ARIZONA SPACE GRANT CONSORTIUM
TWENTY-YEAR PROGRAM PERFORMANCE AND RESULTS REPORT 2003-2007

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Figure 1. AZSGC Activities span sixth largest state
## PART II: AZSGC STATEMENT OF CONSORTIUM CONCURRENCE

This PPR was written with input from program participants across Arizona. All AZSGC Managers and Affiliate Representatives concur with its contents.

<table>
<thead>
<tr>
<th>Name</th>
<th>University/Organization</th>
<th>Signature</th>
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<tbody>
<tr>
<td>Michael J. Drake</td>
<td>University of Arizona</td>
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<td>Susan A. Brew</td>
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<td>Ronald Madler</td>
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<td>Jack Crabtree</td>
<td>Arizona Near Space Research</td>
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<tr>
<td>Anthony Pitucco</td>
<td>Pima Community College</td>
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<td>Angelita Denny</td>
<td>Diné Tribal College</td>
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<td>Joel Rademacher</td>
<td>General Dynamics</td>
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<td>Michael Parker</td>
<td>Rincon Research</td>
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<tr>
<td>Grant Anderson</td>
<td>Paragon Space Development Corp.</td>
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<tr>
<td>Brian D. Perry</td>
<td>Raytheon</td>
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<tr>
<td>Left Organization 7/08</td>
<td>Arizona Aerospace Foundation</td>
<td></td>
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<tr>
<td>Justin Vieira</td>
<td>Northrop Grumman</td>
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<tr>
<td>Shea Ferring</td>
<td>Orbital Sciences Corporation</td>
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<tr>
<td>Leslie Anne Newell</td>
<td>Indigenous Education Institute</td>
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<tr>
<td>David Begay</td>
<td>International Dark Sky Assoc.</td>
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<td>Linda Rogers</td>
<td>NASA JPL</td>
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<tr>
<td>Doug Isbell</td>
<td>National Optical Astronomy Obs.</td>
<td></td>
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<tr>
<td>Kathleen Eastwood</td>
<td>Nat. Undergrad Research Observatory</td>
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<td>Mark Sykes</td>
<td>Planetary Science Institute</td>
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<td>Kevin Kremeyer</td>
<td>PM &amp; AM Research</td>
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<tr>
<td>Chandra Holifield-Collins</td>
<td>USDA ARS SWRC</td>
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<td>Alain Chuzel</td>
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<td>Jackie Drewett</td>
<td>Tuba City Boarding School</td>
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<tr>
<td>Paul Geissler</td>
<td>USGS Flagstaff Branch</td>
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PART IV: EXECUTIVE SUMMARY AND CONSORTIUM IMPACT

Since its inception in 1989, the Arizona Space Grant Consortium (AZSGC) has worked to develop and expand opportunities for Americans to learn about and participate in NASA's programs by supporting and enhancing science and engineering education, research, and public programs in space, Earth, and aerospace-related fields. We sponsor a variety of strategically integrated programs that incorporate research with education to help build a diverse, scientifically literate citizenry and a well-prepared science, engineering and technology workforce. AZSGC has become a catalyst for synergy between NASA, industry, and Arizona’s education and research efforts. Our programs truly extend the arms of NASA—expanding Arizona’s capacity to conduct research, in a way that educates our next generation of scientists and engineers—all in direct partnership with demands of industry and NASA for new talent and the latest innovations. Turn the perspective to that of Arizona’s educators, employers and even legislators: the marriage of public and private research/development with education benefits society by nourishing the workforce development pipeline from those exploring science for the first time, to those traditionally underrepresented in these fields, to university students making career choices, to members of the public who want to apply the latest NASA research and technology to life problems. AZSGC programs that integrate students into the research enterprise greatly enhance educational success: 95% of AZSGC undergraduates participating in mentored internships complete university degrees, in contrast to 54% of their peers, to the benefit of the research enterprise, state/local and tribal governments, and the public. Since 1990, 1,430 members of Arizona’s university faculty and public/private research sectors, (419 over 2003-2007) directly benefited from integrating smart, motivated students into their research enterprises. As a result, 1,186 AZSGC graduates—91% of tracked awardees—joined the NASA, aerospace, STEM academic or STEM workforce, a significant contribution given our state’s, NASA’s and Nation’s unprecedented need for human capital in these areas. AZSGC directly and indirectly supports NASA programs and missions, expands NASA’s expertise and educational

“I spent a total of 5 years [with] Space Grant’s ASUSat1 team. With the experience I had, I graduated with offers from every company that I was interested in…JPL, Motorola, and Honeywell….I was quickly promoted to a job at Kennedy Space Center, and by the time I was 32 years old, I was leading a team of over 100 engineers, and managing a $15 Million dollar a year contract to support NASA,”  

(R. Shea Ferring, Orbital Sciences).
networks, and brings knowledge and awareness of space to a broad range of constituents by integrating students into the research enterprise and leveraging their research into outreach designed to promote the dissemination and understanding of space-related research to precollege audiences and the professional and general public. From 2003-2007, AZSGC Fellowship recipients directly contributed to the research and EPO of many NASA grants and missions including: Juno, Mars Astrobiology Research Lab, Mars Reconnaissance Orbiter (HiRISE Camera), EOS, CALIPSO, LEND, LONEOS, Cosmochemistry, Global Precipitation Measurement, Phoenix Mars Scout, Lunar Reconnaissance Orbiter, Cassini, Mars Odyssey, MODIS, Planetary Geology, Geophysics and Earth Systems Science grants, Hubble, Spitzer, James Webb space telescope programs, NASA Adaptive Optics Development, Exoplanet Imaging grants, and others. AZSGC science writing Interns working with major state newspapers produced 138 bylines, while fellowship, research and higher education program participants generated 245 scientific publications. Taken together, AZSGC educational programs directly impacted a diverse group of **89,429 citizens** and indirectly touched 147,347 more, **28%** are from underrepresented minority groups while **42%** are women (Table 1). This commitment to diversity is a common element of all AZSGC sponsored programs and is shared across our affiliate network.

<table>
<thead>
<tr>
<th>Program Area</th>
<th>Total NASA &amp; Match</th>
<th>Percent of Total</th>
<th>Additional Proposals</th>
<th>Publications</th>
<th>Total Participants</th>
<th>% Women</th>
<th>% Underrepr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fellowships</td>
<td>$2,944,134</td>
<td>31%</td>
<td>$</td>
<td>169</td>
<td>811</td>
<td>40%</td>
<td>19%</td>
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<tr>
<td>Research</td>
<td>$969,045</td>
<td>10%</td>
<td>$1,315,720</td>
<td>9</td>
<td>826</td>
<td>29%</td>
<td>16%</td>
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<tr>
<td>Higher Ed</td>
<td>$1,422,335</td>
<td>15%</td>
<td>$</td>
<td>20</td>
<td>12,914</td>
<td>42%</td>
<td>28%</td>
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<tr>
<td>Precollege</td>
<td>$623,886</td>
<td>7%</td>
<td>$100,000</td>
<td>1</td>
<td>59,441</td>
<td>55%</td>
<td>44%</td>
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<tr>
<td>Public</td>
<td>$2,529,490</td>
<td>27%</td>
<td>$5,432,907</td>
<td>46</td>
<td>15,437</td>
<td>45%</td>
<td>33%</td>
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<tr>
<td>Management</td>
<td>$1,049,724</td>
<td>11%</td>
<td>$</td>
<td>0</td>
<td>0</td>
<td>42%</td>
<td>28%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$9,538,614</strong></td>
<td><strong>100%</strong></td>
<td><strong>$6,848,627</strong></td>
<td><strong>245</strong></td>
<td><strong>89,429</strong></td>
<td><strong>42%</strong></td>
<td><strong>28%</strong></td>
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</tbody>
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**Note:** Demographic estimates of "unknown" participants based on % of known group.

**Table 1: AZSGC 2003-2007 cumulative metrics and accomplishments.**

In a state with little (and shrinking) education funding, our NASA Space Grant is leveraged to make every dollar count. For each NASA grant dollar, AZSGC generates $1.57 in match—an impressive return on investment in any economy. Program impacts span our state and are extended beyond its borders by managers who lead important national SG program initiatives in Earth Grant and student flight program development. AZSGC members, The University of Arizona (Lead), Arizona State, Northern Arizona, and Embry-Riddle Aeronautical universities, work in partnership with 23 affiliates from all sectors to provide cost-effective, creative and truly exceptional educational opportunities.
PART V. FOREWORD

AZSGC is a Phase I NASA Space Grant College and Fellowship Consortium with the three State Universities: The University of Arizona (UA), Arizona State University (ASU), Northern Arizona University (NAU), and Embry-Riddle Aeronautical University (ERAU) the nuclear members. UA (lead institution) is a Land Grant and Carnegie Research 1 university—one of our nation's leading space research institutions, with established programs in space science and engineering research and education in the context of a major undergraduate/graduate public research university. ASU, a Research 1 university, is now the largest university in the U.S., with rapidly growing programs in space science, engineering and aeronautics, and substantial NASA-sponsored research. NAU focuses primarily on undergraduate education and leads AZSGC outreach to precollege and underrepresented groups. It is especially noted for work with American Indian communities in northern Arizona and maintains strong cooperative alliances with nearby Lowell, the U.S. Naval observatory, and the USGS Flagstaff Branch of Astrogeology. ERAU is ranked by *U.S. News & World Report* as having the No. 1 aerospace engineering program in schools without doctoral programs and has the nation’s largest aerospace engineering, engineering physics and undergraduate aeronautical science (professional pilot) programs.

Working with a diverse group of affiliate partners (Table 2), NASA, industry, and local and state governments, we sponsor about 40 independent programs per year to capitalize on local strengths and resources, meet the needs of our students, universities, state, NASA and country and fulfill our mission to expand opportunities for Americans to learn about and participate in NASA's aeronautics and space programs. Our goal is to integrate research with education to help build a scientifically literate citizenry and a diverse well-prepared STEM workforce—to strengthen NASA and America’s future workforce while expanding the capacity of AZ research and educating the next generation of scientists and engineers.

