The Progress of HAB Payloads

At Capitol Technology University, we use step by step motto for our balloon payload with the help from the Maryland Space Grant Consortium (MDSGC). The motto is Crawl, Walk, Run, and Fly. For Crawl, it is the birth of an idea and developing a mission. For Walk, we identify and integrate systems. Continuing by improving the flight simulation testbed and to ensure testing simulates the true mission. When it is time to Run, we start with the industry testing and the mission testing. This would benefit the students with becoming job ready and well-rounded students. The final step is to Fly. Which is to provide real-world STEM application and standardized engineering process. Crawl, Walk, Run, and Fly will help students and faculties with a pass to mission success, funding, environmental, and systems testing.

Crawling is the best name for the first step in starting on a HAB payload. Like babies, who love to crawl, they always are presented with a problem or a challenge. Giving them the birth of an idea. With the HAB projects, there will be goals and objectives for the mission from the idea. The mission will be developed by drawing models and getting the parts that are needed. After the Crawl stage, you will be motivated and better prepared to start the HAB project and begin the Walk stage.

Once someone has the idea, they'll never stop thinking and they keep moving as if they are walking in pace. The walking stage is where you will modeling and testing. First, you will need to make sure that the mission is cost-effective and environment-friendly. Then, continue improving the flight simulation ground test bed and ensure testing simulates the true mission when ground testing. Lastly, validating the idea by your colleagues and professors to sure that everything is going appropriately to the criteria before running the mission.

The running stage is where everyone starts to put pieces together on to the payload. After modeling and getting the basic testing out the way, you'll test the pieces with subsystem and with specific environments, like pressure and temperature. Once proper testing is done then, you'll need to get Technology readiness level (TRL) for future missions. Everyone is running around getting parts together, testing the industry methods and equipment before getting ready to fly.

Once every step and every part comes together, the big goal at the end is to see the payload flying into space. The flying stage is the last and most important stage. Other than seeing your idea launch into space, the payload will need to be complete and running efficiently with any problems it could occur. This will help you understand the standardized engineering process and provides real-world STEM application. The flying stage is where you take your idea to the test and begin the process of your research.

Through the Maryland Space Grant Consortium (MDSGC), our undergraduates have done multiple high-altitude balloon projects and evolved our capabilities with each. From lofting a camera four years ago, we've progressed to payloads including science, communications, and engineering. Starting with two payloads on November 2014, we've averaged two flights a year since. We find two advantages of our high-altitude programs. One, each design builds on the architecture of the previous, so our experimental capabilities are always improving. Second, HABs are an environment for sounding rockets and CubeSat payloads. For undergraduates, we feel that HABs are an essential part of any aerospace or astronautical program. We present best practices and a timeline of payloads in this poster.

TrapSat was a HAB take images and capture small debris in Low Earth Orbit (LEO). For this mission, they used aerogel to capture the debris particles. Aerogel is the lightest substance known to man. Normally, you can touch it and it shatters because it's extremely fragile, but they used silica aerogel, where when something with extreme velocity and force crashes into the aerogel, it completely stops the debris. You can see the streak of the debris and the stopped particle after on the gel.

Automated Position Reporting System (APRS) was a seniors project that flown on the balloon flight with the University of Maryland and had planned to be the backup communication for Hermes.

The idea was to use an APRS beacon which uses amateur radio frequencies to send information. A network of antennas are community driven around the nation, so APRS is used a lot with truckers, cars, and hikers so that family members can track them to sending small amounts of location data (location is the big thing) with a call sign. It will send pings of where you are and you can use it as long as you have an amateur radio license. The payload would collect data, process data into small packets to send the data through a small antenna to the APRS network then retrieve the information from the APRS system. Even though the mission was successful, there was no room for it on the RockSat flight.

