The Skybox Satellite Operator Intern Program - Benefits and Lessons Learned

Emma Lehman, Mark Longanbach
Skybox Imaging
1049 Terra Bella Ave, Mountain View, CA; (603) 496-3597
emmalehman@google.com; longanbach@google.com

ABSTRACT

The Skybox Flight Operator program trains rotating cohorts of college students and recent graduates to fly our constellation of microsatellites. This program has provided significant benefits for Skybox Flight Operations. First, it attracts highly motivated, energized people, who are interested in the many short-term growth opportunities offered by the role, but who may not be interested in a shift-based role with few long-term growth options. Staffing well skilled and enthusiastic individuals allows us to quickly adapt to changes in mission needs; this agility is crucial to a rapidly evolving flight operations system. Second, the recurring training for each cohort keeps other engineering teams engaged, catalyzing interactions and improving the knowledge and abilities of our team. Third, the program has brought a stream of talent into our company, creating a pipeline of full time employment candidates that already understand our satellite fleet. We believe that our program has maintained the health and safety of our satellites, while providing valuable skills and experience to the program participants. In this paper we explain these benefits, and examine the lessons we have learned after two years of running this evolving program.

HISTORICAL OPERATIONS STAFFING

The staffing needs for a satellite operations center is determined by a number of factors, such as system complexity, number of satellites, level of automation, mission scope and stability, and budget and risk tolerance. A system requiring 24x7 support typically has a large team supporting the on-orbit assets. One subset of this support group are the satellite controllers, "SatCons", who are directly commanding and monitoring the satellites. These personnel serve as the the "front line"; monitoring the health and safety of the satellite, executing commands and activities as directed, and escalating anomalies as they are observed.

For government missions, military personnel are often required to have years of experience before being given any significant satellite-related responsibilities. Large commercial entities are equally selective on their minimum years of experience requirement. It is common for commercial centers to have a workforce that largely comprises former military personnel; their attention to detail, situational awareness, procedural discipline and respect for hierarchy makes them ideal candidates to operate high value assets. With this ex-military workforce pool available, in many operations centers junior satellite controllers may already have several years of experience, and senior satellite controllers may have decades of experience. For operations centers that have stable missions, these personnel may be working on the same bus type, with the same mission cadence, for many consecutive years.

Alternative staffing paths *do* exist. Some academic programs, such as the one fostered by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado in Boulder, educate and train Satellite Controllers while they are undergraduate and graduate students, with the support and supervision of faculty and staff.[1] These personnel are primarily focused on operating space instruments, but the mission operations skill sets and training provided are similar, albeit brief, compared to commercial counterparts.

Skybox is constrained by a constantly changing and evolving system and the need to maintain a flexible workforce, and enabled by our homegrown command and control system, which is designed to be simple and robust to fly. Thus the model we selected is much more similar to LASP academia than a military-style program, balancing operational risk with staffing flexibility and efficiency.

PROGRAM BACKGROUND

Skybox Imaging produces Earth imagery and analytics, with the goal of "Indexing the Earth" by extracting information about daily activity around the globe. To achieve this mission, Skybox designs, builds, and operates spacecraft that take imagery of Earth, and develops software that processes those pictures to automatically extract information.

The Flight Operations team at Skybox is responsible for commissioning our satellites after launch and keeping them healthy, robust, and productive throughout their lifetimes. To achieve this mission, we staff our operations center 24x7 with two Satellite Controllers (SatCons) who are responsible for monitoring telemetry, responding to anomalies, and executing maintenance procedures and calibrations.

To staff our team of SatCons, we developed an intern program that draws from aerospace undergraduate and graduate programs at local universities. Our first class of nine student interns began flying our satellite fleet in December 2013, right after the launch of our first satellite. Since then, we have recruited and trained two more SatCon cohorts. To date, a total of 16 personnel have participated in this intern program.

Skybox has launched two satellites, SkySat-1 in November 2013 and SkySat-2 in July 2014. Both satellites are operated in Skybox's Mission Operations Center ("MOC"), which has been staffed 24x7 continuously for over 1.5 years, with the majority of shifts filled by our SatCon interns.

PROGRAM OBJECTIVES

Minimize Operational Risk
The overarching goal of an effective flight operations group is to minimize operational risk while flying a fleet of satellites. We wanted our program risk tolerance to be comparable to the risk of a fully staffed, traditional center. Our low resulting risk profile has been achieved by a thorough certification program, rigid procedure and escalation workflow, and robust satellite design.

Attract the Right People
Traditionally, satellite controller positions are often found to be unattractive to high achievers because the role can be monotonous and lacking potential for long-term growth. With a fixed term-position that offers substantial short-term personal growth opportunities, we sought to attract people who have the technical skills and enthusiasm to improve our system. These development skills are critical to a new, rapidly changing system.

Increase Agility and Adaptability of Flight Operations
The flight operations team at Skybox is responsible for writing, testing, and executing all satellite operations procedures, including those for commissioning, anomaly response, calibration, and nominal operations. This can be challenging because our satellite constellation and ground system is continually expanding and evolving. As our system changes, our flight operations must adapt as well. We sought for our program to attract the types of Satellite Controllers that are capable of assisting the build out of our system, and excited to solve problems as they materialize.

