# The AMSAT® Journal

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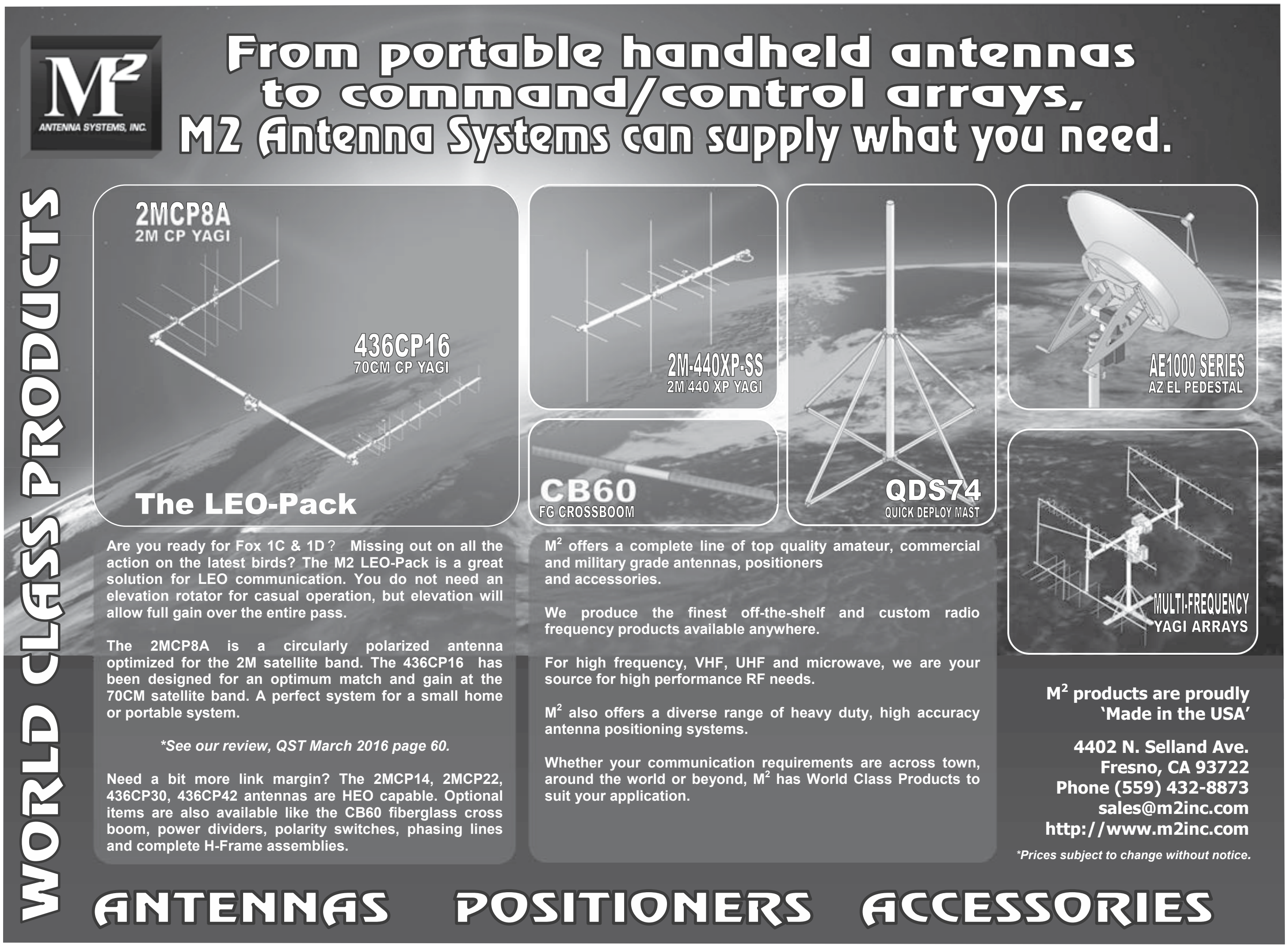
**Volume 45, Number 3** **May/June 2022**

Repurposed NWS Radiosondes

*In this issue —*




## Write for *The AMSAT Journal*

*The AMSAT Journal* is looking for interesting articles, experiences and photos to share with other AMSAT members. Writing for the *Journal* is an excellent way both to give back to the AMSAT community and to help others learn and grow in this most fascinating aspect of the amateur radio avocation.

Find a quiet place, sit yourself down, get out your laptop or pick up a pen, and …

1. *Launch* your inner writer;
2. *Downlink* your knowledge and experiences to others by:
-- Sharing your adventures in the "On the Grids" column or
-- Describing your AMSAT career in "Member Footprints;"
3. *Transmit* lessons learned from operational and technical projects;
4. *Log* some of your more interesting passes across the sky; and
5. *Boost* others to a higher orbit of know-how and experience.

After your article lands in members' mailboxes, and the kudos start arriving for your narrative payload, you can enjoy the satisfaction of knowing you've elevated the collective wisdom of AMSAT to a higher trajectory. Send your manuscripts and photos, or story ideas, to: journal@amsat.org.

Our editors are standing by!

**AMSAT's Mission**

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

**AMSAT's Vision**

Our Vision is to deploy satellite systems with the goal of providing wide-area and continuous coverage. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.

**Radio Amateur Satellite Corporation (AMSAT)**
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**AMSAT Club Callsign: W3ZM**
**AMSAT Websites: www.amsat.org, launch.amsat.org (Member Portal)**



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**The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPG formats. Kindly do not embed graphics or photos in your manuscript. We prefer receiving those as separate files. AMSAT reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations.**

# Apogee View

**Robert Bankston, KE4AL**
**President**

This year's Hamvention theme was Reunion, which was certainly evident among this year's attendees. After a two-year absence due to COVID restrictions, it was great to see everyone face-to-face and talk about the exciting opportunities of amateur radio in space. Like many of our visitors, I was excited and impressed with the progress and accomplishments in our Engineering, CubeSat Simulator, and Youth Initiative programs.

The AMSAT TAPR Banquet on Friday night was an excellent opportunity to come together with our friends at Tucson Amateur Packet Radio (TAPR) and pay tribute to Bob Bruninga, WB4APR (SK), who we lost earlier this year. I want to thank everyone who shared their stories of Bob, who has contributed so much to amateur radio and amateur radio in space.

Attendance at the AMSAT Forum was fantastic. Jerry Buxton, N0JY, and Jonathan Brandenburg, KF5IDY, provided an excellent Engineering update on GOLF, our in-house developed reaction wheels, and the new Fox Plus program. Frank Karnauskas, N1UW, brought us up to speed on the AMSAT Youth Initiative program, which takes an innovative and inspiring approach to introduce youth to amateur radio in space. Last but not least, Alan Johnston, KU2Y, and his students demonstrated the CubeSat Simulator and CubeSatSim Lite, which have made a terrific impact on the STEM education community.

I thank the volunteers who donated their time over the long weekend to serve as AMSAT Ambassadors at our booths. Our volunteers, led by Phil Smith, W1EME, did a phenomenal job in answering questions, helping our members, and making AMSAT's presence at Hamvention 2022 a huge success. THANK YOU!

## 40th Anniversary of the Space Camp

For those not aware, the U.S. Space and Rocket Center in Huntsville, Alabama, celebrated the 40th Anniversary of Space Camp on June 18, 2022. AMSAT Ambassador Tim Cunningham, N8DEU, hosted special event station K4S, demonstrating his field day amateur radio satellite station and answering questions about amateur radio in space. While Tim worked the International Space Station (ISS) several times, along with multiple contacts through other LEO satellites, the highlight of his efforts was facilitating a contact between a graduating Space Camp young lady and an astronaut aboard the ISS. Congratulations, Tim, on a job well done!

## An Innovation Roadmap

Innovation and experimentation are the cornerstones of what sets AMSAT apart in the amateur satellite community and what we need to continue to focus on in AMSAT's future.

In June 2021, AMSAT implemented a strategic plan defining who we are and where we want to go. In this plan, we affirmed our commitment to return to higher orbits and the vital role GOLF plays in helping us to develop the necessary systems and skills to take us there. In addition, we expressed our continued support in providing easily accessible amateur radio satellites in low earth orbit, encouraging the next generation of engineers, software developers, scientists, and mathematicians through STEM educational initiatives, and partnering with ARISS on human spaceflight programs. It is now time that we put that plan into action.

Compliance and Open Projects – Establish export control policy and open project framework to allow AMSAT's return to international collaboration. AMSAT is committed to complying with U.S. export controls laws and regulations, including the International Traffic in Arms Regulations (ITAR), the Export Administration Regulations (EAR), and the Office of Foreign Assets Control (OFAC) regulations. ITAR and EAR regulations govern the shipment, transfer, and access of export-controlled data, items, equipment, materials, and software to non-U.S. persons or entities (domestically and abroad). OFAC regulations impose sanctions and embargoes on transactions or exchanges with designated countries, entities, and individuals.

To ensure compliance with all Export laws, AMSAT must establish an Export Control policy, including procedures for complying with Export Control laws and educating all individuals working at, with, or on behalf of AMSAT, who work with, or have access to export-controlled technical data software, materials, and equipment, on such laws, policies, and procedures. This policy should require actively managing and monitoring compliance with Export Control laws and authorizing the creation of procedures to administer major organizational functions related to export compliance.

AMSAT also recognizes that a critical component of its mission is supporting fundamental research, developing relationships and participating in the worldwide scientific, amateur radio, and amateur satellite communities to further the pursuit of knowledge.

Export control laws restrict foreign national access to items or information that might be contrary to U.S. interests; however, these laws include exemptions for information published or disseminated in the Public Domain. AMSAT must take advantage of these carve-outs, when available, to further its international collaboration and outreach efforts.

As such, we are working on implementing the necessary online project management and collaboration tools to support our open projects and the required publication processes to share what we have learned with the world.

Experimentation and Education – Develop open and sustainable CubeSat programs to provide technological experimentation and educational support in Low Earth Orbits (LEO).

Low earth orbiting (LEO) satellites play a critical role in AMSAT's future. LEO FM CubeSats provide a cheap entry point to amateur radio in space. The lower costs associated with building and launching them make them an excellent platform to support our technological experimentation and STEM education initiatives. AMSAT's Fox Plus program will be the foundation for our future efforts in LEO.

In addition, proposed orbital debris mitigation standards will require all flight systems intended to be flown above low earth orbits to be "proven" in low earth orbit first. AMSAT's GOLF-TEE (Greater Orbit Larger Footprint - Technology Exploration Experiment) was developed to demonstrate the necessary technologies for higher orbits.

Scientific Research – Develop an open CubeSat program to enable scientific research related to amateur radio above low earth orbits. As space becomes increasingly crowded, obtaining a license to launch a satellite above low earth orbit will require a reason more important than amateur radio. Moving forward, we need to incorporate missions that include benefits for the greater good of society, of which scientific research and education appear to be our easiest path.

AMSAT is not a scientific research institution, but we can certainly benefit by partnering with educational institutions to study the long-term effects of radiation exposure on communication and command and control systems. For example, our partnership with Vanderbilt University during the Fox Program provides a template as we chart our return to HEO.
GEO Rideshare – Develop a program to secure an amateur radio payload in geostationary orbit above North America.

