Edge of Space Sciences — Promoting Science and Education through Amateur Radio and High Altitude Balloons

Stratosphere

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Spring Edition

Presidents Corner

by Merle McCaslin

Election of officers for the EOSS organization were held at the February meeting. Jack Crabtree our president for the last three years and one of the founding fathers declined to run for office again, but he is still very active in EOSS. Jack has done an outstanding job as president as several members expressed at the meeting. We all owe a lot to him for giving us excellent leadership in getting a new organization "flying".

The results of the election were the following: Merle McCaslin President Mike Doherty Vice President Greg Dewitt Treasurer Ted Cline Secretary

I believe we have a good team of officers and with your support we can keep flying balloons and have fun doing it.

As Jack pointed out in the December Stratosphere it is hard to believe that three years plus have passed since he and Dave W6OAL got us started in this ballooning business. I have enjoyed the experience and have learned a lot from being involved in EOSS. I continue to be amazed at the outstanding talent the group has in so many different areas.

EOSS had one of our best flights on March 5th in conjunction with the Cherry Creek High School. They had a radiation experiment on board that was successful. A big thanks to Mike Manes for his effort on the experiment. The weather was just about perfect and all of the equipment worked. Channel 4 had three live broadcasts that morning as well as live coverage of the launch that was scheduled at 9:00. They asked us to delay five minutes so they could show it live. Under Tom Isenberg as education lead we participated in the Channel 4 Education EXPO for three days with a booth displaying our equipment and video of last Saturdays launch. A great job by Tom and everyone who helped.

What is the future for the Edge Of Space Sciences? The strides that have been made in the last three years prove we can do whatever we put our minds to. To restate one of our main goals has been to work with students to develop their interest in science.

The next flight is an ozone experiment with Ranum High School scheduled by the end of April. We may have a sponsor to fly a meteorological package along with our own payload. Dr. Ron Humble from Colorado University at Colorado Springs contacted me for a presentation and a discussion of a joint venture with their engineering students. Jack has two other groups that requested presentations. It looks like another busy year. I believe we will have several flights this year.

In the hardware area many of you know the next generation of our Shuttle is being developed now with a new and better controller (thanks to Bob W60RE). We have purchased a Magellan global position board (GPS) which Jack is in the process of testing with the new controller. This hardware will go into a new flight package and be ground and flight tested in the next several weeks . Also, a spin stabilization system using a gyro is in the process of development by Larry Cerney. These items are well along in development and will be completed in the next few months.

Here are a few other items for you to think about and comment on. 1. Color camera for the payload. 2. A portable ground station (travel trailer similar to the one we used at the Symposium loaned to us from the Loveland group). Anyone have a trailer to donate? It could be a tax deductible donation. 3. Automatic Packet Reporting System (APRS) is something I had not heard of until a few weeks ago. Bob W60RE already has it incorporated in both the original controller and the new controller board. (See related article on APRS). 4. How about offering a scholarship for the best EOSS student project? 5. Better two way communications with our members that do not live in the Denver area: Internet, packet more mailings, etc. Lets hear your ideas. I would like to challenge our out of state members to let us know what you are doing. Tell us about your activities and send articles for the newsletter.

Let's have a great year I'm looking forward to it.

JUST A LITTLE MORE GAS.

Contents

E SS Stratosphere

Newsletter of

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Nets

The weekly on the air net is held on the Colorado Repeater Association's 147.225/825 MHz Repeater each Tuesday evening at 8:00 PM.

Meetings

The monthly meeting of E.O.S.S is held at the Castlewood Library at the southwest corner of the intersection of Arapahoe ave. and Uinta st. This is just west of I-25 on Arapahoe ave. Talk-in is on the 146.640/040 MHz repeater.

Membership

Edge of Space Sciences Membership is open to all interested parties.
Student Membership is $2.00 per year.
Regular Membership is $10.00 per year.
To join, send a check to:

Edge of Space Sciences, Inc.
376 W. Caley Circle
Littleton, Colorado 80120

Submissions

Send articles for publication to the editor of *Stratosphere*:

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Internet:rickvg@cscns.com
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EOSS-15 High Road to Last Chance

Saturday, March 5th, Edge of Space Sciences, Inc. (EOSS) in cooperation with Thunder Ridge Middle School and Cherry Creek High School launched its 15th payload. The primary mission aboard the EOSS shuttle was the Cherry Creek Upper Atmpshpere Radiation Experiment. The standard suite of sensors was in full operation for this flight. Here is a very brief rundown on those systems.

- LORAN-C receiver providing latitude and longitude informaton for tracking the payload
- Temperature sensors inside and outside the package
- A pressure sensor used to indicate the altitude of the payload
- Live TV from the onboard black and white TV camera
- The controller, receivers and transmitters used to downlink data from the various experiments and sensors to the ground based control station and the payload recovery teams

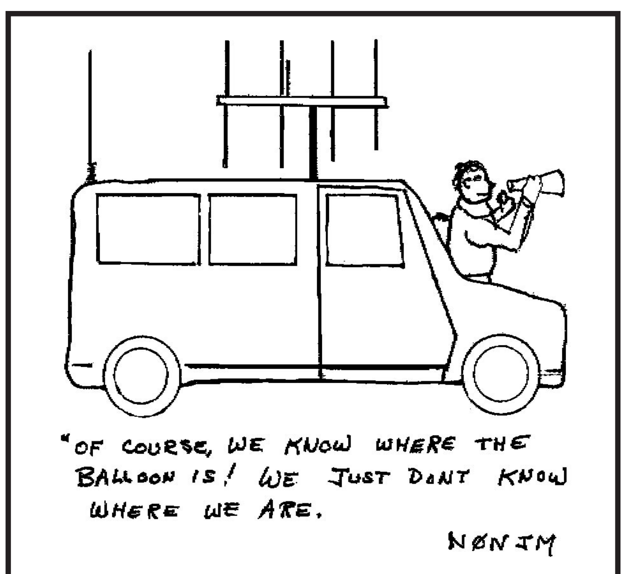
The flight, scheduled for a 9:00 A.M. liftoff was delayed several minutes to accomodate live television coverage from KCNC-TV, channel 4, in Denver. Minutes after liftoff teams in the field began receiving signals from the balloon and the ground station began recording the telemetry containing the data from the various payload systems.