Increase Staffing Flexibility
Our staffing needs fluctuate as we grow our constellation and develop our ground system. During commissioning periods directly after launches, we need increased levels of staffing in the MOC. However, as we enter nominal operations, we can revert to a lean, bare bones staffing for 24x7 operations. As our ground system evolves, the amount of manual work SatCons are required to do decreases. But as we add new technology to future generations of satellites, we may need more operations support. Our training program allows us to increase support quickly by bringing on new cohorts, and also scale back staffing as needs decrease without needing to reassign full-time employees.

Provide Valuable Experience
We desire to jump-start the aerospace careers of recent graduates by giving them a comprehensive education in satellites and satellite operations in the real world. After spending two years at Skybox, program participants will have gained all the skills and knowledge necessary to contribute to flight operations programs anywhere in the world.

Table 1: Skills gained through Skybox intern program

Aerospace Specific	Broad Industry
• Extensive knowledge of satellite mechanical subsystems • Extensive knowledge of satellite flight software subsystems • Understanding of orbits and orbital dynamics • Understanding of the space environment	• Intermediate proficiency in Python programming language • Create, test, and execute complex procedures • Project management skills • Communication skills • Troubleshooting skills

PROGRAM DESIGN

Target Participants

The program targets people who are new to the aerospace industry, and possess a bachelors or masters degree in aerospace engineering or a related field. Our current team includes mechanical engineering, electrical engineering, computer science, and physics students as well as aeronautics and astronautics students. The ideal participant comes to Skybox looking for a broad education on how satellites are designed and operated. Participants have an interest in learning not only about satellites, but also about the ground network and command and control software. They have some programming skills and can learn new skills and systems quickly. They are looking to get their hands dirty - finding and fixing problems the see in our system as well as operating our satellites.

Cadence

We staff our operations center with 2 SatCons, 24 hours a day, using 12 hour shifts. Each cohort works in our operations center for 2 years, and we aim to hire a cohort of 4 operators each year, giving us a total of 8 full-time operators. There is a three month overlap of incoming and outgoing cohorts to accommodate training and program attrition. Cohorts with students only would require additional, or larger, cohorts to staff a full time schedule. Two years was selected as the appropriate minimum time necessary to recoup investment into training a new employee, while also maintaining the enthusiasm level and productivity throughout the time frame. This cadence leads to several configurations:

1. An undergraduate senior can start in the intern program, graduate midway through, and then complete a year of work in his professional career.
2. A postgraduate degree can be started in concurrence with the intern program, with graduation timed alongside the completion of the program.
3. A new graduate can start the intern program, leaving after two years with a solid base skill set for a variety of careers.

There are many different shift schedule configurations that work with this cohort style. Skybox's preferred shift schedule is 12 hour shifts, with an ideal 2 - 3 - 2 configuration (every other weekend off), combined with a several nights in a row followed by a week off. However, the use of students has heavily skewed this configuration, as the schedule is rotated aggressively to accommodate student working hours.

Program Schedule

The schedule for a two-year program is shown in Table 2. Personnel enter certain phases at different times, but all personnel progress through this general schedule framework.

Table 2:   Program Schedule

Aerospace Specific	Broad Industry
-3 - 0 Months	Sourcing & Selection
0-2 Months	Training & SatCon Certification
3 Months	Oldest cohort completes their term and exits
6 Months	Role growth and learning; preparing for shift lead certification
9 Months	Shift Lead Certification
12 Months	Continue Proficiency Growth • Develop year career plan • Support cross functional projects & training • Select capstone project
21 Months	Prepare Continued Excellence • Complete capstone project • Communicate remainder of timeline • Communicate offboarding opportunities • Establish training plans for new personnel
23 Months	Home Stretch • Support external or internal placement • Final review to ensure all projects and work are either completed or handed off • Final review of career plan

Training and Certification

Over the last two years, Skybox has developed a thorough and extensive training and certification program for our SatCons. This training combines classroom training, independent study, and hands-on experience to teach new operators about the Skybox system. Training begins with three weeks of tutorials, individual work, and shadowing. Trainees attend a series of classes taught by satellite hardware and flight software engineers, ground software engineers, ground system engineers, and company leadership. Each class is geared towards the instructor's area of expertise, focusing on the operational perspective.

Along with classes, trainees spend a significant amount of time in the MOC observing shifts and watching SatCons as they perform their duties. Trainees are then inserted into shifts to formally shadow SatCons. Throughout this phase, trainees complete a broad, self-paced set of exercises that range from general questions about our system, to code development, to full simulation rehearsals and procedure walkthroughs.

Once the initial round of training is complete, trainees go through an intensive 1-on-1 certification before being allowed on-console without supervision.

