AC 2008-1435: THE PENN STATE STUDENT SPACE PROGRAMS LAB: TRAINING THE NEXT GENERATION OF SPACE SYSTEMS ENGINEERS

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The Penn State Student Space Programs Lab: Training the Next Generation of Space Systems Engineers

Abstract

This paper addresses the formulation and implementation of the Student Space Programs Lab (SSPL) and its integration into the curriculum at The Pennsylvania State University. The Lab has adopted specific strategies for maintaining continuity in an incredibly dynamic workforce and for sustaining heritage and a knowledge base from one project to the next. A Lab-sponsored first-year seminar course provides an on-ramp and training ground for at least 20 new students each year. The Lab has utilized the resources Penn State has to offer and leveraged opportunities for our students. It also strives to encourage international collaboration as a valuable resource and learning experience for its students. Finally, by providing students the opportunity to participate in SSPL-sponsored projects as part of regular course projects and exercises, the students are able to enhance their educational experience while earning valuable credit towards graduation requirements. Specifically, the Lab supports a Certificate in Space Systems Engineering that formally certifies students' knowledge, experience and effort in developing space systems.

While the SSPL may be a new organization, recent successes and experiences show that the paradigm shift toward collaborative interdisciplinary efforts improves the student experience. This experience will prepare them to make significant contributions to the area of space science and engineering.

Introduction

In August of 2006, faculty and students at Penn State established the Student Space Programs Laboratory (SSPL) in an effort to consolidate and formalize student space systems projects at the University and to improve student opportunities. SSPL united a long history of independent student space projects at Penn State. In the past, Penn State students have delivered payloads for multiple high-altitude balloons, microgravity experiments, sounding rockets, and space shuttle "Get Away Specials." Because of the synergies between projects and because of the growing number and complexity of the projects, the need for a central management structure and systems engineering framework was evident.

The SSPL exists to coordinate current Penn State student space projects and to expose students to the systems engineering process rarely seen in engineering classrooms. The Lab facilitates the sharing of resources between projects, provides effective recruiting to engage students, and supports the infrastructure to attract future student project opportunities. The Lab also coordinates education and public outreach to inspire younger students to pursue careers in science, technology, engineering, and math.

As a development strategy, the SSPL focuses on fostering a collaborative and open environment for its students. By providing a location for students to congregate between classes or to meet for homework discussions, the Lab is a confluence of students from various majors, years,

backgrounds, and experiences. In addition, multidisciplinary teams are encouraged rather than single-major groups. By bridging the otherwise disjoined diversity of students' majors and ideas, the Lab's students are able to learn faster, approach designs from many angles, and ultimately grow as a team to produce more efficient and professional designs.

Student-oriented space projects at Penn State began with the NASA Get Away Special (GAS) payloads designed to fly in the payload bay of NASA's Space Shuttle (see Fig. 1). Penn State students produced three GAS payloads, which launched aboard the Shuttle in 1986, 1996, and 2001. These payloads focused on various objectives from recording orbital debris impacts to seed germination in space.

