The Edge of Space Sciences Handbook

Published by

Edge of Space Sciences, Inc.

A non-profit Corporation

376 W. Caley Cir.
Littleton, CO 80120 USA

Promoting Science and Education Through Amateur Radio and High Altitude Balloons

August 1993

Preliminary (Symposium) Edition

layout update July 13, 2000

EOSS Motto: All it takes is a little more gas.

Foreword

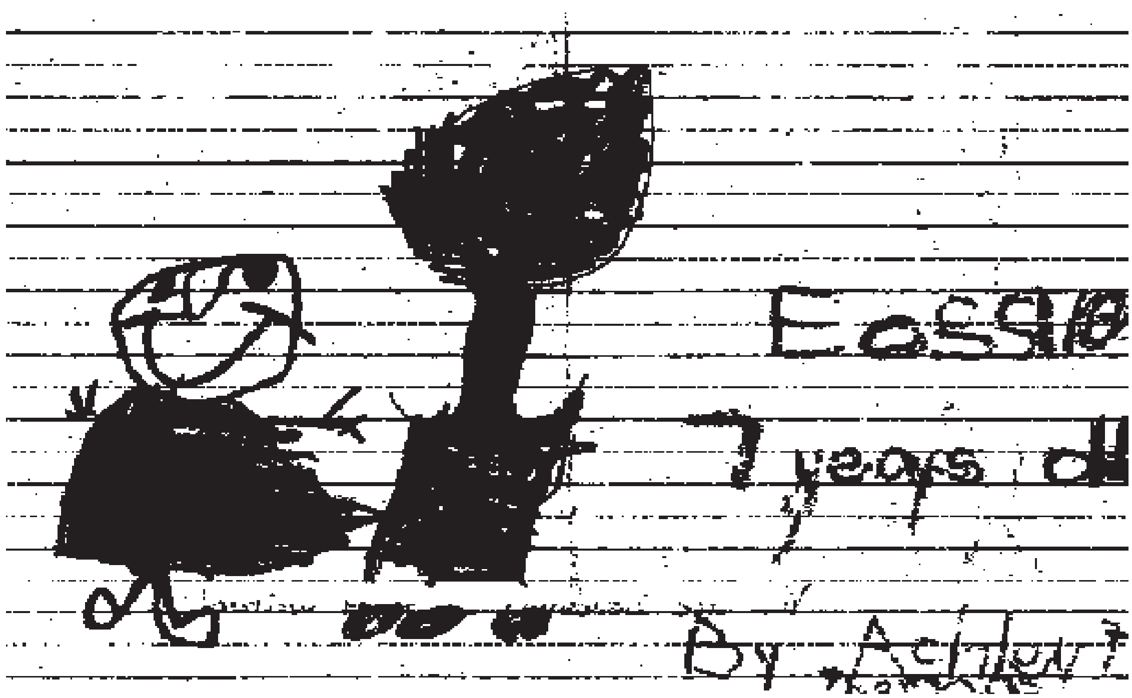
This Handbook is intended for persons interested in learning some of the many facets about unmanned ballooning. It is useful for the new and old comer alike, whether a student, experimenter, EOSS member, or hobbyist.

The Handbook is the result of inputs volunteered by many EOSS members with experience in their respective area. Each contributor's name is placed at the beginning of their section.

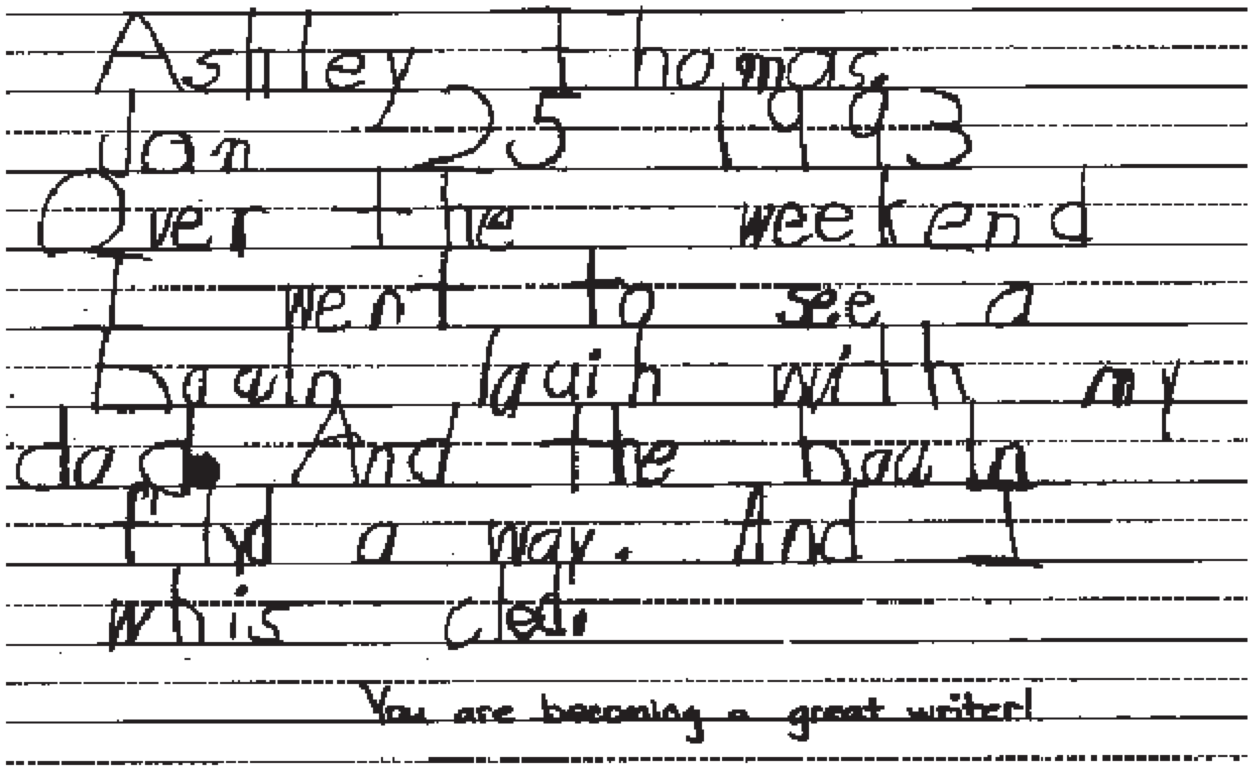
The photographs sprinkled within come from EOSS's "box" of donated photos. In most cases the photographer was unknown. The photos were digitized by Ted Cline, and enhanced by Rick von Glahn.

The Handbook outline was prepared by Paul Ternlund who is grateful to the EOSS members who contributed to its many sections, and to Nate Bushnell, Greg Burnett, Merle McCaslin, and Jim Libhart for their editing assistance. EOSS members are a truly talented and dedicated group. This is a "living" document with many sections yet to be written—some are noted within as "TBW."

The illustration below is very special. Its creator, Miss Ashley Thomas, was seven years old at the time she created it. She is the daughter of EOSS member Brian Thomas. Ashley did the picture for school after witnessing the tethered launch of a balloon in preparation for EOSS 10, one of the balloons launched by Edge of Space Sciences. Ashley did her artwork with colorful crayons that we have had to convert to dull old black-and-white for incorporation into the Handbook. Ashley's art helps demonstrate the ageless fascination that people share for balloons.



The back side of Ashley's picture is captured below:



<u>Semi-Translation</u>:
"Ashley Thomas.
Jan 25 1993
Over the weekend
I went to see a
balloon launch with my
dad. And the balloon
flied a way. And I
was glad".

Teacher's comment:
"You are becoming a great writer!"

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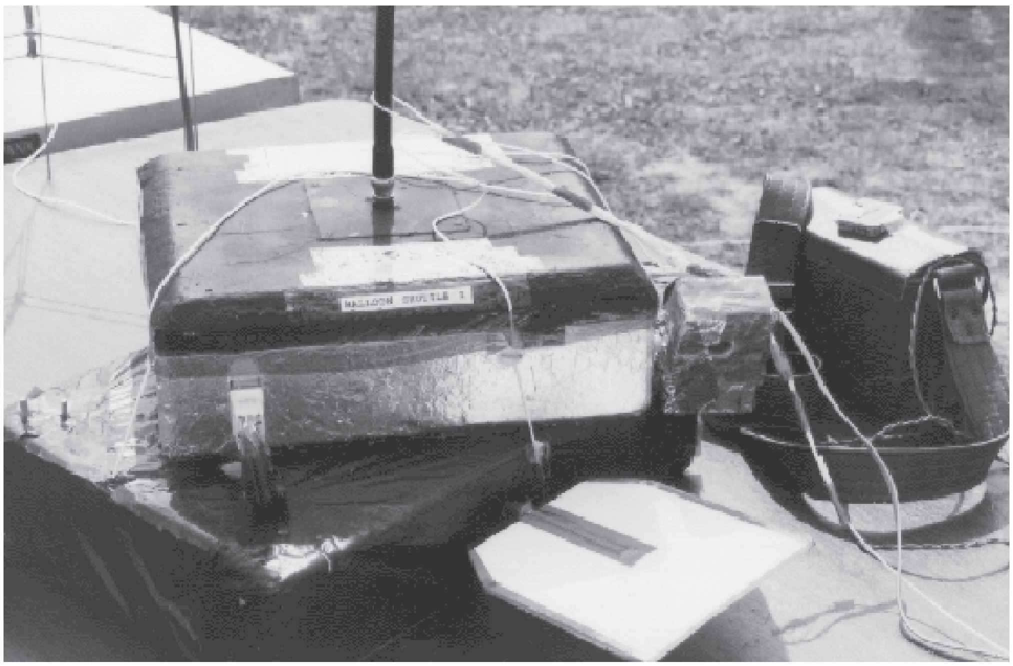
1. Edge Of Space Sciences

1.1. Who we are

<<Jack Crabtree>> Edge of Space Sciences (EOSS) is a Denver, Colorado based non-profit organization that promotes science and education through amateur radio and high altitude balloons. Formed in early 1991, EOSS has grown to a membership of 100 plus individuals who actively utilize amateur radio and balloons to further scientific study of the upper atmosphere and encourage studies of mathematics and science by students. Membership is available to all interested persons. While many EOSS members are amateur radio operators or "hams," being such is not a requirement, although a number of members have taken up the hobby after joining EOSS. Student membership is encouraged and, a reduced membership rate is available. In addition to the normal slate of directors and officers, EOSS is organized with a number of teams or committees. Some of these groups include technical, public relations, tracking and recovery, and education. There is ample opportunity for all members to be actively involved in EOSS projects. EOSS is incorporated in the State of Colorado and is recognized by both Colorado and the U. S. government as a 501(c)(3), tax exempt, scientific-educational organization.



1.2. What we do

<<Jack Crabtree>> EOSS conducts four or five balloon projects each year, sending scientific payloads to approximately 100,000 feet. An on-board computer and command and telemetry system provide for control and real time data down link of experiment data in the payload package. In many cases, live video from the payload is available and views of the earth and the edge of space have been made. Educational institutions and other scientific oriented organizations are encouraged to participate in EOSS projects and programs.

A standardized payload, called the "Shuttle" has been developed and is being refined to accommodate various experiments. Many of them have been designed and built by students. Members have many opportunities to exchange ideas with their fellow members.

A monthly meeting is conducted on the second Tuesday of each month. The formal meeting starts at 7:30 P.M. with an informal gathering at 7:00 P.M. for social and show-and-tell activities. On each remaining Tuesday, a radio meeting-on-the-air, or net, is conducted on 147.225 MHz. Here, weekly updates on EOSS projects and news bulletins concerning amateur radio balloon projects around the country are discussed. For non-radio amateurs, this net can be monitored on most police type scanners.

A newsletter, the *STRATOSPHERE*, is published quarterly containing both technical and non-technical articles for dissemination of information to EOSS members. Two computer accessed bulletin boards are also available. One operates on amateur radio packet while the other is accessed by telephone.

1.3. Student involvement

Students of all age groups are involved with EOSS ballooning. They have provided experiments, assisted with launch operations, communications, and tracking and recovery. High school and grammar school students have created plots as the balloon flies. These are typically: TEMP vs. ALTITUDE, ALTITUDE vs. TIME, VELOCITY vs. TIME, and the balloon flight path. Opportunities are essentially unlimited.

1.4. How your experiment can ride an EOSS flight

1.4.1. Your proposal

<<Paul Ternlund>> If you have an experiment you would like taken to the edge of space, please present your proposal at an EOSS meeting. General meetings of the EOSS are held at the Digital Equipment Building on Chester Rd near County Line Road. Meetings

are on the second Tuesday of each month at 7:30 PM. A ten minute briefing and a short white paper are requested.

1.4.2. EOSS flight number assignment

After review by the EOSS Technical Committee and approval by the general membership, an EOSS Flight number (e.g., EOSS#10) will be assigned to your experiment. This will establish the launch order in case there are other flights in the queue. The period between flights ranges from 1 to 3 months.

1.4.3. Experiment development schedule

<<Paul Ternlund & Mike Manes>> A typical schedule an experimenter might have is as follows:

- Concept formulation (days to weeks)
- White paper preparation (days)
- White paper presentation and 10 minute briefing
- Initial OK by general membership
- Assignment of an EOSS mentor (experimenter's prime contact)
- Tech Committee review & analysis (weeks). During this time, EOSS will work with the experimenter to establish feasibility, detailed interface to the Shuttle, refine scientific goals, and set requirements. This culminates in a Tech Committee go/no-go decision.)
- Preliminary Design (documents previous effort)
- Prelim. Design Review & Tech Committee analysis to General Membership
- General membership go/no-go & flight no. assignment.
- Detail Design (dimensioned drawings, schematics, power & weight, risk analysis, reliability analysis)
- Build
- Test for conformance to requirements
- Critical design review (Present final design, test results)
- General membership OK & schedule flight date(s)
- Integration with EOSS Shuttle & System test (2 weeks)
- Flight
    - Day of launch preflight testing
    - Assist in launch
    - Monitor experiment in flight and collect data
    - Assemble data

- Post-flight debriefing
- Flight data analysis
- Prepare report
    - What was learned?
    - What was not learned?
    - Recommendations for follow-up experiments
- Present report to EOSS
- Publish, distribute report to peer community.
- Gain fame, fortune, notoriety, free ride at MIT???

As you can see, a lot of time and effort is involved in a flight. However, all steps may not be required for every flight.

After a flight schedule is announced, the EOSS Shuttle is readied for flight, a launch site is selected, FAA flight plan filed, helium purchased, the recovery team is assembled, and winds and weather are analyzed.

2. Launch

2.1. FAA rules

<<Jack Crabtree>> Operation of unmanned free balloons is covered under Part 101, Sub chapter F, Air Traffic and General Operating Rules, of Title 14 of the Code of Federal Regulations. In all cases, operation of an unmanned free balloon may not create a hazard to other persons or their property. The EOSS balloon team is well acquainted with the particulars of the FAA regulations and insures that all EOSS projects are in full compliance with these regulations. Careful adherence to all FAA requirements is mandatory for safe balloon operations and continued cooperation of the FAA. Basically, regulations provide for three categories of balloon payloads by weight; up to 4 pounds, those between 4 and 6 pounds, and those six pounds and greater.

2.1.1. Applicability of FAA Regulations to unmanned free balloons

- Payloads up to 4 pounds in weight are basically exempt from the regulations.
- Payloads weighing between 4 and 6 pounds are exempt from the regulations if certain weight-density requirements are met: weigh less than 3 ounces per square inch along smallest side.
- For a single payload weighing above 6 pounds, a number of requirements apply. These include operating limitations such as maximum permissible cloud cover, equipment and marking requirements, formal notification, and position reporting during flight.
- For a payload consisting of two or more packages weighing more than 12 pounds.

2.1.2. Operating Limitations

- In a control zone below 2,000 feet unless authorized by Air Traffic Control.
- Any altitude where clouds are more than 50%.
- Over a congested area for the first 1,000 feet.
- Where impact may create a hazard to persons or property.

