CHAPTER TEN

Launch Procedures

"It takes a stranger person to get up at five in the morning to go to Manhattan to chase a balloon across the state"
- Keith Dickinson (KC0USA)

Chapter Objectives

1.0 The Flight Readiness Review (FRR)

A discussion about readiness to fly a mission is called the Flight Readiness Review. The FRR is held a day or two before a launch (The TVNSP FRR includes a dinner get together of those involved with the mission) and can be broken into the following parts, a mission brief, final assembly, equipment preparation, and checklist completion. Feel free to adapt the FRR to your needs.

1.1. The Mission Brief

The goal of the mission brief is to familiarize the crew with what is to occur with the mission. Telling those assembled the goals of the mission, familiarizing them with the near spacecraft, and sharing the mission plan gives them the mission plan.

1.1.1. Mission Goals

Share the goals of the flight by explaining the experiments onboard the near spacecraft. Even if they are not involved with the construction of the capsules, or responsible for an experiment, it still gives everyone a greater chance to feel involved. It can be exciting for new participates to see the whole picture of a near space mission.

1.1.2. Near Spacecraft Familiarization

This is the time to formally introduce the near spacecraft. Let everyone know if there are any longer than usual projections on the modules, an umbilical to connect, special orientation of the modules, or other features they need to be aware of during the morning of launch.

1.1.3. Mission Plan

A mission plan should brief on at least these topics.

- Predicted Flight Path
- Launch Site And Time
- Planned Driving Course
- Communication Frequencies
- Recovery Procedures

Predicted Flight Path

Begin running predictions for the mission from several days to a week before the launch (predictions more than a week in advance are not very meaningful). Bring the latest winds aloft prediction to the FRR and run it through Balloon Track during the FRR. Be sure new crews see this process, as they may need to run the Balloon Track program, themselves someday. Pay attention to cases where the near spacecraft is predicted to descend over, or land in, undesirable locations. See Chapter Twelve, Section Three for information on making flight predictions. After making the prediction, copy the predicted flight path file to the PC's of crews wanting to see the predicted flight path (see Chapter 12, Section 3.2 for directions on making this file). One more function of flight prediction during the FRR is to determine the balloon's desired free lift or PPL based on the flight predictions (be sure to write down the final desired PPL).

Launch Site And Time

Depending on the predicted flight path, you may need to select a new launch site. Make sure everyone knows if there is a new launch site and that they have the directions to get there. TVNSP tends to have everyone met at an easy to find location and them caravan to the launch site. Before the FRR, check the time of sunrise for launch day. Arrange to meet at the launch site at the appropriate time (usually an hour before sunrise for most launches). Crews need to determine how long it will take them to get there.

Planned Driving Course

Once the launch location and recovery zone are identified, chase crews need to plan their driving course. Ideally chase crews take fast roads to get ahead of the balloon. With any luck, slow roads are never traveled, or if they are, only at the very end of the chase. Keep repeater coverage in mind when planning the driving course.

Communication Frequencies

Now that a driving course has been planned, determine chase frequencies. Use repeaters where possible. You'll be surprised at the people who listen in or even talk with the chase crews during a mission. Be sure there's no problem with the chase crew using a repeater before the mission (usually there isn't). Have chase crews program their HTs and mobile radios for any new repeaters. Also decide on a simplex frequency to use when out of repeater range and stick with it!

Recovery Procedures

Depending on the payload flown on the mission, the shut down procedures for the near spacecraft may change. The presence of a life science experiment on the manifest is an example where new shut down procedures may be required. Since it's not known who will arrive at the recovery site first, make sure everyone knows the updated shut down procedure. For most flights, chase crews are to leave the near spacecraft where it recovered, unless it is a danger or in danger. We like to give everyone a chance to see the near spacecraft where it recovers. See the recovered near spacecraft gives them more encouragement to participate in future missions. There's not a lot more discouraging than to drive three hours after a flight only to have everyone tell you to meet them at lunch because they have already removed the near spacecraft. Be sure to get an on-site photograph of the entire chase team with the recovered near spacecraft.

1.2. Final Assembly

Often there are module related tasks that cannot be completed until the night before launch. The following list is an example of the final tasks best completed at a FRR.

- Module Completion
- Final Weight
- Final Function Test
- Comm Check
- Initial Styro-Fill (if possible)

1.2.1. Module Completion

Most of the modules are completed and tested well before launch. However some items like Thermochrons and some cutdown devices should be programmed the night before launch, rather that several days in advance (once the expected time of launch has been determined). Loading life science experiments is another example of items that must wait until late in the launch cycle. As more people get involved with constructing the modules of a near spacecraft, the more often someone won't be able to have their piece of the flight ready early in the build cycle. Be sure to install any Remove Before Flight tags on items like cameras and beacons. The bright red tags help prevent near spacecraft from being launched with a silent audio locator beacon or a closed camera lens (KNSP and TVNSP has done both).

1.2.2. Final Weight

A final weighing of the capsules, with their batteries included, needs to be made and recorded (don't depend on memory). Now's the last time you will have to make changes to the launch manifest if one of the capsules turns out to be overweight (making a manifest change the morning of launch can be disastrous, so do it no later than the night before). Be sure things like mementos and QSL cards are onboard the modules before making the final weight. Along with recording the total weight of the modules, add the weight of the parachute, an FTU (if used), and any other recovery aids, like beacons. Finally add the desired PPL of the balloon and write the total where it won't be lost overnight. Balloon Dogs need this information the morning of the launch.

1.2.3. Final Function Test

Now that the capsule is in its final assembled state, it's a good idea to download a test program into the flight computer and exercise all capsule functions (I don't always do this, but should). Run the test program for everyone present to see, rather than running the test program the morning of launch when the Closeout Crew can do nothing about malfunctions. Having several people present to observe the test gives the mission that many more opportunities to identify problems before it's too late. Connect the link lines to the modules and check that the spacing between modules is not greater than the spacing permitted by the umbilical between the modules.

1.2.4. Comm Check

The Chase Vehicles planning to go on chase should be present at the FRR to run the Comm Check on the near spacecraft. During the Comm Check, chase crews verify that their trackers see the near spacecraft on APRS. Verification involves two things, first is that the location of the capsules is valid (the GPS has a proper lock) and second that Chase Vehicles can display good data from the capsules.

1.2.5. Initial Styro-Fill

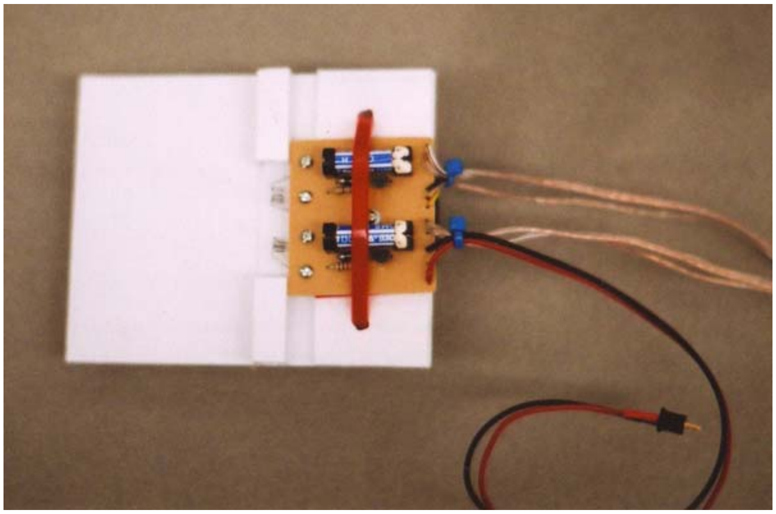
Finally, if possible, begin filling the modules with Styrofoam peanuts. An airframe designed with a battery compartment often can have its lower compartment filled with Styrofoam peanuts at the FRR.

1.3. Equipment Preparation

The FRR is the time to check over the launch equipment. For instance, make sure everything is packed and none of it is missing. Be sure someone has the balloon (or balloons) and someone is planning to haul the helium tanks (if they are not already at the site). Finally items like the parachute can be untangled and packed and any flight termination units (FTU) can be prepared.

Parachute
No matter how careful chase crews are with the parachute at the recovery site, the shroud lines will be tangled before the parachute makes it home. The parachute should be stored indoors with its shroud lines untangled. But it probably won't be, since there are a lot of things to do after the flight. Appoint two or three people to untangle the shroud lines during the FRR. Tie several twister seals on the shroud lines once they are untangled. Then carefully repack the parachute into its carrying case.

Flight Termination Unit
Cut a few feet of nylon load line and melt the ends of the cord to keep the ends from fraying. Pass one end of the cord through the swivel at the parachute apex. Double over that end of the cord and tie an overhand knot. Further secure the knot by applying a wrap of duct tape over the knot. Do not wrap the tape over the bearing in the swivel; only apply tape to the metal ring of the swivel, as the bearing must be free to spin. Check the shape and form of the nichrome coil in the FTU PCB. The coil should be a regular cylinder and large enough that it does not bind the nylon cord passing through it. Also check for continuity between the coil pads of the FTU PCB (this shows there is no electrical break in the nichrome coil). Thread the free end of the nylon cord through the nichrome loop. If it is less than 24 hours from launch, then set the termination time on the stopwatch. Double check that the set time takes into account AM and PM. Close up the FTU inside of its box and verify the nylon cord is free to move through the nichrome coil and box. Double over the free end of the nylon loop and tie an overhand knot in that end. Secure the knot with a second strip of duct tape.



Flight Termination Unit

1.4. Checklist Completion

Complete And Verify Checklist
Every mission needs a checklist. The checklist for the near spacecraft begins during the development of the modules for the mission. The final draft of the checklist usually isn't developed until the FRR. Review the entire draft of the checklist during the FRR. Consider even practicing the checklist on the assembled modules during the FRR so errors can be detected and corrected.

