 13 students and 1 faculty member have already applied.
- All COSGC community college affiliates have unique hands-on programs:

- **Pikes Peak Community College** (PPCC) has been able to add an additional balloon payload team to their already robust program. PPCC affiliate director, Liz Coelho, has presented her program at the Western Regional Space Grant meeting and at a meeting of the Colorado Space Business Roundtable. She is also participating in a subcommittee to help diversify COSGC funding sources.
- Students at **Pueblo Community College** (PCC) continue to work on autonomous robotics projects.
- **Community College of Denver** (CCD) has greatly expanded Space Grant opportunities over the period of performance to include both robotics projects and balloon payloads. This expansion has included the engagement of additional faculty to mentor student projects. CCD Space Grant is participating in the Colorado Robotics Challenge for the

first time ever. In addition, CCD Space Grant students participated in the 2014 RockOn! Workshop at NASA's Wallops Flight Facility and are now building a sounding rocket payload as part of the RockSat C program.

- **Trinidad State Junior College** (TSJC) Space Grant has expanded over the period of performance to provide robotics and balloon projects in addition to a course that supports those endeavors. TSJC Space Grant continues a strong collaboration with Parallax Inc. to facilitate a robust robotics program.
- **Community College of Aurora** (CCA) – CCA Space Grant continues to facilitate the Experimental Design course supported by the lead institution with guest lecturers and launch opportunities. CCA Space Grant has been the seed for the development of a strong STEM initiative on the CCA campus that has garnered more funding and institutional support for student hands-on programs.
- Staff at the Lead Institution provide project mentorship for all community college student projects; teach sections in the CCA Engineering 151 course; facilitate robotics workshops for community college students; facilitate a transfer program to recruit graduating community college students into 4-yr institutions; provide testing facilities for student projects; host tours for community college student groups; provide robotics and balloon payload workshops and mentor community college affiliate directors through new projects and help make connections with NASA centers, government labs and industry.

e. <u>Aeronautics directly address the fundamental research needs of the Next Generation Air Transportation System (NextGen).</u>

None.

f. <u>Environmental Science and Global Climate Change – research and activities to better understand Earth's environments.</u>

- Mission operations were completed for the Drag and Atmospheric Neutral Density Explorer (DANDE) satellite launched on Septebmer 29, 2013. DANDE is a student designed and built, low-cost, density, wind, and composition-measuring satellite designed to provide data for the calibration and validation of operational models and improve our understanding of the thermosphere.
- The PolarCube project is a collaboration between COSGC and the National Snow and Ice Data Center. The project has also garnered the interest of NASA's Earth Science Technology Office. PolarCube won an award in the Air Force Office of Scientific Research's University Nanosatellite 8 program. Collaborators for the PolarCube mission also include the Cooperative Institute for Research in Environmental Sciences and the Center for Environmental Technology.
- Several BalloonSat payloads have included missions to sample the atmosphere for heavy metals, pollution, and cosmic radiation.

g. <u>Enhance the capacity of institutions to support innovative research infrastructure activities to enable early career faculty to focus their research toward NASA priorities.</u>

None.

<u>IMPROVEMENTS MADE IN THE PAST YEAR</u>

- Added 4 new community college institutions to the consortium.
- Established a subcommittee of affiliate directors to work on diversifying COSGC funding sources. The subcommittee has monthly meetings and is working on several actions.
- Change in the department that housed the Colorado School of Mines Space Grant program (and the affiliate director leading the program) has placed the program in a more appropriate department and strengthened CSM Space Grant.

PROGRAM PARTNERS AND ROLE OF PARTNERS IN PROJECT EXECUTION

COSGC MEMBER INSTITUTIONS:

- **Adams State University** [formerly Adams State College] (4-year, Baccalaureate & Graduate): Minority Serving Institution; Facilitates students programs that contribute to Outcomes 1 & 3.
- **Aims Community College** (2-year college) Facilitates student programs that contribute to Outcome 1.
- **Arapahoe Community College** (2-year college) Facilitates student programs that contribute to Outcome 1.
- **Colorado Mesa University** [formerly Mesa State College] (University through PhD) Facilitates student programs that contribute to Outcome 1.
- **Colorado School of Mines** (University through PhD): Facilitates student programs that contribute to Outcome 1.
- **Colorado State University** (University through PhD): Facilitates student programs that contribute to Outcome 1.
- **Colorado State University – Pueblo** (4-year Baccalaureate & Graduate): Facilitates student programs that contribute to Outcome 1
- **Community College of Aurora** (2-year college) Facilitates student programs that contribute to Outcome 1.
- **Community College of Denver** (2-year college) Minority Service Institution. Facilitates student programs that contribute to Outcome 1.
- **Fort Lewis College** (4-year Baccalaureate) Facilitates student programs that contribute to Outcome 1.
- **Metropolitan State University of Denver** [formerly Metropolitan State College of Denver] (4-year Baccalaureate and Graduate) Facilitates student programs that contribute to Outcome 1.
- **Otero Junior College** (2-year college) Facilitates student programs that contribute to Outcome 1.
- **Pikes Peak Community College** (2-year college) Facilitates student programs that contribute to Outcome 1 and 3.
- **Pueblo Community College** (2-year college) Minority Serving Institution. Facilitates student programs that contribute to Outcome 1 and provides machining support for other COSGC student projects.
- **Red Rocks Community College** (2-year college) Facilitates student programs that contribute to Outcome 1.
- **The Space Foundation** A non-profit organization supporting space activities, space professionals and education. Facilitates student programs that contribute to Outcome 2.

