Near Space

How Some Hobbyists are Getting Around the Difficulties Associated with Amateur Space Exploration

Part 2

by L. Paul Verhage

Last month, we covered how hobbyists are getting around the high costs associated with spacecraft construction and launches. You learned a little about the structure of our atmosphere, the location of near space, and the conditions found there. Last month's article closed with a brief introduction to the near spacecraft. In that introduction, the parts of the stack were explained, along with their functions. This month's article discusses some of the benefits gained through beginning your own program and explains how you can build an inexpensive near spacecraft and use it in an amateur science project. Talk about an awesome science fair project!

Some of the Benefits of the Amateur Near Space Program

There are several benefits to creating your own amateur near space program. The first benefit is in the variety of fantastic experiments you can perform. There is also the program management experience you will gain and the inspiration that amateur near space can give. Finally, I see the sense of adventure that comes with each near space mission as an asset.

Amateur Science Experiments That Will Knock Your Socks Off

I have flown many experiments over my seven years and 44 flights in the hobby. Some of my best experiments are described in more detail below. The near space experiments I have flown so far have included recording images, measuring the cosmic ray flux, and making meteorological measurements in the stratosphere. I have also tested new designs and technologies and have let people communicate with one another through near space-based repeaters. Many of these experiments are also being flown by the active near space programs, which were listed at the end of last month's article.

Imaging With Cameras and Camcorders

Some of the most interesting results of a near space mission are in the images returned. Near space missions can record images of sunrise from deep within the stratosphere, the horizon during the day at various altitudes, or of the ground below. Each shows a unique perspective on our planet and its atmosphere.

My video recording of dawn in near space shows an orange band of light hugging the eastern horizon that is topped by a narrow glow of electric blue. The rest of the sky remains pitch black. Beneath the light of dawn, the lights of Kansas City, which were over 100 miles away at the time, were bright. Instead of the sky turning orange at dawn, my videotape shows the ground turning orange. Finally, the Earth's shadow, which is noticeable from the ground, is much more distinct in near space.

Photographs of the horizon during the day show a

blue earth, curved horizon, and black space above. In my photographs, clouds over 100 miles away are visible. Cities and other human artifacts disappear; you would never guess that the earth was inhabited by humans from these photographs. Photographs of the horizon look like they were taken from orbit, so much so in fact, that twice now, photo lab technicians have asked me if I was an astronaut.

Depending on the altitude, photographs taken of the ground can span over 15 miles. Mountains take on a new perspective from near space. They flatten, so only their shadows and creeks indicate their existence. Missions over the years can record the seasonal changes in rivers and creeks. Entire towns and small cities are recorded in a single photograph, along with their roads, railroads, and rivers. You can see everyone's house from near space. The near spacecraft makes the ultimate amateur spysat!

Videotape taken during ascent records the gradual darkening of the sky and the increasing inability of the air to carry sounds. Specifically, high pitched tones drop out early, while lower pitched tones hang in there longer. Meteor observations are possible during night launches, if the module carries a low lux camcorder or image intensifier. In near space, even a full moon can't create the glare that prevents the observation of faint meteors from Earth.

Cosmic Ray Studies with Geiger Counters

One of my favorite experiments is making cosmic ray measurements in near space. Aware Electronics manufactures an inexpensive, lightweight Geiger counter designed for laptop use. The RM-60 Geiger counter is about the size of a deck of playing cards and takes its power from a PC serial port. Its power and data cables are easily interfaced to flight computers.