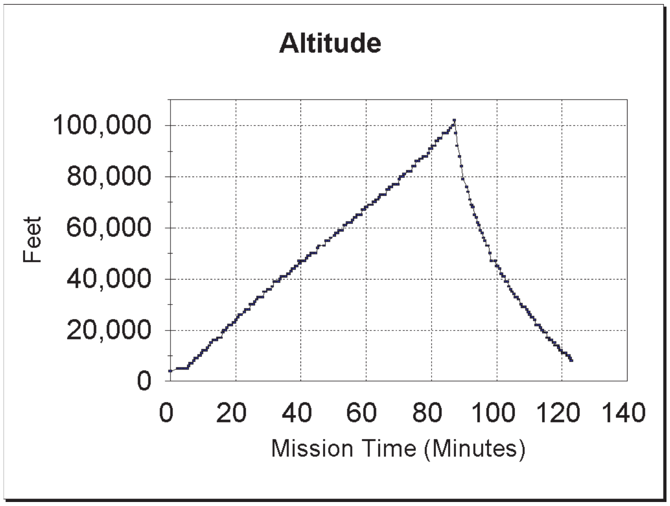
The balloon ascended at a rate of approximately 1000 feet per minute for 87 minutes. At 103,000 feet above sea level the balloon burst sending the payload plummeting towards the ground.

Tracking and recovery teams went into action to ensure we would be able to locate the payload once it had landed. In addition to the LORAN-C position information, the recovery teams track the payload using radio direction finding techniques. Multiple tracking methods ensure recovery should one system of location determination fail. In addition to the ground based groups an airborne search team was aloft to support the search effort providing two services. The aircraft was equipped with radio direction finding equipment to assist ground based tracking stations and the plane also carried a "repeater" to facilitate communications among the ground based teams. A repeater is a special type of radio station that receives and then retransmits radio signals. Because of its high altitude above the ground, this repeater enables mobile stations to communicate over long distances.

Looking west from several thousand feet - Centenial Airport (center), Parker Road (bottom)

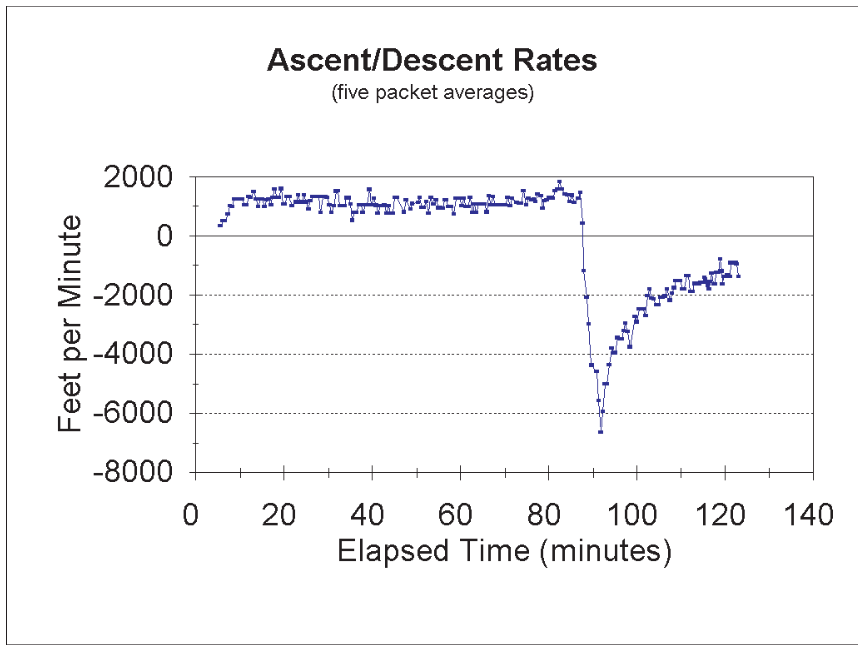
Soon after the touchdown recovery teams were on scene. On the next page I have included several pictures taken by the on board 35mm camera and a few graphs of the telemetry we received from the payload during the flight.

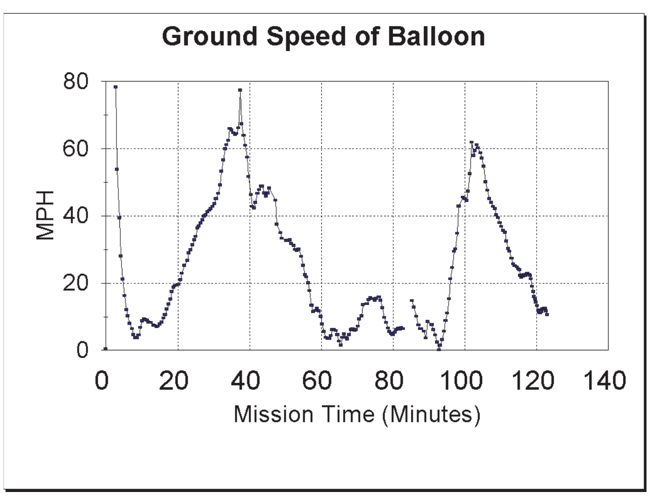




Maximum Altitude Shot - between 80 and 100 thousand feet.

