CHAPTER THIRTEEN

Where To Go From Here

I think the folks doing "garage engineering for high tech" are the balloon people. They're the ones scrounging equipment, improvising environmental tests in their garage freezers, etc. and, most important, appearing to have fun.
- Jim Lux (W6RMK), a senior engineer at NASA/JPL
(This is not an endorsement from NASA/JPL)

Chapter Objectives

1.0 Some Suggested Future Experiments

Here's a list of twenty-five experiments I am either working on or would like to see developed. They range from the well thought out to the way out. The suggested directions for each experiment come either from experience, conversations with others, or in some cases, thinking about how I would approach them. Perhaps you can design one of them yourself. Or better yet, come up with an entirely different experiment. I suspect many of the results of these experiments may be found already published in the literature. This, however, is not the point or purpose of near space exploration. The purpose of near space exploration is to engineer a sensor, fly it into near space, analyze its data, and to discover the answer to the question; it's not to look it up answers in the encyclopedia. I believe there is something ennobling about finding out answers for yourself, by using your own hands and brains. Besides, making a really neat finding makes banging your head against the wall worthwhile. I've rated the following suggested experiments. Those with the H rating have some kind of hardware that I have built. Those with a P rating have parts that I have played around with. Those with the D rating are still in the dream stage.

1.1. Nephrometer (H)

1.1.1. Explanation

The nephrometer is a device to measure cloud opacity. The Galileo atmospheric probe carried one into the atmosphere of Jupiter in an effort to measure the altitudes and opacities of cloud layers during its descent. Nephrometers determine cloud opacity by measuring the cloud's effect on a beam of light. A light source in the nephrometer projects a fixed and known light intensity on a light sensor placed some distance away. The light detector continuously monitors the intensity of light reaching it from the light source. As obscuring material passes between the laser and the detector, the light intensity measured by the detector decreases. The greater the measured decrease in light intensity, the more obscuring (thicker) the cloud at the point of measurement.

1.1.2. Known Work In This Field

I know of no amateurs who are designing nephrometers at the time I am writing this book. I have a have completed design, but it isn't high on my to-do list at this time. I have often seen devices along military runways that appear to function as nephrometers, where they indicate the visibility at the runway for pilots.

1.1.3. Suggestions

Light Source

Probably the best source of light for the nephrometer is the laser diode. The collimated beam of a laser pointer simplifies the design of the nephrometer by doing away with the focusing lens and making it easier to exclude external light sources from interfering with the light sensors. Making the base line between the light detector and the laser source longer increases the amount of obscuring material between the detector and laser, thereby increasing its effect on the laser's intensity (which makes it easier to detect). A laser source will not spread it's beam over a significantly larger area as the base line of the device increases.

Light Detectors

Suitable light detectors for the nephrometer should be either the TSL230 Light To Frequency converter, a photodiode, or a LED wired in reverse. See Chapter Eight Section Five for instruction on these light sensors.

Potential Problems

The only thing changing the light intensity at the detector should be obscuring material between the laser source and the light detector. I can think of three factors that are independent of actual obscuring material that may affect the measurements returned by the nephrometer.

1. The laser source and the light detector may flex slightly, changing the amount of light reaching the light detector.

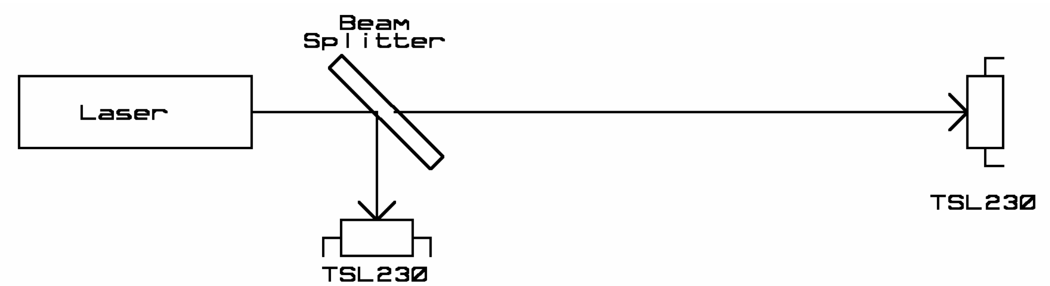
2. The laser's output probably varies with changes in temperature and battery voltage.

3. The sensitivity of the light sensor may change as the air temperature changes.

The first problem appears to be easily fixed by mounting the laser source and light detector to a base made from a wide beam of Styrofoam. When the beam is turned on its side (the wide side of the beam oriented vertically), the width of the base makes it difficult for the weight of the laser and light detector from flexing the beam. To prevent sideways forces from flexing the beam horizontally, glue one or two ribs to the base. The result is a T or C shaped beam. I don't think temperature changes can cause the Styrofoam beam to expand or contract significantly.

I know of no realistic way to prevent the laser source and the light detector from changing through the flight. Therefore I propose a second set of measurements be made during the flight to compensate for any changes in the system. First measure the laser's output without obscuring matter influencing the beam. This first measurement is the reference measurement that is used to determine the effects of the changing laser source and light sensor. Next a measurement is made of the laser's output with possibly obscuring matter can affect the beam. The first reference measurement is compared to the actual measurement. When the ratio of the second measurement compared to the first measurement differs from the first measurement, then obscuring material has been detected by the nephrometer.

I recommend the following design to implement the nephrometer. Place a beam splitter just in front of the laser to break the laser's beam into two separate beams. One beam travels the distance across the nephrometer, where clouds or dust can attenuate the beam. The second beam travels through a short blackened tube where it is sampled very close to the laser where obscuring material cannot interfere with the beam. Both light sensors are identical in design and exposed to the same temperatures and power source. Measurements of the two beams are made in quick sequence, before power fluctuations or temperature changes can affect the measurements independently of each other. Graph the ratio between the two measurements in relationship to the near spacecraft's altitude. The profile generated should indicate the altitude of clouds and their amount of obscuration.



Nephrometer Diagram

1.2. <u>Dust Sampling After Volcanic Eruptions (DH)</u>

1.2.1. Explanation

It's very difficult for dust to travel from the surface of the Earth into the stratosphere. Any dust launched only into the troposphere is quickly removed by weather, like rain. Once in the stratosphere however, dust should remain aloft for months or possibly even years as gravity slowly removes the dust. Remember, there is no weather, and especially rain, to wash dust from the stratosphere. High-energy events like big meteor impacts and volcanic eruptions can send material into the stratosphere. Launching balloons for several months after a volcanic eruption can record the progress of dust removal from the stratosphere.

1.2.2. Known Work In This Field

I know of no amateur program at this time making these measurements. I have experimented with using servo-operated petri dishes as a type of sampler, but still need to do more work. Perhaps photographs taken of the horizon at various altitudes may be used after-the-fact to make these kinds of measurements.

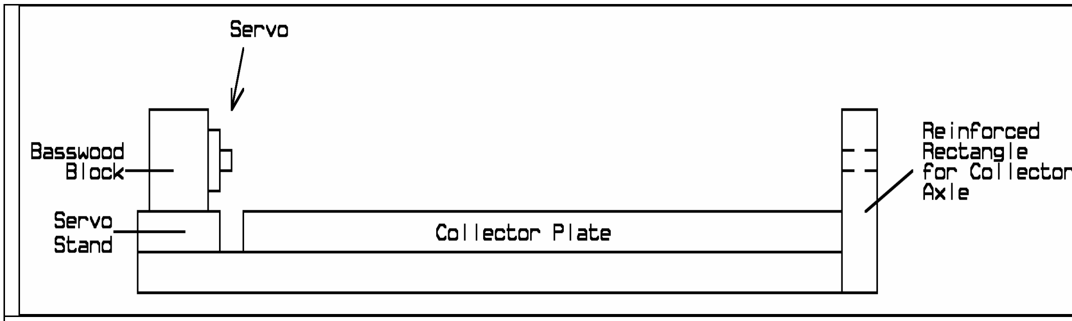
1.2.3. Suggestions

I can think of two ways of sampling the dust in the stratosphere. Either a large collecting plate can be carried on the near spacecraft or stratospheric air can be pumped through filter paper (this last idea comes from the GAINS project that EOSS is working with and from my email conversation with Dr. Brownlee of the University of Washington).

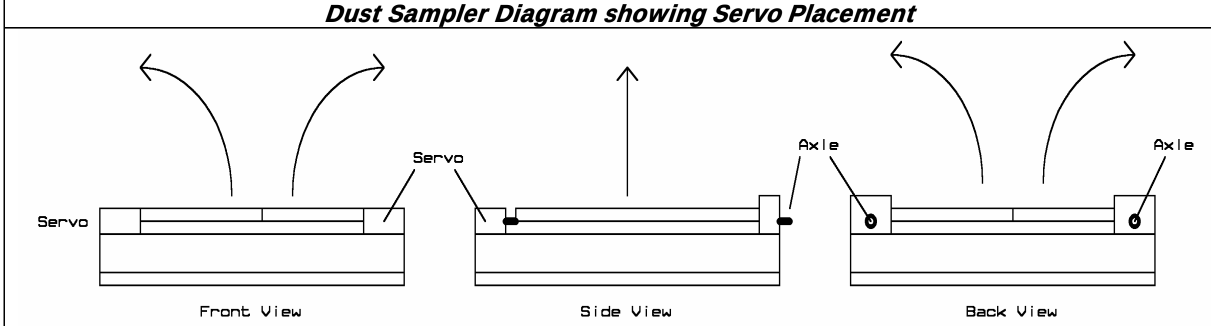
Sticky Plates As Dust Samplers

One way to collect materials in the stratosphere is to let them settle on a collection plate. The collection plate and its cover form the dust sampler. To increase the chances of collecting atmospheric dust, the sampling plate of the dust sampler must be large. To keep the weight of such a large plate low enough for a balloon and for a servo to open the cover, try making the dust sampler from a sheet of ½" thick Styrofoam. The dust sampler requires a sticky film on its plate to hold onto any material that settles on it.

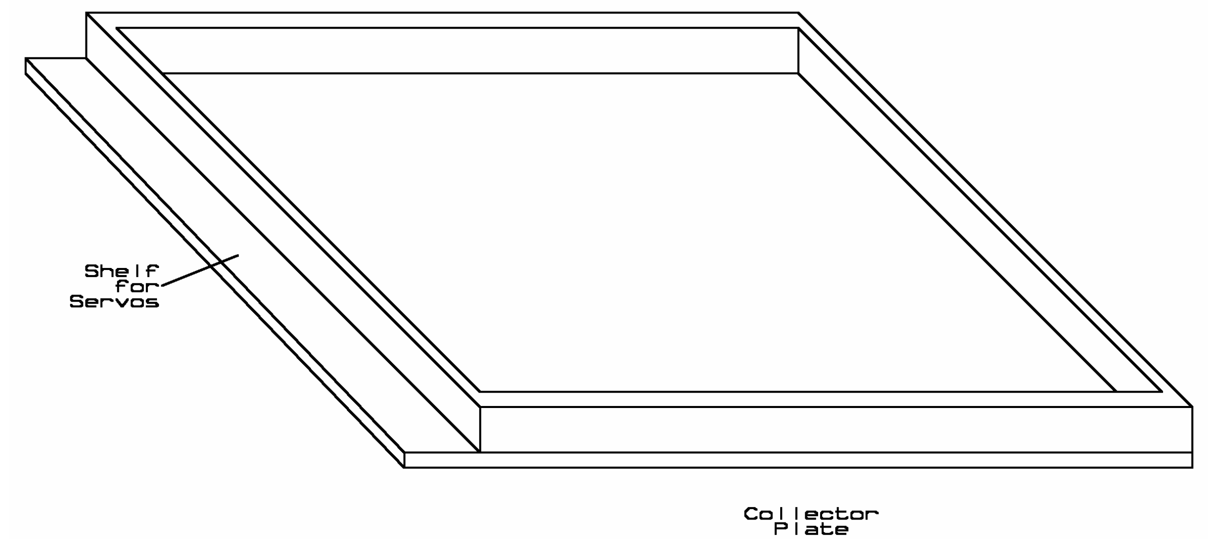
After reading *Sky and Telescope* magazine for October 2003, I discovered professionals use a film of oil on sheets of plastic to adhere any falling dust. With this in mind, a design for a dust sampler is shown in the following diagrams, with construction steps following.



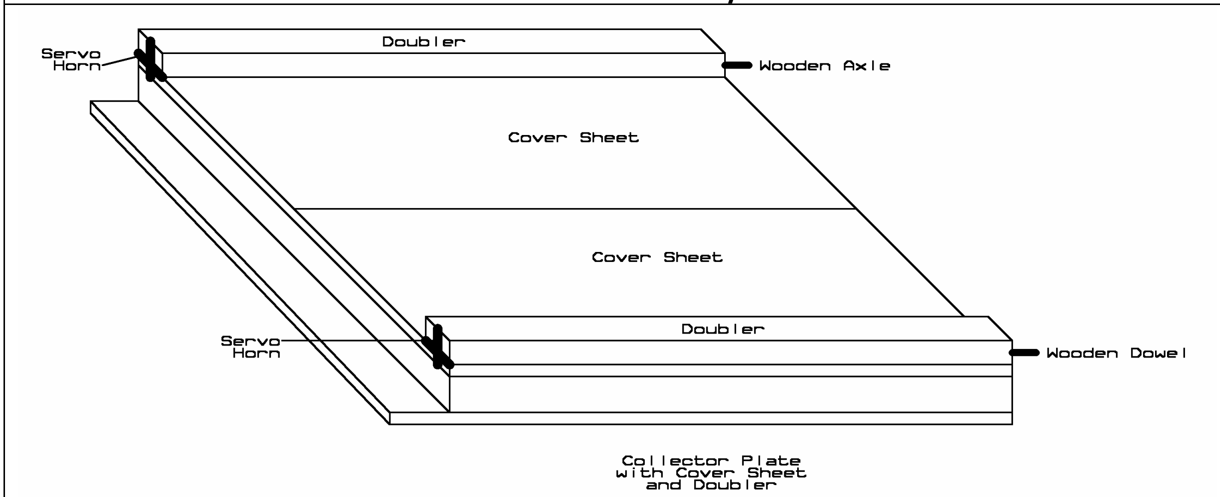
Dust Sampler Diagram showing Servo Placement



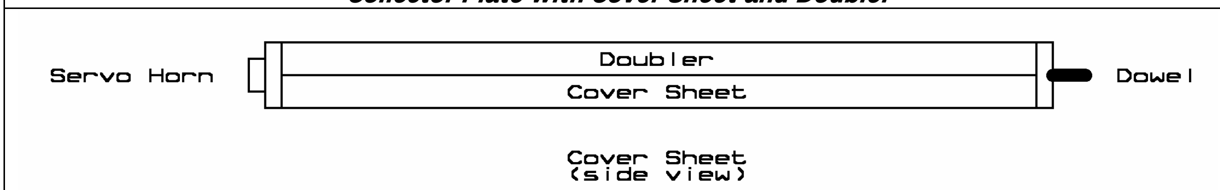
Front, Side, and Back View of the Dust Sampler



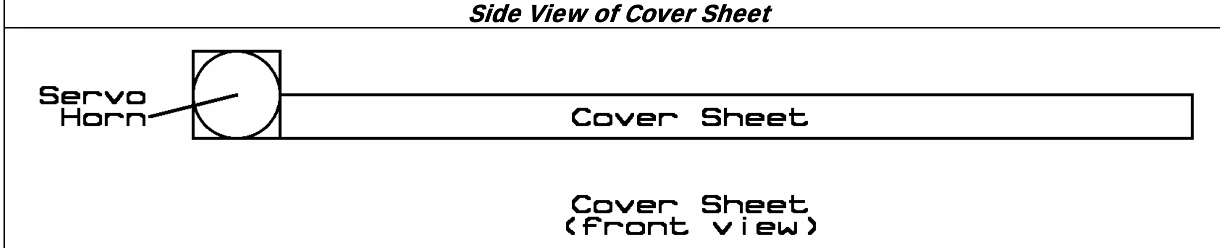
Collector Plate of Sampler



Collector Plate with Cover Sheet and Doubler



Side View of Cover Sheet



Front View of Cover Sheet

Materials

- ½ inch thick Styrofoam sheet
- Hot glue
- 1/8 inch thick plywood
- ¼ by ½ inch basswood strip
- ½ inch diameter dowel
- Servo mounting screws
- #0 or #00 hardware (1/4 inch long bolts, washers, and nuts)
- Two servos
- Three colors of #24 AWG wire (preferably red, black, and white)
- 1/8 inch thick heat shrink tubing

Procedures

√ Determine where the sampler will be carried on the near spacecraft. Perhaps it's easier if the dust sampler is suspended a ways below the bottom capsule in the near spacecraft.

√ Cut two identically sized sheets of ½ inch thick sheet of Styrofoam into a large square (the size depends on how large of a dust sampler your near spacecraft can carry)
√ Identify which cut sheet will be the collecting plate and which will become the cover
√ Cut six ¼ inch wide strips from ½ inch Styrofoam (four of these form the sides of the dust sampler and the other two form reinforcements for the cover)
√ Draw a line parallel to one side of the collecting plate that is two inches from the edge (this is the servo side)
√ Glue one strip to the collecting plate inside the two-inch line with hot glue
√ Glue the remaining three sides to the other edges of the collecting plate with hot glue
√ Cut the cover sheet of Styrofoam in half, down the center
√ Lay the covers on top of the collecting plate and cut off the overhang
√ Make notes on the covers so you cannot switch them around, as the covers are about to modified to the point where they cannot be switched
√ Trim about ½ inch from one end of each cover (this makes the cover about ½ inch narrower)
√ Glue one of each remaining strips to the outside edge of each of the covers (this doubles up the outside edge of each of the covers)
√ Cut four pieces of thin plywood into one inch squares
√ Rotate the servo to one of its fully rotated position

√ Note: The servo horn is to be mounted to the maxed out servo centered servo to form a cross, with arms that are diagonal to the square sides of the servo

√ Remove the servo horns from the servos and center them on two of the squares (to form an X across the squares)
√ Drill small holes for the #0 hardware through two opposite mounting holes in the servo horns and the thin plywood
√ Epoxy the bolts through the holes in the plywood squares (these are the bolted squares)
√ Epoxy the blank squares to the ends of the doubled up covers that are away from the servo side of the collecting plate
√ Epoxy the bolted squares to the ends of the doubled up covers that are on the side of the servo side of the collecting plate

√ Note: Now each cover has a blank square on one end and the bolted square on the other

√ Drill a ¼ inch (or slightly smaller) hole into the center of each of the blank squares

- √ Epoxy a length of ¼ inch dowel into the holes so that the dowel extends about ½ inch beyond the plywood
- √ Cut two pieces of ½ thick Styrofoam into a rectangle measuring one inch by two inches
- √ Cut two pieces of thin plywood to match and epoxy them to the Styrofoam rectangles
- √ Drill a ¼ inch diameter hole into the plywood face of the rectangles that is centered, but ½ inch from one edge (and 1-1/2 inches from the other end)
- √ Lay the covers over the collecting plate
- √ Slide the reinforced rectangles over the dowels in the cover
- √ Apply a thin layer of epoxy to the plywood faces where they make contact with the collecting plate and press them onto the plate and let the epoxy set

- √ Note: Be careful not to get epoxy on the dowels, the cover needs to rotate freely along the dowels

- √ Bolt the servo horn back onto the servo
- √ Rotate the servo to its maxed position
- √ Bolt the servo horn to the bolted squares
- √ Fill the space beneath the servo, but above the collecting plate with Styrofoam topped with a thin sheet of plywood

- √ Note: Cut the Styrofoam and plywood into a square measuring two inches on a side

- √ Use hot glue to glue the Styrofoam to the collecting plate and epoxy to glue the plywood the top of the Styrofoam

- √ Note: You'll need to get the servo out of the way when gluing the Styrofoam and plywood to the collecting plate. The square will fit up against the servo side of the collecting plate.

- √ Close the cover, laying the servo on the plywood face of the space filling Styrofoam and plywood
- √ Mark the outline of the servo
- √ Cut two pieces of the ½ by ¼ inch basswood to a length that fits under the servo mounting ears and against the servo body
- √ Place the basswood against the servo body and mark the location of the mounting holes in the servo ears
- √ Drill small pilot holes into the basswood
- √ Epoxy the basswood into place
- √ After the epoxy sets, bolt the servo to the collecting plate
- √ Place the cover axles into the axle holes in the collecting plate and push the cover up against the axle holes
- √ After the cover is laying flat on top of the collecting plate, push the covers into the servo horn
- √ Bolt the cover to the servo horn

- √ Note: The servo may not be exactly maxed at this point, but this will be corrected in software

- √ Cut the servo cable in half
- √ Split the servo cable back about one inch into three separate wires
- √ Strip about ½ of insulation from each of the three wires forming the servo cable

- √ Cut three lengths of #24 AWG wire long enough to extend the servo cable to the near spacecraft's flight computer
- √ Solder the wires to the servo cable, matching the colors
- √ Slide heat shrink tubing over the soldered connections and shrink
- √ Slide three more pieces of heat shrink over the extending wires
- √ Solder the remaining half of the servo cable to the extending wires
- √ Slide the heat shrink tubing over the soldered connection and shrink
- √ Plug the servos into the flight computer

Download code into the flight computer to position the servos and experiment with the proper settings. You want to position the cover in one of two positions, fully opened and fully closed. This means the servo must rotate 180 degrees with the code.