2.1.3. Equipment and Marking

- Two independent cut-down systems
- Two independent methods to terminate flight of balloon
- Radar reflective device
- Night operations require lights
- Suspension device greater than 50 feet requires color pennants.
- Parachute must be highly conspicuously colored

2.1.4. Notification requirements

- Pre-launch: 6-24 hours
- At launch
- Cancellation if required
- Position reports, geographical and altitude as required
- Derelict status—if control is lost
- Touchdown

2.1.5. EOSS policy

- Full compliance
- For small payloads (less than 6 pounds), use single cut-down
- Notify FAA as a courtesy
- Do not create a hazardous situation

These are only a few of requirements you may be facing. You should read and understand the regulations.

2.2. The Ground Station

2.2.1. Introduction

<<Rick von Glahn>> You've all heard the words, "Johnson Space Center, the mission control center personnel are slowly turning blue in the face." when our astronauts said, "Houston, Tranquillity Base here. The Eagle has landed." Cheers go up and people start their respiration processes once again. It's exhilarating to have your hard worked plans come to fruition and in today's balloon community scenes like that one are often repeated. Granted, we at Edge of Space Sciences, Inc. (EOSS) are not quite in the same league as NASA, and our flights aren't quite so perilous as Apollo 11. Nevertheless, cheers are often heard at our mission control station when onlookers view our controlled cut down of the payload from it's balloon. The ground station on EOSS flights serves the same purpose as mission control in Houston does for NASA flights. We monitor the telemetry, and control the payload.

2.2.2. Equipment

The ground station can be as simple as a two meter hand held receiving a beacon (on really simple flights) and as complicated as several receiving stations displaying packet data, Amateur Television, beacons, information and GPS data, a transmitter sending up commands to the payload to control the amateur TV (ATV) camera's angle of view, activate heating elements, and actuating the cut down system.

The following is a typical list of equipment:

2.2.2.1. Packet

- Yaesu FT470 to receive packets and transmit commands.
- KPC-3 Packet TNC Compac 3/25 laptop computer
- Okidata Microline 92 printer
- Computer paper
- Spare ribbon
- 30 watt amp to ensure we can talk to the payload.
- Various serial and parallel cables to connect the packet station together

2.2.2.2. Amateur TV (ATV)

- ATV down converter
- VCR - taping the flight
- Blank tape
- (2) 19-inch TVs (one for ground station personnel, the other for visitors to the station).

2.2.2.3. Radios

Two Meter

- Icom HT - Launch site intercom
- Icom 2410H - Interact with transmitter hunters in the field via repeaters

HF

- HF Transceiver

2.2.2.4. Antenna Systems

- 2 meter 12 element yagi beam antenna - receives packets and transmits commands to payload
- 70 centimeter 22 element yagi beam antenna with pre-amp- receives ATV from payload
- 40 meter dipole antenna - located at least 100 yards away from Control site to minimize electromagnetic interference to computer systems, used to communicate with fox hunters should they leave the coverage area of all available repeater systems
- Several Mag Mount Antennas used for voice communication to various groups in the field
- Antenna Rotor - Antennas remotely located atop a building. The tripod mounted azimuth and elevation Rotors enable quick antenna repositioning from the ground station
- Several hundred feet of coax to connect the remote beam antenna systems

2.2.2.5. Plotting

- Plotting board
- Overlay grid
- Colorado Recreational road map
- Aviation plotter calibrated to the CO Rec. Road Map
- Aviation sectional maps for latitude and longitude determination
- Plotting markers (sharp and non permanent)
- Cellular Phone - used to maintain liaison with the Federal Aviation Administration keeping them apprised of the progress of our payload

2.2.2.6. Miscellaneous

- 120 VAC power or a generator capable of running all your gear
- (2) 6-outlet power strips
- AC 150 ft. of heavy duty outdoor AC extension cord
- 120 VAC to 12 VDC at 20 Amp power supply
- Duct tape
- Soldering station
- Iron
- Solder
- Dikes
- 12 volt power strip
- Cigarette lighter adapters
- Banana plugs
- Spare fuses
- 75 ohm splitter
- Tripod & 2 meter beam (used for distant repeaters)
- Multimeter
- SWR meter
- Junk BOX - contains lots of, what else, junk
  For example:
  - BNC to PL-259 converters
  - N to BNC
  - PL-259 to BNC
  - Wire
  - Batteries

  - Nuts and bolts
  - Lots of tools
  - and more junk!!
- Tables
- Chairs

2.2.3. Location

Although EOSS almost always locates its ground station at the launch site, it doesn't have to be done that way. Just as Kennedy Space Center in Florida controls the launch of space flights and Johnson Space Center in Texas controls the in flight operations, EOSS or any group could operate the same way. A balloon quickly rises above the local terrain and can be controlled by stations several miles away. From that point on, the communications window to the balloon steadily increases until the moment of cut down.

One proviso here. While the launch team is getting the payload ready for flight, they need to be able to verify operations of all systems aboard. If the ground station is located at a distant site and unable to receive the payload while it is on the ground, the launch site will need a mini ground station to verify operations of all the systems aboard the payload. This essentially means a duplicate of all systems at the ground station with the exception of the high gain antenna systems needed to communicate with the payload over great distances.

2.2.4. Setup Schedule

A typical ground station setup usually starts about two to three hours prior to launch. All members of the ground station team assemble at the designated spot and start plugging all that equipment together. The objective of the set up team is to be up and operating at a minimum one hour prior to launch. Even the most experienced team can find itself short of one vital piece of equipment that is either forgotten, or damaged in transit to the operation site. Checklists are invaluable.

2.2.5. Operations

2.2.5.1. At T-60 minutes

At one hour before lift off, the ground station goes on the air. By then it has verified operation of all it's components and is in a position to report on the payload status as indicated by the various beacons, packet systems and ATV transmissions. The launch team uses this information to verify their launch preparations.

2.2.5.2. At T-10 minutes

At T-10 minutes we start recording data and video. A continuous hard copy of the packet telemetry is printed and used by the plotting team, also located at launch site, to locate the position of the balloon.

2.2.5.3. At Launch

At launch the ground station team takes over control from the launch team. All commands to the payload are sent from this station until Loss of signal (LOS) (minutes before landing usually) when a field team member takes over.

2.2.5.4. At T+n minutes

During the flight the ground station receives the telemetry, plots the position of the payload, controls the camera, and relays information of interest to transmitter hunter field teams. This is the "fun" time for ground station personnel. It's their bird to play with. We usually cater to the whims of spectator gallery with regard to camera views showing what ever interests the crowd. If we detect icing on any of our servo systems, we can activate heating elements aboard the payload.

The Federal Aviation Administration (FAA) is often involved in our fights. They may require that we report our position at various altitudes on the way up and down. We assign a ground station team member to act as liaison to the FAA. It is that team member's sole responsibility to monitor the flight and report to the FAA when each reporting criteria is met.

2.2.5.5. End of Flight Preparations

Prior to launch a cut down altitude is determined. When the balloon ascends to within 10,000 feet of that altitude, the ground team goes into "serious" mode. Once the balloon is near cut down altitude the camera is turned down to show a last view of the ground from maximum altitude. The horizon is then viewed.

At 100,000 feet altitude it's an impressive sight. The sky is completely black. The atmosphere shows as a band of gray (b&w camera) above the horizon and the horizon is ever so slightly curved. Finally we pan the camera up to look at the balloon and parachute. This angle of view is maintained during the cut down procedure to offer absolute verification of a successful release of the payload.

When the balloon reaches it's maximum altitude, we send the arming signal to the cut down mechanism, and then actuate the system to release the payload from the balloon. This is the most dramatic moment of the flight. We definitely want to release the balloon from the payload. When balloons explode, they have been known to foul the shroud lines of the parachute system, producing a faster than anticipated descent and subsequent hard landing. Everyone gets that blue in the face look as the code is entered. Then, voila, the balloon sails away as the payload drops. Almost immediately the parachute inflates and we're on our way down.

2.2.5.6. Descent Phase

During the descent phase, the ground station continues to monitor and relay tracking information to the field teams. Camera views are again at the request of the experimenter or the gallery.

2.2.5.7. Preparing for LOS

Once the payload has descended to 10,000 feet above what we estimate will be the loss of signal (LOS) altitude for the ground station the camera is pointed at the ground. It stays in that position for the remainder for the flight. On several flights views of unique ground features that were of help to the recovery team have been obtained. At this point the ground station's job is essentially over. Naturally, everything from the balloon until LOS is monitored. Contact is maintained with the field teams even after LOS should they require any data that has been collected.

2.2.5.8. LOS

Once LOS occurs, dismemberment of the ground station commences. Everything not related to communications with field teams is taken down and packed up into waiting vehicles.

2.3. Balloons

2.3.1. Reference

<<Merle McCaslin>> One of the references we use is: Basic Procedures For Small Balloon Flights, 1976 put out by the Office of Naval Research. In general, the Navy works with much larger balloons (payloads to 150 lbs.), but the reference is very good for anyone flying balloons.

2.3.2. Terminology

- Tare Weight: The tare weight is equivalent to the weight of the equipment to be lifted + Free Lift.
- Free Lift = 0.10 to 0.25 x (payload + balloon weight)
- Gross Inflation = Payload + balloon weight + Free lift
- Gross Weight = Total airborne weight, exclusive of lifting gas
- Total airborne weight = balloon weight + payload weight.

2.3.3. Site preparations

If possible, a wind screen on the lee side of a building should be used for shelter to minimize the wind effect on the balloon during inflation.

A ground cloth of some type is required to layout the balloon prior to filling. Sheets, plastic, rugs and tarpaulin have been used. The tarpaulin works as well as anything tried to date. Larger balloons usually come with a plastic sheet for this purpose.

2.3.4. Handling balloons

At the launch site, care must be exercised during actual manipulation of the balloon material to avoid damage. Material should be lifted into place, never grasped and pulled into place. Remove all jewelry, watches, and buckles. Also, cotton gloves or plastic gloves are recommended. Gloves of the type used in electrical "clean room" environments work extremely well.

All payload equipment operations should be verified by a pre-approved checklist prior to inflation of the balloon.

The balloon construction train sequence is: balloon, parachute, payload(s). The parachute and payload is laid out on long tables connected prior to attachment of the balloon. The string is purchased from a kite store and has a tensile strength of 220 lbs. There are several knots required in the make up of a balloon train. This is a critical operation and some of the knots must be done just prior to flight. Knots have been secured using quick-setting glue and then wrapped using a good adhesive tape..

2.3.5. Handling helium

Helium must be handled carefully. It is not an explosive gas but is under high pressure up to 2300 PSI. This can be dangerous. When possible, bottles are kept in a truck bed. If they must be moved, they should be moved on a dolly and secured to the dolly and to a post or in some manner at the filling site. Install a gas regulator on the helium bottle to control fill pressure.

Gas transfer or inflation (for Kaysam type weather balloons) should begin only after all other preparations have been made. This is sometimes hard to accomplish but is the way the sequence should be planned. Helium is fed from the bottle through a hose to a PVC pipe that is put in the neck of the balloon about 4 inches. Clamp the balloon neck to the PVC pipe with a hose clamp. It is best to fill the balloon slowly, 15 to 20 minutes for a model 105G. A tare weight (we use pre-weighted sand bags) is attached to the balloon after it is upright. The balloon is filled until the tare weight is lifted off the ground. A very tight string tie is made around the neck of the balloon above the PVC. Then the PVC is removed and the end of the filling tube folded over and tied again and the whole joint taped with duct tape.

2.4. Launch Team

2.4.1. Launch Director

<<Jack Crabtree>> For each balloon flight there is a designated launch director. The launch director should be experienced in all facets of site preparation, preflight readiness, launch operations and, tracking and recovery of the balloon payload. The launch director is responsible for these activities including the safety of all personnel and property.

2.4.2. Balloon Lead

<<Merle McCaslin>> The balloon lead is responsible for having the balloon and support equipment at the launch site. This includes the helium, filling equipment, regulator, houses, ground cloth, tare weights, and miscellaneous items such as the tape, string, etc.

The balloon lead is also responsible for determining the tare weight and assuring the balloon is filled properly in a timely manner. He is also responsible for assuring the complete balloon train is secured and ready for flight.

2.4.3. Payload Lead

<<Mike Manes>> The Payload lead is usually the EOSS member who has served as prime contact for any new experiment which may be aboard the flight. He is responsible for ensuring that the experiment is properly prepared for flight, functional and communicating with the Shuttle. He is also responsible for ensuring that the Shuttle preflight checklist is complete and all functions verified.

2.4.4. Ground Station Lead

<<Rick von Glahn>> The Ground Station at EOSS flights is the control center during the flight. Ground station responsibilities include maintaining contact with and controlling the payload, and relaying information to the field chase teams concerning the status of the flight. The means by which this is accomplished varies from flight to flight depending on what capabilities the payload possesses. On the simplest flight with only a beacon we might not even set up a ground station. On the most complex of flights, we'll have computers receiving packet relayed data from the payload, ATV receivers and VCRs and TVs to monitor the live video as it's beamed down, a command radio used to send control codes up to the payload causing it to change transmit modes on some of the beacons, alter the angle of view on the video downlink and cut down commands to release the payload from the balloon and various other radios used to monitor the beacons, communicate with the field teams and run information nets.

2.4.5. Tracking and Recovery Lead

<<Greg Burnett>> The Tracking and Recovery Lead organizes the Tracking and Recovery Team. He tells the Launch Director about the availability of the Tracking Team to support the launch, and assigns the Field Coordinator for the chase. He conducts a net the evening prior to launch to give final instructions about the recovery process to include frequencies to be used, meeting times and locations of the tracking stations. It is during this net that stations planning to be a part of the Tracking and Recovery Team check in and receive a tactical call sign.

2.5. Launch commit criteria

2.5.1. Launch Checklist

A checklist of pre launch tasks and tests should be prepared beforehand and carefully checked as each activity is completed.

2.5.2. GO/NO-GO decisions

A *preliminary* GO/NO-GO decision is made prior to balloon inflation. Factors such as wind and weather conditions, completion of payload checkout, and road conditions for tracking and recovery will play a major part in this decision. This is an important decision because the expense of the helium —and probably the balloon— is committed at this point.

A *final* GO/NO-GO decision is made just prior to the launch itself. If conditions change or problems with balloon inflation or payload performance are experienced, a HOLD or NO-GO decision must be made.

2.5.3. Launch Team member roles

For each of these decisions all launch team members should be in mutual agreement and then abide by the decision of the launch director. A polling of the team members should precede each decision. Criteria and decision factors include the following:

- The Balloon Lead shall indicate full readiness of balloon "train" which includes the balloon, parachute, cut-down devices, all wiring and cordage, attachments to payload and any auxiliary beacons.
- The Payload Lead shall indicate full readiness of the payload package and auxiliary beacons, if any. A complete checkout of the payload on internal battery power for proper performance should precede the GO vote. Proper operation of any beacons should be verified. The Payload Lead should double check cord and wiring attachments including antennas as well.
- The Ground Station Lead shall indicate full readiness of all ground station equipment and that proper command and telemetry capability is on-line. Any data or video recorders should be ready for activation by at least the final GO decision. Ground station antennas and cables shall not impair launch operations or personnel safety.
- The Tracking and Recovery Lead indicates readiness of all remote tracking and recovery teams. While final deployment and positioning about the anticipated landing site may still be in process, the deployment should be on schedule and no factors adversely affecting personnel safety should be evident.

2.5.4. Weather

Weather conditions at the ground site and the anticipated recovery area should be suitable for launch. For smaller balloons, winds of up to 10 miles per hours can be tolerated but will complicate launch. For larger balloons, 10 miles per hour will probably be excessive. Winds immediately above the ground or launch level can greatly influence launch safety and performance. Before balloon inflation, one or two smaller pilot balloons can be tethered to measure winds as high as the extended balloon train will occupy during the launch sequence. Cloud cover criteria is generally 50 percent coverage or less, and no horizontal visibility impairment at any altitude below 60,000 feet of greater than 5 miles. Specific FAA waiver is required for any exception.