I am often asked, "When will AMSAT put a satellite in geostationary orbit?" The short answer is NEVER,… if we have to do it ourselves. The Federal Communications (FCC) is not going to allow a bunch of weekend warriors to play in geostationary orbit; not to mention, the price of admission, continued operation, and indemnification is beyond our reach. So, our best opportunity is to partner with someone already going there as a secondary payload.

No one has knocked on our door offering a free ride, nor have we succeeded in our numerous cold call attempts. We need someone on the inside or even a friend of a friend, who can get us in the room. If you know someone and an opportunity, I could use your help. Until next time, thank you for supporting AMSAT. Onward & Upward!

## eBay Sellers Donate to AMSAT

Are you an eBay seller? One item, ten items, or a full-time business you can donate a percentage of your winning bid to AMSAT.

To do so, do not list your item with the basic listing tool, select advanced tools. eBay will give you a warning message that it is for large volume sellers, however this is where the eBay for Charity tool is found.

You can "select another nonprofit you love" and search for either AMSAT or Radio Amateur Satellite Corporation. Choose the percentage amount of the sale you would like to donate to AMSAT, and boom!.

When your item sells and the winning bidder pays, eBay will deduct the percentage from your take and forward it to AMSAT.

Please consider giving a piece of the pie to a new satellite and choose AMSAT for your eBay Charity.

## Share Your Experiences as an AMSAT Member

The AMSAT Journal is looking for you to share your satellite radio experiences, likes and dislikes, how you work the birds, and what you like about *The AMSAT Journal*. We'll publish a selection of responses in upcoming issues of the Journal under a column we're calling "Members Footprints." Photos are strongly encouraged! Thanks!

Please send the information requested below to journal@amsat.org --

- Your Name
- Call Signs Held
- Primary Grid Square
- Favorite Satellite Contact
- First Satellite Contact
- First Satellite Ground Station Description
- Current Satellite Ground Station Description
- Reasons You Are an AMSAT Member
- Favorite AMSAT Memory (a satellite contact, symposium, engineering project, event that would never have happened without AMSAT, etc.)
- Favorite Topics Appearing in The AMSAT Journal (could include things like building a homebrew antenna, assembling a ground station, using tablets and smartphones, news of upcoming launches, portable operations, ARISS, etc.

Please Provide a Hi-Resolution Photograph (see www.amsat.org/?page_id=1709).

# Educational Relations Update

**Alan Johnston, Ph.D., KU2Y**
**V.P. Educational Relations**

I greatly enjoyed seeing many of you at Hamvention this year! During the event, I had a great time at the Education Table in the AMSAT Booth and gave an update on the CubeSatSim Project at the AMSAT Forum. At the Education Table, we had some AMSAT CubeSatSims on display, including a CubeSatSim Lite. I had three students help staff the Education Table and Jack Spitznagel, KD4IZ, shown in Figure 1 below.

We had one of the CubeSatSim's in SSTV mode with the camera pointed at the crowd, which turned into a selfie station. Two AMSAT'ers you might recognize are in the selfie in Figure 2.

We also had a new "Build Your Own CubeSat" activity. We had a complete set of non-functional CubeSatSim boards, frame parts, and solar panels, along with instructions on how to plug them together to build a CubeSat. Figure 3 shows one of the dozen kids who worked at it for 10 minutes to build it successfully.

I was delighted with how this activity worked out, and I plan to include the Build Your Own CubeSat activity in the CubeSatSim Loaner along with the instructions. It is also handy to have all the parts of the CubeSatSim so you can show them or point to them when discussing various aspects of the CubeSatSim.

If you have a Hamfest or STEM or Maker event in your area coming up, why not borrow a CubeSatSim Loaner and show it off? Contact me via email at ku2y@arrl.net or on Twitter @alanbjohnston to make the arrangements.

Also, in this month's *Journal*, there is an excellent article about repurposing National Weather Service Radiosondes for amateur radio High Altitude Balloon (HAB) flights. I have flown a sonde on a HAB before, and I highly recommend it.

For the latest CubeSat Simulator news, follow our dedicated Twitter account **@CubeSatSim**.

**Figure 1 – Jack Spitznagel, KD4IZ at the Education Table.**

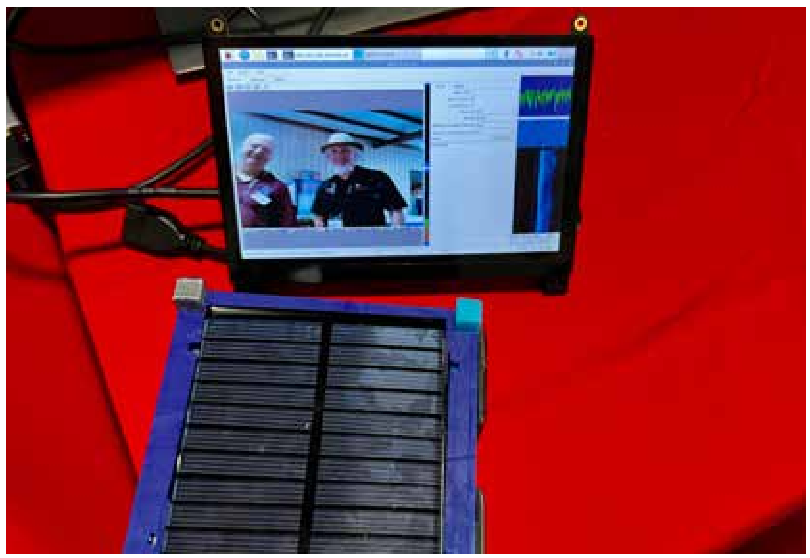
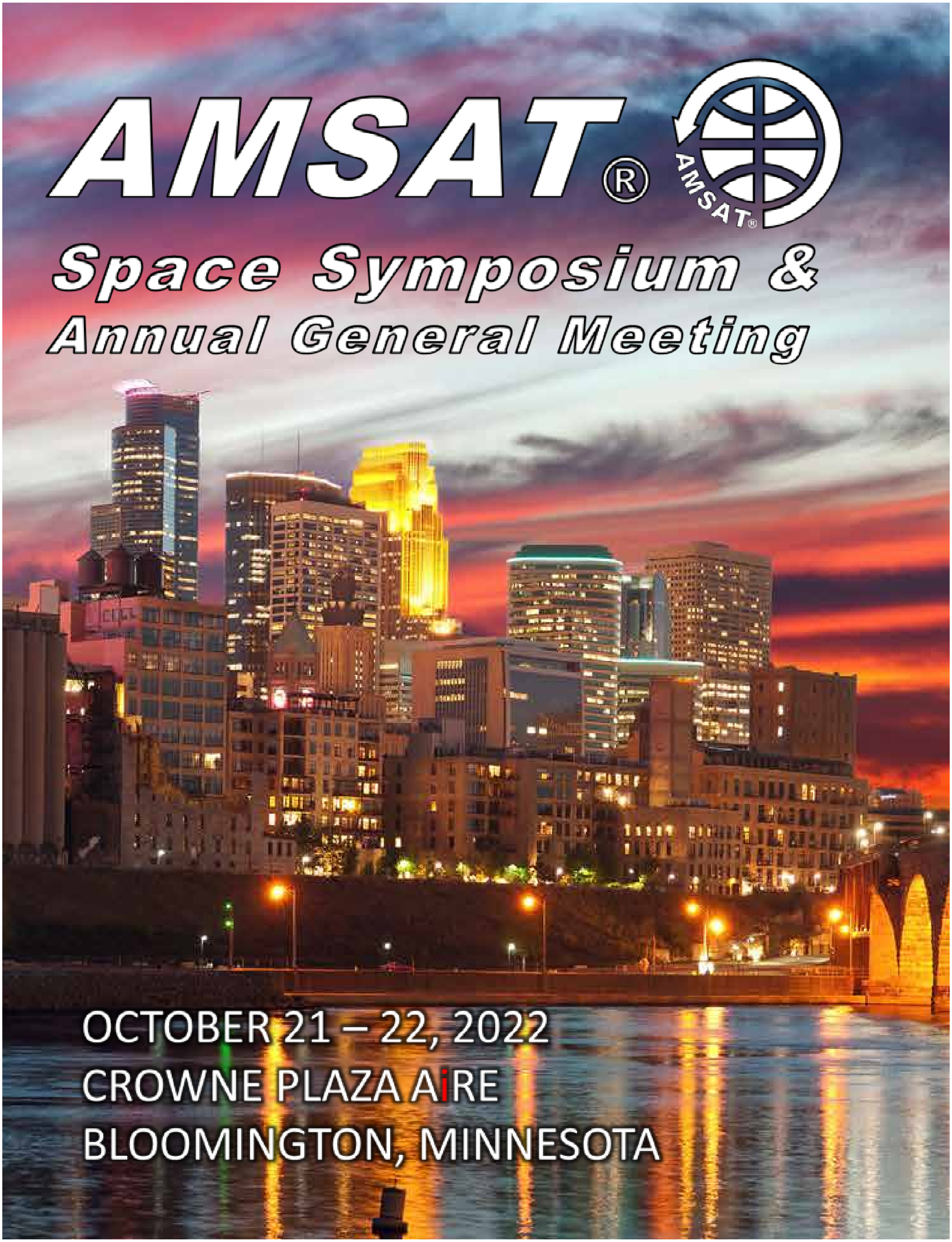


**Figure 2 – SSTV Selfies using the Fox-in-the-Box software with the CubeSatSim and the Raspberry Pi Ground Station.**

**Figure 3 – Build your own CubeSat activity.**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# Using Recovered National Weather Service RS-41 Radiosondes for Amateur Radio High Altitude Balloons

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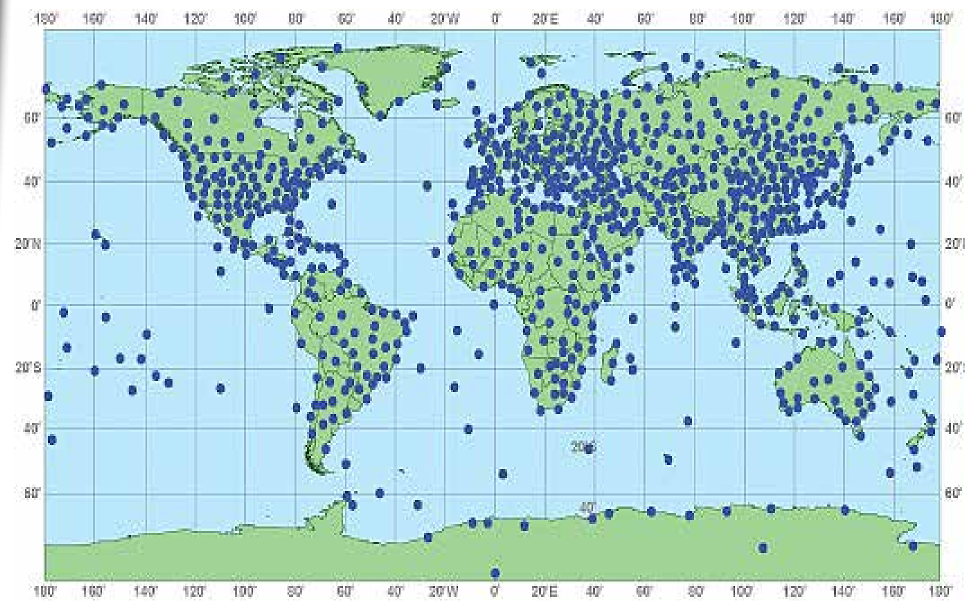



**Figure 1 — Map of radiosonde observations worldwide (Source NOAA).**

**Abstract**

The National Weather Service launches two balloons daily from 92 locations in the United States. In addition, other countries launch weather balloons from approximately 1300 sites worldwide. A few of these radiosondes are recovered by hams and repurposed as educational High Altitude Balloon (HAB) payloads. We have been mentoring the Mt. Carmel High School Amateur Radio Club (MCHSARC) here in San Diego, where we use HABs to teach various topics in electronics, computers and radio. Balloons are an ideal teaching tool, covering many concepts from fundamental physics to how sensor data can be collected and transmitted to a ground receiver. The following article outlines some of our experiences using recycled Vaisala RS-41 radiosondes.

