CHAPTER ZERO

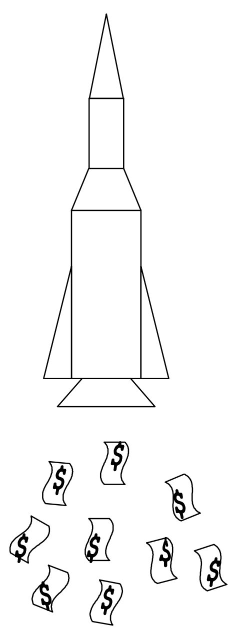
Designing Your Own Program of Near Space Exploration

"It really is a poor man's space program"
-Pete Sias (WB0DRL)

Chapter Objectives

1.0 An Introduction to Amateur Near Space Exploration[A]

Many dream of designing, building, and launching satellites into space. Unfortunately there are problems achieving this dream. But with today's technology and tools, many of us can realize some of this dream.



***Launching a rocket is an expensive proposition** – Do you have money to burn?*

1.1. How Reality Hinders the Layperson's Dream of Space Exploration

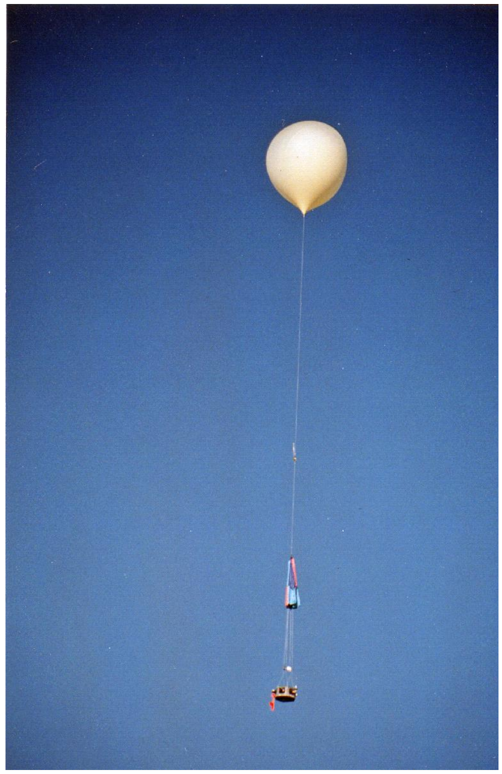
Many people reading this book dream of building and launching a satellite of one's own. However the currently high cost of launch prevents most of us from achieving this dream (this may change in our lifetimes). The cost of launch is just the first layer of cost stopping us. If we are going to spend the money to launch a satellite into orbit, we must guarantee the satellite lasts long enough on orbit to justify the high launch cost. This "insurance through construction" adds a second layer of cost to launching a satellite. How do you know your satellite is constructed properly or well enough to last once in orbit? After constructing a satellite, professionals test the satellite under launch and space-like conditions. These tests involve placing satellites into thermal vacuum and acoustic chambers for hours at a time. Since these specialized facilities aren't used as frequently as the local car wash, test time spent inside of them is very expensive. Testing your satellite after construction adds a third layer of cost to launching a satellite. Next there is the element of time. It can take years for an amateur (and non-amateurs) to construct a satellite. What is your time worth? Time spent constructing a satellite adds a fourth layer of cost to launching a satellite. Finally, there are telemetry costs. Once a satellite is on orbit, you must receive telemetry from it (if you don't then why launch it in the first place?). Do you build a ground station to receive the satellite's telemetry? If you construct your own earth station, don't forget to include salaries and training costs for the engineers operating it. Another option is to rent time on someone else's ground station. This rent is not free. Telemetry is not a one-time cost like the other costs. Telemetry costs grow year after year. One way or another, collecting telemetry from your satellite adds a fifth layer of cost to launching a satellite.

1.1.1. The Final Bill

What is your total cost of launching a satellite into orbit? First, you would pay approximately $10,000 per pound to launch a satellite into Earth orbit on a commercial launcher. Think about it: this is more expensive than a house or car. This is the kind of cost associated with some fine arts and jewelry. Second, you would pay from hundreds of dollars on up for a ready-made CubeSat microsatellite to thousands of dollars, and perhaps more, for the space-rated components needed to construct a larger satellite. Third, add several more thousands of dollars for testing the completed satellite. Fourth, you would spend from months to years of labor in design and construction of your satellite. Finally there is the money spent acquiring the satellite's telemetry. Depending on the situation, this can run into the thousands of dollars. How many readers of this book have this kind of money in their bank accounts? How many readers have enough free time on hand to complete the satellite? Are you still interested in launching a satellite into space?

