The Space Balloon Project

A "How-To" Pamphlet

Verde Valley Composite Squadron 205
Arizona Wing, Civil Air Patrol
Sedona, AZ

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Mission date: November, 2011
Edition of Pamphlet: November, 2014

Introduction

You are about to embark on an exciting, challenging, and rewarding project!

There is a lot of science involved with this project. If you change one of the parameters below, many other things change as well. Each line below fits with the others. And each line has many hours of research behind it. This is our recipe, and it worked. Before you make changes, do a lot of background reading!

Our Working Recipe

* Total payload weight, including parachute, radar reflector, and string: 2 lbs, 6 ounces (or less);

* Payload included:
    * Video camera;
    * SPOT GPS device (NOTE: I would not use this device today -- see below);
    * Two "if found, please contact" laminated signs;
    * One hand warmer;

* Just above the payload, a radar reflector was attached;

* The payload had wire-hanger legs, angled downward (sort of like a lunar lander), to soften the blow of impact, and to help ensure the payload landed upright (see our web site for photos -- link in Appendix);

* We used one, three-foot diameter parachute (a four foot diameter might have been preferable);

* The payload was black (to absorb heat from the sun), and had two layers of shock protection: a one inch Styrofoam material, lined with an 1/8 inch layer of hard plastic. (FYI: Do not paint Styrofoam. The paint damages the chemical structure of the foam.) We used brightly colored duct tape to seal the lid to the payload, which helped in spotting the payload after landing;

* We used a professional weather balloon rated to burst at 19 feet diameter;

* We used well over half of a "K" tank of professional grade, 100% helium;

* We planned on an ascent rate of 1,000 feet per minute;

* We attained an altitude of approximately 88,000 feet before balloon burst;

* Accessories needed were as follows: tubing to go from the helium tank to the balloon, with needed connectors; a clean table free of burrs and hand oil (to inflate the balloon on), latex gloves, others as listed below.

Design Criteria

Your payload and electronics must meet the following criteria:

* lightweight -- as close to 2.0 pounds as possible -- not to exceed 2 lbs 6 ounces;

* the sensitive payload items (video camera and gps) must functionally:

    * withstand 100 mph winds (winds can easily flip the payload over on its head);
    * withstand temperatures of -60 C degrees;
    * withstand speeds of over 150 mph on descent;
    * withstand altitude of 100,000 ft;
    * withstand impact of landing. (At a descent rate of 19.3 ft/sec, this is the equivalent of a cold drop from 68 inches (5 ft, 8 inches). [See table below.]);

* the payload needs to be "openable" & "closeable" many times, with the ability to take out all items and replace them as needed (for battery replacement, equipment calibrating & testing, etc);

* the payload has to have a way to connect easily to the parachute;

* the payload design should be simple and effective;

* the design must ensure that the buttons on the devices are *not* touched during the wild ride;

* the camera lens has to sit parallel to the ground as it flies, so that it films the horizon (not straight down);

* the gps device has to transmit through the payload materials -- must test with the lid on;

* the payload should be brightly colored on the outside;

* if you are launching near water, the payload must be waterproof.

Telemetry -- Tracking Devices

In 2011, this kind of project existed in a "wild west" regulatory environment. We used both a SPOT GPS device, and a cell phone with GPS software. Because of our rural location, we felt it was an acceptable risk to play in the grey area of the regulations.

Today, with the dramatic increase in the number of such projects taking place, I strongly suggest you play by the rules. This means using ham radio technology to transmit your GPS signal. Of course, this means one of your team members will need a ham radio operator's license.

There are several makers of RF trackers out there. My favorite is Big Red Bee. On the web at: http://www.bigredbee.com/index.htm.

