Overview of Launch Day

Balloon Sat flight number five was flown on October 25\textsuperscript{th} 2008. The payload train consisted of a 1200g balloon, a balloon sensor package, parachute, two Space Hardware Club transmitters, one backup transmitter, space billboard, and a Boy Scout ATV package. The team met at 8 am on the 25\textsuperscript{th} and planned the launch for 9 am at the NSSTC near the UAH campus.

The objectives of this balloon fight were the successful operation of the rebuilt transmitters, the space billboard package, the ATV package, and the balloon sensor package. We met at 8 am on launch day to start the necessary preparations. The balloon sensor package was turned on first, because its battery could provide power for at least 6 hours. The balloon started filling using the plastic sensor mount at 8:30 and finished around 8:50 am. The space billboard package was turned on during the filling of the balloon. At about 8:50 the transmitters were turned on to begin GPS lock and begin data transmission. The ATV package was the last to be turned on because of its short battery life. The launch was at about 9:06 am.

Balloon Sensor Package

The balloon sensor package was designed to measure data points about the balloon at its neck and compare the data to atmospheric conditions. This comparison would supply the data needed to design a control valve, to be located at the neck of the balloon, that would release helium in an attempt to slow the balloon’s rate of ascent during flight. The following data points were measured during flight:

- Atmospheric Pressure
- Pressure in the balloon neck
- Temperature inside of the electronics package
- Temperature outside of the electronics package
- Temperature outside of the balloon neck
- Temperature inside of the balloon neck

The data from these sensors was collected every tenth of a second during the flight. The parts of the sensor package are listed below. The package was designed by Jason Winningham.

- Temperature sensor (AD22100)
- Pressure sensor (MPXAZ6115)
- ADC (MCP3208 8 Channel)
- EEPROMS (24LC256)
- Microcontroller (Atmel ATmega168)
- Power (9V lithium battery – 30mA draw)
- RTC (DS1307)

During the flight, the package read data from all of the included sensors. Because the only heating of the package was caused by the electronics, the package had a relatively low temperature difference from ambient temperature. The box had a temperature of -43°C which exceeded the operating temperature range of the RTC chip that kept time during flight. It was rated to 0°C but stopped responding at -37°C. The data sampling was unaffected by this and continued to record at the correct rate even though the chip did operate correctly.

The pressure sensors read to 11.4 kPa during the flight. We knew that the pressure in the atmosphere would exceed the limits of the sensor, but the balloon pressure was completely unknown. The balloon pressure at the neck ended up being nearly the same as the atmospheric pressure. This means that during the flight the pressure sensor limits were exceeded just as in the case of the atmospheric pressure sensor. This lack of accurate data means that altitude could not be plotted correctly when the sensors were not reading properly. The graph of the altitude reached a flat line when the pressure sensor exceeded its lower limit for operation. The sensors did show that there was a minimal pressure difference between the balloon neck and the atmosphere— not enough pressure to effectively release helium through a simple valve.

The temperature sensors recorded data at many different locations. The ambient temperature was measured on the outside of the electronic box by a sensor hanging from wires. The sun unexpectedly affected the sensor significantly. The recorded temperature oscillated as the temperature sensor passed in and out of direct sun exposure during each rotation of the electronics box.

Another temperature sensor was taped to the outside of the balloon nozzle (covered with one layer of tape) to measure the temperature of the plastic. The temperature of the plastic had to be recorded to allow for later valve placement in that location. Because of the severe temperature changes, thermal expansion could cause binding or other issues that can be avoided with this data.

A third temperature sensor was located in the neck of the balloon. This sensor was positioned to measure the temperature of the helium. This was necessary, along with the pressure at the neck, to determine the density of the helium. The density is necessary to calculate the flow rate of the valve considering the pressure difference across the valve.

A fourth sensor measured the temperature of the electronics box. This data was interesting because the package was only heated by the components in the circuit. Because the circuit drew very little current, it heated the package only a small amount. The temperature stayed about 6°C warmer than the ambient temperature of the atmosphere. This information is vital to the preparation of future electronics modules for actual flight conditions.

All together, the balloon sensor package gathered very valuable information. It can be considered a successful in fulfilling its purpose. The data it collected shows that it would be ineffective
to attempt to produce control valve system for the neck of the balloon. The pressure difference is not
great enough to obtain an effective flow rate though a reasonably sized valve. This data collection
module can be used in the future for other purposes involving the measurement of pressure and
temperature. The system requires very little power and it adds only a small amount of weight.

Space Billboard

The space billboard package flew on the flight train modified from its usual configuration. The
standard configuration includes two cameras, each with multiple advertisement slots mounted on a
rotating board in front of them. Camera 1 has two billboards and a blank location designed to get a
normal picture. Camera 2 has three billboards mounted in front of it. Each billboard array rotates
during the flight to capture advertising pictures at multiple altitudes. A servo control system for the
rotation was constructed by Jason Winningham for this assembly. The time interval between rotations
is programmed relative to the timing of the camera picture interval.

During the first two flights, both cameras have experienced a white-out effect. The reason for
this effect was unclear. The issue developed during each flight, growing in intensity as it gained altitude.