1.2. The Near Space Solution

Obviously the costs described above are not showstoppers for everyone; after all, many universities and AMSAT, the Radio Amateur Satellite Corporation, launch their own satellites. The costs involved are more of a problem for most individuals and small groups. In this book I present a solution that works in most cases for these people while increasing the exposure to space related activities. The solution involves designing a satellite for missions into near space as opposed to space (or deep space). What is near space? Near space is that region of the earth's atmosphere between the altitudes of 75,000 and 330,000 feet. The Good to Know section at the end of this chapter discusses several properties of near space. Read that section and you'll see just how closely near space matches the real space environment. But first, take a look at how affordable near space can be, in both dollars and time, compared to the cost of launching a satellite into orbit.



***Launching a Near Spacecraft** – No roar, no flames, and a lot less money but still awesome results and adventure.*

2.0 Amateur Near Space Exploration as an Affordable Hobby

To fly a mission into near space requires more than purchasing a helium-filled weather balloon. You also need to construct a near spacecraft, recovery parachute, launch equipment, and a telemetry station. In addition to spending money building the elements of your program, you will also spend time building the program and chasing missions. I will show you the costs of the bare bones near space program, but keep in mind that a meatier program is still very affordable.

2.1. Building a Near Spacecraft (Avionics, Airframe, and Recovery System)

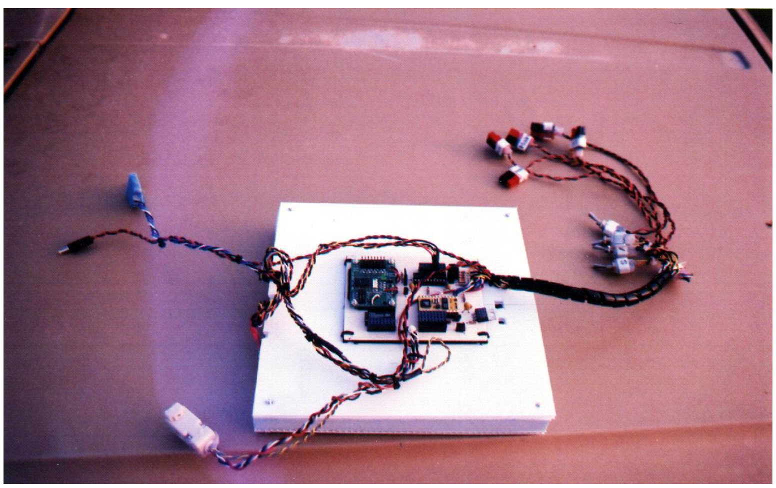
The cost of constructing a near spacecraft is broken into three categories: avionics, airframe, and recovery systems. Note that the design outlined below is for a reconfigurable near spacecraft that is launched on multiple missions without modifications to the airframe or flight computer. Think of building this near spacecraft as building your own reusable Space Shuttle.

2.1.1. Avionics Cost

Avionics is a combination of the words aviation and electronics. Near space avionics is essentially the flight computer of the near spacecraft. The flight computer operates experiments, collects data, determines the status of the near spacecraft, responds to contingencies, and telemeters flight and science data to ground stations.

AVIONICS COST	
Item	**Price**
Etrex GPS Receiver [1]	$110
BS2p microcontroller [2]	80
MIM [3]	83
MAX186 ADC [4]	Free
SSC II [5]	45
ULN2803 [6]	3
DJ-S11 2 Meter Radio [7]	80
Printed Circuit Board [8]	6
Miscellaneous Parts	10
Avionics Cost Total:	**$417**

1-7: See Endnote B for explanations and details.



Flight Computer *– A finished flight computer mounted on a pallet. Something this complex can be built on your kitchen table for less than the cost of a good set of golf clubs.*

2.1.2. Airframe Cost

The airframe is the body of the near spacecraft. The goal is to make airframes light and reusable. Styrofoam sheets meet this requirement while insulating the interior volume of the capsule.

AIRFRAME COST	
Item	**Price**
Styrofoam Sheet	$10
Hot Glue	1
Space Blanket	3
Scrim	1
Ripstop Nylon	12
Link Rings	1
Dacron Ribbon	1
Plastic Handle	3
Airframe Cost Total:	**$32**

***Bill All (N3KKM)** – Preparing two modules in a near spacecraft for a <u>very</u> early morning launch. Each airframe costs less than $50. and is totally reusable.*

2.1.3. Recovery System

The simplest recovery system is a parachute. As your program matures, you will probably add recovery aids to the parachute.