Just before landing - Is that Highway 36 running from left to right just north of the payload??





The camera landed facing straight up, one of the team noticed the timer was indicating a picture was scheduled soon, so, all the members present gathered above the payload and gazed into the lens as this shot was automatically taken.

AUTOMATIC PACKET REPORTING SYSTEM (APRS) AND EOSS

by Brian C. Thomas N0VSA

Not to long ago I was bored and playing around on the Filebank BBS when I found a program called APRS 1.12, Automatic Packet Reporting System. It had an interesting title so I down loaded the program, unzipped the file and started checking it out.

It was interesting to see a screen come up with a basic map of the United States. Then I zoomed in on the Denver area. Well that was nice too but, what else could this program do. Since there was no one else in the Denver area on APRS at the time, it became a little boring to look at an empty map of the Denver area on the screen. I wanted to see something on that screen.

At this point I decided to read the instructions and see what I could do to liven up the display. I have never been one to read instructions first. I soon discovered that I could post things on the screen, little objects all over, but that still didn't have much meaning. I remembered that I had the telemetry file for EOSS 13. I took that file and started entering the different positions that Loran C had posted on that flight. Soon I had the flight of EOSS 13 on the screen. It was fascinating to watch as the program plotted the course of the flight on the Denver area map.

Let me back up a little and explain just what it is that APRS does. The APRS software receives a transmission from a packet station that is properly formatted with latitude and longitude information and plots that stations position on the screen. There are a lot of nice bells and whistles that can be placed on the screen also, but we'll get into that later.

You may ask, "How do I determine my latitude and longitude?" There are several ways to get that information. Many computer mapping programs now offer users the ability to determine latitude and longitude of specific points, and hard copy maps, you know, the things printed on paper, often offer this information too. However, for the technophiles among us, the most 'fun' and accurate way to determine our location is to use either a GPS or a Loran C receiver. Either of these devices may be interfaced with APRS and your TNC (Terminal Node Controller) to automatically transmit your location. APRS will take the latitude and format it, and send the formatted information to the TNC which in turn transmits it over the air. Anyone able to receive the signal who has the APRS program running will be decoded by the program and your location will appear on that stations map display screen.

Rick von Glahn (N0KKZ) knew there was a later version of APRS out there. Being the computer sleuth that he is, he went in search of the newest version. Sure enough a couple of hours later he had found version 4.0. I down loaded that from Rick. At 1200 baud a 759K file can take quite sometime to down load. I would like to thank Rick for going without his computer for so long and I hope that he has recovered from his withdrawal pains.

APRS found its way into a number of packet stations and soon there were several people in the Denver area running the program. It was great to see the several stations pop up on the screen. Then several people started putting different locations around the Denver Metro area, like the launch site of EOSS 15, Stapleton Airport, and DIA (Denver International Airport).

You may have read here in the Stratosphere, heard on the local weekly on the air net, or heard at the monthly meetings that we now have both a second generation controller and a GPS receiver about ready to fly. Bob Schellhorn (W6ORE), developer of both the first and the second generation controller for EOSS, has incorporated the APRS format in both controllers. Thanks go to Bob for doing that.

The new controller should be ready to fly on the launch of EOSS-17. The plan is to fly both Shuttle 1 in its present configuration and to fly controller II as a separate unit. This will allow us to do some actual flight testing of the new controller before she goes on her first solo voyage. The plan is to have the APRS program running at the ground station where we should be able to see the progress of the flight in real time.

EOSS envisions the use of APRS as a fantastic plus to stations monitoring the flight. Any station running the software and capable of receiving the payload transmissions will be able to monitor the progress of the flight. So, if you live anywhere in Colorado, or parts of Wyoming, Nebraska, Kansas, Oklahoma, Texas, New Mexico, Arizona or Utah, you will be able to plot the position of the payload. The more distant stations will only be receiving the VHF beacons when the payload reaches maximum altitude but, it should be fun to see the balloon pop up on your display screens. If you are interested in using APRS for this purpose, I'd recommend you obtain a copy of the program prior to the flight and pass it around to your local packet friends. Test it out prior to the flight so you'll be ready when we fly. One word of advice, set your TNC so it will NOT transmit. In a KPC-3 the command "XMITOK OFF" does the trick. Why disable the transmit capabilities of your station? Two reasons. One, APRS works completely in the UNPROTO mode. No packets are addressed, they are transmitted as "UNPROTO" packets. If you transmit a beacon, or other packet you may miss the location packet. Two, you may interfere with stations close to you while they are trying to capture these location packets. Be aware that APRS sends out lots of packets when it is first turned on . Several stations can swamp the spectrum for several minutes if they all start up simultaneously. Experimentation with APRS prior to the flight will make all this clear to the users of the system and fewer problems will result on flight day.

The APRS program adds another tool in the fox hunters arsenal for direction finding (DF) on an object. If you have portable packet capabilities, you can have a real time update of the payloads location as soon as you have AOS (Acquisition of Signal). Another capability of APRS offers the DF coordinator in the field the opportunity to get real-time updates of current locations of all his fox hunting resources in the field thus being able to better distribute them around the landing area.

