2015 Global Space Balloon Challenge

Most Educational Initiative Entry

Museum of the Coastal Bend
Victoria College, Victoria, TX

Introduction

On Friday, May 1, 2015, the Museum of the Coastal Bend at Victoria College launched a high altitude balloon from Cuero, TX. It drifted slowly over the Texas Coastal Bend before reaching a maximum altitude of 34,274 meters (112,448 feet). It then descended under parachute before landing on a ranch northwest of Victoria, TX. We retrieved the balloon shortly after landing thanks to the generous access granted by the landowner.

Aboard the balloon were two canisters of science experiments designed by Pinon Elementary School in Los Alamos, New Mexico. The science package was designed and built by the students, with help and guidance from the balloon team in Texas and their teachers in New Mexico.

In addition to the elementary student science experiments, the balloon was in support of the Museum of the Coastal Bend's 2015 temporary exhibit *Above Texas Skies*, which educates the public about the rich history of space exploration in Texas' Coastal Bend region. NASA's Columbia Scientific Balloon Facility is in Texas, as well as Johnson Space Center, and SpaceX's forthcoming coastal launch facility. Closer to Victoria, Matagorda Island was home to the world's first private space launch. San Antonio was the site of many discoveries in aerospace medicine. All these locations could be seen as the balloon slowly rotated at its maximum height.

In all, the balloon was an incredible success, both technically and educationally.

Description of the education program

When the Museum of the Coastal Bend decided to enter the Global Space Balloon Challenge in support of the 2015 exhibit, we put out a call to any elementary, middle, or high school that wanted to put experiments aboard our balloon. Pinon Elementary in Los Alamos, New Mexico answered the call. We provided them a "spec sheet" (Appendix A) that would guide their design. The goal was to replicate the process of launching experiments into space. Science teams are provided a certain size and weight target that their experiments must fit into. We didn't provide any guidance on experiments – that was up to the students!

The experiments are described later in the report.

Back in Texas, the museum was using the balloon as a way to get the community more excited about the many decades of space heritage in the Coastal Bend. Few were aware that NASA controls space balloons from just a few hours away, so a meteorologist from the Columbia Scientific Balloon Facility came down to give a lecture and show off some of the balloon materials they use all over the world in support of science.

Facebook, Twitter, and the museum's email newsletter all shared the preparations for the balloon, from testing through flight. We also selected a flight computer that would broadcast live (SSDV) images during the flight. Those images along with live tracking were shared with the museum's audience during flight, as well as with Pinon Elementary.

HABs in support of the program

The HAB was a 1200 gram Kaymont balloon. Suspended from 10 meters of paracord was a 4 ft parachute, under which was a Styrofoam enclosure. The enclosure contained the following:

- 2 science canisters from Pinon Elementary, Los Alamos, NM
- GoPro Hero3 camera, set to narrow field-of-view for minimal distortion
- Extra-large battery pack for GoPro camera
- Pi in the Sky flight computer (PITS), connected to Raspberry Pi A+
- Experimental APRS board for Pi in the Sky, on one of its first test flights for the PITS project.
- GPS antenna connected to PITS
- Two transmission antennas (2m and 70cm, for APRS and PITS respectively)
- SPOT Trace backup tracker
- Raspberry Pi still camera for SSDV and still images
- 4 AA lithium batteries powering flight computer system

The entire HAB assembly (except for balloon itself) weighed 1 kg. The balloon was inflated with helium to 1939 grams of neck lift, as measured by water ballast.

The balloon took 131 minutes to ascend to its maximum altitude of 34,274 meters, at an average ascent rate of 4 m/s. After bursting, the balloon descended at an average rate of 16.3 m/s, reaching a final rate of 7.7 m/s before landing. Final telemetry received was from 3032 meters. SPOT data was used to retrieve the balloon from its resting place on a cattle ranch about half a mile from the road.

The weather was beautifully calm and clear, after weeks of foul weather that had necessitated requesting an extension of the Global Challenge launch window. Weather was so calm and clear that the recovery team was actually able to watch the balloon burst through binoculars.

Students involved

There were 23 students in the 6th grade class at Pinon Elementary. It is a heterogeneous class, with 13% of students having learning disabilities and 25% identified as gifted. Teachers started by explaining the balloon challenge and explaining what a HAB is. After identifying atmospheric conditions in the stratosphere, students worked on their own to research the sort of questions they wanted to answer and design experiments that both answered those questions and might fit within the physical constraints provided by the HAB design team at the Museum of the Coastal Bend. Proposals ran the gamut from "Put a note in it and when it gets back read the messages from whoever got it" to "Due to changes in pressure as you go up, if we put a piece of glass in the weather balloon, would it be cracked when it came back down? I know this happens when you go deep down in the ocean, would it also happen up in the sky?"