2.5.5. FAA requirements

All FAA requirements shall be met. All pre launch notifications must have been made and a concurrence for launch obtained, if required. Compliance with all balloon marking and lighting, cut down, and other FAA requirements shall be in effect. Any waivers shall be current.

Safety shall be paramount at all times.

2.5.6. Final launch decision

Only after consideration of all the above, shall the launch director issue the GO for launch. At this point, the launch should be carried out in a timely manner. If a significant time lapse is experienced due to changing conditions or problems, another evaluation and polling of the launch team should be made.

2.6. Launch sequence

The total balloon string should be stretched out with the balloon upwind of the payload so that the wind will carry the balloon in the direction of the payload. We use several people holding the balloon train. The payload is held by one or two persons and an additional person, stationed at the parachute, applies tension to the system by pulling on the parachute risers. The balloon is then released and rises, picking up the payload. If the wind is high the people with the bottom package may have to run with the payload to prevent the payload from dragging on the ground before it is picked up by the balloon. We have been releasing our balloons slowly, hand-over-hand on the string, but the above method is what is recommended and we plan to do it in this manner.

3. Flight

<<Mike Manes>> Any experimental payload should be able to withstand the flight environment to include:

3.1. Ascent rate

800 - 1200 feet per minute (approximately constant at any altitude)

3.2. Temperature

External air temperatures from +40 to -60 degrees Centigrade

3.3. Pressure

At 100,000 feet, ambient pressure is approximately 0.15 psi absolute (about 1/100th atmosphere) or 5 mbar

3.4. Moisture

EOSS balloons have passed through cloud cover, virga (wisps of precipitation evaporating before reaching the ground), and there is a theory about one flight traveling through a cold front causing condensation to foul electronic components. Moisture droplets from the above should be expected during a flight.

3.5. Electromagnetic fields

Strong EM fields at 144 and 425 MHz from the Shuttle transmitter antennas must also be tolerated.

3.6. View from 100,000 feet

<<Andy Kellett>> EOSS launches balloons to see how things are “up there”. So it makes sense to have a feel for how high “up there” is. If a balloon were left to itself, with no gas escaping from it, it would go up until it popped. Rather than let the balloon pop and tangle with the payload, EOSS cuts the balloon away from the payload. We want the balloon to get as high as possible, yet we don’t want the balloon to pop on its own. So when do we cut the payload and balloon apart? It turns out that for the size and type of balloon EOSS uses and for the weight of the EOSS payload, about 100,000 feet above sea level is the right height to separate.

3.6.1. How high is 100,000 feet?

You can start to get a feel for how high 100,000 feet is by remembering that commercial jets travel at about 30,000 feet. 100,000 feet is about 2/3 of the way through the stratosphere, and the majority of the mass of the earth’s atmosphere is below the balloon at that height. You can tell that there are fewer gas molecules at 100,000 feet when you see video from the balloon. The sky is as black as night, but the sun is still visible.

3.6.2. Comparisons

One way to get a better feel for what 100,000 feet is to convert that height into different measurement units.

3.6.2.1. Miles

If 100,000 ft. is the same as 18.9 miles, we now know that if we walk (at about 3 miles per hour) it will take about 6.3 hours to get 100,000 ft. If you drive (at 55 miles per hour) you could get 18.9 miles in about 20 minutes and 38 seconds.

3.6.2.2. Paper clips

So, is 100,000 ft. far away? If you made a chain of paper clips 100,000 feet long, (each paper clip weighs about 0.5 gram and it takes 10 paper clips to make a one foot chain), the chain would weigh 500 kg (about 1100 lbs).

3.6.2.3. Pop cans

If you stacked pop cans 100,000 ft. high, it would take about 259,500 pop cans (each pop can is 4 -5/8 inches high when you subtract out the part of the can that fits inside the can below it). That’s about 10,800 cases of pop.

3.6.2.4. People

It would take 16,667 six foot people, standing head to foot to reach 100,000 feet, (even more if they stand on each other’s shoulders). So in terms of paper clips, pop cans and human height, 100,000 feet is far away.

3.6.3. Earth's radius

100,000 feet is only 0.48 percent of the earth's average radius. This means if you draw a circle to represent the earth, like Figure 1.

Figure 1

and then draw a dot to represent an EOSS balloon at 100,000 feet, it would NOT look like Figure 2.

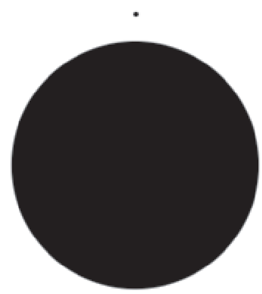


Figure 2

Instead, it would be a dot like that in Figure 3.

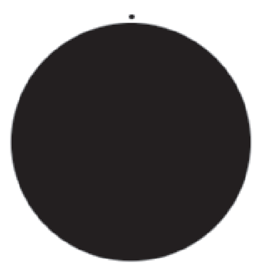


Figure 3

In fact, with the circle we've drawn, it is hard to position a dot to show how 100,000 feet relates to the earth's size.

So, you can see that in terms of the earth's size, 100,000 feet is hardly a bump.

3.6.4. Conclusion

With the majority of the earth's atmosphere behind it, an EOSS balloon at 100,000 feet truly is at the edge of space. The environment at that altitude can hardly be compared with anything we experience on the surface of Earth. Yet all of us live less than twenty miles from this vastly different place.

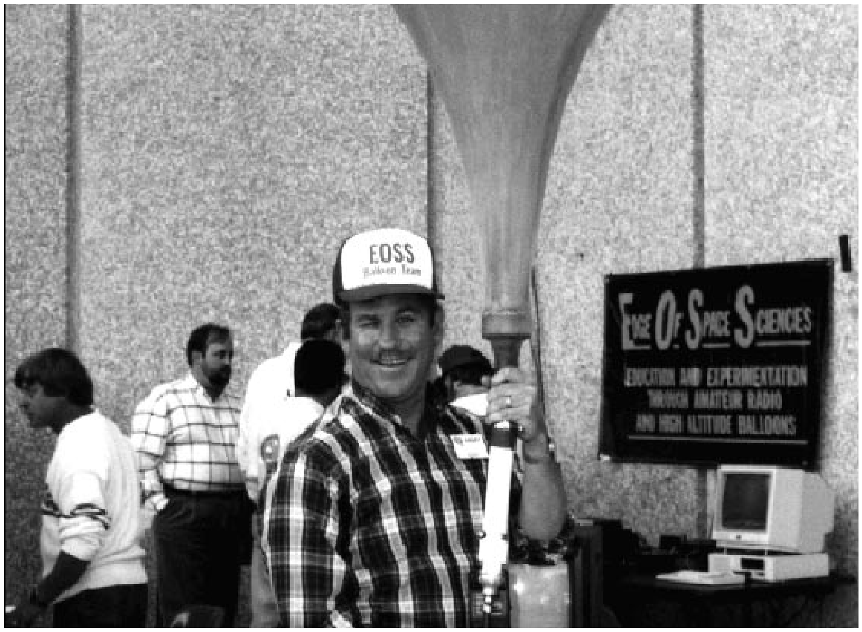
3.7. Descent

Descent rate up to 2000 fpm and infiltration of 100% relative humidity air during descent.

3.8. Impact

The payload must stand the rigors of a landing at the above descent rate coupled with a parachute drag for at least 500 meters across a plowed field.

4. Flight components



4.1. Flight subsystem

4.1.1. Balloons

4.1.1.1. Small balloons

<<Merle McCaslin>> Small balloons are manufactured of either an extensible material, such as natural or synthetic rubber, or a non-extensible material such as various types of plastic films.

4.1.1.2. Extensible balloons

Two sizes of balloons have been used for EOSS flights. They are manufactured by Kaysam of Totowa, New Jersey. These are designed for collection of meteorological data. The balloon increases in size as it rises and the atmospheric pressure decreases. The balloon bursts as it expands beyond it limits and the ascent is terminated. The weather services do not care if the balloon bursts while the payload is attached because they are not as concerned about recovery of the payload. At EOSS we are concerned about the balloon fouling the parachute and impairing its operation. We use a radio command release that is a nichrome wire to cut the string prior to burst. These are the two sizes of balloon we have used of this design: 105G at 1200 GRAMS, and 100G at 1000 GRAMS.

4.1.1.3. Zero pressure balloons

These are the balloons EOSS has used on the Humble flights. They were manufactured by Raven of Sioux Falls S.D. These balloons are designed to float at a predetermined altitude. They are designed to be cut loose from the payload and also must be deflated in some manner. We used the rip panel method to deflate the balloon which uses the payload weight to pull a panel out of the top of the balloon. Humble-I used a 19,000 cubic ft. volume balloon, and Humble-II used a 54,000 cubic ft. volume balloon.

4.1.1.4. Super pressure balloons

This is the type used by Utah State for the attempted launch from Reno, it has a volume of 260,000 cubic ft. and is manufactured by Winzen International, Inc. This type of balloon can float for months under the right conditions.

4.1.2. Cut-down system

4.1.2.1. Requirements

FAA

<<Jack Crabtree>> Part 101 of the Federal Aviation Regulations require that balloon systems with payload weights exceeding six pounds be equipped with at least two payload cut-down systems or devices that operate independently of each other. The use of these devices allow a controlled separation of the payload and parachute system from the balloon. This could occur at the end of the mission or during an emergency situation where it was necessary to terminate the flight.

For Small Payloads

A controlled separation is also often desired with smaller payloads using weather type balloons that burst at altitude. After bursting, remnants of the balloon and the attachment cord can become tangled in the parachute system. A controlled separation before balloon burst will prevent this from occurring. Of course, the balloon operator is now faced with the decision of where to initiate the separation. The operator often wants maximum altitude or flight time before separation. Careful planning and experience is required to formulate the final separation plan.

For Large Payloads

Cut-down systems are also used with zero pressure balloons to help terminate the flight of the balloon when the payload drops a distance of 10-20 feet and yanks on a cord that attaches to the balloon rip panel. Once the panel is ripped open, the balloon quickly deflates and descends. An additional cut-down device is often used to then separate the rip cord (and thus the balloon) from the parachute and payload to preclude entanglement.

4.1.2.2. Current system

EOSS has developed a cut-down system that uses a nichrome wire that when heated by current flowing through it, burns through the nylon cord between the parachute and the balloon. Because several Amperes of current are required, and to minimize the size of wire required between the payload and the parachute, a localized current source is installed at the top of the parachute. This consists of a small lithium 6 VDC battery with at least 1 amp-hour of capacity, and a small relay that switches the battery across the nichrome wire. The nichrome wire is approximately one and a half inches long and is wrapped several times around the nylon cord leading up to the balloon. Wraps must not touch each other. A much smaller 2-conductor wire can then be used between the payload and the separation device because of the low current requirements of the relay. One conductor is connected to +12 VDC and the other to a commandable, open-collector transistor output on the payload controller.

Other separation devices are under study by EOSS and experiments have been conducted with small pyrotechnic devices. Due to safety considerations however, the nichrome wire device has been adopted as the EOSS standard.

4.1.3. Parachutes

<<Merle McCaslin>> For our first flights we used a weather service type parachute. They are not made for the loads we fly and they came down too fast and one was torn. We are now making the parachutes out of a bright orange ripstop material. This material is heavier than we would like, but it has been doing the job. We have used the same angle of parachute as the small paper ones, just increased the length.

The illustration shown is a calculator that can be used to determine the parachute diameter required for a given descent rate and a given payload weight.

Formulas for use in design of parachute follow some variable definitions:
A = Angle, B = Side Length, D = Diameter of Circle.
A / 360 * 4 * B = D
Example: 112.5 / 360 * 4 * 56 = 70 Diameter

D * 90 / A = B
Example: 70 * 90 / 112.5 = 56 inches Side Length.

4.2. Shuttle

4.2.1. Payload box construction

EOSS has flown four types of payload packaging on the 12 flights.

4.2.1.1. Type I

A round foam box 15 inch diameter; 4 inches deep, with half inch wall thickness. This package flew in a vertical position. It had a little wheel ATV antenna mounted above the main package.

4.2.1.2. Type II

Constructed of a rectangular foam box flown in a horizontal position. It’s size was approximately 15 x 4 x 10 inches with half inch walls. The printed circuit boards were laid in the box covered with insulation material. This type was flown in a horizontal position. EOSS experimented with various 2 meter and ATV antenna’s on various flights.

4.2.1.3. Type III

This construction is used on the beacon and cross band repeater. A more solid block of foam approximately 6 inches square and 15 to 18 inches long. This type had a much thicker wall of foam, two to three inches.

4.2.1.4. Type IV

This is the foam core construction. The box can be custom built to size required, the sheets of foam are cut to size and hot glued together. This works very well in area's such as the mounting of the mirror. In this construction the electronic equipment is hard mounted to the box giving a more solid and reliable construction.

4.2.2. Control computer

4.2.2.1. Description

<<Bob Schellhorn>> This controller is comprised of a Z80-based micro controller which has 32K of ROM, 32K of RAM, two PIO's (parallel I/O chips), a Real Time Clock chip, a DTMF decoder chip, an Exar tone encoder chip used for generating packets, a National voltage to frequency converter for translating the minute voltages from the pressure sensor at high altitudes into values the CPU can handle, and a National 8 input, 8 bit analog-to-digital converter used to measure different temperatures. The CPU is kept at 1 MHz clock speed to hold down any interference to receivers on board.

4.2.2.2. Present features

- A two meter beacon transmitter which identifies the balloon in CW including the present altitude in thousands of feet (long form CW mode only).
- Following the CW ID, a packet message is transmitted telling the status of the balloon which includes:
  - Present altitude in thousands of feet.
  - Present temperature of the inside the payload.
  - Present temperature of the outside of the payload.
  - Local time and date.
  - Position of a movable TV camera positioned from the ground to any vertical angle from straight up to straight down.
  - Status of a balloon release device commandable from the ground which allows for the payload to be detached before it is damaged by the exploding balloon.
  - Status of a command receiver to accept commands from designated ground control stations.
  - Status of a confirmation packet message is sent following any commands to indicate if the command was completed or no good. This also is a time stamped log of any and all commands used.
  - A general information packet message sent on command which tells all stations the nature of the mission and where to send any confirmations of receiving the balloon signals.

4.2.2.3. Parameter updating

A terminal can be plugged into the payload prior to launch time to allow for updating parameters. These include:

- Setting the present time and date.
- Changing to a different CW speed.
- Entering a different Call for the ID.
- Entering a selected password used in commanding.
- Changing to a different general information message.
- Check-out other functions such as the release device.

4.2.2.4. Altimeter

The sensor is a Motorola device which gives an output voltage from 5.0 to 0 volts for a given air pressure and is very linear.

The difference in pressure per thousand foot is much greater at the lower altitudes but at near 100,000 feet, the difference in the output of the sensor for each 1000 feet will be only a few millivolts. Since this is too big a job for our 8-bit A/D converter, a voltage-to-frequency converter was used.

The sensor is connected directly to the LM331 with its output running about 4.0 MHz. This output is then divided by 256 and run into a bit on one of the I/O ports. The program detects when the signal changes state and starts a counter which steps until the signal changes again. This number is then used with a lookup table to determine the present altitude.

4.2.2.5. The temperature sensors

These are National LM335's. We tried using LM34's and LM35's which read temperature directly in Fahrenheit and centigrade, but since the temperature range we encounter goes to about -50 degrees Fahrenheit, it was difficult to use sensors that go minus. The LM335's give a linear output of 10 millivolts per degree Kelvin, which never goes minus. We convert the output read by the A/D converter, to degrees Fahrenheit via a lookup table which is inserted into the packet status message to read out from -59 to 179 degrees.