Camera

We used a DXG 572V video camera. We used the following settings, and got decent results:

* Size: QVGA (320 by 240 pixels) (This gave us, with the memory card we were using, 8 hours of recording. VGA would have given better quality, but only 2 hours. As the flight was projected to last 2 hours 15 minutes, we would have missed the landing, which I wanted to see!)
* Quality: Fine
* White Balance: Florescent (for some reason, during tests, this setting worked best);
* Zoom -- full zoom out;
* Auto-Shut-Off: Yes, after 1 minute

The DXG required 4-AA batteries. See below for recommended brand.

Things to test on your camera: if the batteries run out while filming, does the current video file close correctly, or does it get corrupted? If you run out of memory while filming, ditto. Stick the video camera in your freezer for an hour, while filming, for a cold test.

If you can afford it, a HD (High Def) camera will give better results. Go Pro is the leader in the field of durable, action cameras. I highly recommend them. You might also try Flip, another brand.

Another consideration is weight. The DXG was quite heavy. Go Pro and Flip make lighter models. In the end, it comes down to budget. Remember -- there is always the chance the camera will be damaged, or you will not be able to find it!

Balloon and Helium

We bought our balloon from Scientific Sales (1-800-788-5666). (On the web at www.scientificsales.com).

We bought item number 8242, Weather Balloon, 800 Grams Natural, which has a burst diameter of 19 feet. With the other parameters unchanged, this balloon, when inflated correctly, will get your payload to around 90,000 feet -- well into near-space.

You will want to rent a "K" size tank of 100% pure helium. It's the big tank: about 6 feet tall, and looking like a torpedo. Rent the helium from a store which supplies to welders and other hard core folk: do NOT use "party" helium, as they dilute this stuff with other, inert gases.

Do NOT touch the balloon, unless you are wearing latex gloves. The balloon is very sensitive to hand oils.

Regarding the amount of helium: use a jug of water which you hang by a hook to the tube filling the balloon. As the balloon fills, eventually, the jug will lift off of the ground. Be sure to account for the weight of the tube itself -- put the hook near the top of the tube (next to the end which attaches to the neck of the balloon).

How much water? Start with the total weight of the payload: include everything except the balloon itself. Now add one pound for every 1000 ft / min of lift you want. So if your payload weighs 2 lb 6 ounces, put 3 lb 6 ounces of water into the jug to get 1000 ft / min of lift (this ascent rate is average for weather balloons, and with our configuration, will get you to about 90,000 feet). FYI -- one galloon of water weighs 8.35 lbs -- you do the math!

If you add more helium, you will get a faster ascent rate (which likely means a landing site closer to launch site), but because the balloon gets bigger, it will burst at a lower altitude. (The balloon expands as the external air pressure decreases as you gain altitude.) Also, the heavier the payload, the more helium you will need to get the ascent rate you want, which lowers your max altitude. Now you understand the adage, “weight is gold.”

With our configuration, the diameter of the balloon should be around 5.5 feet when it is inflated (on the ground). It only took around 15 minutes to get to this inflation.

Here is a link to an instructional video on how to inflate the balloon. I have distilled the essential information out of the video, and inserted it into the checklist (included in the Appendix below).

http://www.youtube.com/watch?v=JiWyBXtLE5A

Be sure to lay the tank on the ground when inflating, so it cannot fall over.

Tubing

We used heavy-duty plastic tubing, maybe 3/4 inch diameter, with an x-pattern wire reinforcement. At one end was the regulator to the helium tank. It fit snugly over the tube. At the other end, we found at a hardware store, a plumbing connector which fit the tube on one end and the neck of the balloon on the other. Electrical tape secured both sides.

Hand Warmers

Putting some kind of warming device in the payload is a good idea. I would not recommend the brand we used. A little research is needed here. Make sure the brand you choose does not rely on air to stay warm -- there isn't much at 100,000 feet! Also consider the extra weight.

Signs with Contact Info

We put a laminated sign both inside and outside the payload.

