Elijah High Altitude Balloon Project Launch Team

Brandon Blatter, Ryan Erickson, Adam Harden, Dan Hawk, Eric Hoffman, and Chris Maramba

Members and Roles

Chris Maramba is fulfilling dual roles this year, acting as both the Launch Team's team leader and head of supply, logistics, and scheduling. Ryan Erickson is the Engineering Lead for the GPS project. Brandon Blatter is the Engineering Lead for the launch stand project and is also assisting the GPS project. Adam Harden is the team webmaster and is also on the launch stand project. Eric Hoffman is assisting with the GPS project. Dan Hawk is the Payload team liaison.

Equipment

Overview

The 2008 Launch Team will be using the StratoSat flight package developed by StratoStar Systems LLC. This package consists of the following components:

- Command "pod" with onboard GPS and data radio transmitter
- 3 payload "pods" with built-in wireless transmitter
- GPS tracking antenna
- 900 Mhz Module (model 9001)
- Serial Y-cable
- Scadata and Delorme Street Atlas 2008 software
- "Pod" battery chargers
- Parachute
- Various cabling and tethering

Figure 1: StratoSat system

The team will also have available weather balloons and the helium required to fill them. Hardware and software support for the StratoSat package is available through StratoSat Systems LLC. The StratoSat package is covered under a partial warranty covering electronic failure for a duration of two years or 10 launches, whichever happens first.

Balloons

The Elijah launch team recently purchased two weather balloons for use this summer. The team originally decided to use one 1500 gram balloon and one 3000 gram balloon. However, due to supplier shortages, the 1500 gram balloon was substituted with a 1200 gram balloon that should perform as needed. The 1200 gram balloon may be utilized in a tethered launch configuration, to be discussed below.

Under past discussion was the acquisition of helium for the balloon launches. It had been suggested that the MSOE machine shop may be able to supply the gas if enough notice is given and permission is obtained. Commercially, the helium can also be obtained from local welding companies or local party stores. Discussions with these companies concluded that a three day notice must be given to the firm in order to obtain the helium. The primary supplier for the balloon helium ended up to be Aero Compressed Gases, Inc., based out of West Allis, Wisconsin. The company supplies helium in 200 pound, 5 foot high tanks. Cost per tank was $167, and the company held credit card information until the tank was returned. Tanks were able to be picked up the same day of order and there was a delivery option for a cost of $20, plus a one day notice.

It had also been discussed that a positive usage of the team budget might involve purchasing helium tanks for the team. This would remove any issue with tank rental, provide a level of convenience when selecting launch dates by removing the ordering lead times (assuming the tanks are filled at the start of the "launch season"), and allow future teams to take advantage of these benefits. This option was considered, but the budget was not large enough. Research found that one helium tank of the necessary size cost more than $1,500.

Global Positioning System

To help assist our launch teams and future launch teams in tracking and retrieving the balloon payload successfully, we have decided to purchase two new GPS navigation systems for two chase vehicles. The two GPS navigation systems will have touch screens and turn by turn navigation to assist the driver in safely following directions given by the computer operator.

Our budget allowed for buying two way radio GPS units to assist with tracking the balloon once the team leaves the car to locate the balloon. The radios allow each team to send their GPS location to the other radio with the click of a button once the balloon is found.

To further assist the team in tracking the balloon, the team looked into mapping software that allows two GPS signals to be input into the computer. This allows the computer tracker to see the balloon's location on the screen as well as the vehicles location relative to the balloon. The current mapping software only allows one GPS signal, so only the location of the balloon can be tracked on the computer. The car then has to manually navigate with a separate GPS or map to track the balloon.

