Ham Ballooning FAQ or "What little I know about ham ballooning"

by Dave Mullenix, N9LTD

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note: Dave is in the process of building this FAQ. If you have information you can add contact him at his email address.

This is mostly stuff I learned from Joe, WB9SBD, who got me into this mess. I've chased a half dozen of his Near Space Science (NSS) balloons, helped him launch several of them and balloon meistered two launches for the High Altitude Radio Project (HARP). This is version 1.0 of the FAQ, so please excuse any mistakes or omissions.

THE MOST IMPORTANT RULE

Rule #1 for those interested in getting into ham ballooning: Join a group that's already launching balloons to learn the ropes. I can't tell you everything you need to know in a FAQ. Don't try to learn it all yourself by trial and error, learn it from someone who's actually doing it! Start by volunteering to chase the balloons. Chasers are ALWAYS welcome. Special DF equipment is not necessary. There comes a point in every flight where the balloon is laying on the ground and its range is so short that nobody can hear it. That's when lots and lots of people are needed to drive around until they pick up the signal. Once the balloon can be heard, people with DF gear can start tracking it down. Balloons often land in trees and marshes, so hunters and tree climbers are always welcome on chase crews. Bring your hip boots.

Then help with a few launches. See what's involved in filling and launching a weather balloon. Get a look inside the payload box to get an idea of the construction required.

Then find out who in the FAA the group contacts when arranging flights. The regional FAA office will probably have one person who handles most of the ham flights and he will be MUCH more comfortable with your request to launch if you tell him you've been working with a group that's had several safe and successful flights and are following their procedures.

Here's a list of what our group has been using for ham balloons and where we find what we need. As I said above, I got most of this information from WB9SBD.

BALLOONS

We use Totex weather balloons. They seem to be the best quality. We purchase them from:

Kaymont Consolidated Industries, Inc.
21 Sprucetree Lane
P.O. Box 348
Huntington Station, NY 11746
Phone (voice): 516 424-6459
Phone (fax): 516 549-3076

Balloons are sized by their weight in grams. Kaymont currently carries two sizes, 800 and 1200 grams. The 800 gram size will lift 3-4 lbs to 100,000 feet. The 1200 gram size will take a full six pound payload to 100,000 feet. Prices are about $45.00 each for the 1200 gram balloons. Kaymont accepts telephone orders and credit cards.

BATTERIES

Only one type of battery will do: lithium. Nothing that is available on the commercial market approaches lithium's power per pound. We normally purchase military surplus lithium battery packs. They contain 10 D cells in a series/parallel arrangement that produces 15 volts. The packs come apart very easily into two 5 cell strings. The D cells themselves are connected with welded tabs that can be easily cut and soldered into whatever voltage and amp/hour combination you need. The D cells are 3 volts each, so 3 will give you 9 volts, 4 will give 12 and

5 cells will give 15 volts. The cells in the battery packs will typically be out of date, but lithium cells have an excellent shelf life and we've never been disappointed. You can expect 6 AMP hours from each 3 volt D cell.

I connected a single 3 volt lithium D cell to a 10 Ohm resistor, put a Radio Shack RS-232 VOM (lent by Don, K9LYE) across it and let my computer log its progress. The voltage "rose" slightly for the first half hour to 2.81 volts and it then stayed there for 22 hours before it started to drop! It didn't drop to 2.5 volts until 24 hours after starting the test. I put a 5 ohm resistor across a second D cell and the voltage stayed at 2.78 volts for 12 hours. That's 6000+ mah per cell! A 5 D-cell pack will provide about 3.3 watts for 24 hours or 6 watts for 12 hours. You really need about 12 hours of capacity. That gives you four to six hours for the flight and another six hours to recover the payload when it lands.

Here are our results for various resistances across a single 3 volt lithium D-cell:

```
Life   Watts  Watts
Peak    Peak   in    per    per
Ohms   Volts   Amps  Hours  cell   5 cells          Notes
-------------------------------------------------------------------------
10      2.8    .28    24     .78    3.9    (Lifetime measured to 2.5 V)
5      2.78   .55    12    1.53    7.6       "        "
3.3    2.75   .82     8    2.25   11.2       "        "
2.5    2.71  1.08     6    2.92   14.6       "        "
0.77   2.46  3.20   2:14   7.87   39.4    (Lifetime measured to 2.0 V)
```

(That 0.77 ohm load was a mistake. I thought I had 4 10 ohm / 10 watt resistors in parallel. One of them turned out to be 1 ohm. Boy, did it get hot!)

