HANDS ON EDUCATION THROUGH STUDENT-INDUSTRY PARTNERSHIPS

Jessica Brown
Lockheed Martin Space Systems Company
303-977-7798
jessica.brown@lmco.com

Mark Wolfson
Lockheed Martin Space Systems Company
303-977-6061
mark.a.wolfson@lmco.com

12257 S. Wadsworth Blvd.
Mailstop S6040
Littleton, CO 80127

1. ABSTRACT

Lockheed Martin Space Systems Company has invested in the future generation of engineers by partially funding and mentoring CubeSat projects around the country. One CubeSat in particular, ALL-STAR (Agile Low-cost Laboratory for Space Technology Acceleration and Research), has shown how this industry/university partnership benefits both the students and their mentors. Students gain valuable insight into aspects of spacecraft design that are not taught in classes. They also start learning about industry processes for designing, building, and testing satellites before ever working in that environment. Because of this experience, industry is getting more qualified engineers starting fresh out of college. In addition Lockheed Martin's partnership with the university will allow them to use the students to help build affordable CubeSats for internal and customer's research and development projects. The mentoring also challenges the engineers to think differently about similar problems they face every day with their larger programs in order to make the solution simple and affordable.

2. INTRODUCTION

Students from the Colorado Space Grant Consortium (COSGC) at the University of Colorado have been working on a 3 unit (3U) CubeSat bus, ALL-STAR and its first payload, THEIA (Telescopic High-definition Earth Imaging Apparatus), since the fall of 2009 with the help of Lockheed Martin (LM) sponsorship and mentorship. Through this active partnership we have seen how University outreach by industry not only provides enrichment to the community, but many other tangible benefits for all parties involved as well.

3. ABOUT THE ALL-STAR PROJECT

The ALL-STAR program was started by Lockheed Martin and COSGC with the goal of developing a low cost, highly capable CubeSat bus. At the time, LM was in the early stages of exploring the relevancy of CubeSats as mission solutions for our customers. CubeSats are extremely limited by their financial resources which limits their on-orbit capabilities. The cost of their development, deployment, and operation tend to be extremely low in comparison to national assets, such as the Space-Based Infrared System (SBIRS). Because of this, developing a

CubeSat is an endeavor very different than developing these typically large spacecraft which are more process driven.

In 2009, COSGC, headquartered at the University of Colorado at Boulder, was wrapping up production of their first CubeSat, called Hermes. They gained valuable experience with Hermes and were looking to start their next CubeSat project. LM had helped with some of the environmental testing of Hermes so there was an existing relationship between the student organization and Lockheed Martin.

For ALL-STAR, the partnership between LM and the University was designed be much more involved. At the initiation of the project, LM agreed to provide continuous mentoring, the bulk of the funding, and mission needs to drive requirements. COSGC would use a team of undergraduate and graduate students to manage, design, build, test, and ultimately operate the spacecraft.

The ALL-STAR satellite has been under development since the Fall of 2009. At this time, they are finishing up the spacecraft integration and preparing to enter environmental testing. They have been working towards a December 2013 launch with the Educational Launch of Nanosatellites (ELaNa) program. To date, the ALL-STAR project has been a rousing success. The students have effectively passed all of their major design reviews with mentors and completed all of their functional testing with the subsystems. There has been ongoing open communication between the engineers from industry and the students.

4. BENEFITS

Though ALL-STAR has not yet flown in orbit, most of the benefits have been realized before even leaving the ground. Every year, students from the project graduate with different experiences in designing, building, and testing flight hardware. Several of those students leveraged their industry connections and started their careers with LM. ALL-STAR serves as a training ground for these soon to be engineers by providing hands on experience that cannot be replicated in a classroom. It gives them the chance to learn the hard mistakes and get a feel for what it is like in industry before being thrown onto a large, highly risk adverse, mission. It also gives the company a chance to observe the students before considering them for a full time position at the company. LM is benefiting from funding the program by reinvigorated its work force with COSGC recruits and the students are rewarded for their networking with mentors by getting jobs in their field immediately after graduation.

Too often there is a disconnect between academic advances and real world needs. Knowledge sharing between industry and academia can serve to align cutting edge research with real-world applications, as well as inform experts on both sides of advances. For example, graduate students in the electrical engineering department are continuously researching and developing novel antennas without an end use in mind. The LM mentors set a requirement for a very high data downlink rate for ALL-STAR in order to push the envelope of CubeSat functionality. The student engineers were forced to search for something that would meet the needs which resulted in them reaching out to the electrical engineering department and incorporating one of the new antennas into their design. Additionally, industry has been interested in flying new, high sensitivity focal planes, developed for terrestrial uses, which could benefit from advanced algorithms being developed at a university in order to track dim objects. These types of connections are facilitated by the relations set in motion by industry funding programs at universities and cultivating these partnerships.