Fellowship, research, and higher education programs have a strong workforce development emphasis to attract and retain students in STEM disciplines through to STEM workforce.

Precollege programs train teachers and excite students to continue to study in STEM disciplines. Public and informal education programs use strategic partnerships with groups like the Land Grant Cooperative Extension network, the ASU Mars Education Program, science journalism and outreach focused graduate fellowships, to disseminate STEM by informing citizens of NASA’s mission and allowing them to participate in it by using STEM, and NASA data and technologies to solve current problems. AZSGC programs and services reach 81 communities, many in traditionally underserved areas, spanning the sixth largest state in the country (Figure 1).

Arizona Needs and Priorities

**Education:** Education funding in Arizona is very low; in 2006, Arizona ranked dead last in the “Smartest State Award”, based on “per-pupil funding, teacher salaries, student-teacher ratios and the resulting test scores and graduation rates….Public investment in our colleges and universities has dropped steadily….only four states have lower four-year college graduation rates than Arizona…. Fewer than half of those who graduate from Arizona public high schools qualify academically to enroll in a state university,” (Our Opinion: Education crisis engulfing Arizona, *Tucson Citizen*, March 3, 2008).

Governor Napolitano articulates Arizona’s education priorities as follows: to increase science, technology, engineering and math education, to insure STEM teacher recruitment, training and
retention, to improve STEM skills in P-12 students and boost the number of students entering higher education, graduating with degrees in STEM disciplines and ultimately joining the STEM workforce (Executive News Office Release, July 2008). We are active partners in efforts to train STEM educators, excite and inspire P-12 students to pursue science in college, and provide opportunities for students that promote academic success and workforce development. Our Fellowship/Scholarship programs, supported by NASA funds leveraged by local match, provide mentored research, training and nurturing, and have achieved high (95%) graduation rates, with 91% of awardees moving into the STEM workforce and 17% becoming STEM educators.

**Population Growth:** Arizona has one of the nation's highest population growth rates, taxing the infrastructure, and causing major changes to land-use, and stress on the desert environment. AZSGC Public Programs bring NASA research, technologies and educators (many of these Interns and Graduate Fellows) to stakeholder groups—including ranchers, tribes, government agencies and the Arizona Governor’s Growth Cabinet—to provide expertise and training to address pressing community and environmental challenges. Impacts of our Earth Grant Geospatial Extension program have been recognized at local, state, national and international levels.

**Demographics:** Arizona shares a border with Mexico, and Hispanics comprise over 30% of the population. AZ also has one of the country’s largest Native American populations–more than 14 tribes are represented on 20 reservations. Over 25% of Arizona’s families speak a language other than English at home, presenting a great educational challenge. AZSGC has developed the capacity to deliver informal STEM education programs via bilingual student educators. We sponsor “bridge” programs to help prepare students from minority serving institutions (Pima, Diné, and South Mountain community colleges) to enter four-year universities and succeed. AZSGC works in partnership with Native professionals from the Indigenous Education Institute, AZ industry and others to deliver creative and cost-effective programs targeting reservation teachers, students and communities. Our Stargazer summer Astronomy workshop alone served 86 Native students from 9 states representing 18 tribes.

**Arizona’s Economy:** “With its uniquely dry climate and dark skies, as well as a legacy of leadership on more than 50 robotic space missions, Arizona has been the home of world class study in the areas of astronomy, planetary sciences and space sciences (APSS) for decades. … These fields are major economic drivers of the Arizona economy….Over $250M in annual economic impact, nearly $12M annually in tax revenues, 40,000 out-of-state visitors each year, and over 3,300 high paying jobs… the densest concentration of advanced telescopes on the planet… and …a space science legacy nearly unmatched anywhere else in the world…” (J. Burkhart, Arizona Capitol Times, February 2008). AZSGC includes affiliate partners from the public and private APSS sectors, partnering to develop new knowledge and capabilities, training the next generation of researchers, promoting our world class heritage. A partnership with the International Dark Sky Association provides advocacy to our optical astronomy research community, to preserve one of Arizona’s core competitive research strengths – dark skies.

*Throughout this PPR, activities directly supporting SMART goals will be indicated by “♣.”*
AZSGC has a two-tiered, distributed management under the direction of Michael J. Drake (Director) and Susan A. Brew (Manager). UA (Lead) is responsible for statewide program development, and for distributing SG funds based on AZSGC priorities and institution size/scope. AZSGC delegates authority, responsibility, and budget to its four members for geographic breadth and thematic depth. Each sponsors activities and affiliates under direction of an Associate Director: Barron Orr (UA), Thomas Sharp (ASU), Nadine Barlow (NAU), and Ron Madler (ERAU), who command respect within their institutions and the larger technical/education communities and serve at no charge to our grant. Each works with a salaried Manager or Coordinator: Susan Brew (UA), Candace Jackson (ASU), Kathleen Stigmon (NAU), and Olga Diaz (ERAU) (FTEs in CMIS Table III-B). The Director, Manager, Associate Directors and Campus Coordinators form the State Management Team. It meets biannually face-to-face, more frequently through shared programs, and communicates often by phone and email. It plans activities, defines policies, and sets priorities. Major decisions involve consensus among members, the Director and Manager: AZSGC is a team effort. Program evaluation is ongoing, based on internal and external assessment, discussing problems, successes, plans for growth and improvement. To prepare the 20-year PPR, Managers met by telecon to set timelines and develop strategies. SMART goals/metrics provided guidelines for selecting data sets. We wrote to all affiliates, describing the PPR process and requesting input; responses are integrated throughout this report. Managers updated tracking and other data for statewide aggregation and the Manager visited ERAU, our newest member, to explain PPR data requirements. Throughout, communications have been regular and effective.

Core Criteria

**Strategic Plan:** The Managers created and update our strategic plan at State Managers’ meetings. It required few changes this reporting period except to update terminology relating to “outreach” and “informal education” per HQ clarifications. Workforce development and other foci were well within alignment with HQ policy clarification and directives; no changes were suggested in 15-review assessments.

**Consortium Structure (Internal):** At the Member University level, Associate Directors recruit and chair steering committees that select fellowships/scholarships awardees and lend oversight. These represent a major program resource (UA-22 members, ASU-8, NAU-12, and ERAU-4), and include faculty (some program alumni!) from a broad range of space-related fields, representatives from industry, NFP research organizations, Federal Research Labs, minority-serving community colleges, university minority program directors, etc.
Steering committee members are volunteers, and devote many hours to Space Grant because they believe in our mission. At the State (network) level, Associate Directors invite affiliates to join AZSGC when they partner on programs in meaningful ways. Meeting National Space Grant Act objectives, AZSGC has built a broad-based member/affiliate network (Table 2). A “contact” is designated for each who may participate on local steering committees, attend statewide meetings and other activities, and spearheads institutional participation. Our affiliate network is dynamic: institutions come into and go out of affiliation as programs and interactions change. This structure is actively managed to ensure that affiliation connotes active engagement. This is challenging, but creates a network of active partners rather than “attends meetings only” board members. We have four types of affiliates: higher education affiliates recruit interns and administer programs, outreach affiliates partner in education, STEM dissemination and advocacy, military, research and industry affiliates provide facilities, projects/mentors and funding. Proudly, representatives from a growing number of affiliates are AZSGC alumni! Reporting period membership was particularly dynamic. Activities concluded with 12 affiliates (10 associated with ASU Sat efforts). Major consortium rebuilding is evident in the addition of 13 new affiliates. Cooperation among affiliates has resulted in many effective partnerships exemplified by Rincon Research, which contributed 50K towards UA’s first student-built satellites and in 2007 produced six proposals for new CubeSat program funding (see Research Infrastructure). Mike Parker, our Rincon representative, is an active UA steering committee member and mentors (and helps fund) SG Interns.

Diversity: State Managers represent a broad range of NASA-related interests and disciplines; 55% are women and one is Hispanic. All local and statewide advisory groups have members from underrepresented groups, minority serving institutions and women.

Consortium Operations: The Lead Institution maintains a full-time Manager (Susan A. Brew), responsible for AZSGC communications, reports, budgets, working with state managers and more. Campus Coordinators provide focused leadership, manage and administer programs, and contribute to data collection and reporting. Facility support at UA is provided by the Lunar and Planetary Laboratory (LPL) and includes: (1) Main AZSGC Office, Room 349 (13’ x 14’) in the UA Kuiper Space Sciences Building; (2) Bookkeeping services; (3) Storage, meeting, classroom facilities and; (4) Office, computer equipment and supplies. This reporting period has seen many changes in AZSGC leadership and focus: In 2004, Dr. Helen Reed, (11-year) ASU Associate Director, moved to TX taking her satellites program and expertise. In 2005, Dr. Thomas Sharp, an ASU geoscientist, assumed leadership and began to rebuild/realign a program that had been strongly focused on student satellite development. His goal was to grow the faculty/students participant base and broaden program reach. Great strides have been made toward meeting goals but we lack strong engineering faculty participation and have no one to lead student satellite efforts there. Concurrently, ERAU was elevated from “affiliate” to “member” status. Ron Madler, long time ERAU SG contact, mentor, Aerospace Engineering Chair, assumed the Associate Directorship. Our goal is that Dr. Madler will become lead faculty mentor for AZSGC student flight projects; significant strides have been made towards this (see Research Infrastructure). In March 2008, longtime NAU Associate Director Barry Lutz resigned and Assistant Director Nadine Barlow replaced him. Already familiar with AZSGC and NAU SG, this transition has been seamless.
**Resource Management:** Funds are highly leveraged through waived overhead, the Earth Grant Geospatial Extension Specialist salary, university-provided fellowships, and mentor-provided salary for interns, etc. (Chart 1). LPL contributes $150,000 annually in unaccounted subventions (operations, financial services). NASA funds are distributed across AZSGC to maximize leverage (Chart 2); many affiliates contribute funds and services to AZSGC, not vice-versa. The most appreciated “pay-back” is in the form of smart, motivated students—future employees! It is no coincidence that 210 AZSGC graduates now work for our affiliates. Outreach and higher education partners may receive funds and also help with grant writing, etc. Through match, IDC foregone and strategic spending, only 11¢ of every dollar goes to management and administration while 89¢ funds student programs (Table 1). Table 1 also shows the average annual percentage distribution of funds across major program elements.