We order our lithium batteries from:
S & G Electronics
618 S. 62nd St.
Philadelphia, PA 19143
Phone (voice): 215 474-7663

Prices run around $15.00 per pack of 10 cells.

S&G accepts phone orders, but not credit cards. They will ship C.O.D., however. S&G is a real mom and pop outfit and very nice people to do business with.

GAS

(EOSS NOTE: We STRONGLY recommend avoiding use of hydrogen because of its explosive properties. If you are considering it, only do so with the assistance of an EXPERT in its use. EOSS has never flown hydrogen and we have always been able to plan our payloads for the lift properties of helium. Also, EOSS rarely pays for the gas. We are usually working with an educational institution or paying customer who foots the bills for consumables and we insist on helium as an ironclad safety factor at our launch sites as we usually have a crowd of students and visitors present at these events.)

We use Hydrogen because it's cheaper (about $20.00 per cylinder versus $40.00 for helium) and has more lift. Also, we're not too bright. Hydrogen has two drawbacks: it burns and it explodes. On the other hand, it's not super vicious. Your balloon will be delivered with no air in it. Don't let any get in while you're filling it and the hydrogen can't explode in your balloon. If the balloon bursts while filling it indoors, get out and let the hydrogen dissipate for a while. Don't flip the light switch on the way out. Try to do your inflation in an old, leaky building just in case the balloon pops. An old barn with lots of holes in the roof is ideal for working with hydrogen.

Buy hydrogen (or helium) at any welding supply shop. You will need the biggest tank they have, size K or T, which will typically come up to about your shoulder. Put another way, it will just barely fit into the back seat of a Ford Taurus. Try not to get into any accidents when you have a tank full of high pressure hydrogen in your back seat. In the event of a serious traffic accident, you needn't worry about being injured. You will die.

Either size tank will fill a 1200 gram balloon with gas left over.

You should have a regulator for your tank to lower the 2000 pound plus pressure to a few pounds, although in an emergency you can tape the filling hose to the outlet of the tank and then open the valve "very" carefully. I've seen it done, but I don't recommend it.

You can rent regulators at the same welding shop you buy your hydrogen at. If they don't have hydrogen regulators, you can use a nitrogen regulator with a $15.00 adaptor the welding store can sell you. Helium is used a lot, so they will probably have helium regulators in stock. ARRANGE FOR YOUR GAS PURCHASE AT LEAST TWO WEEKS BEFORE FLIGHT. The welding shop may need time to do a credit check on you. If not, they will require a $50 - $100 deposit on the tank. You have to rent the tank, they won't sell it to you. Regulators typically rent for about $5.00 a week. You'll also have to rent the tank at about a dime a day. The welding shop will give you a hazardous material form that MUST be carried in your vehicle at all times the gas tank is on board or you are liable for a multi-thousand dollar fine.

INSTRUMENTATION

The best instrumentation is a GPS receiver sending its data to a packet TNC and a transmitter. This will send you the balloon's latitude, longitude and altitude. They're wonderful! Note, however, that many GPS receivers won't work above 60,000 feet. This is because of export regulations designed to keep Saddam Hussain or somebody like him from using a GPS receiver to improve the accuracy of a Scud missile. The actual regulations ban export of GPS receivers that can measure speeds in excess of several hundred miles per hour at altitudes above 60,000 feet. Motorola GPS boards are reputed to work above 60K feet at typical balloon speeds. Most manufacturers can provide you with versions of their firmware that will work above 60k feet, but you will have to sign a non-export agreement.

Note also that the accuracy of GPS signals is purposely degraded to about 100 yards horizontally and 300-500 feet vertically to keep Russian ICBMs from using them to achieve the +/- 10 yard accuracy necessary to take out a hardened missile silo. This will make your readings, especially altitude, jump around a bit.