If the dust sampler is to be suspended below the near spacecraft, then cut two Dacron kite lines long enough to reach from the bottom of the near spacecraft, down to the dust sampler, across the sampler from diagonal corners, and back up to the opposite corner of the near spacecraft. Cut a second cord the same length and tie them together at their centers. Place the dust sampler into this harness and use a little duct tape to hold the dust sampler inside the Dacron harness. Let the harness come up from the sampler where it cannot interfere with the opening of the covers.

If the dust sampler is larger than the bottom of the near spacecraft, then make a spreader to keep the Dacron lines a part. To make the spreader, cut two lengths of dowel or fiberglass kite spars to a length just longer than the diagonal measurements of the dust sampler. Cut notches in the centers of both rods and epoxy them together to form an "X". Drill small holes near the edges of the arms of the X that are large enough to pass the Dacron cord through. Tie knots in each arm of the Dacron harness that the holes in the spreader cannot pass through. Tie these knots above the reach of the covers of the dust sampler. Pass the lines through the spreader and terminate the ends with bearing swivels. The spreader lets the Dacron harness widen from the bottom of the near spacecraft but remain out of the way of the opening covers.

Thoughts On Preparing The Dust Sampler

I don't know what kind of oil is used in dust samplers, but I imagine it is clear in color. There must be very little contamination from foreign debris in the oil or else it will be confused for near space-collected dust. Pouring the oil must be done in a clean location that will not add additional debris to the oil before the mission. So I imagine a process like this.

- √ Cut a sheet of Styrofoam large enough to cover the opened sampler, but sure to cleanly cut the edges so there is no Styrofoam flaking off the edges (I would recommend hot cutting the sheet)
- √ Set aside an area to pour the oil, it must have a table to work on and electrical power (this will be the clean room)
- √ Open the sampler and remove any dust with compressed air, then wipe down the surfaces with alchohol and lint-free paper towels (such as KimWipes™)[A]
- √ Hang plastic sheets around the work table, leaving enough space for you to work next to the table
- √ Blow as much dust out of the area as possible with fans or clean, compressed air
- √ Wipe down surfaces that seems to retain dust with lint free paper towels and alcohol
- √ Place a few fans on the table that point away from the center and far enough a part that the sampler can sit between them
- √ Run the fans until the sampler is closed

- √ Suspend the Styrofoam cover above the sampler in order to block any dust that may fall during the filling
- √ Wipe the bottom of the suspended Styrofoam sheet and let it dry before proceeding
- √ Open the sampler and wipe out the inside with alcohol-dampened lint free towels
- √ After it dries, pour a thin layer of oil into the sampler

- √ Note: I'd make the layer very thin, perhaps around a 1/16th of an inch or less

- √ Rock the sampler to spread the oil evenly
- √ Close the sampler covers as soon as possible
- √ Consider covering the closed sampler inside a plastic bag to prevent contamination before launch (add directions to remove the plastic bag covering to the pre-launch checklist).

Program the flight computer to open the sampler at an altitude above aircraft and before the balloon bursts. It opened too early, particulate matter from jet exhaust may contaminate your sample and if closed after the balloon bursts, latex and talcum power from the burst balloon may contaminate the dust sampler's plate. Immediately upon recovery, cover the petri dish with a plastic bag. Keep the plate closed and do not open it until it is inside the clean room. Thoroughly clean the exterior of the dust collector before opening it. Pour off the oil from the opened dust sampler into a petri dish. Note that any glassware used in this process must be free of dust. View the collected dust under a microscope.

The amount of atmosphere sampled is determined by multiplying the surface area of the plates by the change of altitude during the time the sampler is opened. The length of time the sampler is opened is another important thing to know. Samplers covering the largest volume of air for the longest period of time have the greatest exposure to dust. Complicating this is the fact that the air pressure drops as the balloon ascends. Lower air pressures are less capable of keeping dust aloft. So the "effective" volume sampled is not simply the volume of air the sampler plate passes through.

A control sampler must be constructed along with the actual sampler. The control is a sample of the same oil that has never been sent up. Another good control is to use oil that has been poured into sampler, but removed before closing up the sampler. The dust collected from the control sampler is compared to the dust from the actual sampler. It looks like a lot of fun is to be had perfecting this process.

Air Pump Samplers

A second option is to pump a high volume of air through a sheet of filter paper. By using a high volume air pump, more atmosphere is sampled. The benefit of using an air pump to sample the atmosphere is that a clean room and large collection plates are not needed.

Potential Problems

Air pumps are rated in cubic feet per minute (CFM) for one standard atmosphere. As the air pressure drops in near space, the pump is less effective at pumping air. High volume air pumps require more power to operate that low volume air pumps. Increased power implies more weight is required in batteries.

Potential Air Pump Designs

Because of current requirements, a relay or MOSFET is required to turn on and shut off the air pump. Orient the air pump horizontally, rather than vertically, so dust cannot fall on the filter paper during the initial ascent. Use a funnel to concentrate airflow into the air pump. Make the funnel with smooth sides and joints so turbulent airflow doesn't cause pockets of air to slow down. When any medium, including air, carrying materials slows down, it loses it ability to keep those materials suspended in the medium. Use smooth surfaces in the funnel to prevent suspended dust from settling out and onto the funnel surface. At the exhaust port of the sampler, suspend a sheet of paper from its top edge to monitor the effectiveness of the air pump to create airflow. The greater the volume of air flowing through the pump per unit time, the greater the deflection it creates on the paper. Use a camera to photograph the position of the paper sheet. I suspect the effective CFM of the air pump decreases just as the air pressure deceases. As an example, when using an air pump with a rating of 100 CFM at a pressure of 500 mb (about ½ of the air pressure at sea level), the effective CFM of the pump is only 50 CFM.

Turn on the air pump once the near spacecraft is above the troposphere and off before the balloon bursts. To prevent contamination upon landing, a door should close over the filter when the air pump shuts off. Use two covers, one on the inflow side of the filter and the other on the outflow side of the filter. If the covers are mounted inside the funnel of the sampler, and next to the filter paper, then the doors can be kept small. Use a servo to open and close the doors. After the flight the filter paper is removed and examined under a microscope. Create a control by launching a second filter paper that is not exposed to airflow from the pump. Orient the control with its face pointing horizontally, like the filter paper in the air pump.

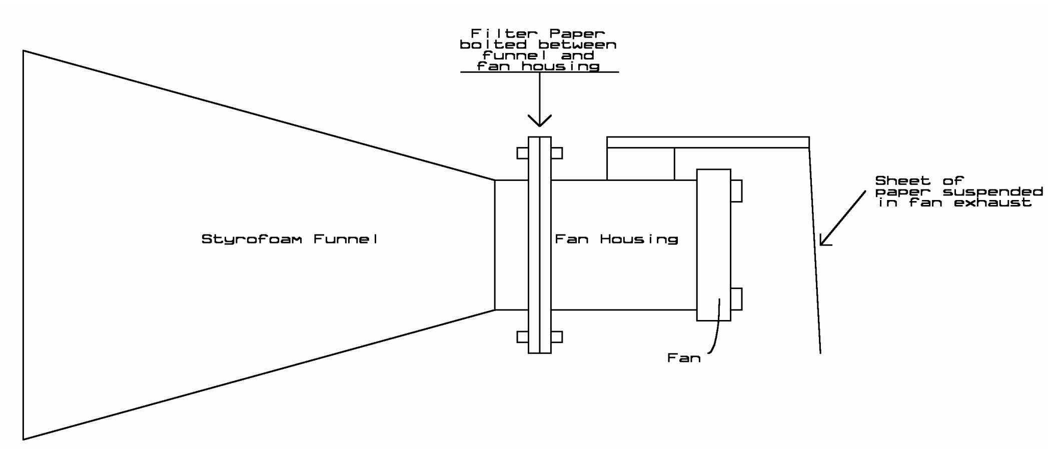


Diagram of Pump Sampler

Because of the changing altitude of the air pump during the flight, the volume of air sampled cannot be determined simply by multiply the CFM of the air pump by the length of time the pump was operated. Normally calculus is used to calculate something like this. It may be too difficult to determine a mathematical function describing the air pressure as a function of time. If such a function can be determined, then the function is integrated over the length of the time the filter was operated. Here are two other ways to make the calculation.

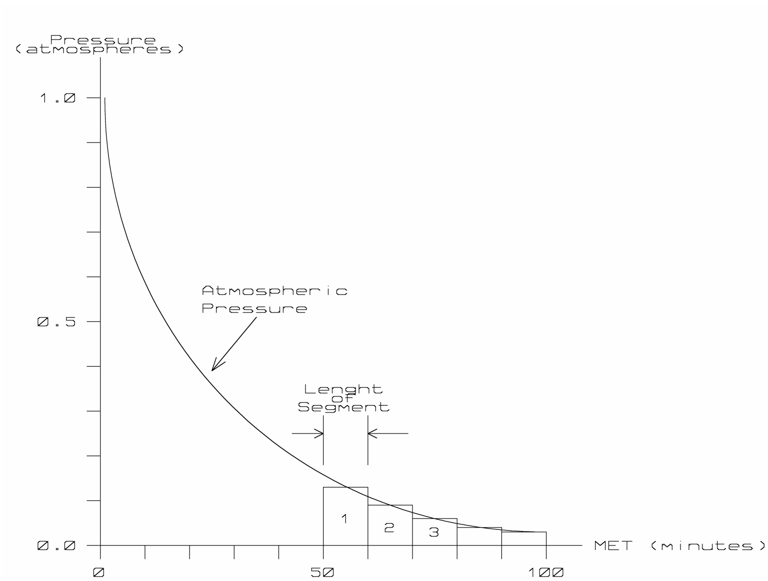
Graphical Approach

- √ Multiply the CFM of the air pump by the length of time (in minutes) it was operated to calculate a total volume of air in cubic feet
  (This is the uncorrected volume value)
- √ Determine the altitudes at which the air pump was operating

Use a sheet of fine square graphing paper to perform the next steps

- √ Graph the air pressure versus the time during which the time pump operated

- √ Note: The resulting graph looks like a pressure versus altitude graph, but the altitudes have been converted to the MET the experiment operated at that altitude
- √ Draw a rectangle on the above graph where:
  - o The top side of the rectangle is the air pressure at the start time of the experiment
  - o The bottom side of the rectangle is at the origin of the graph
  - o The left side of the rectangle is the start time of the experiment
  - o The right side of the rectangle is the stop time of the experiment



Graphical Approach to CFM

Now the calculus step, sans the calculus

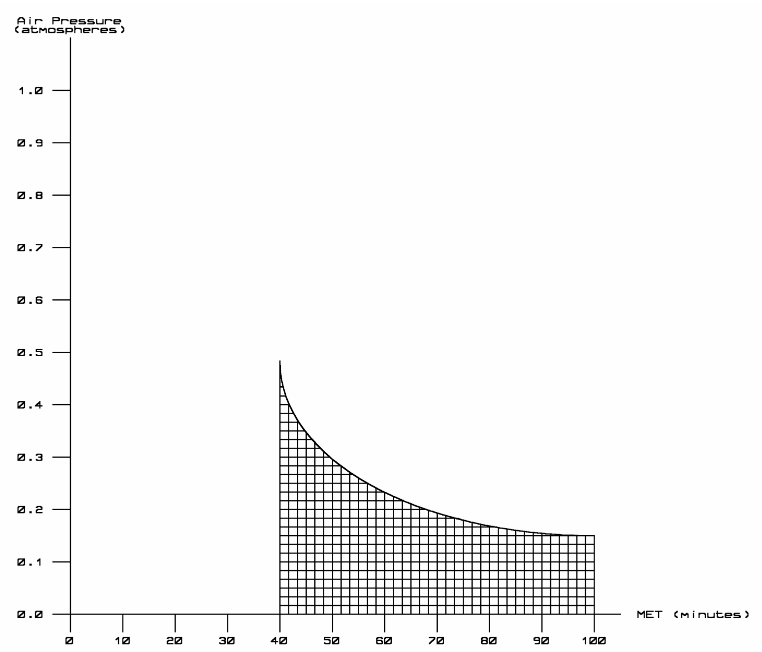
- √ Count and record the number of squares inside the original, uncorrected rectangle
- √ Count and record the number of squares beneath the curve of pressure versus time graph
- √ Calculate the correction ratio by dividing the number of squares beneath the pressure versus time curve by the number of squares in the original rectangle
- √ Note: The result of this division is less than one
- √ Multiply the uncorrected volume value by the correction ratio

The result should be close to the actual volume of air sampled
Note: The finer the squares on the graph paper, the more accurate the results of the calculations

Sampling Approach
This method divides the sampling time into segments. The average pressure during each segment is used as a correction factor for the volume of air sampled during that segment.

- √ Divide the time the experiment was run into a number of equal width segments of time (I recommend at least ten segments)
- √ Determine the altitude at the beginning and ending of each segment
- √ Determine the length of time required for the balloon to pass through each segment (This is the time spent at each segment)
- √ Average the altitude at the beginning and ending of the segment to determine the average altitude during each segment

- √ Determine the air pressure at the average altitude of each segment (This is the average air pressure of each segment)
- √ Divide the average air pressure of each segment by the sea level air pressure at the time of launch (This is the correction factor for each segment)
- √ Note: Because of the great change of pressure experienced during the flight, 1013 mb can probably be used without creating significant errors
- √ Multiple the time at each segment by the CFM of the air pump (This is the uncorrected volume of air sampled)
- √ Multiple the uncorrected volume of air sampled by the correction factor of each segment (This is the averaged volume sampled as each segment)
- √ Sum up all the averaged volumes sampled for all the segments



Sampling Segments

The result should be close to the actual volume of air sampled
Note: The greater the number of segments created, the more accurate the results of the calculations

1.3. Aurora Studies (D)

Aurora over Idaho - *November 2003*

1.3.1. Explanation

Auroras are an inspiring sight. After seeing my first one in Idaho, I immediately wanted to send a near spacecraft up to photograph it from the darkness of near space.

1.3.2. Known Work In This Field

There is no amateur work in this area that I know of. Satellites have been launched to study auroras, however.

1.3.3. Suggestions

Since auroras are not predictable in the long term, experiments for an aurora flight must be designed in advance and be ready to launch in a few hours notice and at night. Don't forget that this means tanks of helium must be on hand. While this is not difficult for professionals who get paid to do studies in the middle of the night, it's difficult to arrange for amateurs. Possible aurora experiments include the following.

- Measure cosmic rays fluxes during an aurora and compare the results to a flight shortly after the aurora
- Measure ionization levels in the atmosphere (see section 1.5)
- Record images of aurora on videotape

Since auroras are caused by storms of charged particles from the Sun, larger cosmic ray fluxes should be detected during the mission. In this case, most of the additional flux is due to the Sun. The increased number of cosmic rays detected can be correlated to the solar wind measurements as determined by the ACE satellite. See the ACE website at http://www.sec.noaa.gov/ace/ACErtsw_home.html for the current solar wind measurements.

Some newer CCD cameras are sensitive enough to record faint stars. A suitable CCD camera is the PC 164C available from Super Circuits. This CCD camera has a lux rating of 0.0003 lux, letting it see in near darkness. For color images of aurora try using the PC 165C CCD camera. However, this camera only has a lux rating of 0.05 lux. Live images of the aurora can be transmitted over ATV, but for the best quality of images, use a camcorder with A/V input or a portable, battery operated VCR to record the images from the CCD camera onboard the near spacecraft. CCD cameras need an optical system to create images. Don't use a pinhole; instead use a wide-angle camera lens for the CCD camera optics. Auroras are large beasts; to see them requires large angles of view, so don't use anything like a telephoto lens.

Do not attempt to use a film camera in place of the CCD camera. A film camera requires about 15 seconds to record a descent aurora photograph. The capsule's spinning and swinging will not allow good still images of an aurora from near space using film cameras.

For the best images, position the CCD camera to point above the horizon but below the balloon. Placed at a 45 degree angle above the horizon might make a good compromise. Positioning the CCD camera at a 45 degree angle prevents city lights below from entering into the camera. It also prevents city light reflected off the balloon from entering into the camera. For additional protection, make a light hood to go over the camera lens and extends several inches beyond the end of camera lens.

1.4. Measuring Cosmic Ray Energies And Directions (H and D)

1.4.1. Explanation

A Geiger counter is good at counting the number of cosmic rays during a near space flight, but it can't determine the energies of the detected cosmic rays. A single Geiger counter also can't determine the direction of the radiation.

1.4.2. Known Work In This Field

There is none that I know of. I have heard of only two amateur flights even measuring cosmic ray fluxes in near space.

1.4.3. Suggestions

There are two measurements I want to make in regards to cosmic rays. The first is their energies and the second is their source (direction).

Cosmic Ray Energies

In one of my Physics classes in college, we used a multichannel analyzer to measure the energies of x and gamma radiation. The detector consisted of a doped silicon crystal or a crystal of sodium iodide (scintillators) place in front of a photomulitplier tube (PMT). When radiation slams into the scintillator it creates a small flash of light, which is too faint to be seen with the eye. The brightness of the flash is determined by the energy of the particle slamming into the crystal. A PMT amplifies the tiny flash of light. Photons from the flash strike the face of the PMT liberating electrons (in some cases, a single photon of light can be detected). Several charged grids inside the PMT accelerate the freed electrons. Each collision between one of the grids and an accelerating electron creates more free electrons, amplifying the original signal. At the end of the tube, the PMT creates a voltage pulse that is linearly related to the size of the original flash of light. The signal from the PMT is digitized by an I/O card in a PC and graphing software then plots the results.

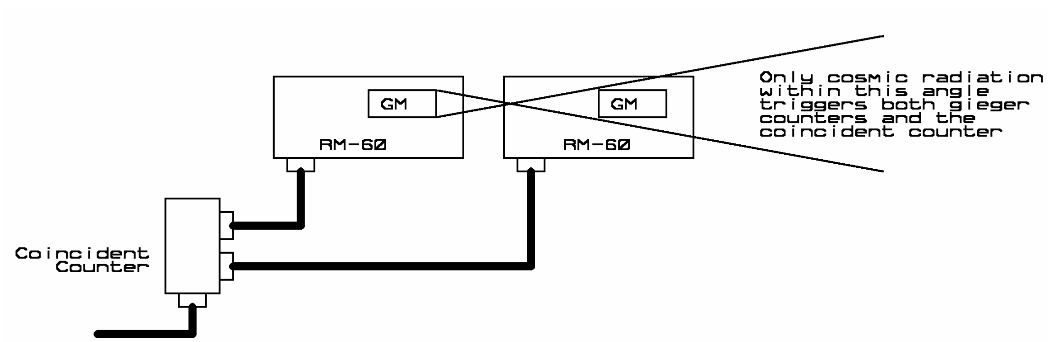
Unfortunately, a PC is not a realistic item to carry on a near spacecraft. But a PC does exist in a single board computers (SBC) form factor called the PC104. Several CPUs, like the 80486 and Pentium can be found in this PC104 form factor. It may take some effort to physically interface a

PMT A to D board to the I/O slots of the PC104. Use a solid-state hard drive to store the multichannel analyzer software and the results from the flight. If the PC104 route is too difficult, then another possible option is to record data from the PMT on an audiotape and analyze it after recovery.

Another suggestion, and one should be easier to implement, is to send materials into near space that physically record nuclear tracks. Materials like acrylic plastic are damaged by the impact of subatomic particles. Etching the acrylic plastic with suitable chemicals changes the damaged regions into tracks visible in simple microscopes. The size and orientation of the tracks indicate the energy and path of each particle. Dr. Fleischer's book, *Nuclear Tracks In Solids*, explains which materials are suitable and the proper etchants to use. It's quite amazing what he and others have done with the clear plastic visors of the Apollo astronauts.

