The Creation and Impact of Corporate Mentorship on Student-Led Satellite Projects

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ABSTRACT

Over the past year, strong relationships have developed between a team of students at the University of Colorado and industry mentors. These students, who are participating in the University Nanosat 5 Program, have found that professional mentorship is a critical part of the learning experience. It has resulted in an increased motivation to succeed, and a more comprehensive level of real-world thinking when designing satellites. The participating professionals also find the experience rewarding and go out of their way to accommodate student needs. At the corporate level, involvement with student projects provides company exposure to rising engineers, networking with other participating companies and in some cases flight heritage of products under development. This effort and support towards education promotes long-term growth for the aerospace industry.

The University of Colorado team has planned from the beginning to pair each subsystem discipline with an industry mentor. As a result, over a dozen professionals are involved in the project. They provide the availability of testing facilities, confirmation of analytical results, and access to flight-rated hardware not commonly available to student teams. Most importantly, early and ongoing guidance by mentors helps students generate logical and realistic requirements; a process critical to mission success not always appreciated by young engineers.

This paper describes the philosophy and implementation used by the University of Colorado student satellite team in establishing professional mentorships and presents the business perspective from a participating corporation. In addition, it proposes that this program-wide methodology can be beneficial to other university teams working in technical fields.

INTRODUCTION

Many students have dreamt since childhood of working in the space industry. Others were drawn to the technological challenge of building spacecraft while in college. However students discovered the field of spaceflight, a helping hand was often there to inspire them. Educational programs and corporate mentorship are an effective way of inspiring the next generation and aid the development of future space programs. In addition, mentorship exposes students to a ‘real-world’ perspective, which gives motivation and confidence to pursue a technical career. This paper will present the establishment of effective mentorship practices, followed by testimonials of success and lessons learned.

NASA has historically played an active role in the United States educational system in the science,
technology, engineering and math (STEM) disciplines by providing research grants to universities, student projects and outreach events at all educational levels. The NASA Education Office mission statement can be summarized into three primary goals: 1) To strengthen the nation’s future workforce, 2) Attract and retain students in the science, technology, engineering and mathematics, and 3) To engage the American population in space exploration. NASA’s strategy aims to accomplish these goals by inspiring the youngest age groups with lectures and visual demonstrations, by engaging students in secondary schools with small projects, and by providing real-world, hands-on experience to students at the college level. This method works well in that NASA has the ability to step up the intensity of the lesson plans as students become more mature and are inspired to pursue careers within the STEM disciplines.

Although this plan is effective, its capability has been consistently decreasing for the past several years as NASA funding towards education has been declining. In 2004, NASA funding towards education was $170 million. It is presently funded to $154 million, and this is projected to fall to $150 million by 2012. This results in less interaction between students and NASA employees. Funding cuts are also not consistent with the recommendations of the “Rising Above the Gathering Storm” congressional report compiled in 2005 which states: “The nation faces several areas of challenge: K-12 student preparation in science and mathematics, limited undergraduate interest in science and engineering majors, significant student attrition among science and engineering undergraduate and graduate students, and science and engineering education that in some instances inadequately prepares students to work outside universities.” This report stresses that a healthy student enrollment in the STEM focus areas will help maintain a leadership role in the high-tech industries in the increasingly competitive international market.

In addition to the concern of decreasing funds for education, the NASA workforce is aging, causing concern for a future gap in talented engineers to lead the Vision for Space Exploration over the next decade. The Committee on Meeting the Workforce Needs for the National Vision for Space Exploration (VSE) stated in a recent report: “Over approximately the past decade and a half, the average age of NASA’s workers has marched steadily upward, and the agency now has a relatively low number of younger workers to assume future leadership roles in NASA as older workers retire.” If it does nothing to achieve a better age distribution across its overall internal workforce, NASA will suffer a gap not only in technical leadership, but also in overall technical experience, especially if the development dates for key VSE components slip and highly skilled workers with experience in the Space Shuttle program retire.” Figure 1 illustrates how the average age at NASA has significantly shifted over the past 10 years. If these trends continue, NASA will lack experienced engineers/scientists in the 2020 timeframe -- when the VSE plans to have astronauts walking on the moon.

Figure 1: NASA workforce age/population over time

It is clear that NASA and other STEM-related industries need to find innovative ways to inspire and train the next generation of employees in order to stay competitive in the world market. Tight monetary budgets, increasing demands and other related agency requirements limit the amount of discretionary funds NASA has available for education. As a result, solutions that utilize or modify existing programs and infrastructure are most attractive to motivate and train the next generation of high-tech employees.