Make sure your GPS receiver has a NMEA output. This is a 4800 baud RS-232 ASCII output in a standardized format. It was originally designed for use on boats, to let things like LORAN receivers work with autopilots. If the GPS receiver can be programmed to send lat, long. and altitude every minute or so, you can connect this output directly to the TNC input and let her rip. APRS programs are designed to handle this data format. However, if the receiver sends its data constantly, you will have some overflow problems feeding a 1200 baud TNC.

webmaster note: When written, the GPS info above was correct. However, the purposeful degradation of GPS position fixes through Selective Availability (SA) which introduced the 100 yard inaccuracies has been suspended for several years. In fact, with the adoption of the Wide Area Augmentation System (WAAS) accuracies are now commonly in the range of 16 to 25 feet. The 60K altitude limit is pretty much gone too. A new paradigm of speed, altitude and perhaps other

> *WAAS analysis site*
> *GPS units that work over 60K feet*

CHEAP ALTIMETER

Thanks to Kevin, WB9YHB, we now have a cheap electronic altimeter. He spotted a Microswitch pressure transducer in a MECI surplus catalog that provides a 1 to 6 volt output that is linearly proportional to pressure. The catalog blurb:

> *PRESSURE TRANSDUCER Absolute pressure sensor for 0-15 PSI range. 45PSI maximum overpressure with 0.333 volts per PSI sensitivity, .75% linearity. Three wire PC mount. Mount holes 2-1/16 O.C. Includes spec sheet. Mfg: Microswitch Mfg P/N: 142PC15A MECI PART NUMBER: 540-6206F*

It's a whopping $2.95, unless you order 10 or more when it drops to $2.50 ea. It's small, light and runs off 8 to 12 volts. It only requires one resistor. I ordered ten of them in Dec, 1994 and they had about 700 left. Hurry and get yours now. :)

MECI
340 East First St.
Dayton, Ohio 45402
1-800-344-4465 9am-6pm EST Mon-Fri Visa/MC/Disc/AmEx

CHEAP FLIGHT COMPUTER

Computers don't come much cheaper than Parallax's BASIC Stamp. This $39.90 device is a printed circuit board the size of a large postage stamp containing a microprocessor, 256 bytes of EEPROM, 8 programmable I/O lines and a 5 volt regulator. One end of the board has a pair of sturdy clips for a 9 volt battery, which will run a STAMP for several days. Small as the board is, half of it is a prototype area containing a 10 x 14 array of isolated plated through holes for your circuitry.

The Stamp has a 4 MHz clock and comes with a built in Integer BASIC interpreter. You write your BASIC program on a PC using Parallax's special BASIC editor and then download it to the Stamp's EEPROM with a cable that connects to your parallel port. (Don't know if a Mac can use the BASIC Editor when running a PC emulator.) The program starts immediately and it restarts every time you connect power afterwards.

Each of the 8 I/O lines can be independently programmed as a TTL/CMOS compatable input or output. An output pin can source 20 ma and sink 25 ma. Each pin can also be an RS-232 input or output at speeds up to 2400 baud. (Note, the output is 0-5 volts, which isn't "true" RS-232, but it works with everything I've tried so far.) The inputs work fine with standard RS-232. The "RS-232 interface" consists of a current limiting resistor.

Parallax's application notes show how to connect an ADC0831 8 bit analog to digital converter chip to the stamp. This is an 8 pin chip with a serial interface that connects to the Stamp with just 3 wires. We currently use two of them and two Radio Shack thermistors (p/n 271-110) to read inside and outside temps. The data is sent to the ground by Morse code, also generated by the Stamp. My next generation board will use a ADC0838 chip, which has 8 inputs. The Stamp also has a Radio Shack reed relay mounted on it which snaps pictures with a 35 mm camera after every ID. The 831s and 838s are available from Digi-Key.

A Cheaper Flight Computer

Parallax has actually found a way to make a BASIC Stamp for even less money! The BS1-IC is a 1.4 x .4 inch PCB with surface mounted parts and 14 pins sticking out of one side so it can plug into a socket like a SIP. (Single Inline Package) It contains EVERYTHING a standard Stamp has except the 9 volt battery clips and it's only $29.95!