4.2.2.6. LORAN-C navigation

TBW *(Bob ‘ORE)*

4.2.3. Beacon

4.2.3.1. Transmitter

<<Bob Ragain>> The EOSS beacon transmitter is crystal controlled (18.5 MHz range) with 5 stages. The final is a 2N3553. The voltage requirement was reduced from the original 16 vdc down to 6 vdc. Present output frequency is 147.555 MHz with the power output tuned to 200 mW. The two watt transmitter strip was originally used for naval sono-buoy telemetry operations.

4.2.3.2. ID’er

The ID’er is a design developed by WN0EHE and is EPROM based. A one bit “channel” of the 8 bit byte is checked as either high or low state. A “high” state enables an audio output tone produced by a ‘555 oscillator. The sequence of highs and lows is selected to produce a Morse code message. The ‘555 oscillator output is subdivided to create a clock pulse for strobing the EPROM to output byte by byte. Any of the 8 “bit channels” can be chosen by DIP switch and each channel can have a different message. Voltage regulation for the TTL chips is via an LM-7805.

4.2.3.3. Packaging

The packaging material is closed cell Styrofoam and is in 3 layers. The two electronics boards and the battery are attached to a 2 inch thick central layer. Two 1 inch thick cover layers “sandwich” the middle layer and are attached with tape, tying the package together. The beacon is suspended by nylon cord from the package(s) above. A loop of “Weed-eater”(R) cord through the middle layer provides an attachment point on top and an antenna support on the bottom and prevents any tensional force on the styrofoam. The electronics boards are inside vented plastic bags. The entire package is draped in another plastic bag for flight.

4.2.3.4. Antenna

The 2 meter antenna is an upside-down quarter wave with ground plane suspended below the beacon package. The radiating element is about 19 inches of stainless steel wire tuned for best SWR. 25 dB of return loss was achieved at 147.555 MHz. The ground plane is four elements at 90 degree spacing with a support ring of about 12 inch diameter. The outer ends of the ground plane elements are bent in such a way to make the antenna flip to a vertical position and skid along the ground as the package is dragged after landing. The antenna is attached to the beacon package by about 2 feet of RG-58 coax to allow the antenna to move independently of the beacon package.

4.2.3.5. Battery

The battery pack is 3 lithium cells in series to provide about 9 vdc at 4 ampere hours capacity. Battery life is calculated at 20 hours at full output but current requirements decrease as battery voltage drops with temperature. Battery life has been tested to more than 30 hours under cold “flight” conditions. The beacon will operate down to 6 vdc.

4.2.4. Command & telemetry

4.2.4.1. Background

<<Tom Isenberg>> Command and telemetry data (information being sent to and from the Shuttle computer, respectively), enables EOSS to control the different devices on board, as well as collect data. All data that we collect has some importance during the flight. Sample telemetry may look similar to the following: W6OAL>CQ: EOSS Balloon Status 09/28/91 09:37:37 AM Altitude; 5000 feet. Temperatures; Inside 88, Outside 72. This information is given every 30 seconds. During the time ground control is sending the computer commands, normal telemetry output will be interrupted and command information will be displayed. Payload altitude is given in a rounded format so you may see two consecutive altitudes the same. If the altitude remains the same repeatedly, then the balloon is not ascending. The temperature inside the Shuttle tells us if the electronics on board is keeping warm. If the temperature drops inside, we know that maybe some damage to the Shuttle may have occurred. The outside temperature is used for comparison. A third temperature sensor tells us that the on-board heater is working. There may be other information contained in the telemetry to indicate more to the ground control station.

4.2.4.2. Hardware

<<Mike Manes>> Two-way radio communications is maintained with the Shuttle and experiment in-flight. Control commands are “uplinked” to the Shuttle from the ground control station. Shuttle status information is “downlinked” from the Shuttle to the ground control station. The downlink data stream is known as “telemetry.” Command and telemetry communications use the 2-meter amateur radio band on 144.34 MHz simplex and 3 KHz deviation frequency modulation (FM). The Shuttle radio is a stripped-down Midland LMR 70-150B commercial hand-held transceiver. Transmit and receive frequencies are crystal-controlled. The transmitter operates at about 1 watt (W) RF output power, and the receiver will respond to signals down to 0.25 microvolt (uV). The internal transmit/receive (T/R) antenna switch is connected to a 1/4 wavelength (about 19”) vertical whip antenna mounted atop the Shuttle package.

4.2.4.3. Transceiver control

This transceiver is controlled entirely by the Shuttle Control Computer. Transmitted audio is audio-frequency-shift-keyed (AFSK) 1200 baud digital data formatted per AX.25 as Unproto Information (UI) frames. This signal can be decoded by ordinary amateur radio packet terminal node controllers (TNCs) in the monitor mode. Packet bursts with telemetry data are transmitted in 2 second bursts every 30 seconds, except while ground commands are being processed. In addition, AFSK CW (Morse code) is transmitted for FCC identification every 9 minutes, and the CW mode may be invoked during the flight by ground command; this mode leaves the transmitter on for most of the 30 second telemetry cycle.

4.2.4.4. Commanding

When the transmitter is off, the receiver is listening for commands from the ground station. Commands are transmitted as a series of standard touch-tone (DTMF) signals, and may be issued by any appropriately equipped 2 meter FM transmitter. To avoid accidental or malicious operation, each command contains an embedded password which is programmed into the Shuttle Controller just prior to launch. Once command decoding is initiated, the Shuttle Controller will delay transmit activation for at least 5 seconds or until a complete command string is received; it will then issue an acknowledgment response on packet.

4.2.4.5. Typical commands

Standard commands include: (1) ATV on/off, (2) ATV camera elevation control,(3) CW Mode on/off, (4) Send special packet message programmed prior to launch, and (5) Balloon release. See Section on Electrical Connections, (4.3.4) regarding additional commands and telemetry specific to the experiment interface.

4.2.4.6. Range

Despite the modest on-board power and antenna, the command and telemetry link to the launch site has been successfully maintained to ranges over 200 miles. This is primarily due to the unobstructed line of sight path to the balloon's lofty height. After touchdown, the link range is typically reduced to less than one mile.

4.2.4.7. Telemetry

Standard telemetry includes: (1) date and time, (2) altitude - derived from a pressure transducer, (3) location in latitude and longitude, plus range and bearing to launch site - via on-board Loran C navigation receiver, (4) Shuttle internal, outside air and experiment temperatures in Fahrenheit, and (5) Shuttle battery voltage.

4.2.5. Video system

4.2.5.1. Camera

<<Dave Clingerman>> We use a black and white camera that was purchased for $185 from Jactec, in La Habra, CA. It is a single multi-layer board that uses a Charge Coupled Device (CCD) array on which the images are focused. A wide angle lens of 70 degrees is their standard. The F stop of the lens is at least 16 and possibly 22 as it focuses everything from a couple of feet to infinity. A scan reversal switch is provided so that if a mirror is employed, as we do, the image transmitted is not reversed. The camera board and lens are enclosed in a plastic housing about the size of a pack of cigarettes. This lends itself very well to the modular construction of the Shuttle that we have been pursuing.

4.2.5.2. Transmitter

The heart of the video system is the video transmitter. It is a full motion, full color, NTSC standard transmitter designed and build by P.C. Electronics of Arcadia, CA. It carries a list price of $189.00. The transmitter has three inputs; microphone, line and video. The microphone is hi-Z, the line 600 ohms and the video 75 ohms, 1 volt peak-to-peak black and white or color from a baseband video source. The transmitter requires 12 volts DC at 500 ma. The output is a 1 watt peak-to-peak RF signal in the 70 cm band. The transmitter is crystal controlled and presently operating on a carrier frequency of 426.25 MHz. Three other frequencies are available at 70 cm.

4.2.5.3. Signal polarization

The Case For Horizontal

I have always advocated the use of horizontal polarization for balloon video operations due to many technical reasons and practical experience. Horizontal polarization, in the beginning (EOSS/WVN-I), was convenient due to the fact that the input to the video repeater was horizontal. All members of WVN that used the repeater were therefore, horizontally polarized on 70 cm. Elevation tracking of the balloon was actually not necessary due to the aperture of even the highest gain yagis.

The reason for elevation tracking at the launch site was the fact that we were directly under the payload. The wavefront from a horizontal omni is always parallel to the plane of the receiving antenna elements when, of course, the receiving antenna is pointed at the payload and the fact that it is a horizontally polarized yagi or collinear array. I will elaborate on that feature later. Another benefit of horizontal polarization is the fact that "noise" is vertically polarized and signal to noise ratio (S+N/N) enhancements of 20 dB or greater can be achieved depending on geological location. The pattern of a horizontal omni can be calculated from its gain as follows. We know the H-plane is 360 degrees and the surface of a sphere contains 41,253 circular degrees (or square degrees). And, we know that the gain of a dipole is 2.15 dBi. Therefore the gain (A) is:

20 Log_{10} of the ratio of (QE) * (QH) to 41,253. A(dB) = 20 Log_{10} (QE) * (QH)/41,253.

When we do a little derivation and turn the crank, we see that QE is approximately 147 degrees or ± 73.5 centered on the horizon. Any null below the antenna is ~33 degrees (± 16.5 degrees) centered on the Z-axis of the antenna. In practice and in measurement it has been confirmed that the energy below the antenna is circular and will only be 3 dB down from the E-plane half power points or yielding a gain of -0.85 dBd.

Why is all this important? Because every fact of it is relative when we compare the calculations to a vertical radiator. At 100 miles out from the launch point and 20 miles above the earth (considering this a flat earth situation) the look angle is -11 degrees (using the convention that the spacecraft plane, parallel to the earth is the 0 degrees reference point or plane).

NOTE: Generally any time a distance on earth is <1/100 the circumference of the earth it may be treated as a flat earth problem.

Problems with vertical polarization

Let me now consider the vertical radiator. First, the terrestrial receiving system will have to tolerate 20 dB more noise than the horizontally polarized system. The gain of a l/4 radiator is twice that of a dipole (5.15 dBi)! Yes, gain is 20 Log_{10} of directivity. A ground plane antenna is essentially a dipole that has been cut in half (half the directivity, twice the gain)

The -3 dB beam width of a ground plane (using the gain equation again), is about 55 degrees (?). How did I come up with that? Let's revisit the gain equation. The gain of a ground plane is 5.15 dBi, divide it by 20 and take the antilog. Now, we have 1.8 = QH * QE / 41,253. Transpose, and we have QE = 207 degrees. Half of this is in the image and must be discounted, so the beam width is ~104 degrees or 52 degrees when observed in a rectangular coordinate system (X,Y plot). The useful lobe of a ground plane is only about 10 degrees -55 degrees above or below the horizontal (ground) plane what ever the case may be. Reference: Vertical Antenna Handbook, Capt. Paul H. Lee, USN(RET.), N6PL, CQ Publishing, Inc., New York.

Beneath the antenna (inverted ground plane) is a 50 degrees cone of silence or ±25 degrees which at 20 miles up dictates a hole in the center of the footprint that is ~20 miles in diameter. Further, at another 10 miles out from this hole, when the balloon is at maximum altitude the signal strength will be down by 3 dB to a yagi tracking the payload because of the lack of parallelism or the elements being displaced by 45 degrees. The cosine of 45 degrees is 0.707 and 20 times the log of 0.707 is -3 dB and at the edge of the cone of silence the attenuation is on the order of -9 dB, 'nuff said.

Taking these proven facts into consideration, we see that the center of the beam width is -36 degrees. This means that when the balloon reaches 100,000' the center of the beam is tangent with the earth only 27.5 miles out from a point directly below it and the -3 dB point is right at 100 miles or where the Brewster angle, null or point of uselessness starts. Let's examine this 100 mile reference point from the perspective of signal strength. The slant range for 100 miles out and 20 miles up is ~102 miles. The space loss for this distance is ~130 dB, however; the receiving system of the vertically polarized signal must overcome an additional 20 dB due to noise or an equivalent path loss of 150 dB at a less than marginal look angle as compared to the horizontally polarized signal that has a -3 dB point that is within the margin of acceptance.

To get an idea of the magnitude of signal we are dealing with let's look at a link; the transmitter outputs a signal of about 0.5 watt peak (27 dBm), a horizontal omni is 2.15 dBi. The signal from this system at the ground is therefore -130 + 29.15, or -100.85 dBm. A -60 dBm signal will produce the required 37 dB signal to noise ratio for a snow free or P5 picture at the TV receiver. Somewhere 43.85 dB of signal is needed to satisfy the requirement. The conversion gain of most down converters, if they are gas FET, is on the order of 30 dB with a 1-2 dB noise figure leaving 13.85 dB to come from somewhere else. How about 13.85 dB of antenna gain this could be in the form of a Boomer or a couple of long yagis and the link is closed. Experience has taught us that 20 dB fades are not uncommon and an antenna mounted preamp can solve this problem along with making up for line losses between antenna system and converter. Now in the case of the ground plane, 3 dB can be picked up in antenna gain but an additional 20 dB of noise must be overcome. The 3 dB, in this case of using the ground plane antenna, above link closure will allow a 17 dB deficit during a 20 dB fade.

Conclusions

I have presented the case for use of a horizontally polarized antenna aboard balloon-borne spacecraft. I have presented the reasons for not using a ground plane. This does not rule out ever using vertical polarization. A vertically polarized gain array is another case. I have kept the mathematics to very simple forms for clarity and understanding. I've never found much use for multiple integrals for the explanation of simple concept. What I profess here is factually evidenced in the library of E.O.S.S. videos which are available from the group's secretary.

If I can ever be of assistance to any ATV balloon group in the planning or evaluation of an antenna system please contact me.

4.2.5.4. Antennas

Types Used

The composite RF signal is radiated by a *Little Wheel* antenna, or a *Candelabra*. The *Little Wheel* is an omni-directional horizontal polarization radiator that has the gain of a dipole (2.15 dB over an isotropic source). The *Candelabra* is an omni-directional vertical polarization radiator that exhibits 3 dB gain over a dipole or 5.15 dBi. Both antennas have shown superior performance in eight of the nine launches of E.O.S.S.

A Horizontally Polarized Gain Array

Little from Big

An antenna developed in the early 1950's by W1FVY and W1IJD, the Big Wheel, was a boon to mobile two meter SSB work. During that era, an omni antenna that was horizontally polarized was desired. The Big Wheel had gain over the Turnstile and Halo. It exhibited a much more uniform omni-directional pattern and had a fairly broad frequency response, >10 MHz (1.5 : 1 VSWR).

The Denver Area group of ATVers elected to use horizontal polarization for their ATV simplex operation in the 70 cm band. Horizontal would provide some isolation from 450 MHz FM operation which is vertical. The video repeater was not yet a reality and our simplex operation entailed all points of the compass. Yagi antennas would have worked and did for some. However, in a "roundtable" on our activity night you could work a rotator to death and stations off the sides and back of the beam would be left out. We needed a fairly efficient radiator that was omni-directional and horizontally polarized. A scaled down Big Wheel—or Little Wheel—seemed to be a natural to fit the bill.

Little Wheel Description

Many of you may have seen a Little Wheel and not recognized it. To describe this array takes longer than building one. It looks like the skeleton of a Three Leaf Clover. Each skeleton leaf is made of a wavelength of material (rod or tubing). The element is formed by bending the material into a Clover Leaf looking loop by making two 90 degree bends a 1/4 wavelength in from the ends.

The elements are mounted to hub that insulates the ends from on another with element phase preserved. The three elements paralleled will have an impedance of 12 ohms. A 50 ohm match is acquired through the use of a capacitor or a capacitive stub. A coax is then attached to the hub to complete the array assembly. The array is tuned by bending the quarter wavelength sections toward or away from each other, vertically, whatever is required to achieve resonance in the desired part of the band.

Prior to the launch of the Western Vision Network/Edge Of Space Sciences (WVN/EOSS) ATV Balloon Experiment, Mr. Bill Brown—WB8ELK, Technical Editor of 73 Today magazine—was consulted as he had flown some semblance of a down scaled Big Wheel on his early ATV balloon experiments. So for us antennas were one of the main topics for consideration. It was thought that in order to increase ATV participation the balloon ATV transmitter could be on the ATV repeater input frequency (426.25 MHz). That way the flight of the balloon could be followed by watching the repeater output, 1253.25 MHz. And so, a Big Wheel scaled to 70 cm was placed on the spacecraft. It performed remarkably well and continues to perform to all expectations not only for EOSS but all across the country.