A good checklist includes flight configuration (where every experiment is mounted, both mechanically and electrically) and a step-by-step procedure of how to power the capsules and test them. A sample checklist is included in this section

1.4.1. Sample Checklist

John Stone (K7JPS) developed the following checklist for TVNSP Flight TV02F

Treasure Valley Near Space Program
Pre-Flight Checklist

Latitude
Longitude
Elevation
Dry Bulb
Wet Bulb
Launch Time

Record Launch Site conditions above

Relay Launch Site information to Mission Control when communications is available

Connect Link Lines between modules

Verify Dacron straps are securely inside the split rings

Connect Umbilical between modules
Shutter release – green wire to green wire

Servo cable – black wire to black wire

Tape Umbilical connection

Connect and measure batteries in Module One

Main Power (four lithium "AA" batteries) - volts
TNC Power (alkaline nine-volt battery) - volts
Servo Power (four alkaline "AA" batteries) - volts
Radio Power (four lithium "AA" batteries) - volts
Audio Beacon Power (alkaline nine-volt battery) - volts

Connect and measure batteries in Module Two

Camera Power (lithium 2CR5 battery) - volts

Styro-Fill Module One

Secure Module One hatch

Check placement of temperature sensor cables in MLI experiment

Styro-Fill Module Two

Secure Module Two hatch

Open camera lens cover

Photographically document capsules (from two angles)

Complete Balloon Fill

Power up Module One

Main Power switch
TNC Power switch
Servo Power switch
Radio Power switch

Power up Module Two

Main Power switch

Verify valid APRS data from Module One

Verify valid APRS data from Module Two

Begin raising balloon

Open module straps on Launch Stand and remove modules

Power up Audio Beacon

Raise balloon until modules are suspended

Release first lanyard and pull free of stack

Release second lanyard

Record launch time above

Now inform everyone, through email and over amateur radio, about the results of the FRR. You should inform people of the following.

- The expected time and place of launch
- Directions for tracking the flight
- Note: This is usually over APRS or on http://maps.findu.com
- The repeaters and frequencies the chase team expects to use
- When and where the near spacecraft is predicted to recover

Now get some sleep, you have a busy day ahead, one filled with excitement and adventure.

2.0 The Near Spaceport

As it is with real estate, so it is with amateur near space exploration. The three most important aspects of an ideal near spaceport are location, location, and location (and in that order). A great near spaceport is a large building with tall doors, surrounded with a large field containing few trees or power lines, has low traffic and distant neighbors, and is a secure at night and early in the morning. Barring that, you'll find ways to make due with less like TVNSP.

2.1.1. Balloon Filling Building

If at all possible, fill the balloon indoor where breezes cannot buffet the balloon when it's near the ground. It's difficult enough to accurately determine a balloon's lift when the winds are knocking it around without having to worry about the balloon being blown into a sharp object. Launch crews can successfully fill balloons outdoors if it is necessary, but doing so adds additional risk. Besides, filling the balloon indoors usually means the temperatures are more comfortable. It's helpful if the selected building has power and lights so you can work safely around the balloon as you fill it at oh-dark thirty. As long as the balloon is filled with helium, you needn't worry about the building's electrical systems. However if you decide to fill the balloon with hydrogen (which I strongly discourage), then the building's electrical system must be sealed and explosion-proof. The building also has to be able to safely vent any escaped hydrogen (that means it must vent quickly).

Filling a balloon inside a building requires the building to have doors tall and wide enough to safely pass a filled balloon through out without rupturing the balloon envelope. Sometime when you meet me, ask about trying to get an inflated balloon through a door that was too small. Ideally the building needs at least ten-foot high doors with twelve-foot high doors being better. The doors can be narrower than they are tall like the balloon. Note that doors narrower than eight feet will not work. Ceilings inside the building need to be at least twelve feet high to safely fill the balloon since an eight-foot tall balloon will be filled with its nozzle a couple feet above the ground. The distance between the walls and the sides of the balloon must be several feet as crews have move around the balloon.

So what kinds of buildings make good balloon-filling buildings? Large industrial buildings or truck repair garages are good buildings. They tend to have large volumes, high ceilings, and large doors for moving equipment in and out. Buildings used to park buses or road-clearing equipment are other options.

An ideal building

2.1.2. Launch Field

Besides the size of the building and its doors, there are several concerns about the region surrounding the building. These concerns also apply when filling balloons out of doors. After the balloon is filled, it must be taken out of the building for launch. The further the balloon is carried away from the building, the greater the risk of damaging the balloon. To reduce the risk, the building needs to have enough open launch field surrounding it that the stack can be launched as soon as it's outside the building. The launch field must be clear of nearby obstacles like other buildings, trees, and fences. Be assured that if there's more wind at launch than planned, those winds will carry the stack into the nearest tree.

In addition to our desire to launch a near spacecraft without damaging it, the FAA requires the balloon to be launched in a way that doesn't create a hazard to uninvolved people and their property. So the launch field must be sufficiently large that the balloon will be high enough for the parachute to safely land the near spacecraft should the balloon burst over private property. Fortunately the balloon goes pretty much straight up after release and with very little horizontal drifting if launched in light winds. If the winds are not light, you shouldn't be launching a big balloon anyways. High surface winds burst balloons, rip balloons from stacks, or drag capsules into trees and fences. Select a launch field located away from major traffic. The sight of a large weather balloon being launched may distract drivers passing by.

2.1.3. Security

Finally there's the issue of security. If possible, bring the launch equipment and near spacecraft to the launch site the night before launch for final assembly, closeout and testing. There can be enough confusion the morning of launch without also having to closeout the capsules and test the avionics while filling the balloon and assembling the stack (although, many times this is the only option). The cost of launch equipment, the near spacecraft, and the tanks of helium require you to lock the building when crews leave for the night. If security is not available then transport the launch equipment and assembled near spacecraft modules the morning of launch. Be sure to transport the modules without breaking its booms and experiments.

3.0 Balloon Filling Procedures

It's finally the morning of your first launch. Last night's Flight Readiness Review (FRR) tested the avionics, selected the launch site, assigned tasks to launch crews, determined chase roads, and selected the launch time. Everyone has arrived at least an hour before launch to prep and launch the stack. Brought to the launch site is the following,

- The module(s) of the near spacecraft
- The balloon (and a backup)
- Film and batteries
- An assembled FTU (if used)
- The parachute (wrapped in its own bag)
- Bags or boxes of launch equipment
- Two or three tanks of helium
- Two or more chase vehicles with APRS

After looking everything over it's decided all is go for this mornings launch. So what's next?

This section applies to filling latex weather balloons and not polyethylene balloons. The procedure outlined here safely fills the balloon with helium.

3.1. The Latex Weather Balloon

Kaymont and Kaysam mail their latex weather balloon via UPS or Fed Ex packed inside of a cardboard box. There's minimal packing material around the balloon, so be careful when you open the box. It's difficult to rip the tape off the box, so when using a knife to open the box use a short bladed knife like an Exacto knife. Cut just the tape and do not stick the blade into the box, as you don't want to cut or nick the balloon trying to open the box. The balloon is stored inside a plastic bag that is tied shut with a rubber band. The balloon is vacuumed out before being rolled into a bundle and packaged. By removing the air from inside the balloon the balloon can be packed into a smaller volume. A balloon can be stored for over a year before being used. When storing the balloon long term, keep it in its box and out of the Sun. However it's best if you don't order the balloon until you need it. When exposed to air the latex of the balloon begins to age more rapidly. So do not open the bag until the morning of the launch. If it is later decided not to launch the balloon, roll the balloon up with gloved hands and put it back into the bag. You'll find the balloon is covered in a talcum powder. While filling the balloon the talcum powder remains on the balloon, but, if the helium is let out of the balloon, then a cloud of talcum will accompany the helium. So be careful not to inhale the helium venting from a balloon.

3.2. Ballooning Filling 101 For Balloon Dogs

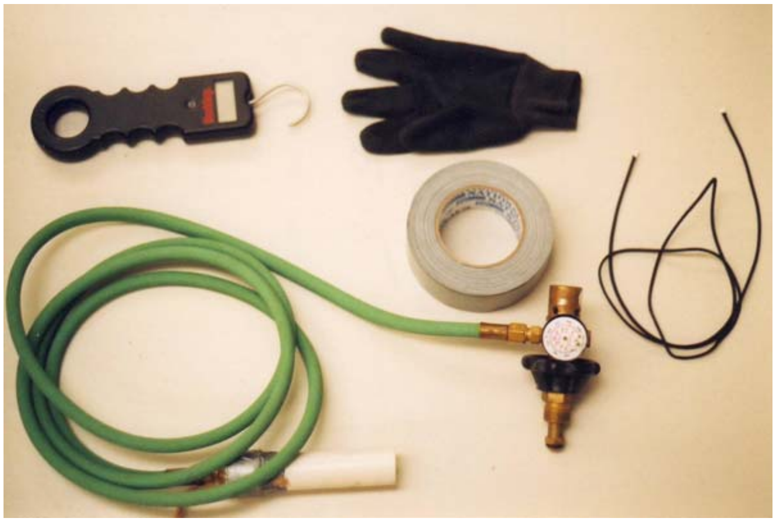
Read the procedure outlined in this section. Then practice the procedure before you launch your first balloon. However, feel free to modify these procedures if needed for your near space program. Whatever changes you decide to make, document and practice them before launching your first near spacecraft. TVNSP makes it a policy to review launch procedures every year at the beginning of the year's near space campaign.

Remember that a filled balloon will be worth over $100. So it pays to be a little paranoid around them. Bursting a balloon on the ground can end a near space mission real fast.

3.2.1. Laying Out The Equipment

√ Lay out the ground cloth (sewn bed sheets) and a tarp beneath the bed sheets if needed
√ Lay the helium tanks near one end of the bed sheet
√ Roll the tanks against each other with their valves on the same side
Note: Never leave the tanks attended standing up or with their caps removed
√ Lay out kneepads (if needed) near the tank valves
Note: Most balloon filling work takes place near the tank valves
√ Place warning signs near the bed sheets if you feel a need to use them
√ Place the balloon and equipment bags (boxes) near the tank valves
√ On the bed sheet, near the helium tank, leave the electronic scale and duct tape.
√ Keep all other work away from the balloon filling area
√ Have the Balloon Dogs put on soft cotton gloves and remove exposed jewelry and hats that may damage the balloon

Note: When working around the balloon, Balloon Dogs aren't aware of how close they are to the balloon until they bump their hats into the balloon. So have Balloon Dogs remove their hats if they have brims.
Note: Gloves protect the balloon from rough skin and prevent skin oil from getting on the balloon, which may weaken the skin of the balloon.



Balloon Filling Equipment – *note the gloves*

3.2.2. The Balloon Filling Process

"L" size helium tanks typically have over 2000 PSI of gas at the start of filling which is enough helium for the balloon to lift over 12 pounds of payload. Watch the regulator's pressure gauge during the helium dump to get an idea of how much helium remains.