## What is a Radiosonde (sonde)?

The National Weather Service defines a radiosonde as a small instrument package suspended below a sounding balloon filled with either hydrogen or helium. As the radiosonde is carried aloft, it measures position, pressure, temperature, and relative humidity. The weather service balloons, made of latex, continue to expand and rise to about 33 km (110,000'), burst and fall. The radiosondes are light enough (85g) that parachutes are no longer used (**www.weather.gov/jetstream/radiosondes**).

Several makes and models of sondes are used on the U.S. National Oceanic and Atmospheric Administration (NOAA) weather balloons. The Vaisala RS-41 sondes, in particular, have been reverse-engineered and are now being reflown on high altitude balloons launched by schools and individuals worldwide. Reverse-engineered information on the RS-41 sonde can be found here: **github.com/bazjo/RS41_Hardware**.

## Why are High Altitude Balloons (HABs) of Interest to the Ham Radio Community and AMSAT in Particular?

The Radio Amateur Satellite Corporation (AMSAT) Strategic Plan 2021-2035


**Figure 2 — Recovered Vaisala RS-41 sonde. Note markings: "Please do not return the radiosonde to the NWS" and "HARMLESS WEATHER INSTRUMENT."**

outlines several objectives and organizational goals, including increasing awareness and interest in Science, Technology, Engineering, and Mathematics (STEM) programs. Among AMSAT's STEM initiatives is High Altitude Ballooning (**www.amsat.org/strategicplan/**).

While satellite missions can take years and cost tens of thousands of dollars to build, a HAB mission can be planned and executed in weeks and costs only a few hundred dollars. Additionally, HABs can be used to teach many amateur radio and satellite concepts at all educational levels. Concepts include radio basics, how they send sensor data from payloads to ground stations, the essential components of payloads and ground stations and how they are analogous to satellite payloads and ground stations. Like a satellite, a HAB must be tracked, and ground stations must be designed and deployed accordingly. HAB payloads range from simple to very complex. In addition, HAB payloads can often be recovered, reducing costs.

## Sonde Recovery Process

If a sonde's landed coordinates are known, it can be picked up whenever convenient. The RS-41 sondes flown in San Diego transmit their landed coordinates for about eight hours. If the final landed coordinates are not already known, then getting within one to two miles usually allows them to be picked up with a portable receiver.

The MySondyGo project has developed software that is used with a TTGO LoRa board to receive the native NOAA Sode data and display latitude and longitude information. Information on the project can be found here: **mysondy.altervista.org/mysondygo.php**. With the landed coordinates in hand, any number of GPS navigation devices and apps can guide you directly to the sonde. Another approach is classic ham T-hunting with an FM handy-talky, directional antenna and attenuators as required.

Once the landed coordinates are known, Google Earth can provide valuable information about its location: open country, in water, on a large building, behind a gated area, or in steep or brushy terrain. It can also give the distance from the nearest road, with Street View showing conditions along the roadside. The sondes can land in trees, so a pole or string with a weight can help recovery. For steep or loose terrain, a pair of hiking poles makes life much easier and safer. For brushy terrain, take long sleeves and pants.

**Figure 3 — Sometimes you get lucky and can just drive up and recover the sonde!**

## Ham Software Flashed on RS-41 sondes

The Mt. Carmel High School Amateur Radio Club (MCHSARC), W6SUN, in San Diego, California, has had much success reflashing the RS-41 sondes with custom Horus 4FSK software written by Mikael Nousiainen OH3BHX. We use 431.05 MHz in consultation with the Southern California Repeater and Remote Base Association (SCRRBA). You can download Mikael's RS41ng software here: **github.com/mikaelnousiainen/RS41ng**.

The Horus 4FSK software transmits altitude, latitude, longitude, internal temperature, and any data received from the sonde's 10-pin accessory connector. Because the RS41's stock temperature and humidity sensors are on an external stalk that is usually damaged on landing, we've experimented with BME280 sensor ICs on the accessory connector. Unfortunately, we've had them fail when they get wet, so we're currently experimenting with various ways to protect them.

The RS41 power button latches on an internal power supply MOSFET switch. The software can turn it off, but the reprogrammed sonde remains on until battery exhaustion: the 10-pin connector supplies 3.0 and 3.7 volt power, ground, and data bus signals. If either supply is shorted to ground, the sonde shuts down. Restarting the sonde requires removing the short circuit and pushing the power button again, which won't happen after launch. (Some groups "hotwire" the MOSFET switch so that power is always on whenever the batteries are in; we might do this.) We suspect that the BME280 shorted the supply when it got wet and caused one sonde to stop transmitting shortly after it was released into rain. Pressure, humidity, and temperature data from the BME280 stopped shortly before the sonde stopped transmitting.

The 3.0 and 3.7 volt supplies can provide at least 200 mA to an external load. A BME280 draws only 0.5 mA, so a 150 ohm current limiting resistor was added. The typical 0.08 volt drop is negligible, but worst-case load is limited to 25 mA. During another launch on an overcast day, BME280 data stopped after the sonde entered a cloud; perhaps condensation disabled it. However, the sonde otherwise operated successfully for the rest of the flight.

Further work is needed to protect the BME280 from water. The BME280 is also limited to minimum temperatures and pressures of -40 C and 300 hPa, restricting accurate data to the lower portion of the flight. Perhaps there are alternatives for lower temperature and pressure ranges.

## Sonde Antenna Modification and Results of RF Output Testing

RS-41 sondes transmit in the 400.15 - 406 MHz Meteorological Aids band, about 7% below our 431 MHz amateur frequency. A change to the antenna length or impedance matching components is required to retune the antenna. Changing the antenna length is easier.

To measure antenna SWR, we must attach a coax cable to the device. First, the shield of the cable is attached to the circuit board's ground near the antenna. Then, the circuit trace between the transmitter and antenna is cut, and the center conductor of the attached coax is connected to the cut trace on the antenna side, as shown in Figure 4.

The sonde antenna is a vertical dipole, fed

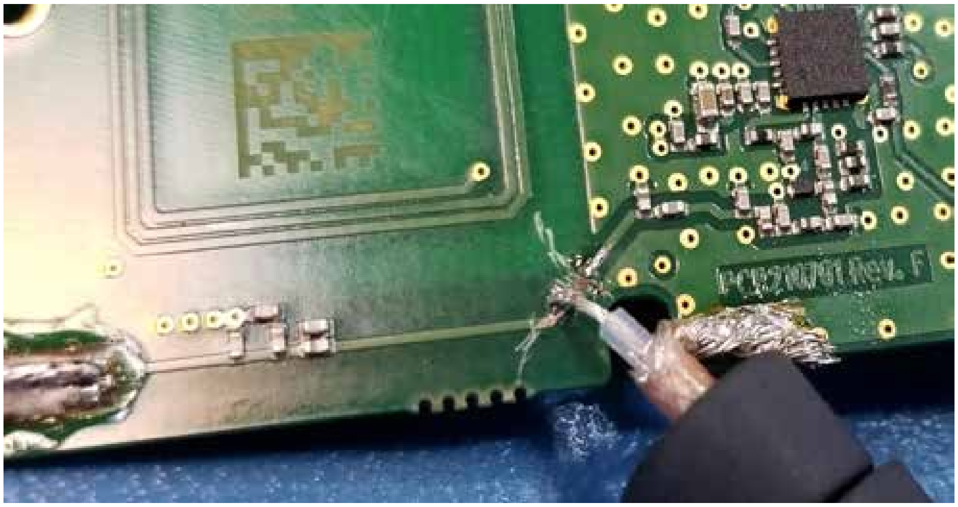


Figure 4 — Coax cable attachment to measure antenna SWR.

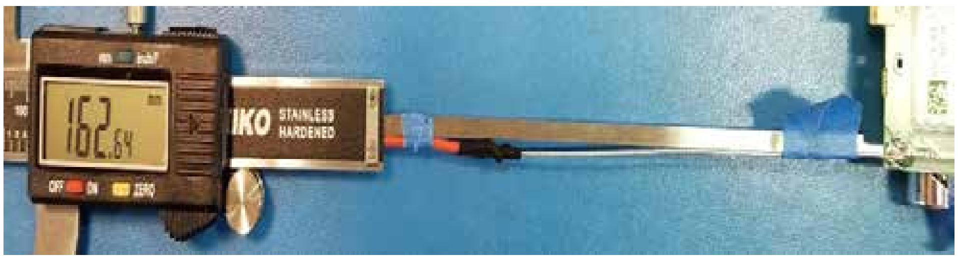



**Figure 5 — The optimum antenna length for 433 MHz use is 163 mm, measured from the end of the board.**

somewhat off-center. Its lower dipole arm is the 135 mm long antenna wire; the upper dipole arm is the circuit board and everything conductive attached to it, such as the long temperature - humidity sensor. It should be noted that the coax cable attached to measure SWR is an addition to the upper dipole arm that is not usually there. To minimize the degree to which this coax cable impacts the measurement, multiple ferrite beads were installed over the coax cable to add a high impedance to currents running on the outer surface of the cable.

The total length from the end of the sensor to the end of the antenna wire is 377 mm, which is a half wavelength at 398 MHz, almost exactly the 403 MHz frequency the radiosondes operate.

The temperature-humidity sensor is not used for our application and is removed. This shortens the length of the upper dipole arm by 125 mm. This significant reduction in length changed the resonant frequency from 410 to 495 MHz. To lower the frequency to the 420 to 450 MHz range required lengthening the antenna wire from 135 mm to 163 mm. The result was the total length of the modified sonde and antenna wire was 282 mm. As expected, the entire length of a 435 MHz antenna is shorter than a 403 MHz antenna.

Output power was measured on the same sonde by moving the coax from the antenna to the transmitter side of the cut trace. Transmit power can be set in software; the 4FSK reprogrammed sondes produce +17 dBm (50 mW).