Across the aerospace industry, affordability has become a ubiquitous mantra. One method for reducing costs for the larger, more established contractors is to employ non-traditional labor sources. The hourly cost for an aerospace

engineer is approximately an order of magnitude greater than that of an aerospace student. Today's students are extremely bright and are capable of completing significant amounts work typically done by aerospace professionals at a greatly reduced cost. While the students are provided with hands on learning experience outside of the classroom, industry and customers can, in turn, receive quality products at fractions of the cost. One of the primary objectives of the ALL-STAR program is to develop a generic, yet capable CubeSat bus that LM and others could utilize to get technology and small science payloads to space for a very low price point. LM has frequently discussed using the ALL-STAR bus as the platform for their CubeSats in order to reduce cost. This construct is not limited to CubeSats though; when provided with mentorship, students are a great resource for many engineering activities, such as subsystem design, drawings, and software development.

During the ALL-STAR project, several mentor/student relationships were found to be more critical than the others. In particular, the communications and thermal subsystems relied heavily on guidance from the industry professionals. This has been attributed to the fact that these two disciplines are not typically emphasized as part of the core engineering curriculums; therefore finding students with both interest and experience proved to be difficult. In the end, however, we found that finding students with interest and aptitude was more than sufficient to create an effective mentoring relationship. The result is mutual benefit as industry fills some holes in the academic curriculum and, in turn, receives new graduates already experienced in these more esoteric disciplines.

One other benefit realized by the professional and student relationship is the complementary blending of cultures. The cultural differences between industry and academia can be represented by considering the differences between CubeSats and Class-A National Assets such as SBIRS, our country's next generation missile warning system. CubeSats are quick-turn, educationally motivated, and have only a moderate expectation for success. The culture that applies to such a product is predicated on an efficient, "good enough", just do it attitude. A National Asset, on the other hand, is an exquisite system that provides a critical capability to our country and demands high reliability with the highest probability of success. The resultant culture is very deliberate, focused on mission success, steeped in process, and employs multiple layers of checks and balances. Bringing these two disparate mindsets together in collaboration fosters a yin and yang balance. The students must slow down and consider processes that have evolved over decades to better ensure mission success, and the professionals must adopt a more agile mindset that is appropriate to the scope of a typical CubeSat project. While the professionals help mentor the students on typical industry expectations and processes, the students mentor the engineers on new ways of approaching the same problem and keeping an open mind. This last major benefit really highlights how mentoring is a two way street.

5. CHALLENGES

In order to realize all the benefits of industry and university collaboration, there are several challenges that must be addressed. The biggest challenge is a conflict in information sharing paradigms. Academic research is heavily focused on sharing of results, publishing papers, and general information exchange. Industrial contractors, on the other hand, rely on information protection to maintain their competitive advantage. This contradiction must be addressed up front to ensure that both parties are on the same page. In the case of ALL-STAR, it was decided from the beginning that all information created by and made available to the students would be open to full public disclosure. This properly put the onus on LM to protect their intellectual property while freeing the students from any concerns.

One of the other major challenges encountered was the high turn-over rate of the students. Over the course of the ALL-STAR project, there have been a rolling wave of approximately four classes of students and has seen three different program managers. They try to maintain a staff of around 20-30 students, approximately a quarter to a half

of which will turnover each semester. This revolving door created a challenge in maintaining continuity of efforts and design. Each semester there are a significant number of students getting caught up and progress is slowed by this learning curve. In addition, there are no students remaining on the project now that were part of the original team so the logic behind some design decisions is often lost. While having long-term mentors helped alleviate the issue, the high turn-over rate seems to have a significant impact on efficiency.

6. CONCLUSION

Corporations and organizations funding and supporting university programs, such as ALL-STAR, is a beneficial endeavor to all parties involved. The entire community benefits from the extra training the young engineers gain and the open communication about industry needs and complementary university developed technology. The students benefit from the networking opportunities with professionals for jobs and mentorship while getting extremely valuable hands on experience while still in school. The sponsoring organization in return can receive valuable products, get their engineers to start thinking innovatively like the students, and has the chance to observe the students work before considering them for hire at their company. The cost and time spent on similar programs to cultivate this industry/university partnership is inconsequential in comparison to the significant return value.