√ Unscrew the tank cap, exposing the tank's valve
√ Screw the regulator into the helium tank hand tight
√ Note: You'll probably have to change tanks during the filling, so keep the second tank next to the first
√ Cut about three feet of sisal cord (the Balloon Loop)
Note: Keep the scissors or knife used to cut the cord away from the balloon
√ Open the balloon bag and unroll the balloon

Note: Toss the trash into the empty box as you go along and keep the clutter to a minimum

- √ Insert the PVC filler pipe into the balloon nozzle
- √ Give the nozzle and pipe a wrap or two of duct tape to keep the balloon from sliding off the filler during the helium dump

Taped Nozzle

- √ Note: The nozzle is the same material as the balloon skin, only thicker, so it's more durable than the balloon itself
- √ Note: Double over the last one inch end of the tape to create a ½ inch tab for removing the tape after the balloon is filled (this really eases the job of tying off the balloon)
- √ Verify the balloon is fully laid out, without twists or being doubled over
- √ Open the tank part way, letting helium slowly fill the empty balloon
- √ Note: The balloon jumps a bit at the start and makes some obscene sounding noises, don't let it startle you
- √ Make sure the balloon is not knotted while it inflates
- √ Once the balloon begins lifting itself off the ground, open the tank more fully, as you still have some 300 cubic feet of gas to dump
- √ Note: It's easy to forget that the balloon is a large sphere when you're working around its base, so watch your head
- √ Don't start measuring balloon lift right away as an entire tank is needed for twelve pounds of lift
- √ Flip the electronic fish scale upside down and let it zero it self out
- √ Note: Use the same scale to weigh the modules as to measure balloon lift
- √ Hook the electronic fish scale to the filler's loop

Weighing Lift with Scale

The measurement from the scale bounces around a little bit, so use the middle value of measurements.

3.2.3. Switching Helium Tanks

If you empty a tank before getting enough helium (the most likely case) you'll need to switch tanks without losing the helium already in the balloon. It takes two Balloon Dogs to switch tanks.

- √ Shut off the helium tank
- √ Balloon Dog One grips the nozzle of the balloon and squeezes tightly

***Death Grip on Balloon Nozzle** – by Balloon Dog One. while Balloon Dog Two unscrews the regulator. Author, sans gloves, secures helium tank.*

- √ Balloon Dog Two unscrews the regulator from the tank
- √ Then remove the cap from the second tank
- √ Then screw the regulator into the second tank only hand-tight
- √ Balloon Dog One now release the balloon's nozzle
- √ Balloon Dog Two verifies the nozzle has been released before opening valve
- √ Note: Opening the second tank while the nozzle is still gripped will inflate the nozzle, possibly popping it off the filler
- √ Open up the second tank and continue filling the balloon
- √ Recap the first tank

3.2.4. Notes On Balloon Lift

The helium-filled weather balloon must lift itself, the capsule, and parachute. However, if you stop here, the near space stack is neutrally buoyant and will not rise off the ground. So extra helium must be dumped into the balloon before it is sealed. This lift generated by this extra helium is called the balloon's positive lift or free lift. KNSP filled its balloons with about one pound of positive lift (or one PPL). So KNSP balloons usually lifted one pound more than the total weight of the payload. TVNSP currently fills its balloon to at least two PPL. At 0.5 PPL the ascent rate is only about 300 feet per minute, which make s a very long flight. At one PPL the near space stack ascends at a rate of about 700 feet per minute. Ascent speeds of over 1000 feet per minute are possible with balloons filled to two to three PPL. The greater the PPL, the faster the ascent rate and the less distance the flight covers. A balloon is a high drag structure; therefore there is a limit to how fast it can ascend, which places limited on the usefulness of adding large amounts of PPL in increasing ascent rates.

A rapid ascent rate is most important when the jet stream is positioned overhead. The less time the balloon spends in a wind stream, the less distance it travels and the easier it is for chase crews to keep up with it (invariably, the jet stream never travels in the same direction as fast roads). Tuning the ascent rate with positive lift is important when the flight is predicted to recover in a less than favorable location. In those cases it may be necessary to extend or shorten a flight. One final consideration is the effect of PPL on the maximum altitude reached by a balloon. It should be apparent that if you fill a balloon with more helium (give it a greater PPL), the balloon's initial volume is greater. Expansion during ascent has less available volume to work with before the balloon bursts, reducing the balloon's maximum altitude. So we can conclude that a faster ascent rate also decreases the maximum altitude of the balloon. However, does the increased ascent rate strongly affect maximum altitude?

Let's say it takes 300 cubic feet of helium to make a near spacecraft neutrally buoyant. To give the balloon one PPL requires you add 14.25 cubic feet of helium. To give the balloon two PPL requires an additional 14.25 cubic feet of helium, or 28.5 cubic feet of helium over the neutrally buoyant condition. At one PPL, the stack ascends at about 700 feet per minute and at about 1200 feet per minute if given two PPL. So to give the balloon two PPL, which roughly doubles its ascent rate and halves its travel distance, requires an increase in initial volume of 4.75% over the one PPL balloon. Now the volume of the balloon must double for each additional 18,000 feet increase of altitude. So a 4.75% change in initial volume is not going to decrease the maximum altitude of a balloon significantly. Here's the take home message. Do not hesitate to add additional helium if you really need to bring the near spacecraft down sooner as you won't be changing the maximum altitude of the balloon significantly. In fact, latex balloons are not consistent from balloon to balloon. One time you may get a balloon with a slightly thinner spot that ruptures sooner and the next time you may be more uniform balloon that ruptures later. The variation from balloon to balloon has a larger effect on the balloon's burst altitude than the amount of helium you dump into the balloon to change the ascent rate by 500 feet per minute. However, the travel distance of a balloon is strongly influenced by the PPL of the balloon. A two PPL flight will travel only about half as far as a one PPL flight.

One additional complication occurs when filling the balloon outdoors. Even the slightest breeze throws off the scale measurements of balloon lift. To guard against an underfill in these conditions, TVNSP (which fills their balloons outdoors) shoots for four or five PPL when they fill balloons for their large missions.

For most flights, where the near spacecraft weight is near the maximum weight (twelve pounds), two PPL is fine (but there's nothing wrong with more PPL). However, if you have a very lightweight near spacecraft, say around three pounds, and a very large balloon then you should have more PPL. Very large balloons carrying very lightweight near spacecraft risk becoming neutrally buoyant. Even if you are using a flight termination device, I don't recommend risking a neutrally buoyant flight. So I recommend going with at least four or five PPL on a very light near spacecraft.

The following goes into calculating the amount of lift needed by the balloon.

- The total weight of each module making up the near spacecraft
- The weight of the parachute
- The weight of any FTU or other recovery system beacon
- The free lift or PPL of the balloon (at least two pounds)

The closeout crew determines the total weight of all modules in the near spacecraft at the FRR. The weight of the parachute was determined when it is first constructed and is documented on the shroud. Like the parachute, weights of FTUs or other recovery aid was determined when the unit is first constructed and is documented on the unit. The desired free lift of the balloon is determined during the flight prediction at the FRR (See Chapter Twelve for instructions about making flight predictions). The final desired lift of the balloon must be written down where the Balloon Dogs can see it.

Did you notice that we're not concerned with the weight of the balloon when calculating the desired lift of the balloon? When the Balloon Dogs measure the lift of the balloon, the helium inside the balloon tares the weight of the balloon.

Begin checking the balloon's lift more frequently when it's close to the desired lift. Make measurements with the helium flow shut off to let the scale-reading settle down. Along with measuring the balloon's lift, you're also weighing the weight of the filler nozzle and hose, so have as little hose as possible suspended beneath the balloon. When the balloon has the desired lift, prepare to tie it off. Note: If there's more helium than desired inside the balloon, don't attempt to bleed it out. It's less trouble to launch a balloon with extra helium than to try to get the amount of helium exactly right. Besides, the more you fiddle around with the balloon, the greater the risk of damaging it.

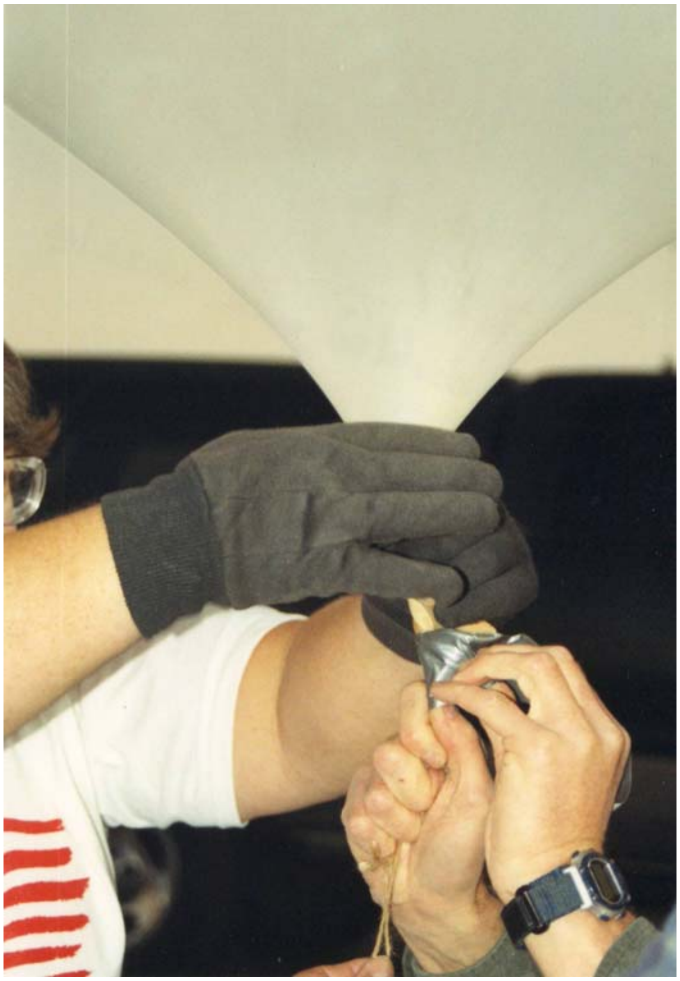
3.2.5. Balloon Tie-Off

Once the balloon is filled to the required lift, follow these procedures.