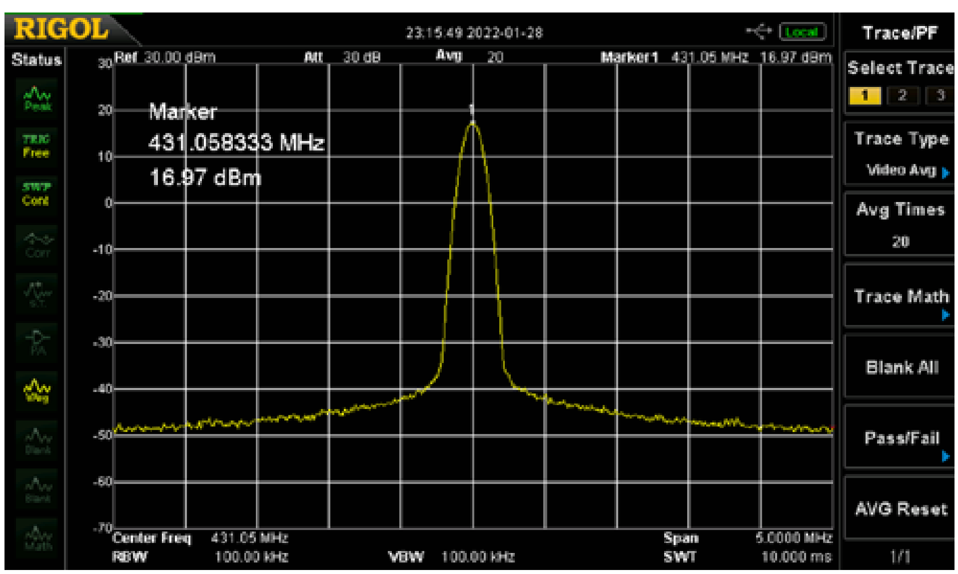



Figure 6 — 4FSK transmitter power.

## Ground Station Software Running on a Raspberry Pi

To decode the reprogrammed sondes that are transmitting in Hours 4FSK mode, the club has been building ground stations with an RTL-SDR and a Raspberry Pi running the Project Horus's Telemetry Demodulator Library that Mark Jessop (vk5qi@rfhead.net) et al., have made available here: **github.com/projecthorus/horusdemodlib/wiki.** Our high school students have built their own ground stations with this software. With additional software, this setup can also decode the sondes as first flown by the weather service. More information can be found here: **github.com/projecthorus/radiosonde_auto_rx**.

Both programs can be installed on a single SD card for the Raspberry Pi, and the user can toggle between them to decode the original Weather Service sonde firmware on 400 MHz or those reprogrammed to transmit 4FSK on the 70 cm ham band. Because the bandwidth of the RTL-SDR is limited to about 2 MHz, it cannot receive 400 and 431 MHz simultaneously.

The dual-mode ground station shown in Figure 7 can decode both weather service sondes on 400 MHz and ham sondes on 431 MHz. The two concatenated filters form a bandpass filter that protects the SDR from strong signals, e.g., ham FM repeaters between 445-450 MHz. This ground station uses a Raspberry Pi 3.

## Antennas - Simple, Sophisticated and Rugged Antennas at Repeater Sites

Antennas sold for the 70 cm amateur band (420-450 MHz) often perform poorly in the 400.15-406 MHz radiosonde band. Collinears have a lot of gain at the horizon at the expense of high elevation angles. Even discones have many nulls in their elevation patterns. (NOAA's radiosonde launch site at Marine Corps Air Station Miramar is only a few km from most of the receiving stations, so elevation angles can be quite high.) Since we use the lower part of the 70 cm band, a simple low gain antenna covering 400-435 MHz is ideal for both stock and amateur-modified radiosondes. This 8% bandwidth is within the practical range of a half-wavelength dipole. Still, you are unlikely to find such an antenna in a catalog because probably no one has asked a manufacturer to build one. But this isn't so bad because part of the fun of amateur radio is designing and building antennas from scratch.


**Figure 7. A dual-mode ground station is built into a protective enclosure.**

## Simple Ground Station Antenna

A simple ground station antenna that the high school students have built is a ¼ wave ground plane for 400-435 MHz. This antenna can be used for both the stock and reprogrammed ham sondes. Details are depicted in Figures 8-11.

EZNEC+ is a popular antenna modeling program that accepts multiple straight "wire segments." The results are very accurate, provided the segment lengths are much greater than their diameters, which definitely applies to this ground station antenna. There is no limit to the number of segments or their orientations. Each segment is defined by specifying the endpoints' x, y, and z coordinates. The upper left figure shows the antenna structure as entered in EZNEC+. The five wire segments of the antenna and the X and Y axis are shown. The calculated SWR over 395 to 445 MHz is shown in the lower-left figure. EZNEC+'s calculated radiation pattern is on the right, showing relative power vs. direction. Here the peak is on the horizon with deep nulls at +90 and -90 degrees in elevation. All antennas have the same radiation pattern receiving or transmitting.

Modeling with programs such as EZNEC+ allows quick "what if" questions when tuning an antenna. For example, the center frequency of this antenna is affected by the length of the wire segments, and the SWR at the center frequency is controlled by the angle of the four ground radials. EZNEC+ can also display things that can't easily be measured, such as the current along the wire segments and the radiation pattern. The effects of metal near the antenna (such as other antennas or support structures) can also be modeled.

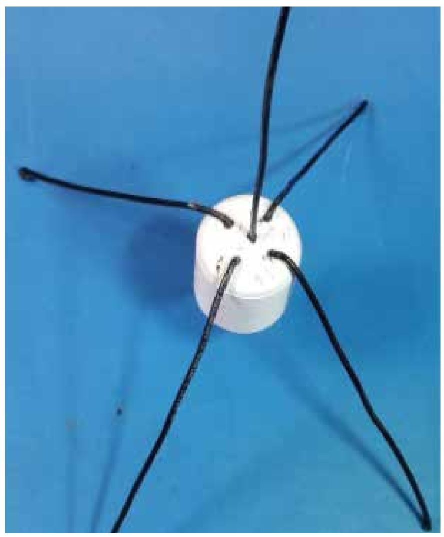


**Figure 8 — Antenna and ground radials ~6.5 inches 12 gauge solid copper wire. Ground radials bent down ~45 degrees, with ends bent for safety.**

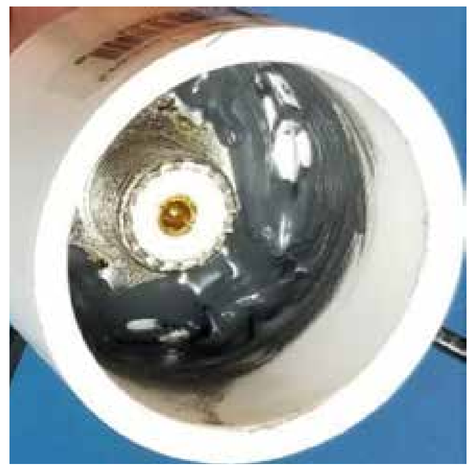


**Figure 9 — SO-239 inside PVC cap, secured and sealed with epoxy. The 1¼-inch PVC cap has an inside diameter of 1.60 inches and fits over 1¼-inch EMT masts. Use a Type 31 ferrite choke on the cable to help reduce cable radiation.**

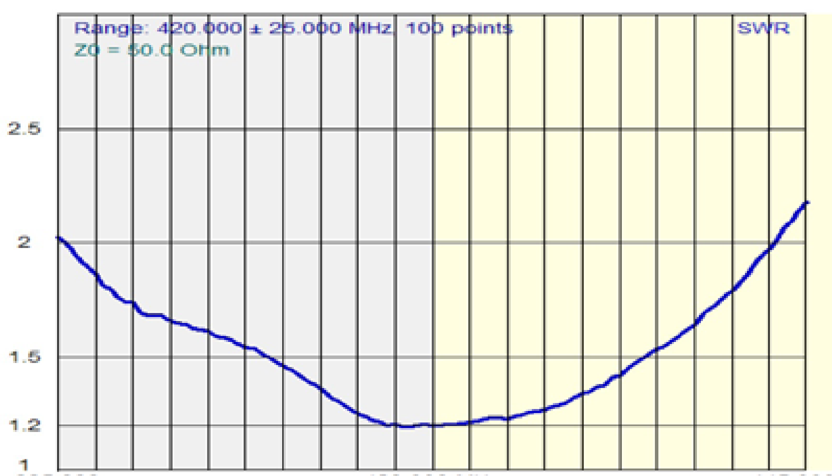



**Figure 10 — ¼ wave ground plane SWR @ 400 MHz = 1.7:1 SWR @ 435 MHz = 1.5:1.**

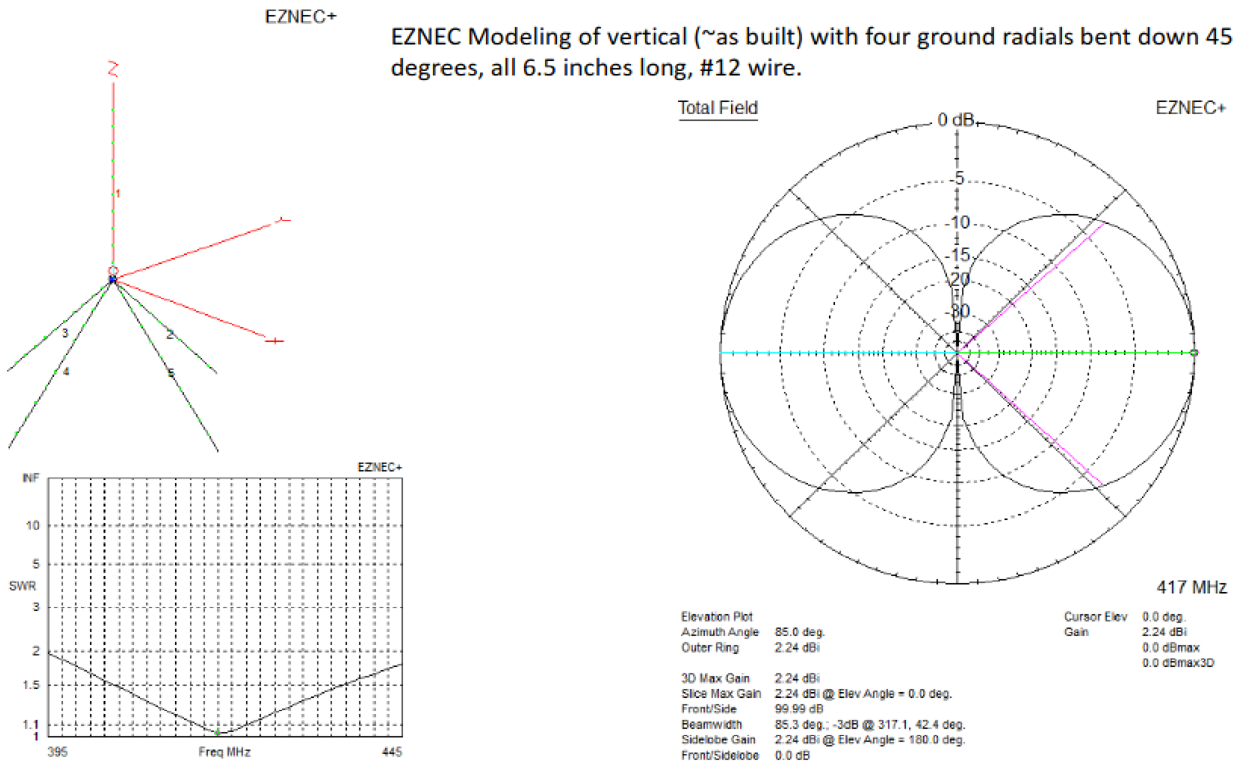



**Figure 11 — EZNEC+ model results for the ¼ wave antenna.**

**Advanced Ground Station Antenna with Pre-Amp and Dual-Frequency Capability**

One successful omnidirectional antenna is a DIY 400 MHz J Pole. This is a very rugged antenna built from a ⅜" Aluminum rod and 3/8-24 to UHF Female SO-239 Ham Radio Antenna Stud Mount Adapter.