**Collaboration and Partnerships (External):** AZSGC Managers bring varied areas of focus/expertise, and develop partnerships outside AZSGC to promote related activities. As Co-Director of the SSI, Michael Drake works closely with Bill Hiscock (MT), Chris Koehler (CO) and personnel at JPL and NASA HQ to promote student flight programs, and develop opportunities for students on NASA missions. Susan Brew serves on the Foundation Awards Committee, and is a frequent program mentor. In this period she advised (WV, MI, WA, LA, WI) personnel on longitudinal tracking, helped (PA, TN, OH) with budgets, (SD, MT) on 508 compliance, (KS, PA) on CMIS preparation, and serves on the ORSGC External Advisory Board. Barron Orr collaborates with consortia and members of over 18 government agencies to establish Earth Grant programs; 14 states currently participate and others want to join. NAU Managers worked with (AK, MT, WY, TX, UT, ID, NM, OK) via the Stargazer program, and Ron Madler was a summer mentor to students from 13 consortia working on the SG student Mars initiative at JPL. In total, this dispersed approach allows us to be productive partners with NASA (within and beyond SG) and other organizations.

**Impacts/Results**

Our distributed management approach allows us to articulate and leverage the different strengths, areas of expertise, contacts and resources brought by each member. The result: AZSGC uses the concept of “focused excellence” (rather than “one size fits all”) to optimize the strengths of each member and all affiliates. Our operational policies and vertical and horizontal communication helps us avoid duplication of effort. A vertical integration of programs helps us enhance the impact of any one program through strategic links to others. Our approach allows us to sponsor a more comprehensive set of SG programs than any member could sponsor individually through top-down management. With our dynamic affiliate structure, the greatest challenge is in maintaining active affiliate engagement when projects end or priorities change. Our emphasis on active participation ensures that NASA dollars are put to optimal use in Arizona. Across our management structure, program development and implementation, our philosophy is one of inclusion—Arizona’s Space Grant belongs to all of us.
VI. PROGRAMMIC ELEMENTS: B1-FELLOWSHIP/SCHOLARSHIP

AZSGC sponsors an average 9.2 fellowship/scholarship programs per year that include: Graduate Fellowship programs at UA and ASU, Undergraduate Research Internship programs at UA (includes 43 Pima CC students), ASU, NAU, ERAU, summer internships at NASA centers and NASA Academy programs. Altogether, programs supported 811 students: 89 Graduate Fellows and 722 Undergraduate Research Interns—in mentor-guided research and EPO, and account for 31% of AZSGC expenditures. ($1,431,800) NASA dollars were more than doubled with ($1,061,432) Arizona match and ($450,902) other federal cost share (Chart 3). The distribution of Fellowship funds among members is based on manager requests and university size/scope (Chart 4).

SMART goals are to: (1) Support a significant number of motivated students and mentors encompassing a wide range of experiences related to NASA’s mission directorates; (2) Actively recruit and support students from traditionally under-represented groups at a rate approaching the 28% (NCES) Arizona higher education demographic; (3) Enhance the “pipeline” through quality outreach, public service and a substantive community colleges bridge program; (4) Optimize opportunities for professional growth through support in generating publications, participating in professional meetings and networking (see Higher Education); (5) Provide career-track opportunities in aerospace industry, NASA field centers and in science journalism; and to (6) Evaluate programs success via quantitative and qualitative methods and longitudinal tracking, to insure continuous process improvement.

Core Criteria

AZSGC uses fellowship programs to expand representation of our nation’s diverse population in the NASA and STEM workforce, with a goal that sponsored programs reflect the higher education demographic for our state (28% per NCES). We also strive to support 50% women at universities with an average demographic of 46%. AZSGC’s deep commitment, philosophies and strategies to foster diversity are discussed in the Diversity section. Success is gauged on the number of applicants, awards and retention. All programs are competitive. Statewide, an average of 2.2 students apply for each award and for some Undergraduate programs, faculty/researchers also apply competitively. Applications are made via standardized web-based forms, read and ranked by local steering committees that assess motivation for seeking a research experience, qualifications, future potential, academic interests and background in relation to available research projects. Reviewers seek to award an ethnically diverse group of students that represents a broad range of academic disciplines and NASA interests.
Consortium Specific

Programs are strategically linked across reporting areas to minimize costs and maximize benefits, with an overarching goal: to provide opportunities for undergraduate and graduate students to learn about, participate in, and share with others, the science, engineering and education of NASA’s mission directorates to help build a diverse, scientifically literate citizenry and a well-prepared NASA and STEM workforce. In addition to participating in research and EPO, students are given opportunities to interact with faculty and industry representatives, attend field trips, workshops and talks with distinguished speakers, participate in a statewide scientific symposium, and join a community of scholars, that provides support through their educations and into the workforce (see Higher Education). Graduate Fellowships focus future scientists and engineers on communicating science to non-professional and professional audiences and are designed around the idea that a technically informed citizenry is essential to national priorities. Fellows become ambassadors for Space Grant and for NASA; awards include a $750 travel stipend to attend professional meetings and make presentations. Undergraduate Internship programs: expose majors and non-majors to a mentored, professional work experience; include students from a variety of backgrounds, technical and non-technical disciplines; and focus on science/engineering, as well as on education, journalism, and science policy. Interns work on and off campus, in industry and at research organizations on projects that reflect the broad scope of NASA focus. All students/mentors complete mandatory evaluations with results compiled and assessed promoting program enhancements. Longitudinal tracking of all participants allows us to gauge longer-term program impacts including success in preparing students to enter America’s STEM workforce, degrees conferred, continuation of formal education, and workforce placement (Table 4: Longitudinal tracking summary).

Impacts/Results

From 2003-2007, AZSGC fellowship programs supported 811 undergraduate and 211 graduate students—25% more than in any previous grant cycle. On average, 40% of awardees are women (fewer than the 46% member university average and the 50% AZSGC program goal, but greater than percentages in STEM disciplines at all member universities). 18.7% of are from underrepresented groups, (20.8% including disabled students). This surpasses the average 18% underrepresented enrollment rates at member universities, and is substantially higher than that demographic in university STEM programs. It falls short of AZ (NCES) higher education minority enrollment percentages [28%]. Of note, two fellowships were awarded to Native American AISES leaders, who led geosciences workshops on the Navajo reservation for teachers and students—serving as inspirations and role models for future Native STEM students.

Programs achieved diversity in other aspects as well: Yearly about 60 UA SG Interns represent 35 different majors; and across the state, interns participated in research representing the broad range of NASA Mission Directorates with 419 mentors: from universities, independent newspapers, industry, NFP Research groups and Federal research labs.

“The interns examined a huge amount of data and preformed time-consuming analysis...that I didn't have time to do myself...They had an opportunity to do real science...with deadlines, writing abstracts, and public speaking. It has been a pleasure to mentor the future planetary scientists for they will carry the torch of learning and research when our leg of the race is finished” (Dr. Timothy N. Titus, USGS, Participating Scientist on Mars Reconnaissance Orbiter).
UA internships provided a bridge experience for 34 Pima Community (Hispanic serving) College students into the four-year university.

Twelve others participated in NASA center internships and NASA Academy programs.

Science writing interns produced 138 bylines. Newspapers are an effective and powerful medium for reaching everyday citizens and decision makers; the work of AZSGC science writing interns was praised by Congresswoman Gabrielle Giffords, who recently hired a science writing alumnus to her senior staff. Interns and Fellows “extended the arms of NASA” by working on more than 25 missions and research grants (See Executive Summary). It is a win-win situation for the students, Arizona’s researchers and NASA.

Program success and prominence inspired many of the state’s most distinguished researchers to apply competitively to serve as mentors. 82% of UA Mentors provide split-or even full- funding—allowing us to support far more deserving students than would be possible with SG funds alone. Even those who fully fund students want them to be part of SG—to work within an infrastructure that gives students and mentors a sense of community, complementary educational activities, a scientific symposium, and prestige (see Higher Education).

87% of Graduate Fellowship funding was AZSGC match or other federal leverage. 32 Graduate Fellows learned that academic scientists have unique opportunities to participate in public science education through their research activities. They designed and implemented programs (delivered through our precollege, higher education, and public programs components) that gave many others opportunities to participate in NASA’s science, engineering and education. These include developing: interdisciplinary classes (see Higher Education), teacher training workshops/curriculum supporting the Phoenix, James Webb Telescope and Juno NASA missions’ EPO. Others led public science education and technology transfer for groups as diverse as government planners and ranchers. Grad Fellow Soshana Mayden established a climate education workshop for journalists who received hands-on training from university scientists. Now, nine journalists from Tucson, Phoenix, Sierra Vista and Navajo Nation newspapers are better prepared to inform the public on these important issues.

