

NASA Engineering Challenges: High Altitude Balloon

Experiment Challenge

Hello and welcome to your first team challenge! Each Community College will have one team with 10 members. For this challenge you and your team will need to submit a proposal for your experiment prior to launching. The main focus here is to hone skills possessed to approach experiments in a scientific way by you and your teammates. Within this document you will find the details of what to expect, background information, and provided materials for you to send an experiment up to 100,000 feet.

I. Challenge:

You and your team are to create experiment/s to be placed in a payload package on a weather balloon and collect the desired data for analysis. You can purchase any amount and any type of sensor to use. You are given a \$100 budget to choose your sensors. Types of sensors and number of ports are covered in the “Sensor Pods” section. You will also write a proposal for your experiment as a team following the guidelines outlined in **Section 5**. Section 5 will also contain a little more detail about the process of this experiment. The flight computer that is attached to the balloon will be able to read out several pieces of data like GPS coordinates, Gyroscope, Accelerometer, Barometer, Magnetometer, Humidity, and Temperature. Knowing that you will receive all of these types of data and other sensors your team chooses to collect data, you will formulate and propose an experiment. Additional details about the flight computer and its data can be found in **Section 2** below.

II. Flight Equipment:

According to FAA rules (see **Section 3** for more information) the total weight of the payload (everything below the balloon including the equipment) must be less than 12 lb (5.4 kg). What follows are the packages that are going to be flown and their weight. Pictures of each item can be seen in the order they appear at the end of this section.

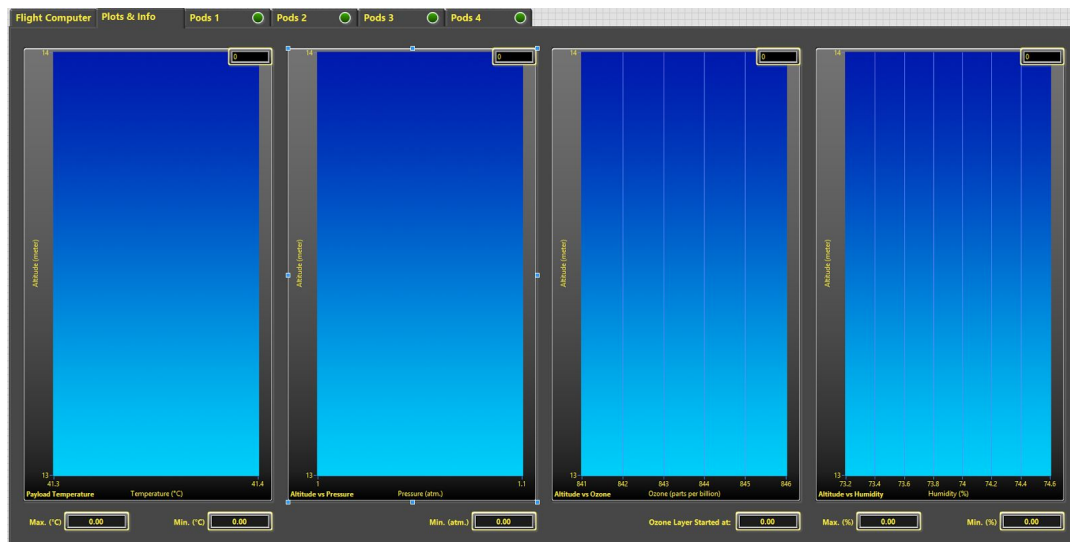
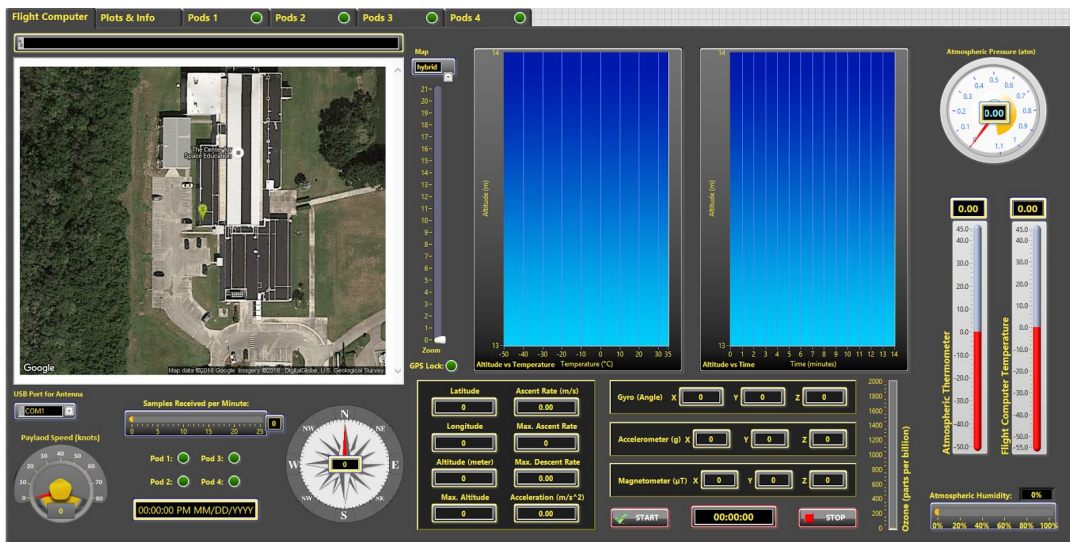
Parachute