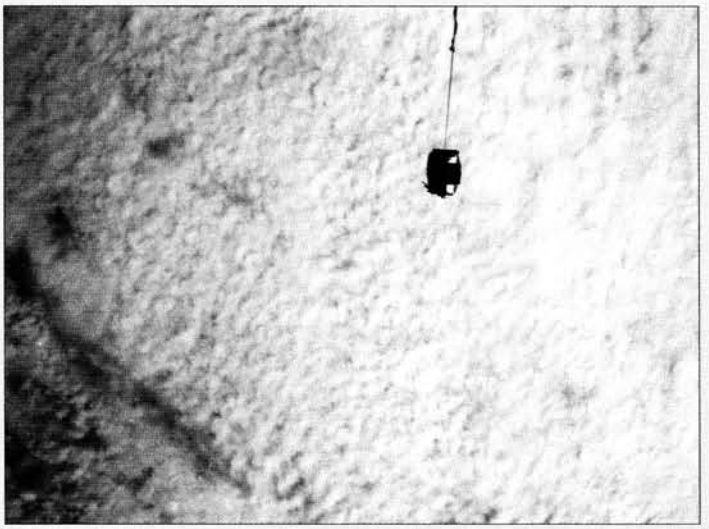
The minimal weight, volume, and power requirements of the RM-60 make it the ideal Geiger counter for cosmic ray studies. The detection of a cosmic ray is signified with a short duration, five-volt pulse. Collecting cosmic ray data entails recording the current altitude from the GPS receiver, then the number of pulses over a specific time span.

Most of the cosmic rays detected on the ground are secondary and not the original — or primary — cosmic rays from outer space. This is because primary rays create showers of secondary rays when they slam into nitrogen and oxygen molecules high in the atmosphere. However, near space is high enough that Geiger counters will begin detecting primary rays. Since the RM-60, combined with the flight computer, can detect a single cosmic ray, my missions into near space can detect a single atom that originated in another star.

Weather Stations

Do you want to know the air temperature, pressure, and relative humidity found in near space? If so, then launch a lightweight weather station. A pressure sensor will show that the atmospheric pressure decreases by a factor of two for every 18,000-foot increase in altitude. Aside from just measuring the current air temperature, a temperature sensor can also permit you to determine the lapse rate (the rate at which the air temperature changes with increasing altitude) and the stability of the troposphere. It also lets you determine the altitude of the tropopause and how its altitude and temperature change over the course of the year. A relative humidity sensor will show you how rapidly the atmosphere dries as altitude increases.

Don't forget the onboard GPS receiver, as it, too, is a part of the weather station. I use data from a GPS receiver to determine the direction and speed of the wind at various altitudes. With this data, I can measure the speed and altitude of the jet stream for myself. On near space missions, hobbyists make the same measurements that the National Weather Service does with its 100 daily radiosonde launches.



An example of a reusable lunch bag-based airframe. Mark Conner's (N9XTN) module is seen being suspended about 10 feet below my module, which provides the tracking services for this flight. Tens of thousands of feet separate the clouds from this near spacecraft.

The Earth, photographed from an altitude of 86,000 feet. Sensors on this mission indicated that the air temperature was nine degrees Fahrenheit at the time. The distance to the horizon was calculated to be 360 miles. Beautiful clouds of fair weather cumulus, marching in rows, fill the scene.

Technology Testing

The air in near space is too thin to conduct a significant amount of heat to/from experiments. Instead of thermal contact with the air, the primary source of heat for exposed experiments is radiation transfer from the sun (unless heaters are added to the experiment). This is similar to the situation found in space and on the surface of most planetary bodies in our solar system.

Launching a piece of equipment on a near spacecraft to an altitude of 100,000 feet is a fantastic way to test its ability to function in a real space flight. In near space, equipment under test is exposed to a combination of cold temperature, low air pressure, and increased ultraviolet radiation. Tests performed at an altitude of 103,000 feet experience the same temperature and pressure found on the surface of Mars. If you include a camera or camcorder on the mission, then you will get images of the piece of equipment during its test with the earth's horizon in space as the backdrop. You may be able to get a sponsorship if a product logo is prominently displayed in the photograph.

Near Space Communications

Amateur radio communications with VHF and UHF radios (some of the most popular radios in the amateur radio community) are usually limited to their line-of-sight. In most cases, line-of-sight is only a few miles. With few exceptions, these kinds of radios don't communicate well with similar radios located over their local horizons. Repeaters — which are automated stations that retransmit radio communications — are usually located on either mountain tops or tall radio towers. They have more distant horizons and can extend the range of VHF and UHF radios to a few tens of miles.