RECOVERY SYSTEM COST	
Item	**Price**
Parachute Fabric (ripstop)	$80
Sewing Tape (twill)	5
Link Rings	4
Bearing Swivels	4
Dacron Line	3
Recovery System Total	**$98**

Handling the Parachute Carefully *- Keep the parachute off the ground and from getting tangled while preparing for launch. This photo was taken by a near spacecraft while we were prepping the balloon and parachute – no one realized it was taking photos at the time.*

2.1.4. Total Estimated Cost for a Near Spacecraft

NEAR SPACECRAFT COST	
Item	**Price**
Avionics	$417
Airframe	32
Recovery System	98
Near Spacecraft Total	**$547**

2.2. Operating a Near Space Mission

I have broken down the costs of operating a near space mission into four groups: the cost of ground support equipment, the cost of consumables, the cost of telemetry, and the cost of tracking and recovery.

2.2.1. Cost of Launch Support Equipment

Equipment to launch a balloon is a one-time purchase. Most of the equipment is used to fill the balloon with helium. The kite winders and folding table are used to launch the balloon and to prep the capsule. After some experience, you will probably add additional equipment to this list.

Launch Support Equipment Cost	
Item	**Price**
Regulator and Hose	$50
Electronic Fish Scale	25
Bed Sheet	5
Duct Tape	5
Kite Winders	10
Folding Table	15
Launch Equipment Total:	**$110**

Launch Support Equipment – *The author preparing to fill a balloon, using readily available equipment. None of the launch equipment is special order.*

2.2.2. Cost of Launch

This is the consumable cost of a mission. If you can discover a way to save and reuse the burst balloon and its helium, you'd make a million.

Cost of Launch	
Item	**Price**
Balloon (1200 gram) [1]	$ 60
Helium (300 cubic feet)	100
String	1
Total Cost per Flight:	**$161**

1: See Endnote C for explanation and description.

A Near Space Stack *– this mission is just a few minutes away from launch.*

2.2.3. Cost of Telemetry

The best way to save on telemetry costs is to make friends with your local amateur radio (ham radio) community. Amateur radio uses packet radio to send digital data over the radio. Many ham radio operators are excited by the prospect of tracking high altitude balloons. So, you may initially be able to add zero dollars to your program to collect telemetry. When you construct your own mobile tracking station, you need a laptop computer, Terminal Node Controller (TNC), Handi-Talkie (HT), and licensed Automatic Position Reporting System (APRS) software. Many of you may already have some of these items.

Mark Conner's (N9XTN) Mobile Tracker *– With this, he can chase a near spacecraft anywhere.*

2.2.4. Cost of Tracking and Recovery

After you launch the near spacecraft on its mission into the stratosphere, you must retrieve it after it lands. This is the fun part of near space missions. It's like a road rally, but no one in the Chase Crew knows quite for sure where they are going to end up! Some flights only go ten miles while others may go over 150 miles, and some people drive gas efficient vehicles while others drive SUVs. Therefore, the cost of tracking and recovery varies for each mission. Fortunately, you can predict the distance traveled by the mission before deciding to launch. After spending money for fuel chasing the near spacecraft, you need to add the cost of a hearty lunch for your Chase Crew.

2.3. Building a Program of Near Space Exploration

Now let's look at the time required to prepare your equipment. Instead of spending over a year building and testing your satellite, you might spend only a few months building and testing a near spacecraft. Instead of waiting another year to get your satellite on a launch manifest, you can launch a near space flight on any day the weather cooperates. Finally, on launch day, the entire mission can be completed in time for lunch.

