Approaching the Final Frontier

Near Space

An Introduction to the Amateur Near Space Program — My Near Space Program

It's safe to assume that most of you are interested in space exploration. In fact, most of you would already have built and launched your own spacecraft, if not for the high cost involved. We have the interest in space exploration, but we're stuck in a lurch. It seems to be a pent up demand with almost no available outlets; however, this column will show you how to create and operate an amateur near space program — the poor man's space program — right out of your house.

Real space programs are unaffordable because they use specialized launch facilities, a global communication network, space-rated materials, and dangerous rockets. An amateur near space (NS) program is affordable because it uses open fields, amateur radio, Styrofoam, and weather balloons.

Now, this is not some watered-down, pretend, science fiction fantasy. Instead, think of an amateur NS program as the garage band version of a national space program. In your amateur near space program, you'll build functioning models of spacecraft and launch them on missions into a space-like environment — and it's cheap! Compared to the cost of building and launching a professional spacecraft, yours will cost less than $5.00 for every $1,000,000.00 spent in construction and will be launched for $1/1000^{th}$ the cost, per pound. You can now afford to be a spacecraft engineer and perform experiments in an absolutely lethal environment. Amateur NS is a high-tech hobby unlike any other you've seen.

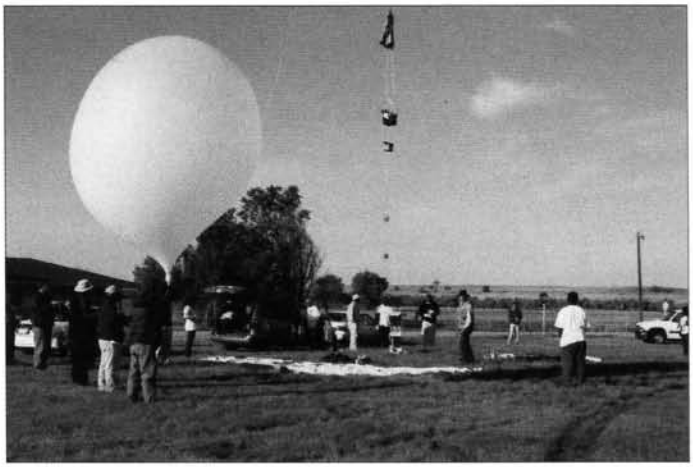
The first amateur NS flight occurred on August 15, 1987, when Bill Brown (WB8ELK) launched an amateur radio on a helium-filled weather balloon. Since that time, amateurs have flown several hundred missions. Today, close to one dozen groups and over 100 people are involved in amateur NS programs. The average participant is a licensed amateur radio operator who makes launches his or her hobby. Most people are involved for the fun of launching and tracking a payload which is capable of reaching altitudes in excess of 100,000 feet; some are primarily interested in the amateur science aspect.

The Typical Amateur Near Space Mission

The NS craft consists of one or more modules filled

An EOSS chase vehicle. It carries a portable weather station, along with tracking equipment. It can communicate with other chase teams, find directions, and track mission progress with APRS. Photo by John and Deb Knapp.

Getting ready for launch. The stack on the left is about to be raised on lanyards, while the one on the right has already been raised. These two flights carried their payloads to altitudes of 98,000 and 99,000 feet.



with avionics, possibly one or more experiments, and a pre-deployed parachute. The NS craft is carried by a load line and a helium-filled weather balloon — collectively called the launch vehicle. The prep and launch can be accomplished by six people in less than an hour. Many times, the prep and launch takes place just prior to sunrise, before the winds have a chance to pick up.

The climb out after launch is very gentle. There is no significant stress on the airframe or experiments (unlike rocket launches). Because of the low stress launch, styrofoam is a major construction material. The ascent rate of the NS craft is on the order of 1,000 feet per minute. This means that the ascent time to balloon burst is less than two hours. The weather balloon expands in volume as it ascends and, depending on the balloon, it can reach a diameter from 20 to 30 feet before bursting. If you know where to look, you can see the balloon with the unaided eye, even at an altitude above 100,000 feet; it looks like a faint star in the daytime sky.