*Preamps* –

The Mt. Carmel High School group uses inexpensive RTL-SDR dongles for our ground station receivers. These devices have a ~7 dB noise figure. We also typically have a coax run from the outside antenna to the dongle adding to the noise figure.

**Figure 12 — Mentor Randy Standke (KQ6RS, foreground) working with students to tune their ground station antennas. Mentor Phil Karn (KA9Q, background) working with students to solder their antennas.**

Good results have been achieved using an inexpensive LNA mounted at the antenna to help overcome losses and noise. One such LNA is the SPF5189Z 50-4000 MHz LNA purchased on eBay for as low as $5.00.

The LNA is powered externally or from the feedline with five VDC injected by a bias "T" near the dongle. Some dongles have an internal bias T that can be turned on to supply LNA power. These LNAs draw about 100 milliamps that the RTL-SDR or external bias T must supply. At 400 MHz, these preamps have a measured noise figure of 0.4 dB or less and 23 dB gain. They also have a high third-order intercept point (Oip3) of +39 dBm making intermodulation less likely. But some of these preamps have a fake SPF5189Z device installed; their noise figures are over two dB, and gain is only 15 dB. We have replaced these fake parts with real SPF5189Z or PGA-103+ devices from Mouser for about $4 each.

Most RTL-SDR-type dongles are very susceptible to overload from strong VHF/UHF broadcast stations and repeaters outside the frequencies of interest. LNAs can make it worse. A bandpass filter can be placed ahead of the SDR dongle or LNA to eliminate this problem. The filter can be a DIY type (e.g., by W1GHZ at **w1ghz.org/filter/Altoids_Tin_Filters.pdf**) or the 433.92 MHz SAW filter type SF2176E or RF1419D 403.5 MHz SAW filter available from Digikey or Mouser. These small 3 mm SAW devices must be mounted on a suitable board, e.g., "Develop PCB for Surface Mount SAW Filter 3 x 3 mm" sold by RFEXTRA on eBay. These filters are matched to 50-ohm coax.

**Figure 13 — DIY 400 MHz J Pole.**

To receive sondes in two different bands with our remote mountain top based ground stations, KQ6RS and N6IZW developed a dual-band filter unit with almost the same loss as a single band filter. Two SAW filters can be paralleled using coax lengths chosen so that the filter for the other band presents an open circuit. This keeps the inactive filter from causing an impedance mismatch with the active filter. Filters reflect out-of-band power, and transmission lines change reflection phase angles by the negative of twice their electrical length. 100% reflected power with a positive phase angle (such as between +1 and +179 degrees) is a shunt inductance. 100% reflected power with a negative phase angle (such as between -1 and -179 degrees) is a shunt capacitance. An open circuit (infinite impedance) has a reflection angle of 0 degrees. A short circuit (zero impedance) has a reflection angle of 180 degrees.

The length of the transmission line selected between each filter and the SMA connector of the filter assembly is chosen to change the out-of-band reflection angle to 0 degrees (or 360 degrees) at the passband of the other filter. The filter loss is about 3 dB for each band. The SAW filters are static sensitive and rated at only 3 V, so a 100 nH DC bypass inductor was added across the input and output connectors to ground.

**A Rugged Antenna for Repeater Sites**

Receiving a balloon at high altitude is relatively easy. The trick is tracking one to the ground so it can be easily located and recovered. To do this, we placed ground stations at two high-altitude repeater sites


**Figure 14 — SPF5189Z preamp "fixed" by replacing the fake SPF5189Z part.**

**Figure 15 — Dual narrow band filter assembly.**

**Figure 16 — A 400-435 MHz sleeve dipole at the Toro Peak repeater site in southern California, elevation 8717' (2657 m).**

**Figure 17 — The sleeve dipole antenna before insertion in a length of PVC pipe. The lower half of the dipole (right side of the photo) is a large cylinder made from a copper screen. The coax braid and screen are attached at the center of the dipole. The center conductor of the coax connects to copper foil, supported by Lexan (top left side of the photo).**

with good views of the usual landing areas. Unfortunately, these sites are hard to access and are often subject to icing and high winds, so their antennas require special considerations.

Not only must an antenna behave well electrically, but it must also be mechanically rugged and mast-mountable. One such design is the sleeve dipole. This is a half-wavelength dipole with the coax feed exiting out of a large diameter cylinder forming the lower half of the dipole. Note that the more common dipole has a balanced feed perpendicular to the dipole arms.

The feed line and the lower dipole half are well isolated because the outside of the coax cable and the sleeve form a shorted coax cable a quarter wavelength long. This results in a very high impedance between the end of the lower half of the dipole and the coax.

## Mt. Carmel High School ARC Experience

The Vaisala RS41 weighs about 85 g with batteries, so MCHSARC has been flying 200 g balloons to reduce the helium required, and this combination typically reaches altitudes of 20 km or higher. The club often flies two sondes on each flight, one transmitting 4FSK for reliable tracking and a second with experimental software and payload, such as a camera. The payloads commonly use a student's callsign to reward the already licensed students and motivate the other students to get their ham licenses. Whenever possible, we recover our payloads, but because our hardware investment in each payload is so low, we don't try to recover payloads that go into Mexico, restricted military areas, or land in extremely remote locations. This is a substantial practical advantage! When we build our own payloads from scratch, we often wait weeks for the winds to be just right for recovery, and even then, we lose them. But when we can't recover our modified RS41s, we simply pick up more that the weather service has launched. (They launch much more frequently than we do.)

We also reuse the recovered NOAA balloon fill valves. This has dramatically simplified filling and launching.

We used to fill our balloons by inserting the fill tube directly into the neck, inflating it with approximately the right amount of gas, removing it to measure free lift, then repeatedly venting or adding gas as needed. Getting a good seal between the fill tube and the balloon neck was tedious, as was verifying the right amount of gas for the desired free lift. Balloons launched by the Vaisala automatic launcher ("Autosonde") have an inflation valve in the neck that looks and works like a tire inflation valve. When we recover one, we almost always find the valve still attached, so we remove and reuse them. We machined a custom fitting for our fill gas line; when inserted into the valve, it opens the spring-loaded valve and allows gas to enter. When the balloon just lifts a calibrated water ballast, we remove the fill line fitting, unhook the ballast, and we're ready to fly. The details for the valve are shown in Figures 18-22.

For the dual sonde payloads with a camera, we use 15 meters of string with a measured breaking force of 30 lbf (133 N). (FAA rules require a breaking strength of less than 50 lbf). We use only 1-2 m with a single payload. The sondes swing under the balloons; this is not a concern for GPS or sensors but produces many tilted camera pictures, some as much as 45 degrees, as the balloon is pushed sideways by wind shears and the payload is forced to follow. We have found that a long string significantly reduces

**Figure 18 —** Recovered valve and retainer ring.

**Figure 19 — Valve external to the balloon.**

**Figure 20 — Internal side of the valve, closed position**

**Figure 21 — Internal side of valve, open position.**

camera tilt as a given amount of horizontal balloon movement creates less of an angle at the camera.

### Villanova University CubeSat Club Experience

The Villanova University CubeSat Club, with help from the Villanova University Amateur Radio Club, W3YP, has started launching HABs with mentoring help from the Mt Carmel High School Amateur Radio Club. An initial HAB carried an AMBASAT-1 payload with a 915 MHz LoRa transmitter. A recent HAB launch carried a RS-41 radiosonde recovered and reflashed by the Mt Carmel High School ARC mentors. We established two ground stations: one on the roof of a campus building at the launch site and another on the balcony of a high-rise building about halfway along the projected flight path.

The sonde payload performed amazingly well. We could track the entire flight path with just the two ground stations, and the final packet received at less than 1000 feet of altitude was received from the campus ground station! Unfortunately, our commercial GPS tracker failed on this payload, but the sonde allowed us to track the payload and ultimately recover it for a future flight.

### Contact Us

For more information about sondes and amateur radio, feel free to reach out to any of the authors of this paper.


**Figure 22 — Details of the machined Delrin fill adaptor used with the recovered fill valves. Dimensions are in inches.**

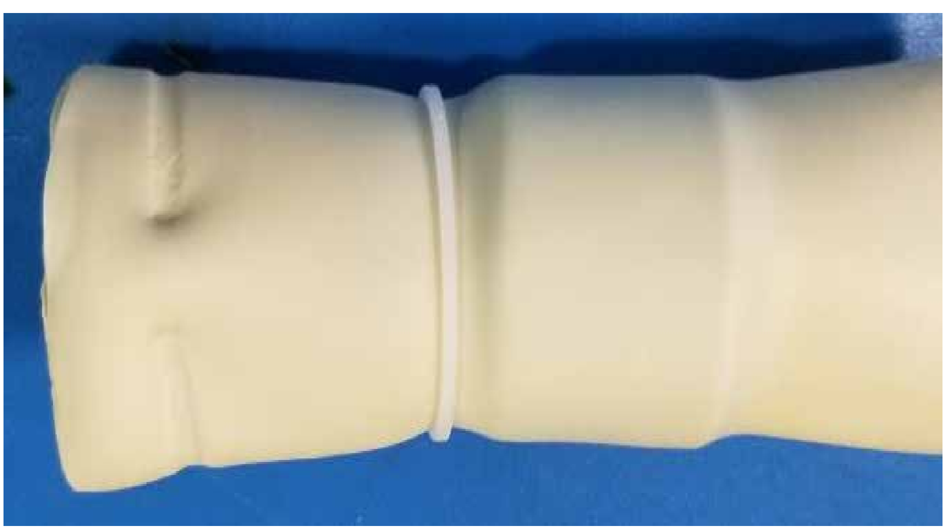


**Figure 23 — Valve inserted into balloon neck. Note the white retainer ring is slightly smaller than the valve outside diameter.**

### Acknowledgments

The Mt. Carmel High School Amateur Radio Club wishes to thank Howard Bassham, K6RYA, for his generous financial support to the club; Cecil Casillas, WD6FZA, Chris

**Figure 24 — End of balloon neck pulled back over the retainer ring and valve.**

Durso, AA4CD, and the PAPA System members for hosting receivers at various PAPA repeater sites in the San Diego area; and Ray Waldemar, WA6NVL and Fredric Raab, KK6NOW, for hosting ground stations. A special thanks to Mark Jessop, VK5QI, and his coauthors for providing the Project Horus Demodulator software and the Amateur Radio Experimenters Group (AREG) for their support of HAB and providing outstanding websites and software tools.

We especially wish to thank John Earnest, KG6EQU, for his tireless dedication to the Mt. Carmel High School students and his facility sponsorship of the Amateur Radio Club.