A near spacecraft makes a fantastic repeater platform. Under ideal conditions, a repeater on a near spacecraft at an altitude of 100,000 feet lets two individuals 800 miles apart communicate with one another using inexpensive handheld radios. You can see that a near spacecraft with a radio repeater imitates a communication satellite. In this case, however, it's much cheaper and it's your communication satellite!

Program Management Experience

Aside from the experiments you can perform once your near spacecraft is on station, there are additional benefits that you can gain from an amateur near space program. For one, you can gain experience in program management. There are several levels of management in an amateur near space program. At the simplest level is the management of a single mission. This means matching payloads to the physical, electrical, and logical characteristics of the near spacecraft.

The next level of management is the planning needed for an entire mission. At this level, you are managing flight readiness reviews, chase frequencies, launch site selection, and the driving course for the chase and recovery crew. There are also flight predictions to be made. Flight predictions usually begin a week in advance of the launch. They are made from weather reports, with the help of software available from the EOSS website (**www.eoss.org**). You can see that launch week is a very busy time for the launch manager.

Beyond the management of a single mission is the management of an entire amateur near space program. Such a program can easily launch in excess of four flights per year. It takes someone with management skills to plan missions over the years. Funding and educational outreach are some of the important issues which require high level management. Managing a near space program is similar to managing a real space program, except that its cost and scale are accessible to the hobbyist.

Inspiration

Many people are inspired by visiting locations like the Grand Canyon. A subset of these people will go on to gain deeper inspiration by actually hiking through the landmark. Just like the Grand Canyon,

A Luckless Idaho Airborne Commando, Captured by a Kansas Farmer

Mr. Potato Head bravely parachuted from near space during Idaho's attempt to invade Kansas. Riding the TVNSP (Treasure Valley Near Space Project) near spacecraft and carrying a camouflage parachute, he made this airborne assault on the farmlands of the Midwest during Great Plains Super Launch 2002.

Unfortunately, before Mr. Potato Head could complete his secret mission, he was captured by a local farmer and turned over to the Dickinson County Sheriff. The sheriff's department released these photographs of Mr. Potato Head, which chronicle the events following his capture.

Here we see the grim, but determined, Mr. Potato Head getting his mug shot. All the while, he was no doubt planning his eventual escape to freedom among the peace-loving people of Idaho.

Finally, Mr. Potato Head was thrown behind bars on a charge of trespassing. It's believed that he never divulged the true nature of his secret mission.

What lesson did Idahoan near space explorers learn from this sad event? They learned that you don't parachute into Kansas from an altitude of 50,000 feet because Kansas farmers really hate that. For GPSL 2004, Idaho will instead attempt to drop propaganda leaflets from near space upon the unsuspecting masses of Kansas.

seeing or hearing about near space will inspire many people. A subset of these people will go on to develop deeper inspiration by designing and launching an experiment into near space.

This experience and inspiration may encourage young people to become scientists or engineers. At a minimum, they will develop a better understanding and appreciation of science and engineering. Near space is a hands-on source of inspiration that lets people see and experience work in a space-related field. If you decide to begin an amateur near space program, be sure to show it to the public. Share it at science fairs and on special days like Space Day, Astronomy Day, and Field Day.

Adventure

There is one last benefit I can think of; in addition to amateur science, program management, and inspiration, there's the adventure. After liftoff of the stack (the near spacecraft and its launch vehicle), crews will begin their chase. A rough idea of the near spacecraft's landing zone is known because of flight predictions; however, the details of the chase and recovery are not known in advance.

Driving over obscure back roads and through tiny towns can be great fun, especially when your convoy is equipped with a dozen antennas, several laptops, and radios. Try stopping at a gas station and waiting for a balloon burst while constantly looking up at the sky — this kind of behavior makes the locals wonder what you're up to. When you show them a tiny dot in the sky and explain that it's your balloon at 90,000 feet, you will amaze most of them.

The last part of the chase, approaching the landing zone, creates a high level of excitement as you attempt to reach the near spacecraft before it lands. Be aware though, the near spacecraft is under no obligation to land close to the road. Depending on the location of the landing zone, your recovery crew may end up going for a hike to recover the near spacecraft and launch vehicle. Most of the time this hike is fun, but it can also be a challenge, so be prepared.