At balloon burst, the recovery parachute opens automatically and the module begins its descent. The initial descent rate can be greater than 6,000 feet per minute at high altitudes because the low air density creates very little drag. As the NS craft gets closer to the ground, the air density increases and the descent slows to a safe landing speed of about 10 feet per second. A module usually takes about one hour to reach the ground.

Examples of Experiments

One amateur NS organization — the Edge of Space Science (EOSS) — has launched missions in support of professional organizations. However, most amateur missions are limited to amateur science. For examples of possible experiments, see my article in the March 2004 issue of *Nuts & Volts*.

Future Experiments

Many other experiments are possible on amateur missions; in future columns, I will provide more details — and results — of experiments. How about designing and testing a Geiger counter telescope? Life science experiments are possible by carrying bacteria and spores into NS. Elementary school students can practice the process of science by planting seeds that were exposed to NS conditions (near vacuum, cold temperatures, low air pressures, and increased UV flux) and comparing the results with controls. A long-term science project becomes possible when students harvest the seeds of exposed plants and send them up on future flights. Sterile petri dishes can be opened in NS in an attempt to

A BalloonSat after recovery. BalloonSats do not carry independent trackers, but rely on the NS craft they are attached to. BalloonSats are designed and built by university students as part of the Space Grant Consortium.

collect bacteria and spores residing in the stratosphere. Life support systems for insects can be developed and tested. (Please do not launch animals more complex than insects into NS; in addition to being inhumane, there are many laws concerning treatment of and experiments with animals.)

Along with science experiments, engineering tests can also be performed. Will a LEGO robot function properly on Mars, with its frigid air temperature and low atmospheric pressure? Carrying a LEGO robot to an altitude of 100,000 feet is one way to find out (and fun, to boot). Imagine young students getting a photograph or video tape of their LEGO robot operating at 100,000 feet with a curved, blue Earth, and black space as its backdrop!

Starting Your Own Amateur Near Space Program

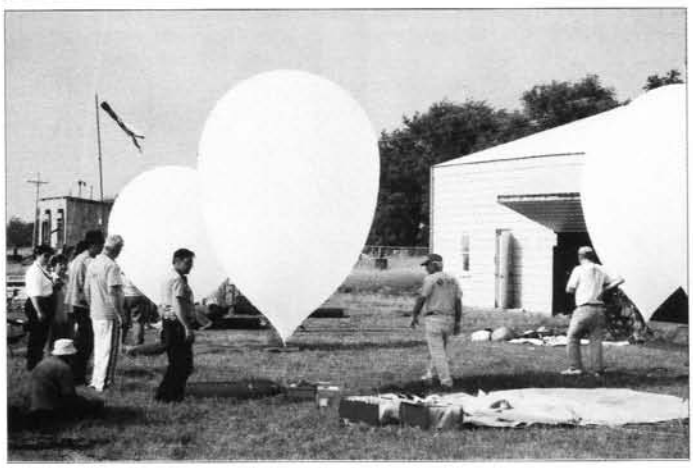
I hope you're finding amateur NS to be as interesting and exciting as I do. It's really easy to start your own program. In less than a year, you could be launching your own module and collecting fantastic results. Just imagine the photographs that could be hanging on your living room wall next year. To get started, you need to accomplish the following tasks:

- Earn an amateur radio (ham radio) license or recruit hams
- Practice tracking objects with APRS
- Become familiar with FAR 101
- Build an airframe
- Build avionics
- Sew or purchase a recovery parachute
- Build one or more experiments
- Assemble the balloon filling equipment
- Learn to use the LiftWin and BallTrak programs
- Practice launch procedures
- Set a launch time and place

While it's not absolutely necessary to earn an amateur radio license, it does make it easier. Without your own license, you're dependent on others to test your NS craft and its experiments for you. The good news is that you no longer need to learn Morse Code to get an amateur radio license.