You don't need to have GPS or Loran C on board to participate. There are several ways to tell APRS your current location. Naturally, using GPS or Loran C will be the easiest, most automatic and probably most accurate, however, APRS allows you to manually enter your position via two methods. The easiest way is to bring up the APRS map, move the cursor to your estimated position and hit the insert key on your computer. This tells APRS to use that location as your current position. Because of the relatively low resolution maps in APRS, this will be somewhat inaccurate, however, for the purposes of informing the DF coordinator of the approximate locations of widely separated DF teams, it should be adequate.

A second and more accurate way to enter your position would be to have a map with you on which you can accurately determine your position in latitude and longitude. Once you have that information you should enter the data on the map screen of APRS. On this screen, the current position of the cursor is displayed in latitude and longitude in the upper left corner. Simply move the cursor until the displayed latitude/longitude matches the position you've determined from your maps and you've got an accurate fix. Pressing the insert key on the keyboard will set this position for your station. This position may only be used in a tactical sense, giving the coordinator a quick visual cue as to the disposition of his forces. For actual direction finding you will still have to use the grid coordinate system currently in use in the fox hunter's group.

Because of the likelihood of interference with reception of packet telemetry from the payload, Mike Manes (W5VSI) has suggested that the DF teams set their radios with a standard repeater offset of +600 KHz. Using this arrangement, the DF coordinator would be able to monitor the progress of the payload and the fox hunters separately by simply hitting the reverse switch on his radio. This method of communications would ensure maximum reliability of beacon reception for all stations while allowing the tracking of the DF teams too. We are looking into the band plans now to see if this plan is feasible. Stations not directly involved with the hunt should keep their radios in simplex mode and disable the transmit capabilities of their TNC to avoid interfering with other stations close by. I haven't experimented with the DF options of the APRS program as of this writing. Once I have that may possibly be a source for another article. APRS does include triangulation routines however, these depend strongly on accurate position fixes for the DF stations. Our current DF procedures will probably be used for a long time until most of the fox hunters have automatic position determining equipment.

Where can I get the latest version of APRS? APRS is posted in the form: APRSxxx.ZIP where the "xxx" is replaced with the version number of that file. From the APRS documentation by Bob Bruninga WB4APR (author):

THE LATEST APRS is posted on 410-280-2503 BBS. After version 3.11 Bob will also always post a file similar to: 400.zip which will contain only the files that changed in the latest release. Bob can be reached at his packet radio address: WB4APR @ WB3V.MD.USA.NA

By monitoring a full service Packet Radio BBS and searching for messages to APRS you can follow any bulletin traffic concerning APRS. Bob (WB4APR) frequently posts bulletins on the latest developments of his software along with the current version number. Where can I get a 'relatively' recent version of APRS? The best place in the Denver Metro area, is on the Filebank BBS, 534-4646. After entering the BBS go to the SIG area and select the EOSS SIG. From there go to the Download file area and get APRSxxx.ZIP. In order to access this area you need to have either a full membership to the Filebank or be on the EOSS membership roster. The program can also be found on the internet at: world.std.com :: pub/hamradio

Once you get it to your machine you need to use a special PKUNZIP option to get the program to unpack and operate properly. For full information on this you could enter: PKUNZIP APRSxxx README.1ST This readme file will instruct you on the proper procedures for unpacking the files. However if you're in a hurry, make an APRS subdirectory somewhere on your hard drive and move the APRSxxx file to it. Then move to that subdirectory and enter: PKUNZIP -d APRSxxx The "-d" command line switch instructs PKUNZIP to create certain subdirectories automatically and place some of the files into those subdirectories. APRS requires this directory structure to properly find it's map, documentation, history and backup files. Without it, the program will not run properly.

Once you have the program running set your radio on 145.070 (in the Denver area) and monitor the frequency for about one half hour. You should see my station on your map screen. I have set my beacon

Attention:

New with this issue, your membership expiration date is included on the mailing label just to the right of your name. Please take note of this and consider sending in your renewal dues. EOSS needs your support to continue its aggressive programs.

Thankyou

to transmit approximately every half hour. If my position does not appear you might look for my PBBS N0VSA-1. I should have a message up on my BBS if I am running APRS or not.

I have formatted the flight of EOSS 15 into the APRS format and it is posted on the Filebank BBS. You can add this to your .HST files that came with the program and replay the flight on your screen. I may do this for some of the other flights that I have telemetry data for.

Currently I have a message into Ed (W0LJF), the packet frequency coordinator, to see if we can find a frequency we can use for APRS without causing disruption of normal packet activity. Ed is busy with other matters right now, but he assured me that he would look into APRS operations and get back to us soon. It would be terrific to see all stations place their latitude and longitude information in the APRS format in their BTEXT.

In closing, I believe that APRS can be a valuable tool for EOSS. APRS adds a new way to look at the flight from the ground station and it may be a useful tool for locating the Shuttle. APRS is mainly a special events type program. What better special event to try it out on than an EOSS launch! It could also be very valuable as a emergency communications and special events tool. If done right, APRS can add a new dimension, literally, to the operations of a special event packet net.

WRITING WITH THE METRIC SYSTEM

by Glenn Cascino, WN0EHE

In Volume 3, Issue 3 of the EOSS Stratosphere, Jack, AA0P, asked if EOSS should go metric. It seems ironic that the United States of America is one of the few industrialized nations in the world that is still using the English system of measurement, considering that even the English have converted to metric! There is no doubt that in theory the metric system is the only way to go, but using the metric system in actual practice is another matter. How many of us know our weight in kilograms or our height in centimeters?