**Figure 25 — MCHSARC students filling a 200 g balloon. Note dual sonde payloads on the left side of the tarp. One transmits 4FSK for tracking, and one runs experimental software with a custom camera.**

**Figure 26 — Students launching the 200 g balloon.**

**Figure 27 — The MCHSARC launch team.**

# Spotlight on the APRS Satellites

**Keith Baker, KB1SF/VA3KSF**
**kb1sf@yahoo.com**

*[Portions of this feature first appeared as Spotlight on the APRS Satellites in the June 2022 edition of The Spectrum Monitor magazine. Thank you, TSM!]*

In previous Journal features, I've been highlighting the many ways for you to get in on the fun of satellite operating as well as sharing information on some of the international organizations that make it all happen. In this feature, I'll shine the spotlight on a series of satellites built and launched specifically for the Automatic Packet Reporting System (APRS). APRS is the brainchild of Bob Bruninga, WB4APR (who, unfortunately, became a Silent Key earlier in 2022), a senior research engineer at the United States Naval Academy. And, as you might guess, the acronym APRS was derived from the suffix of his amateur radio call sign. Bob also officially filed both the full name of his concept (as well as the acronym) as registered U.S. trademarks.

## APRS

As many amateur radio operators well know, APRS is an amateur radio-based system for real-time digital communication of information that can include Global Positioning System (GPS) coordinates, weather station telemetry and text messages. APRS data can also be displayed on a map, which can show stations and objects, along with the tracks of moving objects, as well as search and rescue or direction-finding data. In Bob's words, APRS is a "two-way tactical real-time digital communications system between all assets in a network sharing information about everything going on in the local area."

## Satellite Beginnings

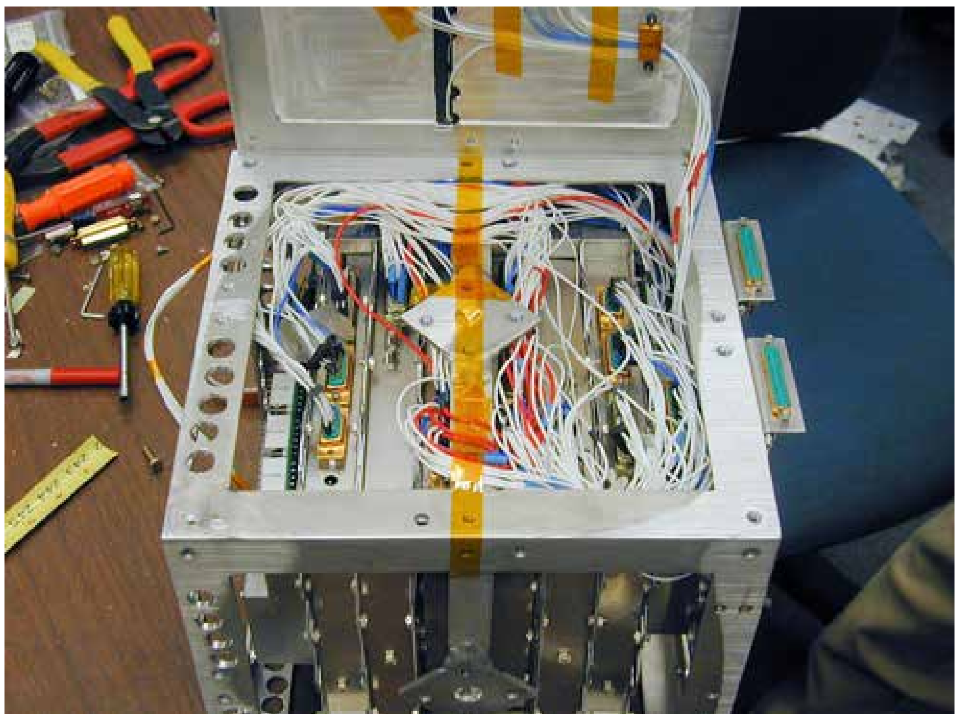
For years since its introduction as another ham radio activity, ham radio operators actively embraced Bob's brainchild.

However, up to that point, it was primarily a terrestrial-based activity. So, back in the mid-1990s, when I was then part of the AMSAT leadership, I recall Bob and I had a passing conversation at that year's Dayton Hamvention. Bob wanted our permission to try running APRS through one of our satellites.

At the time, our AO-16 PACSAT (one of the four original Packet satellites launched back in 1990 and which was "owned" by AMSAT) was orbiting virtually unused, as most store-and-forward packet satellite work had already moved on to the higher throughput FM PACSATs (UO-22 and KO-23). AO-16 was initially designed primarily as an experimental satellite whose transponder suite used an odd combination of digital F.M. and SSB cross-band emissions.

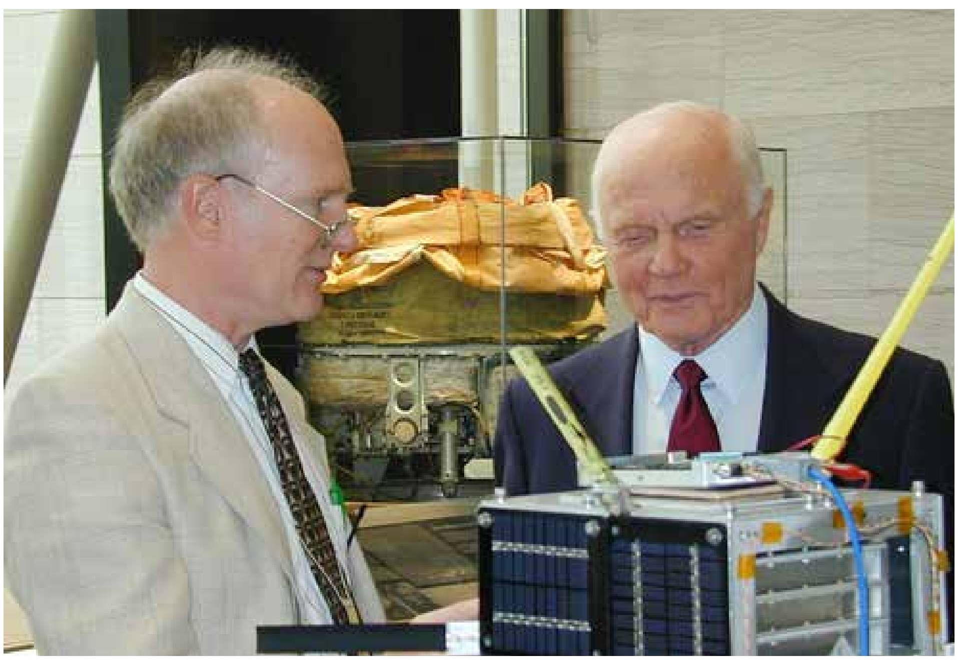
I also vividly remember taking Bob's request back to our AMSAT Board of Directors for discussion. A long-held tradition from the earliest days of the AMSAT OSCARS was to designate Wednesdays as "Experimenter Days." What Bob and his crew wanted to

**Bob Bruninga, WB4APR (SK) (Center), directs two U.S. Naval Academy Midshipmen as they put the finishing touches on the flight model of PCsat, which became NO-44 on orbit. (Courtesy: USNA)**



**The flight model PCsat is shown here undergoing final assembly in the U.S. Naval Academy Lab. Note the drilled holes in the aluminum spaceframe. This technique is frequently used in amateur satellite construction to cut down on the satellite's mass, which often directly relates to launch costs. (Courtesy: USNA)**

**The flight model PCsat is shown here in the U.S. Naval Academy Lab. Note the two black and white painted tape antennas. These are used much like the little sun-powered radiometers we often had as children to give the satellite an approximate 1 RPM spin on orbit. (Courtesy: USNA)**



**Bob shows off an engineering model of his PCsat to NASA Astronaut and (then) U.S. Senator John Glenn at a National Air And Space Museum's Space Day in Washington, DC. (Courtesy: AMSAT)**

try with APRS on AO-16 fit that definition perfectly.

And, I'd like to think the results of those initial (and highly successful) experiments running APRS data through AO-16 laid a firm foundation for Bob's later work at putting APRS transceivers on the NASA Space Shuttle, as well as the Russian MIR and International Space Station (ISS). In addition, and as you will also see, those humble beginnings led to a whole series of APRS satellites that were later developed, launched and controlled by Bob and his crew at the U.S. Naval Academy.

## PCSat (NO-44)

Bob's first dedicated APRS satellite was the PCsat, which became Navy Oscar 44 (NO-44) on orbit. It was launched on September 30, 2001, at 0240Z aboard the "Kodiak Star," a Lockheed-Martin Athena I launch vehicle. This was the first launch from the Kodiak Island (Alaska) Launch Complex. NO-44 was one of four payloads on this launch, a collaborative effort between NASA and the U.S. Department of Defense. Bob and U.S. Navy Midshipmen built NO-44 in Bob's U.S. Naval Academy Laboratory.

NO-44 was the first satellite to directly report its precise position to users via its onboard GPS module. Unfortunately, battery issues caused problems on the satellite resulting in periods where it would need to be reset three times a year. Ultimately, NO-44's mission was declared at an end on April 26, 2003, and deceased on July 17, although this seemed a bit premature. However, the satellite was alive and well in September of the same year and was again functional from September 13, 2003, to October 9, 2003.

Since that time, there have been numerous attempts to recover the satellite fully, but those attempts have now all but stopped. Much like our AMSAT AO-7, NO-44 remains on and active when conditions are favorable for sunlight, usually in mid-day passes, although by the time it moves about 30-45 minutes into eclipse, the power drops and the satellite shuts down.

## PSAT (NO-84)

Parkinson Sat (PSAT) was launched on May 20, 2015, on an Atlas 5 launch vehicle from Cape Canaveral, Florida, and was later designated as NO-84 on orbit. The satellite was once again built at the U.S. Naval Academy and was named for Bradford Parkinson, the so-called "father" of the GPS. The satellite was part of the AFSPC-5 launch and was deployed from an ULTRAsat deployer along with 10 other CubeSats. The satellite operated on a 145.825 MHz 1200-baud APRS uplink and a PSK31 Downlink on 435.350 MHz with 300 mW of power.

As a small CubeSat, it provided over six years of service to the Amateur Radio Community. Sadly, the orbit decayed, and the last downlink of its PSK31 transponder was recorded on December 22, 2021, at 14:40 UTC.

## BRICSat (NO-83)

BRICsat (renamed Navy Oscar 83 or NO-83 on orbit) was yet another U.S. Naval Academy student satellite launched along


**Bob was always a frequent presenter at many AMSAT events. Here he poses with Dr. Tom Clark, K3IO (SK) (Center), and Mark Kanawati, N4TPY (Right), with the flight model of AMSAT's "Echo" satellite at a National Air And Space Museum's Space Day in Washington, DC. The satellite later became AO-51 on orbit. (Courtesy: AMSAT)**


**Bob puts the engineering model of PCsat through its digital paces at a National Air And Space Museum's Space Day in Washington, DC. (Courtesy: AMSAT)**

with PSat but suffered from a negative power budget which made it unable to support all of its primary missions. It was a 1.5U CubeSat and contained an APRS packet radio communications transponder for remote telemetry, sensor and user data from remote users and amateur radio environmental experiments. It used a cross band AX.25 Packet Radio VHF/UHF (Mode V/U) transponder and a HF/UHF PSK31 uplink and downlink. Sadly, this satellite has also since been decommissioned.

### PSAT-2 (NO-104)

PSAT-2 (which became Navy Oscar (or NO-104) on orbit) was yet another experimental APRS satellite built by Midshipmen at the U.S. Naval Academy and developed in collaboration with the Technical University of Brno in the Czech Republic.