APRS is the Automatic Packet Reporting System. Packet radio is a method for transmitting and receiving digital data over amateur radio. Think of it as using a modem over the radio rather than over a telephone line. APRS takes digital packet radio data and displays it in a graphical format on a laptop or PC. The position of your

Some launches, just after the balloons have been filled. Until they are tied and taped shut, the balloons are secured to 120 lb. helium bottles to anchor them while the rest of the NS craft is being prepped.



A beautiful sight — a spacecraft after its mission. APRS reports the landing position to within 100 feet. Recovery crews only had to follow their GPS receivers until the parachute was sighted.

NS craft is displayed on a moving map that is stored in software. Your NS craft is displayed, in addition to your crew, as they chase it, in addition to all of the roads in between its location and yours.

FAR 101 is the Federal Aviation Regulation, Chapter 101. FAR 101 is the bible of balloon launches (along with rockets, tethered balloons, and kites). The Regulations look intimidating, but is actually quite simple, as long as you limit the weight of the NS craft. If you follow the list of limits which follows, there will be no required permission to launch.

- A total weight of 12 pounds for all the modules in the NS craft
- No single module weighing more than six pounds
- No module with a side smaller than six square inches
- Use safe launch procedures and a recovery parachute
- No launching from restricted air spaces without the permission of the owner

FAR 101 is a reasonable attempt to share our air space resources between commercial aircraft, private pilots, and amateur science. To be a responsible user of air space, filing a NOTAM (notice to airmen) before you launch is advisable. Accomplishing this requires only a simple call to a toll-free phone number.

In addition to this column, directions for constructing airframes, avionics, and balloon filling equipment are available by contacting me or other NS groups. The fastest and simplest NS craft to obtain is a reusable lunch bag carrying an APRS tracker based on a Tiny Trak III. Check my article in the February issue of *Nuts & Volts* for details.

Parachute directions are available from the same sources. An alternative to making a parachute is to purchase an amateur rocket parachute and modify it for your use.

LiftWin and BallTrak are programs written specifically for the amateur NS community. Copies of the programs can be downloaded from the EOSS website (**www.eoss.org**); there is no cost for using this software.

Are you still as excited by amateur NS as I am? This column will show you the ropes. Everything from building airframes, trackers, flight computers, and recovery parachutes will be explained in future columns. I'll provide directions for assembling balloon filling equipment and explain prep and launch procedures. Flight predictions and some of weather's effects on flight will be covered, as will putting together a launch and recovery crew.

Perhaps the most exciting aspect of the program — designing experiments and analyzing their results — will

also be featured.

In this column, I want to share the experiences of amateur near space programs with those who are still deciding if they want to begin their own program. I also want the science results of flights to be shared with those readers interested in analyzing data.

I'll use this column to make items which have been exposed to NS — like plant seeds — available to students and their teachers. Suggestions for analyzing data — and, I hope, a few lesson plans — will also be included. New techniques for old problems are another topic I will cover. I'll report on professional organizations involved with NS.

Since I'm a high school teacher, I spend a lot of time traveling. I plan to spend some of that time visiting other groups and launching with them. You'll get to read about some of my NS adventures. Every article will help you build or operate an experiment or analyze the resulting data.

Onwards and Upwards, Your Near Space Guide. NV

More Near Space Web Resources

A list of amateur groups can be found in "Near Space, Part 1" in the February 2004 *Nuts & Volts*; however, I accidentally left out one group (sorry, Harry). If you're in the OK region of the US, then talk to Harry Mueller (KC5TRB) and the Oklahoma Research Balloons (ORB). His website is **www.gbronline.com/harrymue/orb/**

The KNSP website listed in my February article is for my former program. The website is still available online, but there are no more launches from it. On the other hand, the KNSP Email list is still active and managed by Mark Conner (N9XTN); it is the primary information source for Midwest amateur NS launches.

Ralph Wallio maintains a website of theory and current mission records. Check his website out for a flavor of the state of the art and what groups are accomplishing. His website is **http://users.crosspaths.net/~wallio/**

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.