



BLADE: The Balloon Launch Assessment Directive for Engineers

and the Use of the CubeSat Form Factor for an Introductory Systems Engineering Education



Jacob A. Harbuck, Michael L. Pham, Zachary E. Gaines, Cal Poly Pomona - 2020

jaharbuck@cpp.edu , mlpham@cpp.edu , zegaines@cpp.edu

I. Abstract

The Balloon Launch Assessment Directive for Engineers (BLADE) acts as a hybrid ideas lab and skills development program for undergraduates at Cal Poly Pomona. This program, targeted primarily at incoming first year and transfer students, takes the participants from zero knowledge of the engineering design process and walks them through a simplified yet rigorous pathway. This pathway is based on established Systems Engineering processes and is deployed by having students design a mock Cube Satellite with a unique scientific payload for flight in a high-altitude balloon. This program not only brings together a hands-on approach to merging good engineering processes with conducting new and innovative scientific research, but also illustrates the value of the systems engineering process to mission success for engineering students that would otherwise not be exposed to its principles until the graduate level.

By constraining student designs to the 1U CubeSat form factor, it is intended that experiences gained by students taking part in this program may be directly applied to designs for fully-fledged orbital CubeSat missions the university is undertaking. This process is intended to allow for a foundational pathway into space mission development at the undergraduate level at significantly lower programmatic and technical costs.

II. Background Information

Due to the newness of Bronco Space and the limited experience of its members, a cost-conscious, low-risk way for developing skills and experience for new members in system development and design for a CubeSat was needed. If new members were able to develop skills and experience before joining one of Bronco Space's main CubeSat projects, they would be better prepared to work on the project. Based on their experience, the CubeSat, in theory, would be designed better and faster than if they joined with limited experience.

Following the Cal Poly Pomona motto, "Learn By Doing", Bronco Space decided the best way to meet this need was for new Bronco Space members to participate in a hand-on design competition project. BLADE was implemented based on this need and provided new members with experience in CubeSat design, developing scientific missions, and teamwork. Not only did BLADE help new members learn and develop skills, it also helped Bronco Space leadership to improve their leadership and teaching skills, as well as provide opportunities for everyone in the program to learn from failures and successes.

III. Specific Goals & Expected Outcomes

The goals and objectives of the 2019/2020 BLADE program were:

- Develop a platform for longevity and yearly replication of the program
- Maintain a low yearly cost (approximately \$1000 per launch) throughout the BLADE program
- Provide a learning opportunity for new members of Bronco Space
- Receive sponsorships and support from programs on campus and local companies
- Fly and test hardware expected to be flown on one of Bronco Space's future CubeSats

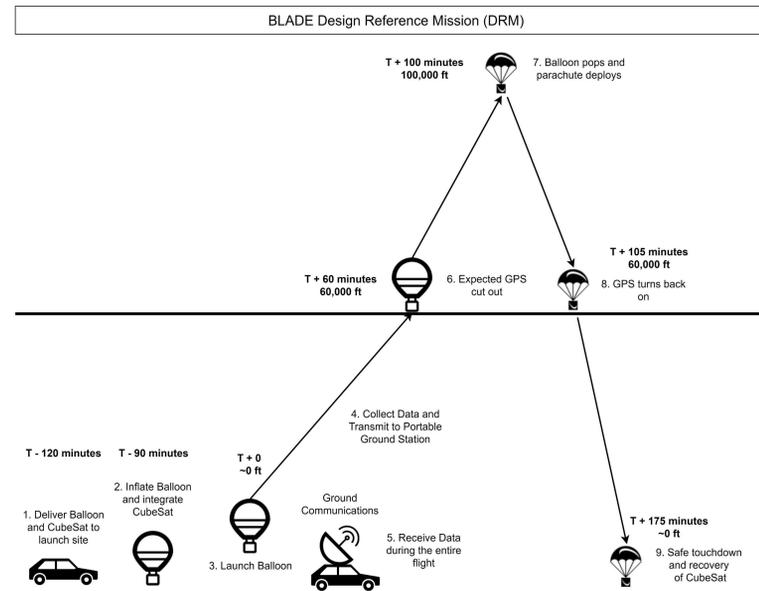
The expected outcomes of the BLADE program are:

- Students learn and improve important skills in engineering, research, and teamwork
- Students develop a familiarity with CubeSats and the CubeSat standard
- Students get excited about working on CubeSat related projects and continue to work on other Bronco Space projects
- Repeatable onboarding project for new members of Bronco Space
- Feedback from students allow Bronco Space leadership to improve the program