PSAT-2 was launched on June 25, 2019, on a SpaceX Falcon Heavy from Kennedy Space Center in Florida as part of Mission STP-2 (Space Test Program 2). It was one of the 24 satellites to be launched on that mission. In August 2019, the VHF payload failed, and satellite control was lost. Then, after nearly two years of downtime, the payload mysteriously reactivated on April 26, 2021, and control was regained. Unfortunately, it, too, has since gone totally silent.

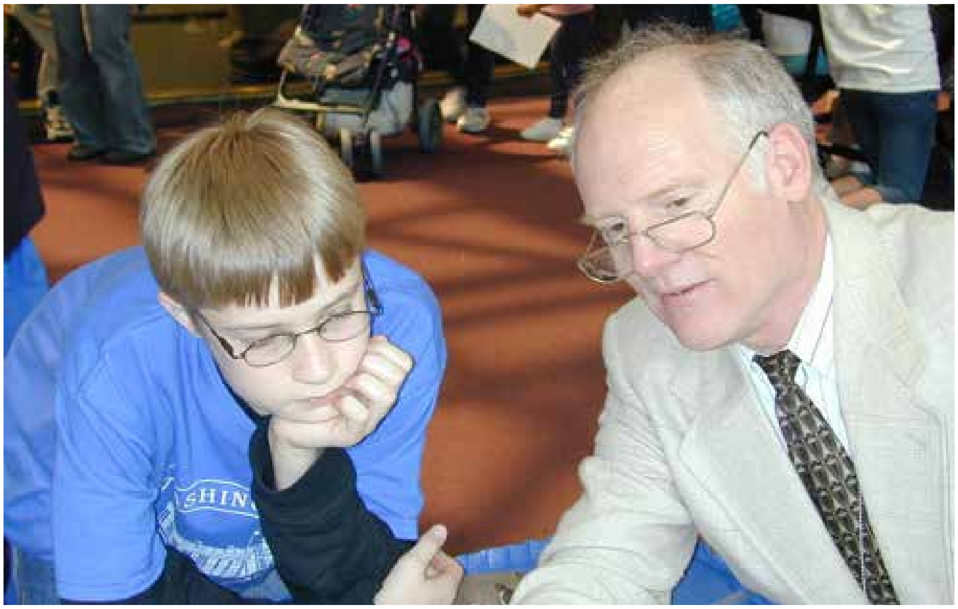
### Shuttle MIR and ARISS

Beginning when Ham-Astronaut Ron Parise, WA4SIR (S.K.), added APRS to his Shuttle Amateur Radio Experiment (SAREX) missions on the U.S. Space Shuttle, APRS-capable equipment has been carried aboard the Russian MIR Space Station and has since become a popular emission mode on the ISS. ISS Packet operation relies on either the Ericcson or the Kenwood D-700s radios now installed on board. When the latter radio is in its autonomous mode, it also gives schools and students ham radio access to the ISS without depending on the busy schedule of the astronauts and cosmonauts. In 2007, the ISS packet operation switched to the global APRS channel of 145.825 to join the constellation of other AX.25, 1200-baud packet digipeaters, and it remains active to this day.

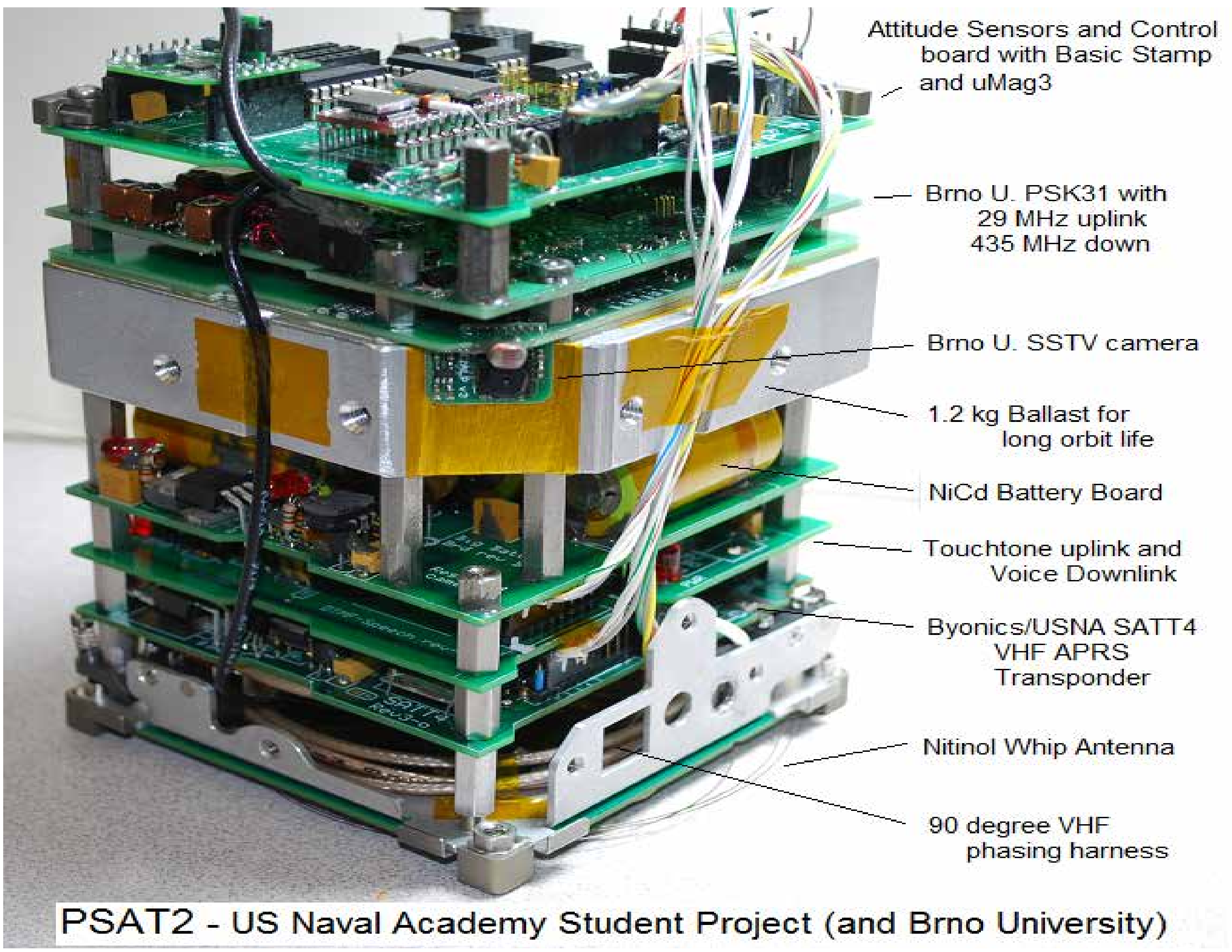
The latest information about the long history of APRS and its use as a part of the amateur radio satellite fleet can be found at www.aprs.org. Then, click on any of the links contained under the "APRS Satellite Projects" header.

### A Final Word

As I noted earlier, Bob Bruninga, WB4APR, became a silent key in early February 2022, having succumbed to the combined effects of cancer and COVID-19. Any way you cut it, during his amateur radio career, Bob made a significant, highly positive impact on both amateur radio and the world by almost single-handedly creating yet another absolutely brilliant application of the radio art. I was honored to have called him not only a personal friend but also a long-standing friend of AMSAT. Bob, may you rest in peace...and *ad astra*!



**Bob was always eager to show off the operation of his PCsat to young visitors at the National Air And Space Museum's Space Day in Washington, DC. (Courtesy: AMSAT).**




**This photo shows the inner workings of PSAT-2. Note the stacked arrangement of components common to most of our AMSAT MicroSats and CubeSats. (Courtesy: Brno University)**

# 2022 AMSAT Board of Directors Election

### Paul Stoetzer, N8HM, Executive Vice President & Acting Secretary

The nomination period for the 2022 Board of Directors Election ended on June 15, 2022. The following candidates have been duly nominated, and their candidate statements follow:

- Mark Hammond, N8MH
- Bruce Paige, KK5DO
- Paul Stoetzer, N8HM.

In accordance with AMSAT's Bylaws, we must hold an election, even though we have three nominations for three open director positions. Therefore, we will host electronic voting on our member portal this year at no cost to the organization.

AMSAT members will receive a link to their electronic ballot by July 15, 2022. Unlike many online polls, the results of all votes cast will not be displayed up to the point of your vote. AMSAT members can only vote once. A vote submitted message will be displayed if you click the poll link again after voting. As three seats on the Board of Directors are up for election this year, all three candidates will be seated on the board when the voting period concludes on September 15, 2022.

### Mark Hammond, N8MH

Mark Hammond, N8MH, holds an Extra Class license, is a Life Member of AMSAT, was AMSAT's first VP of Education Relations and has served on the AMSAT Board of Directors since 2011 as a director or alternate. A self-described "telemetry nut," he has contributed countless hours as a command station for AO-16, AO-51, AO-85, AO-91, AO-92, AO-95, FalconSAT-3, and HO-107 to optimize their availability.

Mark co-developed the SAEBRTrack computer to rotor interface. He operates satellites using FM, SSB, and digital modes. He regularly contributes to the AMSAT-BB, answering operating questions and providing support for the SatPC32 tracking software.

Using @N8MH, he makes timely announcements on Twitter regarding satellite mode changes and availability. He has roved and operated satellites from rare grids such as EL84 (Dry Tortugas near Key West) and BK29 (Hawaii). He assisted with a school ARISS contact with the International Space Station and then donated the complete satellite station to a local university. He enjoys supporting the wide-ranging satellite interests of others.

His vision of AMSAT's future is broad and inclusive. New and potential members need resources, Elmering, and a welcoming atmosphere to become involved in the hobby. Operators require a variety of FM, SSB, and digital satellites to support grid chasing, awards, rag chewing, and emergency operations. AMSAT's history of innovation and technology should continue pushing the envelope with new LEO, MEO, HEO, and GEO satellites utilizing amateur satellites and ride-share opportunities.

AMSAT should continue and expand its productive partnerships with ARISS, ARRL, universities, and other AMSAT organizations. Space is hard and expensive; all opportunities should be explored, limited only by the availability of our volunteer members.

Mark brings to the board the ability to discuss and agree or disagree on issues without being disagreeable. He is a bridge and consensus builder inside AMSAT between users, operations, and engineering.

With 30 years of professional higher education experience and as the Provost of Campbell University, he brings organizational skills, the ability to work with the general membership, Board members, volunteers, and donors, and significant non-profit grant and financial management expertise.

### Bruce Paige, KK5DO

First licensed in 1993, I have been active in amateur satellites and have served AMSAT since 1994. Serving on the Board multiple times, I helped guide the organization during the final building and launch of AO-40.

In addition to serving on AMSAT's Board of Directors, I volunteer for AMSAT and the ARRL:

- Since 1994, I have served as an AMSAT Area Coordinator and now AMSAT Ambassador.
- Since 1999, I have been the voice of the Satellite Segment on the weekly ARRL Audio News – an excellent opportunity to share my enthusiasm about amateur satellites with so many hams.
- Since 2001, I have been the AMSAT Director of Contests and Awards, where it is my responsibility to recognize and celebrate the achievements of our members and the entire AMSAT community.
- I am a Field Card Checker for the ARRL VUCC and WAS programs and a Volunteer Examiner.