- √ Balloon Dog One firmly grasps the balloon nozzle (neck) above the filler pipe
- √ Note: Grab tight, you don't want helium escaping
- √ Balloon Dog Two carefully removes the duct tape sealing the balloon nozzle to the filler pipe
- √ Then slides the balloon filler out of the nozzle and get it out of the way
- √ Then twists the balloon nozzle below Balloon Dog One's grip

The NSTAR Alternative Method

- √ Balloon Dog One rotates the balloon above the nozzle with a gloved hand
- √ Balloon Dog Two carefully removes the duct tape sealing the balloon nozzle to the filler pipe
- √ Then slides the balloon filler out of the nozzle and get it out of the way

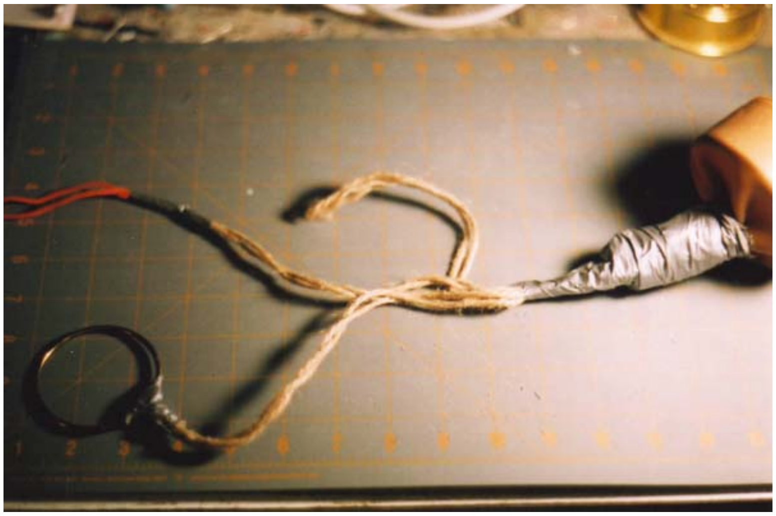


Balloon Tie-Off

- √ Double over the sisal cord and tie it around the twisted nozzle with an overhand knot
- √ Note: Leave a loop of cord hanging down from the knot to form the Balloon Loop
- √ Fold the twisted nozzle in half, trapping the loop's knot and free end of the cord inside
- √ Wrap the nozzle up in gray tape

Taped nozzle and loop

- √ Note: Seal the nozzle and knotted sisal completely; none of it should be exposed from beneath the tape
- √ Note: The loop end of the sisal is left sticking out of the bottom of the tape
- √ Note: Remember you only have a few PPL, so don't use one pound of duct tape to seal the nozzle and loop
- √ Cut another piece of sisal, three feet long (the lanyard loop)
- √ Fold it over and attach the lanyard ring with a Lark's Head knot



Ring on Loop with Lark's Head Knot

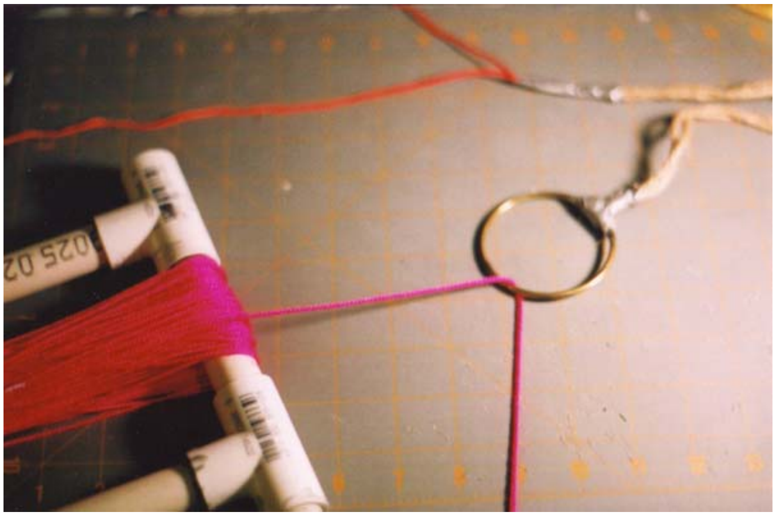
- √ Rotate the joint in the Lanyard Ring so it is located under the Lark’s Head knot
- √ Apply a strip of duct tape around the Lark’s Head knot and the joint in the ring

Note: The Lanyard Ring is made heavy wire bent into a ring and the ends butted together. The joint may or may not be welded together. This leaves a rough spot to snag the lanyards. To protect the lanyards, the joint is rotated beneath the knot and wrapped in a little duct tape. The Lanyards are not to pass over the joint or the tape.

- √ Tie the lanyard loop to the balloon loop, leaving the lanyard loop hanging about one foot below the bottom of the balloon loop

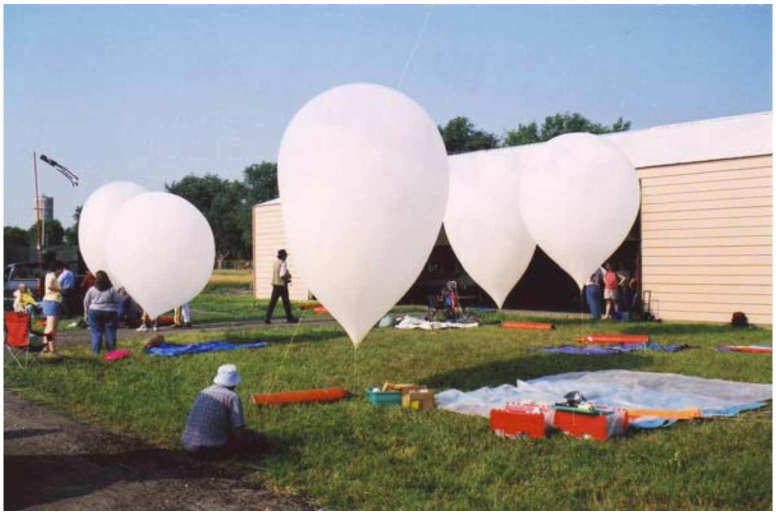
Tied Lanyard Loop

- √ Wrap a layer of duct tape around the knot of the lanyard loop (wrap every knot in tape)
- √ Tie the load line from the parachute to the Balloon Loop
- √ Note: The Load Line is tied next to the Lanyard Loop with a small gap between them.
- √ Unwind a few feet of cord from the lanyard winders
- √ Pass the lanyards through same side of lanyard ring as explained in Chapter Nine, Section 2.3.4.



Lanyards passing through lanyard ring

- √ Assign three individuals to handle the lanyards
- √ Keep the lanyards close to the balloon and keep them from unwinding
- √ Slip the loop of cord over the end of a helium tank valve and let the 150-pound helium tank hold down the balloon as Balloon Dog One probably has a fatigued arm by now
- √ Take a few moments and admire your work as you're half way to launch



Admiring the work

4.0 Near Spacecraft Closeout

Typical activities for the Closeout Crews are as follows

- Set up the Launch Stand
- Strap Modules To Launch Stand
- Connect Flight Batteries
- Assemble Boom Extensions And Antennas
- Connect Link Lines And Umbilical Between Modules
- Power Up Near Spacecraft
- Verify Valid GPS Fix
- Measure And Document Battery Voltages
- Complete Final Styro-Fill

If the morning's mission is just to launch an APRS tracker, then the Closeout Crews have a simpler list of activities to complete. Avoid at all costs, last minute changes to the near spacecraft unless the near spacecraft has failed due some broken item.

Set Up Launch Stand

The Launch Stand is very useful, not absolutely essential. If your team uses one, then have the Close Out crew set it up first. Make sure it's reasonably level then place a sand bag or bag of traction sand at the base to stabilize it.

Strap Modules To Launch Stand

Place each module on its tower platform and confirm the modules are aligned with each other properly. Usually this means the umbilical face of each module is aligned with each other. Now strap the modules to the tower. Don't be in such a hurry to skip this step. Closeout Crews move constantly around the Launch Stand and near spacecraft modules and may bump into them. Strapping the modules to the tower helps prevents an accidental knock-over from ending launch preparations.

Connect Flight Batteries

Flight batteries must be stored in a warm location over night. Cold-soaking batteries over night leaves them below their capacity at the time of launch. Don't give the cold of near space a head start on weakening the batteries. Store the warm boxes for each battery in a warm location also.

Assemble Boom Extensions And Antennas

Mount long boom extensions and antennas after the modules are strapped to the Launch Stand. Depending on the distribution of weight, modules may be unstable with their booms, so make sure the modules are strapped in the Launch Stand. Antennas and long booms can snap a passerby. This may be a justification for purchasing blinking LED beacons. Leave them attached to any possible arm catcher until just before lanyard release.

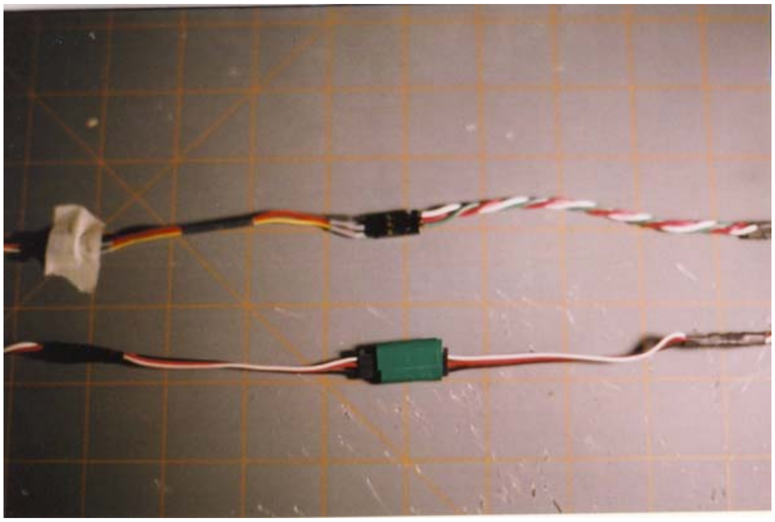
Connect Link Lines And Umbilical Between Modules

Select four identical length link lines for each pair of modules in the near spacecraft and connect corners of two neighboring modules. Verify that the split rings on the corners of the modules are still fully on the Dacron loops of the abrasion jackets. It's very easy when connecting link lines to begin rotating the split ring out of the Dacron loops (a slipped ring). Have a second person go back and verify all the link line connections are good.

Ring Securely Attached

A Slipped Ring

Connect the umbilical between modules if there is one for the mission. Watch the polarity of the connections closely. Sending servo power to an experiment may leave a trail of smoke emanating from the near spacecraft after launch. After making the umbilical connections, cut or rip a one inch long by ¼" wide strip of duct tape and wrap it around the plastic housings of the connected umbilical. The tape prevents the weight of the umbilical from pulling itself a part, especially during descent.



Umbilical - *Untaped example at top, properly taped umbilical on bottom*

Power Up The Near Spacecraft

Flip power switches on the near spacecraft and verify the near spacecraft starts up properly. If a PC or laptop is available at the launch site, the Closeout Crew can download and run a program to test the operation of the near spacecraft. The test program is one last opportunity to verify all connections are made correctly. If you decide to run a test program as part of Closeout, then be sure to reload the mission flight code. Launching a near spacecraft with a test program may look neat, but its murder on getting experiments completed. Double check the program slot the program is being downloaded into (if applicable). Do not shut off power to the near spacecraft until recovery. Write flight code that takes into consideration that the near spacecraft may sit on the ground a while before it is launched.

Verify Valid GPS Fix

If Closeout takes place inside a building, then it will most likely be necessary to carry the Launch Stand outside to perform the GPS verification. More than one person needs to be involved with moving the tower. Check at one of the chase vehicles that the position of the near spacecraft is displayed properly. It may take a couple of minutes for the GPS to determine its correct location, so be patient. Chase vehicles should begin logging data at this point. If there is no valid fix being displayed, check that the HT power is on, that the HT is transmitting, and that the GPS receiver is properly connected.