A More Powerful Flight Computer

Parallax is promising the Super Stamp (or Stamp II as they call it) in Feb 1995. (It was originally promised for Nov 94.) This is another surface mount board, with the form factor of a 24 pin DIP. It will have 16 I/O pins, a 20 mhz clock, 2k EEPROM, 9600 baud RS-232, DTMF encoding and decoding, built in A/D and more. Time will tell if they deliver it all. The price is to be $49.95.

Parallax BBS and FTP site

The Stamp manual, application notes and programs are available on the Parallax BBS at (916) 624-7101 or by anonymous FTP from PARALLAXINC.COM

Avoid the BASIC Stamp Programming Kit

Parallax will be happy to sell you a BASIC Stamp programmer's kit for $99.00. It contains a cable to connect the Stamp to your PC's parallel port, a manual, a set of application notes and a disk with software. The manual, application notes, software and pin out for the cable are available for free download on their BBS and FTP site. On the plus side, the programmer's kit comes in a really neat cardboard box, which I've gotten a lot of use from.

PINOUT for the PARALLEL PORT to BASIC STAMP CABLE

```
DB 25        BASIC        BS-1C
Connector      STAMP     (Stamp SIP)
2            3            5
11            2             4
25            1 <<<        3   (GROUND - Marked <<< on Stamp)
```

All of the BASIC Stamp products are available from Digi-Key or you can order from Parallax at (916) 624-8003.

35mm CAMERA

What's the world look like from 100,000 feet? A camera can tell you. A few 35 mm cameras can automatically snap a picture every ten minutes, but we couldn't find one. Next best is triggering a camera electrically with a reed relay driven by a BASIC Stamp output pin. We use a "Canon Sureshot esprit".

If you remove the bottom screw nearest the tripod hole, you can remove a small plastic plate that uncovers a flexible printed circuit board. If you hold the camera upside down with the lens facing away from you, you will see a horseshoe shaped ring of circular solder pads with one pad missing at the top. Number the pads counterclockwise starting with the pad to the left of the missing pad. Short pads 1 and 3 together

and run a wire from pin 1 and pin 2 to the normally open contacts of the reed relay. Close the relay contacts for 1 second and you'll take a picture.

NOTE: You will have to either use wire thin enough so that you can replace the plastic plate or you'll have to cover the hole where the plate was with black electrical tape. If you don't, a light leak will fog one corner of each picture.

Which way to point the camera? Well ... if you point it down, you get great aerial photographs of the earth below you. It's a lot of fun spotting familiar places and just plotting the balloon's course after the flight by finding landmarks on the pictures. On the other hand, if you point the camera horizontally, you get some magnificent photos at high altitude. Your balloon will go so high that the sky will be black and you can see the curvature of the earth on the horizon. Your choice, I guess.

BASIC BALLOON CONSTRUCTION

The basic balloon setup is one weather balloon, five to ten feet of 50 lb test cord, one parachute tied to the cord at its apex, another five to ten feet of cord tied to the parachute shroud lines with a radar reflector attached to its middle and the payload. You HAVE to have the parachute and radar reflector - FAA regs. Ditto for the 50 lb (max) cord.

RADAR REFLECTORS: We now know for certain that just hanging a space blanket from the package won't work. They barely show up on FAA radars. Best bet: a styrofoam corner reflector covered with space blanket material. Look in a boating catalog for models. Hints: forget aluminum foil, it's too heavy. Ditto for cardboard. Space blankets (very thin aluminized mylar) work fine and are featherweight. Get them from sporting good stores.

Payloads

REDUNDANCY! Live by that word! Have at least two transmitters. Each transmitter should have its own, totally separate power supply. If your package isn't transmitting when it lands, you aren't going to find it. One transmitter can be a milliwatt rig running from a 9 volt battery. Hint: you can buy oscillator modules from Digi-Key for a few bucks each that have frequencies in various HF ham bands. They run on five volts and draw next to no power.