* Harmless *

Weather Balloon Payload

Property of the
Civil Air Patrol

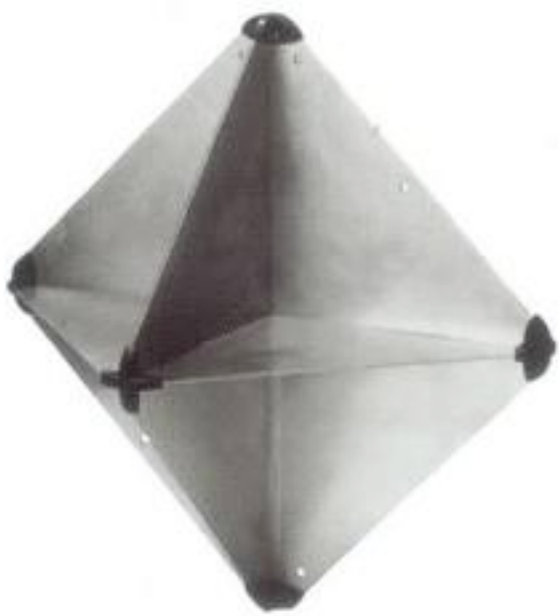
If found, please **immediately** contact
Major Luis Camus at:
Phone: 928-301-3755
Email: sq205cc@gmail.com

Our cadets thank you!

It is important to mention the payload is harmless -- imagine, in this post-9/11 world, finding a big black mystery box in your backyard!!!

Radar Reflector

Here is a picture of an official radar reflector. It is required by the FAA on all weather balloons. It helps the radar of aircraft to see the balloon.



We used a ball of tin foil, wrapped around the string just above the payload. We got the idea from a couple of MIT students. We figured, "if tin foil is good enough for MIT, it is good enough for us!" Another idea: ball up the tin foil and place on the bottom of the payload: it will provide impact buffering there.

Batteries

Energizer Ultimate Lithium batteries performed *very* well. They are rated for very cold temperatures, and last longer than any other make or model by far.

Kite String

We used 30-lb kite string to attach the balloon to the parachute to the payload.

The distance from the balloon to the payload was about 60 feet. This long length minimizes the wild pendulum swings as the winds pick up, and is standard procedure for the national weather service. The parachute was around 20 feet from the balloon. In retrospect, I would put the parachute about ten feet above the payload. This would give lots of room above for the balloon shards to fly off, before hitting the chute.

We had trouble with making knots that held, due to the slick nature of the string. For certain ties, we used sneaker-style shoe strings.

ORM: Operational Risk Management

Now that you are familiar with some of the equipment and design parameters, you are ready for your first ORM pass.

If you are in the Civil Air Patrol, you know from your training ORM has six steps:

1. Identify the hazards;
2. Assess the risks;
3. Analyze the risk control measures;
4. Make control decisions;
5. Risk control implementation;
6. Supervise and review.

It is important that your team go through this process, to create the safest environment for launch and recovery.

See Appendix for our finalized ORM report.

Testing

Payload

The main thing you want to test is how it will do upon impact. This chart shows you how high you should drop the payload, depending on your calculated descent rate (see Parachute, next paragraph).

Velocity in Feet per Second	Distance in Inches	Velocity in Feet per Second	Distance in Inches
5	5	17	54
6	7	18	61
7	9	19	68
8	12	20	75
9	15	21	83
10	19	22	91
11	23	23	99
12	27	24	108
13	30	25	117
14	36	26	127
15	42	27	137
16	48	28	147

Parachute

For a formula for the descent rate of a round parachute, go to www.pcprg.com/rounddes.htm.

There are also several on-line calculators you can use:

http://www.onlinetesting.net/cgi-bin/descent3.3.cgi

http://www.rockethead.net/descent_rate.htm

We used a three-foot diameter chute, and with our weight, calculated it would give a 19.3 feet per second descent rate. Looking at the chart above, we free-dropped the payload from 68 inches, with all equipment inside and running, and saw what adjustments we needed to make to ensure things were secure.

I was never satisfied with the pre-launch research I found on parachutes. Before our launch, I could find no one who could overcome the problem of the balloon shards which result after burst falling over and interfering with the parachute. I'm virtually certain (from our video) that we did not get the slowed descent rate we should have, had the chute functioned correctly.