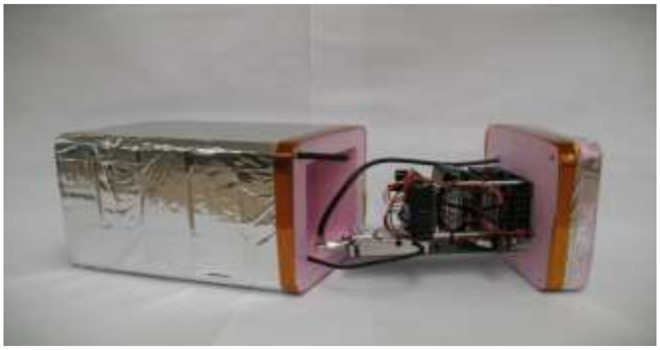

Figure 2: StratoSat Command Pod with Electronics

Command and Payload Pods

The core infrastructure of the Stratosat system is comprised of one Command Pod and three Payload Pods. Both the Command and Payload Pods are primarily composed of a hardened Styrofoam shell. A thin layer of foil covers the exterior of the Pods. Kaptop tape secures the otherwise removable top of the Pod to the body.

While the Command Pod is responsible for carrying the electronics that function a Global Positioning System unit, a wireless network, and a radio to transmit data back to the ground (see Figure 3), the Payload Pods carry relatively few electronics by default. Each Payload Pod is responsible for carrying a system of electronics that create a wireless data link between the Command Pod and itself. These electronics have room for multiple inputs, allowing the Pod to transmit experimental data back in real-time. The launch team only prepared one Payload Pod for flight on launch day.

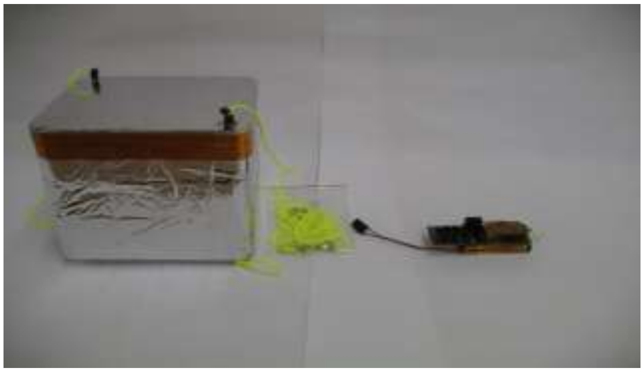

Figure 3: StratoSat Payload Pod and Electronics

Equipment Familiarization and Testing

Initial Power-Up

During one of our first meetings as a team, we decided to try out the StratoSat system in the school parking lot. Our goal was to see whether or not we could get two laptops to track the position of the control module and receive some real time data. We were able to install the map software and StratoStar's Scadata software without any problems. The following three hours were not as productive however. We proceeded to the parking lot to set up the ground station hardware in a car and power up the command module, which is when the real problems started.

Figure 4: StratoSat GPS and Data Receiver System

StratoStar sent a somewhat extensive manual with the complete flight system, with much of the focus on the actual launch procedure and somewhat lacking in the description of how to get the command module communicating with the laptops. We struggled for about an hour trying to establish a connection with the command module when we ended up contacting StratoStar and spoke with the designer of the system. The engineer was able to walk us through the configuration process of the Scadata and map software and some trouble shooting. We were able to establish a connection; however, it was obvious that we were receiving some bad packets of information. The engineer suggested that we cycle the power and try everything again which ended up as the solution to previous few hours of frustration with the flight system.

After cycling the power on the command module, we were able to communicate with the command module and even track its position as the command module was moved around the parking lot. All in all, it was a very good learning experience. We are very happy with the StratoSat flight package, but we found the documentation to be somewhat lacking. The three hours we spent that night setting that up could have been completed in all of five minutes. We were able to start to supplement the StratoSat manual with some of our own fixes and experiences to make it easier for teams in the future to setup the system.

Integrated Systems Test: Tethered Launch

The launch team planned a tethered launch of a balloon with accompanying payload. The goal of the launch was to simulate as closely as possible the preparation, launch checkout, and release of the StratoSat system, balloon, and payload as an integrated whole. Recovery was simplified by tethering a rope to the payload-balloon system, which was reeled in and out on a spool. The balloon reached the ideal height of a few hundred feet, and during the ascent the launch team gained a better understanding of how the balloon behaves before and during the ascent. The launch team utilized the smallest balloon in inventory for this event.