HISTORY OF MENTORSHIP AT THE COLORADO SPACE GRANT CONSORTIUM

The NASA budget of 1988 included the ‘National Space Grant College and Fellowship Act,’ which authorized NASA to oversee and fund ‘Space Grant Colleges.’ These institutional centers were established in each state with a focus on space research, based on the success of the Land Grant Colleges of the 1800s. The Space Grant act grew out of a growing recognition that technology education would be increasingly important to the nation’s future competitiveness. A key finding noted in the act was a call to the university community to create cooperative programs with industry and government institutions.

The Colorado Space Grant Consortium (COSGC) was formed soon afterwards. COSGC is based at the University of Colorado’s Boulder campus, and involves
students at a number of other schools throughout the state. From the beginning, COSGC has followed the principle that the theoretical knowledge being taught in classrooms can be greatly enhanced with hands-on experience. To this end, COSGC supports and manages student-designed, built, and operated space experimentation projects.

The initial projects tackled by COSGC students were technically demanding – sounding rocket payloads flown at NASA Wallops Flight Facility, and ‘Get-Away Special’ (GAS) canisters flown on Space Shuttle missions. Safety is the primary concern in these environments, and safe payload design and certification is outside the scope of most students’ classroom experience. Fortunately, NASA personnel and local faculty were available to help guide the student engineers through this complex process. (It’s worth noting that decreased educational funding at NASA has made such projects less common today.) As Dan Baker, director of the Laboratory of Atmospheric and Space Physics (LASP) writes, “NASA has had a rich heritage of programs that have provided students and their mentors such access [space] … Today Shuttle-based and similar programs have either been terminated, or as with the sounding rocket, been cut back to the bone." These early projects would not have been successful without such assistance. Since then, COSGC has been leveraging the engineering mentorship available in government institutions, at the university, and in the aerospace industry.

COSGC has learned many lessons since those early projects. Today, COSGC operates a tiered set of programs that instill a philosophy of mentorship from the beginning. These stages are named Walk, Run, Jump, and Fly. Each stage represents a stepping stone to the next, and each step provides experiences of increasing complexity until they make the final step to their career.

Freshmen fly high-altitude balloon payloads (BalloonSats) as the final project in a ‘Gateway to Space’ course. Upon completion, students move to suborbital rocket payloads (RocketSats). Junior and seniors work on CubeSat-class satellite projects, and senior and graduate students work on larger spacecraft and more complex missions. An interesting side effect of this program structure is vertical integration: students from the more advanced projects help younger students working on less complex projects. This results in an effective learning process that also reduces the program’s operational costs, since additional staff are not required to assist the students. Students exiting the program are highly sought after by government and industry. Management is especially impressed with these new hires’ level of experience, even before they have graduated from college.

Finding mentors

In the early days, locating mentors was hit or miss, depending on friends-of-friends in an appropriate field, or hoping that word of mouth would reach an engineer who had time and the willingness to work with students. Although some good connections were established, there were still many technical areas left unfulfilled where teams needed it most. Over time, this situation has improved dramatically. COSGC has learned effective ways of approaching companies to ask for mentorship, such as meeting with management teams and discussing possible collaboration (see “Tips for finding mentors” below).

One of the most effective sources of mentorship has been former students themselves. Once employed, these former students, who know firsthand the value of good mentorship, are motivated to become mentors themselves. This creates an ever-expanding network, and often forms new mentorship opportunities within their organizations. Former students who work locally form the bulk of available mentors. But alumni with
distant jobs have often made themselves available to students through email and phone conversations, and have traveled back to COSGC to participate in major student design reviews, etc.

Buy-in

A complaint sometimes heard from mentors in the past has been that they were called in only after a crisis arose, at which point it was difficult to fix problems that could have been avoided had the mentor been involved earlier in the design process. It can also be difficult to find mentors willing to work on short notice, since they often have their own deadlines to deal with. To address this, COSGC has increasingly sought ‘buy-in,’ (a commitment to the mentorship of a project) from mentoring individuals and institutions early on. This establishes a pool of committed mentors before they are needed, eliminating the need to scramble for help later in the project. It also provides mentors an opportunity to give advice early in a project, where their expertise can do the most good. During the ‘buy-in’ phase, each potential mentor is contacted to see if they’re willing and have the time to help. Most mentors have time restrictions, and these are tracked and respected by the students.