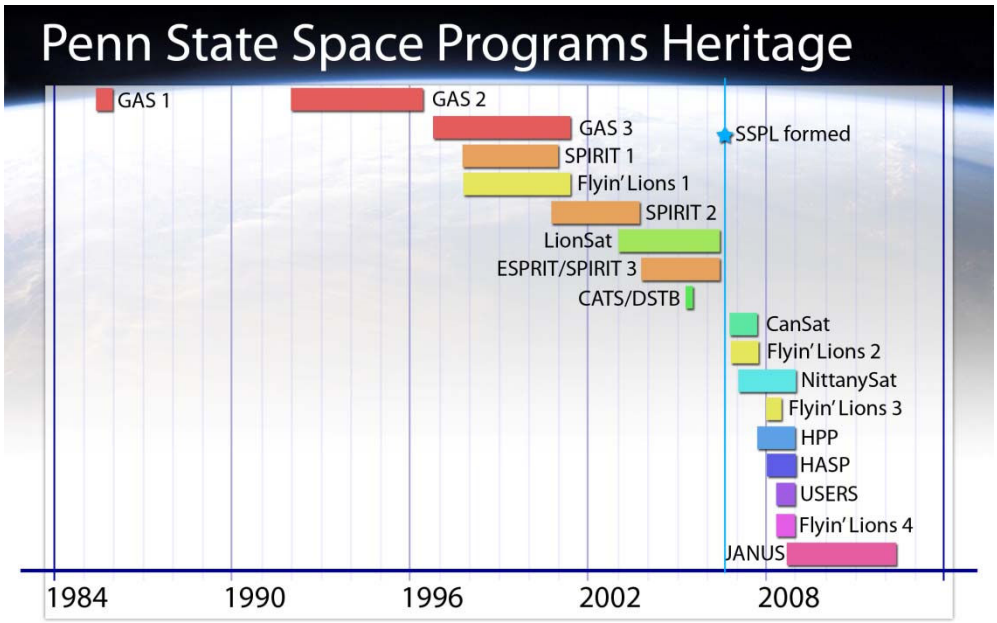


Figure 1 Timeline of SSPL Programs and Projects

Beginning in 1997, Penn State students saw the addition of sounding rockets with the initiation of the SPIRIT (Student Projects Involving Rocket Investigation Techniques) sounding rocket program.[1] SPIRIT was designed to provide the opportunity for students from a wide range of educational backgrounds to gain hands-on experience in the design and fabrication of a research sounding rocket.

The past decade has seen a diverse set of student opportunities in space research. As the GAS program was winding down with the third and last of the Penn State GAS payloads in 2001 (NASA canceled the program in 2004), the SPIRIT program began with its first launch in 2000 and subsequent launches in 2003 and 2006. The Flyin' Lions team was formed in 2000 to pursue microgravity research using NASA's C-9B aircraft (formerly KC-135a) dubbed the "weightless wonder." This program, called the Reduced Gravity Student Flight Opportunities Program (RGSFOP), is run by NASA's Johnson Space Center. The team's objective is to perform research requiring microgravity, and has included developing a device to aid astronauts' exercise in space and performing research on dusty plasma.

In 2003, Penn State was awarded a contract with the United States Air Force Research Lab's third University Nanosatellite Competition. The Nanosat mission, dubbed LionSat (Local Ionospheric Measurements Satellite), was Penn State students' first foray into the area of orbital spacecraft design. With it came the complex challenges of meeting strict fabrication and documentation requirements for launch vehicle and space environments, as well as providing for command and control of the spacecraft on orbit.

Motivation for a Central Lab

As the number of space projects and opportunities grew, so too did the complexity and aggressiveness of the missions. Penn State projects seemed to echo the trends in industry that, with increased mission complexity, a systems engineering mindset becomes critically important for success.

For example, the SPIRIT I mission produced five scientific instruments, including one from the State University of New York (SUNY) in Geneseo. SPIRIT II produced five scientific instruments as well, including two from Clemson University. In contrast, the ESPRIT (SPIRIT III) mission produced seven scientific instruments (including one instrument each from three partner Norwegian universities) in addition to three instruments for attitude determination, four demonstrations of new approaches in structures and mechanisms, and four electronics instruments to support the demonstrations. In addition to science and engineering instruments, each of the three rocket projects was based upon student-built mechanical and electrical support systems.

LionSat added another level of complexity. It was originally designed to fly on the Space Shuttle, similar to the previous GAS payloads, where the restrictions and requirements for a deploying spacecraft from the Shuttle are arguably the most rigorous in the industry.

The challenges faced by the ESPRIT and LionSat missions indicated a need for formal education in systems engineering and project management. When faced with designing and integrating entire systems, students were not prepared by the typical classroom experience for the complexities and intricacies involved.