The payload team did not have a payload ready by the time this launch was conducted. Therefore, the launch team prepared a simple set of electronics that was used to transmit basic, patterned data from the command pod's transmitter. This allowed for the testing of all major facets of the Stratosat system: the onboard Global Positioning System, the wireless link from payload pod to command pod, and the transmitter which was responsible for sending all the data to the chase vehicles.

All necessary precautionary measures were taken to preserve all aspects of the launch for use on the actual launch day. This included the balloon to be used, as the working theory was that recovery and reuse of the balloon could be achieved by carefully handling the balloon and ensuring the balloon is filled properly.

The tethered launch was a success, as it helped the team realize all the equipment that was missing: the correct size nozzle to the helium tank and a car inverter to provide two outlets from a car lighter. The team also gained greater insight into all the steps involved for preparing the balloon and entire payload system. Flaws in the launch process were identified, analyzed, and rectified, and better estimates of the launch day timeline were developed. This allowed the launch team to determine the actual timeline to be used on launch day and understand the margins that existed with scheduling.

Launch Day Activities

Launch

The launch team decided on Saturday, August 10 for the day of the launch with the launch location being a local soccer field in Chippewa Falls, WI. The site was primarily chosen due to its western distance from Lake Michigan and its rural surroundings. Preparations were scheduled to being at the field by 5:30AM with the launch occurring as soon after that as feasible. An early launch time was decided on to keep winds to a minimum during the filling the balloon.

After arrival, the team began setting up the launch location while accompanying members of the payload team began preparing the payload. Of primary concern was the balloon filling, and so this was begun as quickly as possible.

The team had decided on a larger 3000 gram balloon the night before in order to under-fill the balloon and obtain a slower ascent rate, which would help the payload cameras obtain more photos. The filling process was smooth with no mechanical difficulties. However, the amount of time required to fill the balloon was under-estimated between one and two hours. The slow fill rate has been attributed to the use of a previously used helium tank (lower pressure results in slower flow rate) and possible leaks at the connection between the nozzle of the hose and the balloon. While every effort was made to minimize leakage on fill, it is probably a certain percentage of helium escaped and slowed the fill rate of the balloon.

Figure 5: Balloon Filling

During the filling process, the rest of the StratoStar equipment (command pod, parachute ring, connection tethers, etc.) was laid out and ultimately assembled. Command pod communications tests took place near the end of the balloon fill process and while the balloon was full, but before release of the hold-down tethers. Both these tests confirmed the GPS system was operational and transmitting valid location data. The payload team members also confirmed that the cameras and mechanical systems attached to the payload were operational and functioning as expected.

At approximately 8:00 AM, a final check of all balloon, recovery, and payload equipment was performed. Nothing was found out of order, and the balloon was released shortly thereafter with a final lift of approximately 9 pounds.

Tracking and Recovery

After launch, members from both the launch team and the payload team began tracking the balloon to determine its initial direction and speed. The balloon began with a mostly southern heading, but quickly began trending south-easterly at a heading of 155 degrees (±10 degrees or so), which was maintained for the majority of the flight.

It was decided with this information that the team should head south on I-94 while maintaining distance from the balloon. The tracking strategy adopted by the team was reactionary in nature, although a program was used to guess the flight direction of the balloon. The program used the balloon parameters and the weather forecast conditions on the day of launch. Decisions concerning where the tracking vehicles should head were made by determining the general trend of the balloon’s course and speed, and determining the best path for continuing to track or intercept the balloon.

The balloon’s ascent was characterized by a very rapid climb in altitude during the initial and main phase of the flight, followed by a slower ascent once the balloon was above the jet stream. Between 30,000 and 50,000 feet, the balloon encountered the jet stream where it reached speeds over 100 miles per hour. Ultimately, the balloon rose above the jet stream and steadily slowed in ground speed. After more than three hours of flight, the balloon finally gave out at approximately 100,000 feet near Sparta, WI. The launch team proceeded to track the descent of the balloon and its payload, eventually locating it in Rockland, WI.