Students learned that not every question is answerable with a low financial budget or a low mass budget on the balloon. Together with the teachers, students picked the experiments they thought would work best. The three experiments chosen were high-speed film to capture cosmic rays, a small thin piece of glass, and a small piece of bubble wrap. The experiments were packaged into small canisters and mailed to Texas for integration with the “spacecraft.”

On launch day, the class tracked the flight via habhub, and looked at the SSDV pictures. They created a cross-section of the atmosphere and learned the layers. They practiced converting temperature and altitude from the HAB’s telemetry between metric and imperial units. The class compared the balloon’s altitude to the heights of various places and objects around the world (e.g. an airplane flight, Everest, Burj Khalifa, satellites, space station). The class was very surprised by how high the balloon got.

When the film was developed, the class looked at the telemetry spreadsheet and the video from on-board cameras. They graphed temperature vs. altitude, looked at speed vectors, and did mapping from telemetry data.

Effectiveness

The Museum’s HAB was extremely effective, both in the classroom education and in the informal education missions. **Over a thousand** members of the public were exposed to the

HAB project and thereby the aerospace heritage of Texas, as well as the stunning images of the world around them. The class at Pinon Elementary got a unique engineering and earth science challenge that let them design their own high-altitude science experiments. In the words of one student: “This was the best science experiment all year, Mrs. Hermes!”

Technically, the balloon performed flawlessly. Every system on the balloon worked as designed, and it was quickly recovered.

Cost summary

Flight computer (Pi + PITS + antennas)	Roughly $200
Batteries for cameras and computer	$53
Backup tracker	$100 for device, $100 for 1 years’ service
Balloon	$82.50
Parachute	$45
Helium and launching supplies	Roughly $150

Total cost was $730.50. The GoPro already belonged to the museum. The payload, flight computer, antennas, and trackers can be reused in future flights. Receiving radios and antennas were loaned by the local amateur radio club.

Conclusion

The Museum/Pinon HAB project was a resounding success by any metric. It was a low-cost project that provided high-value education to both classroom and informal audiences both in and outside of the museum’s standard audience. It worked to educate students and the public on balloon science, gas physics, atmospheric science, aerospace heritage, engineering, and radio, as well as introducing many of them to the idea of amateur high-altitude balloons. This is a project we are eager to repeat.

Appendix A: Materials provided to interested schools

Museum of the Coastal Bend
Weather Balloon Launch Project

As part of the educational programming for MCB's special exhibit *Above Texas Skies: Space Exploration in the Coastal Bend*, the museum will launch a weather balloon carrying mini experiments.

Balloon Experiment Guidelines:
If you would like to get an exemption from one of these guidelines, please contact us.

- Your experiment should be roughly the size of a film canister. Ideally, it fits inside a film canister.
- Your experiment must be labelled with your name and contact information.
- No living animals or insects.
- If you want to use electronics or radios, contact us first.
- Your entire experiment including container must weigh less than 75 grams.

Examples:

- *Will a piece of bubble wrap pop as it reaches very low atmospheric pressure?*
- *Will seeds that have been to the edge of space grow differently from seeds that stay on earth?*

What to expect from the project:
The balloon will travel to roughly 100,000 feet. Depending on winds, total payload weight, and other factors, we may see altitudes anywhere between 90,000 and 110,000 feet. At 100,000 feet, there is very little air. The atmospheric pressure at the balloon's peak altitude is roughly the same as what your experiment would feel on Mars (and about 1% of what it feels on Earth's surface!). It is also very cold. Air temperatures may be as cold as -60° F.

We will launch your experiment inside our balloon's payload compartment, a small Styrofoam box hanging under the balloon. Riding with your experiment will be electronics that help us track the flight. We have two tracking systems (a primary and a backup) that will tell us how high and fast the balloon is going. The primary system logs that information along with temperature so we have a record for later. There is also a camera pointing out of the payload container so we can see the black sky and curve of the earth from near space.

Once the balloon gets to its maximum altitude, it gets so big that it pops, sending our payload container back to Earth on a parachute. As it falls, we will continue to track it. When it hits the ground, we will make every attempt to recover it. Of course, there is a small chance that it lands in water or somewhere where we just can't get to it. But we'll make every effort to ensure that that doesn't happen. Part of our preflight procedures involve checking the high-level winds so we have some idea of where our balloon might land. We can adjust our launch date and launch location to improve the landing site.

When we recover the balloon, we'll return your experiment to you, along with video of the flight and all the data we collect (balloon position, temperature, altitude, and time). We'll also provide a link to the tracking so that you can follow along virtually.