Fellowship students contributed to 169 professional publications, many in refereed journals. Longitudinal tracking from grant inception demonstrates the powerful role AZSGC plays in propelling

<table>
<thead>
<tr>
<th>Project</th>
<th>1990-2007 Undergrad Awardees</th>
<th>Continue Degree Program</th>
<th>Completed degree</th>
<th>Left Univ. Or Degree Unknown</th>
<th>Transferred to Complete Degree</th>
<th>Univ. Grad Rate</th>
<th>Univ. Sophomore Grad Rate*</th>
<th>AZSGC Grad Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>UA SG*</td>
<td>897</td>
<td>103</td>
<td>748</td>
<td>40</td>
<td>7</td>
<td>55%</td>
<td>72%</td>
<td>94%</td>
</tr>
<tr>
<td>ASU SG</td>
<td>329</td>
<td>50</td>
<td>256</td>
<td>17</td>
<td>6</td>
<td>51%</td>
<td>NA</td>
<td>92%</td>
</tr>
<tr>
<td>NAU SG</td>
<td>171</td>
<td>14</td>
<td>158</td>
<td>11</td>
<td>2</td>
<td>45%</td>
<td>NA</td>
<td>93%</td>
</tr>
<tr>
<td>ERAU SG</td>
<td>123</td>
<td>26</td>
<td>96</td>
<td>0</td>
<td>1</td>
<td>63%</td>
<td>76%</td>
<td>99%</td>
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<td>Total</td>
<td>1520</td>
<td>193</td>
<td>1258</td>
<td>68</td>
<td>16</td>
<td>54%</td>
<td>74%</td>
<td>95%</td>
</tr>
</tbody>
</table>

*1993 onwards: UA awards to sophomores and above only

Table 3. 1990-2007 AZSGC undergraduate awardees graduation rates surpass university rates
students into the STEM workforce (see Tracking Table 4). Over 99% of graduate fellows and 91% of all awardees, are working in STEM. Joel Rademacher, past Intern, Fellow, and MER Payload Project Element Manager, and now AZSGC representative at General Dynamics reports, “My experiences with management and system engineering on ASUSat1 were directly responsible for me getting a job at JPL…Real project training in the university environment should be something that every engineer-in-training gets a chance to experience.”

Another measure of program impact relates to the educational pipeline after the SG experience. “I developed a ‘yes I can’ attitude…to finish my degree [and] to have a smooth transition between the academic world and the working world. I also locked in my desire…to go to graduate school because of NAU faculty and seeing how far an advanced degree can get you [and] how it helped my co-workers at USGS.” (Eric Beitia, NAU 2007 Intern). 95% of AZSGC Interns complete university degrees, far exceeding the 54% average graduation rate at member universities. At least 475 students continued their formal educations and pursued additional advanced STEM degrees; many report that internships provided springboards into the nation’s most distinguished graduate schools. We are equally proud of community colleges students who transitioned into our large universities. In the words of Audrie Fennema (September 2003): “The NASA SG internship helped ease my transition from Pima Community College to the UA….The transition from junior college to the university can be very daunting, especially for non-traditional students like myself…” Audrie graduated in 2004, and is now an Operations Specialist on the NASA Mars Reconnaissance Orbiter’s HiRISE camera team.

Problems/Solutions: Sponsoring over 144 Internships per year, a few are unsuccessful. Each year, one or two students disappear from our rolls, or report disappointing experiences. In response, we appointed “Student Advisors,”—nominated by mentors for being skilled communicators and leaders—to work together and with managers to plan educational and networking events and to maintain communications with groups of interns and mentors to insure that each internship is a success. Another challenge is a budget relative to cost of living that either limits the number of students that can receive awards or awards size. Each year, many deserving students are denied awards due to funding limits. To ensure the program attracts top students, we not only recruit mentors with high quality projects, we also campaign for cost-share support—ultimately provided for over 80% of UA Interns. With recent, deep funding cuts at Member universities, cost share and the potential for new support, will likely decrease. We hope this is not the case. High rates of STEM workforce development, graduation rates, and positive evaluations/feedback demonstrate that AZSGC Fellowship/Scholarship programs make a real and positive difference to students and researchers.

“I was under your program in 1996-1999. It was instrumental in helping me develop my interest in astronautics, and getting me to network with what would become my future graduate advisor…I have gone on to work as a spacecraft navigator at NASA’s JPL…on Mars Global Surveyor, Mars Odyssey, both Mars Exploration Rovers, Stardust, Mars Express (with the European Space Agency), Hayabusa (with the Japanese Aerospace Exploration Agency), and the Mars Reconnaissance Orbiter. I earned a Masters and Ph.D. in Aerospace Engineering and am now the Astrodynamics Team Lead for the AFRL’s Space Surveillance Branch….Thank you for providing what I would call my roots to my career!” (Dr. Moriba K. Jah, Astrodynamics Team Lead, AFRL, and ERAU’s first African American Intern, August 2008).
VI. PROGRAMMIC ELEMENTS: B2-RESEARCH INFRASTRUCTURE

From 2003-2007 AZSGC sponsored an average of 7.4 Research Infrastructure (RI) programs per year involving 826 student/faculty/researchers, and impacting 500 more (Table 1). Each NASA dollar ($351,161) corresponds with $1.75 in AZSGC match ($323,548) and other federal cost share ($294,336). RI activities account for only 10% of AZSGC expenditures—a deceptively low percentage as many students are awarded fellowships for RI program participation with expenditures reported there. SMART goals/metrics are to: (1) Actively recruit/support students from traditionally underrepresented groups at a rate approaching the 28% (NCES demographics); (2) Develop and grow AZSGC RI leadership and capabilities at ERAU to replace lost leadership at ASU; (3) Build mutually beneficial partnerships with NASA and industry; (4) Develop and grow a statewide balloonsat program to serve Members and minority serving institutions; (5) Lead, promote, and develop opportunities for SG students across the nation through the National Student Satellite program initiatives (SSI); (6) Sponsor student team engineering/flight programs; and (7) Measure impacts through evaluations and longitudinal tracking.

Core Criteria

All AZSGC RI programs incorporate collaborations of two or more disciplines. Team engineering and satellite development programs are organized like small companies, requiring all disciplines for success. Experiences in observational astronomy through The National Undergraduate Research Observatory consortium (NURO) introduce students to astronomy, physics, computer science, and engineering.

Consortium Specific

“Embry-Riddle Aeronautical University is an Aerospace-niche school with a very limited research agenda. Space Grant has enabled our students and faculty to be involved in NASA-related research that they otherwise would not have been able to do. These research opportunities have spurred numerous students to go on to graduate school and jobs working for NASA. Space Grant has been the single most important source of opportunity for student research at Embry-Riddle’s Prescott Campus,” (Dr. Ronald Madler, August, 2008).

UA [lead] is among the leading space research universities in the nation; ASU, the state's large urban university, has a substantial component of NASA-supported space research; NAU has a relatively smaller but significant research program. Therefore, SG resources are far too small to make a first-order enabling impact on their research programs. Rather, in most cases we leverage the program in the opposite direction, with AZSGC activities deriving strength and substance from existing university-, NASA- and industry-based research. ERAU on the other hand, has strong aerospace/aeronautical education programs but has lacked significant levels of funded faculty research. ♦ There, SG plays a critical role in incubating and supporting research in all three colleges, enabling faculty to undertake and sustain ongoing NASA research at their predominantly undergraduate university. ♦ RI programs are strategically linked across fellowships and other reporting areas to minimize costs and maximize benefits. They fulfill previously unmet needs at universities by involving AZ students in interdisciplinary space...
science/engineering focused R&D, with opportunities to apply classroom learning to real-world problems while encouraging cooperative programs among universities, aerospace industry and Federal, state and local governments as articulated in the National SG Program objectives. Students work in teams, are held to industry standards, must complete tasks on schedule, communicate about technical work to professionals, peers, and others, and work with faculty, NASA and industry professionals. Programs impact student education, enhance future employability in industry, and contribute to science and technology development. Initiatives include: (1) opportunities for observational astronomy/research through NURO; (2) team engineering and student satellite programs; and (3) developing opportunities for students across America to design, build and launch payloads beyond Earth orbit—while promoting student flight program involvement at all levels—through the SG SSI. In 2000, AZSGC Director Michael J. Drake, presented a “vision” to the National Space Grant Directors’ Council: to send Space Grant student-built satellites to Mars. Carrying a letter of support from then NASA Mars Czar Scott Hubbard endorsing the concept and calling it “visionary”, Drake proposed a strategy to accomplish this—“Crawl, Walk, Run, Fly”—to start simply, build on learning, and ultimately, to accomplish something extraordinary. The Council unanimously passed an initiative to adopt this “vision”, consortia representatives brainstormed about developing capabilities, and the National SSI was born. AZSGC helps lead this initiative; Drake is Co-Director of the SSI council.

Impacts/Results

114 students/faculty from 13 small American colleges/universities observed at the 31-inch telescope at Lowell Observatory, fostering research, collaborations, 24 professional publications (reported in Higher Education), and encouragement for students to pursue STEM careers through AZSGC support of NURO. Others gained hands-on experience to complement classroom learning—developing skills required by NASA and industry—through team engineering projects including building: Moon Buggies, Cansats, a High Speed Rotocraft Autonomous Vehicle, and participating in reduced gravity flights at JSC. From 2003-2007, AZSGC students/managers helped lead an ongoing multi-state initiative with JPL and the NASA Mars Program Office to incorporate student payloads into NASA Mars missions. Dr. Drake helped generate 75K-125K (NASA) funds yearly for summer support of SG students from as many as 13 consortia; one or more AZSGC students/year participated in these internships. Students and managers promoted SSI initiatives on our campuses, with NASA, industry and Congress. Student leaders made presentations to the National SG Directors’ Council, Sean O’Keefe, Adena Loston, Doug McCuistion (NASA Mars Program Manager), Charles Elachi (JPL Director), Senators McCain, Kyl and others. 100% of AZSGC SSI student leaders have been launched into additional opportunities (NASA graduate fellowships) or jobs in NASA or America’s aerospace workforce (see Workforce Development). Managers pursued opportunities at JSC, JPL and NASA HQ to promote SSI and develop launch opportunities. We hosted the SSI web site and helped write the SSI white paper distributed to Congress. Now, proudly, 86% of SG Consortia sponsor student flight initiatives.