Guesses were made as to why this was happening:

- Condensation on the lenses due to moisture in air
- Lack of heating
- Damage to CCD camera due to conditions from previous flights or direct contact with the sun
- Electronic malfunction due to extreme differences between the close, bright billboard and the
distant, dark background

In an attempt to test the first two listed issues, an air-tight chamber (box) was fabricated at
minimal cost ($2) to control the environment of the cameras. The chamber has a built in heating
assembly and a self-sealing quick release for air connections. The conceptual idea was to remove all of
the air from the chamber with a vacuum pump at the air connection, then to re-fill the chamber with
helium already available from the filling of the balloon. The helium would be free of moisture and
would avoid any condensation issues. The helium would also provide a medium for the heat from the
heaters to be transferred to the camera itself. (The heater was not in direct contact with the camera
inside of the chamber)

To test the second pair of issues, Camera 2 of the flight was flown in a previous flight
configuration that was known to operate correctly. This means that camera was simply insulated
(except for the lens) and heated near the battery. To do this, the billboard was removed and the camera
looked solely at the earth and space.

During the last few weeks before the launch, the transmitters were rebuilt to save weight.
Because this would be their first flight in the new configuration, wiring harnesses, and insulation
package, a last minute backup transmitter was also flown. In order to offset this weight, the camera air-
tight chamber was removed. It was more important to fly a backup transmitter as a safely measure than to fly the chamber.

Because the chamber for Camera 1 was not going to be flown, a new configuration for the camera was designed and flown. For this flight, the Camera 1 billboards were cut smaller to reduce the white surface area that the camera was seeing. This excess material was removed from the billboard mount, so the advertisement was un-modified. This would, hopefully, reduce any electronic malfunction due to the contrast between the background and the advertisement image.

On flight day, a checklist was followed to turn on the entire space billboard package. The flight list includes every step involved. Camera 1 was powered on and set up for the flight. Camera 2 was powered on second. Part of the pre flight setup involved turning off each display to save power. After recovery, it was found that the Cannon camera (Camera 2) operated successfully. The Pentax camera (Camera 1) was powered on, but the actual camera cycle was never started. This problem was not recognized until the shut down process during the recovery.

The images from Camera 2 were picture perfect. These are the images posted on our website (spacehardware.uah.edu). This proves that the first three possible issues with the camera are not the cause of the undesired effect. After discussion, it was determined that the best solution for the space billboard package is to purchase cameras with the ability to multi-focus. The current cameras were not designed to do this and are proving ineffective when operating with an extreme difference in distance between the background and billboard. This can be seen from the image quality on the first two flights, which got worse as the payload ascended, but became clear again just before landing. The difference in focus distances is small enough near the ground not to cause any issues.

Cameras are available which can handle the difference in focus distance. For the space billboard payload to continue operation, new cameras will need to be purchased.

Transmitters

For this flight a heavy payload train was expected. In an effort to reduce the transmitter weight, a new packaging was built to minimize weight. The insulation for each of the two transmitters consisted of over 500 grams in the past. After a design change, the insulation weight dropped to 25 grams for each transmitter. The material was changed and a more compact design was implemented. Other changes were made to reduce the length of the wires inside of the payload. The combined weight is currently just over two pounds for both transmitters together.

As a safety measure, a third, backup transmitter was flown to ensure at least one working transmitter on the flight. Though both of the new transmitters worked on the ground, as they are identical designs, if a problem arose in one transmitter, it was likely to arise in the other. This third transmitter was added to ensure a level of comfort.
As previously stated, adding this one pound transmitter required a sacrifice in other areas. This sacrifice came in the form of the air-tight chamber for the camera.

On flight day, one transmitter started having trouble with GPS lock. Having two working transmitters, the flight was not stopped for this reason. Soon after launch, all three transmitters connected and transmitted data as planned. This flight proves that the new transmitters are reliable and can be used without the need for a backup.

Payload Train

The payload train worked very well. From top to bottom, the hardware included the following:

- Balloon
- Neck sensor
- Sensor electronics box
- Parachute
- 2 SHC transmitters
- Space billboard
- Backup transmitter
- ATV

The balloon popped at about 86000 ft. This was expected. Due to the strong winds of the jet stream, a very high lift was needed to minimize the chase distance. This, in turn, lowered the burst altitude. It was a 1200 gram balloon.

The neck sensor and electronics box were discussed earlier. Their location was just below the balloon for obvious reasons. This presents a possible issue of excess weight above the parachute during decent. The weight might cause the parachute to deflate, reducing its effectiveness at slowing down the system. It was decided that because of the high winds, this was not an adverse effect.

The parachute, two club transmitters, the space billboard, and the backup transmitter have all been explained. The ATV payload was an experiment with amateur television for the Boy Scout’s ham radio merit badge. This operated as expected except for a missing antenna during the flight. It is not known where the antenna was lost.

Conclusion

Space Hardware Balloon Sat flight 5 was a success. Valuable data was gathered through student designed experiments. Hands-on experience for students involving student designed, fabricated, and flown experiments is only attained though projects like this. This flight can be considered a success.