Managing student contact

To be effective, mentors and students need to meet regularly. A unique aspect of student missions is that, from the student’s point of view, none of this has ever been seen before; it is all research and development. Monthly contact with mentors ensures a student is not following an unproductive path, and familiarizes students with a common practice in the aerospace industry, where mission success often hinges on oversight. These periodic reviews also allow the students to ask as many questions as they need to: it is important for them to understand that there is no such thing as a dumb question. It also helps instill the concept of teamwork. Student projects may be small enough for one person to design, build and operate, but this is rarely true in industry where teamwork is a critical skill to develop.

Mentorship as a core institutional value

The benefit of mentorship is presented to COSGC students early on. The Gateway to Space course presents numerous guest speakers who have donated their time to pass on their areas of expertise in the classroom. Many of these guest speakers also mentor students at more advanced levels in the program, so the course serves as a personal introduction to these engineers, a true ‘gateway.’ This course also introduces key concepts: that cited research is a valuable resource, that asking for help is part of the learning process, and that teamwork and mentorship are the rule rather than the exception. This aligns with a push in the university community to provide an educational experience closely aligned with what students will see in industry, and meets the goals of the Space Grant Fellowship Act by strengthening the nation’s future aerospace workforce.

THE DANDE STUDENT SATELLITE
MENTORSHIP EXAMPLE

DANDE is COSGC’s entry in the Air Force Research Laboratory’s University Nanosat 5 competition, initiated in 2006 and due for completion in early 2009. The Drag and Atmospheric Neutral Density Explorer (DANDE) is a technically challenging project from both management and engineering perspectives. From the beginning, the students working on DANDE knew that leveraging industry mentors would be critical to the success of the mission. The spacecraft’s objective is to characterize satellite drag by measuring temporal and spatial variability of the neutral thermosphere between the altitudes of 350 km and 100 km. From these requirements, the DANDE spacecraft has evolved into a spherical satellite system (to characterize drag), containing a neutral mass spectrometer (to characterize composition and wind vector) and a set of accelerometers (to characterize deceleration). The complexity of these instruments as well as the system design of creating a spherical spacecraft brought many challenges for the team, which had limited experience in these areas.

Proposal stage, fall 2006

In the fall of 2006, Marcin Pilinski, a graduate student in aerospace engineering, began researching topics for the COSGC entry into the University Nanosat 5 program organized by the Air Force Research Lab (AFRL). As the potential missions objectives were identified, Pilinski and the COSGC staff arranged meetings with local industry members, many of whom had previously worked with the COSGC. These meetings were meant to bring awareness of the proposal work, to provide feedback on the mission scope and to establish potential industry stakeholders who could benefit from the project. COSGC asked the mentors: if the proposal were accepted, how could the corporation benefit from working with the students? COSGC received various answers that were worked into the mission planning. A myriad of ideas for how the mentors and associated corporations could be involved were identified before the proposal writing began. Finally, under the advisement of the COSGC staff, a ‘Mentor Tracking Document’ was created to log contact information, mentor expertise and meeting notes.
Establishing the team, spring 2007

The DANDE team proposal, along with proposals from 10 other schools, was accepted in January of 2007. The Air Force Research Labs will select a winning team in January of 2009 and award them two more years of funding and a launch opportunity as a secondary payload. The initial set of mentors with whom COSGC met the previous fall were immediately involved with the establishment of the student team and schedule. Before the design work even began, the DANDE project had already established credibility and leverage with the mentors. This is because the mentors had been involved in the proposal stage, had discussed ways for the mentors or corporation to be involved in the project, and had witnessed the students’ hard work on the proposal. Of particular interest, Lad Curtis of MicroSat Systems immediately started mentoring Pilinski (the student proposal writer) on the top-level science requirements and program management setup. This early work proved invaluable, as it set distinct goals and management techniques that created a strong foundation and mission statement before the design team was established.