Measure And Document Battery Voltages

Measure the voltage of each battery only after they have been used for a few minutes (if possible) because a measurement under load is a more accurate reflection of battery condition. Record the battery voltages. After recovery the recorded voltages are used to "scale" the flight data battery voltage readings.

Complete Final Styro-Fill

Completely fill the modules with Styrofoam peanuts after testing and once it's known the modules won't need to be opened until after recovery. Use only clean Styrofoam peanuts to fill the battery compartment of each module (and avionics compartment if it isn't already filled). Using a frame to hold the mesh laundry bag of peanuts open makes the Styro-Fill easier. Clean peanuts from a previous flight can be reused. Avoid using peanuts that got dirty falling by on the ground. Also avoid using biodegradable Styrofoam peanuts. These wheat starch-based peanuts dissolve in water. With them, you could find your airframes filled with a gooey mess.

Filling module with packing peanuts – *Note the peanut bag*

If power is available on-site, you may want to consider warming the module interiors with a handheld hair drier. Warming the modules is important (but not critical if using lithium cells) when the modules must be left outside in the cold air. KNSP's only attempt to warm a module before launch caused no harm to the airframe of avionics. More tests are needed to determine the effectiveness of pre-warming modules before launch. If you decide to experiment with warming module interiors, then use a low setting to avoid melting the Styrofoam peanuts and airframe or softening the hot glue adhesive.

5.0 Assembling The Near Space Stack

Take a step back and admire the filled balloon and assembled modules. Soon they will be united into a near spacecraft and make a flight to 90,000 feet. Pinch yourself, this is not a dream, it's for real. You really are going to send all this work and effort into near space where it will experience an environment unlike anything you've ever seen before. At this point things begin moving pretty fast.

Starting with the modules on the Launch Stand, the stack is assembled as follows. Feel free to change the order.

- The Parachute and FTU
- The Load Line
- Balloon Carryout
- Verify Telemetry

5.1.1. The Parachute and FTU

It is not necessary to use an FTU on each mission. If the mission does not use the FTU, skip those steps.

√ Remove the parachute and FTU from its transportation container
√ Open the FTU and set the timer if it has not been done yet
√ Verify the timer is set correctly in regards to AM/PM
√ Install the FTU battery and close the FTU
√ Remove the twister seals on the shroud lines
√ Connect the parachute shroud lines to the parachute ring, matching shroud line number with the ring's split ring number
√ Verify the shroud lines are not twisted

√ Note: If the shroud lines are twisted, disconnect only one split ring at a time and reconnect the ring before disconnecting the second ring.

√ Link the parachute ring to the top module.

Chute linked to module

5.1.2. The Load Line

- √ Cut 30 feet of load line from nylon cord
- √ Note: There's no need to melt the ends of the nylon cord, as the taped knots prevent the cord from unraveling for the three-hour flight.
- √ Tie one end of the load line to the balloon loop
- √ Note: Tying knots weaken the cords the knots are tied in. To keep the knot from loosening and to keep the load line strong, apply a wrap of duct tape over the knot and where the load line and balloon loop meet.
- √ Tie the other end of the load line to either the free loop of the FTU (if used) or the swivel bearing of the parachute
- √ Apply another strip of tape to the knot to keep if from unraveling or weakening
- √ Note: Do not wrap the tape over the bearing in the swivel; only apply tape to the metal ring of the swivel, as the bearing must be free to spin.

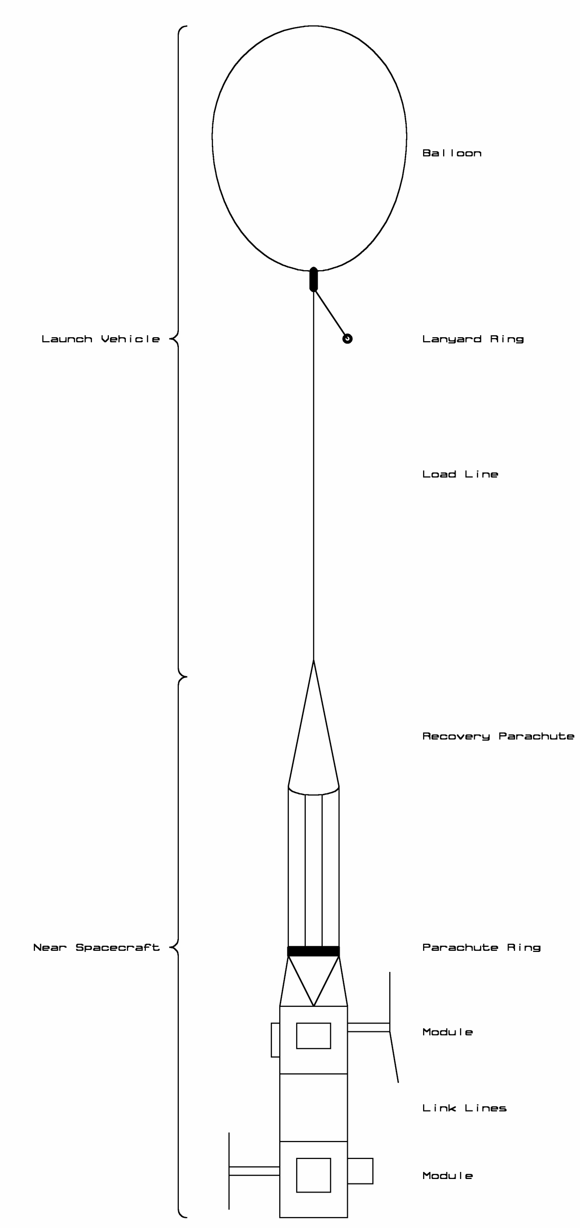


Diagram of Stack

5.1.3. Balloon Carryout

It's time to carry the stack outside of the filling building if one was used. The Balloon Carrier, who is wearing cotton gloves, carries the balloon by grasping the balloon's well-taped nozzle. Launch crews must watch clearances around the building doors; this includes the sides and top. Carrying the balloon outside the door may require the Balloon Carrier to crouch over or even crawl out of the door. Make the process as comfortable for the Balloon Carrier as possible so the balloon can be carried out slowly. Watch that the Balloon Carrier does not head butt the balloon. It doesn't take much of a bump to punch a hole in the balloon. Let the Balloon Carrier know he or she is clear of the building, as they'll probably be hunched over at this point and would appreciate a chance to stand up straight. The Closeout Crew carries the Launch Stand or modules away from the building as the balloon is carried out. Remember there is only thirty feet of load line and parachute between the balloon and modules, so watch the distance between the balloon and Launch Stand. To prevent the load line from being stepped on or tripped over, one or more of the Launch Crew must carry the load line. The parachute requires another person to carry it. Keep the parade tight; you don't want anyone tugging on the load line, balloon, parachute, or modules. Also keep the parade moving slowly. Once outside and away from the building, keep the balloon a short distance away from the Launch Stand and its modules with their antennas.

5.1.4. Verify Telemetry

Check chase vehicles again for telemetry from the near spacecraft. Again verify that a log is being recorded. If the launch site is within repeater range, make an announcement that the launch is about to occur.

The entire stack is completely assembled now. The near spacecraft modules are either on a table, Launch Stand or in the hands of Launch Crew (one module per crewmember). If there's more than one module in the near spacecraft, then the modules are connected with link lines and each split ring is fully looped inside a Dacron loop (no slipped rings). The umbilical connection (if there is one) is covered with a strip of tape. The parachute and ring are attached to the top module and all split rings are fully looped inside their Dacron loops or cords. If an FTU is used, it is secured to the parachute apex with its timer set and battery power applied. Tied and taped to the parachute apex or FTU is thirty feet of load line. Tied at the other end of the load line is the balloon loop, which is securely taped to the balloon nozzle. On the balloon loop is also a two-foot loop of cord with the lanyard ring. Step back a moment and take a breather.

6.0 Raising And Launching The Stack

Several release methods are discussed in this section. Feel free to modify any one of the methods to your needs. Note that everyone involved must wear gloves for protection from string burns.

6.1. Current TVNSP Release Method

Someone must be in charge of the raising. This Launch Director keeps an eye on the balloon's position and directs the position of the crews and the balloon.

- √ Have the lanyard operators tighten up their lanyards before proceeding with raising the stack
- √ Note: They must be holding the balloon down before the balloon carrier can release the balloon or else the balloon snaps up when released. In other words, before release, the balloon carrier is in full control of the balloon. The lanyard operators must be in full control before the balloon carrier transfers control to them by releasing the balloon nozzle.
- √ Position the lanyard operators in 120 degrees arcs relative to the balloon, which is located at their center

Balloon on lanyards – *With rocket looming in background*

- √ The Balloon Carrier can now carefully release the balloon.
- √ The lanyard operators move around as necessary to keep the balloon rising near the Launch Stand
- √ Note: Watch that the raising is not faster than the crews can react and that there is always some slack in the load line
- √ Once the balloon is well above the ground, move it closer to directly above the Launch Stand
- √ The Parachute Handler carefully releases the parachute once the balloon is high enough to begin lifting it
- √ Call a hold and stop the lanyard operators while the Closeout Crew removes the modules from the Launch Stand
- √ Start the audio locator beacon and any other items with Remove Before Flight tags
- √ Before resuming the balloon raising, check that the parachute shroud lines are not wrapped around an antenna or other projection from the top module
- √ Continue raising the balloon until there is no slack between the parachute and the top Module
- √ The first module handler can gently let go of the top module
- √ Note: At this point the bottom module handler continues supporting the bottom module. This person is not be lifting up on the module as much as just keeping it from swinging around.

- √ Lanyard operators continue raising the balloon until the balloon is supporting the bottom module
- √ Before releasing the bottom module, make sure no antenna, line, or experiment is twisted on the link lines
- √ At this point the last handler should be able to release the last module without it wildly swinging around
- √ Continue raising the balloon to give the lower module greater clearance above the ground, but not so high that a launch crew can't grab the bottom module if a problem should occur

Because of lanyard twisting experienced recently by TVNSP, the following release procedure is recommended by the author. TVNSP has been more successful using twisted nylon line than using woven Dacron kite line for their lanyards. Be sure you do not twist the lanyards as you wind them on their kite winders.