After having recovered the near spacecraft, your crew will usually drop off their film and head to lunch. Lunch is a time to share stories of past and present adventures. Don't be too surprised if you turn some heads at the restaurant with your stories. You'll also realize that you probably did more that morning than most people will do all weekend.

Final Comments

The cost of a near space program is low enough that almost anyone can get a foot in the door. An amateur near space program is not a dead-end activity. Just testing materials and their applications to near space is an example of the important work that still needs to be done. Best of all, the results of these tests are applicable to spacecraft engineering and construction. With more and better sensors and electronic devices becoming available to the public, you'll always have new experiments to perform in near space. If space exploration appeals to you, but the cost is prohibitive, then consider beginning your own poor man's space program. Where

Six stacks are about to be launched. You'll actually count eight balloons because of the red piball (pilot balloon) and the extra balloon on Don Pfister's stack. The piball was launched by EOSS to gauge wind speed and direction before GPSL 2002 launched.

The author lifting the module of one of his near spacecraft. The second module is green and can partially be seen in the grass. The "Remove Before Flight" tag is a reminder for launch crews to open the camera before launching the mission. (Photo courtesy of Shari Conner, K9XTN)

else can you practice what it takes to build and launch a spacecraft?

This article can't give you enough information to begin your own near space program, so please consult one of the near space groups for help. Otherwise, check with Parallax for my upcoming book on creating and managing your own poor man's space program with the BASIC Stamp 2p.

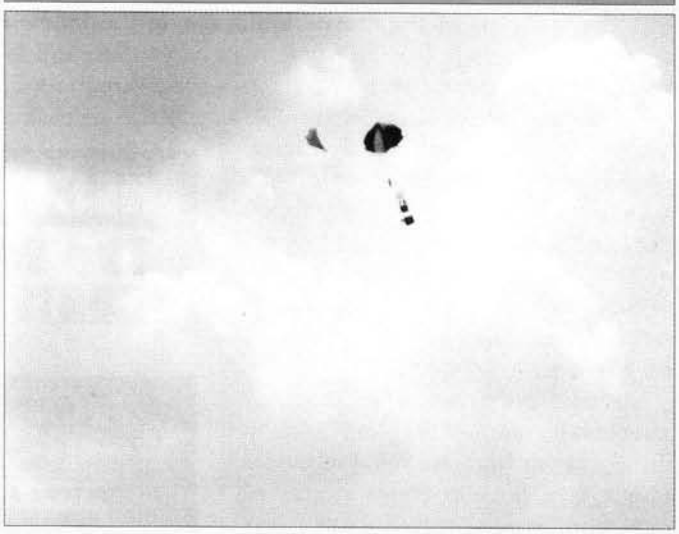
You can begin your amateur near space program right now by studying for your amateur radio license (if you don't already have it). Several businesses, including some of those advertising in *Nuts & Volts*, sell the book, *Now You're Talking*. This book is one of the best study guides for the amateur radio test. Are you worried about the Morse code test? Don't worry, because you are no longer required to know Morse code. Consult the ARRL website (**www.arrl.org**) for the location of the amateur radio club closest to you. Your local amateur radio club is your best resource for earning your ticket.

Onwards and Upwards! **NV**

About the Author

L. Paul Verhage is an electronics teacher at the Dehryl A. Dennis Professional Technical Education Center in Boise, ID. He began working in the amateur near space field in 1994 and has accomplished over 40 missions. His book, *Amateur Near Space with the BASIC Stamp 2p*, will be published this year by Parallax.

The descent of a near spacecraft. This one may belong to Mark Conner's (N9XTN) near space program, NSTAR. What's left of the balloon is visible to the left of the parachute. Flight predictions allowed chase crews to be close enough to the descending mission that Doug Eubank (KA0O) of NSTAR was able to get this photograph (and three other ones that morning — amazing).



Announcing *N&V's* Near Space Column

Part 1 of L. Paul Verhage's near space article in the February Nuts & Volts generated an overwhelming response from our readers. In light of this, we have invited Paul to become our monthly columnist on the subject of near space. His column will begin in the April issue.