After several months of on-console support, an additional certification workflow begins for an intern to become the lead of a shift. This certification has a similar methodology to the original SatCon certification, but with greater technical and leadership requirements. The lead certification covers more extensive scenarios involving tough operational decisions, anomaly responses, and escalation workflows; all areas critical to making command decisions on our satellite fleet in real-time.

With each cohort, we ask for feedback and improve on the training program design. To date, we have successfully trained and certified three cohorts of SatCons using this training structure.

Development and Off-Console Projects

All SatCons are encouraged to improve our processes, tackle problems, and take on individual projects. This is defined as development work, which can either be worked on concurrently on a shift, or during off-console time, which is any time an employee is not working "on-console" in the MOC. SatCons can work on any small project or problem, with appropriate review by a member of our Flight Ops Engineer team.

All projects worked on by our SatCon workforce must have a high impact towards significantly improve the efficiency of our current operations, or servicing the next generation of our satellites. These projects are supervised by full time personnel, but are largely spearheaded by the SatCon personnel. Having a queue of projects is especially helpful to capitalize on the opportunity for student personnel to work full time over their summers, in which case a hybrid blend of both on-console and project work can be maintained.

PROGRAM OUTCOME

Excellent System Uptime and Operational Risk Posture

To date, Skybox's system uptime matches or exceeds commercial standards for the satellite imagery industry. Our uptime performance results are a combination of a robust satellite design, quick response times to anomalies observed, and the proficiency of our SatCon personnel to identify, escalate, and recover from issues.

Increased Proficiency in our Flight Operations Team

Our program has increased the overall proficiency across our flight operations and SatCon team. The yearly training the satellite controllers go through is a good refresher for our entire team, and forces us to update our institutional material and documentation, capturing off-hand knowledge accrued within the team. In addition, it enforces interaction between flight ops and other teams as Skybox spacecraft engineering experts teach the operators about their subsystem. This interaction fosters relationships between the teams that leads to better communication of issues, improvements to the satellite and ground system, and an overall more operations-friendly constellation.

Strong Recruiting Pipeline

In the initial two rounds of student-only hiring, we received approximately 10 resumes for every opening. These came from explicitly targeting a few select schools; nearly all resumes met the majority of the minimum requirements prior to the selection process.

In the last round of hiring for this program, which also included new graduates and was marketed as a strict fixed-term program, we received approximately 25 qualified resumes for every opening. We continue to receive interested candidates and references outside of our hiring periods, and expect to see stronger showings as we expand our hiring pipeline to new schools.

SUMMARY AND LESSONS LEARNED
We continues to iterate on our flight operations program at Skybox, and we have learned a large number of lessons along the way:

Cohort Experience Composition
It is better to maintain either an all student, or all new graduate, group of personnel. A mix of students, who can only work 1-2 shifts per week, and graduates, who can work a full 40 hour week, can lead to rapidly diverging levels of training, proficiency, and skills amongst cohorts. To ensure a standardized training and onboarding process, and avoid scheduling overhead, cohorts should consist of either all students or all new graduates.

Balancing School and Work
It is best to enforce a firm policy to establish sufficient rest breaks between work and school (i.e. a student cannot attend school all day and then work a night shift). Students and new graduates are excited to work many hours and test their limits. While all-nighters can be a common practice in school, they are not acceptable for satellite operations.

Sick Time
The student and new graduate workforces utilize a significantly small amount of sick time compared to average employees, which allows for a leaner schedule. However, it is important to account for a sick time margin, and have processes in place for when people call in sick. Otherwise, covering these missed shifts is often difficult for the other team members.

Shift Frequency
A minimum individual frequency for MOC shifts must be maintained, or the total proficiency of the team will not reach sustainable levels. If the proficiency is too low due to students working sporadic shifts, other members of the organization (flight operations engineers, satellite engineers) will be interrupted to help with anomaly recovery support or advice that a more experienced crew would have been able to handle. At Skybox, we enforce that our SatCons go no longer than 2 weeks without working in the MOC before performing remedial training or shadowing.

Company Communication
Email and phone communication from the MOC will reflect the experience level of the group. If the program is staffed with students who have spent minimal time in a professional environment, this can lead to poor communication, misunderstandings, and even the false illusion of incompetence. To mitigate this, always ensure a newly certificated controller is paired with a well tenured shift lead, and provide templates and example emails for SatCons to use when communicating to a wide audience.

Scheduling
An all student SatCon crew leads to unpredictable swings in student scheduling, especially surrounding mid-terms and finals. This requires hiring, training, and staffing at a level to ensure full coverage is provided with minimal attendance. Care must be used to ensure the team has the flexibility to work more hours when they become available, or to be clear with the student SatCons on the minimum availability requirement for the year.

CONCLUSION
Skybox has been able to run a successful and robust 24x7 flight operations center using a staffing structure that would traditionally be seen as overly aggressive or risky. This effort has been successful due to our thorough certification program, sourcing and hiring the appropriate personnel for an agile operations environment, and constant drive to reduce operational risk.

References
1. *CU Students at LASP.* (2015). Retrieved from http://lasp.colorado.edu/home/about/cu-students-at-lasp/