SPACE BALLOON LAUNCH & RECOVERY

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Week 1: Mission Overview
Video of Launch, Basics of Hardware, Mission Execution Basics & Legal Boundaries of Operation

Week 2: The Airframe & Its Components

Flight Computer, Payload Bay, Payload Bay Temperature Recorder, Spot Tracker, APRS Tracker, GoPros, Location Buzzer, Flight Train (Balloon, Parachute, Attachment Line)

Week 3: Flight Planning

Calculating Flight Weight & Helium Requirements, & Learning to use the CUSF Landing Predictor to best pick a suitable Launch Site

Week 4: Actual Launch & Recovery

Most likely done on a Saturday. Meet at Squadron Building then travel to Launch Site, On-Site Craft Preparation & Launch, Followed by Craft Tracking and Recovery after Craft Re-Entry

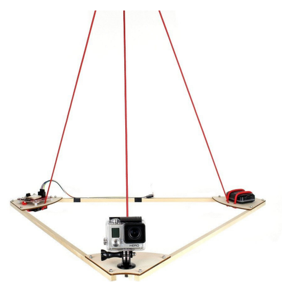
Week 5: Using the Data We Recover

Downloading Flight Computer Data & Converting to Google Map Overlay... Downloading Payload Bay Temp Data, Downloading GoPro Video

WEEK 2
THE AIRFRAME & ITS COMPONENTS

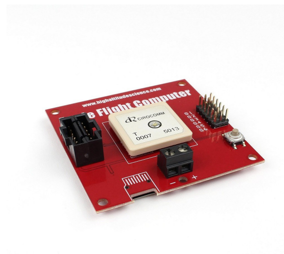
The Airframe you will send to the edge of space is an incredible assembly of components that help to ensure your mission will be a success. Each is important to some degree toward the execution of the mission. Some components, like the Tracking Devices, are critical. Why? Because unless we can recover the craft, much of the mission is useless and we have lost a great deal of expensive equipment. All of these components play a role in ensuring that your flight is worthwhile and that you recover your hardware to fly again another day. In this section we'll look at the most critical components in detail.

THE AIRFRAME ITSELF



The Airframe is supplied by High Altitude Science, LLC, and is a triangular-shaped wooden craft that is purpose-built to be a near-space vehicle. It contains various attachment points that serve as a basic framework upon which you can attach various flight components of your choice. It is lightweight but strong, and its flat shape helps it to land right-side-up. Landing this way is important because if the craft were to flip upside down upon landing, the GPS tracker may not function correctly which could prevent it from reporting its position to you, which could prevent you from locating your craft once landed. Some high-altitude balloonists use styrofoam coolers as an airframe, which can turn over upon impact with the ground, then lose tracking capability, and may never be found.

THE EAGLE FLIGHT COMPUTER



The Eagle Flight Computer is supplied by High Altitude Science, LLC, and is specifically designed for high-altitude balloon launches. At the heart of the Flight Computer is a specialized GPS Receiver. Unlike common GPS receivers which cut out at approximately 65,000 feet, the Eagle's GPS receiver continues to operate at over 260,000 feet... over 4 times the capability of a standard GPS receiver, and over twice as high as our space balloon will travel.

Bear in mind the Flight Computer is not a “tracking device.” It will not be reporting back to us in real time during the flight. Instead, it records spacecraft position information (Latitude/Longitude, Altitude) onto an SD Card every 6 seconds, which creates a large file of data that we can retrieve from the craft once it lands, to know exactly where the craft has been, and exactly how high.

The Flight Computer will also provide other interesting data, such as speed of the craft at different points of the flight, air temperatures, barometric pressure, and relative humidity. All of this information is also recorded every 6 seconds, just like the positional information.

The Flight Computer is powered by 2 Energizer Ultimate Lithium batteries. Why Lithium and not normal Alkaline Batteries? At the edge of space the craft will be subjected to bitter cold temperatures exceeding -50 degrees Fahrenheit. At these temperatures regular Alkaline batteries would die and you would not be able to record data once the Flight Computer lost power.