- **Trinidad State Junior College** (2-year college) Minority Serving Institution. Facilitates student programs that contribute to Outcome 1.
- **University of Colorado at Boulder** (University through PhD) Facilitates student programs that contribute to Outcomes 1 and 3 and fulfills duties as Lead Institution.
- **University of Colorado at Colorado Springs** (University through PhD) Facilitates student programs that contribute to Outcome 1.
- **University of Northern Colorado** (University through PhD) Facilitates student programs that contribute to Outcome 1.
- **Western State Colorado University** [formerly Western State College] (4-year Baccalaureate) Facilitates student programs that contribute to Outcomes 1.

COSGC programs are only possible through collaborations with industry; government labs; academic departments, programs, and labs; NASA centers; and non-profit community organizations. These partners provide mentors, hardware donations, launch opportunities, funding, and/or testing facilities. The following is a list of partners that directly contributed to COSGC student projects this award period:

INDUSTRY PARTNERS:

- **Lockheed Martin –** Serves as Chair for the COSGC Advisory Board; Provides mentors for Robotic Mining Competition team at Colorado School of Mines; Provides testing facilities and funding for student satellite missions at University of Colorado at Boulder (CU); and judges for the Colorado Undergraduate Space Research Symposium; provides mentors for Community College of Aurora Experimental Design teams and CU CubeSat missions.
- **Visser Precision –** Guest lecturer for Community College of Aurora's (CCA) Experimental Design course.
- **Road Narrows Robotics –** Provides mentors for robotics projects at University of Northern Colorado.
- **Ball Aerospace -** Mentors for satellite missions at the University of Colorado at Boulder
- **Analytical Graphics, Inc.** – Site licenses for Satellite Toolkit software used by students at University Colorado at Boulder (CU) for satellite missions; Provides free workshops for students; Speaker at CU course; and mentors for CU space hardware projects.
- **Composite Technology Development** – Serves on COSGC Advisory Board; Provide financial support and mentors for University of Colorado at Boulder student sounding rocket payload project.
- **Advanced Circuits** – Providing electronic components for the student ALL-STAR PropSat, and PolarCube CubeSat missions; HELIOS II and RocketSat missions.
- **SparkFun Electronics** – Support of statewide robotics endeavors including access to hardware and mentors for projects statewide.
- **Sierra Nevada Corporation** – Mentors and funding for the Colorado State University rocket project; Mentors for satellite missions at the University of Colorado at Boulder; provides test facilities for space hardware missions; donates hardware; and provides judges for the Colorado Undergraduate Space Hardware Symposium.
- **Northrup Grumman** – Provides mentors for satellite missions at the University of Colorado at Boulder; and provides judges and the keynote speaker for the Colorado Undergraduate Space Research Symposium.

- **Equinox Interscience** – Provides mentors for satellite missions at the University of Colorado at Boulder.
- **Instar Engineering** – Provides mentors for satellite missions at the University of Colorado at Boulder.
- **Digital Globe** – Provides internships for COSGC students.
- **FirstRF** – Provides mentors for University of Colorado at Boulder (CU) satellite projects.
- **National Instruments** – Provided mentors for the RockSat X mission at CU.
- **SpaceX** – Provides mentors for CU student projects.
- **Insight Analytical Laboratories –** Provided guest lecturer for the Space Technology teacher course at the Space Foundation.
- **Parallax Inc.** – Provides mentors, hardware, and software for the Trinidad State Junior College (TSJC) robotics teams.
- **High Country Technology Consultants** – Provided content experts to help TSJC faculty and students learn to use a 3D printer and has continued to support TSJC projects with technical assistance.
- **Howl Woodworks –** Provides technical construction support for TSJC robotics projects.