After the conclusion of launch operations for the ESPRIT mission, the participating students and faculty took the opportunity to review the strengths and weaknesses of past projects. The establishment of a central organization evolved as a logical solution to improve Penn State's capabilities. Student-oriented labs at other schools, such as the University of Michigan's Student Space Systems Fabrication Lab and Utah State's Small Satellite Program, have shown dramatic successes.[2,3]

Students have commonly advocated for more formal recognition for their work, improved collaboration between projects, better resources, and opportunities for practice of systems engineering and project management. Faculty were interested in finding ways to provide real projects for science, engineering, and systems engineering that were an integral part of the educational process and a method to integrate their teaching, research, and service missions.

Industry has been interested in programs that go beyond book learning and, in particular, those that are able to provide training grounds for systems engineering principles.

SSPL Organization

The primary focus of the SSPL is the integration of real-world space-systems project work with the traditional curriculum to better educate Penn State students and prepare them for careers in space science and engineering.

The overall structure of the SSPL is comprised of four interlinked programs: the Flight Program, Technology and Mission Development Program, Infrastructure Development Program, and the Education and Outreach Program (see Fig. 2). Each program was established with a specific purpose to facilitate student space research and projects at Penn State.

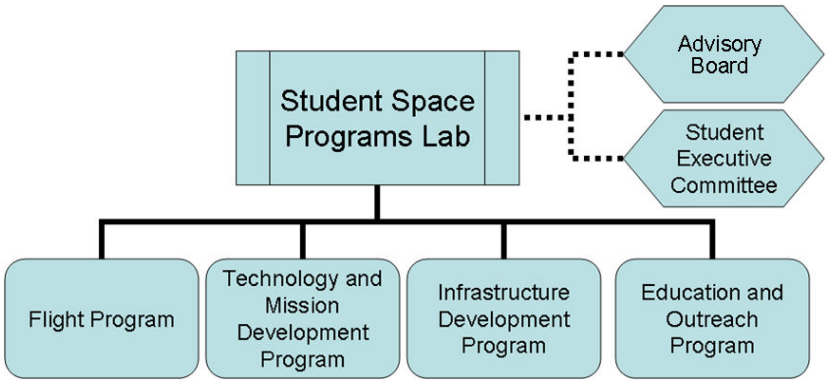
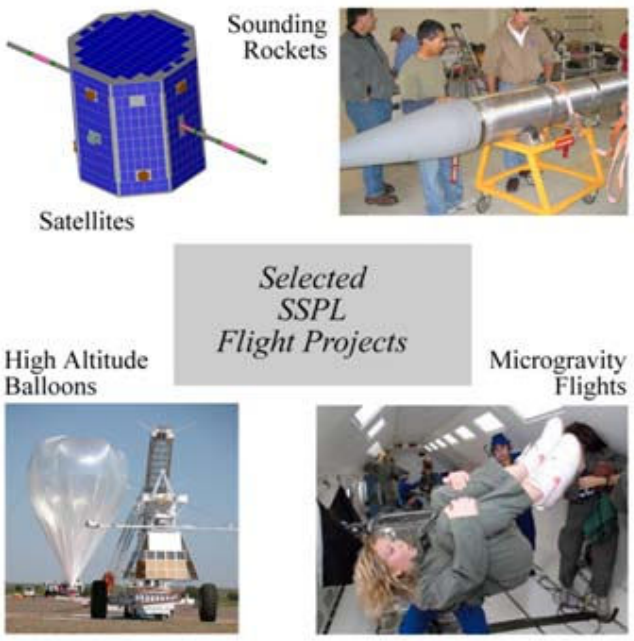


Figure 2 SSPL Organization

The Lab is jointly managed two groups. The first is an Advisory Board comprised of faculty advisors from various disciplines and organized by the Director of the Lab. The second group is the Student Executive Committee comprised of the student project leaders and organized by the Student Programs Manager.

Flight Program

The Flight Program is the most visible and largest program. It includes all complete life-cycle projects using platforms such as high altitude balloons, aircraft-based microgravity, sounding rockets, and satellites. Specifically, the program focuses on giving students the experience of working through a complete project life-cycle from concept through post-flight data analysis, as well as documenting and passing on the effort when graduation or other priorities intervene. The program's goal is to have multiple projects spanning various levels of complexity and in different phases of design.