Cosmic Ray Direction

Cosmic ray detectors have already determined that galactic magnetic fields hopelessly scramble the flights of cosmic rays. There is no way to determine the original direction and source of cosmic rays, unless a statistical study of a large number of cosmic rays can sort it out. But this fact does not prevent us from determining the direction of cosmic rays in the atmosphere. Recall that a Geiger counter only measures the presence of ionizing radiation, and not the direction of its travel. But there is a way around this. When two Geiger counters are placed in close proximity, cosmic rays traveling in the direction aligned with both Geiger counters can be sorted out from those that do not travel in the same direction. The coincident counter is an AND gate with inputs from two Geiger counters. Only when both Geiger counters produce a detection at nearly the same time, does the AND gate produce an output. The time available to detect a coincidence is the length of time it takes for ionized gas inside the GM tube to recombine. The length of time for a quenching gas to recombine the ions inside the GM tube is referred to as the tube's dead time. The dead time is shortened by the presence of a quenching gas inside the GM tube, usually an inert gas like Argon. During the dead time, no further detection of radiation is possible. This creates an incentive to design GM tubes with very short dead times. In the case of the RM-60, the dead time is on the order of 20 microseconds. Since cosmic rays travel at relativistic speeds, two RM-60s within 20,000 feet of each other can detect coincidences. Two RM-60s and a coincident counter electrically connected between them makes a Cosmic Ray Telescope (CRT). To make the CRT more effective, mount the CRT to a servo-operated scan platform, as outlined in Chapter Seven, Section Four. During a near space mission, take several measurements at each altitude, with the CRT positioned at a different azimuth.



Two RM-60 Geiger Counters AND a Coincidence Counter *– Only cosmic radiation within the angle shown will trigger both geiger counters and the coincident counter*

A more pressing problem than the time it takes cosmic rays to travel the length of the CRT is that as the distance between the GM tubes is increased, the beam diameter of the telescope decreases. As the area of the sky being viewed decreases, so does the cosmic ray flux entering the CRT. Improvements in resolution are offset in decreases in sensitivity. Also, as the beam diameter, or field of view of the CRT decreases, rotation and rocking of the near spacecraft smears out the CRT's field of view. For amateur near space, it's only realistic for us to measure cosmic ray fluxes where, we use short length CRTs, with the RM-60s are positioned next to each other, and at large changes in elevations. My first and only CRT test, which appears to have recovered in a reservoir, attempted to measure cosmic ray fluxes at three elevations, 0 degrees, 45 degrees, and 90 degrees. With the RM-60s mounted next to each other, the beam diameter of the CRT was 7.5 degree. Depending on the results of the experiment (which I never got back), I was going to attempt other elevation measurements on the next flight. Perhaps you can have better luck than I did. I'd like to add one more point about finding sources of cosmic rays by determining their direction. If a nearby star goes supernova, it may be a source of increased cosmic ray flux. In that case, the CRT should be able to determine that the supernova is a source of cosmic rays. However, if the supernova is really close and powerful, chances are we'll be more interested in avoiding the cosmic rays than measuring them!

1.5. Atmospheric Ion Measurements (P)

1.5.1. Explanation

Cosmic ray collisions with molecules in the atmosphere break a part those molecules and create atmospheric ions. The movement of these charged ions can be detected with resistors and an operational amplifier
.

1.5.2. Known Work In This Field

I know of no one making this kind of measurement.

1.5.3. Suggestions

The Society of Amateur Scientists, operated by Shawn Carlson, has developed a atmospheric ion-measuring device which is simple to construct. The plans were initially published in the September 1999 issue of *Scientific American* under the Amateur Scientist. Kits may still be available from the SAS. If not, there is sufficient information in the Amateur Scientist article to build the atmospheric ion counter.

Once I complete my kit, I plan to compare the ion count at various altitudes with the cosmic ray counts my RM-60 measures. Perhaps measuring ion concentration is one way to measure cosmic ray energies.

1.6. UV and Ozone (H and D)

1.6.1. Explanation

Ozone in the stratosphere prevents most ultraviolet radiation from the Sun from reaching the Earth's surface. Ultraviolet radiation is divided into three bands, called UVA (320 to 400 nm), UVB (290 to 320 nm), and UVC (100 to 290 nm). UVA is not absorbed by ozone as both UVB and UVC are. The amount of ozone in a column of air can be determined by measuring the UV flux. Alternatively, the concentration of ozone can be measured by an instruments carried aloft by balloons. A device to measure ozone, an ozone sounder, is called an ozonesonde.

1.6.2. Known Work In This Field

Ozonesondes are launched daily by professional organizations. I know of no amateur near space groups launching their own ozonesondes. Ground-based UV measurements are taken through telescopes pointed at the Sun and carrying special UV filters. By taking into account the elevation of the Sun, the amount of ozone in the column of air above the telescope can be determined. The units of ozone are given in Dobsons.

1.6.3. Suggestions

Ozonesondes pump air through a cell containing a solution of sodium iodide. The chemical reaction between the ozone and sodium iodide creates a small current. The amount of current generated is measured and compared with the airflow of the pump or fan pulling ozone-containing air through the chemical cell. The ozonesondes create a signal that is the standard for radiosondes, allowing to be interfaced to a standard radiosonde. Ozonesonde kits are manufactured and are available over the Internet. Refill kits are available to refurbish and refly the same ozonesonde. However, I found the cost to be prohibitive.

An alternative is to use a light detector sensitive to ultraviolet radiation. One method is to use a broadband light detector and cover it with a UV filter. A second method is to purchase a UV photo-detector. Hammamatsu is one manufacturer of these devices. Do not use a flame detector. Flames give off UV radiation and the flame detector is used in fire-fighting robots. My research has uncovered that these flame detectors do not create a signal that is linear with UV flux. They produce a signal when the UV flux is intense enough to trigger them. Recently I have come across UV and violet emitting diodes (UVEDs). Wiring them backwards creates a UV sensitive photodiode. Refer to Chapter Eight, Section Five for using LEDs as photodiodes.

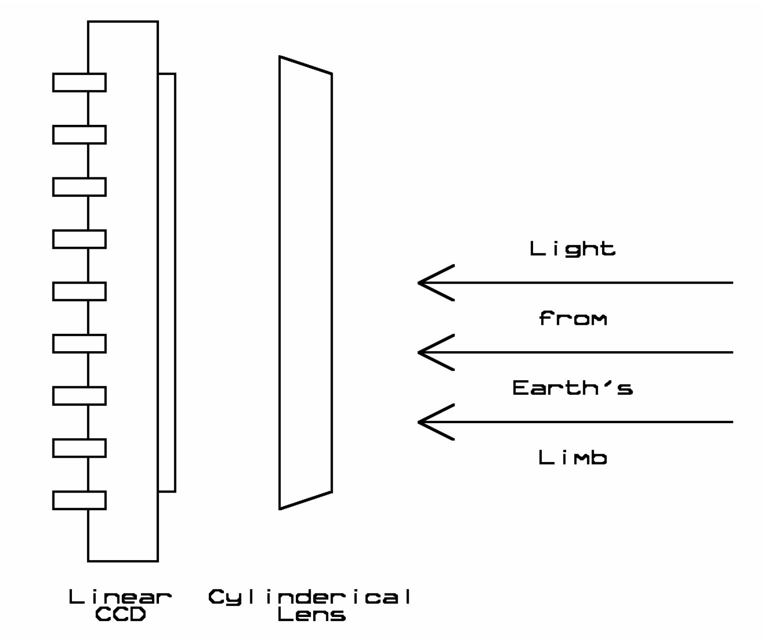
To get a reading of the absorption of UV by ozone, the UVED must be sensitive (emit) in at a wavelength below 350 nm, which is the lowest end of the UVC band, and all of the UVB and UVC bands (100 nm to 320 nm). After finding a UVED sensitive to that region of the spectrum (they don't exist now, but they may exist soon), the UVED detector must point to the Sun to get the most accurate reading. There are a couple of approaches to solving this problem. One is to build a despun section for the near spacecraft. As the near spacecraft rotates on ascent, the despun section rotates in the opposite direction, keeping every instrument on the despun section in a fix position. Either the flight computer must be located on the despun section or command and control between the flight computer and instruments on the despun section must be accomplished by a radio link. The second suggestion would necessitate a slave flight computer on the despun section. Perhaps a RC helicopter gyroscope could be used to determine how fast and in what direction to rotate the despun section. These gyros output a PWM signal that changes as the direction and amount of rotation of the gyro changes. A second option to determine the spinning of the near spacecraft is to detect the position of the Sun, which changes very slowly during the ascent (roughly one or two RPM as experienced by past missions). Another option is to take measurements only while the Sun is drifting through the UV sensor's field of view. This method requires the construction of a sun sensor to detect when the Sun has entered the field of view of the UV detector. See this chapter, Section 1.14 for notes on the Sun Sensor.

A third option to record the output of the UVED for an entire rotation of the near spacecraft is not a viable solution, because the rotation of the near spacecraft changes, sometimes speeding up, other times slowing down or even reversing directions.

1.7. Limb Sounding (D)

1.7.1. Explanation

Satellites measure atmospheric structure and gas concentrations by limb sounding. As the Sun sets in relationship to a satellite, the Sun passes through more atmosphere until it passes behind the limb of the Earth. Special filters or spectrometers determine the composition of the atmosphere at various levels.



Limb Diagram

1.7.2. Known Work In This Field

Near spacecraft are not suitable for measuring the composition of the atmosphere by observing the Sun rise or set. However, the brightness of the atmosphere as a function of elevation above the Earth's limb can be measured. I know of no one doing this sort of measurement.

1.7.3. Suggestions

The best idea I have had on this topic is to use a linear CCD chip at the focus of a lens, perhaps a cylindrical lens, since the measurement in only one dimension is needed. A CCD is needed, as many measurements over a small angle are required to sound the atmosphere above the Earth's limb. If an array of photodiodes were used in place of the linear CCD, the resolution of the array would not be as great as it would be with a linear CCD. At Kansas State University In the late 1990's I was shown a linear CCD with a sample and hold feature. After the array is signaled to make a measurement, the results from each element in the CCD array was stored until read out, one element at a time. This feature is needed as by the time the results from one end of the array was readout, the other end of the array would be experiencing a different amount of light. Take multiple limb soundings and compared them to each other as the altitude changes or to soundings at the same altitude but recorded on different days.

Potential Problems In Limb Sounding

Not taking limb soundings at the same azimuth or the same elevation confounds comparing different soundings. Variations in elevation may be the easiest to correct, as the increased in brightness of the Earth's limb may be easy to pull out of the data. The detection of Earth's limb in each sounding becomes the pixel to align other limb soundings. The remaining problem with this method is the missing data that results. Some limb soundings will start sampling at a lower elevation while other limb soundings will begin sampling at higher elevations. Data on the extremes of the CCD will be lost in the alignment process.

I can think of two ways to get around the azimuth problem. Either mount a limb sounder to a despun section or take a limb sounding only when the Sun is in the correct location with respect to the limb sounder. This requires the use of a sun sensor. It's really beginning to look like the development of the sun sensor would be a good idea.

To compare limb soundings, load the results from each limb sounding into columns of a spreadsheet. Align the columns until the Earth's limb in each column is located in the same row for each column of data. Then graph the results by plotting light intensity vertically and the altitudes horizontally. Draw lines across each column in the graph connecting equal light intensities, called isophotes (equal light brightness)

1.8. Passive Thermal Tests (H)

1.8.1. Explanation

Near spacecraft risk getting too cold rather than getting too hot, unless, that is, the electronics inside the airframe generates a great amount of heat. The temperature in near space can drop below –60 degrees Fahrenheit -- not a good temperature for many devices! Systems that actively heat the interior when it gets too cold can be designed, however, they require batteries to operate the heater. The drain on the battery from an electric heater is quite substantial, necessitating a separate battery for the heater than is independent of main battery power for the avionics. To save weight and make use of the solar heater always present in near space, the Sun, passive heating methods are preferred over active ones.

1.8.2. Known Work In This Field

Several TVNSP experiments have been designed to determine which construction techniques are best for airframes. Other than TVNSP, I'm not aware of any other near space groups performing these experiments.

1.8.3. Suggestions

The following conditions are a few suggestions of the many possibilities available for testing passive warming of near spacecraft.

- Construction Materials
- Insulation Materials
- Insulation Techniques
- Airframe Color

For example, other materials may insulate near spacecraft better than ¾" thick Styrofoam. If such a material is identified, it needs to be lightweight and easy to build with. Is space blanket effective enough to justify using it? Perhaps wrapping the airframe in a different material will retain interior heat. What about how the space blanket is used? Materials may be more effective at insulating an airframe when used in a particular way. Materials with the lowest albedo should keep the airframe warmer by absorbing the greatest amount of solar radiation. Aside from absorbing radiation, materials also emit radiation. An ideal material has a high absorption of solar radiation external to the airframe but low emission of infrared radiation from inside the airframe.

1.9. Gas Measurements (D)

1.9.1. Explanation

Explorer II made attempts to determine the gases and their ratios in the stratosphere (the collected air samples were analyzed in laboratories after the flight). Atmospheric probes dropped by spacecraft into the atmosphere of the planet Jupiter and soon the moon Titan, also attempt to measure gases in the atmosphere (but of other planets or moons).

1.9.2. Known Work In This Field

Ozondesondes are one sensor used to measure atmospheric constituents that are used regularly. There may be other programs to measure gases in the atmosphere by balloon. Aircraft are used regularly to measure levels of pollution above cities.

1.9.3. Suggestions

I have two suggestions for measuring gases in the atmosphere. The first involves in-situ measurement and the second involves sampling for later analysis. Carbon monoxide and oxygen sensors are available to the public. However, as I understand, their output tends to be more digital than analog. That is, they are used to indicate whether conditions regarding oxygen into an engine are acceptable or if carbon monoxide levels are too high. A second option to purchasing ready-made sensors is to construct one on the workbench. Like the ozondesonde, ambient air can be pumped into a chemical cell where the gas of interest chemical reacts inside the cell. One example is carbon dioxide gas pumped into a solution of sodium hydroxide. A precipitation is produced that clouds the liquid inside the cell. A LED and photodiode together can measure the resulting cloudiness.

The second option is to carry sampling bottles onboard the near spacecraft. At a programmed altitude, the bottle is opened to the air. Afterwards, the bottle is closed, sealing the air sample inside. Servo controlled valves are available at hobby shops that cater to RC aircraft hobbyists. The valves are used to control the deployment of pneumatically operated landing gear. The one problem preventing this from being a simple method is the lower air pressure in near space. When the sample returns to the ground, the increased atmospheric pressure will attempt to crush the bottle. So it may be necessary to pump sampled air into the sample bottle. Alternatively, a stronger, perhaps thin walled aluminum, sampling bottle can be used. Gas ratios should not change between the ground and near space, but let's try measure it.

1.10. Repeaters And Digipeaters (H)

1.10.1. Explanation

The higher a VHF, UHF, or microwave antenna is above the ground, the greater the range of the radios using that antenna. Lower frequencies like HF make use of the ionosphere to bounce and skip radio transmissions around the world, so they don't benefit from higher antennas like higher frequencies. Adding a repeater to a near spacecraft makes the near spacecraft look like a commsat. Though not official, this form of communication is termed, Earth-Balloon-Earth (EBE). One of the near space records Ralph Wallio maintains is the record for the longest distance communication via EBE.

1.10.2. Known Work In This Field

Many groups have carried voice repeaters into near space. I wouldn't be surprised if every program hasn't carried a repeater at some time. Voice repeaters appear to be very popular with non-participants who can use them to make long distant contacts with a Handie-Talkie. Less frequently, digipeaters are launched into near space.

1.10.3. Suggestions

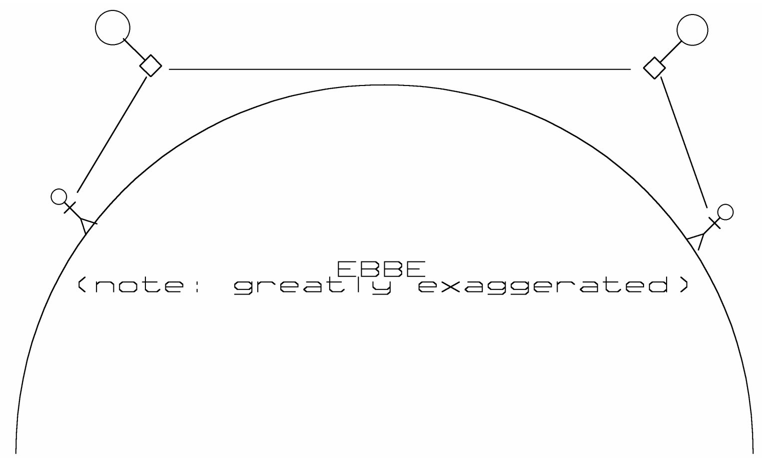
The easiest way for a near space program to get into voice repeating is to use the simplex repeater sold by Radio Shack. Their repeater records up to 30 seconds of conversation, keys the radio, and retransmits the recorded signal. The repeater operates on "AAA" batteries and only requires a handheld radio. An external antenna is preferable, but one TVNSP flight successfully flew a handheld with its rubber ducky antenna. The shortcoming of the simplex repeater is that it transmits on the same frequency that it receives. Unless repeater users understand this and the delay between transmission and reception, they will double with each other. One way to reduce doubling is to transmit on one frequency and receive on a different one. Frequency splits can be programmed into most HTs for this purpose.

Some dual band radios are capable of performing as repeaters, but repeaters with a frequency split on located different bands. The shortcoming of this repeater design is that anyone without a dual band radio or two separate radios is incapable of listening into conversations.

To make the repeater strictly legal with the FCC, a means of shutting off the repeater must be incorporated with the repeater. One way is with the Flight Termination Unit (FTU) used to separate the balloon from the load line. Instead of activating the relay to heat the nichrome coil, the relay is used to provide power to the repeater. When the repeater must be shut off, the signal to the FTU is brought to ground, opening the relay and shutting off the repeater. I have personally made this minor modification and programmed a flight computer to turn the repeater on and off. Now you only need to find a means to signal the FTU from the ground. This last requirement is left as an exercise for the reader, as the author has not had the time to experiment sufficiently with DTMF decoders.

If a digipeater is on the manifest for your near space launch, be sure to use a second radio and TNC (unless the flight computer uses a MIM or Tiny Trak). Do not digipeat on the tracker frequency or use the same TNC as the tracker. As the near spacecraft ascends, the amount of packet data is will hear increases. With digipeating turned on, Chase Crews may lose tracking and status data from the near spacecraft as the TNC spends more time digipeating traffic than sending position reports. .

Another exciting event is to attempt communication hops through several balloons carrying repeaters. This EBBE method of communication has only recently been attempted and promises to allow communications over nearly half the United States. To attempt EBBE communication requires coordination for the times of the launches, the distance between launches, and the frequencies used by the repeaters onboard the near spacecraft. The launches must place the near spacecraft within each other's communication footprint long enough to allow sufficient communications. The farther the launch sites are from each other, the higher the balloon must rise and the shorter the allowed time for communications. Of course, the greater the distance between the balloons, the greater the range allowed between two amateur radio operators using the system. Of course once EBBE becomes more commonplace, there will be attempts for EBBBE! I can just see the fun that will entail.



***EBBE –** Earth → Balloon → Balloon → Earth communication*

Be sure to pass the word if you plan to launch a repeater on your near space mission. Let those in the predicted footprint of the signal know what frequency to communicate with and the time to expect the launch. This is especially true if EBBE is to be attempted.

1.11. <u>Long Duration Missions (D)</u>

1.11.1. Explanation

Currently, most near space missions use latex balloons that are guaranteed to burst. These flights are limited in duration unless measures are taken. Carrying two balloons is one such way. Longer flights allow more amateurs to work balloon-based repeaters and more terrain below to be photographed. By drifting neutrally buoyant, ground photographs are taken at uniform altitudes, making comparisons between photographs easier.

1.11.2. Known Work In This Field

HABET has experimented with making neutrally buoyant balloons using two latex weather balloons. The first balloon is filled to the point that it just about lift the near spacecraft. The second balloon is filled with a few pounds positive lift and carries the balloon into near space. At the proper altitude, the second "grape balloon" is cut free, leaving the first balloon with the near spacecraft. Ballast is released from the near spacecraft to trim its ascent rate. Mark Caviezel (KC0JHQ) of ES-OS is developing his own affordable zero pressure balloons that allow long duration flights.

1.11.3. Suggestions

The suggestions in this sub section are divided into those focused on the near spacecraft and those focused on the ground. In the near spacecraft issues of flight termination, power systems, flight path, and mission manifest are important. On the ground issues of logistics and public outreach (which is partly governed by the mission manifest) are important.