The parachute is needed to ensure the balloon descends at a reasonable speed. The total apparatus weighs 0.536 lb (0.243 kg). It has a diameter of 36.4 inches (92.5 cm).

Flight Computer

The flight computer transmits GPS data in three dimensions along with sensor data to the ground receiver computers. It has a total weight of 1.5 lb (0.689 kg) with the box.

The flight computer is the main source of data that is down-linked from your flight. The down-linked data is fed into a software that shows the balloon's flight path in real time along with altitude, pressure, humidity, and speed. Below are pictures of the front and plot pages of the software.



Sensor Pods

The sensor pods are essentially smaller versions of the flight computer. They will send incoming data from the sensors to the flight computer via a short range wireless network. They each weigh approx. .375lbs. We will provide you with a sensor pod when you arrive at KSC. Please supply a list of all tools and items for sensor integration. There are 4 ports for analog sensors and 4 ports for digital sensors. An additional 4 sensors may be attached but they must all use I2C communication protocol. Any questions on sensor compatibility may be fielded to the FSGC

Payload Containers

There will be 3 total payload containers, one for each team. The containers have an interior volume of 432 cubic inches. The interior dimensions are 8 inches by 6 inches by 9 inches. The empty weight of each container is 0.5 lb (0.22 kg). Each container is made of styrofoam with a reflective/bright outer covering, which protects it from some of the harshness ascending through the atmosphere and makes it easier to see in case of recoveries. This is where you will house your experiment(s).

GPS Transmitter Apparatus and Camera

This package may contain one FindMeSpot GPS units with a weight of 0.312 lb (0.141 kg). One of these units will up-link location data in two dimensions to a satellite once every ten minutes. This data is down-linked from the satellite and displayed on their web site. By activating the FindMeSpot we are able to have a second set of location data on the payload even when it may not be line-of-sight to the tracking antenna sites. One significant drawback to this system is that it does not report when the package is above 10,000 feet in altitude. Its primary advantage is that it continues to report for several days and the data is received even if the package is not line-of-sight to the tracking site. It is also accurate within a couple of feet.

Retrieving the payload is not our primary concern. Due to our proximity to the water and swamp lands there is a high risk of permanently losing the payload. Also, due to the sensor data stream and constant motion of the payload containers, integrating a camera with the flight computer for live feed or still pictures has proven difficult. The decision may be made to include one or two GoPro camera's into the flight computer payload container. We will only include a FindMeSpot unit if we include a camera that must be retrieved.

We have roughly 6 pounds available for payloads. That means each team is allowed up to 2 pounds of payload to use with their box. The lighter the better since we need to stay at or under a 12 pound total weight. Also, with a lighter load the balloon will travel to a higher distance.



III. General Information:

Ahead you will find information about the atmosphere. Because your balloon will be traveling through part of it, it may be useful to understand each layer and its properties. You will also find a section about Federal Aviation Regulations for weather balloons.

The Atmosphere

The atmosphere is a collection of gaseous nitrogen, oxygen, and water vapor that make our planet Earth habitable. These gasses work together to absorb the sun's powerful ultraviolet radiation and retain the planet's heat, without our atmosphere, there would not be any life on Earth. In our atmosphere there are five distinct layers: troposphere, stratosphere, mesosphere, thermosphere, and exosphere. Each layer has distinct properties and individual functions that separate them from their surrounding layers. They are briefly described below with websites attached for further information.

Troposphere

Familiar to humans because of its close proximity, the troposphere is the lowest layer of the atmosphere. Starting at the ground, the highest elevation of the troposphere reaches 11 kilometers, which is roughly the same height as the top of a cumulonimbus cloud or the top of Mount Everest. It is in this zone where life and weather exists.