“I believe the technical experience and networking with individuals within the aerospace industry and academia provided an invaluable addition to my engineering education. It is one thing to sit in class, listen, take notes, and complete homework problems, but the opportunity to apply that knowledge, work with esteemed space centers and engineers, and participate in an actual project added a depth and understanding that now allows me to participate confidently in my current endeavors. I cannot sufficiently express how much is gained by participating in these programs...”  
(Melissa Wallace, 2004 Intern, NASA JSC, ADCO, SSI).

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Three Corner Sat (3CS)—an effort among ASU SG, CO, and NM, part of the University Nanosat Program—was selected for the Delta IV heavy demo launch Dec 2004 from KSC. Although it was released at too low an altitude and was lost, Air Force sources say the “Nanosats were successfully integrated onto the DemoSat in a remarkably short four-month period, providing a successful demonstration of a responsive space mission" and a major accomplishment for SG students. Two UA CubeSats were completed and launched in 2006 from Baikonur, with CubeSats from 6 other SG consortia. The Dnepr launch failed and payloads were lost. Nevertheless, we are proud to have produced UA’s first student-built satellites, enduring partnerships with industry, and professional development opportunities for scores of students. In 2007 Rincon Research partners wrote six proposals to bring funds and life back to this effort. In 2005, AZSGC, in partnership with ANSR, established ASCEND!, a statewide, balloonsat program for teams from Members and minority serving community colleges. Through six high altitude balloon flights, 70+ undergrads have participated in the full "design-build-fly-operate-analyze" cycle of a space mission. Additionally, ASCEND! data are generating exciting technology R&D at ERAU involving regional communications: “A balloon stabilized at [70,000] altitude carrying a radio repeater payload has a radio range of about 325 miles radius…. [It] would be able to provide statewide, if not regional communications…[a] great benefit during an emergency situation…[and] would provide the communications link for many hours or even days....” (Crabtree, 2008). ERAU is also building a sustainable undergrad aerospace R&D program with their SWE chapter. Underway is a debris sensor for possible launch on AggieSat III (with TX) with testing at Baylor, and payloads and infrastructure for high altitude ballooning. ERAU is also teaming with HI and AFRL to build a student satellite for Earth orbit.

In all, RI initiatives resulted in nine reviewed papers and proposals generated $1,315,720 in new grant funding. Most important, programs sustained/grew partnerships with NASA, industry, and other research institutions and propelled students into the NASA and aerospace workforce. Great strides were made in rebuilding AZSGC RI capabilities and leadership: ANSR founder (AZSGC representative) Jack Crabtree, joined ERAU’s technical staff to assist students on flight programs, Ron Madler spent a semester at JSC and a summer at JPL with the National SG SSI student team, building relations and growing expertise, and ERAU SG students won 8 of 11 awards at campus-wide research poster competitions! We developed new leaders and partners, and are building new competencies as students and educators.

Problems/Solutions: Launch failures, lack of access to reasonably priced (for education institutions) launch opportunities for student-built satellites and low levels of diversity (16% of RI participants are from underrepresented groups and 29% women) are program shortcomings. In partial remedy, we have added two minority serving community colleges to ASCEND!, and continue to work diligently to develop and link to opportunities that insert and maintain exceptional minority students in the STEM pipeline (see Workforce Development).
The AZSGC Higher Education component accounts for 15% of expenditures (Table 1) and serves students and faculty from member universities and three minority serving community colleges (see Minority Serving Programs). NASA funding ($712,151) is more than doubled through ($727,244) AZSGC match and other federal cost share ($17,840) (Chart 8). 7.6 programs per year support 12,914 students/faculty and impact 2,053 more. All programs are strategically linked across reporting areas to minimize costs, maximize benefits and address SMART goals geared to: (1) Recruit and support a diverse group of participants (see Diversity); (2) Promote initiatives to develop interdisciplinary courses/curriculum and teacher training; (3) Sponsor group educational activities for Interns, Fellows and others, to complement and enhance student learning; 4) Foster community, build linkages and promote networking among students, faculty, researchers, industry professionals, and the public; (5) Provide a diverse group of students, opportunities for educational/professional growth and promotion.

**Core Criteria**

By design, all AZSGC higher education activities are interdisciplinary–geared to expose participants to NASA research–simultaneously providing glimpses into the work of peers and colleagues to promote collaborations. Three new courses utilize interdisciplinary content to address the educational needs of underrepresented, disabled and distance learners. “Geospatial and Instructional Technology Certification” courses at Mesa and Pima (Hispanic serving) community colleges, designed by a Graduate Fellow, provide instruction/certification in remote sensing technologies applied through Earth science lessons. “Universal Design and Accessible Space”, developed by a Graduate Fellow, involved disabled students in research using qualitative and geospatial techniques, math, science and geography, to evaluate campus environment accessibility, to ultimately improve access for the disabled. “Introduction to Indigenous Astronomy”, developed as an NAU distance-learning course by AZSGC partners in the Indigenous Education Institute, incorporates astronomy, physics, and cultural anthropology.

**Consortium Specific**

An overarching programs theme is to listen and learn from our students, and to incorporate their “Generation Y Perspective” into the way we conduct business, and engage others in exploration through Space Grant. AZSGC may be the first Consortium with a Facebook account and student advisors to help develop and deliver programs! We provide content-rich program web sites and activities to enhance Internships and Fellowships and promote a sense of community, to make our large universities feel less impersonal. For example we host a web-based “peer tutoring” program, allowing interns to help peers with subjects ranging from physics to unicycling. To insure current Interns/Fellows (as well as those who have completed programs but continue to work toward degrees) remain engaged, we invite present and past awardees, mentors, steering committee representatives, and others with interests in NASA, to up to five events per semester. Recent examples include trips to observatories, Phoenix Mission Science and Operations Center tours, and talks on topics ranging from global warming to the “Implementation of the Vision of Space Exploration from Industry’s Perspective”.

**Chart 8: AZSGC 2003-2007 Higher Education Funding**

- AZSGC:  
- O_Fed:  
- NASA:  

$0  
$500,000  
$1,000,000  
$1,500,000  

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AZSGC students and managers work to recruit students into STEM—while building community relations and funding support—by participating in five or more large community, NASA and campus events a year. From 2005 onwards, all ASU interns and fellows attend formal outreach training, conducted by ASU/NASA Mars Education program personnel, to learn how to effectively instruct and excite others about NASA's programs. We sponsor a student space advocacy group, the UA chapter of the Students for the Exploration and Development of Space (SEDS) and generate (non-NASA) funding for members to participate in the national organization. We advocate for student/faculty professional development through participation in workshops, courses, NASA center visits, and national professional society meetings. The Arizona/NASA Statewide Undergraduate Research Internship Symposium highlights the Higher Education component. The event, organized and run as a professional scientific meeting, is the grand finale of the undergraduates’ yearlong Internships and showcases undergraduate research. As many as 120 students from across the state make oral presentations on year-long research projects to mentors, university/industry representatives, NASA dignitaries, family, and friends. Sponsored for 17 years, the well-publicized event promotes networking and celebrates student and researcher dedication, accomplishments and hard work. David Zahn (2006 Intern) speaks for many: “The Symposium was truly the opportunity of a lifetime!”

Impacts/Results

- 28% of program participants are from under-represented groups, and 42% are women—meeting AZSGC diversity goals, and achieving one of our highest inclusion rates of women. Impacts and communications improved markedly when we established a Facebook account and student advisors. Since 2005, 115 ASU SG students have been trained to deliver NASA content focused outreach, and participated in 26 university outreach events reaching 3288 students. Evaluations show that the “Introduction to Indigenous Astronomy” course “is life changing for more than a few students…. It has been taught every semester for 3 years, with guest professors from all over the world. Hundreds of students have been exposed to an observation-based native astronomy and learned to find their ways around the sky using western and native methodologies,” (Maryboy and Begay, 2008). 485 students left their Space Grant experiences skilled in constructing and delivering a scientific presentation and in writing a scientific abstract—skills they will use in graduate school and on the job. AZSGC students participated in 60 professional meetings, 7 professional workshops, and other training, and made 13 presentations to the National SG Directors’ Council and other NASA dignitaries. They produced 20 publications (plus others reported in RI and Public Programs). Josh Nelson, a 2005 AZSGC Intern was elected president of SEDS national. Through a range of educational activities and events, we promote inclusion, and help create a “community of scholars” for SG students.

Problems/Solutions: Problems are tied to funding limitations. The success and growth of the Undergraduate Research Internship Symposium has caused costs to escalate. Over 220 students, mentors and guests attended the 2007 symposium banquet. In 2005 one Navajo student alone had 8 proud family members travel from the reservation to attend! Financed with limited AZSGC cost share, we may be forced to limit participation to students and mentors or charge for the attendance of family and guests. Another problem facing higher education programs is related to deep funding cuts at Member universities that may serve to decrease AZ cost share funding. We hope this is not the case as our workforce development success (91%), graduation rates (95%), and positive feedback from students, faculty, university administrators and others, clearly demonstrates that AZSGC Higher Education strategies enhance education and promote success.
VI. PROGRAMMATIC ELEMENTS: C1-DIVERSITY OF PARTICIPANTS

AZSGC recognizes that nurturing and expanding the STEM workforce in an increasingly diverse global environment requires that we contribute to the creation of a diverse community of learners. Our programs are all about creating such opportunities. We work towards the larger goal of a STEM workforce that reflects the population in all its dimensions, not only for inclusiveness, but on the principle that excellence and diversity are necessarily intertwined. This is a compelling government interest as the U.S. strives to maintain competitiveness, and is underscored by the Act of Congress which created Space Grant in 1988. Dimensions of diversity are not limited to ethnicity, race, gender and physical abilities. Therefore we seek to reach both those already preparing for STEM careers and those who might consider such a choice if given the opportunity. In bringing together an array of experiences, backgrounds, and skills to the teaching and learning process, we strive to help our member universities, our affiliates and our state make the most of all the qualities represented in our diverse population.

