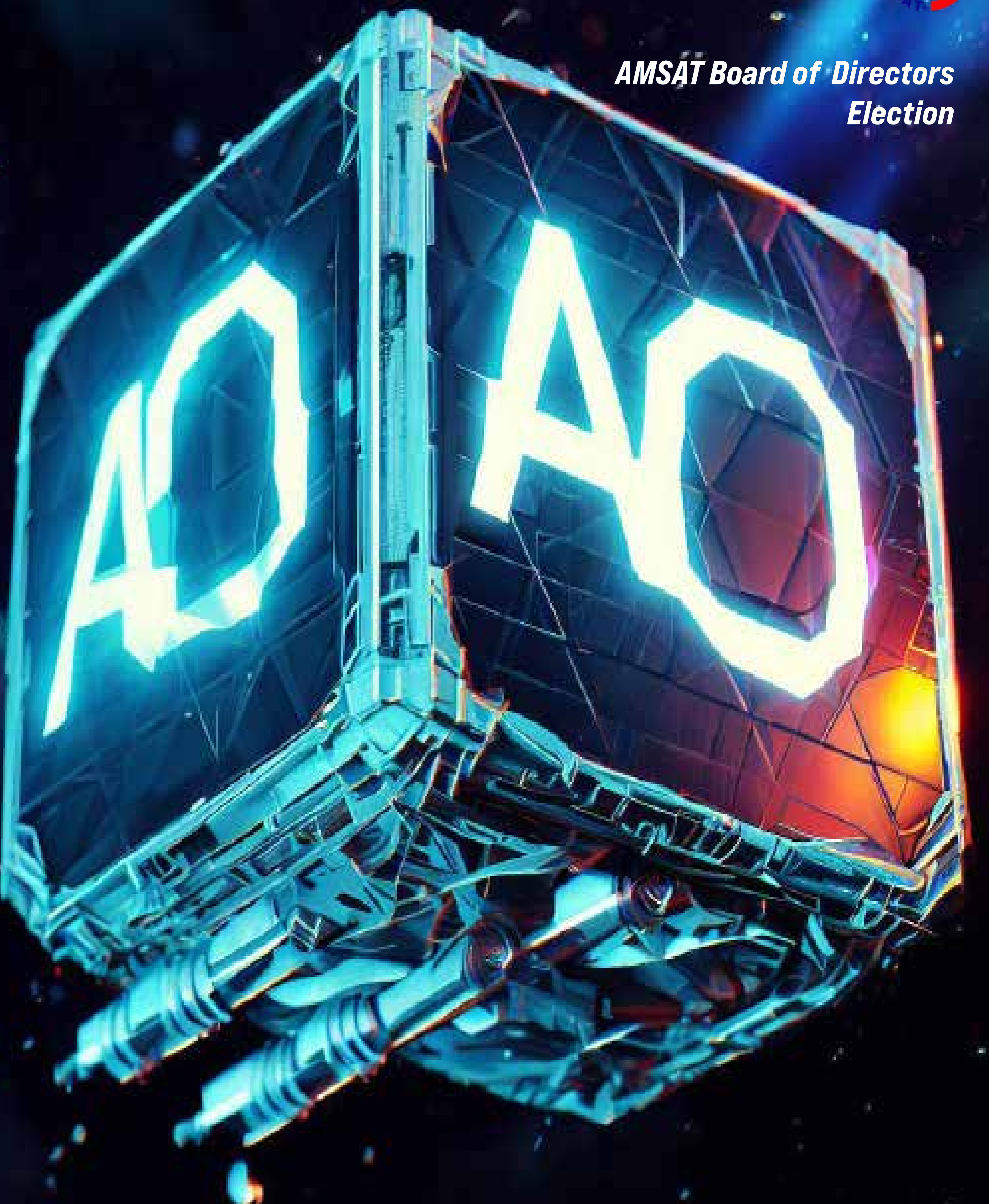
THE AMSAT JOURNAL

AMSAT Board of Directors Election



Contents

May/June 2023 • Volume 46 • Number 3

2023 AMSAT SPACE SYMPOSIUM AND ANNUAL GENERAL MEETING DALLAS, TX, OCT. 20 - 21, 2023

The 41st Annual AMSAT Space Symposium and General Meeting will be held Friday and Saturday, October 20-21, 2023, in Dallas, Texas, at the Sheraton DFW Airport. The 2023 symposium will feature:

- Space Symposium with Amateur Satellite Presentations
- Operating Techniques, News, & Plans from the Amateur Satellite World
- Board of Directors (BoD) Meeting, open to AMSAT members
- Opportunities to Meet Board Members and Officers
- AMSAT Annual General Membership Meeting
- Auction, Annual Banquet, Keynote Speaker and Door Prizes!

The Symposium includes presentations, exhibit space, and the AMSAT Annual General Meeting.

Radio Amateur Satellite Corporation (AMSAT)
P.O. Box 27, Washington, D.C. 20044

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

Hamvention 2023

I had a great time at the 2023 Hamvention in Xenia, Ohio. It was nice meeting many of our members, as well as our friends from ARISS. On Saturday, during our AMSAT Forum, our vice-presidents of Engineering (Jerry Buxton, N0JY), Education Relations (Alan Johnston, KU2Y), and Development (Frank Karnauskas, N1UW)) showcased the important work being done on GOLF (Greater Orbit Larger Footprint), Fox Plus, ASCENT (Advanced Satellite Communications and Exploration of New Technology), CubeSat Simulation, and Youth Initiative programs.

Admittedly, I was in complete panic mode the week before Hamvention. Our Hamvention Coordinator, Phil Smith, W1EME, who worked tirelessly all year to ensure everything went smoothly, was suddenly unable to attend this year's event. Luckily, Barry Baines, WD4ASW, and Steve Belter, N9IP, stepped in to fill Phil's BIG shoes. I want to thank Phil, Barry, Steve, and all of our volunteers — too many to name, for making AMSAT's Hamvention 2023 a success.

Symposium

I am pleased to announce this year's 41st Annual AMSAT Space Symposium and General Meeting will be held Friday and Saturday, October 20-21, 2023, in Dallas, Texas, at the Sheraton DFW Airport. The 2023 symposium will feature:

- Space Symposium with Amateur Satellite Presentations
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We'll announce symposium registration and hotel reservation details, Sunday tour(s) and our banquet keynote speaker at a later date.

PacSat

GreenCube satellite (IO-117) has been a big hit, so I was excited to not only learn that AMSAT Engineering AMSAT's Advanced Satellite Communications and Exploration of New Technology (ASCENT) program has a team working on a new radio system dedicated to amateur radio digital Store and Forward packet data communications but, also to be invited to sit in on a weekly teleconference with our PacSat Team. What a talented and dedicated group of volunteers. Thank you for the invitation. I look forward to your continued progress and demonstrations.

AMSAT's annual Board of Directors election is coming up. This year, we have five well-qualified candidates for the four seats up for election:

- Barry Baines, WD4ASW
- Jerry Buxton, N0JY
- Drew Glasbrenner, KO4MA
- Frank Karnauskas, N1UW
- Zach Metzinger, N0ZGO

Our 2023 Board of Director Election will open on AMSAT's Member Portal (**launch.amsat.org/**) from July 15th through September 15th. You should have received an email inviting you to vote. In addition, there will be a link at the top of the Member Portal homepage after log-in.

AMSAT, as an all-volunteer member organization, has been keeping our promise to advance the art and science of amateur radio in space for over 54 years. This is due not only because of the volunteers' hard work over the years but in considerable measure to the support of the membership. It is both an honor and a pleasure to serve as your President. I look forward to continuing on our path – Onward & Upward!