2.3.1. Beginning Six to Twelve Months Before Launch

- √ Earn an amateur radio (ham radio) license
- √ Or recruit local ham radio operators
- √ Practice tracking with APRS
- √ Become familiar with FAR 101[D]
- √ Build the airframe
- √ Build the avionics
- √ Sew the parachute
- √ Build one or several experiments
- √ Program and test the BS2p flight computer
- √ Assemble the balloon filling equipment
- √ Learn to use the Balloon Track program[E]
- √ Practice launch procedures
- √ Set a launch place and date

2.3.2. The Day Before Launch

- √ Pick up two tanks of helium
- √ Complete the Flight Readiness Review (FRR)
- √ Recharge the capsule's batteries

2.3.3. The Day of the Launch

- √ Arrive early to the selected launch site
- √ Fill the balloon with helium
- √ Prep the capsule
- √ Assemble the stack (capsule, parachute, and balloon)
- √ Raise and release the balloon
- √ Go on a cross-country adventure chasing the balloon
- √ Celebrate your victory with lunch at your favorite restaurant
- √ Make plans for your next launch

2.4. The Total Bill

Near space exploration is affordable; in fact, it's less expensive than many popular hobbies. For less than $1000, plus the cost of your experiments, you can build a program and fly two missions (one practice and one real) into near space. Launching a twelve-pound near spacecraft, 1.5 pound parachute, and 1200-gram balloon costs ten dollars per pound of payload. Compare this to spending $10,000 per pound of payload to launch a satellite into Earth orbit. The tasks required to develop a program of amateur near space exploration and launch your first missions can be accomplished within one year of the start date.

A near space program is one of the ultimate experiences for the technically minded. A near space project requires knowledge in a wide variety of subject fields including high tech radio technology, electrical engineering, mechanical engineering, mission planning, data analysis, recovery system design, and public relations. What ever your interest, there's something for you in a near space program.

3.0 The Near Spacecraft as an Example of an Amateur Built Spacecraft

Once in space, spacecraft are for the most part out of reach. They are on their own and unable to rely on the human hand to correct them. Being so remote, spacecraft must send telemetry if we are to know what they sense. The benefit of this remoteness is that spacecraft can perform remote sensing of the Earth and the space environment around them.

Once launched, near spacecrafts have the same limitations and abilities. Near spacecrafts are also out of our reach and must rely on sound engineering design to remain functional. We depend on reliable telemetry to monitor their progress throughout their missions. And, like spacecrafts, near spacecrafts can also remotely sense large swaths of ground and the near space environment around them.

So what kind of spacecraft does the near spacecraft most closely match? According to Rick Fleeter of Aero Astro, and other individuals, small satellites are classified by their weight. I have listed these weight categories in the table below.

SMALL SATELLITE CLASSIFICATION	
Category	**Mass**
Picosatellites	0 to 2 kg
Nanosatellites	2 to 20 kg
Microsatellites	20 to 200 kg

The Federal Aviation Administration (FAA) regulations limit the weight of near spacecrafts if we desire to launch them with minimal hassle. This weight limit is twelve pounds distributed in two or more packages, each package no more than six pounds in weight. This places the near spacecraft squarely within the nanosatellite category. If you decide to build a near spacecraft, you would be constructing a functioning model of a nanosatellite. Ask your neighbors if they build nanosatellites in their kitchen during their spare time!

Designing and building a near spacecraft is not the end of the story. Launching and recovering a near spacecraft is an involved undertaking. You must assemble ground support equipment, design flight procedures, train personnel, and implement a near space communications infrastructure before launch. As you can see, a near space program closely resembles a real space program, but on a much smaller scale.

4.0 My Philosophy for Managing a Near Space Program

Here are two of the factors influencing today's satellite market: first, companies and space programs cannot get unlimited funds from their sponsors or customers. Second, the customer (a company or the public) wants to see rapid results.

How do today's satellite designers meet these two requirements? Designers start by keeping a spacecraft's mass low. Low mass makes satellites less expensive to build and launch. This makes effective, capable microsatellite and nanosatellite designs one of the hottest goals of today's satellite market. To meet the need for rapid turnaround time, many satellites are designed under some sort of a faster-cheaper-better paradigm. This includes designing nanosatellites with a small design team, where each member of the team is knowledgeable with most aspects of the satellite design. This also means a lean management style with limited numbers of management or responsibility layers (which is a very good thing, as you will never have enough people involved).

What limitations apply to you as a near spacecraft designer? First, you have a weight limitation placed upon you by the FAA (There are also other reasons to keep capsule weights low, and I will cover those in later chapters). Second, you probably do not have enough time, money, or commitment from other individuals. As a result, you design and build near spacecraft in ways similar to today's microsatellite designers. You design and build lightweight near spacecraft. You manage a small team of personnel where each team member is knowledgeable of most, if not all, of the near spacecraft and its launch systems. You build your near spacecraft in a manner similar to the Naval Research Laboratory (NRL) or the first OSCAR (Orbiting Satellite Carrying Amateur Radio) satellites. You do not design and construct large and expensive near spacecrafts requiring years to build and launch. Finally, you do not use committees for the design and construction of near spacecraft. Besides, committees design near spacecrafts slowly (if at all) and often the product is still unacceptable to most people.