Many of us already use the metric system extensively when we deal with the physical sciences. We use Watts, volts, amperes, farads, joules, coulombs and even degrees Kelvin without thinking much about it. However, when it comes to writing with these terms, some of us have problems. Is a decibel written "db" or "Db" or "DB" or "dB"? How about gigahertz? Is it "ghz" or "Ghz" or "GHZ" or "GHz"?

Table 1 shows some of the base mks (meter, kilogram, second) metric system units and their symbols. These symbols should not be capitalized or italicized, except those symbols derived from proper names which should always be capitalized, such as "B" for bel, named after Alexander Graham Bell, or "Hz", named after Heinrich Rudolph Hertz. Do not add the letter "s" to the metric symbols to make them plural or follow them with a period.

QUANTITY	NAME	METRIC SYMBOL
length	meter	m
mass	kilogram	kg
capacity	liter	L
time	seconds	s
current	ampere	A
temperature	kelvin	K
capacitance	farad	F
electric potential	volt	V
electric resistance	ohm	Ω
energy	joule	J
force	newton	N
frequency	hertz	Hz
inductance	henry	H
magnetic flux	weber	Wb
magnetic flux density	tesla	T
power	watt	W
power ratio	bel	B

TABLE 1: SOME METRIC SYSTEM UNITS AND THEIR SYMBOLS

Table 2 shows the metric prefix, symbol, and multiplying factors that are used to form names and symbols of multiples and submultiples in the mks metric system. Note that prefixes with exponents of six and greater are capitalized and the rest are written in lower case. If you mean to say milliwatts write "mW" not "MW". Now you know that decibel is written "dB" and gigahertz is written "GHz".

PREFIX	SYMBOL	MULTIPLYING FACTOR (10 raised to this power)
exa	E	18
peta	P	15
tera	T	12
giga	G	9
mega	M	6
kilo	k	3
hecto	h	2
deca	da	1
deci	d	-1
centi	c	-2
milli	m	-3
micro	µ	-6
nano	n	-9
pico	p	-12
femto	f	-15
atto	a	-18

TABLE 2: METRIC SYSTEM PREFIXES AND THEIR SYMBOLS

The most precise version of the metric system is known as the International System of Units or SI (from the Systeme international d' unites) which is accepted internationally and uses symbols that are not ambiguous and is therefore the preferred system of measurement for science and engineering. Happy metric writing.

Radio Direction Finding From an Airplane

by Warren Gretz, N0FVG

Ed Boyer and I have been helping locate the EOSS payloads from an airplane using radio direction finding for the last several flights.

To be able to Direction Find (DF) from an airplane using amateur radio equipment there are two options one is to have good sturdy outside antennas, or use a small easily moveable antenna on the inside. Since we don't own the airplane, I selected a small DF loop to use on the inside of the airplane. This antenna was given to me by Bob Ragain WB4ETT a fellow direction finder. He had experimented with it for a different application but, it was stored in his junk box.

This antenna must be pre-tuned to the frequency we are hunting to be effective. This has not been a problem since we know what the beacon frequency is going to be before the day of the launch. I also use a radio frequency attenuator to keep the signal at proper level for direction finding. This antenna does not give a real deep null, but one that is useable.

The morning of the balloon launch, Ed and I arrive at the airplane early enough to mount all of our radio gear in and on the airplane. This equipment consist of a repeater on 70 centimeters used for communication with the ground direction finding team. We have a packet station which includes a lap top computer. We also have 2 meter and 70 centimeter radios and a battery to power all of this equipment. All of these radios require antennas which we mount external to the airplane.

We plan to be in the air shortly before the balloon reaches maximum altitude. Once the equipment is in place we check the position of the balloon from information the ground direction finding team provides and make a decision when to take off in the aircraft.

Once in the air, I immediately begin to DF and give Ed direction as to the heading to fly. We can generally fly direct to the position of the beacon. As we get closer to the beacon, the attenuator is adjusted to decrease the signal level. The amount of attenuation gives me a good indication as to how close we are to the beacon. If we arrive into the area early, we continue to circle around the beacon signal until it reaches our altitude. On the last two balloon flights we have been successful in locating the payload prior to touchdown and following it until touchdown. On EOSS-15 we got a short video of the payload in the air.

We find that it takes three people to make this operation successful. One person flies the airplane and operates the radio. The second person does the direction finding. The third person barks out the position and altitude of the payload from the incoming packet information from our on-board packet station. Since all three of us are pilots we can share somewhat in these duties. We enjoy airborne direction finding but it is also takes a lot of hard work.

EOSS-15/Cherry Creek High School Experiment

Mike Manes, W5VSI

At the 12/14/93 EOSS meeting, Pat Ryan and his physics class from Cherry Creek High School submitted a proposal to fly a Geiger counter experiment aboard an EOSS balloon. The school would supply the instrument and signal conditioning per EOSS spec for a real-time telemetry down-link. The scientific goal was to record the beta radiation profile from the surface to the edge of space, and the group hoped to present their results at the Channel 4 Education Expo in early March. The Cherry Creek proposal was accepted on the spot, subject to the normal weight, power and temperature tolerance restrictions. Chalk another one up for Tom Isenberg and the Education Committee! Experiment hardware development was to be a collaborate effort between EOSS and Cherry Creek High School.