Flight Termination Systems

Either way, with multiple latex weather balloons or ZPBs, cutdowns and cutdown systems must be perfected before attempting a long duration near space mission. When the cutdown system of a near spacecraft doesn't function, the near spacecraft is left aloft for its batteries to fail. Once the batteries fail, the near spacecraft can no longer send telemetry. At that point the FAA declares the near spacecraft derelict. The location of a derelict near spacecraft is unknown and represents a risk to air traffic. Being responsible for a derelict near spacecraft makes you very popular with the FAA. The solution is to use multiple, redundant cutdowns. Each system must include it's own power, antenna and receiver or timer. Design cutdowns to use multiple frequency bands, rather than just one. Another option is to include a pager controlled cutdown. Using a stopwatch-operated cutdown should be the ultimate failsafe. Before using a flight termination system, cold soak it in dry ice for 24 hours to make sure it will properly function in the chill of near space.

Power Systems

Consideration should be given to meeting long term power needs with solar cells and rechargeable main batteries. Because of the prolonged cold soaking, battery chemistry is another important issue. This is especially true during the night when internal temperatures are expected to drop to their lowest point when there is no sunlight to warm the exterior of the near spacecraft. Non-rechargeable batteries have an ultimate limit at which they will no longer produce enough power for the near spacecraft. Using solar power and rechargeable cells gets around this limitation.

Flight Path

For the simplest flight prediction, fly the mission in the stratosphere where winds tend to remain at the same heading. If flown lower, the location of moving lows and highs complicates the flight path. Besides, floating above 60,000 feet keeps the near spacecraft above controlled airspace, simplifying any possible planning with the FAA. Be aware that when the Sun sets, the helium inside the balloon cools and contracts, lowering the altitude of the near spacecraft. In the morning as the helium warms, the near spacecraft will rise, but not as high as the day before. This is because over many hours, the small helium atoms leak from balloons, reducing the balloon's lift. So use more helium that is needed for a short duration mission..

Mission Manifest

Three important tissues here are redundant tracking, the power budget of the near spacecraft, and how the flight manifest relates to the planned public outreach.

Carry multiple tracking systems on the near spacecraft to lower the risk of it becoming derelict, even when the flight termination works properly. Each tracker needs its own power supply, GPS, HT, and antenna.

Determining the power budget of a near spacecraft is not much of an issue when the flight only lasts for three hours. On long duration missions, the capacity of the batteries and their recharge rate (if solar cells are used) must be balanced with the current draw of devices onboard and their duty rate. If using multiple sources of power, then each bus is consisted independently of the others. Don't forget to factor in the fact that batteries cannot be recharged at night in your calculations of the required total battery capacity.

Monitor the current on each power bus as a part of telemetry. Op-amps can be configured to act as current to voltage converters and the result fed into a ADC channel for monitoring. High-risk items can be off-loaded to power busses that are considered non-critical. Another option is to design latching relays into power circuits. This allows ground crews or even the CC/PS to take devices off-line should it appear they have failed and are exceeding their power allotment or battery levels have dropped low enough that non-critical items must be taken off-line. Onboard devices may be at a higher risk of failing because of their long-term exposure to cold temperatures.

Logistics On The Ground

There are two groups of people to be concerned with; those in fixed locations like Mission Control or Tracking Posts and the Chase and Recovery Team

A Mission Control is much more important for long-term missions that it is for our typical four hour near space mission. First, Mission Control is the liaison with the FAA. If there's any question about the mission, the FAA needs a single phone number to call. Mission Control provides a location to get weather updates for new flight predictions off the web. They can generate new flight predictions every three hours when updates to the models are made available. Mission Control is also a way to gather many experts together for monitoring the progress of the flight. When the near spacecraft is out of range of Mission Control, they will depend on support sites located along the flight path to forward information. Doesn't this sound just like Mission Control back in the beginning of the Space Age? Since a long duration mission may require 24 hours, a schedule to relieve crews in Mission Control is needed.

For the Chase and Recovery Team, a long duration mission can be thought of as a twenty-four hour road rally. Cars making the entire trip need to be inspected before launch to make sure they're up to the driving. Each vehicle needs more than one occupant, even if the car is not actively tracking. Drivers need to take turns driving to prevent fatigue. Some chase vehicles will not need to make the entire trip, as they can start the chase when the near spacecraft passes close to their homes. As a result I would expect the number of cars in the Chase Team to increase as the mission progresses. Depending on the winds aloft, there may be no need to drive the entire time. If the Chase Team can get ahead of the near spacecraft they may be able to get some sleep during the night. A KOA® Kampground or such location may be an ideal place to wait the night as it's easier to set up antennas at a campsite then at a motel. This adds another responsibility to Mission Control, calling ahead and making reservations. When the Chase Crew does stop for the night, someone should be tasked with monitoring communications and near spacecraft telemetry.

Public Outreach

If going to this much trouble for a long-term mission, then get some outside attention for it! The media should be notified and asked to attend the launch and recovery. Between the launch and recovery ask them to visit with Mission Control. Because of liability issues, the media may not want to go on the chase. However, there's no reason they can't interview members of the Chase Team via cell phone.

Because of the large swath of country a long duration mission covers, get amateur radio clubs involved to set up public tracking posts. Locations where large numbers of people who are not in a hurry, like shopping malls and parks, to are good places to set up tracking posts. Carrying items like SSTV and repeaters on the flight manifest is a good way to interest the public. At the tracking post they can watch as live images as they are transmitted or talk to other observers in another state through the near space repeater. As for a launch date, perhaps Field Day would be the best time. On Field Day many hams have already planned to be out and showing amateur radio to the public.

1.12. High Altitude Rocket Launches (P)

1.12.1. Explanation

A portion of the thrust of a rocket motor is used to overcome drag and does not accelerate the rocket. The force of drag on a rocket is related to the density of the air the rocket must pass through. If the air density decreases by a factor of two, then the amount of drag the motor must overcome decreases by a factor of two. Predictions made by the Idaho Tripoli indicate that a rocket launched at 100,000 feet, where the air density is only 1% of that at sea level, would go some 2.5 times higher than it would launched at sea level. The reduction of drag at 100,000 feet means more of the motor thrust goes into accelerating the rocket to high speeds and that there is less drag to slow down the rocket once the motor cuts off. The drag issue at engine cut off gets better because the air density is decreasing with increasing altitude. Just where drag begins to slow down the rocket (at motor burn-out), there's less air to help drag do it.

Before the beginning of the Space Age, physicists like James van Allen were launching rockets from balloons, called rockoons, to study cosmic rays.

1.12.2. Known Work In This Field

On the amateur side, Bill Brown in conjunction with the Huntsville, Alabama L-5 (HAL-5) Society has developed HALO, High Altitude Lift Off.

Website: http://hiwaay.net/~hal5/HALO/index.shtml

1.12.3. Suggestions

There are several issues to resolve. For instance, what is entailed with launching rockets above controlled airspace (60,000 feet)? What is the requirement to carry rockets through controlled air space? What safing mechanisms are required to ensure there is no premature rocket launch? What safing mechanisms are required to bring a rocket back down to the ground should the launch be aborted?

Launch Issues

From HALO's experience, it appears that there is less trouble if the launch takes place over the ocean. As far as mechanisms to prevent launch, several switches (relays) should be used in the launch chain. For instance, an altimeter switch could be used to prevent a launch until the balloon is above the specified altitude. Switches to detect when the launch rail is properly oriented (like the old mercury switches) should also be included. A timer is another switch in the launch chain to prevent unauthorized launches. One last switch is the fusible link. The fusible link breaks the launch chain of switches when a launch abort of balloon burst is detected. Since no system is prefect, it is preferable that the launch chain fail by preventing a launch, rather than initiating one.

Rocket Issues

High power rocketry has certification levels that are administrated by amateur rocketry societies like Tripoli and NAR. Be sure that certified individuals with up to date memberships to organizations like Tripoli and NAR are involved with the project. Launching a rocket at 100,000 feet involves entirely different solutions to stability. On the ground, fins and the distribution of weight in the rocket are the primary means of insuring stability. Amateur rocket designers ensure their rockets have a center of pressure about one caliber behind the rocket's the center of mass. In near space, with its low air density, there is much less air to produce pressure on the rocket when it pitches or yaws. One way to address this issue is to use larger fins. However, in near space the fins rapidly become very large and a waste of mass. A large and heavy gyroscope that maintains stability through angular momentum is unsuitable because of its excessive weight. However, a lightweight gyroscope used as input to a guidance system is a possibility. Actively gimballing the motor is a difficult proposition. Gimballing requires servos under the control of a microcontroller getting it's input from the Sun or a piezo gyro. While the weight may not be much, the space required inside the rocket tube for gimballing is best left to more propellant. In place of gimballing the engine, thrust vectoring with graphite vanes (like the V-2) may be possible. Perhaps the best guidance method is to launch the rocket out of a rifled barrel. The spin up of the rocket as it leaves the launch tube may be able to keep it straight. In essence, the rocket becomes its own gyroscope.

According to the International Aeronautical Federation (FAI, from the French – go figure), space begins at an altitude of 100 kilometers. This is equivalent to 62.5 miles or 330,000 feet. If launched from 100,000 feet, a rocket need only make an additional 230,000 feet. With the reduced drag of near space, a rocket capable of making 100,000 feet at sea level should make an additional 250,000 feet if launched at an altitude of 100,000 feet. A rocket performance program run by a member of Idaho Tripoli at my request calculated this improved altitude. Currently, most rockets I have seen capable of making 100,000 feet are very large and heavy. It is necessary to design a minimum mass rocket if a near space launch to space is to be attempted. A back of the envelope calculation by the author indicates a rocket capable of achieving a speed of one kilometer per second at motor burn out should touch space if launched at 100,000 feet. This brings to mind the question, what does it take make a rocket capable of going into orbit? To achieve an Earth orbit requires a rocket to reach a speed of seven kilometers per second. The kinetic energy of such a rocket is 49 times greater than a rocket only capable of traveling at one kilometer per second (kinetic energy scales with the square of the speed). Forty-nine times more kinetic energy means there must be 49 times more propellant onboard the rocket without increasing the rocket's mass, including fuel weight. While rockoons make great sounding rockets, they make lousy orbital vehicles.

1.13. Near Space Return Vehicle (NSRV) (D)

1.13.1. Explanation

Why chase when you can have the near spacecraft come to you? Currently Chase and Recovery Crews drive after every near spacecraft launched. While most of us enjoy the road rally, there are times when it would be better if the near spacecraft would return to a predetermined safe location. There can be other reasons to control the descent of a near spacecraft. Perhaps an experiment calls for photographs to be taken at particular locations. Or just perhaps the mission profile requires that the flight not recover in the bottom of a canyon or the top of a snow capped peak. For times like this, a near space return vehicle (NSRV) operating similar to the Space Shuttle would be ideal. Besides, creating a NSRV adds another challenge to anyone's near space program.

1.13.2. Known Work In This Field

In Canada, Art Vanden Berg has had success with a NSRV design. See his webpage at http://members.shaw.ca/sonde/index.htm

1.13.3. Suggestions

There are two design approaches to the NSRV. One design utilizes a vehicle flown on wings and the other utilizes a vehicle flown on a parafoil (used in place of standard hemispherical recovery parachute). If the winged vehicle approach is selected, then experiments must be designed to fit inside the glider. If the parafoil approach is used, then experiments and airframes remain as they are for the near space program outlined in this book. Most likely the weight of the control mechanisms, like servos, is similar between the glider approach and the parafoil approach. The major difference between the approaches is regards to dead weight. The weight of NSRV wings becomes part of the payload weight under FAR 101. As a result, the weight of the wings is weight that cannot be utilized for experiments. In the parafoil approach, the weight of the parafoil, like the standard hemispherical recovery parachute, is not a part of the near spacecraft. As a result, changing a hemispherical parachute to a parafoil does not effect the weight available to experiments as much as using wings.

Glider Approach

A release mechanism must be designed that cleanly separates the NSRV from its balloon. Because of the thinner air in near space, the glide speed of the NSRV is initially higher, but slows as the NSRV approaches landing. Steering is accomplished by more than turning a rudder. When the rudder turns, it creates drag, making the glider slow down and descend faster. When steering the glider, turn the elevators up a little to counteract the descent caused by the rudder's drag.

Wing Cautions

The concerns regarding wings are different, but still important. Airfoils develop lift when air passes over them. The amount of air passing over the airfoil determines the lift generated (assuming the same airfoil is used). The greater the air speed or the air density, the greater the lift developed. At high altitudes, where the air density is very low, the wing must pass through the air much faster. As the air density increases, the airfoil travels slower while still providing the same amount of lift. At high speeds, wing tip flutter, a rapid vibration of the wings, places stress on the root of the wings. When enough flutter, one or both of the wings can rip away from the fuselage. At this point the controlled aspect of the recovery is over. There are several ways to avoid this. Strengthening the wing roots is one approach, but it adds weight to the NSRV. Another approach is to use wings with a longer root. The delta shaped wing like those used in the Space Shuttle is an example of this approach. However, delta wings develop less lift that traditional straight wings. Going from straight wing to delta wing changes the NSRV design from that of a long glide ratio slope glider with conventional straight wings to more of a delta wing with its shorter glide ratio. The shorter glide ratio reduces the range of the NSRV, possibly requiring the NSRV to land at a location other than the launch site. At a minimum, a GPS receiver and electronic compass are required inputs to the flight computer to guide the NSRV. Program the final destination of the glider into the GPS and rely of the GPS receiver to calculate the range and bearing to the destination. A compass is required to indicate the heading of the NSRV, which may not be the direction it is gliding. An additional input that may be desired is an artificial horizon to keep the glider level. Dan Paulson (KD7OST) of TVNSP is working on these issues.

Parafoil Approach

The same items in regards to guidance of a winged NSRV are issues for the parafoil approach. However, instead of steering the NSRV with a rudder and two ailerons, steering the parafoil is accomplished by pulling on a single Dacron line attached to the ends of the parafoil. Each end of the Dacron line is attached to one point on the outside edges of the parafoil. The middle of the Dacron line is wrapped a couple of times around a spool. The steering servo rotates the spool to steer the parafoil. When the spool is rotated clockwise, one end of the parafoil is pulled down and the other end is slack. When rotated counter clockwise, the opposite end of the parafoil is pulled down, steering the parafoil in the opposite direction. The larger the spool's diameter or the greater the spool's rotation, the greater the steering effect.

Parafoil Cautions
Slow rotation of the balloon relative to the NSRV during an ascent risks twisting the shroud lines of the parafoil. A method to prevent the parafoil shroud lines from twisting into a knot is paramount to a successful recovery. One method to prevent tangling of the parafoil shroud lines is to stow the parafoil during ascent. This solution creates two new concerns. First, the parafoil must deploy with a high level of reliability. Second, the parafoil must be oriented correctly during deployment such that airflow opens the parafoil. NASA's X-38 approach to parafoil recovery is to use multiple sets of parachutes or parafoils, each designed for a different speed and pressure regime. Of course relying on multiple recovery devices multiples the reliable deployment concerns.

1.14. Sun Sensors (P)

1.14.1. Explanation

Many experiments I am contemplating require some sort of steering or at least an awareness of the Sun's position. A sun sensor is one solution to this need.

1.14.2. Known Work In This Field

The only sun sensor I have heard of is marketed by AeroAstro and is designed for microsatellites.

1.14.3. Suggestions

Any electronic component capable of detecting light should be able to form the basis of a sun sensor. The one design I have in mind uses photocells (photoresistors). The resistance of photocells depends on how much light is falling on them. One way to detect this change in resistance is to connect a photocell in series to a second, fixed resistor. Connecting a voltage source to one end and ground to the other forms a voltage divider. As the light intensity changes, so does the voltage drop across the photocell. The Basic Stamp can detect a change in voltage when the voltage increases above or below 1.4 volts. Changing the fixed resistor to a trimmer pot allows you to adjust the sensitivity of the photocell to sunlight. Now when the light intensity increases to a certain point, the logic state of the I/O pin changes from low to high or from high to low. Place the photocell into end of a opaque tube, and the photocell will not change states until the tube is pointed close to the Sun. This design is limited to telling the CC/PS when the Sun is pointed in a particular position. Finer position sensing is possible if several sun sensors are used, with each pointed at a slightly different direction.

Instead of placing the photocells into the bottom of tubes, place a fence between the photocells. The shadow cast by the fence indicates which photocell is not pointed directly at the Sun. The fence is less sensitive to azimuth pointing errors that the tube design is.

Instead of programming the flight computer to measure the voltage from each photocell voltage divider, input the voltages from each photocell voltage divider into a series of comparators. Instead of checking the entire set of sun sensor I/O pins for their logic state, the CC/PS only needs to check the output of the correct comparator to be sure the Sun is located in one particular direction.

An alternative to photocells is to use phototransistors. The benefit of using phototransistors is their increased speed over the photocell. Phototransistors control the current flowing through them based on the amount of light shining on their base. The greater the light intensity, the greater the current they let flow through them. Connecting a phototransistor in series with a resistor between five volts and ground creates a "pseudo" voltage divider. The current that the phototransistor lets flow to ground creates a voltage drop across the resistor. Measuring the voltage drop across the resistor indicates the light intensity on the phototransistor. As with the photocell sun sensor, you may want to use comparators to indicate which sensor is most closely pointed towards the Sun.

1.15. Sounds In Near Space (H)

1.15.1. Explanation

Except for special cases, as in the case of light, waves require a medium to exist. As an example, water supports and carries a water wave. Air is the medium that carries the sound wave. Sound waves are compression waves, so they're not like water waves that travel as rising and falling water. Tiny compressions and rarefactions of air are waves of sound. When you hear a sound, your ears are detecting tiny bursts of high and low pressure in the air (the changes in pressure are very small). Remember that all waves have a characteristic called wavelength. High pitch tones or frequencies have a shorter wavelength than low pitch sounds or tones. As the air pressure drops, the average distance between the air molecules gets greater. We can calculate the average distance between air molecules as a function of the air pressure. We refer to this average distance between air molecules as their mean free path. So as the altitude increases and the air pressure drops, the mean free path between molecules increases. Thinner air also doesn't carry sound very well. So as the air pressure drops, what frequencies that can be carried are not carried with sufficient energy, so they get fainter.

1.15.2. Known Work In This Field

Some of my former students at Nampa High School designed a near space beeper experiment using a BS-1 IC, LEDS, and a piezo speaker. Sounds in near space have been measured indirectly by KNSP and TVNSP on missions flying camcorders and audio locator beacons.

1.15.3. Suggestions

It should be the case that air molecules can only carry sound waves with wavelengths longer than the mean distance between the air molecules (I have yet to verify this). Recall from your physical science courses that the longer the wavelength of a sound wave, the lower its pitch, or frequency. The distance between molecules determines how far molecules can move before colliding with each other, or their mean free path. As the air pressure drops, there are fewer molecules in a volume of air and therefore their free mean path increases.

As a near spacecraft ascends and the air pressure drops, the highest frequency tones are affected first. The increasing mean free path between molecules means it's difficult to carry high pitch sounds effectively. As the capsule continues to climb, lower and lower frequency sounds begin to fall off in volume.

To determine near space's effects on sound, Nampa High School students designed a sound and light circuit with the Basic Stamp 1-IC. Seven LEDs and a speaker where connected to the BS1-IC. Seven tones were programmed in the BS1-IC. When a tone was played, its LED was illuminated as a visual indicator (in case the tone couldn't be heard, we would know it was being produced). The assembled circuit was positioned in front of a camcorder. Throughout the mission, the camcorder recorded the LED and sounds of the circuit, with the edge of the Earth as a backdrop to the experiment. From the results of the experiment, we determined frequency is a large factor in whether a tone is heard or not in near space. But my calculations of mean free path and wavelength at altitude do not predict which tones are affected at each altitude.

Two Useful Equations
The mean free path of air molecules is determined using the following equation.

```
L = 1 / (pi * sqrt(2) * N * D^2)
```

Where

L = the mean free path
N = number of molecules per cm3
D = average diameter of molecules (2 x 10^{-8} cm)
pi = 3.14159

The number of molecules in a cubic centimeter of air at sea level is equal to $3x10^{19}$.
At lower pressures, the number of molecules per unit volume drops off linearly with pressure. So if the pressure is reduced by half, there will only be half as many molecules per unit volume.

The wavelength of a sound wave is determined the equation,

```
Wavelength = velocity/frequency
```

The speed of sound changes as the altitude changes.

Altitude (feet)	**Speed (cm/sec)**
Sea level	33500
10,000	
20,000	
30,000	
40,000	
50,000	29500
60,000	
70,000	
80,000	
90,000	
100,000	30200

1.16. <u>Tethered Capsules (H)</u>

1.16.1. Explanation

On two occasions, the Space Shuttle attempted to deploy tethered satellites. The satellites were connected to a conductive tether that was wound around a winch. Astronauts on board the Space Shuttle unreeled the satellite from the shuttle for a distance of some miles. Twice the experiment has failed. When it works properly, the tether between the satellite and the shuttle will cut through the Earth's magnetic field, creating a current. This current can be used as a power source or be used to do work and raise or lower satellite orbits.