EDUCATIONAL RELATIONS UPDATE

Alan Johnston, Ph.D., KU2Y

I had a great time at Hamvention! Thank you to all the volunteers who helped organize, set up, run, staff, and tear down the AMSAT booth for the event. A big thank you to Dennis Veselka, KI4KNC, for helping staff the Education table. Also, a special thank you to Carsten Glasbrenner, son of Drew Glasbrenner, KO4MA, AMSAT Vice President of Operations. He helped staff the Education table on multiple days and did an amazing job of showing off the AMSAT Fox Engineering Model and engaging with kids as they passed by. According to his dad, he has been busy with soldering projects lately and, later this summer, will hopefully build a CubeSatSim!

Figure 1 — Education Table at the AMSAT Booth at Hamvention staffed by Carsten Glasbrenner.

At the AMSAT Forum at Hamvention, we showed off the new beta V2 CubeSatSim hardware. We had hoped to announce the first beta hardware release, but we ran into some issues. We're now targeting a fall release. Look for an announcement. The V1 hardware is still fully supported and has the same functionality as the V2 hardware. Blank PCB set are in stock on the AMSAT Store www.amsat.org/product/amsat-cubesatsim-pcb/ shipping to US addresses. The AMSAT UK Shop also has them in stock and ships to non-U.S. addresses: shop.amsat-uk.org/product/amsat-cubesat-simulator-printed-circuit-board-set1. In other good news, Raspberry Pi Zero's are slowly becoming available for purchase for list price in the US and the rest of the world. You can easily find them using the excellent rpilocator website: rpilocator.com.

I see more and more hams on the Mastodon social media network these days, including many of my friends from Twitter. You can find me there at @ku2y@mastodon.radio, along with ARISS @ARISS_Intl@mastodon.hams.social. If you make the move, make sure you contact me so I can follow you!

If you are interested in doing a demo for a group or school, I can ship you a loaner – contact me via email ku2y@arrl.net.

I'm always interested in your CubeSatSim projects. Feel free to share them via email or on social media.

ENGINEERING UPDATE

Jerry Buxton, N0JY

The Devil is in The Details

It is often said that "AMSAT builds and operates" its satellites, which is very true and speaks of our Engineering and Operations teams in producing and carrying out a satellite's mission.

The engineering part is represented in *The AMSAT Journal* and to the public, typically being the general ham population, in writings and presentations made by our engineers or myself. As our common interests lie in radios, in particular, the design and creation of the radios are the most interesting, with growing interest in the other systems that support a satellite.

Another significant part of what is needed to bridge the "builds" and the "operates" statements is not so often spoken of and certainly not in detail because of the inconvenience of the NDA (Non-Disclosure Agreement) and due diligence regarding export regulations. The "devilish details" appear within our satellite's mission integration process, specifically its dispenser and the dispenser to the launch vehicle (LV).

At our last weekly engineering meeting, because of our progress concerning a launch date, part of the discussion and review included a slide with the introductory listing

Figure 1.

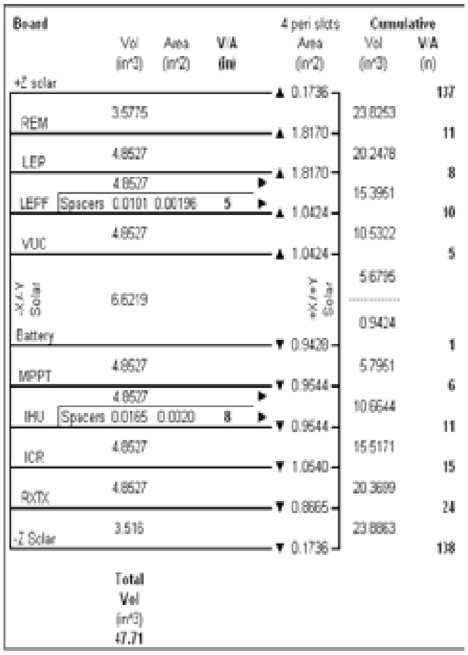

Figure 2 — Schematic of Volumes and Areas for venting analysis.

of some of the details typically needed to satisfy the launch requirements and get us on the rocket. While this is a good list — put together by our GOLF Systems Engineer, Eric Skoog (K1TVV), "off the top of my head," it is not necessarily the entire list. It was intended to point out considerations in the final Engineering Model/Flight Model (EM/FM) design (see Figure 1).