- √ All three lanyard operators must have a cutter ready to cut the lanyard if they hang up during release
- √ Identify the first lanyard operator and his or her lanyard
- √ A launch crew grabs the lower module
- √ The lanyard releaser releases the first lanyard from the PVC pipe
- √ Note: The lanyard can be either let to slip off the pipe or cut
- √ The first lanyard operator carefully pulls the lanyard through the lanyard ring
- √ Note: Look for signs of the load line twisting and wrapping the lanyard
- √ When the first lanyard is free of the lanyard ring, the lanyard operator quickly pulls the lanyard away from the stack and calls "clear the lanyard"
- √ Note: If the lanyard does not clear, see if it can be carefully pulled out. If not, then cut the lanyard as high as possible.
- √ Verify the last lanyard operator is ready for lanyard release
- √ Release the last lanyard and carefully pull it free of the lanyard ring
- √ Note: Call "clear the lanyard" once the lanyard is free of the lanyard ring
- √ Note: If the lanyard hangs, call "cutting lanyard" and cut the lanyard at the winder. When the lanyard is cut, then call "lanyard free"
- √ Once the lanyard is free release the bottom module
- √ Record the time of launch for mission elapse time (MET)

Now you can hop into your chase vehicle and pretend you're a part of the movie Twister (although we know that balloon chasing has more adventure and realism).

6.1.1. Notes On Lanyard Release

The lanyard release is the weakest link in launching near spacecraft. Many of the TVNSP launches released lanyards with no one at the bottom module. When the lanyards were released (either singly or at the same time), the near spacecraft rose without catching on the lanyards. But until the problem with lanyard twisting is resolved, the author recommends the lanyards be released individually with a launch crew present at the bottom module. Oh, and you may want that person to wear a hard hat in case the modules pull lose from the load line or an experiment is prematurely released.

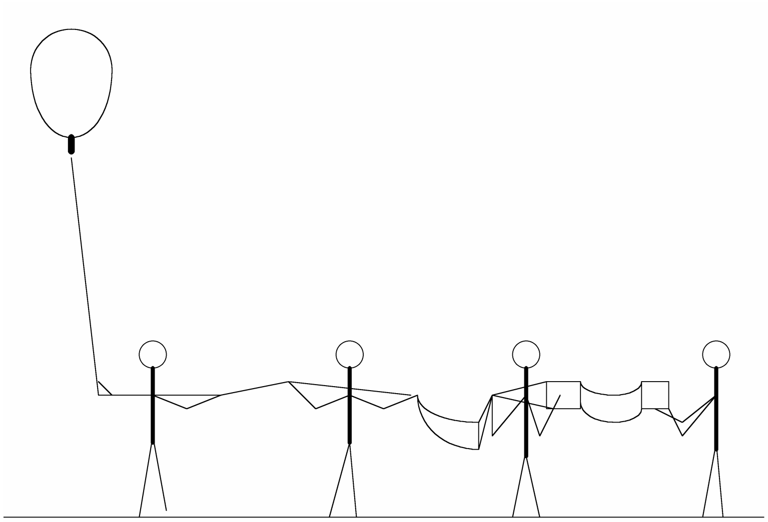
6.2. KNSP Release Methods

KNSP used a combination of two methods for launching near spacecraft. For the first three years balloons were as outlined in Subsection 6.2.1. For its last year, KNSP used the method outlined in subsection 6.2.2. Both methods worked, but the first method is more difficult for the load line handlers. This method should be reserved for launching lightweight near spacecraft using small balloons with small amounts of lift. As an example, a tracker inside a lunch bag and carried by a 300-gram balloon works well with this method.

6.2.1. KNSP's First Release Method

Look at the cover of amateur radio magazine, QST, for the moth of January 1999. On the cover you will see the KNSP launch crew preparing to release a near spacecraft. Note that everyone was wearing gloves (hint hint).

- √ Tie the stack together as normal, but do not attach a lanyard ring to the balloon
- √ Appoint two load line handlers
- √ Spread the launch crew out, each holding a piece of the near space stack
- √ Note: The modules are not on a Launch Stand, each module is held by a launch crew
- √ Spread out the entire stack with the balloon downwind
- √ Begin raising the balloon by grabbing the load line instead of the balloon nozzle
- √ Two load line handlers work the way down the load line by about one foot at a time
- √ Each time the load line is grabbed one foot closer to the parachute, the balloon rises one foot higher
- √ Launch crews fall out of the stack when they reach the load line handlers
- √ Note: Restraining the balloon by just the thin load line is difficult work if the balloon has significant lift, but much easier once the parachute is reached
- √ Continue raising the stack until the load line handlers are at the parachute shroud lines
- √ Load line handlers carefully let tension build on shroud lines as they let the parachute up
- √ Ensure the last module handler is ready to be the only one in control of the stack
- √ Carefully release the parachute
- √ Note: The last module handler on feels the balloon lifting with its free lift or PPL
- √ Release the module



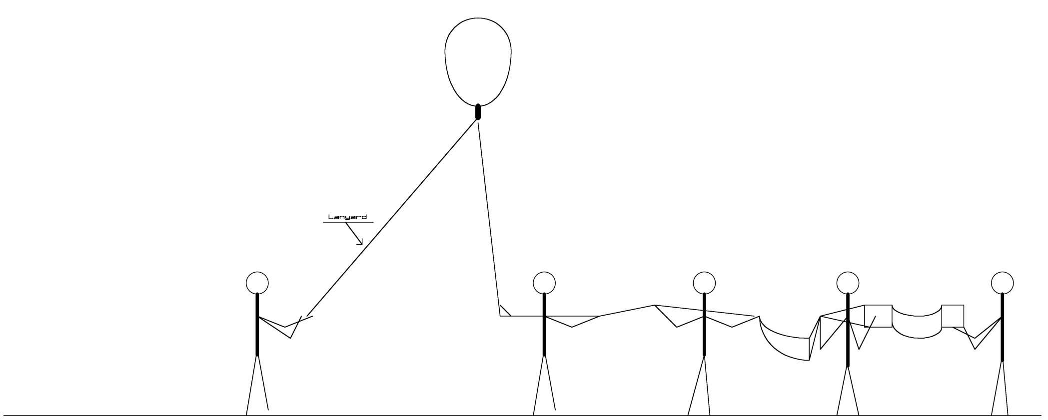
KNSP First Release Method

If there is any wind, the last handler must walk or run downwind with the module before releasing it. While running with the wind, let the module lift from your hands. When you do not run with the wind when releasing the last module, the stack swings like a pendulum below the balloon. This leads to all sorts of havoc should the module swing into the ground before gaining enough altitude to clear the ground or other obstacles.

6.2.2. KNSP's Second Release Method

After experiencing difficulty launching in winds, Dan Miller (KE4SLC) recommended the following release method, which I believe, has been used with SSOK in Salina, Kansas. Remember, everyone must wear gloves.

- √ Tie the stack together as normal, but do not tie a lanyard ring to the balloon
- √ Instead, tie one or two additional cords of additional load line (lanyards) to the nozzle of the balloon
- √ Note: The additional lines were left wrapped on their cardboard cores.
- √ Raise the balloon as outlined in Section 6.1, except no there are no winders attached, the lanyards and the load line is used as the load line is the previous method
- √ Cut the lanyards to length before releasing the near spacecraft
- √ Note: Lanyard handlers still keep hold of the lanyards
- √ Release the near spacecraft by simultaneously releasing the load line and lanyards
- √ Note: The lanyards hang down to the to the modules during the flight, but since there is no weight on their ends, they tend to swing out and away from the parachute, rather than wrapping around it.



KNSP Second Release Method

The first flight this method was used on, successfully launched the near spacecraft in higher winds that KNSP was accustomed to, however, one of the lanyards remained in front of the slow scan camera for most of the flight!

6.3. Other Release Methods

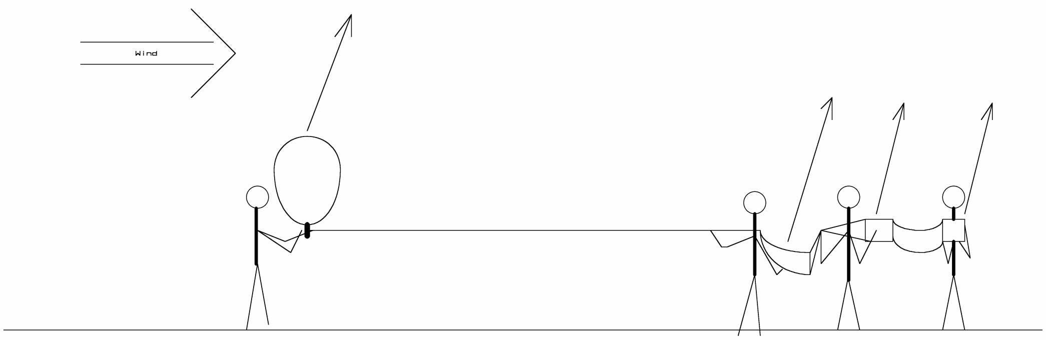
The remaining release methods have been brought to the author's attention by the near space programs, EOSS and HABET.

6.3.1. EOSS Release Method

Sometimes referred to as a Hail Mary launch. Need I mention it again, but everyone wears gloves.

- √ Appoint a launch manager
- √ Tie the stack together as normal, but do not attach a lanyard ring to the balloon
- √ Spread the launch crew and stack out, each crewmember holding a piece of the stack
- √ Note: The modules are not on a Launch Stand, each module is held by a member of the launch crew
- √ Spread out the entire stack with the balloon upwind
- √ Everyone but the balloon handler holds their part of the stack out away from their body

- √ Note: Do not grab hold of your piece of the stack, just support from falling
- √ At the launch manager's signal, the balloon handler releases the balloon
- √ The balloon rises and drifts downwind, picking up all the pieces of the stack

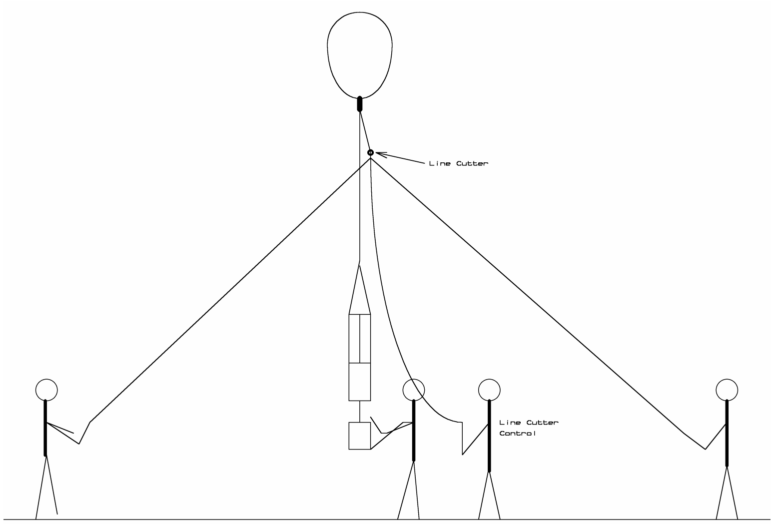


Hail Mary Launch (EOSS) *Arrow shows wind direction*

TVNSP has used this method to launch in high surface winds. The stack was released in the wind shadow of a building.