How about if amateur near space giving tethered satellites a try?

1.16.2. Known Work In This Field

Twice KNSP operated a tethered capsule (flights 98A and 98B). The first time the capsule deployed properly, but the camera failed, so no photographs where recorded. The second time the flight computer glitched, preventing the experiment from taking place. I have not heard of any other attempts.

1.16.3. Suggestions

The KNSP Tethered Capsule Experiment relied on a servo modified to be a winch.[B] Many robotics websites explain how to modify a servo for continuous rotation, so it is not covered in this book, or you can buy pre-modified, continuous rotations servos directly from Parallax, Inc. A reel was attached to KNSP's modified servo and approximately twenty feet of 50 pound test Dacron was wound around the reel. The tethered capsule was attached to the end of the Dacron kite line. The servo and reel were housed inside the docking unit and the tethered capsule was pulled tightly into the face of the docking unit. During the mission, the flight computer was programmed to operate the modified servo as if it where a regular servo. But instead of placing and holding the servo in one specific position, the servo spun continuously when instructed to position itself away from neutral. In response the servo began spinning and unwinding the tether and lowering the tethered capsule. A number of seconds later, the flight computer instructed the flight computer to place the servo into the neutral position, stopping the servo's rotation. At the end of the experiment, the flight computer instructed the servo in a new position that was opposite of the first position. The new position reversed the servo, winding the tether back onto the reel. By experimenting on the ground, it was determined that the rewinding required more time that the unwinding. At the programmed time, the servo was instructed to place itself back into the neutral position, stopping the rewinding of the tether. To ensure the tethered capsule remained firmly against the docking unit, occasionally momentary commands were given during the remainder of the mission to rewind the tether. During descent, at approximately 500 feet above the ground, the servo was again instructed to unwind the tether. This kept the near spacecraft from landing on top of the tethered capsule and also allowed Recovery Crews to observe the deployed tethered capsule.

Future Plans

I have three changes I would like to make the first KNSP attempt at tethered capsules. First, I would like to place a small digital camera and RF link into the tethered capsule and return images of the underside of the near spacecraft when the tethered capsule is deployed. Parallax has the perfect 433 MHz RF modules for this. Second, the Earth's atmosphere develops an electrical charge (the fair weather field) of on the order of 100 volts per meter. A tethered capsule placed five meters below a near spacecraft should experience a voltage potential of 500 volts between the near spacecraft and itself. It may be possible to use a conductive tether to measure this potential. The near spacecraft would seem to be an ideal platform for measuring this charge as a function of altitude. Note that this fair weather field is not related to the potential difference the Space Shuttle sees when its tethered satellite cuts through lines of the Earth's magnetic field. Third, to ensure the tethered capsule remains firmly attached to the docking unit, a servo-operated latch should be implemented. Before the tethered capsule can be lowered, the docking latch must be released. After being rewound, the docking latch is locked.

1.17. Satellite Testing (D)

1.17.1. Explanation

The use of pico and nano satellites is somewhat popular with universities. For $75,000, they can build and launch a one-pound satellite measuring four inches on a side. These pico-sized satellites are called CubeSats. The CubeSat concept was developed at Stanford University. One Stop Satellite Solutions (OSSS) inn Utah is one distributor of the kits, and they will arrange to launch your CubeSat once you complete it. Another nanosatellite idea is the CanSat concept by Dr. Twiggs at Stanford. The CanSat uses a pop can as the airframe. Once a student finishes building their CanSat, it is launched on an amateur rocket. Finally, the Colorado Space Grant along with others has designed the BalloonSat program. In BalloonSats, college students design a functioning nanosatellite model and attach them to near space trackers.

Because of the costs involved, it's highly desirable to test even CubeSats before their launch. Some tests, like vibration and acoustical testing, which simulates a rocket ride into orbit, is best performed on the ground in test chambers. However other tests can be performed in near space at very reasonable cost. Aside from testing complete CubeSats in near space, portions of microsatellites occasionally need to be tested independent of the rest of the satellite. Here again, balloons can perform a valuable service. Because of weight constrains, its more difficult to test anything larger than a complete nanosatellite.

Satellite testing is one of many functions of the National Scientific Balloon Facility (NSBF). Once you develop a proven program, you can offer to test CubeSats and satellite components for less than the equivalent test on the ground. In addition, your test can return photographs of the CubeSats with the Earth's horizon at 100,000 feet as a backdrop. However, remember that we are using amateur radio for telemetry. As a result, we cannot make a profit testing satellites.

1.17.2. Known Work In This Field

EOSS is working with the Colorado Space Grant to test BalloonSats. GPSL 2003 took place in Colorado to support the BalloonSat program that year.

1.17.3. Suggestions

BalloonSats, CubeSats, CanSats, or portions of satellites can be tested inside a near spacecraft or mounted as part of the stack for greater exposure to the near space environment. This section explains how to make a harness for BalloonSats and CanSats and a bumper for CubeSats, and discusses an idea to carrying CanSats.

BalloonSat Harness

This is how the author built a harness for the BalloonSats launched at GPSL 2003 in Deer Creek, Colorado. The harness will work for CanSats also, since both BalloonSats and CanSats have a single tether point (in the case of the CanSat, the tether point is for its parachute) The harness is designed to integrate a BalloonSat or CanSat into the near space stack just like another module. It's made up of a Dacron cross and a length of dangling Dacron that attaches to the chain of BalloonSats or a single CanSat.

Materials

- 150 pound test Dacron kite line
- Five #0 bearing swivels

- Split ring
- Heat shrink tubing large enough to cover knots in the Dacron (3/16")

Procedure

√ Cut three lengths of kite line, at least four feet long

√ Note: two lengths make the Dacron cross and the remaining length is the dangling Dacron. The cross pieces must be the same length, but the dangling Dacron can be a different length.

√ Mark the center of two of them with a permanent marker
√ Pass both of them through a ring in a bearing swivel
√ Align their center marks and center the bearing over the mark
√ Tie a knot in the Dacron, trapping the bearing swivel in the knot and centered over the centering marks in the Dacron
√ Mark six inches from the ends of the Dacron with a permanent marker
√ Slide a short length of heat shrink over the Dacron if you want to cover the knots
√ Slide a bearing swivel over the Dacron line (four swivels total)
√ Center the marks in the Dacron inside the ring of the bearing swivel and tie an overhand knot in the doubled over line
√ Heat shrink the knot if desired
√ Mark six inches from both ends of the remaining length of Dacron
√ Slide one end of the Dacron through the open ring of the bearing swivel in the center of the crossed Dacron lines
√ Tie an overhand knot in the doubled over Dacron
√ Slide a length of heat shrink over the knot and shrink, if desired
√ Slide a second piece of heat shrink over the dangling Dacron
√ Slide the remaining free end of the dangling Dacron through a ring of the last remaining bearing swivel
√ Center the mark inside the bearing ring and tie an overhand knot in the doubled over line
√ Slide the remaining heat shrink over the knot and shrink
√ Put a split ring into the open ring of the swivel bearing on the dangling Dacron

Using the BalloonSat Harness

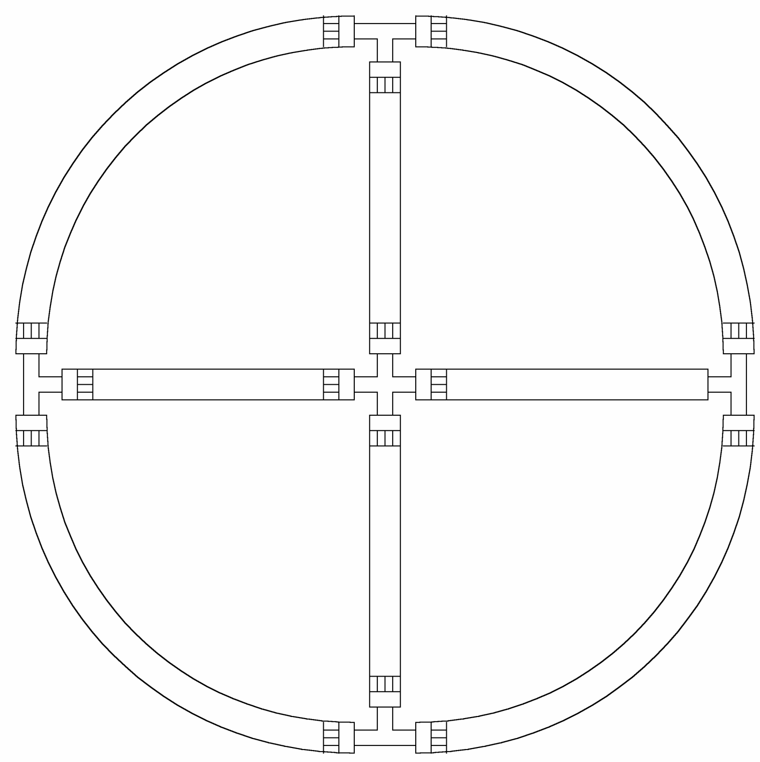
The BalloonSat harness is designed to suspend BalloonSats beneath the last module in the near space stack. The four bearing swivels in the Dacron cross connect to the lift rings in the bottom of the last module in the near space stack. The Ballonsats have a metal post through their center(s) that attach to the split ring in the end of the dangling Dacron. The harness basically makes the BalloonSats a part of the near spacecraft.

The CubeSat Bumpers

A sample satellite bumper is described in this section. This is a simple design that should work with the lightweight CubeSats. Use this design as a beginning and modify it as needed. Unlike the BalloonSat harness, this design has not been tested yet.

Materials

The following materials are bent into a spherical frame made up of octants.



CubeSat Bumper

- Fifteen feet of stiff poly hose
- Three plastic barbs
- One package of hot water pipe insulation tubing
- Twenty-four inches of three-inch diameter heat shrink tubing
- Eight pieces of one-inch long, 3/32” diameter heat shrink
- Four lengths of 24” long Dacron, 200 pound test
- Six small hose clamps
- Eight #3 or larger barrel swivels
- At least eight inches of heat shrink tubing
- Eight one-inch split rings
- Scissors and a lighter

Procedure

√ Melt the ends of the Dacron line with a lighter to keep the lines from unraveling (Use just enough heat to seal the ends, but not to change their lengths significantly)
√ Mark three inches from each end of a link line with a laundry marker
√ Cut eight pieces of one-inch long 3/32” diameter heat shrink tubing.
√ Slide two pieces of heat shrink tubing onto the link line
√ Slide two barrel swivels onto the link line
√ Center the loop of a swivel over a 3" mark on the link line and tie an overhand knot with the doubled over string
√ Trim up the excess string from each knot. Melt the new ends of the nylon string
√ Slide a piece of heat shrink tubing over the knot and center it.
√ Slide the second piece over the knot at the other end.
√ Apply heat with a heat gun and shrink the tubing securely over each knot.
√ Repeat the above process with the other three link lines

- √ Make three marks on both ends of the link line, each mark three inches further in from the knot (3”, 6”, and 9” from the knot)
- √ Double the link line at the 6” mark and knot the line on the 3” and 9” marks

- √ Cut the poly tubing into three lengths, five feet long
- √ Cut the heat shrink into one-inch long pieces (24 bands)
- √ Bend each length of tubing into a circle
- √ Slide eight pieces of heat shrink bands on each tubing
- √ Select one tubing piece to be the equator and set it aside for a moment
- √ Slide the loops of one of the link lines through the circular tubing
- √ Slide the loops of the second link line through the second circular tubing
- √ Insert a barb into all three poly tubing circles and lock the ends together
- √ Combine the rings into a sphere with mutually perpendicular great circles formed by the rings
- √ Position the bands of heat shrink so that two bands are in each 90-degree segment
- √ Clamp the intersections of the great circles together with the hose clamps
- √ Cut the hot water pipe insulation tubing to fit each 90-degree segment
- √ Slide the tubing over the segments, making sure the heat shrink bands and the link line loops are placed over the tubing
- √ Gently heat the heat shrink, do not crush or melt the tubing
- √ Slide on the split rings to the link line loops

Using The Bumper
One way to protect an externally mounted CubeSat during landing is to surround the satellite with bumpers and mount the bumper frame above the top module. Mounted above the top module, the recovery parachute slows the final landing of the satellite even more, as the weight of the lower modules is taken off the parachute by their landing on the ground. Attach the satellite bumper below the parachute ring and above the top module in a stack. The satellite bumper does not support the weight of the near space capsules below it. Instead, it hangs suspended inside the loops in the link lines. A different set of lines attaches the CubeSat-mounting frame to the split rings of the satellite bumper. The lines need to be reasonably tight to keep the CubeSat from swinging outside the bumper. The bumper flexes on landing and keeps the CubeSat from making contact with the ground. A camera mounted to an E-Quad of the top module can photograph the CubeSat during its flight.

1.18. Photovoltaic Systems (P)

1.18.1. Explanation

For long duration flights where a sufficient amount of primary batteries weighs too much, photovoltaic (PV) arrays may be the solution. Even when PV arrays are not strictly necessary, experimentation with them can be valuable. Remember, it’s always a sunny day in near space, so take advantage of the free power.

1.18.2. Known Work In This Field

The Voice Of Idaho Amateur Radio Club tested a PV array on their first near space launch. TVNSP has designed a PV array suitable to operate an Alinco DJ-S11. However, at this time, it has not been tested in a mission.

1.18.3. Suggestions

There are at least three major types of silicon solar cells on the market (in the past a very inefficient selenium based solar cell was available and today more efficient gallium arsenide cells are used on some satellites). The first silicon type is the single crystal solar cell and is the most expensive type. These have a uniform texture and color to them. Not all single crystal solar cells are created equal, as the most efficient ones are also the more expensive ones. The next type is the polycrystalline solar cell. These solar cells have a cracked appearance to them. As they are rotated, different crystals in the cell reflect more brightly. These solar cells are less costly than single crystal solar cells and produce less power. They also are more fragile than the crystalline. The last type of silicon solar cell is the amorphous solar cell. These are the least expensive and produce the lowest power. They are a fairly uniform purple color to them. Amorphous solar cells are always found mounted to a frame or base. Their low power probably makes them unsuitable for near space use since much more efficient solar cells are not so expensive as to make them unavailable. One area where amorphous solar cells shine however is in their ability to bend. If a curved surface must be covered in solar cells, then amorphous solar cells are the choice.

Solar cells are constructed of very thin disks of doped silicon. As a result, they are very fragile. As a result, most commerically available PV arrays are mounted to glass covers and metal frames. Since amateur near space faces severe weight constraints, these PV arrays are unsuitable. Instead, purchase individual solar cells and make your own PV array. To make a PV array for amateur near space use, the individual solar cells must be soldered together to create the voltage and current levels needed, then mounted to a lightweight and durable backing to prevent them from breaking.

Solar Cell Electrical Characteristics

Solar cells, like photodiodes (which they are related to), are not voltage sources. Instead, solar cells are current sources. The typical solar cell produces 0.5 volts, regardless of the dimensions of the cell. The size of the cell (that is its surface area) determines the amount of current it produces (the load the solar cell is under does vary their voltage, but we are assuming a constant load). The greater the surface area, the more current produced by the cell. Solar cells that produce several volts are actually many cells wired together (so shouldn't we be calling them solar batteries?). The face of a solar cell is crisscrossed with a metal grid, forming the positive electrical connection for the cell. Along the edge of the solar cell's face is a border of silver. Solder to any point on the border to make an electrical connection. The back of the solar cell is coated in a thin layer of silver. Solder to any point on the back to make the negative connection to the solar cells. Before soldering wires to the solar cell, pre-tin the wires. Pre-tinning the wires speeds the process of soldering wires to the solar cells, reducing the chances of damaging them. Use stranded wire to connect solar cells. Solid wire is too stiff, risking breaking solar cells or soldered connections (but probably solar cells first). It's not difficult to solder to solar cells, but be quick so the heat of the soldering iron does not damage the solar cell. Use a DMM set to DC voltage to verify the solar cell's terminals and polarity.

To electrically assemble the PV array, first determine both the current and voltage requirement needs of the near spacecraft subsystem in question. Solar cells are connected in a combination of series and parallel. Connecting solar cells in parallel (soldering back to back and front to front) increases their current capacity. Connecting solar cells in series (soldering front to back) increases their output voltage. To create a PV array, first create a series chain of solar cells to meet the voltage requirement. Then make several chains and wire them in parallel to meet the current requirement.

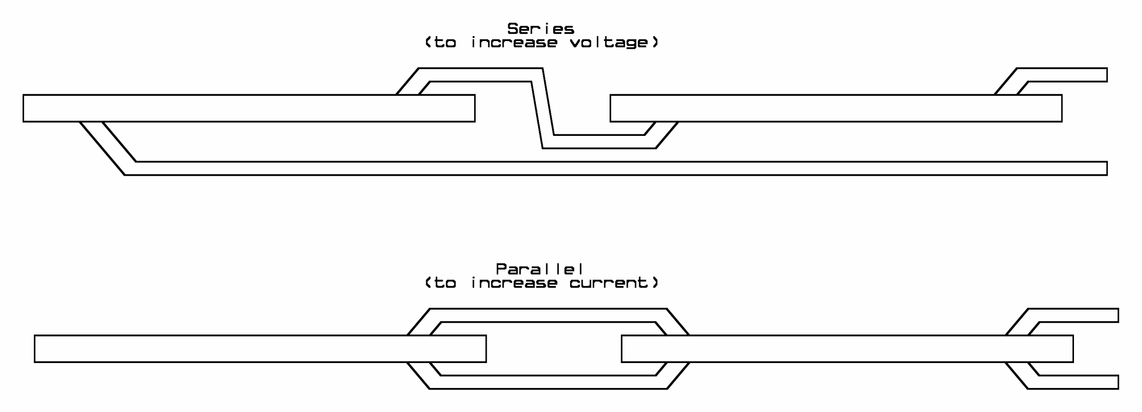
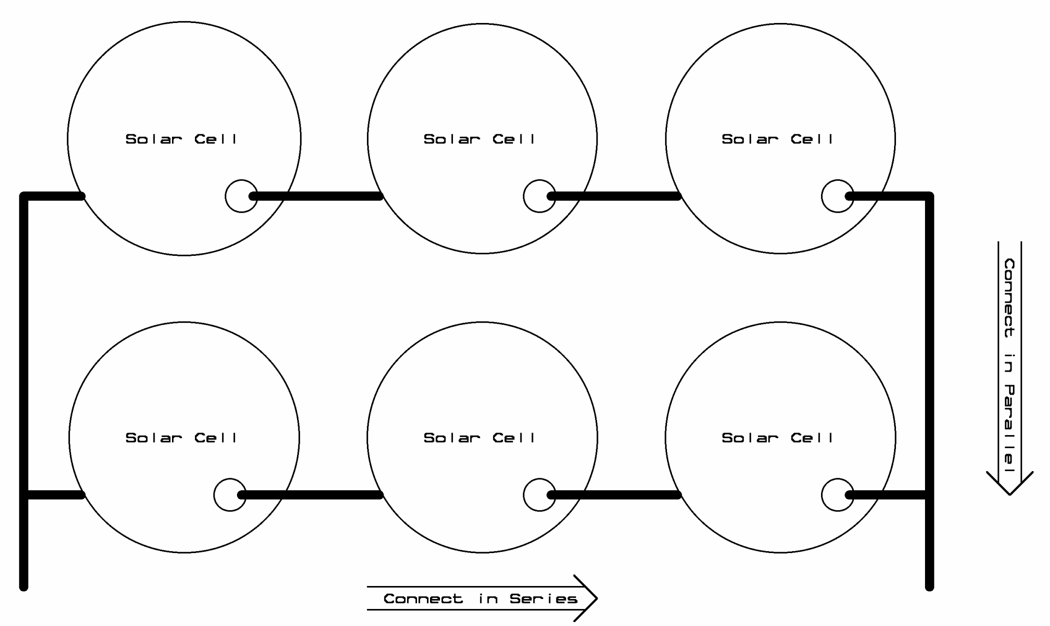


Diagram of Series and Parallel Combinations *– Series to increase voltage (top), Parallel to increase current (bottom)*

A PV array can be used as the primary power system for a device (preferably a non-critical one) or as a trickle charger a battery during a mission. To recharge a battery, the voltage of the PV array must be at least two volts greater than the battery voltage. To get the longest lifetime out of a battery, use a smart charger to control the recharging of the battery. If the battery cost is not great, and the recharging system is to be kept simple, then a trickle charger is suitable. If used to recharge batteries during a mission flown partially at night, the PV array requires a blocking diode to prevent the battery from discharging into the solar cell during the night (ummm, wouldn't running current back into a PV array make it emit light?). Keep in mind that the blocking diode drops the voltage output of the PV array by 0.7 volts. Two benefits of flying a PV array into near space is that the colder temperatures in near space increase the output current of the PV array as well the increased intensity of sunlight. If you will be using a diode in the PV array, then solder it into the array near the end of the power cable. Since the current and voltage are not very great, a 1N4001 diode should be good enough. If you are designing a larger array, then read the voltage and current limits of the diode before soldering it into the PV array. Measure the voltage of the PV array with a DMM set to voltage before proceeding. Record this value, as you will measure the PV array again shortly. Cut the leads of a diode to a length of about ½ inch. Strip about ½ inch of insulation from the positive wire in the PV array. Wrap that bare lead around the lead of the diode that is not closest to the band around the diode. The band (the cathode side) is to be connected to the most negative terminal in order for current to flow. Use a DMM set to voltage and measure the voltage of the PV array a second time. It's best if the second measurement is made at close to the same time as the first measurement and in the same lighting conditions. You should see that the voltage of the PV array is about 0.7 volts lower. If you measure no volts, then the diode is in backwards. Now slide a length of heat shrink tubing over the diode and its soldered leads and shrink it, covering the diode completely.