Paul Ternlund took the lead as the prime EOSS contact to work with the school in preparing the experiment for flight; yours truly volunteered to help out with the shuttle interface as required. Paul and I agreed that the simplest form of interface between the existing shuttle and the experiment would be an analog voltage signal connected in place of the existing Auxiliary Temperature channel normally used to monitor the ATV mirror servo temperature. This channel was originally installed to help us control power to the servo heater added to keep the servo from slowing down mid-flight. We have learned to make that judgment simply by observing servo response, however, so the temperature telemetry was no longer critical to the flight. Paul set up meeting with Pat Ryan and his students at the high school on January 6th. Pat demonstrated their Chaney Electronics kit-built GM-1 Geiger counter. We looked over the schematics and suggested a workable signal conditioner, outlined a development and test plan and flight schedule to mesh with the Expo. Pat and his students prepared a Preliminary Design Review that was presented and accepted at the 1/11/94 EOSS meeting. Included was a time line of tasks necessary to meet a 2/26 launch; this would allow for a one week launch delay and still make time to prepare results for the Expo on March 11. It turns out that Cherry Creek owns two of the Chaney instruments and they agreed to let EOSS experiment with one in parallel.

The program really took off when Pat and Eduardo, a Spanish exchange student, joined us at the 1/29 Tech Committee meeting. We decided that the experiment could mount on the side of the shuttle, thus protecting the wiring harness. The Shuttle could supply their modest DC power requirements via a fuse from the ATV switched power bus. A vacuum test was scheduled to determine whether arcing or corona might develop around the 600 volt GM tube. The EMI from such discharges could interfere with the shuttle command receiver and jeopardize mission safety. After the meeting, we bench-tested both instruments, and worked out more details on the power and signal conditioning electronics. One of the instruments proved to have a very inaccurate GM tube unsuitable for the experiment, but which would still serve as a signal source to help EOSS test the interface. Pat and his students made numerous contacts with the National Center for Atmospheric Research (NCAR) in Boulder and other agencies in an attempt to learn the approximate range of radiation to expect during the flight. This data was essential to tuning the signal conditioner gain so that the highest peak measurement would still read “on scale” on the telemetry channel. Surprisingly, none of the sources knew the answer. Could it be that the data collected on EOSS-15 just might be a valuable addition to geophysical science? The prospect of publishing in a scientific journal generated a lot of excitement!

In the meantime, Paul made contact with a fellow ham, Larry N0TAO, who had extensive experience in radiation measurement and GM counters. Larry indicated that he recalled some NASA experiments from the 1950’s that indicated that we should expect the peak radiation to be about three times that on the surface. Lacking further, we agreed to design the system to peak out at 250 CPM (counts per minute), which is five times the 50 CPM we have read on the ground. Just in case this guess turned out wrong, we decided to add the GM counter “click” signal to the ATV sound channel. This could provide usable data even if the telemetry channel failed or topped out.

During the next couple of weeks, Cherry Creek students Chris Ciarillo and Mike Lukas designed and etched a PC board for the signal conditioner and stuffed it with parts. Jenny Halcomb and Greg Korbel ran the vacuum tests and discovered some arcing between a pair of closely-spaced traces; this was corrected with a liberal coat of corona dope. Calibration of output voltage vs. radiation was performed by Brian Abrams, Brian Temple and Erik Arentzen. In the meantime, EOSS bread-boarded the circuitry and tested it live on the shuttle. A final design was presented at the 2/8 EOSS meeting, and plans were firmed up for a 2/26 launch from Thunder Ridge Middle School. On 2/19, Pat and another student, Brian Abrams, joined Paul and me to integrate their hardware into the shuttle hardware. While Pat and I debugged and tested the signal conditioner and built up the power conditioner, Paul and Brian designed and built a Styrofoam-insulated foamcore enclosure for the electronics. The complete experiment package added only 155 grams to the Shuttle weight, keeping the total under the 6 pound FAA limit for commandable cut-down. The system came together nicely and operated to nominal spec on the bench. Calibration was rechecked using thorium-containing camping lantern mantles as a gamma radiation source. Counts per minute were measured using a lab event counter. With the flight scheduled but a week away, we all breathed a sigh of relief.

Murphy Strikes Again!

Merle McCaslin and I ran a system cold soak test on 2/21 down to an ambient temperature of 30 F. Thermocouples were installed in various spots, including the interior of the GM module. The shuttle was powered up using the flight batteries still in place from the previous flight. Live packet telemetry and ATV audio was monitored on the air. Twelve bucks worth of dry ice were loaded into the chamber along with the shuttle and the circulating fan cranked up. We had determined that the experiment would be ready to fly if it still operated properly when the shuttle core temperature hit the zero degrees Fahrenheit which we have seen on a few earlier winter flights. Everything seemed to operate correctly as the chamber temperature plunged, and we chatted about how great it was going to be to fly again that coming Saturday. The subject matter, and our mood, altered abruptly, though, when the experiment temperature dropped below 30 F about 45 minutes into the test. The telemetry signal began to decline and the audio started to change character. When we hit 16 F, telemetry read zero and the audio clicks had turned into occasional dull thumps. A few quick checks with a meter confirmed that the GM-1 output had all but ceased. Recognizing that our 2/26 launch was now in serious jeopardy, we made a desperate change to boost the signal conditioner gain by a factor of five and dunked the system back in the chamber. Within an hour, our faces became rather grim when we observed the same failure as before. Although it was tempting to challenge the problem and fix it in time to make schedule, it wouldn't be fair to the rest of the team to leave them hanging and try to pass the word at the last minute if Murphy decided to hang around. A week's postponement was in order and was announced on the next evening's weekly EOSS net.