<http://www.windows2universe.org/earth/Atmosphere/troposphere.html>

Stratosphere

The stratosphere is the second closest layer of the atmosphere with the starting elevation of 11 kilometers and ending around 48 kilometers. One of the most important features of the stratosphere is that it is home to the ozone which comprises 24% of our atmosphere. The ozone is what protects the Earth from the harmful ultraviolet radiation. Because of the ozone absorbing all of the radiation, the temperature in this layer actually increases with altitude.

<http://www.windows2universe.org/earth/Atmosphere/stratosphere.html>

Mesosphere

Located between 48 kilometers and 95 kilometers, the mesosphere is the least understood layer of our atmosphere. Several interesting events take place here such as noctilucent clouds, sprites, and ELVES lightning. It is also in this layer where meteorites burn up in our atmosphere. Research is done in this layer with sounding rockets as jet planes and weather balloons cannot fly high enough and satellites cannot fly low enough.

<http://www.windows2universe.org/earth/Atmosphere/mesosphere.html>

Thermosphere

Starting at an altitude of 90 kilometers and ending around 1000 kilometers, the thermosphere is near the top layer of our atmosphere. NASA's space shuttles and the International Space Station orbit at an altitude of 120 kilometers in the thermosphere. The majority of the sun's radiation is absorbed here leading to a temperature between 500 to 2000 degrees Celsius and the temperature is measured by looking at the motion and speed of gases.

<http://www.windows2universe.org/earth/Atmosphere/thermosphere.html>

Exosphere

Depending where you are geographically, the thermosphere and the exosphere will intersect around 640 kilometers and the exosphere ends around 640,000 kilometers. This is the region where space and our atmosphere mix and where the atoms and molecules escape into space. It is also in this layer where satellites orbit the Earth.

<http://www.windows2universe.org/earth/Atmosphere/exosphere.html>

Federal Aviation Regulations

United States Federal Aviation Regulations for High Altitude Research Balloon Mission (FARS) has created the guidelines for flying high altitude balloons. It is important to familiarize yourself with what is allowed during flight of your balloon. These regulations can be found at:

<http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&rgn=div5&view=text&node=14:2.0.1.3.15&idno=14>

IV. History:

High altitude balloons are used to conduct scientific experiments in the atmosphere. Some of the experiments analyze atmospheric sciences, cosmic rays, gamma rays, infrared astronomy, magnetospheric physics, and micrometeorite particles.

The history of high altitude balloons starts with human curiosity about what's above us. Public experiments involving a research balloon first occurred in France in 1783 by a physicist and two physics instrument constructors. Their unmanned balloon successfully flew for 45 minutes, landed 20 kilometers from their launch site, and amazed about 300,000 spectators.

http://inventors.about.com/od/astartinventions/ss/airship_3.htm

In 1934 and 1935, the Army Corps teamed up with the National Geographic Society and launched two balloons in Rapid City, South Dakota in a location called the Stratobowl. Explorer I reached an altitude of 11.5 miles and had two men that had to parachute to the ground after their balloon burst. There was more success with the Explorer II where a maximum altitude of 14 miles was met and the two passengers returned safely in the balloon to the ground. An altitude of 14 miles with a manned crew would not be met again until the astronaut program began.

<http://www.stratobowl.com/stratobowl.html#balloon>

The National Oceanic and Atmospheric Administration (NOAA) is a program that researches the different systems on the earth to help provide advancement in science and our understanding of the planet. Part of the research the NOAA performs is of the earth's atmosphere. This research is done by launching balloons at over 100 points across America every twelve hours. If there is inclement weather, balloons are released every four hours in those zones to help scientists better understand the system.

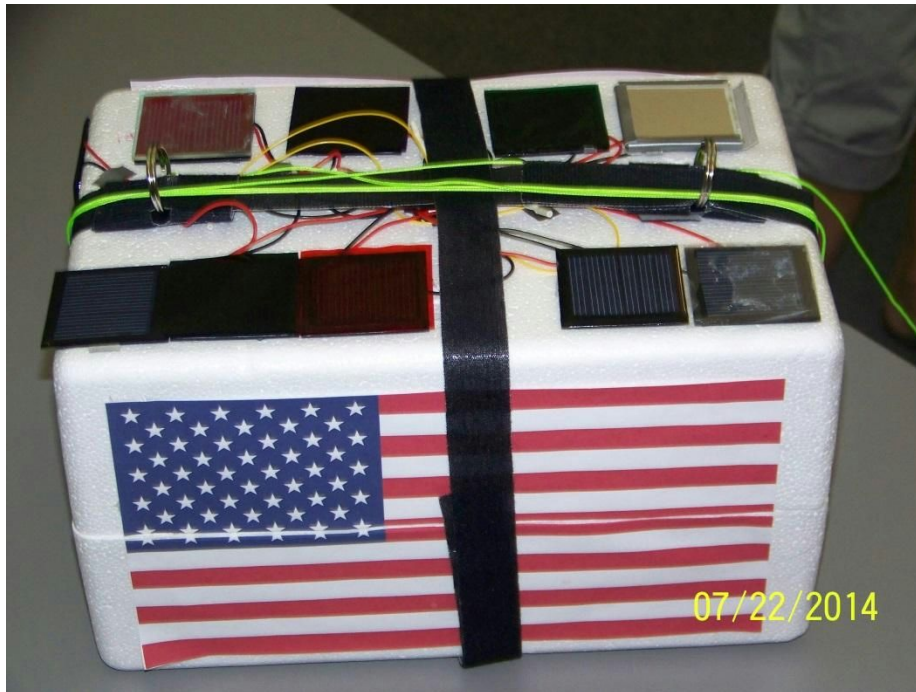
<http://www.erh.noaa.gov/mhx/tour/OfficeTourUpperAir.php>