THE “SPOT” TRACKER

The SPOT tracker is manufactured by SPOT, LLC, and provides the real-time location of the craft every 2 ½ minutes. It is small and lightweight, about half the size of a modern cellphone. It uses an internal GPS receiver to determine its position, then uses Communications Satellites in space to send its location, which can then be seen on the SPOT website or SPOT app. Its ability to communicate via these communications satellites, and not relying on cellphone towers, is critical because at higher altitudes the cell towers are unreachable.

However, even the SPOT tracker will become ineffective above about 60,000 feet, because of the coverage beams of the communications satellites, and the capability limitations of the SPOT tracker's internal GPS receiver. As a result, there is a “blackout period” of an hour or longer, when the SPOT is too high to communicate with us. Once the balloon reaches maximum altitude and bursts, and then the craft begins its descent back into the atmosphere, we will reacquire a signal from the SPOT device as it passes below 60,000 feet on its way back to Earth.

It is powered by Energizer Ultimate Lithium AAA batteries, for the same reason as the Flight Computer... Lithium is the only commercially-available battery option that can stand up to the frigid temperatures of the near-space environment.

THE STRATOTRACK TRACKER

The StratoTrack unit is another type of Tracking device for our near-space craft. Similar to the SPOT tracker, it uses a built-in GPS receiver to provide real-time position information which can be viewed from a website to determine current location. However, the StratoTrack communicates a little differently.

Unlike the SPOT tracker which utilizes communications satellites to relay its position, the StratoTrack uses a built-in APRS (Automatic Packet Reporting System) transmitter to transmit its position to a network of ground-based Amateur Radio (Ham) radio stations. These radio stations then transmit the position to a tracking website which anyone can access to see the device's position.

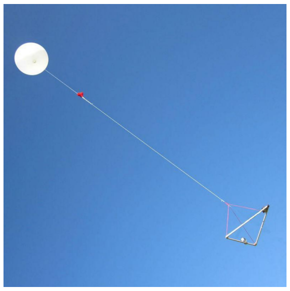
The StratoTrack is attached to the flight train line below the Parachute, and is powered by 1 Energizer Ultimate Lithium AA battery.

Note the StratoTrack operates on FCC-licensed Amateur Radio frequencies (144.390 MHz in North America), and must be operated under the supervision of an FCC-licensed Amateur Radio Operator.

THE GO-PRO VIDEO CAMERA

The GoPro camera system includes a high-definition camera and a ruggedized outer case for protection. The GoPro records onto an onboard SD card, from which video and pictures can be downloaded after the craft lands and is retrieved. The GoPro is powered by rechargeable lithium batteries, so is perfectly suited to withstand the rigors of near-space. To allow for extended-duration recording time, it is outfitted with a GoPro Battery "BacPac."

THE FLIGHT TRAIN



The "flight train" consists of all components of the spacecraft, from the balloon to the airframe. It's called a flight train because just like a freight train, all of the components are attached together in a line. The balloon is tied to a piece of string that leads down to the parachute... the parachute is tied to a piece of string that leads down to the main airframe. Once the balloon bursts at maximum altitude, the parachute is then free to open and slow the descent of the craft as it plunges back into Earth's atmosphere.

WEEK 3
FLIGHT PLANNING

MISSION "PHASES"

We now begin to move from a point where we were just talking "generalities and basics" about high-altitude balloon launches.. into a point where we're going to actually make a launch happen. This is a large project! We have to think about all the items we will need, what we will need to keep an eye on, who will have which responsibilities, and more. Like most any large project, the easiest way to digest it is to break it into smaller, more manageable "chunks", or as we'll call it, "phases." Different members of your Launch Crew may have different responsibilities within each phase. Here are the Mission Phases, listed in the order that we'll carry them out:

PREPARATION PHASE: You're already in it! This is where you brief your group about the mission and your expected objectives for it, gather the items you'll need, and plan a date and location for the launch, based on launch crew availability, wind conditions aloft, and other weather factors such as the 50% minimum clear sky requirement for balloon launches that is mandated by the FAA.

DEPLOYMENT PHASE: You've got everything together you need for the launch, and today is the day! You've begun the Deployment Phase, which is where your launch crew deploys to your chosen launch site. Deployment Phase will continue until you've reached the site, found a suitable spot for launch, and ensured that the weather conditions are favorable.