HABScope was made during the Capitol Brazil program, which was when we worked with around 20 Brazilian exchange students. This was interesting because the idea was to attempt to use an infrared camera on a telescope to do infrared astronomy. You cannot do infrared astronomy from the ground because the atmosphere blocks the infrared light so the perfect use was to use it using a HAB. They were not sure that it was going to work because this was the first project that we did that used attitude stabilization with fans and grease bearings on the rope that would allow the payload to spin but not the rope, so they would eliminate any outside interference as possible because they needed stable shots for the mission. Unfortunately, due to the balloon launch being too heavy(more than 12 lbs is too heavy) and the ending of the Capitol Brazil program, the mission could not fly.

Cloud 360 also dealt with the capital Brazil program. The idea was to take PH readings and 360 videos during the duration of the flight. This was to take PH readings of the clouds because they wanted to test the difference on any day on any type of clouds. There are different types of clouds that absorb water, so they wanted to test the acidity of them. That mission flew up to five times. It successfully took 360-degree video of most of the flight. It was difficult to take video or use any type of electronics that high in the air because of the cold temperature, so they were able to take video for about 75 percent until the camera turned off. Luckily they took the advantage that it was summer time to take video because of the warmer weathers. The test took videos for about an hour and a half, where when in cold testing weathers it took about 15 minutes until the camera turned off.

The purpose for Hermes 3.0 was to test the iridium beacon module use in space because the idea was to use the beacon for communication and location using a complicated triangulation. The reason for using the Iridium for location because you cannot use GPS at high altitude because GPS modules would shut down at high altitude and it would turn off. Unless you have military grade or government grade GPS, it would assume that you were building a missile so it shuts off. , so we used the ranged data that iridium uses to give an idea of how you are from the CubeSat (Hermes 2.0). Given that if they knew the altitude of the satellite, they would be able to backtrack the range data into orbital ephemeris. The Hermes 3.0 balloon payload was behind schedule so the payload was rushed together last minute and on the day of the flight, they sent the payload up and they received 15 different data points then stopped at high altitudes. After a certain time, the tracking data did not align with the data from the balloon so they stopped receiving messages. At the landing site, they had found that the container had broken open so they had lost all flight hardware including the 360-degree camera and the iridium beacon module. Despite the failure, the mission was a success because they were able to use the BM at high altitudes and poor pointing conditions and they were to able to collect data while falling. This project allowed us the learn the value of good systems engineering and taking your time with good and complete testing. Even though they are high risk and low-cost missions, to have a bit of respect for them.

TrapSat Burn was they wanted to test nichrome to use it on the CubeSat mission CACTUS-1 to open up the payload. Nichrome wire is a strong filament wire that when exposed to voltage, it would burn and whatever you tie it with would open up. The TrapSat project was where the students wanted to test release burning in nichrome wire to open the hatch to expose aerogel. The flight itself took 10-15 minutes before the nichrome wire would burn. They were able to test this on the balloon flight and it was successful, but they decided not to use it on the RockSat flight

The HAB projects matter to the students because they are a hands-on experience of what you will learn for your career. If you're an AE major, you can learn to code; if you're an SE major, you can learn electrical. You will go outside of the 'bubble' of your major. Students from AE, CS, EE, SE and more from the STEM pathway can all design and build payloads. A student typically commits for a semester, 2-3 months, although some have gone quicker due to balloon deadlines. A typical team is 5-6 people, but 2 person teams have flown as well. As far as skills they need to learn, they don't need exact skills, as long as you're willing to be open to learning as the project progresses. Teamwork is essential. At the end of the project, most students go off to finish and graduate. Some will stay and evolve their project to fly on a Sounding Rocket (via the RockSat program), and two successful sounding rockets became the payloads for our first CubeSat (Cactus-1).

While the HAB balloon project is for everyone students will get the most benefits from this experience. The students will get a comprehensive STEM education that will help them get good hands-on experience. Since there will be professors, scientist, engineers, and other assistance, students will be able to maintain industry relations giving them stronger networking. Working on a multidisciplinary team will help the student improve on their teamwork and communication skills. HAB balloon is for anyone, so no matter the major or career, anyone can participate, but knowing this for the knowledge and experience is for the younger generation since they will help us move forward to a better future.