6.3.2. HABET Release Method

This is probably a better way to release the lanyards but requires extra equipment. In 2000, the author was privileged to meet with the HABET crew, thanks to the efforts of Ralph Wallio. At the time, HABET used an FTU device to sever the lanyards restraining the balloon. As the author recalls, the lanyards passed through a plastic tube. The lanyards were tied to the load line near the balloon nozzle or where tied to the nozzle. Cut on the side of the plastic tube was a slot large enough for the FTU. The FTU's nichrome coil stuck into the tube where the lanyards could pass through it. After the balloon was raised and ready for launch, a current was sent through the nichrome coil, melting the lanyards. The plastic tube with the FTU fell away from the load line.



HABET Release Method

7.0 What To Expect

Here's what to expect for a flight and some advice.

7.1.1. What To Expect

You won't sleep well the night before a launch. When you wake up, you'll begin your day running on adrenaline. You'll have a fear that it will be windy this morning. You'll also have an unnatural fear that you've forgotten something critical. After a few launches, you'll get a custom to it.

It takes about one hour to fill a balloon and close out the near spacecraft modules. Plan to be at the launch site at least an hour before launch, which means for an early morning launch (when winds are usually at their lowest) the launch crew needs to arrive to the launch site in the dark. A typical ascent rate is 700 to 1200 feet per minute, with an average around 1000 feet per minute. Typically the ascent rate is a little faster for the first 20,000 or so feet, and then it levels off to a constant ascent rate for the rest of the flight. There appears to be no slowing down in ascent rate before the balloon bursts. If at possible, get ahead of the balloon and find a place to stop before the balloon bursts. Chase Crews can see the balloon in flight and detect the balloon's burst with the unaided eye. It absolutely amazes people to see a 25-foot diameter balloon at an altitude of 100,000 feet. Use APRS to determine the bearing and elevation to the near spacecraft. The elevation of the balloon is close to the inverse tangent of the balloon's altitude divided by its range (the reason is this approximate is that it takes take into account the Earth's curvature). Here's a quick table for estimating the balloon's elevation. The first column is the ratio of altitude to range and is rounded to one decimal place. The elevation is given in degrees.

Altitude	Range Elevation
0.3	15
0.6	30
1.0	45
1.7	60
3.7	75

With your arm extended, the distance between your upright thumb and bottom of your hand is about 15 degrees.

The balloon is visible as a star in the sky. With binoculars, some people can detect the parachute. Place the balloon next to a light pole or similar object to help other people locate it. By watching the balloon in reference to a fixed object, you will detect the balloon's drifting. Expect the ascent to require between 1.5 to 2 hours.

At the time of burst, the balloon "star" fades out over about one second. Initially at balloon burst, the near spacecraft descends very rapidly. Anywhere from just the balloon's nozzle to most of the balloon remains on the load line (the rest drifts down on its own and much slower than the near spacecraft). Depending on burst altitude, the initial descent speed can be in excess of 100 mph or 8000 feet per minute. During descent, the near spacecraft experiences lots of shaking and bouncing. This is why it is important to pack the interiors of the modules in Styrofoam peanuts or find some other way tie the avionics and cables down. Don't let the high descent rate worry you, as the near spacecraft gets closer to the ground, the descent speed slows down to safe levels. The burst balloon hanging off 30 feet of load line tips the parachute several tens of degrees, causing a lot of swinging and spinning of the near spacecraft (another reason to pack the interior with peanuts). If an FTU is active on the mission, the descent becomes much more gentle after balloon is cut away. Plan on having one hour before landing once the balloon bursts. Estimate a rough predicted landing site by extending the distance from launch to burst by 50% while maintaining the same heading as from launch to burst. If the ascent followed a curvy path, so will the descent. Don't let changes in the descent course fool you into thinking the predicted recovery zone is going to be different. Expect the descent course to be a mirror image of the ascent course, but only to cover half the distance. The parachute (if it is brightly colored) can be seen more than 5000 feet above the ground. Stop the chase vehicle if you wish to look for it, but remember, stopping lets the descending capsule get ahead (parachutes are under no obligation to stop for you). It gets more dangerous if you are very close to the landing near spacecraft because you want to see it before touchdown. Be cautious at this point and keep your eyes on the road. If the near spacecraft recovers in a tree, chances are it will be suspended by the parachute on an outside branch. Exercise caution when recovering the near spacecraft caught in a tree. If Recovery Crews are not close enough to see the parachute land, APRS may not get them right to the recovery site. Depending on the terrain and your distance, telemetry may be lost several hundred or even more than one thousand feet above the ground. Go to the last known site and begin traveling downwind. As Recovery Crews get close, telemetry from the near spacecraft will be received. The audio beacon described in this book can be heard 100 feet away, so carry one on each mission to help locate the recovered near spacecraft.

Also be sure to get permission before walking into private property to recover your property. KNSP and TVNSP have never had trouble with landowners. Indeed, almost all of them have been interested in what we have done. KNSP and TVNSP have sent landowners either pictures or a bumper sticker that went up in the near spacecraft.

7.1.2. Some Advice

Teach all launch procedures to your launch crews. Consider teaching launch procedures to your local astronomy or radio club as you may interest them in participating. Have launch crews practice filling and launching the balloon annually, before beginning the year’s new near space campaign. Test the APRS setup of chase crews before their first launch. Take a module of the near spacecraft out for a drive and verify new chase crews are able to track and find the module. Don’t attempt to hide from chase crews, as the near spacecraft doesn’t try to hide either (all good near spacecraft want to be found). After building new avionics, run them for at least four hours on the ground for sending it up on a mission. Document everything! When possible, launch close to sunrise before the winds have a chance to pick up. Expect the first launch to take more than one hour. If financially possible, have an extra balloon and helium at the launch site. Be gentle with the balloon, but not paranoid. The balloon is surprisingly durable when first filled, except around sharp objects. Remember, the balloon is going to expand several times in diameter before it bursts; so dull or blunt objects are less likely to burst the balloon. Keep first flight simple, perhaps even a low altitude flight (low for amateur near space is 50,000 feet). Clearly explain to everyone interested where the balloon is predicted to travel to and recover. Plan a driving route before the launch. Usually you will be able to follow the routine until near the recovery zone. Coordinate chase frequencies before launch day. Be sure chase crews know the frequencies and have programmed them into their HTs. Most of us do not know how to program new frequencies into our HTs without the directions that came with the radio.

Good To Know - The Lifting Ability Of Gases

I wrote an article for QST on high altitude ballooning back in early 1999. In the article I discussed the lift of balloons based on their volume of gas. I made an error in my calculations and didn't explain the material in as much depth as I would have liked. So here’s an attempt to expand the content of my QST article. I hope you enjoy the physics and chemistry content as much as I did.

The near spacecraft reaches near space because its expendable booster, the balloon, has buoyancy. Buoyancy occurs when an object's volume displaces more weight than the weight of the object. As an example, if a balloon displaces a volume of air that has a weight of 12 pounds, but the balloon and its gas has a weight of only three pounds, then the balloon has buoyancy of nine pounds and it floats.

In this example the balloon can lift a payload with up to nine pounds of weight. At nine pounds of weight the balloon becomes neutrally buoyant and will no longer rise.

The way to determine the weight of a volume of air is to multiply the volume by its density. To determine the density, we'll make use of some material you learned in college chemistry. The mass (which will be treated as a weight, although strictly it is not a weight) of a chemical compound or element is given by its atomic mass. We can convert atomic masses into grams by taking advantage of the law that a physicist by the name of Avagrado discovered. Since compounds and elements consist of atoms or combinations of atoms, the weight of a mole of a compound or element in grams is equal to its atomic mass. This occurs because every atom of the same element has the same mass and the atoms in each molecule of a gas are identical. So the mole becomes just a conversion factor, like converting pounds to kilograms. Since we're working with gasses, we take advantage of their equal volumes at the same temperature and pressure. We'll use standard temperature and pressure (STP), which is 0 degrees Celsius at one standard atmosphere (760 mm Hg).

One mole of a gas at STP has a volume of 22.414 liters. One mole of the gas has a weight in grams equal to its atomic mass. The density of this gas (and in fact, of anything) is equal to the weight of the body divided by its volume. If the density of a gas is less than the density of air, then that gas is buoyant and will float, or rise. Our atmosphere consists of 79% nitrogen (with a molecular mass of 28.013 grams), 21% oxygen (with a molecular mass of 31.999 grams), and 1% argon (with an atomic mass of 39.948). Remember that oxygen and nitrogen are diatomic molecules, so the atomic mass of these molecules is twice the atomic mass of the individual atom. Averaged together and we get an average mass for a mole of atmosphere of 29.249 grams. Divide by the volume of a mole of gas at STP and we get a density of 1.305 grams/liter (g/l)

Compare this density with the density of hydrogen, helium, ammonia, and nitrogen. The atomic or molecular masses of these gasses are 2.016 grams, 4.003 grams, 17.030 grams, and 28.013 grams, respectively. Their densities come out to 0.090, 0.179, 0.760, and 1.250 g/l respectively. Notice that all of them have a density less than air, and so all will float in the air. Their effectiveness at lifting payloads into near space depends on how much lower their density is compared to the air. To determine this, let's convert the lift of each of these gases in pounds/cubic foot (I'm avoiding metric because of my American audience). We'll do this by subtracting the density of each gas from the atmosphere and converting grams per liter to pounds per cubic foot. The conversions are 28.32 liters per cubic foot and 453.6 grams per pound. A mole of gas occupies 0.79 cubic feet of volume. So one cubic foot of each of these gasses lifts the following weight when compared to air.

Gas	Lift (pounds/ft3)
H_2	0.070
He	0.070
NH3	0.034
N_2	0.003

Because of rounding errors, helium appears to lift as much as hydrogen. Hydrogen only lifts 8% more than helium (1.215 g/l vs. 1.126 g/l).

Let's create a situation where a balloon/payload combination will reach 100,000 feet when hydrogen is used as the lifting gas. Then how high will these other gasses get the payload before bursting?

Gas	Maximum Altitude
H_2	100,000
He	98,000

NH3	78,000
N_2	About 0 feet

So we can see that using hydrogen in place of helium in the balloon will get the near spacecraft about 2% higher, although the effect is more pronounced with heavier stacks and smaller balloons that reach lower altitudes. Ammonia does reasonably well, in fact I hear that there are hot air balloonist who fly on ammonia. Nitrogen provides such little lift that it achieves unacceptable altitudes (it may be unable to even lift the weight of the balloon).