The Mad Rush

After the experiment was returned to the bench, each of the suspect temperature-sensitive components was chilled one at a time with cold spray. The GM tube was spared this trauma, however, for fear of thermal shock damage; no spare was available. The trouble was isolated to the power inverter. This circuit converts 9 volt dc power to about 120 V ac at 50 KHz; a voltage multiplier then rectifies the ac and boosts to about 550 V dc to bias the GM tube. Chilling the inverter transformer and transistor resulted in a significant drop in the measured GM voltage and radiation response. The inverter topology was a very simple blocking oscillator that relied upon the gain of the transistor and the saturation properties of the transformer's ferrite core material. Both are known to vary a lot with temperature, so it was concluded that the Chaney kit was designed for a more balmy environment, and nothing less than a redesign could change that. Fortunately I had some parts from a current-fed sine-wave push-pull power inverter that didn't depend on temperature-dependent parameters. After its transformer was rewound to provide 120 V ac, the circuit came right up and provided the original 550V dc to the GM tube. It passed the cold spray test without a hitch, so it installed into the Chaney board in place of the original inverter. The next Saturday, Merle and I re-ran the cold soak test. To our dismay, the symptoms recurred, this time down around 20 F. Still no good! Some quick checks confirmed that all the circuitry surrounding the GM tube was operating properly. Note that we had still left Murphy a graceful exit: the GM tube itself could be the warm-blooded culprit. The tube was marked "LND 7127". A call to Victoreen, whom I suspected made GM tubes, resulted in an informative chat with their engineer Kathy Sfiligoj. She was very interested in our project, and even put me in touch with LND, her competitor. A call to Bob Lehnert at LND, Inc. revealed that chilling would reduce the fill gas pressure which determines operating voltage. He also noted that 550 V may be a bit hot for that tube. Both Kathy and Bob confirmed that excessive voltage could result in quench failure and may permanently damage the tube's sensitivity. This particular model tube was an out-of-spec version of an instrument-grade tube. It was supplied at low cost for experimentation, and its performance couldn't be guaranteed. He was also enthusiastic about our work and offered to donate a pair of Type 712 instrument-grade tubes for any future flights. The cold-soak data and input from the experts pretty well fingered the GM tube as the sensitive culprit. The only solution remaining was to keep the tube warm. A Minco flexible strip heater drawing about 80 mA from the supply was fashioned to fit around the GM tube and was surrounded by a foamcore insulating housing. The shuttle interior temperature telemetry sensor was fitted next to the heater. Heater power set up to be switched via an unused command function. The plan was to hold the GM tube temperature between 30 and 80 F. Taking a further clue from Kathy and Bob, another command function line was set up to drop the GM tube voltage by about 10% to halt any in-flight quench failure; it would also significantly reduce the tube's sensitivity, but that wasn't its intended purpose at the time. Having blown enough bucks on dry ice already, and with not a clue as to what further action might help the situation, we decided not to run a third cold soak and hope that this last set of measures would be enough to make the experiment at least partially successful. Bench testing with the shuttle at room temperature showed that the heater could raise the tube temperature by at least 40 F. We hoped that this would be enough to get the tube out of harm's way for most of the flight.

Another successful flight

The payload, launch and ground station crew began to assemble in the parking lot at Thunder Ridge Middle School in southeast Aurora, CO around 0700 in a bright, calm morning on March 5. The weather forecast was excellent and Paratrak had predicted a near-easterly flight of about 50 miles. Rick N0KKZ guided Brian N0VSA masterfully through his first ground station setup, while Jack AA0P prepared the shuttle for flight and Merle K0YUK prepared the launch string and balloon for inflation. Around 0800, Pat Ryan and his Cherry Creek physics class arrived right behind Tom N0KSR with his middle-school plotting crew. By 0830, the Cherry Creek team had been briefed on ground station operations and had completed the pre-flight checkout of the experiment. Andy N0SIS had confirmed FAA launch clearance for 0900 with Denver Center and Denver Tracon. As Merle and his crew began inflation, the Channel 4 News van arrived and announced that they would like to cover

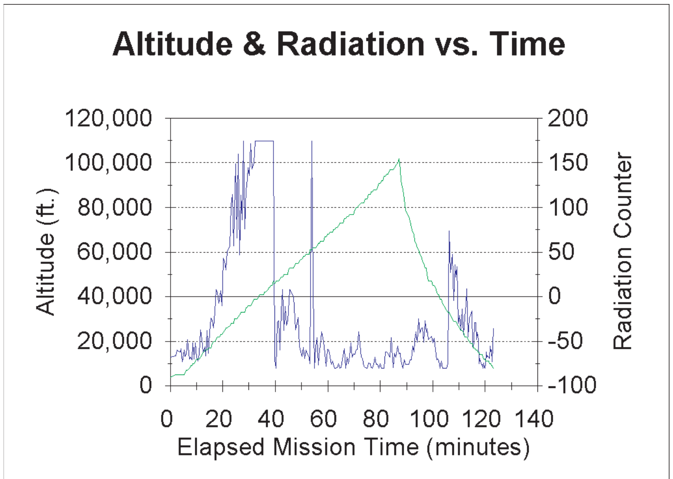


Figure 1.

the launch live. Andy received FAA clearance for a five-minute delay to fit Channel 4's program slot as the flight string was being walked out to the soccer field.

The ground station confirmed all systems were go, and on a prompt from the TV crew, the flight string was paid out. The system rose like an elevator in the calm air amid the obligatory cheers from the assembled multitude. With Mother Nature now in the driver's seat, our focus now centered on the ground station. The Cherry Creek crew had set up an audio recorder next to the ATV monitor speaker to capture the click audio in the event telemetry was lost. That turned out not to be necessary, however. Telemetry data was copied 100% over the entire flight, and Loran C remained locked for all but a few minutes.