Based on components found in various flight projects and the research environment, the remaining three programs that develop the capabilities of the SSPL are focused on advancing capabilities in technology, infrastructure, and education to specifically address the recurring needs identified by students, faculty, and industry.

Technology and Mission Development Program

The Technology and Mission Development Program focuses on improving the capabilities of the Lab and ensuring new opportunities for its students. As the name implies, this program focuses on developing technology and planning future missions.

Technology Development. The technology development side of the program allows for the development of technology outside of a specific flight project. This typically occurs for one of two reasons: a technology addresses a specific student interest that may benefit future SSPL efforts, or the technology is identified as mission-enabling or mission-enhancing for future efforts.

First, as a student lab, it is important to allow students to explore their own interests. Often these interests can be recast in a way that also adds to the capability of SSPL. Similarly, this program allows for the integration of outside student groups, such as senior capstone projects or students pursing independent studies and theses.

Second, previous projects have occasionally struggled with pressures from students trying to prepare mission-critical components on the project timeline. With a dynamic student workforce, student-built mission-critical items present a high risk to the mission. When recurring critical components are identified, such as those in power, communications, or other standard subsystems, this program can support students developing these components in *anticipation* of future needs. Other components may be intended specifically for a future prospective project,

but complex enough that SSPL must mature the technology before the mission begins or is proposed as a feasible project. To date, some advanced technology projects have included magnetometers for rockets and satellites, telemetry systems for rockets, and specific instruments for a range of platforms.

While most of the advanced technology projects tend to be smaller in nature, the Lab is now sponsoring a group of students to develop a next-generation sounding rocket boom system. The system is a redevelopment of the boom system that flew on ESPRIT. The new design will be an optimized, robust design with more capability. The boom team involves approximately 10 students.

Mission Development. The mission development side of the program focuses on identifying and pursuing new projects and funding through proposals or other similar means. Also viewed as critical to the students' training, SSPL ensures that students are involved in the proposal process. Once an opportunity is identified, a small group of students (typically advanced students who have a firm grasp of systems engineering principles) will form a team to review the announcement of opportunity criteria, map the criteria to the Lab's interests and capabilities, and then perform the first-order feasibility study and mission design. Experienced faculty members provide oversight and guidance to the process. The students involved in this process gain valuable experience for later endeavors in academia or industry. Once the mission is accepted, students have the opportunity to see their proposal mature into a tangible flight project. Since the Lab's formation, students have proposed for and been accepted by the National CanSat Competition, NASA's RGSFOP microgravity program (2006, 2007), USAF's Nanosat-5 program, and NASA/LSU's High Altitude Student Platform Balloon Program. Students were also heavily involved in developing the Student Collaboration component of the JANUS proposal for NASA's Small Explorer (SMEX) program.

The largest mission development effort to date, involving approximately 30 students, is for an upcoming CubeSat mission. The team is maturing technology anticipated for the mission while some of the more experienced students are developing the mission concept and systems engineering plan. This includes developing a requirements-tracking tool modelled after the common DOORS system and using that to draft project objectives, verification and validation procedures, interfaces, and resource allocations.

Infrastructure Development Program

In addition to component-level research and development, the Lab oversees the development of new facilities to enhance the development, testing, and integration of SSPL projects. One of the program's key objectives is to create a vertically integrated laboratory where the dependence on outside facilities or services is minimized. In the past year, the Lab has focused on improving such facilities as thermal–vacuum systems for component testing and calibration; adding capabilities for vibration testing; and preparing a satellite command and control station.

Beyond the development of facilities, the infrastructure development program is committed to developing the processes and procedures required for the verification and validation of spacecraft components. It is the program's goal not only to serve as an asset for SSPL projects, but also as a resource to other universities and outside organizations. For example, in the past year, the Lab assisted a local company to do a portion of the qualification for an antenna to be flown on an upcoming orbital mission.