If many people want to get involved in your near space program, then I think it is best to divide them into small groups and give each group responsibility for designing their own near spacecraft. However, do have them select a standardized design as outlined in this book, so the modules are compatible. Don't get discouraged if no one volunteers to get involved in your program. Being the only person with the responsibility to build an entire program is possible, but you will probably need to rely on occasional outside expert help. You will also require the help of others when you're ready to launch. But you have time to get that help, and having a completed near spacecraft helps getting that tracking and recovery support.

Here is an example of what is possible when only a few people manage a near space project. Back in 1996 I created the Kansas Near Space Project (KNSP). It required less than two years to build and launch the first near spacecraft, and that was without the help of this book. I was very fortunate to have access to experts when questions did arise. The KNSP launched nineteen missions in just thirty months. KNSP near spacecraft reached altitudes ranging from 51,500 feet to 114,600 feet (an amateur record at the time). KNSP flights returned video, still images, cosmic ray counts, along with other experimental results and tests. The project even launched cockroaches into near space!

So here it is in a nutshell: if you want to explore near space, run your program like today's microsatellite designers. Rely on small teams. Make sure each team member understands as much of the near spacecraft as possible. Do not let members of the team focus on tiny portions of the program or near spacecraft. Construct several near spacecrafts quickly and cheaply. You will have time to expand near spacecrafts in the future; so don't get bogged down with endless design revisions. Do not try to design a near spacecraft that pleases everyone, as chances are it cannot be done. If design modifications are necessary, rely on designing multiple generations of near spacecraft where each new design is based on previous designs. Evolution in design is better than revolution in design as there will be fewer errors. Read this book to select a standard and try to stick with it.

5.0 Is Near Space Right for You?

Can you afford to be somewhat single minded about a hobby for a few months? Do you enjoy reading some of the less popular science books in the Borders bookstore? Do you want to design some really clever experiments? Do you get a thrill risking several hundred dollars of your own equipment? Do you thrive on the excitement of driving into small towns in vehicles loaded with high tech electronic equipment? Do you have a desire to drive dusty gravel roads eating two pounds of road dirt? Do you want to attract the attention of the techie babes (or if you are female, the techie studs)?

If you answer yes to these kinds of questions, then amateur near space exploration is just your kind of hobby. After beginning a near space program, you're going to have some of the most amazing pictures hanging on your living room walls.

6.0 The Organization of This Book

I have written this book in fifteen chapters (zero through fourteen) and five appendices. Each chapter deals with one aspect of building and operating a near space program. After each chapter's primary focus is a short topic covering background information. This information is for those who want to know more than just how to build and launch near spacecrafts. Each chapter concludes with a short humor section. Some of the humor will be top lists while others are humorous, but true stories from my near space files. I believe you will enjoy the content and humor of each chapter.

After completing the contents of each chapter, you will have a functioning program of amateur near space exploration. Following this book will spare you some of the head banging I went through when designing my own near space programs. This book will also introduce you to some of the people in the amateur near space community and I hope you will have the opportunity to meet these people. They are all wonderful to work with and know.

So are you excited about amateur near space exploration? Are you ready to begin building your own program of amateur near space exploration? Then pour yourself a nice cup of tea and start reading!

Onwards & Upwards!
– L. Paul Verhage

Good To Know: The Near Space Environment

Near space? This is probably a new term for you. Let me explain why I call the region of the Earth's atmosphere above 75,000 feet near space.

Most aircraft fly at altitudes below 50,000 feet. Military spy planes, the U-2 (not the rock band) and SR-71 for instance, fly at higher altitudes (higher than 100,000 feet in the case of the SR-71). Flights of the X-15 reached higher altitudes still. However the X-15 was really a rocket with wings rather than an airplane. According to the International Aeronautical Federation (FAI), space begins at an altitude of 62.5 miles or 100 kilometers. This is equal to 330,000 feet. At 63,000 feet the atmospheric pressure is equal to the vapor pressure of water at a temperature of 98.6 degrees F. In other words, your blood would boil. This altitude is called the Armstrong Line, or the boundary of the aerosphere. Above this transition zone the sky changes from dark blue to black and you can begin to detect the Earth's curvature. This transition occurs somewhere around 75,000 feet. I call the region of Earth's atmosphere above 75,000 feet near space because of what it looks like. Besides, 75,000 feet is a good round number.