The bulk of the documents, collectively called "deliverables" in integration lingo, are all about safety aspects concerning the LV and the CubeSat dispenser, including our payload's dispenser-mates hitching the same ride. In a "bottom line" sense, they don't want you losing parts of your satellite, getting jammed in the dispenser, interfering with the myriad LV RF frequencies in use for the launch and control of the vehicle, or being somehow affected by the LV emissions causing unforeseen consequences with your payload and especially, not blowing up.

Referring to the list, in that range safety category are:

Venting Analysis – documenting the ability of your space vehicle ("SV" in the new jargon) to handle the rapid pressure change from roughly sea level, including airport elevation, to drop altitude on any ride up for a launch drop, up to the extent of atmospheric pressure. Specific flow rates must be met and may vary from mission to mission. An example graphic from a venting report is shown in Figure 2.

Mass Properties — total mass, center of gravity, moments of inertia — all are important in loading the dispenser and the dispenser to the LV, "weight and balance," if you will, so the LV is within its flight profile. It is also of concern when you are ejected from the dispenser regarding the separation of the payloads and maneuvering performed by the upper stage.

Electrical Report – Specific documentation supporting the proper design, placement, and function of the switches and disconnects that prevent power from being applied to the satellite systems until the SV is clear of the upper stage, as determined by timing from release to satellite start-up. The base requirements for this are in the CubeSat Design Specification published by Cal Poly and can be further restricted by the launch provider. These include some that you are probably familiar with from our mentions, including the "RBF pin" which is a device that further safes the satellite from accidental start-up during handling and transportation up to the integration in the dispenser, and the "separation switches" which are specified as a minimum of two separate cutoff switches that prevent power from being applied while in the dispenser after the RBF pin has been removed. These switches are typically at one end of the SV and in two rails such that when the dispenser is loaded and closed, they remain pressed against your neighboring CubeSat rider, or in the case of a 3U-like GOLF, they press against the pusher plate that will propel the SV out of the dispenser (Figure 3). Tests for these included them remaining off and resetting the satellite start-up sequencing during instances of "chatter" causing rapid open/close in the dispenser caused by the shock and vibrations experienced during launch.

Materials List – this documents the majority of the types of materials used in the various components and systems on the satellite and may include any hazardous materials (e.g., flammable, explosive, radioactive) if those are not required in a separate document. Unlike the transportation of hazardous materials, where the specific information of the materials is kept in case of a "bad day," it's good to know what went everywhere if the launch doesn't go as planned. It is also used to determine any products that may experience "outgassing," see the Outgassing information in the Thermal Vacuum Bakeout Test and Report following.

Environmental Test Plan – referring to the specific plans, tests, and expected results for the colloquial "shake and bake." Rocket motors, in general, create many random vibrations and shock events. At the same time, they power the LV skyward and beyond the period of maximum dynamic pressure. The resulting coupled loads through the rocket stage mounting to the payload dispenser to our payloads inside the dispenser create quite a ride for any size payload. Interestingly, our 1U Fox-1 CubeSats and, to a slightly lesser extent, the GOLF 3U are a good size for handling many of the vibration stresses due to their frequencies. They tend to be lower frequency which affects larger SV payloads, while the small CubeSats are