Education and Public Outreach Program

The faculty of the Penn State Electrical Engineering Department have a long history of ionospheric and atmospheric research, and in lecturing on courses in these areas. The educational program includes several courses at the graduate and undergraduate levels that are focused on space science education.[4, 5]

SSPL is also focused on the education of the next generation of scientists and engineers. Every past student project has incorporated educational outreach as one of its activities. Each project typically sponsors events such as classroom visits and demonstrations, open houses, or other functions to spread the excitement of science and engineering to students in grades K–12. The Education and Public Outreach (EPO) program is dedicated to continuing the rich relationship Penn State students have with other area schools and throughout the Commonwealth. The section below on Education and Public Outreach on page 12 describes some of the specific efforts SSPL has made in this area.

Strategic Plan—The First Year

The four programs described above form the foundation of the Lab. For the Lab to mature and prosper, an adaptable strategic plan must identify priorities, deficiencies, and methods to address them. To this end, the students and faculty identified several key priorities deemed necessary to

achieve the desired resources and capabilities. With the SSPL in its infancy, the key priorities for the inaugural year centered on

1. providing an on-ramp for new students in order to develop an experienced workforce,
2. diversifying flight projects,
3. integrating the Lab with the Penn State curriculum,
4. interfacing with existing university research interests,
5. improving our domestic and international partnerships, and
6. developing a rich set of educational outreach activities and relationships.

These challenges are applicable to many student groups even outside of the space systems realm. The following sections describe SSPL's philosophy for meeting these challenges and the successes encountered.

Student On-Ramps: The CanSat Competition

One of the challenges observed throughout past projects has been the problems of recruiting new students in the later phases of the project lifecycle. Once the project reaches the advanced stages of design and fabrication, new students are often overwhelmed or intimidated by the difficult learning curve they need to overcome in order to contribute meaningfully to the team effort. This is not a result of any deficiencies on the students' part; rather, since they were not present during the early project development, they were not exposed to the project-specific details or the general tools and skills required. To compound the problem, these later-stage "crunch times" are exactly when new personnel are needed most and the fully engaged students rarely have the time required for intensive training efforts.

SSPL initiated the CanSat project as a training program for younger or inexperienced students. The CanSat Competition is an annual event open to North American high schools and universities and sponsored by several organizations including AIAA and NASA.[6] The project provides any interested student with an introduction to space systems and training for future projects within SSPL. Each year, first-year students led by experienced upper-class students will develop a miniaturized payload and will participate in its launch on a model rocket during the summer. CanSat provides new students a chance to learn the tools required for more complex projects and to network with faculty and upper-class students.

The overwhelming success of the CanSat program prompted the Lab to recast the project into one of the topics for a formal First-Year Seminar. At Penn State, each incoming student is required to take a one-credit first-year seminar in order to facilitate their transition into college and to engage them in the learning process. During the fall semester of 2007, 20 first-year students enrolled in the CanSat class (named "*This is Rocket Science*"). During the course, the students performed the concept design and definition for the next CanSat entry. The students were exposed to experienced students from other SSPL projects as well as to faculty members from several engineering disciplines and with extensive backgrounds in space science and engineering. Several students from the course now hold prominent positions in SSPL's flight projects.

For students who wanted to gain a more hands-on experience, the older students volunteered to host optional training sessions to begin developing hardware prototypes for the rocket and satellite payloads. The students learned basic circuit analysis, machining, and were introduced to software packages for electrical and mechanical design. It is our hope that these students will be motivated to form the core of the SSPL's future endeavors.

Diverse Project Portfolio

SSPL is focused on maintaining a diverse portfolio of active projects for several reasons. The first is to provide the Lab with funding support to continue the development of its facilities and capabilities for the benefit of the participating students. Secondly, a diverse project portfolio also brings with it better opportunities for student learning. Ultimately, the goal is to have concurrent projects in every phase from concept development through operational testing on various space flight programs.