Mounting Solar Cells

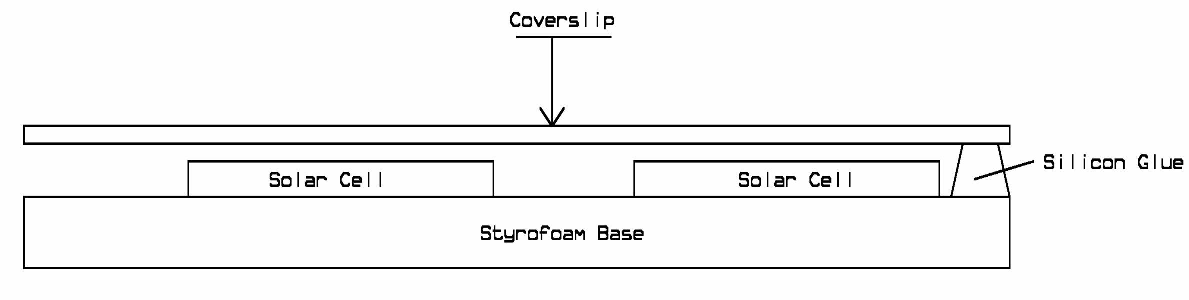
Two characteristics are important when mounting the soldered solar cells to form a near space PV array, weight and rigidity. The PV base material cannot be so heavy to make the near spacecraft overweight. Also, the material needs to resist flexing or the solar cells will break. One ideal material that meets both of these requirements is the same Styrofoam used in the module airframes.



Photovoltaic Array (PV) *– Solar Cells chained in series to meet voltage requirements, then in parallel to meet current requirements.*

Position the soldered solar cells next to each other on your workbench. Measure the dimensions of the array and add then a border to the final size (try a one inch border). Cut the Styrofoam sheet to this dimension. Mount each solar cell to the Styrofoam base with a small dab of silicone glue. Do not coat the entire back of the solar cell with a layer of silicone glue or any other adhesive. Using a single dab insures each solar cell is free to expand and contract at a different rates than the Styrofoam. I have seen differential expansion between a basswood backing and a silicon die shatter the silicon. You may have to cut a small trench into the Styrofoam backing to mount the diode (you want the diode to rise no higher than the top surface of the solar cells. To prevent movement of the PV array wires from breaking their connection to the solar cells, put a dab of silicone rubber over the cable to attach them to the Styrofoam backing. This acts as a strain-relief. During landing there is a risk that the solar cells may be damaged.

The one-inch border around the PV array backing is to reduce this possibility, but if you are still concerned, than make a cover slip for the PV array. Cut a very thin sheet of clear plastic to the same dimensions as the Styrofoam base. If possible, use something other than 1/8" thick Plexiglas, as it's heavy for it's size. Place thin spacers (thin cardboard or plastic strips) on the surface of several of the solar cells in the PV array. Make the spacers long enough that their ends extend beyond the edge of the Styrofoam base. This way they can be pulled out after making the cover slip. The spacers keep the cover slip off the surface of the solar cells in the PV array. Apply dabs of silicone glue to the corners of the Styrofoam. If the PV array is large, then consider applying silicone glue to places in between the solar cells, also. Place the cover slip over the solar cells and let the silicone glue set. After the adhesive sets, carefully pull the spacers out from the PV array.



PV Array *– Details of Coverslip*

Since uniformity is one concern with amateur near space, use the same connectors on your batteries for the PV array. So for instance, if you use Anderson Powerpole® connectors[C] (as I recommend), for the batteries, then terminate the PV array power cable with Powerpoles also.

1.19. Bolometers (D)

1.19.1. Explanation

A bolometer is a device that measures small amounts of radiant heat. Typically they consist of a heat-detecting element with a resistance that that varies as its temperature changes. The Wheatstone Bridge is used to measure the tiny changes of resistance in circuits, so I think it would be appropriate for the bolometer. Satellite-based bolometers are used to measure the heat emitted from the ground and from astronomical sources.

1.19.2. Known Work In This Field

I have found no one experimenting with building a bolometer for near space use.

1.19.3. Suggestions

There are two approaches I would like to investigate. The first is to design a bolometer similar in fashion to the traditional bolometer in which the temperature-sensing element changes its resistance. The second approach uses a passive infrared (PIR) sensor (which may be very difficult to implement) or a thermocouple and produces a voltage that changes as the bolometer detects differing amounts of heat.

Resistance Output Approach

Here I would plan to use a thermistor as the temperature-sensing element. As the temperature of a thermistor changes, so does its resistance. Jameco sells a line of thermistors for fifty-nine cents each. Their temperature coefficients are on the order of 4 ohms per degree Celsius. I would try a smaller value thermistor since they experience the greatest percent change in resistance with changes in temperature. The amount of radiant heat impinging on the thermistor from sources on the ground is miniscule. So a means to amplifying the amount of radiation is required. For this, optics is used. A small telescope gathers more radiation from the source and focuses it on the thermistor. There are two ways to increase the radiation gathered by the telescope. One is to increase the field of view of the telescope. The larger the field of view of the telescope, the more radiation gathered. But as a consequence, the resolution of the instrument decreases. The second way to increase the radiation collected by the bolometer is to increase the diameter of the telescope's objective. The objective is either the main lens of a refracting type telescope or the mirror of a reflecting type telescope.

Increasing the diameter of the objective increases the weight of the optical system, which is a problem when your module goes over six pounds in weight. There is a relationship between the diameter of an optical system, its focal length, and its field of view. For a fixed diameter of objective, the shorter the focal length of the objective, the wider its field of view. However, a shorter focal length implies a shorter length telescope, making it lighter and easier to mount to the airframe.

In any case, the thermistor must be a part of a Wheatstone Bridge. As the thermistor's resistance changes, it unbalances the bridge, letting current flow through the bridge. The direction of the current flow depends on which element of the Wheatstone Bridge is the thermistor and the direction the resistance of the thermistor changes (whether it increases or decreases as it gets warmer). A fixed resistor across the outputs of the Wheatstone Bridge generates a voltage drop according to the amount of current flowing through it. Before the voltage drop of the current sensor in the Wheatstone Bridge can be connected to the ADC, the ADC and resistor must share the same ground and the direction of current flow, known. I will leave these as an exercise for the reader, since I have not played with it myself.

Voltage Output Approach

Passive Infrared

The passive infrared (PIR) based motion detector contains a sensor with two crystals of a heat sensitive material. Each crystal generates a tiny charge when radiant heat impinges upon them. However, the amount of generated charge is very tiny. It's so small that random fluctuations in the crystal and air will swamp any signal generated by the presences of body heat. The purpose of the frensel lens in front of the motion sensor is break the view of the sensor into segments, where each segment sees a different portion of the field of view. As long as nothing in the field of view changes, then there is no change in the outputs between the two crystals of the motion sensor. When a warm object walks into range of the motion sensor, only one of the crystals is initially affected. The crystals begin generating a different amount of charge, which is detected by the electronics inside the sensor. When the difference between the two crystals is great enough, electronics inside the motion sensor trigger an alarm.

To use a PIR, I see two modifications that must be made. First, a new output from the motion sensor must be found. Perhaps even connecting directly to the PIR sensor itself since a motion sensor with only two digital states (ON and OFF) will not work as a bolometer. The bolometer must have an analog output that varies with IR striking it. Second, the second crystal of the PIR must be exposed to a constant temperature reference to compare to the other crystal. The reference crystal is insulated from the radiation entering the bolometer and is kept at a constant temperature. Perhaps a heat pipe immersed in LN2 would make a good reference source.

Thermocouple

A thermocouple consists of two dissimilar metal wires twisted together. As the temperature of the thermocouple changes, the voltage generated by the thermocouple also changes. The voltage generated is very small (on the order of microvolts per degree), so an amplifier is required to use the thermocouple. To use a thermocouple, place the tip of the thermocouple at the focus of the telescope used in the bolometer.

Would the thermocouple-based bolometer be more accurate with a constant temperature reference? If so use a second thermocouple kept at a constant temperature as the reference. Place the outputs from both thermocouples into the inputs of a differential amplifier (diff-amp). What constant temperature source would I recommend? I believe liquid nitrogen (LN2) should be used as the reference. LN2 is the lowest easily available constant temperature sources for the amateur. As long as the LN2 is available as a temperature reference, it maintains the same low temperature of 79 kelvins, or –315 degrees Fahrenheit. Styrofoam containers insulate well enough to keep nitrogen liquid for hours. Make the cold cup by carving up a thick piece of Styrofoam. Place the reference thermocouple inside and fill the cup with. Leave the lid of the cold cup loosely fitting because as LN2 boils off, the nitrogen gas must be free to escape. The exterior of the cold cup should be covered in MLI to reflect solar radiation. To be honest, the greatest reason I wish to build this instrument is that I think a gold or silver color instrument requiring me to pour LN2 into it just before launch is a really cool thing to build. Seeing one of my near spacecraft lifting off, trailing a cloud of cold nitrogen gas is an appealing notion.

1.20. Radiation Budget Experiment (P)

1.20.1. Explanation

A planet's radiation budget is the measure of the radiation absorbed by the planet from space compared to the radiation emitted by the planet back into space. As a near spacecraft ascends, the amount of air below it (a source of heat) increases as the air above it decreases. Making measurements of heat emitted above and below the near spacecraft indicate how much heat is emitted at different levels of the atmosphere.

1.20.2. Known Work In This Field

No one I know is investigating this. I have never read whether there is a change in the radiation (mostly infrared, I believe) emitted at various layers of the atmosphere. However, I would expect that since the Stratosphere is warmer than the Troposphere, the radiation emitted by the atmosphere below the near spacecraft will change significantly once the near spacecraft reaches 50,000 feet.

1.20.3. Suggestions

In a past issue of the astronomy magazine, *Sky and Telescope*, an article in the Amateur Telescope Making section discussed an automated observatory capable of determining if it was cloudy that night. If it was cloudy that night, then the computer-controlled observatory wouldn't bother opening the observatory and making observations with the telescope that night. The computer located at the observatory made the cloudy sky determination by measuring the voltage created by a Peltier junction.

Peltier junctions are semiconductor thermocouples operated in reverse. As a voltage is applied to them, one side get colder and the opposite side gets warmer. There's no violation in thermodynamics here. The warmer side gets much warmer than the colder side gets cold. Peltier junctions are great cooling systems when it's not practical to pump freon or chilled water over a warmer surface.

The Peltier junction can operate backwards like a standard thermocouple. The difference is that the Peltier junction is made up of many semiconductor thermocouples, which increases the voltage generated by the Peltier junction. In the automated observatory example, the Peltier junction is mounted outside the observatory. One side of the Peltier junction faces the ground and the other side faces the sky. Clouds retain heat emitted by the Earth at night. Without clouds overhead, the warm ground emits infrared radiation into the black (very cold) skies. When clouds are overhead, the sky appears to the Earth to be warmer, so the Earth emits less infrared radiation. Remember, heat can only flow from a warm location to a cooler location, unless work is performed to move heat backwards across this temperature gradient. The maximum difference of temperatures between the ground and the sky occurs on cloud-free nights. The least difference in temperatures occurs on cloudy nights. When determining if the nighttime sky is cloudy, the automated observatory measures the voltage generated by the Peltier junction. When the voltage is too low (not enough difference between ground and sky temperatures), the computer determines it’s too cloudy to open the observatory.

As the Peltier junction sensor of the mission ascends, the temperature difference between the two faces changes. However, I believe the changing air temperature will make interpretation difficult. I can think of two ways that may get around this. The first uses two Peltier junctions and the second places a constant temperature reference in contact with one of the faces of the Peltier junctions (yep, you guessed it, LN2).

One Peltier Junction

In this method, the Peltier junction is given a constant temperature source on one face. Just like the bolometer in subsection 1.19, I think LN2 would make the ideal temperature reference. With such a cold reference, the voltage generated by the Peltier junction is greater, increasing the precision of the measurements. To create a liquid tight seal (so the LN2 doesn’t leak out), use a metal cup. The bottom of the cup is place in contact with the Peltier junction and then filled with LN2. Now there’s a problem with this design. Anyone touching the cup will receive frostbite very quickly. So the metal cup must be surrounded with a Styrofoam cup. A loose fitting lid tops it off. The Peltier junction is mounted to the end of a boom to give the bottom face of the junction an unobstructed view of the ground. Which side is exposed to LN2 must be determined before hand. I believe measuring the voltage produced by the Peltier junction when the junction is placed on a warm surface and touching the top surface with an ice cube in a plastic bag can determine the correct orientation. As long as a positive voltage is produced, then you have the correct orientation of the Peltier junction. If a negative voltage is produced, then switch the leads or flip the junction over.

Two Peltier Junctions

In the second design, two junctions are assembled into the experiment. However, the junctions must be turned with opposite faces pointed at the ground and at the sky. The effects of cold air on the faces of the junctions are identical in this configuration since they are both exposed to the same air temperature. The effect of colder sky (in relation to the ground and air mass below) does vary, as opposite faces of the junctions are oriented to the ground. As one junction decreases the voltage it generates, the other increases the voltage it generates. Instead of using the voltage generated by one junction, use the difference between the voltages of the two junctions as a measure of the heat coming from the ground and air mass below the near spacecraft. I believe this is sufficient to remove the effects of air temperature on the Peltier junction without relying on a constant temperature reference.

Processing Radiation Budget Measurements

After recovery, the radiation budget measurements are charted with the altitude from the GPS receiver. If two Peltier junctions are used, then the difference between the two junctions is used as the radiation measurement. If a single junction is used in the experiment, then only the absolute voltage as determined by a single channel of the flight computer’s ADC is used. Unfortunately, I don’t of a good way to convert the measurements into some kind of absolute units (I haven’t researched this project very much, yet). So the radiation emitted at different layers of the atmosphere is compared and graphed. As the altitude increases, the radiation emitted by the atmosphere increases as the mass of atmosphere below the near spacecraft increases and the blacker, or colder the air above appears. The increase in heat emission with altitude may not increase linearly with altitude. In fact, some altitudes may not experience a significant increase in emission with increasing altitude. After processing the data from the flight and graphing it, compare the results to the same measurements taken at a different time of the year, as there may be a seasonal change. Perhaps this experiment will only be able to determine the altitude of the Stratosphere.

1.21. Blood On Near Space Demonstration (D)

1.21.1. Explanation

As stated in Chapter Six, Good To Know, the ambient air pressure affects the boiling point of liquids. Lower the pressure enough and liquids, including blood, at body temperature will begin to boil. This demonstration is designed to illustrate this fact very dramatically.

1.21.2. Known Work In This Field

I know of none at this time.

1.21.3. Suggestions

Some large scale RC aircraft use pneumatic systems to deploy landing gear (it makes the deployment of landing gear look more realistic than the instant snap that a servo creates). The RC aircraft company, Robart, manufacturers an entire line of pneumatic systems, under the name of Air Control. One component of Air Control is the Speed Control valve, a servo operated valve. The Speed Control valve exhausts air from a reservoir when a servo sets the valve. It can also vent air overboard when the speed valve is set to a third position. The speed valve is the heart of this demonstration. There are three major topics to discuss in this demonstration, the liquid, the container and getting an airtight seal, and doing the demonstration.

The Liquid

To demonstrate the lowered boiling point of liquids in near space, a speed control valve must exhaust the air inside a container filled with a red liquid that will pass for blood. As a substitute for real blood (which would coagulate anyways), use either red-dyed water or alcohol. Alcohol has the higher vapor pressure, so it should begin boiling at a higher air pressure. Using alcohol in place of water may be cheating, but remember, it's the effect we're after. The effect will be more dramatic if the liquid is hot to begin with. This is especially important, as the liquid will cool during the mission. Be very careful if you heat the alcohol. Never directly apply a flame to alcohol to warm it. Inside use a water bath. Get the water boiling hot first, remove it from heat, and then place the alcohol container inside the hot water to warm. Keep the cap on the alcohol container so it doesn't evaporate away from the heat.

The Container And An Airtight Seal

To increase the safety of this demonstration and to reduce its weight, use a plastic container, rather than a glass container, as the blood bottle. It would be ideal to use a plastic version of a chemistry flask, but I don't know if anything like that exists. The next best option is to use a plastic bottle with a screw-on cap.

This demonstration requires that the blood bottle remain out of view of the camcorder until it is time to open the speed valve. I recommend placing the blood bottle on the end of a boom that is mounted to a quad panel next to the camcorder's view. A rotating mirror is used to change the camcorder's perspective. Read Chapter Seven, Section Five for information on building a rotating mirror for a camcorder. The boom holding the blood bottle must be wide enough to secure the container. The means to secure the bottle to the boom cannot interfere with the view the camcorder has of the red liquid in the bottle. Perhaps a bed of hot glue will be enough.

A means of sealing the blood bottle airtight is required. The air inside the blood bottle must be exhausted on command as a slow air leak in the blood bottle will weaken the impact of the demonstration. A possible solution is to seal the blood bottle with a screw-on cap and to wrap the threads of the container with Teflon tape. The cap must have a port in it so that an air hose can be attached to it. The port must have a hollow tube attached to it so the air hose can be secured to the cap. If the cap doesn't include a tube, you'll have to drill a hole in the cap just large enough to pass the tube through. Seal the tube to the cap with hot glue or epoxy so it remains airtight. If air does still leak, then use a little vacuum grease inside the cap to seal the air leak. As a final guard against air leaks, you may want to wrap the cap and top of the container with duct tape.

Now it's time to build the blood bottle's pressure control system. Attach an air hose to the cap of the blood bottle and route the hose along the bottle arm and into the airframe at the bottle arm's quad panel. Terminate the hose at the Speed Control valve. To operate the Speed Control valve, it must be securely mounted to a frame that also securely mounts the valve's servo. If the servo and valve are free to shift positions, the servo will not open the valve reliably. A sheet of 1/8" thick plywood and basswood blocks suffices as the frame's base. Epoxy the basswood such that the servo mounting flanges can be screwed to the basswood. In RC aircraft, the Speed Control valve is secured to a bulkhead. Attach and brace a second sheet of 1/8" thick plywood to the frame base as the bulkhead. Drill a large enough hole in the bulkhead to mount the valve. A link rod connects the servo horn to the valve's arm. The link rod assembly is the traditional RC aircraft method for connecting servos to airplane control surfaces.

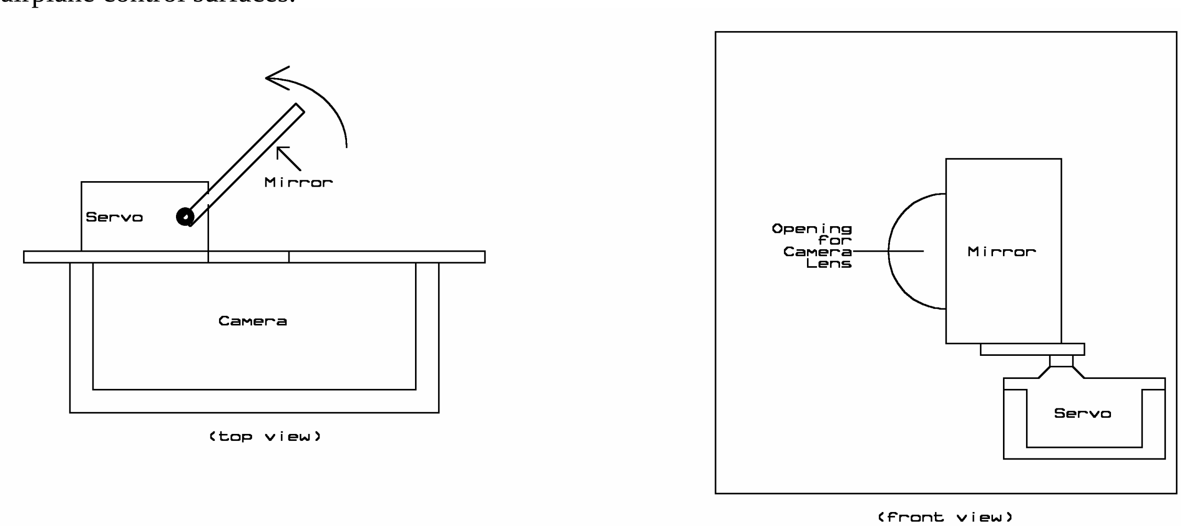


Diagram of capsule with mirror, camcorder, and bottle on boom *– Top View (left), Front View (right)*

Doing The Demonstration

Write flight code to operate the demonstration. The code must rotate the mirror into place once the near spacecraft is above 75,000 feet where the skies are black. After a short pause the open the Speed Control valve with its servo. I recommend the following script be added to the video as a voice over.