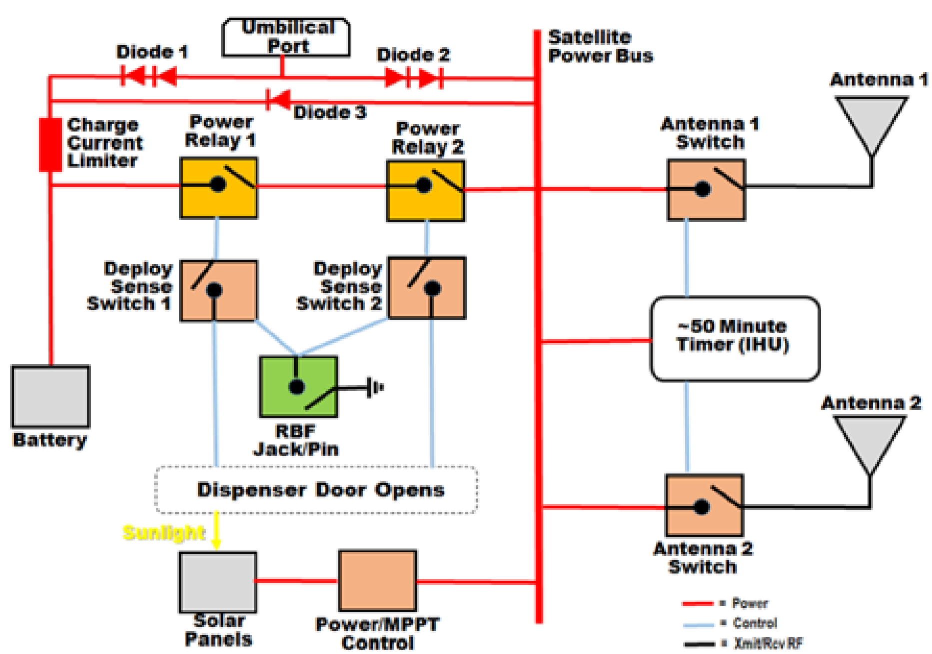

Figure 3 — Power Inhibit Switches for the Battery Circuit and Deployables.

more sensitive to higher frequency loading. That does not rule out the sheer intensity of any particular force during launch causing a problem, for example, the [NDA] G force we had to test one of the axes for with Fox-1. NASA-STD-7001 specifies acoustic and random vibration test levels concerning the maximum expected flight level (MEFL), as shown in Figure 4. Because the design of each of our CubeSats is different, despite the similar bus stack, we test to MEFL +3dB to thoroughly verify each bird's construction integrity. Essentially, we want to know if it flies apart before putting it on a rocket so we can correct the situation while it's still "hands-on."

Fox-1Cliff almost certainly suffered a failure due to launch environment forces, and RadFxSat-2 may have seen something similar as the cause of the low signal strength. Fox-1Cliff was the second Fox-1 to be constructed and already had some of the bugs we found from the series. Unfortunately, she was hot on the heels of Fox-1A and had no time to have learned or apply any corrections. Additionally, Fox-1Cliff had been tested for a launch that was later scrubbed, and after some time, Spaceflight was able to find a launch for her that was in line with the orbit we were seeking. However, no two rockets are the same. While the similarities between the two allowed a resolution to certify without the need for another vibe test, I suspect there was just enough difference to have put enough force on a component or solder joint in the receive amplifier to render her deaf.

Multiple vibe/shock/acceleration tests, with at least the first being proto-qual (MEFL +3dB), is a risky situation, and it is our preference to have just one test to establish confidence that we will survive launch with the actual launch being "just one more" to survive. That is a matter of our risk tolerance, with the alternative being much more time and money spent on developing hardware for acceptance and qualification testing, which, with the slight but unique changes to each Fox-1 and expected for the GOLF satellites, is not desirable to repeat for each iteration of the satellite.

Fox-1D, the third constructed, was alongside Fox-1Cliff in construction early in the program and was destined for the same launch as Fox-1Cliff. Again the scrubbed launch eventually gave us another opportunity and allowed us to put -1Cliff and -1D on different LV for some survivability insurance. However, the new ride for Fox-1D meant there was no way out of another vibe test, which broke a connector at the +Z end of the bus to the solar panel. That was white-wired/repaired on site (Burns' home in NH) and submitted for another, but this time to the lower Flight Acceptance levels, having just been tested at protoflight levels. Fox-1D became AO-92 and worked well for the duration of the battery.

Battery Report – This document may be stand-alone or incorporated into other overarching documents, such as the Missile System Prelaunch Safety Package (MSPSP). In either case, the makeup, structure, safety precautions, and additional information specific to the SV battery are documented to satisfy the range safety requirements, which vary by launch provider or mission. Generally the same, they may have different limits or ways of demonstrating the satisfaction of the requirements. In the case of Fox-1A, we had to put a dead short on one of the charged A cell NiCd and record the current and temperature over time until the cell expired to prove the venting capability of the cell vs. catching fire or exploding. And in the case of the latter event, wiping out me, a friend, and my wife. That was exciting, I must say.