In addition to the aforementioned CanSat project, since the Lab's inception, SSPL has proposed for and been awarded six new missions in addition to CanSat: NASA's RGSFO (twice), the US Air Force University Nanosat-5 Program (UNP), a pathfinder sounding rocket project with NASA's Wallops Flight Facility, NASA/LSU's High Altitude Student Platform (HASP) balloon program, and the Student Collaboration portion of the proposed JANUS SMEX satellite mission.

The RGSFO mission in 2007 marked the first Penn State Flyin' Lions flight since the original teams flew in 2001 and 2002. The team completed the microgravity flight this past March and is currently finalizing the data analysis. Their flight in 2008 will be an improved re-fly of the 2007 experiment.

The UNP project, now referred to as SSPL's NittanySat project, is a two-year contract with the Air Force to deliver a functional satellite. NittanySat will have a similar scope to LionSat[7] (which was part of the Nanosat-3 Program) but with a different mission. NittanySat will study the phenomenology of *D*-region radio wave absorption. The mission proposal was prepared by ten students in cooperation with faculty and, since its acceptance, has involved nearly 80 students.

Penn State recently agreed to pilot a collaborative sounding rocket program with NASA's Wallops Flight Facility. For the pilot mission, Penn State serves as the Integrator and provides the systems engineering for the experiment portion of the payload. As the Integrator, Penn State will have the primary responsibility for managing and coordinating design, development, and integration of the Pilot payload, ensuring compatibility with the prescribed configuration. The Pilot mission will gather experience in preparation for broader program (currently dubbed USERS). Boston University, Penn State Mont Alto, and Penn State University Park are providing experiments for the pilot mission.

The instrument to fly on HASP is the High Energy Monitor Instrument (HEMI), which is the Lab's first step at developing a Gamma Ray Burst (GRB) Detector. Ultimately, HEMI is intended to be a student instrument for measuring GRBs on a future satellite. As the challenges for developing student satellite hardware are significant, a precursor balloon flight will provide

the necessary heritage to enable a more costly and complex project. The HEMI was included as an instrument for the Joint Astrophysics Nascent Universe Satellite (JANUS) mission to NASA Small Explorer program. If selected, the HEMI will provide meaningful science to the JANUS mission on the energy of gamma ray bursts.

Integration with the Curriculum: The Space Systems Engineering Certificate

In 2007, a Certificate in Space Systems Engineering was made available for students, primarily in the CoE, who wish to obtain recognition for completing a core set of courses in Space Systems Engineering–related topics in addition to participating significantly in a space systems project.[8] As such, the Certificate is intended to acknowledge those students who have gained a proficiency in space systems engineering through coursework and project work. The project work is to be documented through the submission of a report on their effort. This program, under the direction of and jointly administered by the Electrical Engineering Department, the Communications and Space Sciences Laboratory (CSSL), and the Aerospace Engineering Department, is designed to prepare students for careers in the space industry. It will also be of interest to students with a more general interest in systems engineering and interested in bolstering their credentials. It is intended that the Certificate will provide to potential employers a credential indicating that the student has achieved a level of competence in space systems.

Space-systems projects provide excellent design experiences that match well with the formal educational, rather than just the classroom, aspects of the design activity. Developing instruments and subsystems to meet the scientific objectives, given the constraints of economics, time, and other factors, provides real-world challenges for students. In order to address project requirements, students form into teams composed of a mix of academic backgrounds to focus on the range of problems presented by the design and construction of an instrumented rocket payload, satellite, or other space system. Additional benefits are derived from the experiences of integration, testing, sensor calibration, and participation in the flight operations associated with these projects.

The Certificate adds a degree of academic formalism to the student's project based work and recognizes a certain level of achievement. A student who completes the Certificate will:

- be better prepared (in terms of breadth and depth of knowledge) to enter the space industry,
- have completed a hands-on project experience representing the application of principles learned,
- have a deeper understanding of the following:
  - systems approach to engineering;
  - several technical subjects related to space systems and physics;
  - processes and procedures for development of space hardware;
- be able to work in multifunctional teams.