The DANDE student design team first met in January of 2007. It consisted of a dozen students, most of whom were graduate students with a wide latitude of experience working on satellites. The DANDE management team created a ‘Personnel Budget’ that identified strengths and capabilities within the student team, to identify areas where help was needed. The task for the team was to develop requirements at the system and subsystem levels. The team was made aware of the mentors who were available to the project and their capabilities and interests they had with the project. As a result, a series of trade studies were performed to help simplify the design and make use of available resources. General concepts such as the spacecraft spherical shape, system architecture, ground communication, and separation systems were discussed and studied to ensure the requirements were met with the simplest design. In addition, the distinct mission objectives and rules implemented by the AFRL allowed for quick resolution and the ability to start design work by the summer of 2007. The involvement of industry mentors at this stage helped the DANDE system to be scoped to the minimum level of complexity necessary to meet the mission requirements before the design work began. If this mission scaling had occurred several months later (say fall of 2007), it could have resulted in loss of resources and could have caused lost work and student frustration.

The DANDE management and COSGC staff used a few additional practices to retain mentors over the remainder of the project. The ‘Personnel Budget’ and the ‘Mentor Tracking Document’ were combined to identify gaps in the student talent and to highlight mentorship expertise. The management team worked throughout the spring and summer to ensure that by the preliminary design review, every subsystem would have a mentor. The ‘Personnel / Mentor Budget’ was also enhanced to log subsystem contact with their respective mentors on a monthly basis to identify stagnant student-mentor relationships.

The mentors brought into the project were found through specific connections from students, staff, and by introducing DANDE’s needs to local corporations. The majority of mentors who have been a part of the DANDE project over the last year and a half had prior establishments with COSGC. However, some students have developed mentor relationships through their own connections, which the team has embraced. Currently, the team has 20 industry mentors who are in contact with DANDE team members on average of once per month. Although all of the DANDE mentors are in technical fields, many provide facilities and/or knowledge on personal time and are not directly endorsed by their affiliated organization. Table 1 displays a list of mentors who are regularly involved on the DANDE project. Note that each subsystem is paired with a mentor and that a large number of mentors are providing support on their own personal time.

Table 1: List of Mentors Working with the DANDE Team

<table>
<thead>
<tr>
<th>Mentor</th>
<th>Expertise</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jasenko Alagic</td>
<td>Electrical Engineer</td>
<td>**Ball Aerospace</td>
</tr>
<tr>
<td>Paul Anderson</td>
<td>Management / Electrical</td>
<td>**Lockheed Martin</td>
</tr>
<tr>
<td>Bruce Bowman</td>
<td>Neutral Density Research</td>
<td>Air Force Space Command, Researcher</td>
</tr>
<tr>
<td>Poti Doukas</td>
<td>Structural Analysis Engineer</td>
<td>**InStar Engineering and Consulting</td>
</tr>
<tr>
<td>Tim Flaherty</td>
<td>Machinist</td>
<td>**Lab for Atmospheric and Space Physics (CU)</td>
</tr>
<tr>
<td>*Jeff Forbes</td>
<td>Neutral Density Research</td>
<td>Professor, CU Dept of Aerospace Eng Science</td>
</tr>
<tr>
<td>Dan Hall</td>
<td>Antenna / Com Engineer</td>
<td>FIRST RF Corporation</td>
</tr>
<tr>
<td>Bryan Helgesen</td>
<td>Release Mechanism Engineer</td>
<td>Space Dev Inc (Starsys)</td>
</tr>
<tr>
<td>Fred Herrero</td>
<td>Neutral Mass Instrumentation</td>
<td>NASA Goddard Space Flight Center</td>
</tr>
<tr>
<td>Tim Holden</td>
<td>Attitude Control Engineer</td>
<td>**Ball Aerospace</td>
</tr>
<tr>
<td>AJ Hoyt</td>
<td>Release Mechanism Engineer</td>
<td>Space Dev Inc (Starsys)</td>
</tr>
<tr>
<td>Keith Kelly</td>
<td>Antenna / Com Engineer</td>
<td>FIRST RF Corporation</td>
</tr>
</tbody>
</table>
There are additional mentors, not on this list who have been available to the team intermittently throughout the project development. For example, a long-term relationship exists between Ball Aerospace and COSGC. In March of 2007, Ball invited students to perform a two-day vibration test on their engineering design unit. Leading up to and during the test, several Ball engineers, management and test conductors made themselves available to work on the vibration procedure and test methodology.

**The DANDE / SpaceDev relationship**

Perhaps the greatest example of the impact of corporate mentorship on the DANDE project can be seen in the relationship between the separation team and SpaceDev. The COSGC staff first approached the company’s management during the SmallSat conference in August of 2006. It has since played a major role in both the development of DANDE’s separation system, and in the supply of hardware.