IV. Methodology

The needs, goals, and objectives were met through the creation over our BLADE program. The methods used to meet these objectives through BLADE were:

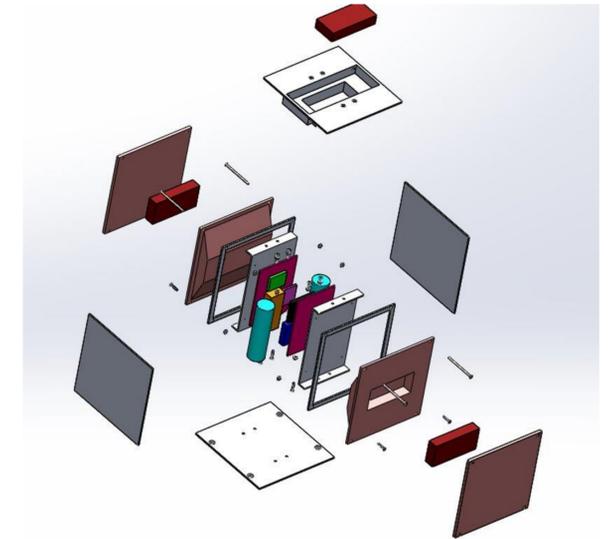
- A year long design competition consisting of teams of new student members of Bronco Space
- Teams choose their own mission and payload
- Each team goes through a simplified design process which includes system engineering, CAD, programming and testing
- Weekly hands-on workshops covering different topics in the design process
- Teams present their designs through three major design reviews throughout the Fall semester
- One team is selected to continue to the manufacturing phase after the last design review
- The selected team builds and tests their design in the first half of the Spring semester and launches by the end of March
- The selected team analyses their data from the flight
- Teams provide feedback throughout and after the project to help improve the program



V. General Results

The BLADE project was implemented in Fall 2019 with new members of Bronco Space. Through the Office of Academic Innovation at Cal Poly Pomona, \$8000 of funding was acquired for the BLADE project. Initially six teams with about five members each signed up with each team choosing their own leader from their group. The hardware selected to be tested was unavailable during the project. The curriculum was developed weekly, which led to a few problems with the aggressive timeline. This contributed to a change in the timeline which pushed back the preliminary design review to December and the critical design review to February. The workshops had to be removed after the first few weeks and were replaced with working meetings due to teams needing more one on one time with Bronco Space leadership to help them with their designs and to answer questions.

As the fall semester went by, a few of the teams dropped out due to various reasons. Two teams remained and presented their designs during the critical design review. The team EDALB was selected with their design to test radiation resisting materials. With the plan to use \$1000 per launch, \$500 was allocated to EDALB and \$500 was allocated towards the balloon. In the manufacturing and testing phase, our university transitioned online due to COVID-19. This pushed back the timeline until the university opens the campus again.



Exploded View of EDALB's CAD model

VI. Conclusions

Overall the BLADE program had a successful first year. The program met the need for a cost-conscious and low-risk way of developing skills and experience for new members of the club. Despite the issues, the leadership of Bronco Space adjusted and made changes to the program as needed to achieve the main goals. A team with the best design was selected to move forward into manufacturing, testing, and launching their design. Even though the first run through is still on-going due to COVID-19 preventing manufacturing and launching, enough feedback and lessons learned were acquired to continue developing and improving the BLADE program.

VII. Next Steps

The main lessons learned were:

- Develop the curriculum and design guides before the program begins
- Design the curriculum around learning and applying knowledge rather than accomplishing a task
- Plan weekly meetings or work sessions for each team to have one-on-one time with experienced members of the club
- Plan for schedule margin and changes
- Make sure teams are aware of the time commitment needed, especially the team leaders
- Invite professors and outside industry to look over the curriculum and attend design reviews and provide valuable feedback to the teams

These lessons and other feedback acquired during the first year of BLADE is currently being implemented in the new BLADE curriculum. New changes in the curriculum includes more detailed examples and explanations as well. The current plan is to have the Fall semester portion of the curriculum completed by early August and the Spring semester portion of the curriculum completed by January 2021.

One of the long-term goals with BLADE is to publish the curriculum for other universities to use. We are open to sharing the BLADE curriculum with other universities. We encourage other clubs to learn from the program for implementation in their own onboarding and skills development program.