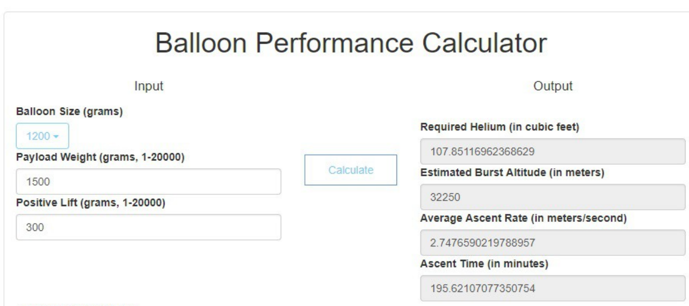
LAUNCH PHASE: You're at the Launch Site, the launch area has been prepared, weather conditions are favorable, and now launch is imminent! Here you enter the Launch Phase. Members are focused on preparing the mission payloads, ensured everything has good batteries and is operating properly on the ground, while a separate sub-crew is preparing the actual balloon for launch. Once everything on the Pre-Launch checklist is checked... and double checked.. ESPECIALLY the tracking equipment... you will launch the craft!

RECOVERY PHASE: You've released the spacecraft, it's out of your hands at this point and you've entered the Recovery Phase! Here you'll track the craft, monitor the Video Link if available, continue tracking through ascent and re-entry, then recover the craft and return to your squadron building. Mission accomplished:

So.. continuing on with the “Preparation Phase”... You're now familiar with the components that make up the near-space craft. You understand what makes it climb, how it returns to Earth, and all the electronics that capture and send data about the flight. Now we'll take a look at the procedures that go into making sure your flight is a success... dividing the Mission into more manageable sub-parts, how much helium you'll need, how much weight you can carry, and where the craft will likely end up upon landing.

For obvious reasons, we normally would want our craft to travel as high above Earth as possible.. that will give us the best views, and also give us the most flight data possible. But how can we know how high our balloon will go before bursting? How much payload weight can we carry without affecting the balloon's maximum altitude? To answer these questions and more, we can utilize the free Balloon Performance Calculator, provided online by High Altitude Science, LLC. The Calculator can be accessed at:

http://tools.highaltitudescience.com/



The Calculator requires that we input the Balloon Size, the approximate weight of the Payload we intend to carry, and the amount of lift in grams (depends upon how much helium we put in the balloon). Obviously, these are open-ended questions because we will play with these numbers until we find out what gives us the most altitude. So let's dive right in and do just that!

Balloon Size: Although there are several sizes of Balloons available for purchase, the **1200-gram size** is recommended, because it is the best match between price, size, and maximum altitude for a good-sized payload. But as with the other numbers, feel free to experiment with other balloon sizes to see what the results might be! For our purposes, we'll calculate using a 1200-gram balloon.

Pros/Cons: Smaller balloons are easier to handle and less expensive, but will either require that you carry a lighter payload weight or it will not fly as high into the atmosphere. Larger balloons are more expensive and a little more difficult to deal with on the ground, but they will let you carry more payload weight higher away from Earth.

Payload Weight: This is the combined weight of our entire craft (minus the latex balloon itself). The parachute, the airframe, and every other component that the balloon will carry to near-space. Remember that if we keep the Payload weight below 4 pounds total, it keeps us within within legal limits of a balloon flight without extra complications. If we go above 4 pounds payload, we have to add a cut-down device, reflective material for ATC tracking, among other requirements that will severely complicate our flight beyond our needs, and make it more expensive. So we'll plan on **1500 grams Payload Weight, or about 3.3 Pounds**. That gives us plenty of payload weight for all the things we might want to send up with the balloon, but is light enough to keep things simple and less expensive.

Pros/Cons: Lighter payload weights will let you use a smaller balloon and still achieve a high altitude. Higher payload weights will require a larger balloon to reach the highest altitude.

Positive Lift: Simply put, this means as you hold onto the inflated balloon, how much upward "pull" are you feeling? Positive Lift is what lifts the balloon and our payload. Of course, the more helium we inflate into the balloon, the more positive lift the balloon will have. This "positive lift" is measured by attaching a digital scale to the balloon neck, and holding the other end of the scale with your hand, while someone adds more helium to the balloon. As more helium is added, you will see the lift in grams shown on the scale begin to increase.