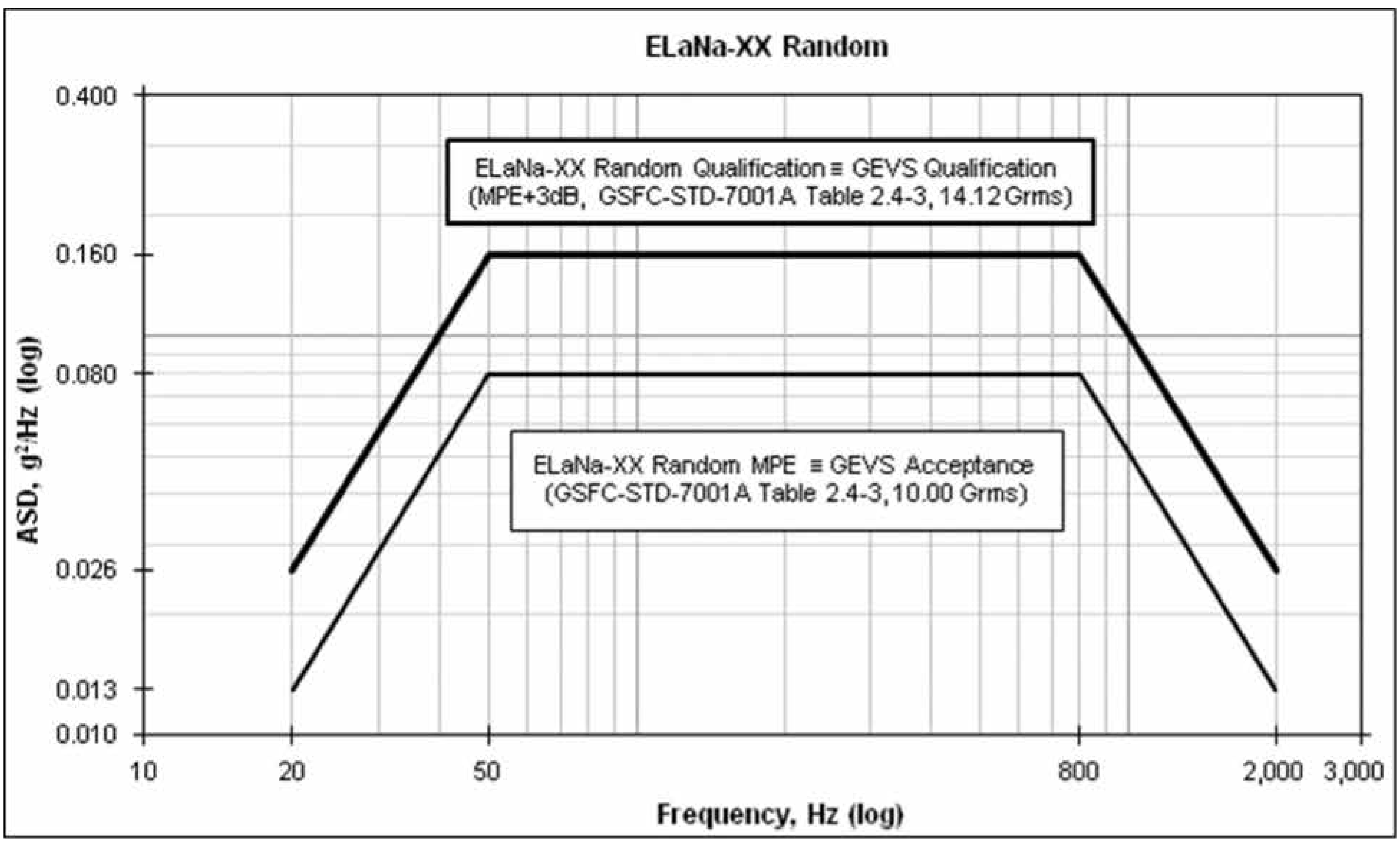

Figure 4 — ELaNa XX (GEVS) Random Vibration Profiles.