SpaceDev, a firm that develops aerospace mechanisms formally started working with the DANDE team in early 2007. Several SpaceDev engineers met with the student team on a regular basis. Initial efforts focused on systems requirements review, with subsequent collaboration on the system architecture. Over a substantial period of time, the combined student/SpaceDev team performed a thorough evaluation of mission requirements relative to the separation system, including launch environments and induced loads on the separation interface, required joint stiffness, orbital environments, life cycles, reliability of release, accessibility and ease of use.

Performing detailed requirements reviews and establishing trade studies early in the spacecraft design process resulted in an optimized separation system and satellite configuration. Upon careful review, the team baselined the SpaceDev LSRM-5000 (Low Shock Release Mechanism) based on demonstrated performance and inherent ability to satisfy all mission requirements. SpaceDev mechanisms engineers collaborated with the student team and reviewed initial concepts for integrating the LSRM with DANDE, including the sizing of and material suggestions for kinematic mounts used to position DANDE relative to the spacecraft/launch vehicle separation plane and to react externally-applied transverse loads. Expanding on the base concepts, the students developed new ideas of their own and brought them back to SpaceDev in increasing levels of detail for consultation and input. SpaceDev engineers validated some of the new concepts and countered with new suggestions each time. This collaboration between SpaceDev’s experience and the students’ analytical skills contributed to a rapid convergence on a concept separation system that satisfied stiffness constraints, could be constructed within their budget and minimized weight while creating a minimal impact on the satellite’s outer profile which is critical to this scientific mission.

SpaceDev’s involvement continued throughout the satellite prototype phase by loaning hardware and providing engineering test support. The student team was loaned two flight-like, fully-functional LSRM units that were subsequently used to support a variety of independent tests to validate the satellite structure sub-system. These included multiple release tests, random vibration and sine bursts to qualification levels, post-vibration release tests, and separation tests in microgravity.

**Additional DANDE / industry mentors**

A few of the DANDE/mentor relationships are profiled below to illustrate the different levels of involvement and how they are linked to the project. These summaries identify the mentor’s background, previous relationship with COSGC and how they became involved in the project.
Figure 3: Mentors assisting the DANDE student team. From top left: Poti Doukas, Dan Hall, James McDonald and Tim Flaherty

Poti Doukas is a structural engineer working for Instar Engineering and Consulting, Inc.. He was originally contacted by COSGC staff and has been a mentor of the team since May of 2006. Poti has met with the team several times to discuss structural design, analysis techniques and has significantly shaped DANDE into its current design. He was also able to advise the systems engineering team prior to the PDR and CDR reviews, helping to professionalize the review documentation and presentation.

Tim Flaherty is a machinist at the Laboratory for Atmospheric and Space Physics. Tim was approached directly by a member of the DANDE team whom he mentored on his own time in spring of 2007. Tim also mentors a local group of high school students competing in the First Robotics program and has offered use of the machine shop during his First Robotics mentoring sessions. He has clarified details relating to tolerance specifications on drawings and helped assemble the DANDE engineering unit. In addition, Tim has taken the structures team in for two consecutive weekends to formally teach technique on the CNC machine and, in the process, built one of the parts for the DANDE engineering design units. The team is in contact with Tim on a weekly basis to discuss anything from tolerances, to the ordering of proper tools.

Farzin Lalezari is the CEO of FIRST RF Corporation of Boulder, a company specializing in antenna design and communications. Farzin was contacted directly by a member of the DANDE team. He responded: “when you’re ready, come on over.” and offered his RF test chambers to evaluate DANDE’s antennas. Upon testing, the team found the results to be below expected levels. Farzin and several of his employees have since been working with the team to improve the spherical antenna design. The team has performed more than 4 half-day tests at the corporation. During these tests several engineers were assigned to help to help install and tune the antennas on the spacecraft. In December of 2007, several FIRST RF antenna design engineers participated in a 4-hour design review at the University of Colorado to finalize the revised antenna design.

Tim Holden is an employee of Ball Aerospace Corporation who specializes in attitude design and control design. As a former student of the University of Colorado, Tim designed the attitude control system of the SNOE student satellite, a non-COSGC related project at the university that was launched in 1998. The DANDE attitude control system has similarities to SNOE, and since joining the project as a mentor, he has played a large role in helping the team improve the system, write requirements and define helpful tests. Tim has been present at the student practice reviews and is a go-to mentor for a variety of different questions.