Strategy: The strategy for ensuring the involvement and participation of women, underrepresented minorities and persons with disabilities encompassing our Fellowship/Scholarship, Research Infrastructure and Higher Education activities varies in some of the specifics among the four member universities in the AZSGC. However, all subscribe to an approach that does not rely on quotas, scoring systems, race/gender exclusive eligibility requirements or separate selection tracks in the evaluation of potential program participants. The selection process is based on the individualized and holistic consideration of the future potential of applicants, as illustrated by the published review process/selection criteria. For example, the UA Undergraduate Research Internship Program website states:

"Review Criteria: The most important factor – by far – is the content and quality of the responses to the three open-ended questions in the student applications. GPA, motivation for applying, interest-level, potential, and involvement (work, volunteerism, and other activities) are also considered. Experience is NOT a factor in the selection process as the internship is designed to provide opportunity, even to the less experienced." From: [http://spacegrant.arizona.edu/opportunities/internships/how_does_it_work].

How does an essentially race and gender neutral selection process contribute to our diversity goals? Our internships are about creating the opportunity to gain experience, and thus the assessment considers potential. It is our position that such potential lies in all possible candidates, and thus it is essential that we raise awareness of the opportunities SG provides to all students, encouraging their participation no matter what their background. In 2002 we began a systematic effort to identify and contact student advisors, university agencies and student organizations who shared our vision of creating opportunities for students including those traditionally underrepresented in STEM. At UA alone, this has meant over 30 university services, chapters of societies, and clubs (e.g., American Indian Science & Engineering Society - AISES). It also meant more regular contact with disciplines outside the STEM fields as we have learned (1) STEM fields currently engage a less diverse population (see: NSF 07-315 Women, Minorities, and Persons with Disabilities in Science and Engineering: 2007); and (2) some of these non-STEM students discover their true calling through a SG experience. The “high tech” in our approach includes technologies such as our website, listservs and social networking websites (e.g., Facebook). The “high touch” involves face-to-face contact with the leadership and membership of the organizations noted above and presentations in keystone introductory STEM courses. It also demands a “one student at a time” philosophy that starts with SG leadership, and
then is all Mentors, Fellows and Interns. The result: a growing cadre of SG “ambassadors” including alumni, current awardees, mentors and partners noted above. The process is evolutionary by nature, but the time and effort committed can have extraordinary results.

Core Criteria

AZSGC ultimately would like to see the composition of students involved in our programs reflect the diversity of students in higher education in Arizona. Underrepresented minorities make up 27.9% of Arizona’s total higher education population according to NCES statistics. They account for 18.5% of the population of our member universities. Our target for gender is 50%, and we try to reach persons with disabilities at levels comparable to those of member university student populations (1-3%). These targets provide guidance only. They are never used as numerical benchmarks in the selection process for any AZSGC programs.

Impacts/Results

Between 2003-2007, the overall participation in AZSGC Internship, Fellowship and Higher Education programs involved 18.7% underrepresented minorities, 40.3% women, and 1.7% persons with disabilities. We began with strong results in 2003 (23% underrepresented minorities), but then markedly lower numbers of minority applicants at ASU, and leadership changes in our diversity-building partner program at ERAU (the McNair program), contributed to a drop to 15% in 2006. However, 2007 figures suggest we are back on track (19% minorities, 47% women, 3% persons with disabilities). The process of meeting our diversity target has made a difference to AZSGC, resulting in changes not only to our diversity approach, but fundamental aspects of our overall programs. Two examples show how: SG Intern Angelita Denny, of the Navajo Nation, transitioned from Diné (Tribal) College to the UA, was noticed by Steering Committee member Dr. Eric Betterton (see Minority Serving “Dr. B”), did an outstanding job as an Intern, went on to become a Math instructor at Diné, and proposed a mini-bridge program to help her students in transition to a 4-yr institution learn typical pitfalls and ways to overcome them. Setting up the program involved students from AISES at both Diné and UA. Program success resulted in new mini-bridge programs at Pima CC and ASU, through a SG graduate fellow. In 2003, then graduate student Chandra Holifield, working for the USDA SW Watershed Research Center (SWRC) approached SG looking for tips on establishing a program to promote diversity. Together we launched an initiative that combined training potential mentors to work with students new to science (as many underrepresented students are) with peer advising provided by her as an additional support. Since that time, SWRC has engaged 15 student interns. Two transferred, 13 finished the program, and 9 were from underrepresented groups. Dr. Holifield-Collins established SWRC as an AZSGC affiliate, joined the UA Steering Committee and regularly contributes to our programs. In 2005 she received USDA’s Administrator's EEO/Civil Rights Award for the ingenuity of her program and the impact of her efforts.

Problems/Solutions: While results are in range with our targets, the targets themselves do not reflect realities. For example, the U. of Phoenix Online Univ. (headquartered in AZ) accounts for 21.5% of NCES students in AZ, though the majority live elsewhere in the U.S. NCES does not distinguish between minorities holding legal residence status and those with U.S. citizenship. In AZ, legal residents who are not U.S. citizens are predominantly Hispanic, and make up 3.6% of our population—but must be turned away under current SG guidelines. In AZ, the majority of underrepresented minority students attend community colleges, one of the reasons AZSGC has made a concerted effort to establish sustainable partnerships with these institutions.
VI. PROGRAMMATIC ELEMENTS: C2-WORKFORCE DEVELOPMENT

Workforce development has been AZSGC’s highest priority since our grant’s inception. All sponsored programs work in compliment, to attract, educate and nurture, while providing opportunities for students to develop capabilities required by graduate schools and employers. From 2003-2007, our Statewide Undergraduate Research Internship programs involved 722 students in mentored research experiences at universities, in industry and at NASA centers. Graduate Fellowships focus future scientists and engineers on communicating science to non-professional and professional audiences, skills valued by employers. Research Infrastructure programs provide students hands-on opportunities in NASA-related R&D while developing teamwork and leadership skills frequently lacking in graduates with experience limited to a classroom setting. Higher Education programs build community and linkages, and provide opportunities for educational and professional growth that enhance mentored research and training. To measure the success of our approach, a full longitudinal tracking effort was implemented in 2002. In addition, we ask all program participants to tell us whether SG involvement has had positive impacts on their educations and employability, and if so how.

Impacts/Results

Results demonstrate compelling workforce development success by several measures: (1) 95% of AZSGC Interns complete university degrees, far exceeding the 54% average graduation rate at member universities (Table 3); (2) At least 475 AZSGC students have pursued advanced STEM degrees; and (3) 1107 awardees have joined America’s STEM workforce (198 of these also completed additional advanced STEM degrees). In all, over 91% of tracked AZSGC students (over 99% of graduate fellows) have entered America’s STEM workforce or are pursuing additional advanced STEM degrees (Table 4). Add to this an overall glowing praise of programs and experiences by participants—with suggestions for program enhancements/improvements frequently incorporated into the way we do business—we are confident that AZSGC programs meet goals put forth in founding legislation and subsequent agency directives.

“I just wanted to let you know how much of a key component the UA/NASA Space Grant Internship was during my interview sessions with IBM….almost every manager began by saying “so tell me about this Space Grant Internship”, which was at the top of my resume…. Without this great experience…I would have had nothing but the name on my back. It was like walking into a battle with Space Grant as my sword, because I literally blew them all away!” (Everett Benally, January 19, 2005).

Methods: Our workforce development approach is multi-pronged. Managers work diligently to identify local (and NASA) research opportunities, and to provide our students access to these. Throughout this review period, we have taken full advantage of amazing opportunities stemming from the fact the NASA Phoenix Mars Lander Mission is led by UA (lead institution) and our home department LPL. We integrated over 25 undergraduate research interns, and 2 graduate fellows into Mission operations and they have worked alongside the world’s premier scientists and engineers. In 2005, Cherie Achilles and Stephanie Barnes began SG Internships with...
Phoenix, with little background, but with intelligence and enthusiasm. Now they are Instrument Sequence Engineers for the Surface Stereo Imager (SSI), responsible for generating all the commands sent to the instrument on Mars. Patricia Wroblewski and Clayton Chu, mechanical engineering students, are SSI Downlink Engineers, journalism student Chelsea Hodson writes news releases for Mission public affairs and Gerard Droegge, with a background in chemistry, is a key TEGA team member. For further inspiration and workforce incentives, Interns work alongside AZSGC alumni operations leaders: Rolfe Bode is Phoenix Test Engineer and Chris Lewicki, flight systems engineer from JPL. Alumni become models for current students, exemplifying what can be achieved through hard work and seized opportunities. AZSGC has many other examples! (Note how SG students impact Earth Grant and their own careers in Public Programs.) We help students discover the world of opportunity within NASA and aerospace industry for those with serious interests in space technology and research. Figure 2 shows how we leveraged opportunities to propel AZSGC team engineering and student satellite programs (SSP) leaders through the education pipeline and into the NASA and aerospace workforce.

![Figure 2: AZSGC research programs create and link extraordinary opportunities for students.](image)

We reape the benefits of creating a proud, supportive community: students provided opportunities and guidance towards personal/professional growth, want to pass the favor on when they get jobs. Chris Lewicki was the keynote speaker at our 2006 Statewide Symposium (see Higher Education), and provided insights and advice about “How to get that BIG JOB in the Space Program.” The multi-generational aspect of mentored learning is a strong force in developing opportunities for new explorers. A growing number of AZSGC grads are now faculty and industry participants on local and state steering committees and program mentors. The emphasis on documenting program accomplishments via SMART goals/metrics and longitudinal tracking has had markedly positive impacts on AZSGC workforce development and related program accomplishments. Within our universities and beyond, AZSGC awards are viewed as prestigious and important; students are honored and proud to join the Space Grant family. We have high expectations for students and routinely put them forward to promote their work and our programs–even to members of Congress and to top NASA officials–and their leadership skills and poise grows exponentially. We publicize student success fueling confidence, inspiring others and contributing to community pride. For example, we helped Yuri Robeson, a young Hispanic woman, engage in a succession of NASA opportunities following her Internship (see Figure 2). Subsequently, we contributed to a feature article for the UA Daily News showcasing Yuri’s accomplishments. The article was forwarded to The Hispanic Outlook in Higher Education and Diverse Issues in Higher Education to inspire other Hispanic students, who we hope will seek out opportunities through Space Grant in the future.
VI. PROGRAMMATIC ELEMENTS: C3-LONGITUDINAL TRACKING

While all AZSGC programs have internal and external evaluation systems, these are inadequate to assess long-term workforce development impacts. For the 15-year PPR, we initiated a statewide effort to longitudinally track all participating fellowship/scholarship students from the 1989 grant inception forward (student awards began in 1990). We developed an internet tracking form, searched for past student contact information buried in SG program records and university alumni databases, contacted past mentors, department co-sponsors, sent postcards to old “permanent address” listings, etc. We created a database system to manage tracking results, with employer groups classified by CMIS categories. As a result, in the 15-year PPR, we were able to report workforce data for 313 AZSGC Interns and Fellows from across the state. This was a milestone achievement for us, allowing us to learn, often years later, that SG participation had important and positive impacts on educational experiences and workforce development.