Let us compare environmental conditions at mean sea level, at 85,000 feet, and on Earth orbit or 300 miles overhead. In the table below is listed the following conditions: average air pressure, distance to the horizon, color of the sky, and cosmic ray flux and type of cosmic ray at these three altitudes.

Some Visible Characteristics of Near Space				
Altitude	**Pressure**	**Horizon**	**Sky Color***	**Cosmic Rays****
Ground	1013 millibars	3 miles	Blue	4 counts/min All secondaries
85,000 feet	20 millibars	350 miles	Black	700 counts/ Min Primaries and Secondaries
300 miles	0 millibars	1500 miles	Black	? All Primaries

*** Chapter Fourteen discusses the topic of sky color   ** Chapter Eight discusses the topic of cosmic rays**

You can see from this table that conditions in near space are much closer to what astronauts see in orbit than to what we see on the ground. The atmospheric pressure at 75,000 feet is about 3% of the air pressure at mean sea level. Put another way, near space has at least 97% of the vacuum available in space. The atmosphere of near space is far too thin to scatter or refract sunlight. This makes the sky above the horizon black, rather than blue as seen from the surface. With so little air above 75,000 feet, sunlight is more intense than at the Earth's surface. In near space the Sun's UV flux increases. The increased UV flux occurs because near space is within the Earth's protective ozone layer. Not only does the atmosphere protect us from dangerous UV, the atmosphere also protects us from cosmic radiation. At altitudes above 62,000 feet the cosmic ray flux is some 200 times greater than on the ground. In near space the energy of each cosmic ray is also much greater. During an ascent into near space the air temperature drops to between –60 degrees to –90 degrees F. This combination of low pressure and temperature makes near space lethal to unprotected animal life. Conditions at 100,000 feet are identical to environmental conditions on the surface of the planet Mars.

At 80,000 feet the Earth's horizon is over 300 miles away. This is over one hundred times farther away than the horizon is for an adult on the ground. At 100,000 feet, the Earth's horizon increases to over 400 miles away. Compare this to what Shuttle astronauts see. In low Earth orbit astronauts see a horizon that is about 1500 miles away. Astronauts see a horizon that is only four times more distant than the horizon in near space.

One final observation: earlier it was stated that near space is not a microgravity environment. Because of the $1/R^2$ nature of gravity, at an altitude of 100,000 feet the near spacecraft weighs 1% less than it does at sea level. It's not microgravity, but it is measurable.

In most characteristics the near space environment is closer to what Space Shuttle astronauts experience in orbit than what we experience closer to the surface of the Earth.

Near Space Humor: A Real Near Space Mission [F]

JNSC *– Preparing to launch from the Johnson Near Space Center.*

The early morning of June 6, 1998, was clear and starlit. On mornings like these I begin my day with a trip to the office. There I check out the latest weather reports, winds aloft reports, and any late email messages. According to the morning's winds aloft report, our near spacecraft would recover near Kansas City. After completing these preliminaries, I drove to the KNSP launch site, the Johnson Near Space Center (JNSC). As the program manager I try to arrive first at the center where I turn on the lights and throw open the doors to welcome my volunteer launch crew. However, this trip to the JNSC would be a little bit different. Only a few miles away from the JNSC, a deer decided to run out in front of my Ford Escort. Needless to say, the deer did not win this confrontation. My car did not do so well either. There was no way I could drive this car on the chase. I would have to ride with someone else.

This launch would be our second time to launch two near spacecrafts at once. Usually KNSP only launches one near spacecraft at a time. Launching two at a time permits KNSP to get twice the data and experience with only a little more than one launch's worth of effort. My seasoned crew efficiently filled both balloons (1500 grams each) and certified the near spacecraft ready for launch. I believe the first near spacecraft launched was the Asimov II. It carried a small Styrofoam glider among other experiments. The program for this flight would release the glider at 50,000 feet. But the release mechanism decided to act up on this flight and released the glider at an altitude of 200 feet instead. If nothing else, it verified the mechanism worked and that a glider can be released from a near spacecraft and recovered. Next followed the launch of a near spacecraft named Sagan. Whereas the Asimov II was a general purpose near spacecraft, the Sagan was solely designed to loft a camcorder into near space as part of a KNSP program called VINES (Video In NEar Space). The second launch was flawless. Now it was time to pursue the near spacecraft. Mark Conner (N9XTN), the KNSP Meteorologist, gave four chase crewmembers a ride for this flight. Originally his passengers had planned to take the author's car on this chase, but the deer changed those plans.