Jennifer Young is a spacecraft thermal engineer at the Laboratory for Atmospheric and Space Physics (LASP), and a former COSGC student. She was approached by a DANDE team member, and upon hearing of the team’s challenges offered to mentor on her own time. She first met with the team for lunch and discussed methods for designing a thermal system using Thermal Desktop software. She has since played an active role as a mentor having meetings with the DANDE thermal team, giving software pointers and at times uploading software files to her own computer to validate student work.

DANDE project performance

The DANDE team has greatly benefited from professional support. The overall performance and confidence of the students is high and many of them have opened their minds to careers in the space industry. As a result, the team is a small cohesive group with the determination to perform well and to seek help when necessary.

Successful projects at COSGC are typically attributed to effective mentorship. DANDE is one such project. The DANDE project has reached beyond the typical senior and graduate level project because of the integrated mentorship and buy-in from aerospace companies, faculty, and government labs initiated at the beginning of the project. The DANDE team has become a role model for other projects within COSGC. As a result, many DANDE team members are mentoring younger students engaged in space projects such as BalloonSat, RocketSat and CubeSat.
BENEFITS OF MENTORSHIP

Benefits to students

The most tangible benefit of mentorship to students is access to an expert in exactly what they’re working on. But there are a number of other benefits as well:

- **Exposure to real world practices and techniques.** Perhaps the most important aspect of student-run projects is the practical experience gained from working on real aerospace missions. This experience is only enhanced by doing things ‘by the book’ as explained by engineers who do the same things on a daily basis. This experiential knowledge can’t be taught in the classroom, and is extremely attractive to future employers.

- **Deliverables keep projects moving.** Students often need structure to get things done. Exposing them to standard project management practices such as timelines, milestones, and deliverables will not only keep their project on-schedule, but also give them a taste of how things work in the industry -- another attractive trait for potential employers.

- **Setting achievable goals.** Setting a realistic scope and achievable requirements is critical for any project faced with a limited budget or timeline. A frequent problem in student projects is biting off more than they can chew and setting unrealistic requirements (often added to the mission late in the design). This is purely due to a lack of experience, something most students have in common.

- **Increased motivation to pursue a space-related career.** Mentors have a large collection of stories about previous projects. These are both useful as engineering advice, and serve to excite students about working in the space industry. Good mentorship can make the difference between successful and unsuccessful missions. Students who are inspired by successful projects are more likely to work hard and pursue careers in the field.

- **Career Advice.** One of the roles of a good mentor is to provide information on the field they work in. Students have many questions about the industry that can best be answered by someone who has chosen that profession. This ‘advisor’ role is more personal than simply providing sound engineering advice.

Benefits to mentors

While the mentorship process is valuable to students through relationship building, drawing from corporate industry experience and exposure to real-world issues, there are obvious benefits to mentors and corporations as well. As Dan Baker wrote: “Hands-on experience is invaluable. No aerospace industry can afford to provide it to a beginning employee since present-day projects have no room for learning by trial and error.”

- **Exposure to potential future talent.** A fundamental foundation to successful mentoring is relationship. As such, mentors benefit from exposure to new, rising talent who can add significant value to an organization. Regrettably, college new-hires often bring little to no real-world, hands-on experience. It is a huge benefit to corporate employers to be introduced to graduates who have already been in the trenches, building and flying projects while guided and instructed by industry experts.

- **Opportunities for increasing product technology readiness.** In the case of DANDE, SpaceDev benefited from the increased technology readiness level of the LSRM product. While the student team was enabled with demonstrated, reliable, flight-like hardware, SpaceDev was able to leverage experience gained from the satellite test program. SpaceDev sees this as ultimately translating directly into increased product reliability and pedigree, customer confidence and higher sales.

- **Corporate Networking.** – Students love to talk about the work they are performing to their friends, family and other corporations. As a result, many of the mentor’s corporations are aware of the other involved parties and learn about their capabilities. Many of DANDE’s mentors meet each other at conferences and reviews, leading to possible future collaboration.

- **Increased company morale.** Students are an energized bunch who are highly motivated to learn. This is especially true when they are enabled to directly apply their creative talents and skills into tangible products. The concept of working on “extremely cool” projects such as spacecraft that will orbit a planet, monitor surrounding environments, and communicate data are highly motivating for future learning and growth.