V. Procedures and General Concerns:

As aforementioned, we have the ability to down-link data from the flight computer carried aloft by the balloon to receivers on the ground. We have three receivers and computers with the specific software. We typically designate one receiver as Mission Control. This computer stays at the Kennedy Space Center Visitor Complex. A second receiver and computer travels with the ground recovery team. We will only be using two of the three receivers for this launch.

The flight computer down-links the data at specified intervals. It can be set to down-link once per second but our experience is that this has not worked well for us. We usually set the receivers for once every 30 seconds.

On launch day your sensors will be set up with our flight computer. We cannot send a flight computer to each team. Therefore, it is important that you bring the sensors, along with your layout plan, to the competition. The instructors will help each team integrate the sensors with the flight computer and their placement in the payload container. Please provide a list of tools and materials needed to integrate your sensors



with the payload containers. Also note that since the sensors may be exposed to the outside environment (see picture below); the sensors have to be placed on top of the payload container. Other equipment, like batteries etc., will be placed inside the box. So make sure to take note of the size and internal volume of the

box so that you have the most optimized setup for the experiment. It does not have to be complicated and there is not much of a limit except for the weight mentioned earlier.

On the day of the launch, most of the tasks for launching the balloon will be handled by the instructors with some assistance from the teams. All the three experiments will be launched on the same balloon platform. Do not stress since the main focus of your team should be the experiment and proposal. Everyone will have the chance to experience the balloon launch.

Weather balloon launches are tricky, especially here in Florida. This state has been labeled as one of the hardest places in the country to launch a weather balloon.. One of the most formidable issues is the weather. Deciding when to launch is crucial. It would be wise to investigate and experiment with the link that is posted below. This link takes you to a site that can predict a balloon flight with reasonable accuracy based on the parameters you type in. This website uses constantly updated weather reports to

give a best prediction of the landing area of the balloon. We want to try to avoid a water landing for obvious reasons. The site will be most useful to us about a week from the competition dates, as we aim to pick a place to launch. Once again the launching site is something that we will have to decide that gives us the greatest chance to recover the equipment. It is still a good practice for your teams to go through the process and maybe even get a location closely agreeable with ours.

<http://predict.habhub.org/>

You and your team are to develop an experiment to be placed in a payload package on a weather balloon and collect the desired data for analysis. The proposal will have a 2 page minimum with a 4 page maximum (not inclusive of the sensor layout diagram). You will write a proposal for your experiment as a team and scored on the following:

Proposal – 80 points:

- Title of Proposal/Question being answered - What question do you want answered with your experiment? (10 points)
- Significance of the question - What is the significance of your question? Why did it need to be asked? (15 points)
- Background science related to the question - What is the science related to your particular question and research? (20 points)
- Budget and parts list – Provide a list of sensors and a detailed parts list, including the necessary tools to assemble your payload. Also, a detailed list of websites where items can be purchased. All items must be purchased from a United States seller. A cost for each item must be included with a total item budget that does not exceed \$100. (10 points)
- How will analysis of data be conducted? - How will your collected data be examined? (15 points)
- References (10 points)

Payload integration and data retrieval – 20 points:

- Assembling your sensors, batteries, etc. in the payload enclosure. (10 points)
- Retrieving data from your sensors. (10 points).

DUE DATES:

February 22, 2016: Proposals Due from all Colleges for the High Altitude Balloon Experiment (send via email to Gene Tavares: Eugene.Tavares@ucf.edu)

March 22, 2016: Hardware and Parts Distributed for High Altitude Balloon Experiment to Each College

April 15, 2016: Preparations for High Altitude Balloon Experiment Competition are Completed