The second incident of the launch occurred when the Asimov II passed 14,000 feet. Its onboard GPS hiccupped. This hiccup fooled the onboard electronics, placing the near spacecraft into descent mode. Now that it was in descent mode, the near spacecraft stopped performing experiments. The near spacecraft continued to transmit telemetry, but only engineering data and no science data. The Sagan continued sending telemetry every sixty seconds. It also continued recording video and would attempt to record balloon burst. I had high hopes for some spectacular video footage.

At 90,000 feet the Asimov II balloon burst, terminating its flight. At the same time, Chase Crews noticed the altitude of the Sagan was 98,000 feet, a record altitude for KNSP at the time. However we also noticed that the last telemetry was fifteen minutes old. Apparently the Sagan had failed at 98,000 feet. I surmised the balloon had burst and that the descent damaged its electronics. Fortunately there was a back-up, low-power transmitter on the Sagan. The plan was to use that beacon to track the Sagan after we recovered the Asimov II.

In Bonner Springs, Kansas, we left Bob Davis (K0FPC) to begin tracking the Sagan. Mark, Charles, Nathan, Tater, and I continued to Independence, Missouri to recover the Asimov II. There was so much traffic on the roads that I thought we would never get there. Eventually we did get through Kansas City and approached one of its suburbs, Independence. The wonderful thing about tracking a near spacecraft with APRS is that you know its exact location. You also know exactly what roads get you there. I gave helpful comments to Mark as he drove, but Mark probably thought I was not being very helpful at all. We made a turn into a residential section of town and were approaching the near spacecraft, finally. There were so many cars parked on the side of the road that we could not see the near spacecraft on the ground. However, we did notice some half dozen people gathered in a circle, looking down at the ground. It did not take a rocket scientist to figure out what was going on, although we did have five rocket scientists in the car. As we pulled up to the curb I said to everyone in the car, "X-Files, everyone." We exited the car and approached our audience. "Don't worry about it, we'll take care of everything," we said walking up to them. We explained to the homeowners and their neighbors what they had found. As is usual, we found the homeowners interested in what we were doing. Except this time there was a surprise for us! The homeowner had called a local television station. That's right; he called the news rather than the police when this strange object parachuted into his front yard. In fact, his wife saw the near spacecraft from the living room window as it landed in the yard.

It was fortunate that a television crew was on the way. This gave KNSP the opportunity to ask the local community to help look for the Sagan. Presently the news crew arrived and interviewed the homeowner and the author. That evening, a story about a near spacecraft landing in someone's front yard made the television news in Kansas City! After the interview we packed up the near spacecraft and headed back to Bonner Springs. From there we began our sweep in search of the Sagan. We received extra help when Don Pfister (KA0JLF) and his wife, Cris (N0XZB) met us. Unfortunately, the beacon of the Sagan had the same frequency as some home electronics. I'm sure many homeowners wondered what we were doing driving slowly up and down their streets, occasionally stopping the cars to get out for a walk around someone's yard with radios. I suppose we should count ourselves lucky that we were not arrested.

Since we were not detecting the Sagan's beacon, we decided to take to the air. From the air you can see for miles and also into fenced-in backyards. Outside Leavenworth, Kansas we found a cemetery that owned a private airstrip. The plan was to find a private pilot willing to take one of us up in his or her airplane. We arrived at the airstrip to find a locked gate. Fortunately, an old man on his motorcycle did show up a few minutes later. He turned out to be a private pilot who owned a Cessna 152 parked at the airstrip. Best of all, he said he'd be delighted to take a passenger up at no cost in search for the Sagan. Nathan volunteered for the ride. We outfitted him with some radio gear and saw him off. With any luck he would return with a visual confirmation of the Sagan's landing position.

While we waited, Don was occupied with business of his own. The next thing we knew, he had arranged for a flight with an ultralight instructor. The instructor owned a two-seater ultralight. Don would ride in the back as observer while the pilot flew him over the Leavenworth. We also outfitted Don with radio gear and saw him off. However, on its trip down the runway, the ultralight's engine throttled down and the pilot taxied back. The engine's fuel supply had stopped supplying the engine. After a few seconds of searching, the pilot found the cause of the problem. Don's helmet had bumped the fuel valve above his head. Don had accidentally killed the fuel flow to the engine. Fortunately he discovered this while still on the ground. There was no floor beneath his feet. Don worried about being pulled out of the ultralight when they were taxiing on the runway if he did not keep his feet up. Now not only did Don have to crouch down for the flight, he also had to keep his legs up. Now that Nathan and Don were airborne I felt confident we would find the Sagan.