This process can be rejuvenating for the participating company, as that energy flows to industry partners. There is also a significant level of satisfaction that comes from the opportunity for the mentor to share from and apply life experience and then witnessing first-hand the positive impacts on the student team.

**Use of the ‘Student Card’.** Students generally can use their student status to gain cost-effective access to facilities that may improve the technology level of corporate-sponsored hardware. For example, DANDE tested the SpaceDev LSRM mechanism through the NASA University Microgravity program. This provides
students the opportunity to work with experiments aboard NASA's 'Weightless Wonder,' a facility not easily available to many businesses.

Professional development. By teaching others, one gains a higher level of understanding of the subject matter. Mentorship is a good opportunity to put this into practice and to enhance the professional's ability to present his/her ideas to others.

LESSONS LEARNED
COSGC has developed some best practices for finding and keeping mentors for an organization.

Tips for students and institutions
Don’t abuse the resource. Respect each mentor’s schedule and avoid pressing for more time than they have available to give. It’s often best to have one person as the point of contact, to prevent the mentor from having to explain the same thing to multiple people.

Don’t starve your mentors of information. Don’t drop the ball on these relationships - keep them informed. Mentors get annoyed when they are only called when big problems emerge right before launch, especially when they could have made a difference much earlier. Periodically let your mentor sanity-check your work; what you don’t know can kill you. And if mentors are unneeded for an extended amount of time, try to keep in periodic touch with them via email updates, newsletters etc.

Do your homework. A mentor is not going to do your work for you, and generally doesn’t have time to bring you up to speed on the all the basics. Research your system extensively, and ask intelligent questions. Impress your mentor with your knowledge, and they’ll be happy to help you with the details.

Listen closely. Respect your mentor’s expertise, and if they’re emphatic about something, do it unless you have a very good reason not to. Some years ago, one of COSGC’s satellite subsystem teams asked a mentor how to condition a flight battery. The mentor gave them a full set of instructions. The students decided that was too much work, and skipped many of the steps. When the mentor found out, he withdrew from the advising role, saying, “why bother when I’m not going to be listened to?” He had a point.

Honest and open communications are key. Engineering is about the truth, even if that means saying “I don’t know” or “I screwed up.” Consistently following this rule will make it easier when something does go wrong.

Once COSGC students were working on a vendor-loaned part, when it seized up and sustained potential damage. Instead of exacerbrating the problem by delaying contact with the vendor, an immediate call produced an assessment of the cause and recommendations to keep it from happening again.

Involve mentors at the very beginning. It is important that mentors are involved with a team from the very beginning of a project. This ensures they are a part of the process, and ensures that they are available to help once the project begins. Mentors are particularly valuable during the mission definition phase of a project, and provide credibility to proposals.

Thank your mentors. It’s good form to do something to acknowledge and thank your mentor for their efforts. A signed letter or plaque from the team, taking them to lunch and letters to their boss, all go a long way to maintaining a healthy and rewarding relationship, and ensuring its continuation.

Schedule the initial meetings. Students may be shy about contacting professionals for help. It may be helpful to have someone in authority (faculty, staff, and student managers) schedule the initial meetings between the team and the mentors, to make sure the ball gets rolling.

Tips for mentors
Don’t be afraid to push your students. Students have many things competing for their attention, and they may drop the ball. Establishing fixed meeting times, creating agendas, assigning tasks, and following up on commitments will often do wonders for a floundering student team, and establish good habits for later employment. Don’t be afraid to hold students accountable. Some of COSGC’s best mentors have stepped in, rolled up their sleeves, and run their sessions with a firm hand.

Honest and open communications are key. It’s natural to want to praise students for their effort, but if a design appears risky, make sure the students are aware of that, and why. Point out possible alternatives, but let the students find their own solutions.

Give the big picture. Every mission has over-arching goals and objectives, which may not be evident to those working at the component level. A student working on a part will get more out of the experience if they understand how that part fits into the whole system. In industry, the whole system may include such things as Q/A, human resources, marketing, etc. Students need to ask themselves, “Is this good for the company?” when making decisions.
Help cultivate character. Mentoring is far more than honing technical skills. Factors vital to success in life, including one’s career and value to future employers, include truthfulness, self-discipline, hard work, and working well as part of a team.

Advice for finding mentors

It’s one thing to approach a company’s management and ask for money; it’s another thing to approach a company and ask for expertise. Finding mentors does not have to be difficult; below are some suggestions that have worked well for COSGC.