Today, newcomers to the facet of HAM Radio that flies ATV on helium filled weather balloons may wish to experiment with the Little Wheel, a proven high altitude ATV radiator. By using horizontal polarization on the balloon flights for ATV transmission may attract greater participation than vertically polarized radiators. This participation could be brought about by the fact that there is a lot of "small signal" work done at 432.1 MHz. These very serious VHFers have their arrays horizontally polarized. Sometimes the arrays are made switchable to vertical for long haul FM or even circular for Amateur Satellites. At any rate there are an abundance of operators out there that may not be intimately interested in ATV ballooning but could track and report if asked.

We see that an antenna development for one facet on amateur radio led to its scaling and use in a second facet which has ultimately placed it at the "edge of space."

A Vertically Polarized Gain Array

Background

According to my ledger a considerable number of groups are flying the "Little Wheel" antenna on their balloon payloads for the ATV radiator. I am, of course, am very happy that the "Little Wheel" has enjoyed such success and enhanced the enthusiasm of ATV Ballooning (kiting, rocketry, RCing and not quite yet Frisbiing). However; not everyone in the nation or the world has chosen to propagate their video (ATV) signal in the horizontal.

Recently, in Denver, the local ATV repeater group Colorado Amateur Television League (CATL) has decided to try a vertical input on the video repeater, (426.25 MHz input/1253.25 MHz output). All interested ATVers then had to put a 90 degree twist on the tails of their horizontally polarized 70 cm antennas so the repeater could once again be accessed. This change in philosophy and ultimately polarization caused a bit of a problem. With a horizontal input to the ATV repeater and with the balloon borne ATV transmitter on

426.25 MHz we used to repeat our balloon launch video throughout our service area. Now, in order to capitalize on the maximum amount of ATV participation during the local balloon launches, “Edge of Space Sciences, Inc.” (EOSS) had to request their technical committee come up with a spacecraft antenna that would be vertically polarized, light weight and perform considerably better than a “rubber duck”.

Preliminary Design

As Chief Scientist / Technical Committee Chairperson of EOSS, without hesitation or reservation, I elected to take up the challenge and launched into a rather extensive research program to design, create and test a vertically polarized, gain array. The research went something like this; KISS Method - what’s first and available? The stinger, the spike, the quarter wave monopole, the coaxial collinear, the “J”, the old sewer pipe type monopole was even considered. The monopoles around a quarter wave length were known to be semi-radiating dummy loads, to one degree or another. Even though, mathematically proven they do exhibit 3 dB over a dipole, the Brewster angle (or Pseudo Brewster Angle) is too great to place the main lobe maxima on the horizon when the edge of space is encountered. The monopoles exhibit narrow bandwidths due to a high Q.

Physically, if affixed rigid to a near spaceborne vehicle, they are subject to and influenced by spacecraft dynamics, then you have the polarity characteristics that resemble the tail of a horse, swatting flies. How about the 5/8 wave or a coaxial collinear to solve the problem. Not quite, similar problems to those previously presented will be experienced. Given; however, the Brewster angle will be lessened and the energy will be more on the horizon. They are inefficient as they burn up power; first in the matching scheme secondly in its dielectric. Considerable consideration was given to a configuration that would shift the high current node inherent at the base of radiators such as a quarter wave monopole or 5/8 wave radiator which burns up a considerable amount of power in heating the ground plane.

Any light weight “spike” type of radiator will pendulum. Sure there are techniques for reducing the penduluming but they involve added weight which isn’t acceptable. The accounts I’ve read of ATV Balloon operations that have used stingers and such for their ATV signal radiators indicate it’s definitely not the way to go.

How about a solitary folded dipole, in an effort to gain the bandwidth required to properly propagate an ATV signal? Same problems with stability as the monopole, plus the added problems of mounting vs. feeding. For example; mount it on the side of the spacecraft and you shadow the opposite side seriously hampering reception on the two adjacent sides. Dangle it below the spacecraft and the pattern will be distorted by the feed line. How about employing a pair of folded dipoles for balance and reducing the feedline effects by moving the feedline far enough out of the pattern so as not to effect either radiator? Then a nice bi-directional array has been created that will twist and turn on the feed line and drive operators nuts that are trying to view and/or record the video, as the signal strength goes from P~ to P(N) and back again.

Detail Design

The folded dipole, to me, still had some interesting features I thought could be pressed into service if I could come up with the right combination / configuration and win the approval of the EOSS technical committee or for that matter the EOSS Membership-At-Large. With calculator in hand an investigation was undertaken to determine what sort of design could be conjured up that would allow the basic folded dipole to produce a pattern that is omnidirectional, in the horizontal plane and exhibit a predominately vertical E-field. The folded dipole was examined from the very basics such as optimum material diameter of the top and bottom radiating elements. Similar diameters allow a 4:1 impedance transformation and a terminal impedance of 288 ohms. Why not three radiators around a center hub and stand them off by 0.25 wavelength? That way the pattern would became more than bi-directional and the feed impedance would be a third of a the folded dipole by itself. That feed impedance of approximately 90 ohms would be easy enough to match to 50 ohms with a 0.25 wavelength of RG-62 (93 ohms) or a balun of sorts like a bazooka (coaxial Q-bar). The geometric mean of 50 and 90 is 67. A quarter wave length of 75 ohm coax would probably suffice. However, the bazooka would provide some structural integrity to the array and therefore could not be flexible. The bazooka would also serve as a partial reflector to this three element array.

Build

Creating a 50 ohm air line that is a quarter wave at 70 cm was only a matter of turning the crank on the coaxial transmission line equation. Brass tubing 7/16” O.D. and 0.375” I.D. of approximately 0.035 wall provided the larger diameter (D). It also fits very nicely over the threaded end of a BNC connector when the threads are removed. The other variable, the smaller diameter, (d) is then 0.1226”. A piece of standard 1/8” (0.125) brass brazing rod or hobby tubing would work very nicely as the center conductor for this length of air line. If made of rod, one end needs to be tapered to a point -More- from about one inch back so as to fit the BNC center conductor solder cup. Once soldered in place this center conductor/connector assembly could be inserted in the 0.375” brass tube and the connector soldered to the tube. The opposite end of this tube is to be fitted with a 3/8” brass nut that has had a 3/8” drill bit run through it to remove the threads and allow it to be slipped over the brass tube. Three of the six flats of the nut, every other one, require a 0.093” diameter hole in the center of the flat. These will later receive the very ends of the folded dipole elements. The tube can now be slipped through the nut to the point where it would be flush with the edge of the nut and then soldered in place. A Teflon shoulder washer is needed to serve as both “center conductor spacer” and “element end insulator”. This can be created from 1/4” thick Teflon sheet. The shoulder part would be 0.625” diameter, 1/8” thick while the center portion is 0.375” diameter and 1/8” thick. A hole 0.125” diameter is to be drilled in the center of this shoulder washer in order to pass the center conductor. The washer could then be placed over the center conductor and slid down till the 0.375" portion would fit inside the brass tubing and bottom out against the 0.625" diameter shoulder. A 0.750" diameter brass disk with a 0.125" hole in its center could be fitted on top of the shoulder washer and soldered to the center conductor.

Three, 36" lengths of 0.093" (3/32") diameter brazing rod were marked in the center and from that mark measured 6.0" both ways from it and marked again. From each of these marks measure 5.0" toward the ends on the rod and mark again. This leaves about 7.0" on each end of the rod. Now, it's just a matter of folding it up like a coat hanger. The elements (top & bottom) need to be a half inch between centers which allows the terminal impedance to be approximately 288 ohms. The two, 7.0" end pieces when bent parallel to each other will be approximately 2.0" apart. The very ends are then bent in a very mild "S" curve to bring the ends within a half inch of each other. One of the ends of a single element are to be inserted in one of the holes in the brass nut that has previously been soldered to the brass balun tube. The other end of the element is to be soldered to the brass cap that was previously soldered to the center conductor of the balun. All three elements will be soldered in place in like manner.

Test

Testing of the array was accomplished by first sweeping the device with a Texscan UHF Sweep Oscillator, Wiltron SWR Bridge and presenting a visual indication of bandpass on an HP-1743 Oscilloscope, using it in the X vs. Y mode. Some slight bending had to be done to bring the 1:1.0 portion of the curve to the portion of the spectrum where I wanted it, (425-431 MHz). Resonance at desired bandwidth accomplished, next the E & H plane pattern measurements and last but not least the gain determination.

The National Bureau of Standards (Boulder Labs) where I work has several antenna ranges, all usually tightly scheduled. I patterned my outdoor range after theirs. My test methods may be a little crude but very repeatable. I made my rotational platform sufficiently far (30 meters) from the source as I am only interested in "far field" measurements. After calibration the array was rotated in the "H" plane to ascertain any discrepancies such as deep nulls anyplace in the 360 degrees of coverage. The smoothed pattern was so smooth that the transition from element to element was barely discernible (<+/-1.5 dB). Next the array was turned in the E-Plane and what was anticipated and hoped for of the pattern became reality. In the design stage I had anticipated the balun/bazooka might act as a reflector to the upper portion of the elements, it did. The pattern observed was a skewed main lobe center of the E- plane, by thirty five degrees. Some minor lobes were of course evident at the top of the pattern but for all intents and purposes were insignificant. The envelope appeared to very much resemble a classic "cosecant squared" relation that is very desirable of search radars on airborne platforms and quite relative to our balloon missions. A hard copy of both E & H planes were plotted. Here was a case where an antenna was created out of necessity to fulfill the requirements of a previously good array but of the wrong polarization. The design phase related and the outcome of the project. I offer the dimensions and construction details in case this type of antenna will serve your purposes as well as it has ours (EOSS). If you'd rather just purchase one of these please let me know. It is available through Olde Antenna Lab as the *Candelabra*.

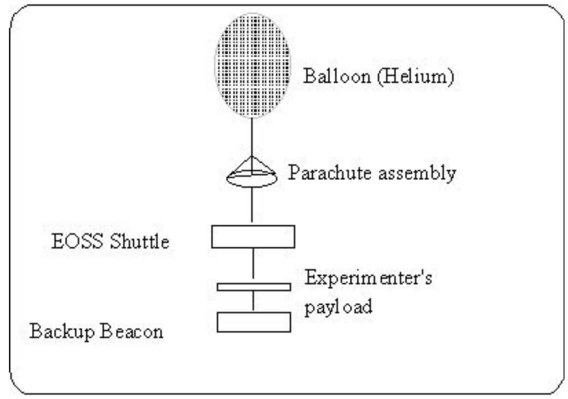
4.2.5.5. Equipment source options

An optional resource of the video system is a Digital Video Board produced by Elktronics of Findley, OH and retailing for $99.00. This board uses a Read Only Memory (ROM) can be programmed with custom video frames. These frames can be graphics (logos), call signs, messages, or whatever the imagination dictates. The frames are "on-board" timer controlled and can be interspersed with live video from the camera. The board operates on 12 volts DC and draws about 160 ma. We have used it on some missions where the over all current budget is minimal. Another option available in the video system is the Digital Audio Board from Ming, Inc. of Sacramento, CA, for $125.00 . This board can be configured to output a prerecorded message under "on-board" timer control, or store and forward a message on command. It is a 12 volt device that draws 200 ma. The memory is 4 megabytes long using Digital Random Access Memory chips (DRAMS). The audio is routed to one of the video transmitter subcarrier inputs and becomes the audio on the video down link. We noticed, early on, that the DRAMS are very sensitive to RF fields and therefore hasn't been used much on the Shuttle. An option available to the video system that is actually part of another system that will be described by another author is the microprocessor control. One of the many control features is the ability to position the camera in elevation, +/- 90 degrees. This is done through a voltage reversing relay that positions the mirror or, as in past cases, the camera itself. There are times when it is advantageous to be able to look other than just at the horizon. The Earth beneath the Shuttle can then be observed. This has been a distinct advantage to the Fox Hunters. The terrain of the shuttles intended landing area can be observed and identified. Positioning of the mirror for the camera to image skyward affords witnessing and confirmation of balloon release, when so commanded.

4.2.5.6. Background

The video system has been through many iterations to get where it is today. However, it is very versatile due to the stress we have placed on modular construction, reconfiguration of this and other systems to meet mission requirements, is not labor intensive. The six portions or components that make up our present video system have been covered. It is by no means a cast in concrete system or sacred philosophy. We have created a working system that has been the product of much trial, suggestion and change. We will continue to modify both hardware and philosophy in an effort to better the performance and meet the requirements of our student project engineers and managers. This is the mode in which we wish to function and the intent of our charter. I am very much of the belief that we are only limited only by our imaginations. Don't be afraid to dream, visualize a new concept, let others know what you're thinking and together we will make things happen. I have been associated with Amateur Television (ATV) since the mid 60's and it is my belief that Scientific and Educational Ballooning has been the biggest boost to this facet of HAM Radio since its inception. "It's

Amateur Radio that you can see”.



4.3. Experimenter’s package / Shuttle interface

<<Mike Manes>> As of November 1992, the EOSS Shuttle has rather limited support for experiments. We are engaged in weight and power reductions and development of a more versatile command and telemetry interface with a goal of simple adaptability to a wide variety of potential experiments. The current plan is to provide for four 0.0 to +5.0 V 8-bit analog inputs reported via telemetry in Vdc, several TTL level digital inputs and outputs, and a 1200 baud bi-directional serial bus for more complex telemetry and commanding. This specification will be updated when that project is completed early 1993. Experimenters are warned not to use the following data as definitive. The EOSS Tech Committee should be consulted for the latest information prior to experiment construction.

4.3.1. Size

20 cm (8”) cube max

4.3.2. Weight

170 g (6 oz) max

4.3.3. Attachment

Flush to bottom of Shuttle, 4 points on 12.5 cm (5”) grid using tie wraps & dowels.

Foamcore board 5 mm or more thick with hot-melt, or RTV glued and reinforced joints has proven itself strong, light and thermally insulative. Additional thermal insulation in the form of building-grade Styrofoam sheet may be added if required. The package should be completely covered in aluminum foil for EMI protection. Elmer’s glue is effective for foil attachment. Foil seams at access covers should lap at least 2 cm.

A typical EOSS flight system profile may appear as follows:

4.3.4. Electrical connections

All electrical interface to the experiment will be via a 12-pin female Molex connector mounted on the rear vertical surface of the Shuttle located on vertical center and 10 cm (4”) above bottom surface. Mating connector is a Radio Shack RS 274-232 or equivalent. Pin-outs are <TBD> at this time.

4.3.4.1. Power

The Shuttle can supply up to 100 mA of +10 to +15 Vdc unregulated battery power for a 3-hour flight duration. This source is commandable on and off via ground command, and is interrupted by the Controller automatically under low battery and touchdown conditions. EOSS reserves the right to kill experiment power to preserve flight safety. This source is protected by a 125 mA slow-blow fuse. Experimenters should supply RC or LC filtering to avoid conducted EMI. This source can present up to 100 mV PP of 16 KHz noise from the ATV transmitter. Additional power requirements must be supplied as part of the Experiment Package.

4.3.4.2. Control

1. Telemetry

At present there are 4 spare 0 to 3.32v analog telemetry inputs available. Each is sampled at 30-sec intervals and reported as Lens Temperature. The only other available means of returning real-time information to the ground is via the television camera, which can be aimed 10 degrees past the nadir. Additional data logging must be provided by the Experiment.

2. Digital Commands

a. Three 200 mA max open-collector NPN (2N2222) outputs referenced to power ground are commandable on and off by ground command issued manually using a DTMF (telephone touchtone) keypad. These are called Functions A, B and C.
b. A resistively current-limited (250 mA) source of polarity-selectable battery power pulsed at 3 selectable msec pulse widths via DTMF keypad from the ground. This source was originally designed to drive a 6V R/C servo motor in angular steps in either direction. Function B is common to the drive for this source.