Here is a link to a video showing the problem with the balloon shards:

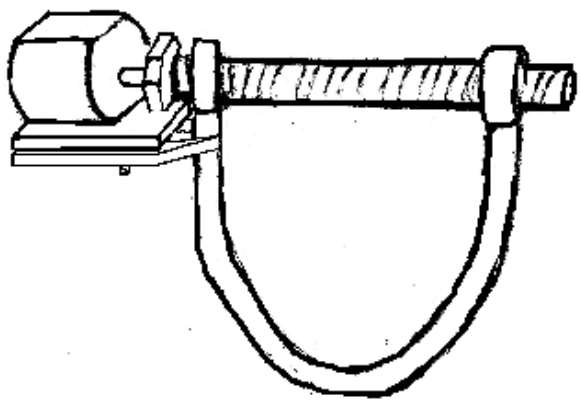
http://www.youtube.com/watch?v=0HbXVVVFahM

Here is some very technical info on parachutes:

http://www.aeroconsystems.com/tips/tips002.htm

Because it was bugging me, I did some research after our launch. It turns out the best solution is a “cut-down” or “cut-away” gadget. Here is one diagram.

CUTDOWN DEVICE



I lost the link to his PDF file online. The little box on the left is a motor. Upon receiving a signal, the motor turns the bolt, opening it. Once it opens, the string up to the balloon slips out, and the balloon is released...pretty high tech stuff!

There are various schemes, aside from a remote-control trigger, in use: one uses a timer to trigger the release mechanism, and another uses an altimeter (or pressure sensor), so that when the balloon reaches a certain height, it is released. A few methods use the burst itself to trigger the release, but to me this seems risky: both the burst balloon and the payload will be falling at the same rate, and will be in close proximity to each other. Could still end up tangling...

Links on the "cut down" issue:

http://www.eoss.org/hardware/quick_release/index.htm

https://sites.google.com/site/ucsdnearspaceballoon/equipment-used

http://www.cs.wright.edu/balloon/images/9/97/ZTR_Device_Report_(MTM).pdf

Another issue is ensuring the parachute actually opens. There are several designs (one using wicker) of devices which you insert inside the chute to keep it open. During ascent it doesn't create much drag, and during descent you are certain the chute will stay open.

I'm thinking we might do some testing on this in the future. In the meantime, my best guess is to keep the 60 feet between the balloon and payload, but put the chute only ten feet above the payload. This gives 50 feet for the shards to fly off before they hit the chute.

<u>Entire package</u>

You want to assemble the entire package, and turn everything on, and test the data (i.e., the video and audio, and the GPS pings), to make sure the electronics do not interfere with each other.

You also want to make sure the materials you are using (tape, Styrofoam, tin foil, etc) do not interfere with the GPS system.

Pre-flight

Trajectory Modeling

This is a great site to give you a general idea of where your balloon will go.

http://weather.uwyo.edu/polar/balloon_traj.html

While this site gives great models (you will need Google Earth for the visual version), they are not accurate enough to give precise landing sites.

If you need help working with Zulu (GMT) time, go here:

http://www.wrh.noaa.gov/eka/satellite/timetable.html

Here's a site to convert lat / long coordinates from format to format (includes three formats):

http://www.rcn.montana.edu/Resources/Converter.aspx

Weather

Any of the weather sites will give you good wind / weather data. The main thing you have to watch for is high winds, if you are prepping the balloon outside. It is much harder to handle the balloon if it is windy. We set a starting max wind speed at 5 mph. Anything higher, and we would have scrubbed.

Watch the weather daily for a month before your launch date. And look at past year weather data. Get a feel for your local weather. Make the weather your friend!

If one of your team members belongs to AOPA, of course, there are great wind resources there.

Checklist

It is essential to have a detailed checklist for the launch. See ours in the Appendix.