It gets down to 60 below zero Fahrenheit at 40,000 feet. An insulated package is necessary. A styrofoam beer cooler is light, cheap and a great insulator. If it's well sealed, things will stay quite toasty inside. Our lowest inside temps have been about 32 F. with a leaky package (lots of antennas sticking out through holes that weren't sealed with goop) to about 70 F. with very tight packages. Our HIGHEST internal temp was 132 degrees F with a very tight package containing two transmitters that used a total of about ten watts from two battery packs. Remember, about 1/2 of all the power your transmitter draws stays inside as heat.

Put an audio beeper on the outside of the package. This will help you zero in on it if it lands in dense brush or woods. MAKE SURE THE BEEPER CAN BE TURNED OFF FROM THE OUTSIDE AND PUT PROMINENT INSTRUCTIONS FOR DOING SO ON THE OUTSIDE OF THE PACKAGE! We had a farmer find our package and take it back to the farmhouse. The beeping was so annoying that he put it in a metal granary to muffle the sound - and the signal we were tracking went to zip! Luckily, we had our address on the package.

PUT YOUR ADDRESS AND PHONE NUMBER ON THE OUTSIDE OF THE PACKAGE! Mention a $50.00 reward to the finder. So far, we've had one package found by duck hunters, who promptly switched the transmitter off. A second package wound up in a metal granary and a third had its single set of batteries die on the way down. (Remember what I said above about trial and error? These are some of the errors.) We got all three back because people found them and called us.

DON'T PUT AN ON/OFF SWITCH FOR THE TRANSMITTERS ON THE OUTSIDE. You WANT that signal to stay on so you can track it down!

Put "HARMLESS HAM RADIO TRANSMITTER" on the outside. After all, many people get concerned when a package bristling with antennas and going "BEEP BEEP BEEP" parachutes into their bean field.

The Federal Aviation Administration (FAA)

Unmanned Free Balloons are covered under section 101 of the Federal Aviation Regulations (FARs) along with Moored Balloons, Kites and Unmanned Rockets. Call your local control tower and they will mail you a copy of this section. Be prepared to play some telephone tag.

NOTIFYING THE FAA: The FAA wants to know about your flight at least one week in advance. If this is your first flight, call them a month in advance and talk things over with them. You will typically want to call the local "Center". Here in Wisconsin, we call Chicago center. If you can't find their number in the yellow pages, under Department of Transportation, try calling the local airport control tower. Be prepared to play some telephone tag. If other people in your area are flying balloons, ask them who they talk to and get the number from them. (See The Most Important Rule above.)

The FAA center will want to know when you intend to launch, where from (distance and direction from a town on a map), how high you expect to go and what direction you expect it to travel in. This last part can be hard to answer a week in advance, but generally it will follow the prevailing winds in your area. Here in Wisconsin, we always guess that the balloon will travel to the south east. You should also leave your number in case they have questions. If the person you want to speak to isn't in, be sure to leave your name and number so they can get back to you.

24 hours before launch, you have to call your local Flight Service Station (FSS) and file a Notice to Airmen (NOTAM) giving the launch site, date and time, expected max altitude, expected rate of climb, expected direction of travel and landing spot. Your local FSS will have an 800 number. These people can also give you the winds aloft if you ask. Most pilots have no use for winds aloft over 30,000 feet, so tell the FSS that you're launching a balloon and ask for wind speed and direction for as high as they have data for. This will typically be about 50-60 thousand feet. Try to get the winds aloft for a reporting station to the west of you because 24 hours later, those winds will have likely moved to your location.

Call FSS the morning of the launch for current winds aloft. You can then get a pretty good idea of where it's going to go so your chase crew can position themselves accordingly.

Call the FSS as soon as you launch and give them your estimated climb speed. They probably won't need to hear anything else from you until the balloon goes above 60,000 feet. Once above 60k, you're in uncontrolled airspace and the FAA doesn't have to worry about you, so tell them when you pass 60k. Call them again when you descend below 60k and when you land.