ACADEMIC PARTNERS:

- **Community College of Aurora (CCA) Biology –** Guest lecturer for CCA Experimental Design course and mentors for balloon payloads.
- **CCA Chemistry –** Guest lecturer for CCA Experimental Design course.
- **Colorado Mesa University (CMU) Mechanical Engineering Department –** Provides mentors for CMU student robotics projects.
- **University of Northern Colorado & (UNC) School of Sport and Exercise Science** – Provides control data and mentors for UNC Space Grant student research.
- **Fort Lewis College (FLC) Physics & Engineering Department** – Provides mentors and laboratory facilities for FLC Space Grant student projects.
- **Center for Astrophysics & Space Astronomy** – Mentors and financial support for student long duration, high altitude balloon and sounding rocket missions at University of Colorado at Boulder.
- **Montana Space Grant Consortium** – Serves on COSGC Advisory Board.
- **Virginia Space Grant Consortium** – Collaborates on RockOn! Workshop.
- **University of Colorado at Boulder (CU) Electrical, Computer, and Energy Engineering Department** – Provided senior design experience to develop the new PolarCube CubeSat mission.
- **CU, Aerospace Engineering Department** – Provides mentors for CU student satellite missions.
- **CU, Mechanical Engineering Department** – Provided senior design experience to develop the propulsion system for the ALL-STAR mission.
- **CU, College of Engineering and Applied Science Dean's Office** – Provided cost match dollars used to support travel, student projects, and general CU Space Grant operations.
- **Integrated Teaching and Learning Laboratory, University of Colorado at Boulder (CU)** – Provides machining, electronics, and software for CU student projects.
- **The Center for Environmental Technology** – Provides mentors for the PolarCube mission at University of Colorado at Boulder.

- **Cooperative Institute for Research in Environmental Sciences** – Provides financial support for student BalloonSat mission at University of Colorado at Boulder.
- **Colorado State University (CSU) Department of Mechanical Engineering** – Provides mentors and testing facilities for students projects.
- **CSU Department of Atmospheric Science** – Provides mentors for graduate student research.
- **University of Colorado at Colorado Springs (UCCS) Chemistry Department** – Provides mentors for Pikes Peak Community College (PPCC) balloon payload projects.
- **UCCS Biology Department** – Provides mentors for PPCC balloon payload projects.
- **UCCS Health Sciences Department** – Provides mentor for UCCS Space Grant student projects.
- **UCCS Head Athletic Trainer, Brian Hardy** – Mentors UCCS Space Grant student projects.
- **PPCC Biology** – Provides mentors for PPCC balloon payload projects.
- **Fort Lewis College (FLC), Physics Department** – Provides mentors for the Western State Colorado University (WSCU) robotics teams.
- **FLC, Astronomy** – Provides mentors for WSCU astronomical observing efforts.
- **Community College of Denver (CCD) Engineering Graphics and Mechanical Design Department** – Mentors for CCD balloon payload and robotics projects.

GOVERNMENT PARTNERS:

- **NASA's Wallops Space Flight Center** – Provides launch support for RockOn! Workshop and RockSat-C and –X student payloads programs.
- **NASA's Earth Science Technology Office** – Provides mentors for the new PolarCube CubeSat mission.
- **NASA Jet Propulsion Laboratory** – Provide speakers in courses at University of Colorado at Boulder and judges for the Colorado Undergraduate Space Research Symposium.
- **Air Force Office of Scientific Research** – Provides mentors for the DANDE satellite mission at University of Colorado at Boulder.
- **Air Force Space Command Space Analysis Center (A9A)** – Provides mentors for the DANDE satellite mission at the University of Colorado.
- **National Snow & Ice Data Center** – Providing mentors and mission development for the PolarCube mission.
- **Air Force Research Laboratory** –Provides mentors and testing facilities for the University of Colorado at Boulder (CU) DANDE satellite mission and mentors for the CU PolarCube mission; provides mentors for Colorado State University (CSU) graduate research projects.

NON-PROFIT COMMUNITY PARTNERS:

- **Edge of Space Sciences** – Provides balloon payload launches to statewide program.
- **Great Sand Dunes National Park** – Provides the venue for the annual Colorado Robotics Challenge and provides resources during planning of the event.
- **Colorado Space Business Roundtable** – Provides financial support for the Colorado Undergraduate Space Research Symposium.
- **Four Corners Stargazers -** hosted star parties attended by Fort Lewis College (FLC) Space Grant students.

- **The Durango Nature Center -** hosted star parties attended by Fort Lewis College (FLC) Space Grant students.
- **Old Fort Lewis -** helped update lighting and maintaining roads to the observatory for use in student research.
- **Sunburn Camps** – Provided guest lecturer/content for Space Foundation program.
- **Gunnison Valley Observatory** – Provides use of observatory facility to faculty and student researchers at Western State Colorado University.
- **GJ MakerSpace -** Provides work space and mentors for Colorado Mesa University (CMU) students working on robotics projects.
- **Loveland CreatorSpace** – Provides facilities and mentors for the University of Northern Colorado student robotics projects.