FAA

You must file a NOTAM a few days before your launch. And the day of launch, you must contact your local FSS. Here is the contact information we used: yours will be different, according to your location (except for the FSS number -- it is national).

1) Our primary FAA contact person:

Albuquerque Center
Richard Fite
505-856-4540 x4535
richard.fite@faa.gov

2) Nationwide FAA FSS service:

Call them to file a NOTAM in your area a few days before launch: 1-877-487-6867.

3) Front-Line Manager:

Ours was to be phoned at (505) 856-4575 one (1) hour prior to launch and immediately when the payload has landed. The FSS you work with can give you the number of your local front-line manager.

Also, there are a series of FAA regs governing weather balloon launching. The recipe provided here adheres to them. However, you might want to go on the FAA web site and read the complete regs.

Launch Day

You will need some criteria to determine go / no go, depending on the weather. And you will need some method to contact team members in the event of a scrub. We used a phone tree.

You will also need a clean table or tarp to lay the balloon on. Remember, it is very sensitive to skin oils. Use latex gloves, and watch for sharp edges.

Lay the tank on its side when inflating -- so it cannot fall over.

We used heavy-duty double-sided tape to secure the electronics to the payload. This stuff really helped: it kept things in their places, and it provided some shock absorption.

The Search

Google Earth and Google Maps were essential tools during planning and recovery.

Be aware there are three lat / long formats, and each device uses a different format. Get your conversions right!

Depending on your geography, you might need to go on dirt roads. Make sure you have the right vehicle for your landing site.

If your landing site is out of cell phone range, plan a form of communication with your chase vehicle. We rented a satellite phone. It was $8.00 a day, plus $2.50 per minute. It had a large ($900) deposit, but we needed it where we were!

Wrap Up

If you do not have altitude telemetry on your payload, look at the images you retrieve just before / after burst, and compare them to Google Earth. The lower right of Google Earth gives altitude data. In this way you can gauge the heights your balloon attained.

We gave each participant a Certificate of Achievement at the end. Good morale building!

Budget - Prices for Various Items

* Prices with tax and shipping included, as of November 2011.
* Pick and choose what you like -- then total.

Hand warmers	Bass Pro: cost for 4, incl shipping -- not happy with these.	$10.40
	Another option: This type is microwaved or boiled. http://www.roshgo.com/Merchant2/merchant.mvc?Screen=CTGY&Category_ Code=00602 (above web address on two lines -- continues with no spaces) $3.99 each plus tax/ship. 4by6 inch. Reusable. Buy 2	$15.00
Camera	Other project used Go Pro. We could get Go Pro HD Hero 960 http://gopro.com/cameras/hd-hero-960-camera/ Price listed is eBay, brand new, incl. shipping, buy now. Could bid to get lower.	$175.00
Camera memory	GoPro needs 16 gig for 120 min recording Kingston - with shipping - 16 gig	$50.00
	Duracell 32 gig: (tested in extremes) http://www.google.com/products/catalog?hl=en&safe=off&q=16+gig+sd+card+ duracell&cid=16590900125128667283&os=sellers#scoring=tp (above web address on two lines -- continues with no spaces) This memory is "Class 4" -- not very fast -- but seems solid (from user reviews)	$35.00
Batteries	Energizer Ultimate Lithium - 4 AA	$15.43
Payload box	You can probably find materials cheap or free	
Balloon	16 foot diam. Burst diam 19 feet. retail 79.95, but it was on sale http://www.scientificsales.com/ProductDetails.asp?ProductCode=8242 800-788-5666.	$86.00
Parachute	We had one, but there are many stores online	
Note lamination	At a copy store	$6.00
Copies	Checklists, etc	$12.00
Kite String	30-lb, 500 feet, from online store	$12.00
Helium	K-tank, 100% pure	$90.16
Gas for chase	Prices may vary :-)	$40.00
Tools	Glue, tape, misc	$20.00
Tubing and parts	Tubing and parts	$20.00

Appendix

Checklist

* Make sure that all of the participating cadets and senior members are present & signed in.
* Safety briefing. Risks. Potential hazards. Hydration (location of water).
* Have wind block tarps and cars at the ready. (Circle the wagons).
* Set up two tables and helium tank. Get out all materials.
* Make sure balloon table is clean and smooth.
* Videographer -- start filming the whole launch process with second camera.
* One hour before launch -- call FAA.
* 40 minutes before launch -- activate a hand warmer. Do NOT yet place in payload. It needs to breathe to heat up.