5. Typical Flights

5.1. Altitude

EOSS balloons can carry payloads to over 107,000 feet (approximately 20 miles) above sea level --literally to the edge of space.

5.2. Duration

<<Merle McCaslin>> Typical flight duration is about three hours but we have also had a derelict that flew for 18 hours. Typical ascent, at altitude and descent times are given in Table 2 as a function of the EOSS flight classifications.

Table 2. Approximate Flight Durations

Ascending	Class A,B,C,D	90 minutes
At altitude	Class A,B	0 minutes
At altitude	Class D	until flight termination
Descending	Class A,B,C,D	60 to 90 minutes

5.3. Distance traveled

Distance traveled varies with the winds aloft. We have flights that have gone as few as19 miles surface distance from liftoff to going over 200 miles into Nebraska. Typical distance is 50 miles.

5.4. Direction of travel

Direction of travel also varies with the winds aloft. We have traveled in all directions east of the Rocky Mountain chain.

5.5. Cost

<<Merle McCaslin>> EOSS owns or has some donated equipment it uses for many flights. There are also some expendables resulting in costs for each flight. The big expense items include helium, balloon, and batteries.

5.5.1. Recurring Costs

5.5.1.1. Balloons

The cost of flying balloons varies widely based on the mission. Listed here are examples of the cost EOSS has incurred to date for the recurring portion of the flights.

The 105G 1200 gram balloon EOSS normally flies is $68.00 from Kaysam and a minimum of a 100.00 order. The 2000 gram balloon flown on the University of Colo. flight was a $200.00 balloon.

EOSS has flown two zero pressure balloons manufactured by Raven. The cost of the first one a 19,000 cu. ft. balloon was $375.00 and the second one was a 54,000 cu. ft. which cost $572.00.

5.5.1.2. Helium

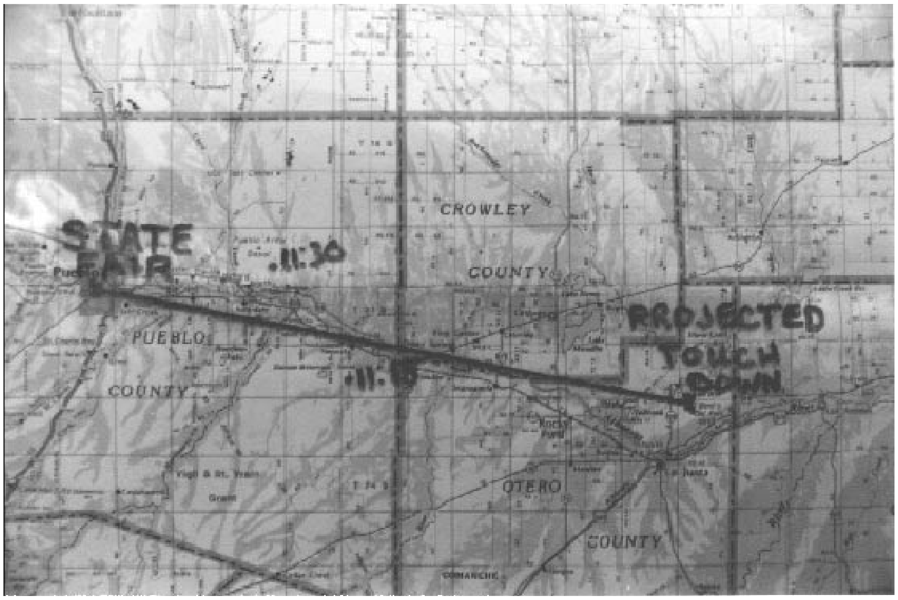
Cost of Helium ranges from $48.00 per bottle to $80.00 per bottle. A minimum of two bottles required for the 105G and four required for a second balloon in case of a failure. The larger Raven balloons required five to six bottles of helium for the weights we were flying.

Using these figures you can estimate a minimum of $150.00 to $200.00 for a simple flight for the recurring cost.

5.5.2. Non-recurring Costs

The non recurring costs would need to be estimated on an individual basis. They depend on the complexity of both the payload and the experiment to be flown.

6. Tracking and Recovery



6.1. Landing Point Estimation

6.1.1. Winds aloft

<<Tom Isenberg>> While the balloon is in flight and gaining altitude it goes through many different layers of wind. At different altitudes the wind direction and speed change, sometimes every 1000 feet. Knowing this, you can see that the flight path the balloon takes can be quite exciting.

In order to have an idea where the balloon and payload are going so the tracking team can minimize their effort recovering the Shuttle, EOSS obtains the winds aloft both the evening before launch and the morning of the launch. The process gives the students working on this phase of EOSS participation the chance to visit the National Weather Service and work on computers to input the information to be processed.

6.1.2. The National Weather Service

<<Michael Doherty>> The National Weather Service (NWS), in Denver Colorado, provides EOSS with its first hard data on launch conditions and winds data used to predict the flight of the balloon. Twice a day at 1100 and 2300 Zulu the NWS launches its sounding balloon. This sounding down-links information on barometric pressure, temperature, and humidity on approximately 1680Mhz. The altitude is computed using the barometric pressure, and the wind velocity is calculated by converting the altitude and change in angle of the receiving horn into a ground speed.

When the sounding balloon reaches 100k ft, a printout of WINDS data is graciously requested from the NWS personnel. This file is a text listing of altitude, wind speed, and wind direction for every minute of ascent. Critical points are selected from this file to be entered into the Paratrack program, the criterion used is to find those points where there is a significant change in wind direction and/or velocity (this is usually called an educated guess).

Paratrack is given this data file of select points, plus a predicted ascent and descent rate of the EOSS balloon, whereupon the program is run and a graphic of the predicted flight path, plus bearing and distance to touchdown are displayed.

If sounding data is not available, or the launch is some distance from Denver, doppler winds data is available from several sites in Colorado. This is the information given to the fox hunters and is the first indication of where the balloon is going.

While at the National Weather Service, it is convenient to get up-to-the-minute weather predictions. This general information is useful to the ground crew people in deciding the best launch time. Information on front passages, jet stream locations, and general outlook for the launch site (cloud cover, precipitation and ground winds) is easily available and typically quite accurate.

6.1.3. Paratrack Program

Paratrack is the name of the computer program that calculates the distance and direction, in compass degrees, where the Shuttle is expected to land. The accuracy of the distance and direction is usually within 10 to 15 miles of where we typically find the Shuttle. The information is plotted on the map and a location is sent by amateur radio to the field. The trackers use the information to disperse in select areas around the “bulls eye” zone. You can see that this process is very important to EOSS.

6.1.3.1. PTRAK5 Update

<<Rick von Glahn>> Bill Brown’s (WB8ELK) excellent balloon tracking program, PARA.BAS, has undergone a few modifications at my hands. These mods improve the user interface providing PARA.BAS with a menu driven interface with default options built into the program. This modified version of the program is called PTRAKx.EXE, where x represents the current version. Plans to launch balloons from remote locations made PTRAK4 less than ideal for predicting landing points. In order to remedy this problem I made a very simple change to the user interface and code. There is now an option on the main menu to start the program in Launch Point or Drop Point mode. The former is the standard PARA.BAS program. The latter will figure a landing point relative to the position of the balloon at cut down.

User Instructions

To use the program, enter the winds aloft at the expected landing area as usual. Start the program with the drop point option enabled. PTRAK5 will initialize with the balloon at maximum altitude, and compute the path of travel as it descends. The graphic functions of PTRAK will become a bit less meaningful in this mode. In the Launch Point mode all calculations are made relative to the take off point. In the drop mode calculations are made at the point where the payload is separated. If you use the graphic mode PTRAK will indicate a touchdown relative to the “home” position on the map. Naturally this isn’t going to be the location where payload separation occurs. However, I left the function active as it does give a graphic picture of the path the balloon travels as it makes its descent.

In order for this option to be useful you MUST know the location of the balloon when it begins its descent phase. This will be a problem in some cases, however, I hope that all really long range flights will incorporate either GPS or LORAN C telemetry indicating the payload’s exact location. If this data is not available, the program can still be useful if our tracking team has a good bearing on the balloon at cut down time.

Other minor modifications.

a) Configuration file: This file contains default data for the program including the default map, wind data file, ascent rate, descent rate and text editor. Previous versions of PARA.BAS and PTRAK required you to enter the wind data information via a somewhat rigid entry procedure. I’ve implemented a mod that calls a text editor for this data entry. It’s easier to enter the data as you can correct mistakes and it is now possible to edit a previously created data file.

b) User interface (a minor revision): Some external menu files were called into the program in previous versions. These “graphic” screens are now created within the program. This mod enables the program to be run in either color (default) or monochrome mode. To start PTRAK5 in monochrome enter “PTRAK5 /M” on the command line. Should you wish to analyze a different wind data file you may specify that file on the command line. Just enter the filename on the command line (PTRAK5 winds.dat). You can combine the /M and wind data file items on the command line.

c) Also, a rudimentary help screen is available by entering PTRAK5 /? or PTRAK5 /H on the command line.

6.2. Tracking

6.2.1. Tracking team

<<Greg Burnett>> The Tracking and Recovery Team consists of up to twenty mobile and fixed station hams with radio direction finding skills. Their equipment includes beam antennas that they aim at the beacon aboard the balloon. The Tracking and Recovery Team is the EOSS balloon “lost and found department.” During flight, the team takes bearings on the balloon’s radio beacon to track its progress. The team’s goal is to track the balloon so that it can be recovered. The educational value provided students participating with this team are exposure to practical direction finding techniques, antennas, map reading, compass use, taking bearings, triangulation concepts, and teamwork.

6.2.2. Triangulation Tracking Program

6.2.2.1. Apple Macintosh PowerBook Computer

<<Paul Ternlund>> The trackers use a standard map and grid system. They take bearings at fixed times and report them by radio for entry into an Apple Macintosh PowerBook Computer. A speedy and accurate balloon position estimate is the principal result. The PowerBook, running Augmented Triangulation Software written by WB3JZV, assists the tracking process in four areas: (1) triangulation, (2) position estimation, (3) plotting, and (4) station performance monitoring. This is implemented with custom macros for Microsoft Excel for the Macintosh.

- During *triangulation,* the PowerBook calculates a point for each unique pair of bearings by solving trigonometric equations.
- During *position estimation,* the PowerBook determines a best guess for the balloon's position from the scattering of the triangulated points. (Twenty bearings at one sample time can produce 190 points. In the real world these points do not superimpose. This is typically due to poor bearing accuracy that can be caused by signal multipath, improper location of beacon signal maximum, poor tracker positioning, etc.)
- During *plotting,* the PowerBook uses the excellent scatter charting capability of Excel to show the relative positions of all the trackers, the triangulated points, and the estimated balloon position for each sample time.
- During *station performance monitoring,* the PowerBook records each time a station's bearing is ignored because it diverges from another's, or it produces a triangulated point deemed too far from the main point cluster.

We generally request bearings be taken by members of the Tracking and Recovery Team on a mark given every 15 minutes during ascent, and then approximately every 5 minutes when the payload is descending and close to touch-down. It then takes about 2 minutes to collect and enter the data, and another 2 minutes to calculate the balloon's position estimate using a PowerBook 140.

6.2.2.2. Before the Mac

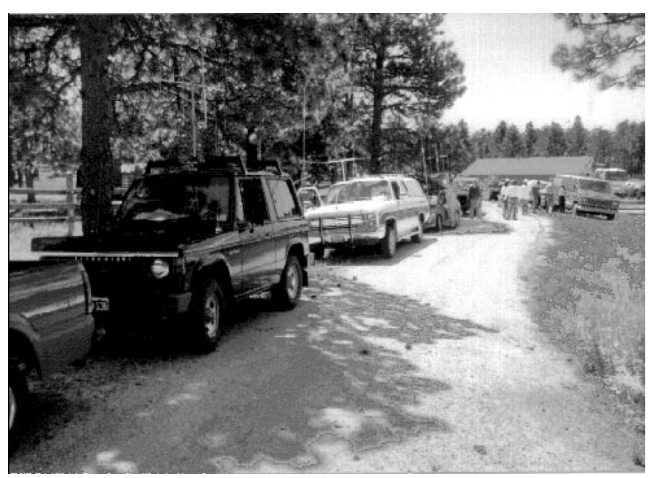
Before the Mac PowerBook was used, our Field Coordinator did balloon position estimations on-the-fly. While this worked amazingly well due to the Coordinator's skill, they were prone to error; therefore, risky. With the PowerBook, *all* available bearing data from cooperating stations gets recorded and used in triangulation calculations, and then a consistent algorithm is applied to determine the balloon's estimated position. Scatter plots are helpful because an operator can immediately see when trackers bunch together. (Best results occur when trackers surround a beacon.) Station performances are available throughout the hunt, and this can help indicate a problematic station.

6.2.2.3. The future with GPS

TBW(Bob 'ORE)

6.3. Recovery

Once Recovery Team members arrive at the Shuttle landing site, it is important to collect information on the spot which may be useful to increasing the reliability and recoverability of future flights. The first person to the landing scene is responsible for seeing that the following actions are executed as well as conditions permit until a member of the Technical Committee takes over:



6.3.1. Functional verification

The Recovery Team should be equipped with DTMF command, ATV and packet receive capability, and provided with a current command list and password. All commands should be exercised and response noted, and telemetry should be recorded while the Shuttle and experiment is in situ. In addition, the functionality of all tracking beacons should be verified. This data will be supplied to the Technical Committee for analysis and review during debrief.

6.3.2. Power shutdown

After functional verifications, power to the Shuttle, all beacons, and any experiment should turned off to conserve batteries for post-flight testing and to prevent unnecessary radio transmissions.

6.3.2.1. Shuttle power

- Shuttle battery power is controlled by a marked toggle switch on the ground power panel. This also controls Shuttle-supplied power to any experiment. Turn the switch to OFF.

6.3.2.2. Beacon power

- Beacon power is controlled by a pair of wires protruding from the flight package, twisted together and taped over. The tape should be removed, wires separated and one or both wire ends re-taped.

6.3.2.3. Balloon release power

- The balloon release device, located above the parachute apex, may be powered down similarly to the beacons.

6.3.2.4. Experiment power

- Experiments which carry their own power source(s) should be treated in accordance with the Experimenter's previous instructions. Lacking same, the experiment will be left as-is.

6.3.3. Record keeping

Ambient conditions at the landing site, including location, surface conditions, weather and winds should be noted, along with any other unusual observations. The physical condition of the Flight System should be inspected, noting obvious damage, evidence of parachute drag, orientation and condition of antennas, connector integrity, external harness damage, etc. One of the most effective means for recording these conditions is photography or videotaping; these media also provide extremely valuable source images for publications, PR, etc.

6.3.4. Flight system recovery

After all landing-related information and photos are complete, the flight system my be prepared for transport back to Denver. The overriding goal in this exercise is to minimize damage to the flight system components for an accurate post-flight analysis and to minimize refit effort for the next flight. Specifically:

6.3.4.1. Separating Components

Flight system components are typically assembled in a series string at the launch site using nylon cord. This cord is easily cut using sharp wire cutters. Do NOT cut indiscriminately, however!

- If the balloon nozzle remains with the flight system, cut its cord a few inches below the support ring, but above the release mechanism. On zero-pressure balloons, there is a second rip cord which may also be cut. If the release device has functioned, these cords will have been separated at the release devices. Pack up the balloon remnants for the return trip.
- Leave the release device and control module attached to the line connecting the top of the parachute to the balloon.
- Working from the Shuttle toward the parachute, disconnect the 9-pin Molex release harness connector from the shuttle. Cut the tape securing the release harness away from the Shuttle housing and support lines, taking care not to nick the harness or cut the support lines below the knot tying them to the parachute.
- Once the release harness is free above the Shuttle support line knot, cut the single nylon line between that knot and the lower parachute shroud line knot. The free release harness cable with the shuttle connector should be hanked using a wire tie, such as used on garbage bags. This completes detachment of the parachute from the Shuttle.