The Launch Mechanics

First of all, you need to know how much gas to put into the balloon. What you want is enough gas to lift the balloon, your payload, radar reflector and parachute plus six ounces to one pound of extra lift. One pound of extra lift will give you about a 1000 foot per minute initial rate of climb. This will give you about a 2-3 hour ride to 100,000 feet. On a very calm day with slow winds aloft, you can put in six ounces of lift and get a longer trip up and more usable time at high altitude. Here's the WB9SBD method of achieving the desired amount of lift:

1. Construct a simple scale by suspending a strong rod from a rope tied around its middle.
2. Hang your payload, parachute, radar reflector, suspension cables and EVERYTHING else that will fly EXCEPT the balloon to one end of the rod.
3. Hang a one or two gallon plastic jug from the other end of the rod.
4. Fill the jug with water until the rod is balanced.
5. Add six ounces to one pound of extra weight to the payload end. (Hint: bread comes in one pound loaves - a WB9SBD discovery)
6. Add enough water to balance the rod again.

You now have a jug of water that weighs exactly as much as what your balloon will have to lift plus 6 to 16 ounces extra.

FILLING THE BALLOON

Fill the balloon indoors or in an area that's very well protected from the wind. You don't want to have to fight the wind because the balloon is very fragile and it will burst. Look for an old barn or airplane hanger. Be aware that the balloon will just barely clear a barn door when it's filled. A home garage door isn't high enough.

Spread a tarp on the ground to protect the balloon and spread the balloon out on the tarp. Handle the balloon with gloves.

Lay the gas tank next to the balloon. (It can't fall over if it's laying on the ground.) The regulator manufacturers recommend that you crack the valve slightly to blow out any dust before screwing on the regulator. Be aware that the threads on hydrogen tanks are "backwards" - you turn them counter clockwise to tighten them. (This gave me a bad moment on my first solo launch.) Run a hose from the regulator to your filling adaptor.

THE FILLING ADAPTOR: This is a piece of plastic tubing wide enough to be a snug fit into the open end of the balloon - 1.5 to 2 inches should do it. PVC pipe is fine. Somehow neck the other end of that tube down to the point where you can attach the hose from the gas tank to it. Also put a hook on the tube - perhaps by epoxying a piece of coat hanger wire to the side of the tube, near the end where the hose attaches. Now tie some twine from that hook to the jug.

Start the gas flowing and the balloon will start to inflate. Try not to get any air into the balloon, especially if you're using hydrogen! When the balloon lifts off the ground, the jug of water will keep it from going anywhere.

Continue to fill the balloon until the jug "just" lifts off the floor. You now have enough gas in the balloon to lift your payload, parachute, radar reflector and connecting cords plus the extra six to sixteen ounces of water you put in the jug.

Sealing the balloon: using heavy twine, tie the balloon neck off tightly above the filling adaptor. Remove the adaptor. Tie the neck again, four to six inches below the first piece of twine. Tie your payload cord to the neck between these two pieces of twine. Now bend the neck over double and tie it again, twice. You will now have the neck of the balloon bent over double, with the payload suspension cord nestled in the bottom of the bend and the whole thing securely tied. You're ready to launch. (You can use tie-wraps instead of twine if you wish, but they're heavier.)

IS EVERYTHING TURNED ON?

Check now! Is your transmitter transmitting? Can you talk through the repeater? Is your GPS sending data? Is your audio beeper beeping? Is your IDer IDing? It's best to have a checklist because you will feel "very" foolish if you launch with something turned off! (Don't ask me how I know this.)

The Launch

Take the balloon outdoors with somebody else carrying the payload and parachute. Stretch the payload out downwind from the balloon, with somebody holding it. You can then just release the balloon or let it out hand over hand until you're holding the payload, then let go. It's best if people hold the payload, parachute and radar reflector to keep them from being dragged along the ground. Now call FSS and let them know you've launched.

The End

Oops, deadline's up and this has to go out. I remind you once again that this is version 1.0 of the BALLOON FAQ. I promise you that I've left things out and made mistakes. If you have additions, corrections or criticisms, please send them to:

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djmullen@facstaff.wisc.edu   e-mail (webmaster note: dead email address left for reference)
n9ltd@WD9ESU.EN53IE.WI       packet
(608) 249-7130               Clear Skies BBS
Dave Mullenix, 2502 Brentwood Pkwy, Madison, WI 53704  Snail Mail
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end of faq
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