Helium and Balloon

* Lay tank on its side;
* Attach regulator to tank;
* Prepare 3 lengths of "tie-off" 30-lb kite string: one: 4 feet long; two: two feet long.
* Three people get gloved as follows:
    * "Nozzle" person puts on gloves;
    * Gloved nozzle person takes out gloves for others, assists putting them on;
      (Balloon is **very** sensitive to hand oils and dirt);
* Open tank valve -- learn sensitivity and clear air from tube, without wasting too much gas;
* Attach balloon to PVC connector and tie with short piece of string (Figure 1 below);
* Attach jug of water to hook on tube;
* One gloved person holds neck of balloon -- others stand by -- only touch if needed;
* Fill balloon;

Helium and Balloon	Payload and Electronics
* Keep filling;	* Lay out all equipment (gps, camera, hand warmer, tapes, payload, string 4 straps, lid, parachute, string, tin foil ball, tools)
* Get second jug of water ready -- we will use it during the tie-down procedure.	* Turn on gps. Verify operational.
	* Also log into weather sites...

When balloon is full:

* When jug lifts slightly, start tie off procedure; (Add H20 to jug to hold down);
* Take four-foot piece of string, wrap around back of neck, ½ inch above PVC (1 inch from top of neck), even string ends, and tie like you are tying your shoes. (Figure 2)
* Keep winding string around, tying each time around. String should cover ½ inch of neck when finished. (Figure 3)
* Tie two ends together -- make ends parallel, wrap around finger making a loop, pull two ends thru loop;
* Remove balloon from PVC -- hook it to a weight using loop to keep it steady.
* Bend neck up and tie off, using 2 foot piece of string. Use same technique. (Figs 4, 4A)
While tying, insert string at top of parachute thru loop in neck of balloon.
* Tie two ends as before -- feed one string thru the loop that you already made to secure;
* Attach long piece of kite string (60 feet) to bottom of parachute;

* Place the GPS in the foam.

* Place 2-sided tape on bottom of GPS;
* Place foam and GPS into payload;
* Place 2-sided tape on bottom of camera;
* Place camera into slot in foam;
* Tape the hand warmer to left side wall;
* Tape small note to inside (back?) wall;

* Turn on camera -- start recording;

* Place the little foam supports in.

* Place lid on top.

* Get the big "return to" note ready. Trim edges not needed.
* Tape the lid shut, taping the big note on the outside side of the payload.
* Wind string straps around payload - tie tight;
* Add short string leads -- tie tight;

* Attach kite string with parachute on it to the short string leads.
* Wrap tin foil around string near top of pod;
* Form a "human chain" to hold the segments of the device stretched out -- balloon, string, chute, string, more string, more string, more string, and finally payload;
* Release each segment until the last: just above the payload.

* Countdown..Launch.
* Watch ascent with binoculars -- get a fix on direction.
* Celebrate a successful launch!

* Go to HQ; * Set up tracking station;
* Review the early morning trajectory models;
* Look at pings which we get on the way up - compare to models;
* Look at winds sites; * Prep chase vehicles and equipment.
* Wait for GPS ping. Plan course of action if no ping.

* Create maps for chase teams. Program lat / long into their GPS devices.   * They go!
* Stay in phone contact every 30 minutes.
* They find it. Do the recovery procedure. TAKE PHOTOS / VIDEOS.
    * Camera:
        Remove from payload;
        Open screen -- if unit is on, go to next step. If off, you are done.