6.3.4.2. Parachute and shroud lines

The next steps are best done with three people:

- pull the parachute and shroud lines out straight, from the parachute apex past the spreader ring down to the Shuttle support line.
- Attempt to get all the lines straight and untangled as in flight, but resist the temptation to untangle the shroud lines above and below the spreader ring if they are mingled; this is best done back at home base. Balloon material, if present, may be cut away, taking care not to nick the shroud lines.
- Starting at the top, close the parachute down into a tube and tie it closed at about 2-foot intervals using wire ties or equivalent. Continue until the shroud lines are taut radially out to the spreader ring. Repeat this process for the lower shroud lines.
- After the parachute and release mechanism are tied up. Neatly fold the parachute at the wire ties. During transport, protect the parachute system from getting tangled or ensnared by other stuff.

6.3.4.3. Experiment package

Leave the Experiment attached to the Shuttle if the two are butted together. Otherwise, disconnect the Experiment harness from the Shuttle connector and cut the Experiment support line close to the Shuttle. Hank the line and harness using wire ties. Abide by any additional recovery instructions which may have been provided by the Experimenter.

6.3.4.4. Antennas

The Shuttle antennas should remain connected unless there is risk of transport damage. The 2m command/telemetry whip may be disconnected via the BNC atop the Shuttle. The ATV antenna may be separated at the BNC at the bottom of the ATV coax; supplementary mechanical support around this connector may be cut away.

6.3.4.5. Shuttle and beacons

- Place the Shuttle in an upright position for transport with 4" or more of clearance under it to prevent excessive bending of the ATV coax. Protect the ATV mirror from damage, and tape the Shuttle power switch OFF (Ground Power) if deemed appropriate.
- Separate the remaining beacons by cutting their support lines near the top; lines may be wrapped around the beacon packages. Protect antennas from damage during transport.

6.3.4.6. Before departing the landing site

- Make sure that ALL flight components are recovered, including all beacons, Experiment packages, and any protruding components which may have broken off during landing. If there is evidence of an extended parachute drag, walk along the drag mark searching for possible debris. Familiarity with the pre-flight configuration shown at CDR will definitely be helpful. If in doubt, contact the launch site.
- Collect any remaining pieces which may have broken away and pack them carefully for transport to prevent damage which may impair post-flight analysis.
- Police the area before leaving, collecting any remaining debris.

Appendix A - EOSS Flight History

<<Warren Williams & Merle McCaslin>>

E0SS-1 (WVN-1)

PLANNED LAUNCH DATE :	Nov. 18, 1990	
ACTUAL LAUNCH DATE :	Nov. 18, 1990	
LAUNCH SITE :	Robert F. Clement Park	
BALLOON:	Kaysam Meteorological Balloon #100G Weight: 1000 grams.	
PAYLOAD PACKAGING:	Type I	
PLANNED LAUNCH TIME:	9:30	
LAUNCH/TOUCHDOWN TIME:	9:30/12:05	
ACTUAL ALTITUDE/DISTANCE:	96,000 ft./132 miles	
ASCENT/DESCENT TIME:	Aprox. 1.5 hours./30 minutes	
ASCENT/DESCENT VELOCITY:		
LOWEST OUTSIDE TEMP:	-50 F	
LOWEST INSIDE TEMP:	+50 F	
PREDICTED TOUCHDOWN:	Hi-Plains Mini Market, Elbert, Co.	
ACTUAL TOUCHDOWN SITE:	Near Flagler, Co.	
EXPERIMENTS:	First time for all equipment.	
SPACECRAFT FREQ:	2 Mtr. Beacon	147.555
	ATV, camera pointed down	426.250
	10 meter CW beacon	28.800
	AIR data down link	403.500
GROUND NETWORK FREQ:	Tracking , Public Info	147.225
	Public info, long range:	7.232
PROJECT LEAD:	Jack Crabtree	
BALLOON LEAD:	Merle McCaslin	
LAUNCH SITE LEAD:	Jack Crabtree	
PR LEAD:	Tim Armagost	
TRACKING & RECOVERY:		
RADIO NET LEAD:	Elileen Armagost	

COMMENTS: This was the first flight under the Western Vision Network ATV club direction. Used A.I.R. altitude/temp module to down link on ATV audio subcarrier.

WEATHER CONDITIONS: Launched from Clement park, almost no wind.

RESULTS: ATV picture was fair quality. The 2 Mtr. beacon disappeared at touchdown. An airplane flown by Vince Lawrence, N0UA with Paul Ternlund, WB3JZV and Tim Armagost, WB0TUB aboard used the 10 Mtr. beacon to locate the package just before dark. They had a false tally-ho when they found an old parachute from the NOAA weather service . The Paper parachute was torn down the middle. This type of parachute is not strong enough for our weight of payload.

E0SS-2

PLANNED LAUNCH DATE :	Saturday, Mar 4, 1991 Canceled WX overcast & rain	
ACTUAL LAUNCH DATE :	Saturday, Mar 11, 1991	
LAUNCH SITE :	Robert F. Clement Park	
BALLOON:	Kaysam Meteorological Balloon #105G Weight: 1200 grams.	
PAYLOAD PACKAGING:	Type II	
PLANNED LAUNCH TIME:	9:00	
LAUNCH/TOUCHDOWN TIME:	9:03	
ACTUAL ALTITUDE/DISTANCE:	111,000/74 miles	
ASCENT/DESCENT TIME:	11:28 burst 2:25	
ASCENT/DESCENT VELOCITY:		
LOWEST OUTSIDE TEMP:		
LOWEST INSIDE TEMP:		
PREDICTED TOUCHDOWN:	Four miles NW of Lafayette, Co.	
ACTUAL TOUCHDOWN SITE:	Near Ted's Place, NW of FT. Collins	

EXPERIMENTS: Movable ATV camera via RC model control on 6 meters and a 35 mm camera mounted on payload box. 2 Mtr. digital recorded voice.

SPACECRAFT FREQ:	2 meter beacon	147.555
	ATV, camera pointed down	426.250
	10 meter CW beacon	28.800
	AIR data down link	403.500

	6 meter for RC servo	50.
GROUND NETWORK FREQ:	Tracking , Public Info	147.225
	Public info, long range:	7.232

PROJECT LEAD: Jack Crabtree
BALLOON LEAD: Merle McCaslin
LAUNCH SITE LEAD: Jack Crabtree
PR LEAD: Tim Armagost
TRACKING & RECOVERY: Greg Burnett
RADIO NET LEAD: Elileen Armagost

COMMENTS: Used 'AIR' altitude/temp module to down link on ATV audio subcarrier. Little wheel ATV ant above package.

WEATHER CONDITIONS: Moderate winds at launch site used plastic over balloon for control. Static charge when plastic was removed.

RESULTS: ATV picture ok, able to control camera right after launch first time we were able to look up at balloon and at horizon. Lost RC of ATV camera after a few thousand ft. No pictures from 35 mm camera. The explosion of the balloon tangled the parachute, and the package came down hard. Some of the parts of the flying balloon were recorded on ATV. The beacon stayed on and package was found in 45 minutes.

<u>E0SS-3</u>

PLANNED LAUNCH DATE : Sept. 28, 1991
ACTUAL LAUNCH DATE : Sept. 28, 1991
LAUNCH SITE : Denver Museum of Natural History.
BALLOON: Kaysam Meteorological Balloon #105G Weight: 1200 grams.
PAYLOAD PACKAGING: Type II
PLANNED LAUNCH TIME: 9:00
LAUNCH/TOUCHDOWN TIME: 9:37/11:47
ACTUAL ALTITUDE: 107,000/19 miles
ASCENT/DESCENT TIME: 92 mins. 41 secs/39 mins.
ASCENT/DESCENT VELOCITY: 1,108/2590 (ft/min)
LOWEST OUTSIDE TEMP:
LOWEST INSIDE TEMP:
PREDICTED TOUCHDOWN SITE: 109 degrees, 19.4 MILES
ACTUAL TOUCHDOWN SITE: 104 degrees, 20. 6 MILES (1.6 MILES FROM PREDICTED)

EXPERIMENTS: First flight of W6ORE flight micro processor, ATV camera controllable via commands to controller, 2 Mtr. CW beacon and packet. A balloon release with capability of command from the ground and a 35 mm camera.

SPACECRAFT FREQ:	2 Mtr. Command & packet	144.340
	ATV	426.250
	10 meter CW beacon	28.800

PARTICIPANTS: E0SS, CRA portable repeater and Explorer Post #2268, Astronomy Group for Performance plotting, trajectory calculations, and atmospheric studies.

GROUND NETWORK FREQ:	Tracking , Public Info	147.225
	Public info, long range:	7.232
	Remote Recovery team:	145.160

PROJECT LEAD: Jack Crabtree
BALLOON LEAD: Merle McCaslin
LAUNCH SITE LEAD: Marty Hill
PR LEAD: Tim Armagost
TRACKING & RECOVERY: Greg Burnett
RADIO NET LEAD: Nate Bushnell
EDUCATION LEAD: Tom Isenberg

COMMENTS: The balloon was seen thru telescope at burst at 107,000 ft. The package landed hard and was found in 15 minutes.

WEATHER CONDITIONS: No wind at launch, CAVU. Very stable high press.

RESULTS: Parachute top support released and dropped the parachute lines down on payload soon after launch. ATV camera failed to move during cold temperatures. ATV pictures poor, no contrast and weak. Commands to release balloon didn't work (servo was too cold). On impact, the controller program hung up sending a single tone on the 2 Mtr. beacon freq. (possible CPU address lines shorted on landing) The 35 mm camera fell off and was lost during flight.

E0SS-4 "Humble Telescope"

PLANNED LAUNCH DATE :	January 4, 1992	
ACTUAL LAUNCH DATE :	January 4, 1992	
LAUNCH SITE:	Eagle Crest High school, Aurora.	
BALLOON:	Raven Mfg. Zero Pressure, 19,000 cu. ft.	
PAYLOAD PACKAGING:	Type II	
PLANNED LAUNCH TIME:	8:50	
LAUNCH/TOUCHDOWN TIME:	08:58/unknown LOS at 10:54:04	
ACTUAL ALTITUDE:	92,000 ft.	
ASCENT/DESCENT TIME:	1:56 to release/unknown	
ASCENT/DESCENT VELOCITY:		
LOWEST OUTSIDE TEMP:	-59/-71 degrees F exp. lens	
LOWEST INSIDE TEMP:	+24 degrees F	
TOUCHDOWN SITE:	51 miles from launch site and 9 miles east of Hoyt	
	EXPERIMENTS: Solar Telescope to measure the Mg II region of the uv light spectrum. " Humble Telescope". A telescope with sun sensors and a 35 mm still camera to photograph sun spots. Still camera shutter enable and ' picture taken' feed back to the packet. Two new separation devices. 1. hot wire cord cutter by Jack AA0P 2. Pyro cutter by Mike W5VSI	
	PARTICIPANTS: The Scientific experiment was built by students from CU, CSU and Green Mountain High School. CRA portable repeater. Sponsors include Alan Kiplinger of Solar Max'91, Sigma Chi Fraternity, NASA and NOAA.	
SPACE CRAFT FREQ:	2 Mtr. Command & packet	144.340
	ATV	426.250
	10 meter CW beacon	28.321
GROUND NETWORK FREQ:	Tracking , Public Info:	147.225
	Public info, long range:	7.232
PROJECT LEAD:	Jack Crabtree	
BALLOON LEAD:	Merle McCaslin	
LAUNCH SITE LEAD:	Jack Crabtree	
PR LEAD:	Marty Griffin	
TRACKING & RECOVERY:	Greg Burnett	
EDUCATION LEAD:	Tom Isenberg,	

COMMENTS: First Zero Pressure Balloon with a rip panel flight termination system. Two command cut down systems and an independent cut down timer. New larger parachute for a heavier payload. Nine hours and 33 min. from launch to recovery. Recovery by WB4ETT, N0QCW & K0ELM at night using portable 10 meter RDF.

WEATHER CONDITIONS: Very windy and cold, wind caused launch problems.

RESULTS: At point of launch release, the payload hit the ground, slid several feet and hit a snowbank hard enough to bend the telescope frame and cause damage to the still camera. ATV Camera had limited control when halfway up but regained full control later. Video quality good, but 2 mtr beacon interfered with camera. At 92 thousand feet, the command was given to enable the still camera. The packet generated about 20 continuous messages indicating pictures being taken; then beacon and ATV went off. It was not known until sometime later that the balloon had been released about the same time that the signals disappeared. Batteries were dead on arrival. Solar camera mechanical damage caused high current drain. The pyro release device worked well.

E0SS-5

PLANNED LAUNCH DATE :	April 11, 1992
ACTUAL LAUNCH DATE :	April 11, 1192
LAUNCH SITE :	Robert F. Clement Park
BALLOON:	Kaysam Meteorological Balloon #105G Weight: 1200 grams PAYLOAD PACKAGING: Type II
PLANNED LAUNCH TIME:	09:00
LAUNCH/TOUCHDOWN TIME:	09:01/11:06
ACTUAL ALTITUDE:	106,000
ASCENT/DESCENT TIME:	1:22/unk.
ASCENT/DESCENT VELOCITY:	
LOWEST OUTSIDE TEMP:	-80 F @ 52,000 in descent

LOWEST INSIDE TEMP:	+13 F at 30,000 in descent	
TOUCHDOWN SITE:	92 statute miles from launch, 35 miles NNE of Limon, CO	

EXPERIMENTS: IASS stabilization experiment, VOR experiment Mike Manes, Tracking beacon by Neal Tenhuzen and a nichrome wire balloon release by Jack Crabtree

SPACE CRAFT FREQ:	2 Mtr Command & Packet	144.340
	ATV	426.250
	10 meter CW beacon	28.321
	2 mtr. beacon	147.555
GROUND NETWORK FREQ:	Tracking , Public Info	147.225
	Public info, long range:	7.232

PROJECT LEAD:	Jack Crabtree
BALLOON LEAD:	Merle McCaslin
LAUNCH SITE LEAD:	Jack Crabtree
PR LEAD:	Marty Griffin
TRACKING & RECOVERY:	Greg Burnett
EDUCATION LEAD:	Tom Isenberg

COMMENTS:

WEATHER CONDITIONS: Nice day very little wind. Balloon went straight up like a flag pole.

RESULTS: The stabilization experiment worked well at low altitude, it was able to stop the rotation of the payload and turn the package in the opposite direction. Later in the flight the ground station had intermittent contact with the payload . The Beacon batteries died at lift off and the antenna broke. Ground Control lost 2 Mtr. control at cut down time and Mike W5VSI was able to send the release command from the field at 10:22:55.

The Controller went into a premature touchdown mode at 19,000 ft 10:56 Greg Burnett ,K0ELM & Eric Brisnehan, navigator, witnessed the descent & landing from a quarter of a mile away, parachute looked good on descent. VOR experiment did not work; part of the problem was RFI from ATV.

<u>E0SS-6</u>

PLANNED LAUNCH DATE :	May 30, 1992
ACTUAL LAUNCH DATE :	
LAUNCH SITE :	Bob Weston Sand Hills Farm 12 miles east of Longmont, Co.
BALLOON:	Raven Mfg. Zero Pressure, 54,000 cu. ft.
PAYLOAD PACKAGING:	Type II
PLANNED LAUNCH TIME:	9:30
LAUNCH/TOUCHDOWN TIME:	09:45/03:45
ACTUAL ALTITUDE:	75,000 ft
ASCENT/DESCENT TIME:	?/18 hours
ASCENT/DESCENT VELOCITY:	
LOWEST OUTSIDE TEMP:	
LOWEST INSIDE TEMP:	

PREDICTED TOUCHDOWN:
EXPERIMENTS:

SPACE CRAFT FREQ:	2 Mtr. Command & Packet	144.340
	ATV	426.250
	10 meter CW beacon	28.800
	2 Mtr. beacon	147.555 / 147.765
GROUND NETWORK FREQ:	Tracking , Public Info	147.225
	Public info, long range:	7.232

PROJECT LEAD:	Jack Crabtree
BALLOON LEAD:	Merle McCaslin
LAUNCH SITE LEAD:	Jack Crabtree
PR LEAD:	Marty Griffin
TRACKING & RECOVERY:	Greg Burnett
EDUCATION LEAD:	Tom Isenberg

COMMENTS:
WEATHER CONDITIONS: Calm during filling then wind came up prior and during launch.