Now let's compare the cost of hydrogen to helium, and calculate an altitude per dollar. Back in Kansas I purchased a tank of helium for $60. The tank held 245 cubic feet, so it had a cost of $0.24/cubic foot. Hydrogen was available at $30 per tank and each tank held 300 cubic feet. So hydrogen cost $0.10/cubic feet. Taking into account that helium lifts less payload weight per cubic foot (about 8%), I get the following values for cost per foot altitude, normalized to hydrogen.

Gas	Cost/altitude
Hydrogen	1
Helium	2.5

By this table, it's apparent that hydrogen is your best value for the dollar, if your only concern is for getting the highest altitude for the dollar. Let's take a look though at the chemical properties of these two gasses.

Helium is a nonflammable, inert gas. This means helium is incapable of chemically combining with other elements. It will neither chemically absorb nor give off energy when it mixes with other gasses in the atmosphere. Helium is a simple asphyxiant that displaces oxygen in the air. However, it does have the benefit of giving you advanced warning by causing you to talk like Donald Duck. So if your Balloon Dogs begin speaking funny, it's a warning to get them out to fresh air. Hydrogen is also a simple asphyxiant, but it gives even less warning that you're not getting enough oxygen. In low concentrations of helium or hydrogen, individuals may develop headaches, dizziness, and deeper breathing.

Of course we know the other hazard of hydrogen, it chemically combines with oxidizers like oxygen (as do a lot of elements). The chemical combination is very energetic. Fortunately though, it burns up, rather than spreads around like liquid fuels. On the other hand though, hydrogen burns with a clear flame and produces very little radiant heat. If hydrogen is slowly escaping and burning, you probably won't notice until you walk into the flame. The greater risk from hydrogen is from it escaping from a burst balloon and rapidly mixing with the air. The balloons you receive from Kaymont and Kaysam are vacuumed out prior to shipping, so there's no oxygen to mix with the hydrogen in a balloon. A spark then can cause an explosion that will literally bring the house down. So as long as the hydrogen stays inside the balloon, there's no risk. Possible sources of spark include lights and electrostatic discharge. A source of electrostatic discharge comes from the filling process itself. As hydrogen gas flows rapidly through a plastic and ungrounded filler, it generates a large static potential that can discharge when a balloon bursts. The Hindenburg Disaster is a terrible example of the dangers of hydrogen.

My take on the matter is that the risk of an explosion is too great to use hydrogen. I've seen balloons burst and leak indoors, when you would have thought it wouldn't happen. If you feel the need to use hydrogen, here are a few safeguards to use. But please do not think this list is complete, because it's not. However I think it will convince you that hydrogen is not worth the trouble of using. First, fill the balloon outdoors, or inside a building without a roof or a very leaky roof. Second, use a grounded filler. Use a hydrogen hose and connect it to metal filler. Ground the hose and filler to an earth-ground. Third, allow no smoking or flames around the balloon while filling. If filling indoors, all electrical equipment, including lights need to be explosion-proof or non-sparking. Do not shut off the lights, or turn them on, when a balloon has burst. Making or breaking an electrical contact inside the switch creates a spark. Fourth, be familiar with the electrical properties of the near spacecraft. Are their switches to turn on before launch? If so, save it for after the near spacecraft is outdoors. Finally, Balloon Dogs should be well protected. Wearing eye and ear protection is a must. In fact wearing a motorcycle helmet would probably be a good idea. Consider the clothing balloon dogs are wearing also. Are they wearing a nylon jacket? Nylon creates static and will melt and cling when it burns. Look into borrowing flame resistant clothing when filling a balloon.

Large quantities of natural gas are transported across the United States everyday. We have tankfuls of the stuff in many homes and still we seldom experience a disaster with it. We should have the same level of safety with hydrogen, but since you're handling it on the amateur level, expect more trouble.

Whether its helium or hydrogen, there are safety concerns when transporting gas cylinders. When transporting compressed gas, avoid carrying the tanks inside closed cars. Ruptured tanks cause explosions in a closed container, like a car. Its best to move cylinders in the back of an opened truck. In all cases, immobilize the tanks during transport. You don't want tanks falling over and rolling around. I can tell you the clank of colliding tanks is very disconcerting. Pack material like a blanket between the two tanks to keep them from rolling into each other. Take the tanks straight to the launch site by a safe route. Don't risk an accident or involving innocent travelers.

Near Space Humor - Humorous Events Of Near Space Programs

Bill Brown
WB8ELK Field Day Balloon 1992 Hancock, NH

I decided to do something entertaining for Field Day. I designed a simplex repeater with a converted Fischer Price kid’s talking toy and an ICOM 2-AT. It worked great, 8 seconds record and 8 seconds playback. I flew it during high noon of Field Day and listened as some folks nearly 400 miles away managed to contact me through the balloon repeater. I believe hams from 8 states were able to talk through it.

Since everyone was at Field Day, I couldn’t convince anyone to come help me launch the balloon or chase it. So I filled the balloon and launched it all by myself in my backyard. Also, none of the foxhunt crew was available either, but I managed to get some of the Field Day sites to give me some final beam headings just as the payload landed near Manchester, NH. One of the fellows who had been at the Nashua Field Day site was on his way home and managed to hear the balloon briefly as he zipped along on the highway. He contacted me late in the evening and told me about it. I fixed up my makeshift DF gear and headed out to the area he told me about. Sure enough I could hear a very very weak signal for about 100 feet along the highway. It was very very strange, only that one spot had a signal. I drove all around the region and only could hear it there. So I started to walk down a gravel path in the now near pitch dark. I didn’t have my flashlight with me at that point. Suddenly the signal got a lot stronger and I started to walk faster toward the signal. Then I stopped as I was about to put my foot down since it seemed a bit strange. In the very dim twilight, my next footstep seemed to be very very dark gravel. I carefully lowered my foot and it just kept going down and down. I backed up a bit and went back to my car for my flashlight. After retracing my steps I was startled to see that my last footstep was on the very edge of an 80-foot deep gravel quarry!!!!

I found my way down a path to the bottom of the quarry and walked directly to the payload. It was lying in the gravel and sand at the very bottom of the quarry!!! No wonder I had a hard time hearing the signal from the road.

EOSS (From Mike Manes, W5VSI)
Our candidate is the transcript Tom Shillings testimonial at Cec Girz's retirement party in September (2002). Tom is a member of the GAINS team at NOAA that Cec managed until her retirement. We saw a video of it at one of the EOSS meetings, and it had us rolling in the aisles! Here's a snippet off my error-prone head.

Tom is rushing to finish dinner with his wife so he can make the EOSS meeting that night:

Tom S: "I've got a meeting I've got to get to at 7 tonight."

Tom's Wife: "Oh really? Who with?"

Tom S: "The Edge of Space people."

Tom's Wife: "Oh…..some space people, huh? Where's the meeting?"

Tom S: "Fort Logan."

Tom's Wife: "Fort Logan….isn't that the state mental hospital?"

Tom S: "Yeah. They have a room there."

KNSP
From the author's recollection.

This would be KNSP's third flight (Flight 97B). Being so early in the history of KNSP, there was still lots of interest in chasing the balloon. So over eight chase vehicles were assembled for the mission. The mission carried a backup locator beacon that ultimately created this story. The beacon was a two-meter milliwatt beacon based on a clock crystal. It weighed around ½ pound and was tied to the load line. After weighing the capsules and parachute, the balloon was filled for one PPL. After checking everything out, the balloon was taken outside the Johnson Near Space Center and launched. It was immediately obvious that there wasn't enough lift in the balloon from it's very anemic ascent rate (about 300 feet per minute). In fact it looked like the balloon was traveling horizontally about 100 feet above the ground (I imagined it would be bouncing off the ground the entire mission). It did eventually gain enough altitude to make a safe, but very long flight. It traveled north from Manhattan, Kansas for five hours before landing. Recovery was in a cornfield near Lincoln, Nebraska. The Chase Crew was able to keep up with the stack for the entire flight, so when it landed, we were only minutes away.

A farmer and his wife spotted the descent into their cornfield while they were finishing their lunch. Since there was a sky diving class nearby, the farmer thought it might be a student in trouble. The farmer boards his ATV and drives out to render assistance. As he gets closer (the near spacecraft was ½ mile from their home), he sees that this is definitely not a skydiver. It was a six-sided object with antennas and making a beeping noise. At that point, if I were the farmer, I would have high-tailed it out of there. Instead, he retrieves it, loads it on his ATV and drives back home with it. Remember that I said we were minutes away from the near spacecraft as it landed? Well, by the time the farmer got back home, there were eight out of state cars parked in his driveway waiting for him. I can't imagine what he must have been thinking at that point. All ended well, though. The family was pleased to get the attention and we gave them an autographed bumper sticker that had ridden in the near spacecraft to an altitude of 79,000 feet.

NSTAR

Don Pfister reminded me of this one over the weekend while we were at the St Joe Hamfest.

I went to one of the Near Space Balloon Group's launches near Gardner, Kansas one weekend. I believe this one was in early spring of 1999, but can't remember for sure. Bill (N3KKM) and Don (KA0JLF) each had a payload flying. The surface winds were a little breezy, about 10-15 mph from the north. We were launching from a large parking lot near some softball fields.

The fill was fairly normal, and Don and Bill measured the lift as well as they could given how much the balloon was bouncing around in the breeze. They got the balloon tied off, all the payloads attached, powered up, and tested, and finally we were ready for launch. The balloon was released and the other handlers lofted their payloads into the air.

The balloon rose normally for a few seconds, and then began to come back down. It was immediately apparent we didn't put enough helium in the balloon to get everything airborne. Downwind of the parking lot was an unfenced and plowed cornfield, so we weren't too concerned with obstacles. By the time the balloon had reached the edge of the parking lot, the lower payload had struck the ground. We started walking over to the payloads to catch them.

Now that the lower payload was resting comfortably on the ground, the balloon had more free lift. Up it went again, jerking the bottom payload off the ground and drifting downwind again. Of course, once the lower payload was off the ground the whole train was again too heavy to fly, so it came back down, but another 30 yards away.

After seeing this happen, we realized it was a little more serious. This up-and-down cycling would continue indefinitely, and the whole works was moving south with the breeze at about 15 mph. The nearest obstacle downwind was close to a mile away - a fence and a set of power lines. Our only choice was to run after the payload and get it under control before it got to that fence and power lines. What began as a walk turned into a full sprint, with several of us hauling butt across this plowed cornfield chasing a balloon the hard way.

I think we were about 200 yards into the cornfield before we caught the balloon. We brought it back to the launch area (where many of the rest were still having a good laugh at the sight of us sprinting after the balloon) and talked about what to do next. Since it would be difficult to untape the balloon neck and get it back on the filler, it was decided to cut loose the bottom payload (the top one had the GPS tracker in it). There was enough lift to get this payload airborne and so we let it go solo.

Somewhere I think there's a videotape of all this.