        If the red light on the back is blinking,
        press the "shutter" button (top of camera);

        Now you should have the camera on, but not recording.
        Wait two minutes -- it should auto-shut-off.

Figure 1

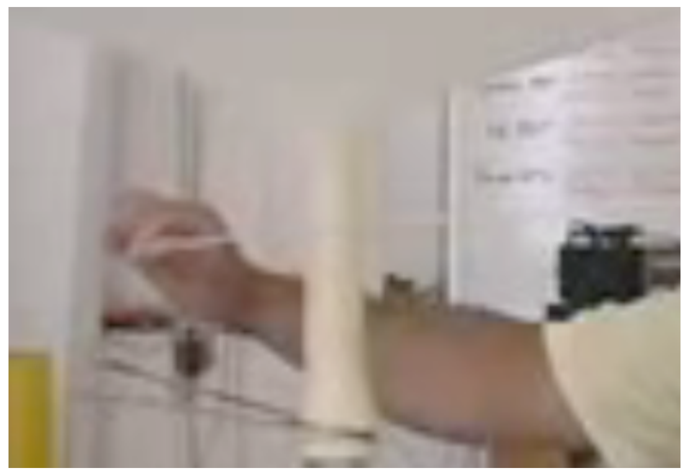


Figure 2

(Photos in Figures 1-4A from a video produced by InterMet Systems.)

Figure 3:

Figure 4

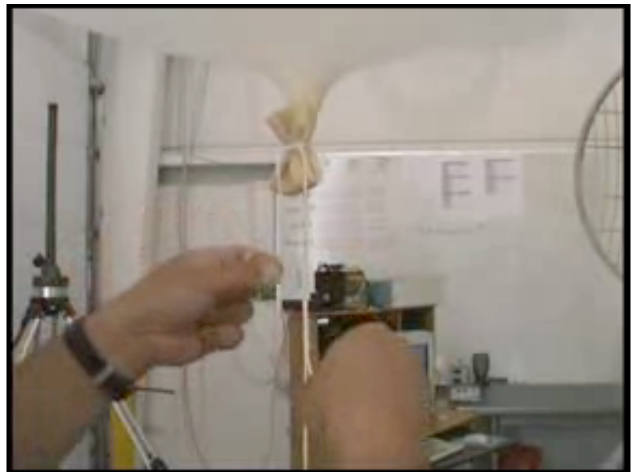


Figure 4A

*** End of checklist ***

<u>Tracking Station</u>

(This document assumes you are on a Mac -- of course, the links will work on any Internet computer.)

1) Open a browser
2) Under File, choose "New Tab" a bunch of times
3) For each url below, go to a new tab, and copy and paste the url.

Now you'll have all the sites up and ready to go!

BigRedBee tracking site.

<u>Google Maps</u>

www.google.com

click "Maps"

<u>Google (another tab)</u>

www.google.com

ready to do a search for weather in a desired location

<u>Other winds site</u>

http://www.usairnet.com/weather/maps/current/arizona/wind-speed/

AOPA (for winds)

www.aopa.org

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Open Google Earth

To Do after finished initializing tracking station:

* Choose the trajectory models you wish to view.
* Plot the morning's telemetry on the map.

This way you can compare actual data to projected data -- but really, you need data from the descent to give you a realistic picture of how accurate the model is.

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Now monitor each site.
* Click on the tab you want.
* Click the "refresh" button (to get latest winds, pings, etc).
  (Little 3/4 circle with arrow on it -- upper left)

* Plot the morning's telemetry on Google Earth.

****

As soon as we get a descent ping, plot the lat/long in Google maps.

Find the closest town.

Do a Google search for "weather town, st"

Get wind speed and direction. Compare to other wind sites.

**** end of tracking station document ****

A good balloon FAQ - very technical but thorough

http://www.eoss.org/pubs/faqloon.htm

Other useful links

* Our web site -- lots of pics and videos.

http://www.verdevalleycap.us - go to the Aerospace Education page.