AMSAT has accomplished a lot in the past 10 years. We have kept our promise to keep amateur radio in space with the recent launch of four satellites, another waiting to take off, and two more on the workbench. It has been an honor to serve on the board during this time, and I am proud to have had an active part in that decision-making process.
I am committed to our return to HEO and providing flexible communications

to allow both analog and digital modes across multiple bands. We are responsible to the entire AMSAT community to be inclusive and place scientific discovery and experimentation at the hands of the operators instead of just a few closed-minded engineers.

AMSAT needs true leaders on its Board of Directors. Leaders with vision, who can work with others and are able to build a consensus. Leaders who are willing to roll up their sleeves and get the job done.

I would appreciate your support to allow me to continue my work on the AMSAT Board of Directors, leading us forward and higher, in a responsible way. Vote Bruce Paige, KK5DO, for AMSAT Director. I encourage you also to cast a vote for Mark Hammond, N8MH, and Paul Stoetzer, N8HM.

**Paul Stoetzer, N8HM**

Thank you to the members who nominated me to run for re-election to the board of directors. An AMSAT Life Member, I served as AMSAT's Secretary from 2015-2017 and have served as Executive Vice President since 2017. An active satellite operator, I have made several thousand QSOs via satellite, including confirmed QSOs with all 488 grid squares in the continental United States, and 86 DXCC entities worked. In addition, for several years, I have run the AMSAT demo station at the Dayton Hamvention, demonstrating satellite communications to hundreds of amateur radio operators that stop by.

Over the past couple of years, AMSAT has faced many challenges, including those related to the COVID-19 pandemic and the retirement of our long-time office manager, Martha. We have successfully navigated through these challenges, closing our physical office in Maryland and transitioning The AMSAT Journal to a digital publication, and are strongly positioned for the future. In fact, our cash reserves have tripled in the seven years I have been involved with the organization.

As a member of the board of directors, I will continue to search for ways to return amateur radio to High Earth Orbit (HEO) through our GOLF program while supporting amateur radio's continued presence in Low Earth Orbit both through our new Fox+ program and our Linear Transponder Module project.

Additionally, I will continue to advocate for our continued participation in and support of Amateur Radio on the International Space Station (ARISS), including potential future lunar opportunities with the Artemis project. I will also continue to monitor regulatory developments, including orbital debris mitigation regulations, that affect our projects.

Professionally, I am a Senior Communications Specialist at the Federal Election Commission in Washington, DC, where I have developed an understanding of the Federal regulatory regime and a wide variety of communications, technical, and leadership skills.

Although this election is not contested, I would appreciate your vote of support for myself, Mark Hammond, N8MH, and Bruce Paige, KK5DO. Thank you for your consideration.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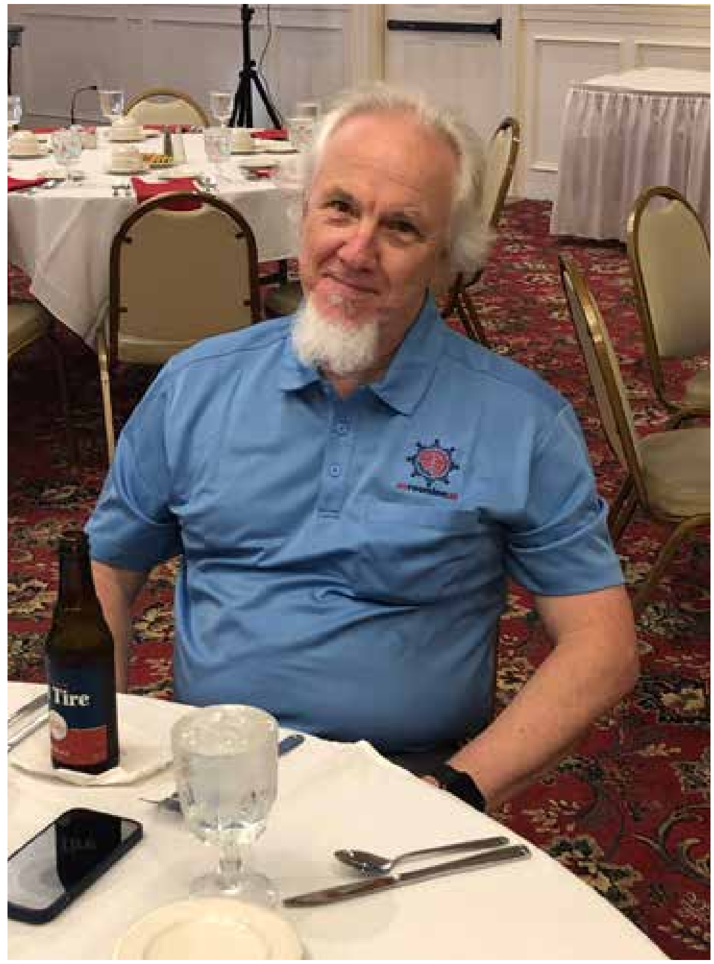
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## Support AMSAT

**AMSAT is the North American distributor of SatPC32, a tracking program for ham satellite applications. Version 12.8d features enhanced support for tuning multiple radios. Features include:**

1. The CAT commands of the IC-9100 have been extended again. The program now also controls the DV mode (DV for 'Digital Voice') of the radio. With the FT-817 the program now additionally supports the CWR mode.

2. All SatPC32 programs now process significantly larger Keplerian element source files. Especially because of the numerous new Cubesats, the number of data sets contained in the source files has increased significantly. For example the file Cubesat.txt currently contains data for nearly 400 satellites.

3. In all programs (SatPC32, SatPC32ISS, Wisat32, WinAOS and WinListen), the list of satellites contained in the source file ('Available' list in menu Satellites) is now displayed in alphabetical order to facilitate locating individual satellites.

4. The program SatPC32ISS now also allows the creation of up to 12 satellite groups. The new Cubesats have also increased the number of 'in-band' satellites. Originally, in-band operation in amateur radio was only available at the ISS.

5. In order to accelerate a change between the individual satellite groups, the 'Groups' window can now be called up by clicking on vacant areas of the main window, except in the Satellite menu. Such free positions are located on the right and left of the frequency window.

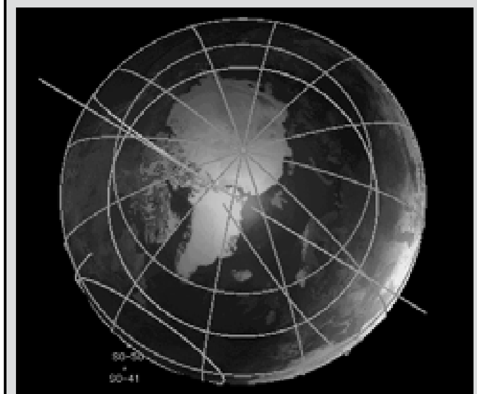
6. In the Satellites menu the data sets of the satellites contained in the active source file can now be displayed. When called, the data set of the currently selected satellite is displayed. The feature helps you to immediately know the identifier of the satellite.

7. The program has improved control of the sub-audible tone required by some satellites. The program can now automatically switch the sub tone on/off when switching between PL tone satellites and others, changing between u/v and v/u satellites, changing the group, closing the program, etc.

A registration password for the demo version may be obtained for a minimum donation of $40 for members and $45 for non-members.
Order by calling 1-888-322-6728. The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.

## MacDoppler

*The premier Satellite tracking and station automation application for the Macintosh*



MacDoppler gives you a seat right in the heart of the Operations & Command Centre for every satellite in orbit, providing any level of station automation you need from assisted Doppler Tuning and Antenna Pointing right on up to a fully automated Satellite Gateway!

It will calculate the position and relative velocity of the satellites you are tracking and automatically adjust the Doppler shift on both transmit and receive as well as pointing your antennas with predictive dead spot crossing so that a pass is never interrupted.

A Universal Binary that runs native on Intel and M1 Macs and provides separate panels for the map (2D or 3D), the radio and rotor controls, a sorted table of upcoming satellite passes and a Horizon panel that graphs upcoming passes as a function of elevation over time.

***Now available from AMSAT at a special member discount donation!***

https://www.amsat.org/product-category/software/

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# Join the 2022 AMSAT President's Club

## *And Help Return Amateur Radio to High Earth Orbit!*

**AMSAT is excited** about developing and launching the next generation of Greater Orbit Larger Footprint ("GOLF") satellites. AMSAT has an immediate need to raise funds to cover development, launch and related expenses to *Keep Amateur Radio in Space*. We have set a fundraising goal of $125,000 to help keep AMSAT viable and effective in the competitive world of space communications.

**GOLF-TEE** (Technology Exploration Environment) is a rapid development satellite headed for LEO to fly and validate ADAC, deployable solar panel wing, radiation tolerant IHU, SDR and other technologies.

**GOLF-1** is planned as a "High LEO" mission with a STEM payload in the progression of GOLF satellites.

**With your membership,** AMSAT is pleased to recognize your generosity. All members receive:

**Commemorative Coin 2" with 4-color enamel accents and polished gold finish.**



**Full-color membership certificate**


**Embroidered 2.5" Iron-on AMSAT Logo Patch**

Higher tier members receive even more benefits! You can join with a single payment or with twelve affordable monthly payments with your credit card. For payment by check or electronic transfer, contact Frank Karnauskas, VP-Development at N1UW@AMSAT.org.

### *Go to AMSAT.org/donate and join today!*

| Tier | Core | Bronze | Silver | Gold | Platinum | Titanium |
|---|---|---|---|---|---|---|
| Annual Donation | $120 + | $300 + | $600 + | $1,200 + | $2,400 + | $4,800 + |
| Journal Listing | X | X | X | X | X | X |
| Certificate | X | X | X | X | X | X |
| Coin | X | X | X | X | X | X |
| "RBF" Key Ring | X | X | X | X | X | X |
| Desk Plaque | | | X | X | X | X |
| TAPR/AMSAT Dinner @ Dayton | | | | X | X | X |
| Symposium Admission | | | | | X | X |
| President's Symposium Lunch | | | | | X | X |
| Symposium VIP Recognition | | | | | | X |

Recognition items available for U.S. addresses only. For contributions from elsewhere please contact Frank Karnauskas, VP-Development at N1UW@AMSAT.org. AMSAT is a 501(c)3 corporation. Donations may be tax deductible. Check with your tax advisor. President's Club membership does not include AMSAT Annual Membership.

# With a 50-year Legacy of Success, AMSAT Volunteers …

**Build satellites** that Keep Amateur Radio in Space!

**Promote space education** through ARISS and STEM-based initiatives.

**Manage satellites in orbit** and ensure they are available for public use.

**Create and maintain vital partnerships** with government, industry, educational institutions, and amateur radio organizations to foster space research and communication.

**Learn, teach and share innovations** and best practices in space communications with other radio operators, students, government and the public.

**Show and share their passion** for amateur radio in space everywhere they go!

**Will take amateur radio to the Moon**, to Mars and to deep space … with your help!

**Go to https://www.amsat.org/volunteer-for-amsat/ and help create AMSAT's future legacy!**