Bear in mind that the "Positive Lift" figure is NOT how much weight you'll be lifting... it's how much lift your balloon will have OVER AND ABOVE the Payload Weight itself. In other words... if we are planning to carry a Payload Weight of 1500 grams, and want 300 grams of Positive Lift, the balloon needs to have a total lift capability of 1800 grams (1500 grams of Payload plus an extra 300 grams of lift power). Simply put, once you begin inflating, simply look for "1800 grams" to show up on the Digital Scale. That will lift your 1500 gram payload to "neutral buoyancy", plus an extra 300 grams to spare that will start it rising toward the sky once you are ready to launch.

Pros/Cons: Excessive positive lift (adding too much helium) will let the balloon carry very heavy payloads and lift off quickly, but because you have already inflated the balloon to a large size before you release it, it will not rise as far before it reaches its bursting width and pops. A low amount of positive lift (adding too little helium) will make the balloon rise too slowly, and the flight may last 5 hours or more and travel hundreds of miles, complicating your efforts to track and recover the craft after flight. For learning purposes, and also as a good starting point for an actual flight, we'll begin with entering a **Positive Lift of 300 Grams.**

Once you enter these required numbers into the blocks on the left side of the Calculator and then hit "Calculate," it will output a set of numbers on the right side of the Calculator, including Required

Helium, Estimated Burst Altitude, Average Ascent Rate, and Ascent Time. Play with the numbers on the left side of the page. You'll see they have a huge effect on the flight characteristics, and it will help you to plan what your flight will accomplish, and the amount of helium you'll need to purchase to get that done. Helium will need to be purchased in large bottles from compressed gas suppliers such as Red Ball or Nexair. These suppliers are located in most any town of reasonable size, all across the country. You will also need a balloon fill nozzle which attaches between the balloon and the helium tank, which you can purchase online from retailers such as High Altitude Science, LLC.

Once you have played with the Calculator numbers and decided on a final payload weight, balloon size and amount of lift (helium) needed, you can begin to use some of the other numbers you obtained from the Calculator, to predict where your balloon will land. To do this we will use the **CUSF Landing Predictor**, located at:

http://predict.habhub.org/

As soon as you get to the site, you'll see it opens with the map located over England. No worries, you can use your mouse to slide the map to your general area of the world. You can also use your mouse wheel to zoom in/out on the map as you navigate. Once you get the map navigated to the general area where you are thinking of launching from, click “Set With Map”, located in the Calculator space at the bottom right of the page. Then, click on the map where you would like to do the launch. You'll see that a red/white bullseye will appear on the map at that location. Next, you would just populate the other fields in the calculator, such as Launch Altitude (elevation of your launch site in Meters), Launch Time (in UTC Time.. Google for “current UTC time” to get an idea), Launch Date, Ascent Rate in Meters per Second (remember the Performance Calculator page gave you that), Burst Altitude (the Performance Calculator also gave you that), and the Descent Rate in Meters per Second (this will depend upon Payload Weight and Parachute Size, but a 3.3 Pound Payload with a 4-Foot Parachute will yield a descent rate of about **5 Meters/Second**).

Once you have all that information plugged in, click “Run Prediction” in the lower right-hand corner of the page. The Landing Predictor will go to work. Based on all the numbers you plugged in, plus all the forecast conditions aloft that the Predictor goes out and finds, it will promptly come back with a Predicted Flight Path that shows up on the map. Along the Flight Path you'll also notice a little “burst” symbol at some point... this is the approximate location where the Predictor thinks your craft will be, when your balloon bursts. At the end of the Flight Path you'll see a green bullseye.. that is where the Predictor thinks your craft will land.

How accurate is this Landing Predictor? If you plug good numbers into it, don't be surprised if your craft lands within just a couple of miles of where predicted. Of course all of this is just based on weather forecasts at different altitudes aloft, so as you can imagine it can't be expected to be completely accurate. What to do? Plan on landing your craft in a LARGE, open, unpopulated area free of trees as reasonably possible. Move your Launch Area to different points on the map, and run the calculation again, until you find that your craft is predicted to land in a large, safe, open area. Once again, nothing is guaranteed, but by modifying your Launch Site until you're likely to land in a large open area somewhere, you'll lessen the risk that your craft will end up landing in the top of an 80-foot tree where only the local Fire Department can retrieve it.