"This is near space"
Short pause, then the mirror rotates the camera's view into position
"This is your blood"
Short pause, then the Speed Control valve is opened
"This is your blood on near space"
"Any questions?"

Preflight Checklist

- √ Fill the blood bottle with the hot red liquid
- √ Note: Start with hot liquid, as it will cool during the ascent
- √ Seal the container airtight
- √ Confirm the Speed Control valve is in the closed position
- √ Start the camcorder and launch the near spacecraft

1.22. Gravity In Near Space (D)

1.22.1. Explanation

Due to the $1/R^2$ nature of gravity, the Earth's radius, and its mass, the acceleration due to gravity decreases by just over 1% at an altitude of 100,000 feet.

1.22.2. Known Work In This Field

No one that I know of is attempting this measurement

1.22.3. Suggestions

To detect the reduction in Earth's gravity compare the weight of a test mass at the ground before launch and once again when the near spacecraft is above 100,000 feet. If the test mass weighs one pound at sea level, then its weight at 100,000 feet is about 4.5 grams less, or just under the weight of a nickel. A means to weigh a test mass is required to perform this demonstration. Perhaps a digital scale can be modified for this purpose. The output of the scale must be made available to the flight computer, or other microcontroller, which records the results. However, the small accelerations experienced by the near spacecraft as it ascends become a source of error in the measurements. The magnitude and direction of the error varies constantly throughout the flight and appear as "noise in the signal". The noise may even swamp the effects of reduced gravity in near space. I can think of two methods to reduce the "noise in the signal".

First, the scale test mass and scale must be isolated from as much balloon and wind induced acceleration as possible. The experiment can be mounted inside a mini-airframe that rides within a real airframe. Shock cords suspend the min-airframe inside of the real airframe, absorbing some of the acceleration. Also consider mounting the scale on a bed of foam rubber or other shock absorbing material. Look at what material is used to cushion laptops that are used inside automobiles.

A second means to decrease the effects of this "noise in the signal" is to make weight measurements of the test mass frequently during the mission. Over the entire flight, the residual errors in the measurements should be consistent. A trend in reduced weight should show up in a graph of the weight of the test mass versus the altitude of the near spacecraft. Have the flight computer take many measurements during the flight. Measurements taken during the mission must include, the current altitude and the current weight of the test mass. After recovery download the data and import the data into a spreadsheet. A graph of altitude versus weight should show a jittery weight that decreases in step with increasing altitude. Add a trendline to the graph, selecting linear regression. With such a small increase in altitude (100,000 feet isn't very significant to the radius of the Earth), the graph may appear linear.

1.23. Landing Bags (D)

1.23.1. Explanation

The Mars Pathfinder Lander relied on airbags to cushion its final impact with the Martian surface. While the Earth's atmosphere is dense enough to aerobrake a near spacecraft with parachutes, the idea of deploying a landing bag during descent is too appealing to ignore.

1.23.2. Known Work In This Field

The only organization I know attempting this is the Jet Propulsion Laboratory (JPL). But then, they hardly count as amateurs, do they?

1.23.3. Suggestions

JPL designed the Mars Pathfinder to deploy air-filled landing bags shortly before impact with the ground. The landing bags were made of a durable material that resisted abrasion and bursting during the landing. In our case, since landing bags are not the primary recovery system of near spacecraft, they can be a simpler design. I think a toy vinyl flotation ring[D] would be sufficient. The ring cannot be inflated prior to launch or else it will burst in the near vacuum of near space. Instead, inflate the ring prior to landing, say 5,000 feet above the ground. Two ways to inflate the landing bag are with a source of compressed air or with an air pump.

Compressed Air

Robart RC equipment is the source of compressed air in this suggestion. A Speed Control valve is connected to an aluminum reservoir (bottle). Prior to launch, the air reservoir is filled with air through a check valve. The Speed Control valve is kept in the closed position. The hose from the Speed Control valve is routed to the filler of the vinyl ring through a quad port. Leave the reservoir inside the airframe and route the check valve to the exterior of the airframe through the same quad port as the check valve. During descent, the flight computer when the altitude is low enough to deploy the landing bag and opens the speed valve, filling the donut.

Air Pump

In place of a source of compressed air inside the airframe, a small air pump can be used to inflate the vinyl ring. The pump will require more time to inflate the ring than the compressed air. So run a test on the ground to determine the time required to fill the donut and add an extra minute. Then determine at what altitude filling must begin by assuming a constant descent rate of 1200 feet per minute (so multiply the time required to fill the flotation ring by 1200 and the result is the altitude to begin filling). One source of an air pump is the air pump used in automatic blood pressure monitors. I purchased one through a surplus catalog and they still may be available. Route a hose from the input side of the air pump to the outside of the airframe through a quad port. Do not try to pump air from inside the airframe to the vinyl ring, as the input port of the air pump may be covered with a Styrofoam peanut during the flight. So route a hose from the output side of the air pump to the filler of the vinyl ring through the same quad port as the output side of the air pump routes.

Attaching The Vinyl Ring To A Module

Loosely mount the vinyl ring to the outside of the airframe with Dacron cord. The Dacron must keep the deflated ring in place, but not bind the ring as it inflates. It's easier to let the vinyl ring hang limply from the bottom of the airframe. However, for a more professional look, consider giving the vinyl ring a covering of aluminized Mylar. Cut a single sheet and tuck it around the edges of the deflated ring. The Mylar must be wrapped loosely enough not to bind the inflating vinyl ring. To prevent the Mylar from falling free of the airframe, tack the Mylar at one point to the airframe or the ring.

Note that a landing bag also works in cases of unplanned water recoveries. The ring becomes a floatation device should the near spacecraft recover in a lake.

1.24. Rocket Assisted Landing (D)

1.24.1. Explanation

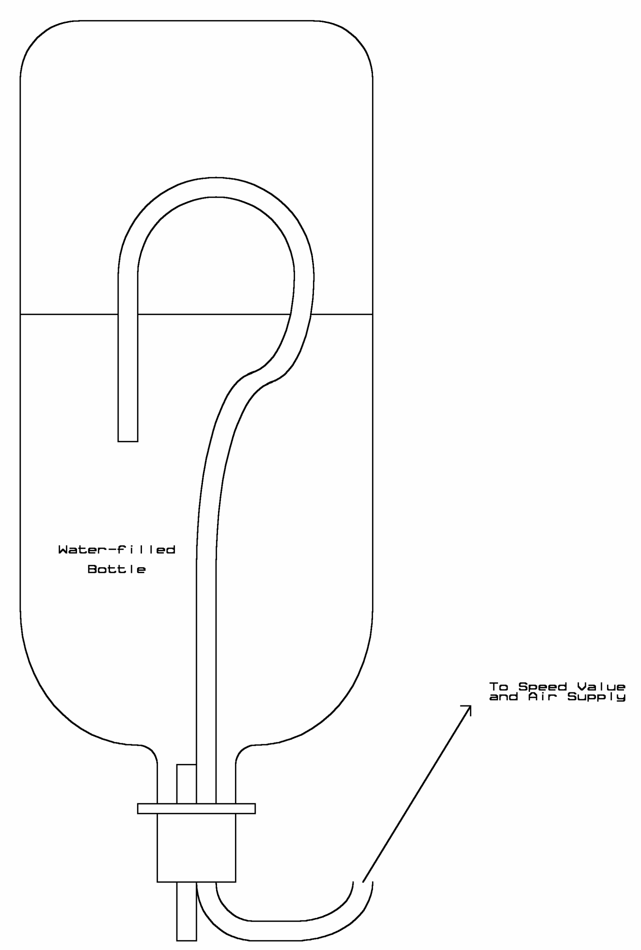
Before the Mars Pathfinder was released from its parachute to bounce like a Martian beach ball, it fired a solid fuel rocket mounted just below the parachute shroud lines. This rocket thrust was the last blast of deceleration before the Mars Pathfinder impacted the ground. Something similar can be attempted with amateur near spacecraft, but not with rocket motors that generate hot thrust.

1.24.2. Known Work In This Field

Except for experimental glider programs, no program attempts to land the near spacecraft with anything but a passive parachute.

1.24.3. Suggestions

Setting a field on fire when the near spacecraft lands aids in locating the recovery site. However, the costs of such a landing far outweigh the benefits. Here's a better idea. Almost everyone has at one time or another played with toy rockets that develop a cold thrust. I'm referring to water rockets. The technically inclined people have developed water rockets from two and three liter pop bottles. One such two-stage water rocket has reached an altitude of 1000 feet. These are not your father's toy water rockets. Toy water rockets require a pressure chamber partly filled with water and a source of compressed air. Having not tried this yet as a near space application, I recommend using two bottles.



Cold Thrust Rocket Assisted Landing Motor – *The Pressure Chamber*

The first bottle is the pressure vessel and is sealed with a servo-operated valve. The second bottle is the pressure chamber and is partially filled with water. The pressure vessel connects to the pressure chamber with a hose that connects to its screw-on cap. A second hose forms an inverted "U" inside the pressure chamber before exiting the pressure chamber through its screw-on cap. The inverted "U" prevents water from leaking out of the pressure chamber until the servo-operated valve is opened and the pressure chamber is pressurized from the pressure vessel.

Note that one end of the "U" extends to the bottom of the tank and its other end loops out of the water and terminates below the water level. If the tube is filled with water, then a siphon forms, draining the water out of the tank. During ascent, air pressure inside the tank will eventually begin pushing water out of the tank through the tube. To prevent the slow draining of the tank during ascent, plug the end of the nozzle with a rubber cap, wax, or clay. You want to use a material that will resist the gradually increasing difference between tank and atmospheric pressure, but not the rapid rise in pressure when the motor is fired.

There are two hoses then that pass through the screw-on cap, one for the pressure delivery hose from the pressure vessel and a second for the exhaust of the pressure chamber. There's no reason the motor hose can't terminate in a T or other junction to create multiple mini-motors. Multiple motors are useful in avoiding problems where a single motor is not aligned with the center of gravity of the near spacecraft. The motor should be fired when the near spacecraft is near the ground. If the motor exhaust is located in the bottom capsule, then the result of firing the motor is to offset only the weight of the bottom capsule, letting the parachute slow the capsules even further. However, if there is too much thrust, the motor lifts the bottom capsule up into the capsule above it where the collision may damage the capsules. If the motor exhaust is placed inside the top capsule, then firing it will soak the bottom capsule. In that case the top of the bottom capsule requires a plastic roof. When acting on two modules, the motor has more difficulty trying to lift both capsules up, so there's less risk of taking the weight off the parachute and collapsing it.

One issue that needs to be addressed is making sure enough air can flow through the pressure delivery hose to make the motor effective. Because of the requirement for high thrust, a Speed Control valve and its tubing may not be large enough to let air flow fast enough to pressurize the pressure bottle effectively. However, do not think of this as an obstacle to success, rather, think of it as an opportunity to launch more near space missions in support of an experiment. One last idea. In place of a second pop bottle to provide pressure, consider using a CO_2 cartridge from a pellet gun. A servo can be used to operate the gas release mechanism from the pellet gun.

1.25. Reefed Recovery Systems (D)

1.25.1. Explanation

A reefed parachute has a cord running around its perimeter that prevents it from opening fully. As a result, its descent speed is increased. A faster drop to the ground reduces the drift the recovering near spacecraft caused by the wind. At a lower altitude, the reefing system allows the parachute to open more fully, slowing the near spacecraft to a safe landing speed.

1.25.2. Known Work In This Field

I know of no amateur group experimenting with this, however, reefing parachutes are popular with professional recovery systems.

1.25.3. Suggestions

Here's how I plan to approach reefing parachutes some day.

- √ Sew Dacron loops to the bottom of the parachute that are independent of the shroud line loops
- √ Note: The loops are how the reefing line keeps the parachute from opening fully
- √ Build and test two FTUs (Chapter Six, Section Six)
- √ Note: The FTUs are used to cut the reefing line
- √ Build a case for each FTU

FTU Case Notes:

- The FTU case keeps the reefing line from tugging on their nichrome coils and insulates the coil from cold temperatures
- The cases must have mounting tabs to secure them and the FTU to the canopy
- The FTU and cases are mounted such that their nichrome coils extend below the bottom edge of the canopy where the reefing line can pass through them
- The cases must have a closure that allows access to the nichrome coil and the reefing line

- √ Place the FTUs on opposite sides of the parachute canopy and mark their location

- √ Sew reinforcing panels (Dacron?) to both sides of the parachute canopy where the FTUs are to be located
- √ Make the reinforced panels a little larger than the FTU cases
- √ Punch holes in the canopy reinforcement for the mounting tabs of the FTU cases
- √ Secure the cases to the canopy with nylon wire ties
- √ Route cables for triggering the FTUs along shroud lines

Using Reefing Lines

- √ Determine the circumference of the opened parachute
- √ Cut two 50 pound test Dacron kite lines
  One to a length 1/3 the parachute circumference (short reefing line)
  The second to a length 2/3 the parachute circumference (long reefing line)
- √ String the long reefing line through the reefing loops and one of the FTUs
- √ Tie the ends of the long reefing line together, forming a loop
- √ String the short reefing line through the reefing loops and the remaining FTU
- √ Tie the ends of the short reefing line together, forming a loop
- √ Connect FTU triggering cables to the flight computer when the stack is assembled
- √ Launch the near spacecraft
- √ Monitor the near spacecraft's altitude during descent with the GPS receiver and use a back up software timer in the flight computer in case the GPS stops sending data

At this point, the short reefing line prevents the canopy from opening fully, so the near spacecraft descends faster than usual and drifts less

- √ At some point during descent, trigger one FTU to cut the short reefing line

Now the long reefing line prevents the parachute from opening fully, but now the near spacecraft descends slower than before the short reefing line was cut

- √ Later in the descent, trigger the second FTU to cut the long reefing line

Now the canopy is fully opened, the near spacecraft descends at its normal speed

It goes without saying that this process must be tested thoroughly. Also, launch the first test of any modification to the recovery system in a region where there is no private property to possibly damage.

2.0 Developing A Program

These suggestions come from my experience forming two near space programs (KNSP and TVNSP) and helping others begin their own near space programs

2.1. Read

The more, the better. There's a wealth of information out there waiting to be applied to amateur near space. Some sources apply directly to amateur near space, while other sources are only indirectly applicable.

As an example, a book on parachute design will give you ideas on making or modifying your recovery system. Robotics books can be applied except for the parts about wheels, since a near space capsule is a robot on a balloon.

2.1.1. Sources

Here are some of the references I have read over the last seven years I have been involved with amateur near space.

- BASIC Stamp Programming Manual, Parallax Inc.
- Computers In Space, James E. Tomakyo, Alpha Books
- Engineer's Mini-Notebook (all of them), Forest Mims III, Siliconcepts
- Meteorology, Danielson, Levin, and Abrams, WCB McGraw Hill
- Micro Spacecraft, Rick Fleeter, The Edge City Press
- Mobile Robots, Joseph L. Jones, Bruce A. Seiger, and Anita M. Flynn, A. K. Peters
- Parachute Recovery System, T. W. Knacke
- Practical Electronics For Inventors, Paul Scherz, McGraw Hill
- Research Balloons, Carole S. Briggs, Lerner Publications
- Space Mission Analysis And Design, Wiley J. Larson and James R. Wertz, Space Technology Library
- The 6.270 Robot Builder's Guide, Fred Martin, Pankaj Oberoi, and Randy Sargent, MIT
- The Idiot's Guide To Meteorology,
- The Mars Pathfinder, Price Pritchett and Brian Muirhead, Pritchett and Associates
- The Pre-Astronauts, Craig Ryan, Naval Institute Press
- The Satellite Experiment's Handbook, Martin Davidoff, ARRL

As you can see, some of these books are only indirectly related to near space. Some of the books listed above are more motivational or historical. Some of the experiments I try today are derived from what was attempted in the past.

2.2. Crew Training

This cannot be stressed enough. To be successful, your crews need to know what they're doing. You will be stopped constantly during a launch for further instructions when you are the only one who knows what is going on. Launches go much faster when your crew is knowledgeable. When you're the only knowledgeable person, flight predictions are only made when you have time. When many people are making predictions errors can be identified, preventing a launch in questionable wind conditions. TVNSP tries to meet at regular intervals (sometimes every two weeks) for training and review. If you are the program manager, then see the following items are done.

- Document your procedures
- Teach everyone how to perform all the steps of launching a near spacecraft
- Practice launch procedures at the beginning of each year's launch campaign
- Help trackers set up their equipment

Make checklists and "application" notes for your team. Update the checklists before each launch (by the FRR) and keep them concise and clear. At your early meetings, teach everyone present how to perform each task. I feel the following tasks should get the greatest emphasis.

- Making flight predictions
- Filling and tying off the balloon

Other tasks like assembling the stack and using lanyards historically have been less critical for TVNSP.

Everyone forgets. So every year, before the beginning of the year's near space campaign, TVNSP crews meet to review procedures. We get out the filling equipment and run through the procedure. TVNSP also reviews making predictions.

You will notice there is a lot involved with setting up APRS on a laptop. TVNSP has documented their recommended APRS +SA settings. When a member wishes to set up an APRS tracker, they bring their equipment to a meeting and get the help they need. By the end of the meeting, they should have a functional APRS tracker. During the morning of a launch is a very bad time to help someone set up his or her tracker. During a chase is equally a bad time for someone to be using APRS for the first time.

2.3. Support

Even though a near space program is less expensive than a space program, it can be difficult to support out of pocket. However, I have found that being single does improve my ability to run a near space program off of my paycheck. To do so means you have to commit to it like it is your only hobby.

2.3.1. Monetary Support

Being a part of amateur radio club allows the near space program to be a part of their annual budget. While it probably won't pay for every flight, the club may be able to pay for one or two flights each year. Be professional and responsible so the near space program is a feather in the cap of the club. In public venues, be sure to mention that the program is a part of the local amateur radio club. Even try to increase membership in the club with the near space program.

Consider flying experiments for other groups and organizations. In some cases, they can be asked to help offset the cost of the launch by perhaps providing the balloon or a tank of helium. Since the program uses amateur radio equipment for telemetry, no profits can be made from launching amateur near space missions.

Ask for donations. Local civic clubs or your helium supplier may be able to sponsor a flight once a year. A thank you to the sponsor can be attached to the outside of a module and photographed before launch. Another way to thank a sponsor is to fly a memento into near space and present it to the sponsor after recovery. Good mementos include a patch or bumper stick from the sponsor. After the flight, return the memento mounted to a frame along with photographs from the flight. Be sure, however, that the cost of making the presentation doesn't end up costing more than the donation.

2.3.2. Volunteer Support

Not just money is needed to operate a near space program. Each program seems to have its core of dedicated individuals. However, there may be times when that isn't enough people to successfully launch a near spacecraft. KNSP made use of volunteers who would lend a hand to launch a near spacecraft but not to chase or recover it. Other times KNSP made use of volunteers who couldn't help launch, but who would lend a hand if the landing zone was in their neck of the woods.

The only way to get this kind of support is to talk it up. Get around to all the local clubs, be they radio, astronomy, civic, or other. Get people excited about what your program is accomplishing. After a couple of flights you will have some of the neatest photographs and videos to show. Displaying a photograph taken from 85,000 feet makes people think you're an astronaut (just ask Bill

Brown). Images like these attract attention and interest. Also, think long term, and give presentations annually. Each year there's always someone new to the club.

2.4. Get Involved In Special Events

Spread the word about what the program is doing and get some public attention. When possible, launch in support of special events that commemorate the sciences and technology. Good examples include the following.