Network, network, network. People say all the time, “It’s a small world.” In the world of small satellites, this is definitely true. Typically, one can find a connection to a company or person in the area their project needs help with by reviewing all the people they know or have networked with before. Utilize this network to expand it and reach into areas not currently involved with your program or students. Attend events like The Small Satellite Conference to extend this network.

Make contact and meet. Ask existing contacts for names of people that might be interested in helping students or have a special skill that you need. Pick up the phone and call. Arrange a meeting to tell them about what your students are trying to do. Bring students to that meeting. Share the benefits the mentors will have on the students, their company, and the community. Remember, you are not asking for money and you are not asking for something that has no return to the company. Schedule the next meeting before you end the first meeting.

Go to the top. Meet with upper management when the opportunity becomes available. CEOs and vice presidents can help spread the word through the company and help you find those genuinely interested in giving back to the next generation. Prepare for this meeting by researching what the company or organization is doing and how your students can compliment what they are trying to accomplish.

Practice good communication. Provide regular updates to those that you have met with to let them know how the mentoring is going and get feedback from them. Present new needs and ask if they know anyone that could help.

Never give up. Don’t be afraid to ask for help. No matter how small or how big the request, if you don’t ask, you won’t know the answer. And no matter what, don’t give up or stop trying. They will come, and over time you will have a network of mentors and industry friends that will help your students flourish and programs be successful.

CONCLUSION

The Colorado Space Grant Consortium over the last twenty years has used mentorship to help students succeed on challenging projects. In the process, many lessons have been learned for how to establish mentors early within a project and how to retain contact over the course of the mission. Simple things such as ‘buying-in’ the mentors during the proposal stage, maintaining strong contact on a regular basis and being well-prepared prior to meetings are just a few of the techniques which can improve the relationship and benefits to the mentor and students. DANDE, a current project at the Colorado Space Grant Consortium has used these techniques over the course of the last year and a half and has found success. The team has a high level of morale and confidence with their work and a clear understanding of professional practices within industry.

Industry involvement in college education is a clear win-win situation for students, mentors and corporations. However this is also a win for the NASA workforce and other technical fields in that mentorship provides college graduates with hands-on experience for low cost. NASA budgetary tends have shown a gradual decrease in educational spending as work on the Vision for Space Exploration accelerates. The result of this shift has caused a variety of educational programs to be scaled back, allowing for less interaction between students and NASA engineers. Industry mentorship can restore this shortfall without the need for additional government funds. Industry can increase the effectiveness of existing programs by mentoring students and mold them into an experienced, focused and inspired generation.
AUTHOR / INSTITUTION BIOGRAPHIES

SpaceDev Corporation

SpaceDev is an entrepreneurial space systems company that develops high performance, innovative components and systems that are changing how we get to, explore, and use space. SpaceDev’s products range from spacecraft actuators that power the Mars rovers, to hybrid rocket technologies that powered the first commercial astronaut to space, to microsatellites controlled by the internet to Dream Chaser™, a winged and piloted orbital commercial spacecraft.

Senior engineer and business manager Bryan Helgesen has a passion for mentorship and entrepreneurship, and along with other heritage Starsys engineers and leaders, has developed long-standing relationship with COSGC and the University of Colorado. This relationship has materialized and grown through various opportunities including summer internships, new technology development via Small Business Technology Transfer Programs, and providing precision space mechanisms for university flight spacecraft and instruments.

Colorado Space Grant Consortium (COSGC)

The Colorado Space Grant Consortium is a state-wide program that provides Colorado students access to space through innovative courses, real-world hands-on satellite programs, and interactive outreach programs. The COSGC is funded by NASA as part of National Space Grant Program. The COSGC involves 13 colleges, universities and institutions around Colorado, directly involving more than 200 college and university students, and reaching hundreds of students and teachers each month through public outreach programs.

A former COSGC student, Chris Koehler has been director of the COSGC since 2005. He also serves as Chair of the National Council of Space Grant Directors, and Chair of the Executive Board for the National Space Grant College and Fellowship Program.

Bruce Davis and Mike Grusin are graduate students in Aerospace Engineering Sciences at the University of Colorado. Both hold leadership positions on the DANDE satellite project, and value the relationships they have formed with their mentors.

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1. NASA Office of Education Mission Statements, http:\education.nasa.gov\about\vision
2. Data taken from NASA FY08 Budget Request and the FY04 Budget Reports