With in an hour both Nathan and Don returned to the airstrip with no sight of the Sagan. Either they didn't see it, or the near spacecraft landed outside our predicted recovery zone (it turns out the Sagan recovered on the very edge of the predicted recover zone). The only thing to do now was to go home and hope someone would find the Sagan and give KNSP a call. Before we left for home though, we stopped at a pizza parlor for a well-deserved dinner. My volunteers were not helping the situation any with their jokes about my deer collision. Have you ever had a time when you wished everyone would change the subject?

The next morning the television station, Channel Four, gave me a call asking for additional details. After lunch they called a second time: one of their listeners reported seeing the previous night's newscast. The listener had an object similar to the Asimov in his backyard. I immediately called the second homeowner to determine if what they had was a radiosonde from the National Weather Service (NWS). No, it was not, the device had a KNSP label on it! I drove the two-hour trip to Tonganoxie feeling like I was at 98,000 feet. Once there, I finally recovered the Sagan and drove it home. At home the first thing I did was to review the video of the balloon burst. Talk about spectacular! The camcorder was recording as the balloon shredded at 98,000 feet in pitch-black skies. As the Sagan made its screaming descent, fragments of latex and a swirling cloud of talcum power remained behind. This is not the first record of a balloon burst in near space, but it was the clearest record of the event. I could not have asked for more!

Now, this is not a typical near space mission. Normally they go a lot more smoothly. Nothing gets lost, and chase crews are usually close enough to observe the landing. Instead of a 36-hour flight, typical near space missions take only three hours to complete. Chase crews most often share lunch after the recovery and are home in time for dinner. I hope soon you will have stories to tell of your own near space adventures.

A

This article was adapted from the author's 18 March 2002 presentation at the Space and Robotics 2002 Conference, Albuquerque, NM. The Idaho Space Grant Consortium and Dr. Basart of Iowa State University made this presentation possible

B

1. **Garmin makes several models of the 12 channel, Etrex Global Positioning System (GPS) Receivers. The basic Etrex is the least expensive model available. Garmin is online at www.garmin.com**
2. **The BS2p is the BASIC Stamp® 2p microcontroller module by Parallax, Inc. This microcontroller is based on one of the Ubicom SX microcontrollers and is programmed using the PBASIC language. Parallax is online at www.parallax.com.**
3. **The Micro Interface Module (MIM) is a one-way radio modem (a mo rather than modem?) for radios. The MIM is also built around a Microchip PIC microcontroller. A MIM can be ordered from http://web.usna.navy.mil/~bruninga/mim22.html.**
4. **The MAX186 is an analog-to-digital converter (ADC) IC with a resolution of 12 bits and eight separate channels. An ADC converts analog voltages from a sensor to digital values for the BS2p. Maxim IC will send two free sample ICs if requested. The Maxim website is at www.maxim-ic.com.**
5. **The Serial Servo Controller II (SSC II) was developed and is sold by Scott Edwards Electronics (Seetron). The SSC II is also based on a Microchip PIC microcontroller. Sending simple serial commands to the SSC II allows the BS2p to position up to eight servos and reduces the workload of the BS2p. Order SSC II's from the web at www.seetron.com.**
6. **The ULN2803 is an eight darlington pair IC. This IC allows the BS2p to control up to 12 volts at currents of one amp, compared to the 5 volt, 20 mA limit inherent to the BS2p.**
7. **Alinco is a manufacturer of amateur radio gear. The DJ-S11 is a lightweight, handheld radio with an output power of 340 mW. This is sufficient power for line-of-sight communications of over 300 miles.**
8. **This price assumes you make your own printed circuit boards.**

C

One 1200-gram balloon can carry near spacecrafts to altitudes of least 85,000 feet.

D

FAR 101 refers to Federal Aviation Regulation, Section 101. This section governs untethered balloon flight.

E

Balloon Track is a program for predicting the flight of a balloon, including its recovery zone. The program is available at no cost from the Edge of Space Sciences website at, http://www.eoss.org.

F

Excerpted (and embellished) from the author's article in the February 1999 issue of QST.