- Astronomy Day
- Space Day
- Star Parties
- Museum Open Houses
- Field Day

If your program cannot launch at times like those, then set up a static display or launch a dummy payload. In either display type, show how tracking is done and examples of the telemetry and results from flights. You may want to hand out diskettes with actual flight data in a spreadsheet format. Include directions with the diskette explaining how to process the data and generate interesting result. Also try to get some public exposure for your crews.

2.5. Visit Classrooms

If you know a teacher then talk to him or her about your program. If your program fits in with what his or her class is doing, you can be given permission to present to the class. It can be tough to present if the teacher doesn't know you. So be ready to explain what your presentation can do to excite children. Don't be disappointed if you can't present any time soon. Teachers have their own lesson plans and you may not fit in those plans. It can also help if you know the spouse of a teacher.

Before presenting to a classroom, ask the teacher about special interests of the class. Have lots of visual displays that are appropriate for the age of the class. I found elementary students like to see and touch the parachute. If you're presenting to a science class, recommend flying an experiment for the class. Share possible experiments with the teacher. It's best if the teacher works with the class on setting up the experiment, but be ready to offer help if asked. You may have to provide parts for the experiment. Classrooms have limited resources and it can take some time to receive equipment that they order. Be ready to provide equipment so the teacher doesn't have to purchase items out of pocket. Be ready to have an experiment ready to go, in case the class has trouble deciding on an experiment or can't build it in time. Sweat the details. If your first classroom presentation and experiment fails, you may not have a second chance. After arranging for students to design an experiment, have them also create a name for the experiment and a mission patch to accompany it. See to it that the patch printed and attached to the experiment. Additional copies of the patch can be laminated and placed onboard the near spacecraft. After recovery, give the flown patches to the students.

Be careful about inviting students out to the launch. Any student attending a near space launch needs to be accompanied by their parents or guardians. Under no circumstance allow unsupervised students to attend launches and/or go on chases by themselves.

Possible classroom experiments include the following.

2.5.1. Seeds In Near Space

Small children like planting seeds. Seeds also make a great way for children to practice applying the scientific method to an experiment they helped design. Consult Chapter Eight, Section 7.3 for directions on flying seeds into near space. To encourage future experiments, offer to fly seeds from the surviving seeds next semester or next year. You could offer to fly later generation seeds every year.

2.5.2. Balloons Filled With Various Gasses

Consult Chapter Eight, Section Ten for ideas on flying balloons into near space. Aside from balloons filled with gasses, also consider flying marshmallows into near space and photographing the results. Students should design and construct the lightweight sample holder. Remember to place the sample holder arm far enough from the camera to keep the samples in focus. This may require a ground test before the flight. Returned images of the samples will be far more interesting when you have the edge of the Earth in the background of the samples. If balloons contain various gasses, make sure to label the balloons with a felt-tipped marker. Don't rely on people remembering which balloon carried which gas.

2.5.3. Measuring The Temperature Of Samples

A temperature sensor array is needed to perform this experiment. Consult Chapter Eight, Section Nine on constructing temperature arrays. Have students collect or make sample materials to send into near space. The color or method of construction influences how they retain or lose heat. The vacuum of near space and ultraviolet radiation of the Sun also has an impact on samples that's not easy for students to recreate on the ground. Double-check any code the students write before launch as a part of a ground test. As a part of the ground test, have the students process the generated data log. After the flight, give students a copy of the data log.

2.5.4. Flight Logs

Generic flight logs make a good math exercise. Students get to practice what they have learned by using real data collected in near space. Give the classroom copies of cleaned up flight log so they can make graphs. Example graphs include, ascent rate, latitude and longitude of the balloon, air temperature at altitude, and cosmic ray counts. Be sure the teacher is comfortable with the format of your data, or else the teacher cannot help out students with questions. Along with the data, include a copy of a video taken in near space that the teacher can play, photographs taken at altitude to pass around or give out, or even stickers of photographs taken of the near spacecraft or images from near space (younger children like stickers).

2.5.5. Analyze Ground Photographs

Give the class a set of ground photographs taken from near space along with the latitude and longitude of the photographs. Have the students find the location of photographs on a map. Before a flight, demonstrate how the capsule will take photographs during the flight. Also give the students a graphic of the expected flight path. After the flight, present the students with a set of 4 by 6 inch prints with the altitudes of the photographs. Also give them a copy of the flight log. Students can relate the time of the photograph with the GPGGA sentence in the log. They can use this data to determine the latitude and location of each photograph.

Photographs indicate geomorphic features of the ground. Find and read an introductory text on Geomorphology for more information. A flight six months later shows how foliage changes over the course of a year. It also shows how rivers and creeks can also change.

2.6. Develop And Fly Experiments For Other Groups

Remember there are more than just school students out there. The scouts, 4H, Boys and Girls Clubs may want to participate in a near space mission. Heck, there's even civic clubs out there. Why shouldn't adults be doing their own amateur science experiments?

2.7. The Media

Invite the local news media to cover one of your missions. Be sure to ask them to cover any experiments you are flying for schools and clubs. The news media may not be able to go on the chase for liability reasons, so work with them and give them materials from past flights.

3.0 National Organization

There is no national organization for near space at this time. One reason is that the numbers of groups and their members remains low. With more exposure, this may change in the near future. Currently, these are the parts of a national organization, virtual national organization, so to speak.

3.1. Ralph Wallio's Records Website

Ralph Wallio (W0RPK) maintains a website with a focus on many aspects of amateur near space. One of the most popular is his list of amateur near space records, where he keeps track of the state-of-the-art. Ralph keeps track of the following amateur near space records.

- Highest GPS Reported Altitude (ASL)
- Lowest Reported Maximum Altitude (AGL)
- Highest Continuous Ascent Rate (averaged over >10,000ft)
- Lowest Continuous Ascent Rate (averaged over >10,000ft)
- Longest Great Circle Distance, Release to Touchdown
- Shortest Great Circle Distance, Release to Touchdown (at least 50kft maximum altitude ASL)
- Longest Mission In Time, Release to Touchdown[E]
- Heaviest Payload
- Lightest payload
- Largest Balloon Envelope(s) (Fully Expanded Volume)
- Smallest Balloon Envelope (Fully Expanded Volume)
- Greatest Telemetry Downlink Reception Range (Two Categories)
  - VHF/UHF near line-of-sight
  - HF via any mode of propagation
- Greatest Two-Way QSO Repeating/Transponding Great Circle Distance
- Total Missions Flown
- Longest Recovery Time (any method)
- Touchdown Prediction Closest to Actual Coordinates

Ralph's website is located at http://showcase.netins.net/web/wallio/ARHABrecords.htm

3.2. Balloon Announcement Email Lists

There are several active email lists in the amateur near space community. When forming your own group, consider establishing an email list for it. You should also consider subscribing to the current email lists to keep up to date with what's happening across the US. By doing so, you will be kept informed on upcoming Super Launches (covered in the next subsection).

All the currently active near space related email lists are hosted on Yahoo.Groups. When at their website, try subscribing to some (all?) of the following email lists.

- ANSR: Based in Tucson, AZ
- EOSS: Based in Denver, CO
- HABITAT: Based in the Kansas City, KS metro
- HamBONE: Based in New York
- KNSP: Based in the Midwest
- NAHBG: Based in Seattle, WA
- Project Traveler: Based in Hutchinson, KS
- TVNSP: Bases in Boise, ID

3.3. Super Launches

The first Super Launch was the Great Plains Super Launch (GPSL) and occurred Manhattan, KS in July of 2001. The name, Great Plains Super Launch, was the idea of Bill All (N3KKM) when we were looking for a name to call our attempt to simultaneously launch balloons from four near space programs. Three balloons were launched at the first Great Plains Super Launch. At the second, a total of eight balloons were launched in support of six near space missions. A second Super Launch has been formed in Idaho. This Super Launch is called, the Northwest Super Launch (NWSL) and is scheduled as to not to conflict with GPSL. The author hopes to begin the Strato-Bowl Super Launch (SBSL) in a few years. With the creation of more near space programs, these additional Super Launches can take place. Think of them as a Field Day specifically for amateur near space.

Super Launches are more than just launching a bunch of balloons at the same time. It's a chance to meet other programs and share knowledge and history. The GPSL includes a more formal symposium element the day before the mass launch. Social events are also planned. As currently planned, the GPSL is sponsored by different near space programs each year. Once your program is established, consider sponsoring a Super Launch.

3.4. Benefits Of A National Organization

If sufficient numbers of people get involved with amateur near space, a national amateur near space organization can be started. There are several benefits to be gained, once there are enough people or programs are involved.

3.4.1. Liability Insurance

Like any hobby, liability insurance has become necessary in this world. No accidents have occurred with any amateur near space program to date. The NWS launches over 75,000 radiosondes a year with very few incidents over their 65-year history. That being said, it is still a good idea to look into liability insurance through a club or through your homeowner's insurance.

One benefit of a national near space organization is that group insurance can be purchased, saving every group money. Such insurance would be tailored to the needs of the amateur near space community.

3.4.2. Publications

With enough launches each year, an annual report of sorts could be published. A year in review becomes affordable when sufficient copies are printed.

3.4.3. Awards Programs

Currently the only planed sponsorship of a near space award is by TVNSP. The near space program with the currently highest flight, as documented by Ralph Wallio's Records List, receives a plaque. As new altitude records are set, the award is updated and sent to the new winner. With more groups involved in a national organization, more awards can be sponsored.

4.0 The International Geophysical Year Plus Fifty

The author proposes the following amateur science event to coincide with the fiftieth anniversary of International Geophysical Year. A part of this celebration will focus on amateur near space programs.

4.1. A proposal to create and manage a coordinated amateur science program in celebration of the fiftieth anniversary of the International Geophysical Year (IGY)

4.1.1. Name of Program

IGY + 50

4.1.2. Dates

1 July 2007 to 31 December 2008 (corresponding to the fiftieth anniversary of IGY)

4.1.3. Purpose

To encourage the exploration of the Earth, from pole to pole, and from the oceans to the top of the atmosphere, by amateur scientists from around the world in the spirit of IGY

4.1.4. Overall Goals

A. To create as many amateur science programs as possible
B. To encourage amateur science activities
C. To give guidance to these groups

D. To collect as much data and stories as possible in an organized fashion
E. To host a symposium at the conclusion of the program
F. To publish a book of the results at the conclusion of the program

4.1.5. Specific Near Space Objectives

A. To create as many amateur near space programs as possible
B. To coordinate a large number of balloon launches with each mission carrying at least one experiment
C. Develop a suite of suitable near space experiments
D. Coordinate mass-purchases to lower costs
E. Launch, chase, and recover several long duration (cross-country) balloon flights

4.1.6. Governance

I believe at least five committees are needed
A. Directors to oversee all other committees
B. Membership to register and track all participating groups or individuals
C. Public Relations to spread the word and line up supporting organizations or donors
D. Standards to develop a standard for terminology and a format for experimental results
E. Publications to see to the publication of a final book, symposium, and webpage

4.1.7. Background

Beginning in the spring of 1950, James Van Allen (University of Iowa) began leading discussions with American researchers, and eventually European researchers, to create a coordinated, worldwide research program in order to better understand the Earth's upper atmosphere and outer space. Together they declared the 18 months between July 1957 and December 1958 to be the International Geophysical Year (IGY).

As a part of IGY, the Eisenhower administration declared America's intention to launch an earth-orbiting satellite. Later the Soviet Union also announced their intention to do the same. The opening of the Space Age is due in part to IGY.

IGY was the last time a peaceful and professional worldwide effort was made to scientifically explore the regions above the surface of the Earth (the two prior times were International Polar Years in 1883 and 1933). I'd like to commemorate the fiftieth anniversary of IGY with what will essentially be an amateur reenactment. But this time it will be an effort of amateurs exploring and experimenting.

4.1.8. Starting IGY + 50

A. Get sufficient agreement to begin the program
B. Develop an organizational chart for the committees and define their responsibilities
C. Develop a website for the program
This website should have at least three sections.

The first section is the Groups Section and is a list of links to those groups that have been formed and are planning to take measurements.

The second section is the Help Section. This section is for those giving or needing help. If a group needs help, they list their requirements there. If you have help to give, you list your specific help there. Any donors or mass-purchases are listed in this section.

The third section is the Events Section. This section lists individual, regional, and global events of interest. The list encompasses scheduled events, tours, or nice to know events.

D. Develop an email list for the program
The email list doesn't replace those email lists now in, or planned to be in, existence. Just include the email list in your program's emails, so we can all share information.

4.1.9. Conclusion

Please share this idea with anyone who may be interested in being a part or supporting those getting involved. We have a few years to get new groups up to speed in designing their programs. I believe we need to develop a recruitment video and a series of posters to help spread the word. I'd like to see some early media coverage of the program. Opportunities to have amateur experiments be a part or performed in conjunction with professional experiments should be explored.

IGY + 50 won't work unless many people make an effort to get involved. Please discuss this issue with me so that I can gauge the level of support and further refine the concept.

L. Paul Verhage
Program Manager, TVNSP
paul.verhage@boiseschools.org

4.2. The Near Space Part Of IGY + 50

If sufficient interest is generated, the author will set up a website for the International Near Space Year (INSY), the near space part of IGY + 50. Currently the planned URL for INSY is at: http://www.insy.org

The website will have three sections. The first section is the Groups Section. It is for those groups that have been formed and are launching, or planning to launch near spacecraft to announce their participation in INSY. There will be links to their official websites. The second section is the Help Section. This section is for those looking or needing help. If you can help financially or with equipment, please let us know. If your group needs help, again, let us know. The third section is the Events Section. It will contain information on special offers or INSY meetings. It will also have the link to HABET, Hank Riley's website, which provides announcements of launches and Ralph Wallio's Records website.

The author also plans to sponsor an email list for INSY. The INSY email list is not to replace those email lists now in, or planned to be in, existence. The INSY email list is in addition to those in existence. Once (if?) INSY is setup, please include the INSY list in your emails, so we can all share information.

In conjunction with the Super Launches, there will also be a conference or symposium during this period so all groups can meet in person and share the results of their flights.

Finally, I'd like to publish a journal at the close of INSY. It would include articles from all groups participating in INSY. In each section, groups will be asked to write about their experiences and show pictures.

Please share this idea with any group who may be interested in launching or supporting those who launch. We have a few years to get groups up to speed in designing their own near spacecraft. If you can help out, please contact me at the email address given in the help section. I'd like to see many science fair entries using data from near space flights. The only way this can happen is if you create a near space group and get the local community involved.

I'd design a recruitment video that will be available at cost to those groups making their participation in INSY official. I'll also try to arrange news coverage.

INSY won't work unless you make an effort to get involved. Please do so. With this book and information available over the Internet from the other near space groups, you can design and launch your own near spacecraft.

Good To Know - Notable Firsts Of Amateur Near Space Exploration

Jeff Melanson, KD7INN, of the TVNSP, suggested this section. Good idea, Jeff! Many people have documented the history of professional near space exploration, but up to this point of time, no one has written any kind of history about amateur near space. So here’s my small attempt to record some of the important firsts of amateur near space. Perhaps someone, maybe every a reader of this book, will write a more complete history.

The first amateur near space launches took place in Finland in 1967. Amateur near space began in the United States on 15 August 1987, when Bill Brown launched his first balloon carrying amateur radio. The payload consisted of 2m CW IDer and ATV IDer. No live ATV from near space or GPS receiver was carried. Over fifteen years later, look at the difference!

1967 May 28	Ilamari program launches first amateur balloon in Finland. Payload consists of 2m and 70 cm beacons and a 2m to 70 transponder (OSCAR-like two band repeater). Ilamari flew a total of 18 missions through 1980.
1987 Aug 15	Bill Brown launches the USA’s first amateur near space capsule, The Birthday Balloon - it was Bill’s birthday (Findlay, OH). Payload consists of two IDers, one on ATV and the other on 2m (CW beacon). Capsule is recovered by DFing.
1988 Jun 4	Indiana launches its first near space flight, The W9PRD Balloon Launch (Greensburg, IN). In 1990, this group became Windtrax and eventually launched balloons for 22 Indiana high schools, involving over 2000 students.
1988 Oct 23	Bill Brown launches a 2m digi-peater.
1988	Bill Brown launches first ATV black & white camera into near space. (Mojave Desert)
1988	Bill Brown launches first film camera into near space.
1990 Feb 10	BYBG launches their first flight. (location, Argentina).
1990 Nov 18	EOSS launches its first near space capsule, WVN-1 (later called EOSS-1) (Denver, CO). Payload consisted of an ATV system and camera, a 10m beacon, and temperature and pressure sensor.
1991 Jan	SSOK launches its first near space capsule, SSOK-1 (Salina, KS).

1991 Aug	Bill Brown writes first article on amateur near space flights for 73 Magazine
1992 Jan 2	First amateur launch of a zero pressure balloon, EOSS-4 (Denver, CO)
1993 Feb 6	First near space capsule carrying Loran-C, EOSS-10 (Denver, CO)
1993 May 2	First near space capsule to carry a GPS receiver, EOSS-12 (Denver, CO)
1993 Aug 20-22	First balloon symposium. Hosted by EOSS, (Denver, CO)
1993 Dec 4	HABET launches its first near space capsule, HABET-1 (Des Moines, IA). Payload consists of SAREX Robot QSO software
1993	Dave Mullinex writes first FAQ on amateur near space
1994 Feb 27	First 9600 baud packet sent from near space, HABET-2 (Des Moines, IA)
1994 Nov 12	First GPS documented flight into high near space (above 100,000 feet), SSOK-9 (Salina, KS). Altitude reached is 111,557 feet
1996 Nov 2	KNSP launches its first near space capsule, KNSP Flight 96A (Manhattan, KS). Payload consists of dust sampler, two 35mm cameras, and Geiger counter
1997 May 11	First rocket launch from a near space platform, Space Launch-1, (Hampstead, NC). Rocket reaches an altitude of 36 miles.
1997 Oct 4	HABITAT launches its first near space capsule, 98A (Kansas City, KS). Payload consists of APRS tracker and a camcorder
1997 Dec 9	The launch of PCIS-1 (later to become SkyQuest-1), (Plymouth, MA). Payload consists of a expendable 2m CW transmitter because of the mission’s proximity to the Atlantic Ocean.
1997 Dec 13	First camcorder carried into near space, KNSP Flight 97D (Manhattan, KS)
1998 Oct 10	First live SSTV images of near space, KNSP Flight 98D. Uses Kenwood Visual Communicator, VC-H1
1998 Oct 10	First capture of a landing near space capsule, KNSP Flight 98D (Manhattan, KS), Payload caught by Dan Miller (KE4SLC)
1998 Oct 24	University of South Dakota launches its first near space capsule, Margaret-Myrtle, payload consists of APRS tracker, 35mm camera, and dust collector
1999 Oct 9	TVNSP launches its first near space capsule, TV99A (Boise, ID). Payload consists of Geiger counter, camera, and weather station
2000 Feb 8	Into The Air launches its first near space capsule, ITA-1, payload consists of fireball CW beacon
2000 March 25	NSBG launches their first flight from Kansas City.
2000 Oct 7	NSTAR launches its first near space capsule, 00-A (University of Nebraska, Lincoln, NE). Payload consists of flight computer and 2m simplex repeater
2001 Apr 22	Project Traveler launches its first near space capsule, 2001a (Hutchinson, KS). Payload consists of a PIC-based Flight Computer and a 35mm camera
2001 July 1	First Super Launch, GPSL 2001
2001 July 27	Ham-Bone launches its first near space capsule, HamBONE-LD1. Payload consists of flight computer with pressure and humidity sensors, 10m and 30m beacons
2001 Sept 15	ES-OS (Experimental Sub-Orbital Society) launches its first near space capsule, ES-OS ONE (Denver, CO). Balloon consists of envelope built by Mark Caviezel (KC0JHQ)
2001 Nov 17	First video tape of an entire flight, from launch to landing, TV01H (Boise, ID)
1991	Bill Brown launches first cross band repeater (440 in and 10m and 2m out) into near space (Peterborough, NH)
	Joe Mayenschein (WB9SBD) launches first near space capsule, Repeat-1. Payload consists of air pressure sensor, 28 MHz beacon, and dual band

	repeater (10m and 2m).

Near Space Humor - Comix

Crater - *At the recovery site of a near spacecraft that broke free of its parachute.*

So Close… *yet so far*

[A] KimWipes™ are an excellent product. They are made by Kimberly-Clark, makers of Kleenex.™

[B] Many robotics websites explain how to modify a standard servo for continuous rotation, so it is not covered in this book. Optionally, Parallax, Inc. sells inexpensive continuous rotations servos (Part number 900-00008).
[C] Powerpole® is a registered trademark of Anderson Power Products.
[D] Your editor pictures a near space capsule wearing a bright yellow ducky pool float.
[E] You really don't want this record. Groups get it when their near spacecraft are lost for several months and later found (usually by a stranger).