* The MIT students' project: http://space.1337arts.com/

* The Brooklyn Space Program. These guys gave us the idea...
http://www.brooklynspaceprogram.org/BSP/Space_Balloon.html

* Another great device for tracking:
https://sites.google.com/site/ucsdnearspaceballoon/documentation/how-to-use-the-microtrak-aio-beacon

The story of our launch and recovery

After planning the project for nearly a year, Verde Valley Composite Squadron 205 in Sedona launched its space balloon at sunrise on November 12. The payload consisted of a video camera and a personal GPS device. The camera was used to record video and audio from liftoff, to balloon burst in subspace, to landing. The personal GPS device was used to track the payload trajectory.

Our squadron's resolve to see this project through was tested when the payload failed to transmit latitude and longitude signals a few minutes after liftoff. It was extremely demoralizing to our squadron at that point because we had no method to precisely track the balloon's trajectory. However, the squadron did not give up. Our AEO and Project Manager, Lt Prahas Nafissian, and Project Engineer, Lt William Tripp, used a university computer model to predict our balloon's trajectory and landing site. A search team was sent out. They came back empty-handed. (We later learned that they had missed the landing site by about twenty three miles.) After six hours and forty five minutes of problem solving, at 2:45 p.m. on the 12th, we shut down our tracking station, still without GPS data.

At about 10 p.m. that night, Lt. Nafissian decided to check the tracking system again and, to his surprise and delight, found that the system started receiving signals again at 3:15 p.m., eight hours after launch. (We found out later that the GPS satellite system itself had gone off-line just minutes after our launch.) The next morning, another search was conducted and they came back empty-handed again. (We found out later that because of their excitement and sleep-deprivation, the search team made a mistake in translating the lat/long coordinates from one format to another. They were off by half a mile.) The next morning, on 14 November, a third search team was dispatched. They found the payload intact about 130 miles from the launch site. The mission was completed.

The video camera recorded two hours and twenty minutes of audio and video. We estimate, by comparing images to Google Earth (which has altitude data) that the balloon reached about 88,000 feet into subspace. We know from weather data it withstood winds of at least 100 miles per hour. We have great launch and descent video but, more importantly, beautiful and awe-inspiring footage of subspace. The squadron plans to use this data for the CAP's Aerospace Education Program, not only for its senior and cadet members, but also for middle-school and high-school students. You can view footage of the launch and subspace flight at the squadron's website at http://www.verdevalleycap.us. Go to the Aerospace Education page.

Space Balloon Project ORM Process

Note: the numbered items correspond to the six numbered steps in the ORM process.

1. Breaking valve of helium tank
2. Seldom (with proper risk control)

3. Use hose to go from valve to balloon; One person handle tank, operate valve
3. Cover over valve at all times unless filling; Lay tank on ground

1. Dropping tank on a foot
2. Seldom (with proper risk control)
3. Lay tank on ground

1. Snakes
2. Likely
3. Assign one person to watch out for snakes

1. Loss of property (to wit: balloon) when filling
2. Likely
3. Fill jug with water heavier than payload. Attach to balloon before filling.

1. Tearing of balloon / skin oil on balloon (care)
2. Likely
3. Latex gloves; Lay balloon on table (measure length of balloon)
3. People around it managing it as it inflates; No sharp objects on person

1. Weather - winds
2. Frequent
3. Build into the plan that early in the morning we look at various
weather web sites, and if winds above 7 mph, we use a phone tree to cancel.
3. Plan on an early launch.
3. November launch -- look back at past weather data.

1. Communications
2. Likely
3. CAP radio equipment (portable repeater) or sat phone as backup to cell phones

1. Mechanical - pursuit vehicle; 4-wheel drive.
2. Occasional
3. General inspection

1. General motor vehicle safety
2. Occasional
3. General inspection

1. Hydration
2. Likely (unless measures taken)
3. Bring a case of water.
3. Remind people to drink.

1. Usual hazards associated with hiking
2. Occasional / Likely
3. Discuss hiking hazards at meeting prior to event.