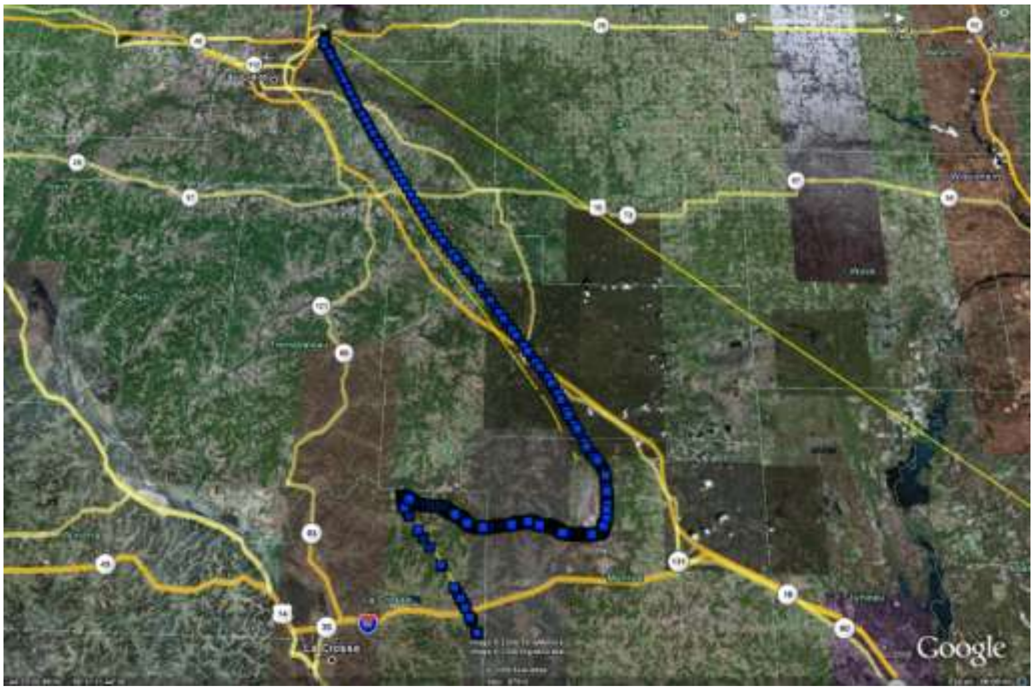

Figure 6: GPS-Generated Ground Track of Balloon's Flight

After approximately 1.5 hours, the balloon was located in the branches of a tree approximately 40 feet above the ground. Because of the height of the balloon and its entangled state, the owners of the land were eventually contacted and asked to evaluate the situation. It was ultimately decided that the only option to recover the payload was to cut down the tree. The owners eventually cut down two trees to obtain the payload. The first tree fell down, but was the wrong tree. The balloon and payload were still 40 feet above ground, and in a different tree than initially thought. Once the second tree fell, all balloon remnants and payload were obtained. All data from the payload was usable, and all camera’s attached were still functioning, even after the crash landing into tree, crowning the whole Elijah balloon experiment as a great success.

Flight Analysis

A review of the entire system after the flight showed that the system performed almost flawlessly during flight. The GPS system was found to be accurate in its measurements and the payload was shown to have worked as expected. A flaw was found in the parachute's setup, which caused it to tangle it its cords and not deploy properly. This was confirmed by a review of the GPS data, which shows a decent rate of the balloon system far too high for a fully open parachute. Photos of the parachute on decent show later confirmed that the parachute did partially deploy, but not to its full extent.

Conclusion

The launch, tracking, and recovery of the high altitude balloon, the StratoSat system, and the scientific payload showed that despite technical and monetary limitations, traditional forms of communications, and a starting unfamiliarity with the equipment at hand, a successful balloon launch and recovery is still very much possible.

Specifically, the team's ability to overcome the challenges presented with the GPS system, the recovery of the balloon, and scheduling showed a strong ability for the Launch Team to function as a coherent unit. The team's further ability to work from a minimal understanding of the equipment available and project goals to a fundamentally complete knowledge of the StratoSat system showed, not only dedication on the part of the team members, but also the strong viability of the StratoSat system for future launches. Of those items that were not fully successful, such as the parachute deployment, an understanding of the current flaws involved was obtained and will be passed on to the subsequent team so that the process may be improved.