**Methodology and Process:** Since 2003, the longitudinal tracking of awardees has become a major ongoing consortium commitment; our goal is to track all program awardees. Extraordinary effort has been devoted to developing, improving and institutionalizing a statewide tracking system that allows us to document accomplishments—especially in meeting congressional mandates behind the Space Grant Act and NASA Education program Outcome 1 “Contribute to the development of the STEM workforce goals”. In the process we have learned a lot through trial and error, networking, and sharing ideas and strategies with managers of other programs. Through lessons learned we have added required fields to program applications for birth date, a parent’s name/address, a permanent email address (rather than an impermanent university email address), and a tracking agreement to fellowship application forms that applicants must sign to be considered for award. We put our UA Graduate Fellows, Undergraduate Interns and Research Mentors alumni databases online with a positive result to tracking efforts, fundraising, etc. We discovered many resource sites useful for tracking past students including: university records, alumni databases, Google, professional networking sites (LinkedIn, Spoke, ZoomInfo), reverse white pages, NASA500, Classmates.com, Facebook (especially for students who graduated after 2002 when the site came online), professional publications directories, etc.–the list goes on. In Arizona, tracking is an ongoing challenge and a major team effort. Finally, we communicate our tracking goals/needs to mentors and department personnel across our universities who provide information from their records when available; we always return the favor by sending them any new information gleaned about their students. With information we provided them, several departments are implementing alumni databases based on our model. With hard work and perseverance, we are accomplishing something important for Space Grant and our universities.

**Metrics:** In 2005, HQ mandated that consortia report the status and progress of students receiving “significant” awards supported under Fellowship/Scholarship, Higher Education and Research Infrastructure programs, including longitudinal results. Per AZSGC policy, students receiving direct support are funded under large, statewide, Undergraduate Research Internship and Graduate Fellowship programs, reported consistently under Fellowships/Scholarships. (RI and Higher Ed programs generally fund group activities.) Per NASA guidelines, tracking is mandated for “large award” recipients (>5K, >160 hours work). In Arizona, only Masters and PhD students routinely receive awards in excess of 5K through Graduate Fellowship programs sponsored at UA and ASU, with only a handful of undergraduate students being paid more than 5K. Still, AZSGC has elected to track all awardees since 1990, as the true “significance” of awards comes from the extraordinary research experience/opportunities, provided students, more
than the monetary value of awards. HQ personnel developed a longitudinal tracking table, workforce “categories” and other guidelines to begin to define and structure a tracking program for the National Space Grant program and ultimately all NASA education programs. AZSGC contributed to guidelines development and helped refine workforce category definitions, etc. In all, imposing HQ defined guidelines on top of our existing system presented challenges, but ultimately had a markedly positive effect by providing greater structure and a defined “end point” for being “tracked”.

Although in no way a recommendation for a revised national mandate, we in AZSGC maintain a greater level of tracking data detail than required by HQ guidelines, to enhance the ultimate usefulness of results. For example, we seek workforce placement by employer, rather than by general workforce categories. As a result, with the click of a button, we can inform representatives from Raytheon, that 56 graduates now work for their company, encouraging continuing support of Space Grant and justifying monetary donations to our programs. We also collect graduation dates and degrees information, not required for HQ tracking tables, but easily accessible in university student records. As a result, we can document an extraordinary 95% graduation rate for AZSGC students across the state compared to an average 54% rate for our member universities, addressing an area of utmost concern in Arizona education (see Table 3 in Fellowships).  We can demonstrate to NASA and Congress that AZSGC is meeting the goals of the National Space Grant Act with 91% of program awardees entering America’s STEM workforce or pursuing additional advanced STEM degrees.

**Impacts/Results**

AZSGC has made significant progress in meeting our statewide longitudinal tracking goals during the 2003-2007 reporting period (Table 4). All member universities have developed and maintain tracking databases, and capture tracking data for all awardees. We have completely populated the NASA Longitudinal Tracking Table with statewide data for all AZSGC awardees from grant inception. Sadly, we cannot include it here; in 12 pt. font it will not fit on one page. We have tracked 1301 students, 99% of Graduate Fellows and 91% of Undergraduate Research Interns. Of these, 99.5% of Graduate Fellows and 91% of all AZSGC awardees, have entered the NASA, aerospace, STEM academic, or STEM workforces, or are pursuing additional advanced STEM degrees. Awardees tracking–albeit difficult and time consuming–allows us to demonstrate compelling program impacts: AZSGC fellowship/scholarship awards serve as catalysts for students to continue into advanced STEM degree programs, and into America’s STEM workforce.
VI. PROGRAMMATIC ELEMENTS: C4-MINORITY SERVING INSTITUTIONS

In 2006, when consortia were challenged to develop new relations and to sustain/strengthen existing ones with minority serving institutions, AZSGC was struggling to revitalize relations with Diné (Tribal) College, and to increase minority student participation in shared programs with Pima (Hispanic Serving) Community College and other institutions. The words of TXSG Director Wallace Fowler provided inspiration: develop minority-serving programs by meeting with institutional representatives and asking them to propose ways to cooperate to meet common goals. His insights helped shape SMART goals that have led to revitalized efforts, new initiatives and a new way of conducting business: (1) Meet minority serving institution representatives face-to-face to define common STEM education goals; (2) Request proposals for initiatives to positively impact STEM education at their institutions; (3) Plan together for program sustainability (beyond the tenure of any one teacher); and (4) Assess program impacts through internal/external program evaluations to insure continuous process improvement.

Impacts/Results

In Nov. 2006 we convened an “AZSGC/Diné STEM Think Tank” with participants from the Diné Tsaile (AZ) and Shiprock (NM) campuses, Navajo government agencies, members of UA AISES and AZSGC managers. The group concurred with Angelita Denny (AZSGC Intern alumnae, Diné Math instructor and SG contact) that “Entering a large university such as the University of Arizona was like being thrown to the wolves!” New initiatives were proposed and implemented. A math peer tutor/preceptor training program, math/science excellence awards, and funding for science lab supplies enhanced STEM at Diné. A (mini-bridge program) workshop at UA for Diné students provided useful information, resources, and personal contacts with support staff and other Native students to ease the transition to large 4-year university. (An unanticipated benefit was that four UA Native students learned about SG through the workshop, and applied for and were awarded Internships in 2008!) ASU SG hosted a similar workshop for Diné students. We met with Pima CC representatives, including the Division Dean of Science, Technology, Engineering and Mathematics, resulting in a summer Math for Science Academy to help bring promising minority students up to college level math. Promising new relations were forged with South Mountain CC and Pima CC NW to involve faculty/students in statewide (balloonsat) ASCEND! activities (see RI), with students subsequently participating in the Statewide Symposium (see Higher Education). Collaborations have had impacts at the institutional level: (1) A new awareness among faculty and administration of AZSGC commitment to STEM education at minority serving institutions has permeated Pima, Diné and our AZSGC members, resulting in a more regular and sustainable relationships; (2) Pima development officers are publicizing AZSGC efforts to recruit new minority STEM students; and (3) UA AISES students who participated in the Diné “STEM Think Tank” were awarded Graduate Fellowships to conduct reservation geosciences training and are now establishing SG ties to the new Tohono O’odham Tribal College to teach atmospheric sciences there in 2009.
From 2003-2007 AZSGC sponsored an average of 9.8 Precollege programs per year that served 59,441 students, teachers, administrators and parents, and impacted 2,553 more (Table 1). Highly leveraged, each NASA dollar ($271,634) corresponds with $1.30 in AZSGC match ($128,166) and other federal cost share ($244,086). Activities account for 7% of AZSGC expenditures (Table 1), but efforts are even greater: Graduate Fellows and others lead Precollege programs, with expenditures reported in Fellowships. By design and directive, most AZSGC efforts are subsumed in university-level and Public Programs. Improved Precollege science education, however, is a critical state need. It was recently announced that a staggering 60% of high school students and 50% of elementary and middle school students, failed Arizona’s science standards exam. In this light, AZSGC Precollege programs geared to attract and retain students in STEM disciplines through a progression of educational opportunities for students, teachers, and faculty are especially significant. Equally important are efforts to train STEM educators—not only to excite and inspire P-12 students—but to excite and inspire while instilling basic competencies to insure that students are prepared and able to study science in college.

All programs are strategically linked across reporting areas to minimize costs, maximize benefits, and to best respond to opportunities, guided by SMART goals to: (1) Align programs with AZ and National Standards; (2) Leverage funding; (3) Direct programs to underrepresented and underserved populations; (4) Support NASA Education programs; (5) Support teacher training; and to (6) Evaluate programs to insure continuous improvement.