Interfacing with Penn State Research Interests

As the Lab matures, interfacing with researchers and organizations previously unaffiliated with SSPL will create additional opportunities for collaboration. This collaboration typically is in the

form of relationships within Penn State, partnerships with other universities, and cooperation with industry sponsors. SSPL has made several significant efforts to maintain and improve these collaborative relationships.

The Center for Space Research Programs (CSRP) has been established in order to capitalize on the resident expertise and infrastructure developed from past projects and to attract new space research projects to Penn State.[9] Although housed in the CoE, the SSPL is a university-wide resource and accessible to students throughout the University. In a sense, it is the "student branch" of CSRP. Through its existing relationships, CSRP provides SSPL with connections to new research interests throughout the university and with external organizations. It also provides a valuable knowledge base in project management and engineering expertise that will benefit SSPL projects and their students.

JANUS has been key in helping to involve the students and faculty from Penn State's Departments of Physics and Astronomy & Astrophysics with SSPL projects. On the HEMI team (JANUS student instrument) in particular, the number of science students rivals that of the engineers—a record for the Lab's past projects and a trend the Lab is working hard to encourage.

International and Domestic Partnerships

External partnerships were an integral part of the previous SPIRIT missions. The SPIRIT program partnered with the State University of New York (SUNY) in Geneseo for SPIRIT I, Clemson University for SPIRIT II, and the Norwegian Universities of Bergen and Oslo and the Technical University of Narvik for ESPRIT. Because of the international collaboration, the ESPRIT partnerships were a particularly diverse and rewarding experience for all involved students.

Penn State is currently developing a memorandum of understanding between Penn State and Norwegian universities to continue the history of collaborative projects.[10] NittanySat builds on the collaborative heritage of the SPIRIT program by involving groups from the University of Graz in Austria and universities in Norway.[11] New partners, such as the Geophysics Institute at the University of Alaska will also support the mission. Also, started in Fall 2007, a group of students are developing a new boom system for Norway's Andøya Rocket Range to meet their upcoming needs. This project falls under the Lab's Advanced Technology and Mission Development Program.

Through the Advisory Board, the Lab is assembling a list of topic experts who are willing to guide and mentor students in all areas of project development including systems engineering, science, hardware design, and education and public outreach. In addition to Penn State resources, an increasing number of these experts are from NASA centers and industry partners. The lab has had offers from major aerospace companies to provide red-team reviews to provide critical reviews of the students' designs. Other partners visit Penn State to deliver presentations on systems engineering, or active projects relevant to the students' efforts.

Finally, student space projects often provide industry partners with a relatively low-cost—albeit high-risk—ride to space. By donating or discounting hardware for student rocket and satellite

projects, industries can develop heritage for their technology. In exchange, the projects gain valuable resources that may normally exceed the resources of the university environment. For example, the ESPRIT mission successfully flight-qualified a company's embedded computer system for all NASA sounding rockets[12] in exchange for donations of significantly discounted hardware and engineering support. Both the SPIRIT Program and LionSat have developed relationships with several companies that have contributed to the projects' successes.

Education and Public Outreach

As education is a key priority for SSPL, the Lab supported the re-establishment of the Penn State chapter of Students for the Exploration and Development of Space (SEDS). SEDS is an international student-led organization committed to furthering education and awareness of space. As part of SSPL, SEDS forms the cornerstone of the Lab's formal education and outreach program. As part of this mutual relationship, the two organizations are able to share resources and knowledge in order to accomplish the common goal of providing educational opportunities for learners of all ages.

Other important educational resources are the Pennsylvania Space Grant Consortium, which is valuable partner in providing support for space research, and the Penn State College of Education.

Continuing Efforts

Since the Lab began in 2006, the number of students involved has swelled to keep pace with the increasing number of projects. The challenge has moved from attracting and retaining students to facilitating inter-project collaboration, helping students become technically prepared to meaningfully contribute to the Lab's projects, helping them to document their work for future generations, and introducing them to the faculty and industry experts.