Radiation intensity remained relatively constant up to about 18,000 feet and then began a marked rise (See Fig 1). The tropopause was encountered about 34,000, and the GM heater was turned on to raise its temperature above 30 f. So far, so good. Things were operating just as expected. There are always surprises, though; heaven forbid that this balloon stuff ever gets routine! The radiation telemetry continued rising much more rapidly than expected, and reached full scale around 40,000 feet. All that could tell us was that the radiation flux exceeded our 250 CPM worst-case estimate. At about 48,000 feet, we suggested cutting back on the GM bias voltage, not to clear a quench failure, but to decrease the tube's sensitivity enough to see the data vary; a post-flight calibration at low voltage would help discover the actual radiation level. Cherry Creek agreed, and the command was issued and executed. Just in time, as well! Although the telemetry dropped drastically after the command was issued, a clear peak was observed minutes later between 50 and 60,000 feet. After the peak had passed, the telemetry data gradually fell down near the zero level. At 65,000, we tried commanding the GM voltage back up to normal, but the data went out the top again, so we restored the low-voltage condition for the rest of the flight until about 35,000 in the descent phase. The radiation telemetry taken during descent reasonably mirrored that taken during descent, again confirming the peak around 50,000 feet.

Another surprise was that the balloon burst at 102,000 feet. The last time we had flown this type of balloon, burst didn't occur until over 30 minutes after we had passed 100,000 feet. Expecting similar performance this time, we turned the ATV camera out to view the Earth's horizon and the curvature of its atmosphere against the blackness of space at about 95,000 feet. This exhilarating view suddenly went topsy-turvy, and Rick aimed the camera back upwards. Sure enough! We had missed seeing the burst event. Fortunately, this minor disappointment was the most serious mishap in the entire flight from our perspective at the ground station. The dauntless EOSS Lost & Found Dept. may have more chilling tales to tell, but the bottom line is that they once again preserved their flawless recovery record. By 1700 that afternoon, the payload was back on the same bench it occupied less than 24 hours earlier. Except for a thin coat of fertile Colorado Eastern Plains dust on the ATV mirror and some cracks in the Loran pre-amp coax sheath, there was no sign that it had ever moved!

Experimental Results

Armed with a copy of the telemetry data provided by Rick N0KKZ, Cherry Creek's Brian Abrams massaged the data to merge the low and high voltage data sets to produce the results shown in Fig. 2. Lacking a new calibration run at low voltage at press time, the sets were merged by a combination of offset and slope matching. Although re-calibration should yield more precise results, the data as shown exhibit an order of magnitude change in radiation intensity relative to that measured on the ground. This is over three times greater than what was expected. Another anomaly is the fact that the radiation intensity dropped down to near-ground level from above 50,000 feet up to perigee. Pat Ryan theorizes that the peaking may be due to the fact that the beta radiation, which is believed to be the dominant species in the stratosphere, is a product function of cosmic radiation intensity and atmospheric density. Although cosmic radiation is expected to increase continuously with altitude, air density is also dropping at the same time. If there

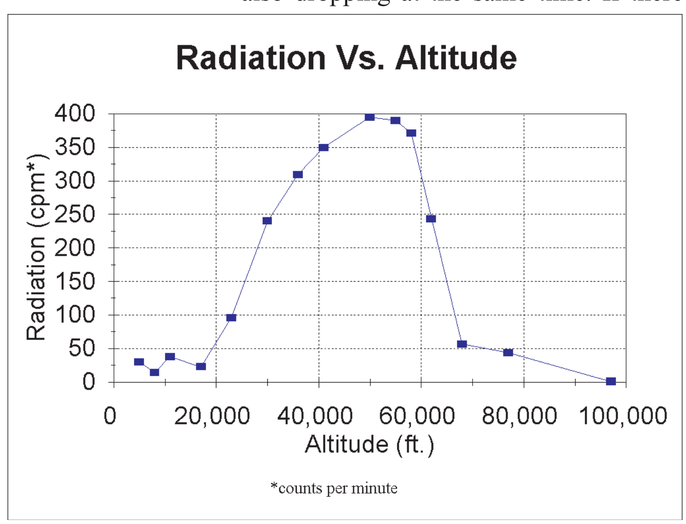


figure 2.

is a paucity of air molecules to interact with the cosmic rays, beta radiation will also be low.

Conclusions

Refined calibration data may very

well show that the magnitude of radiation indicated by telemetry is much lower than what we presently infer, and even then, the fact that the GM tube is expected to respond to cosmic radiation as well as gamma and beta with varying efficiencies raises questions regarding the species measured. Despite all this, there still remains a reasonable chance that Cherry Creek High School and EOSS-15 have indeed made a measurable, perhaps even significant, contribution to the field of atmospheric physics. Whatever the ultimate scientific value of this project turns out to be, there's no question that a lot of folks gained some valuable education and experience and had some fun in the process. In that light, I for one rate EOSS-15 as one of the most successful.

Recommendations

Pat Ryan hopes to resolve some of the scientific questions through more research into the literature. He has also indicated more than a passing interest in flying a better characterized two-tube true beta instrument next school year. That instrument would carry an alpha-only shield on one tube and a combination alpha/beta shield on the second. Digitally subtracting the counts of the second tube from the first will yield net beta response. Both tubes will also respond to gamma and cosmic radiation, but those responses will also be canceled out in the differencing process. Considering the success and fast pace of Cherry Creek's first balloon project, even discounting the pain, I wish Pat and his students Godspeed and eagerly anticipate reviewing their next EOSS proposal as early in the school year as possible.

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