RESULTS: Problem during launch main cord cut by the painter line that was in the main eyebolt at the bottom of the balloon. This happened twice. The first time the balloon was lowered and retied, and the same thing happened on the 2nd attempt. It was released in this manner and flew the total flight on the rip panel cord. In this condition the cut down system had no effect and the package could not be released. This caused the zero pressure balloon to stay in flight until night-time when the cooling effect caused the balloon to lose altitude. The balloon landed some 18 hours after launch and was recovered by a very dedicated tracking team. It landed 38 miles NNW of North Platte, Nebr. Recovery time was 0515 hours.

E0SS-7 (RMRL DUAL BAND REPEATER)

PLANNED LAUNCH DATE:	July 8, 1992		
PLANNED LAUNCH SITE :	Robert F. Clement Park		
BALLOON:	Kaysam Meteorological Balloon #100G Weight: 1000 grams. PAYLOAD PACKAGING:		Type III
PLANNED LAUNCH TIME:	08:00		
LAUNCH/TOUCHDOWN TIME:	08:00/1036 LOS 09:40 burst 10:55 recovery		
ACTUAL ALTITUDE:	No instruments		
ASCENT/DESCENT TIME:	Aprox. 140 min./Aprox. 56 min.		
ASCENT/DESCENT VELOCITY:			
TOUCHDOWN:	5 miles east of I-25 @ El Paso County line		
EXPERIMENTS:	Rocky Mtn. Radio League cross band repeater which weighed 3.1 lbs. and a 10 meter beacon.		
SPACECRAFT FREQ:	Input	446.000	
	Output	147.555	
	10 Meter beacon	28.321	
GROUND NETWORK FREQ:	Public info, long range tracking:	7.232	
PROJECT LEAD:	Bob Ragain		
BALLOON LEAD:	Merle McCaslin		
LAUNCH SITE LEAD:	Jack Crabtree		
TRACKING & RECOVERY:	Greg Burnett		
COMMENTS:			
WEATHER CONDITIONS:	Winds Calm and CAVU		

RESULTS: Worked very well, Balloon tracked visually during ascent. Burst confirmed visually.

E0SS-8

PLANNED LAUNCH DATE :	Aug 29, 1992		
ACTUAL LAUNCH DATE:	Aug 29, 1992		
LAUNCH SITE :	Colo. State Fair, Pueblo, Co.		
BALLOON:	Kaysam Meteorological Balloon #105G Weight: 1200 grams.		
PAYLOAD PACKAGING:	Type II		
PLANNED LAUNCH TIME:	09:30		
LAUNCH/TOUCHDOWN TIME:	10:57/12:48		
ACTUAL ALTITUDE:	109,000 (per Table Mesa) @ 12:15		
ASCENT/DESCENT TIME:			
ASCENT/DESCENT VELOCITY:			
LOWEST OUTSIDE TEMP:			
LOWEST INSIDE TEMP:			
PREDICTED TOUCHDOWN SITE:	097 DEGREES AT 71 MILES		
ACTUAL TOUCHDOWN SITE:	092 DEGREES AT 63 MILES (north of Rocky Ford Qtr. mile East of. Rd 21/2		miles so. Rd. 5)
EXPERIMENTS:	IASS Stabilization experiment designed by the students to reduce the rotation		of the payload.
SPACECRAFT FREQ:	2 Mtr. Command & packet	144.340	
	ATV	426.250	
	10 meter CW beacon	28.321	
	2 Mtr. beacon	147.555	
GROUND NETWORK FREQ:	Tracking , Public Info	146.880	
		146.970	
	Public info, long range:	7.232	
PROJECT LEAD:	Suzanne Wahrle		

BALLOON LEAD: Merle McCaslin
PAYLOAD LEAD: Mike Ditto/Mike Manes
LAUNCH SITE LEAD: Jack Crabtree
PR LEAD:
TRACKING & RECOVERY: Greg Burnett
RADIO NET LEAD: Marty Hill

COMMENTS: Tracking and position plotting of ATV signal also via the 60 ft. dish on Table Mesa approx. 160 miles from touchdown.

WEATHER CONDITIONS: Windy during filling and launch.

RESULTS: Unable to command package on 2 Mtr's, no packet and unable to control stabilization vanes. Signal disappeared at touchdown. Package was turned on from an airplane. Package was found around 7:00 p.m.

<u>E0SS-9</u>
PLANNED LAUNCH DATE: Oct 30, 1992
ACTUAL LAUNCH DATE: Oct 30, 1992
LAUNCH SITE : Longs Peak Middle School, Longmont, Co.
BALLOON: Kaysam Meteorological Balloon #105G Weight: 1200 grams. PAYLOAD PACKAGING: Type IV
PLANNED LAUNCH TIME: 09:00
LAUNCH/TOUCHDOWN TIME: 09:28/10:53/Recovery 12:30
ACTUAL ALTITUDE: 92,000
ASCENT/DESCENT TIME: 55 min./39 min.
ASCENT/DESCENT VELOCITY:
LOWEST OUTSIDE TEMP:
LOWEST INSIDE TEMP:
PREDICTED TOUCHDOWN: 074 degrees/88 miles

EXPERIMENTS: New shuttle package of foam core construction with a fixed video camera with a controllable mirror.

SPACE CRAFT FREQ: 2 Mtr. Command & packet 144.340
ATV 426.250
Tracking beacon 147.555
Tracking beacon 147.585
GROUND NETWORK FREQ: Tracking , Public Info 147.225
Public info, long range: 7.232

PROJECT LEAD: Jack Crabtree
BALLOON LEAD: Merle McCaslin
LAUNCH SITE LEAD: Jack Crabtree
PR LEAD: Jack Crabtree
TRACKING & RECOVERY: Greg Burnett
EDUCATION LEAD: Tom Isenberg

COMMENTS: Student participation was good. The school teachers were very happy with the education aspects of the launch.

WEATHER CONDITIONS: Cloudy wet day rained all the way from Littleton to Longmont. The clouds cleared over Longmont prior to launch. There were moderate winds during filling & launch.

RESULTS: Release cable broke just prior to first attempt to launch. It required repairing and then it worked fine. New package and mirror for ATV all worked well. First Video of the Balloon being released from payload.

<u>EOSS-10</u>
PLANNED LAUNCH DATE: Feb. 6, 1993
ACTUAL LAUNCH DATE : Feb. 6, 1993
LAUNCH SITE : Pueblo, Co. Univ of Southern Colo.
BALLOON: Kaysam Meteorological Balloon #105G Weight: 1200 grams. PAYLOAD PACKAGING: Type IV
PLANNED LAUNCH TIME : 10:00
LAUNCH/TOUCHDOWN TIME: 10:00
ACTUAL ALTITUDE: 98,000 (est., data in error) @ 11:35 005 dgs.
ASCENT/DESCENT TIME:
ASCENT/DESCENT VELOCITY: 978/1430 (ft/min)
LOWEST OUTSIDE TEMP: -77 F
LOWEST INSIDE TEMP: -5 F

PREDICTED TOUCHDOWN:		
ACTUAL MILES /BEARING	004 dgs./15.7 miles	
EXPERIMENTS:	2nd Flight of the new shuttle package and first flight of Loran C.	
SPACE CRAFT FREQ:	2 M Command / Packet	144.340
	2 M CW Beacon	147.555
	ATV:	426.250
GROUND NETWORK FREQ:	Tracking, Public Info	147.970/146.88
	Public info, long range:	7.232
PROJECT LEAD:	Jack Crabtree	
BALLOON LEAD:	Merle McCaslin	
TECH COMMITTEE LEAD:	Mike Manes	
GROUND STATION LEAD:	Rick von Glahn	
TRACKING & RECOVERY:	Greg Burnett	

COMMENTS: This was a demonstration/educational flight for the University of Southern Colo.. A four hour class was held at the University on Friday the day prior to flight for interested parties. They hope to start a balloon group in Pueblo.

WEATHER CONDITIONS: Launch conditions were very windy. Some of the worst winds we had experienced since EOSS 4 (Humble 1). Upper winds were unusual with two weather fronts in the area.

RESULTS: Loran C worked well. It did lose lock during ascent but locked in after a reset command and stayed locked the rest of the flight. Loran was in manual with chain 9610 and secondaries of 1 & 4. The Altitude sensor did not work properly, a software problem which was corrected for the next flight. The flight was 16.04 miles and the launch team had visual tracking of the balloon a good percentage of the ascent.

EOSS-11

PLANNED LAUNCH DATE :	APR. 3, 1993	
ACTUAL LAUNCH DATE :	APR. 4, 1993	
LAUNCH SITE :	Robert F. Clement Park, Littleton. CO.	
BALLOON:	Kaysam Meteorological Balloon #105G Weight 1200 Grams. PAYLOAD PACKAGING: Type IV	
PANNED LAUNCH TIME	10:30	
LAUNCH/TOUCH DOWNTIME	11 A 10:51	
LAUNCH/TOUCH DOWNTIME	11 B 12:23	
ACTUAL ALTITUDE:	98,000	
ASCENT/DESCENT TIME:		
ASCENT/DESCENT VELOCITY:	1207/1453 (ft/min)	
LOWEST OUTSIDE TEMP	Sensor broken on first launch attempt.	
LOWEST INSIDE TEMP	-6 F	
PREDICTED TOUCHDOWN:	118 dgs./31 miles	
ACTUAL TOUCHDOWN:	115 dgs./53 miles. (last data @ 7,000 ft. @ 14:42)	
EXPERIMENTS:	3rd Flight of the new Shuttle and 2nd Loran C Flight. Loran C was put on automatic.	
SPACE CRAFT FREQ:	2 M Command & Packet	144.340
	2 M CW Beacon	147.555
	ATV:	426.250
GROUND NETWORK FREQ:	Tracking, Public Info	147.225
	Public info, long range:	7.232
PROJECT LEAD:	Jack Crabtree	
BALLOON LEAD:	Merle McCaslin	
TECH COMMITTEE LEAD:	Mike Manes	
GROUND STATION LEAD:	Rick von Glahn	
TRACKING & RECOVERY:	Greg Burnett	

COMMENTS: First Flight (11 A) Problem was not enough lift caused by old balloon (manufactured in 1981) filling nozzle broke and lost helium and high winds gave a false lift. It only traveled a few hundred feet across the road on to a golf course. The external temp sensor was damaged.

Second flight (11 B) used a new balloon (manufactured in 1992) with increased tare weight and had a normal high wind launch.

WEATHER CONDITIONS: Very windy and caused problems on 11 a launch, CAVU.

RESULTS: Loran C lost lock a good part of the flight. The Altitude sensor worked normally (still needs calibration at high altitudes.) The computer delivered a false touchdown signal at 17,000 ft. Bob Schellorn, W60RE made a software fix for the next flight.

<u>EOSS-12</u>

PLANNED LAUNCH DATE :	APR. 30, 1993 (launch canceled high winds)	
ACTUAL LAUNCH DATE :	MAY. 2, 1993	
LAUNCH SITE :	University of Colo. at Boulder	
BALLOON:	12 A 2000 Gram balloon supplied by A.I.R. 12 B Kaysam Meteorological Balloon #105G Weight: 1200 Grams.	
PAYLOAD PACKAGING:	Type IV	
PLANNED LAUNCH TIME	7:30	
LAUNCH/TOUCHDOWN TIME:	12 A: 7:46/7:59	
LAUNCH/TOUCHDOWN TIME	12 B: 11:46/?	
ACTUAL ALTITUDE:	97,000	
ASCENT/DESCENT TIME:		
ASCENT/DESCENT VELOCITY:	1314/1703 (ft/min)	
LOWEST OUTSIDE TEMP	-55 F	
LOWEST INSIDE TEMP	-3 F	
PREDICTED TOUCHDOWN:	135 dgs. 47 miles/Burst @ 12:58 110 dgs. 19 miles	
ACTUAL MILES /BEARING	111 dgs. 35.6 miles/@ 13:48	

EXPERIMENTS Fourth Flight of the new Shuttle and third for Loran C. Loran C was in manual mode 9610,1,4. First flight of GPS package built by CU Students. GPS package supplied by A.I.R.. Large orange parachute.

SPACE CRAFT FREQ:	2 M Command/Packet	144.340
	2 M CW Beacon	147.555
	ATV:	426.250
	CU GPS Package	432.??
	AIR GPS Package	403.50
GROUND NETWORK FREQ:	Tracking, Public Info	147.225
	Public info, long range:	7.232

PROJECT LEAD:	Jack Crabtree
BALLOON LEAD:	Merle McCaslin
TECH COMMITTEE LEAD:	Mike Manes
GROUND STATION LEAD:	Rick von Glahn
TRACKING & RECOVERY:	Greg Burnett

COMMENTS: First launch (12 A) went to about 14,000 ft. The cut down system received an inadvertent command (which is unverified). The parachute was released and the packages and parachute landed in some tall trees a half mile away from the launch site. The Boulder Fire Dept. rescued the four packages and the parachute for us. This flight had four different packages, Shuttle, Beacon, CU GPS and Air GPS. The balloon train was over 80 ft. long.

The second flight 12 B we did not fly a command type cut down system we let the balloon burst to terminate the ascent.

WEATHER CONDITIONS: 12 A Wind calm / 12 B slight breeze

RESULTS: All four packages worked fine and downlinked data to the ground stations. Loran C, (stayed in lock the complete flight) both GPS packages and the beacon. The landing site for 12 B was just a half mile east of the new Denver International Airport.

Appendix B - EOSS Flight VCR Tape Index

<<Merle McCaslin>>

TITLE	DATE	LENGTH	LAUNCH LOCATION	REMARKS
EOSS-1*	11-18-91	9 min	Clement Park Littleton, CO	First flight sponsored by Western Vision Network
EOSS-2*	3-11-91	9 min	Clement Park Littleton, CO	RC movable ATV Camera.
EOSS-3*	9-28-91	9 min	Denver Museum Denver, CO	First flight of the flight controller board.
EOSS-4*	1-4-92	14 min	Eagle Crest High School, Arapaho County, CO	First Raven Zero Pressure Balloon. Humble Telescope.
EOSS-5*	4-11-92	11 min	Clement Park Littleton, CO	IASS stabilization experiment.
E0SS-6	5-30-92		On a Farm near Longmont, CO	54,000 cu. ft. zero pressure. Humble II Telescope. Misc. video no formal tape.
EOSS-7	7-8-92		Clement Park Littleton, CO	RMRL Dual cross band repeater. Misc. video no formal tape.
EOSS-8	8-29-92		CO State Fair Pueblo, CO	Misc. video no formal tape.
EOSS-9	10-31-9	31 min	Longs Peak Middle school Longmont, CO	Video on education,the launch and flight from longmont. First video of cut down.
EOSS-1O	2-4-93	30 min	Univ. of S. Colorado, Pueblo, CO	Video of a windy launch at U.S.CO
EOSS-11	4-4-93	30 min	Clement Park Littleton, CO	Video on the launch and good pictures of the fox hunters. This is the Video AA0P took to the Dayton Hamfest.
EOSS-12	5-2-93	30 min	Univ. of Colo. Boulder, CO	Video on both launches and the Fire Dept. rescue.

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*EOSS-1 thru -5 on one tape

Appendix C - Changes to this Handbook

<<Rick von Glahn>>

Each section of the Handbook is authored by different persons. As noted above by the << xxx >> credit, persons responsible for each section are given credit.

Should you wish to contribute to any section, contact the author of that section. Many email addresses are available on the EOSS web site at: http://www.eoss.org/

Additions to the Handbook are welcome. Format them in plain text with blank lines between headings and paragraphs. Send these additions to me at my email address, rickvg@iex.net.