Core Criteria

AZSGC Precollege programs focus on teacher preparation/development. Examples are: (1) The GEMS Space Science Teacher Training workshop designed for grades 3-5 teachers to explore the Sun-Earth-Moon system while being trained in core science/math curriculum; (2) A quarterly newsletter for STEM teachers; (3) A Science Teacher Colloquium Series for high school science teachers; (4) Challenger Center training grants for teachers from underserved/underrepresented schools; (5) Planetary Science Teaching Kits; (6) Grants for educational materials and supplies (including star cylinders and a mobile star chamber), for Indigenous Education Institute to use in educator training workshops; (7) A Graduate Fellow developed/taught science and spatial literacy courses for parents working towards a General Equivalency Diploma (GED); and more.

Consortium Specific

Many activities are associated with NASA precollege and STEM pipeline projects. A statewide 5-12th grade teachers/students balloon satellite program, “Changes in Altitudes”, is supported and funded by NASA Phoenix Mission EPO. A Graduate Fellow worked with Phoenix Mission EPO and NASA’s Science, Engineering, Mathematics, and Aerospace Academy, to create MarsBots, a national standards-based robotics module and missing segment of NASA’s robotics curriculum. Another Graduate Fellow worked with James Webb telescope EPO to lead Astronomy camps for Girl Scouts leaders. AZSGC also partnered with the NASA Science Directorate to sponsor six rookie FIRST Robotics teams. To direct resources to areas of greatest needed, many programs serve reservation and rural area teachers/schools. We are especially proud of creative and cost-effective programs geared to
our Native communities: AIMER, (the American Indian Mobile Educational Resources classroom), educators and a travel trailer retrofitted with networked computer workstations bring state-of-the-art computer technology and the excitement of aerospace and other sciences to American Indian students and reservation communities; and Stargazer, a summer workshop for Native American high school students (with a related teacher training workshop) that immerses students in observational astronomy, physics, aeronautics, indigenous astronomy, and Native cultural “ways of knowing”.

Impacts/Results

From 2003-2007, 44% of 59,441 served by AZSGC Precollege programs are from underrepresented groups and 55% are women, well exceeding diversity goals. Of these, 30 teachers a year enhanced their educations while earning college credits through AZSGC sponsored colloquia; Parents in adult education classes learned basic science that allows them to partner in their children’s educations; 19 teachers were trained to teach Arizona’s core science/math curriculum through the GEMS Workshop, and over 900 STEM educators per year were informed about important scientific happenings and educational opportunities through science educator newsletters. The Indigenous Education Institute conveyed indigenous sky knowledge to teachers/students from AZ, UT, NM, OK, AK, as well as NASA educators and Solar System Ambassadors. 25 “Changes in Altitudes” schools from across Arizona—including 2 NASA Explorer and 7 reservation schools—participated in 8 exciting balloon launches and the full "design-build-fly-operate-analyze" cycle of a space mission. In 2007 NAU SG sponsored our first balloonat training workshop for teachers. Modeled after workshops in CO, an in-house capability provides substantial savings on travel costs. Stargazer workshops served high school students from 18 tribes from 9 states. Since 2005, 115 ASU SG students, trained to deliver NASA content, provided activities for 8,795 students and teachers. Graduate Fellows, and other program volunteers led additional activities including a Science Speakers Bureau where over 50 UA faculty and graduate students from a variety of STEM fields offer 107 different presentations on 36 scientific topics. As AZSGC Interns and Fellows lead programs that inform Precollege audiences, they gain experience as educators. In combination, AZSGC Precollege programs meet needs in AZ education and forge cooperative relations between our universities, Arizona’s P-12 educational community, and informal educator networks—all dedicated to improving Precollege STEM education in our state. Many program participants, turned-on to science through these activities, are now college STEM students. A teacher tells the story best:

“I was the Gifted and Talented Middle school teacher at Tuba City Boarding School on the Navajo Reservation of Arizona for the past 13 years.... The Space Grant Satellite Launch Program allowed our Native American gifted students...to ’step out’ of the classroom, off the ’Reservation,’ and into the world of experimental scientists, engineers, university students, and professionals....Their self-confidence and self-esteem soared as high as their experiments sailed aloft.... Through Space Grant, they have been able to create, design and implement nationally recognized projects, have gained self confidence, learned the skills of hands on scientific experimentation and have gone on to become capable university students,” (Jackie Drewett, August, 2008).

Problems/Solutions: The biggest challenges faced in our Precollege component are support and funding: Our successful balloonat program will lose Phoenix sponsorship as Mission activities wind down. We are working to develop new funding to continue this program. Costs are also an issue for AIMER, where the high fuel costs make traveling to remote reservation communities increasingly costly. We are disappointed to discontinue Stargazer, a one-of-a-kind educational program; not being teacher training focused, we have ended program support.
AZSGC sponsors an average 9.4 public service programs per year that include Earth Grant (Geospatial Extension Program), the NASA Juno Mission website, AIMER, NEMO partnership, the climate science media engagement, Girl Scouts astronomy camp, informal STEM education, a community health initiative based on NASA Earth systems science, an NAU public science lecture series, external relations with industry, government and the research sectors in Arizona, and a number of smaller public programs. While CMIS accounts for 15,437 direct and 147,374 indirect participants (Table 1), actual participants are 17,256 direct and 208,485 indirect when the figures are adjusted to account for reporting requirement changes in 2005. These programs account for 27% of AZSGC expenditure ($2,529,490) (Table 1).

Through a relatively small NASA Space Grant investment ($26,336), we were able to leverage $522,193 in Arizona match and $1,980,961 in other federal cost share (Chart 8). SMART goals are to: (1) Actively engage members of the public from traditionally underrepresented groups (2) Bridge the gap between Earth systems science research and geospatial technology and societal needs in Arizona; (3) Leverage funding to extend the reach of SG beyond direct investment; (4) Support science education needs in underserved schools; (5) Engage SG students in informal education initiatives; and (6) Track impacts and evaluate programs success via quantitative and qualitative methods (plus longitudinal tracking of graduate fellow/undergraduate intern participants), to insure continuous process improvement.

Core Criteria

Informal Education Guidance: Over the past 20 years, AZSGC Public Service projects have been aligned with the NASA guidance for Informal Education announced in FY2007, with the stated intent to increase learning, educate students, educators and the general public on specific STEM content areas, and expand the nation’s future STEM workforce. All informal education initiatives involve: (1) Standards-based education materials; (2) Educators/facilitators who actively participate in the design and/or delivery of the programs who are qualified or trained in STEM fields; and (3) Learning objectives (and where appropriate, educational standards). AZSGC programs are designed to enhance understanding, increase the educational value of the experience, visual, or activity, and explore topics in depth. This is true for both direct contacts (those participating in programs delivered face-to-face by our members) and indirect (those who participate in programs resulting from our capacity building efforts delivered by our trainees as well as those downloading educational materials from our Public Programs websites).

Consortium Specific

Participant diversity in AZSGC Public Programs reflects the diversity of our state. In all, 33% of program participants are from groups traditionally underrepresented in STEM fields, 45% are women, and just under 2% are disabled. Our largest public service initiative is called Earth Grant, or the Geospatial Extension Program, which combines the extensive technology transfer network of a Land Grant University (through Cooperative Extension) with facilitated access to the scientific assets of all Space Grant member universities and affiliates to bring Earth systems
science to society. In support of NASA Science Mission Directorate’s Applied Sciences Program, bridging the Earth systems science gap is a challenge that AZSGC has embraced with vigor and creativity, launching hands-on educational outreach (and inreach) that helps bring NASA science and technology to bear on the major issues facing Arizona today. Examples include the development of online spatial decision support tools for vegetation monitoring, strategic wildfire planning and invasive species management, as well as field-based handheld mapping solutions to locally-relevant spatial data collection and analysis. AZSGC has created powerful partnerships, which have optimized and extended NASA’s investment. For each NASA SG dollar spent on public programs, AZSGC has obtained $20 in state funds and $75 in other federal funds (the direct role we played on sponsored projects) (Chart 8). By aggressively pursuing external funding through 36 additional proposals, we have leveraged $5,432,907 (primarily through the Earth Grant program) (Table 1). Through the AIMER Mobile Educational Resource/Computer Classroom, we reach more than students in science education in underserved schools by inviting whole community participation. AZSGC recognizes the importance of involving students in the communication of scientific discovery to the public. We actively facilitate the integration of SG interns and fellows into Public Service activities. Some AZSGC students play a major role in public service: 82 interns and 21 fellows have contributed directly to our public service initiatives during this reporting period. Most others have some public service experience (at ASU it is required; all awardees are trained to be public educators.). The AZSGC tracks impacts and evaluates programs success via quantitative and qualitative methods and longitudinal tracking, to insure continuous process improvement.

Impacts/Results

AZSGC public service is all about impact. All of our programs are explicitly designed to reach a much larger audience than those who participate directly. AIMER reaches parents and members of reservation communities through work with teachers and students in underserved schools. Journalists trained in the “Climate Change for the Press” reach the general public. ASU students, trained to provide educational outreach as a form of public service reached 19,457 people in community public service events. The Earth Grant program illustrates to breadth and depth of AZSGC impact: 660 education events in 61 different Arizona communities involved 23,061 participant contact hours. A survey of Cooperative Extension agents trained at some of these events suggests that on average, each educator trained on NASA-related technologies has in turn shared what was learned with 827 clients, and of these, 51 actually adopted (e.g., purchased or installed) the technology. The program has produced 46 publications, 15 of which are in peer-reviewed important journals such as PNAS, Space Policy, and Remote Sensing of Environment. Equally important are 7 major websites equipped with decision support tools like e.g., http://rangeview.arizona.edu) which account for 23,465 average daily user sessions and a total of 18,329 educational downloads, and 24 technical reports and other important non-peer reviewed publications. The demand for services has resulted in the invitation for AZSGC participation at the highest level in Earth science policy formation in the state: The Arizona Governor’s Advisory Councils for Forest Health and Invasive Species as well the Growth Cabinet. The work has been recognized with achievement awards from scientific societies (e.g., the Society for Range Management; Association of Natural Resource Extension Professionals) and important commercial Earth science technology firms (ESRI).