The Student Executive Committee has become more critical as the scope of the Lab grows. Providing a forum for the project managers and subsystem leaders to discuss the state of their respective projects and their needs helps the leaders of the lab understand the similarities and differences of each project. Where projects overlap, collaboration has naturally evolved as an appropriate solution. Three of our projects are collaborating on power supply design; others are sharing ideas for mechanical designs. Knowing project weaknesses has also been useful. When one project is lacking a particular skill or talent, older students from other projects have been able to cross project lines to give and train the newer students. This has proven to be an incredibly valuable resource.

In addition to students informally helping others, students across the lab are helping to develop formal training procedures and tutorials for bringing new students up to speed quickly and thoroughly. Training new students is a large time commitment for older students who are usually busy working on their projects. By providing tools and resources for training, it saves time for both the trainer and trainee.

With the complexity of projects and the number of participants growing, documentation is becoming more and more critical. The Lab has taken extensive steps to establish a formal collaborative document server for each project. The server provides an easy, web-based interface for each group that allows for version control, document sharing, Gantt charts, issue tracking, contact lists, and discussion forums. The server is secure with access customizable on a project-by-project basis and accessible over the internet with any web browser. In addition to project documents, the document server provides a central location for standards and specifications, user manuals for all lab equipment, design guides, training, and tutorials.

Finally, providing a context for the students' efforts and resources to help them excel is also a Lab priority. To this end, the Lab has begun to arrange for faculty and industry scientists and engineers to discuss their work with the students. Giving students the perspective of what the "real world" scientists and engineers gives them a new perspective into their own efforts. Similarly, the Lab also strives to arrange for topic-specific experts (again, either faculty or industry partners) to deliver "crash courses" on a variety of topics. The talks serve a dual purpose—to quickly introduce students to topics they have not yet seen (or may never see) in class and also to often provide a point of contact for students to follow up with any questions.

Results

The establishment of the Student Space Programs Laboratory at Penn State has resulted in a paradigm shift in how student space systems projects are approached. The Lab is able to provide better opportunities for its students through more numerous and complex projects and can continually adapt to future challenges. It includes several laboratory rooms, including a clean room for instrument assembly and the other resources for space hardware development.

In less than two years, the Lab has made significant progress on the objectives it set out to address. Six new flight projects were added to provide new student opportunities: the CanSat Competition, Flyin' Lions Microgravity Project (2006 and 2007), NittanySat Nanosat, HEMI Balloon, the Pilot national sounding rocket program, and JANUS. As a result, the number of active students has swelled to about 100. Students now receive formal recognition through the Space Systems Engineering Certificate and through the CanSat first-year seminar, which also provides an on-ramp into the program for younger students. Important new partnerships were established such as with CSRP and SEDS that will bring more capability to the Lab. Furthermore, existing international partnerships with Norway and Austria were renewed with the NittanySat and the Andøya Sounding Rocket Boom projects.

Through these efforts, the Lab already has become integrated into the Penn State curriculum, which will bring with it benefits for the students involved. Five senior design project teams completed projects for the Lab in the spring 2007 semester, including students from the Electrical, Mechanical, or Aerospace Engineering Departments.

NASA centers and aerospace companies have validated the Labs' goals and the qualifications of its students by specifically targeting the Lab for recruitment. Employers have remarked that the hands-on experience and exposure to systems engineering is a valuable asset in the Lab's

students. The Lab is now routinely requested to assemble resume packets for intern and full-time positions.

Conclusions

SSPL is a new organization, yet it has already demonstrated that it can significantly benefit the students of Penn State and the aerospace community at large. The past year has resulted in significant advances in student space research environment at Penn State. Continuing efforts will see greater improvements in the capabilities of the organization and consequently better opportunities for its students.

Most importantly, SSPL has demonstrated that it can provide students with the education and training necessary to make them valuable assets in today's space industry.

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