Figure 5 — The venting at 2 minutes 37 seconds is shown here. Recall that the stopwatch is 10 seconds. behind the real event time. The venting lasted about 5 seconds.

TIME	VOLTAGE (mV)	CURRENT (A)	Amp-Seconds	mAh	Cumulative mAh
00:00	67	67.0			
00:10	38.9	38.9	529.5	147.1	147.1
00:20	32.0	32.0	354.5	98.5	245.6
00:30	26.4	26.4	292.0	81.1	326.7
00:40	24.8	24.8	256.0	71.1	397.8
00:50	25.7	25.7	252.5	70.1	467.9
01:00	28.3	28.3	270.0	75.0	542.9
01:10	31.0	31.0	296.5	82.4	625.3
01:20	33.5	33.5	322.5	89.6	714.9
01:30	34.0	34.0	337.5	93.8	808.6
01:40	32.9	32.9	334.5	92.9	901.5
01:50	31.8	31.8	323.5	89.9	991.4
02:00	30.9	30.9	313.5	87.1	1078.5
02:10	2.7	2.7	168.0	46.7	1125.1
02:20	2.7	2.7	27.0	7.5	1132.6
02:30	1.7	1.7	22.0	6.1	1138.8
02:40	0.0	0.0	8.5	2.4	1141.1
02:50	0.0	0.0	0.0	0.0	1141.1
03:00	0.0	0.0	0.0	0.0	1141.1

Table 1 — The energy expended during the test.

Figure 6 — First RF Transmission and Clock Time, with the faintly visible rise of the signal "hump" at the moment the transmitter became active.

Elapsed Time* (minutes)	Clock Time (hh:mm:ss)	TX Antenna Released? (Yes / No)	RX Antenna Released? (Yes / No)	TLM TX? (Yes / No)	Initials
5 minutes	20:38:10	NO	NO	NO	ENS
10 minutes	20:43:10	NO	NO	NO	ENS
15 minutes	20:48:10	NO	NO	NO	ENS
20 minutes**	20:53:10	NO	NO	NO	ENS
25 minutes	20:58:10	NO	NO	NO	ENS
30 minutes	21:03:10	NO	NO	NO	ENS
35 minutes	21:08:10	NO	NO	NO	ENS
40 minutes	21:13:10	NO	NO	NO	ENS
45 minutes	21:18:10	NO	NO	NO	ENS
50 minutes	21:23:10	NO	NO	NO	ENS
After 50 minutes		Tone: 21:24:30 TX Ant: 21:24:35	RX Ant: 21:24:46 IHU BOOT: 21:25:08	TLM TX: 21:27:09	ENS

* Elapsed time relative to release of both separation switches (T_0 at step 22)

** (LV ICD 3.3.6.3 and 3.4.2.5 met)

14.	Stop the video camera and SDR RF recording.	25:27:12?	June 7, 2018	ENS
15.	At what elapsed time was the first deployable antenna released? Elapsed time **TX:** 51 min & 25 seconds; **RX:** 51 min & 36 seconds.		June 7, 2018	ENS
16.	At what elapsed time were transmissions observed? Elapsed time: 53 min & 59 seconds		June 7, 2018	ENS

Table 1: Status of deployables and transmitter taken every 5 minutes after final release of separation switches in Step 22 in RadFxSat-2 DITL Test Procedure (AS RUN – Third Run – 7 Jun 18).docx

Figure 7 — Status of deployables and transmitter taken every 5 minutes after final release of separation switches in Step 22 in RadFxSat-2 DITL Test Procedure (AS RUN – Third Run – 7 Jun 18).docx.

Transmitter Survey – referring back to the paragraph describing the "bottom line," that part referring to interference to/from the LV is what the transmitter survey documents. The frequencies and levels of emission from the LV are given, and you must certify that those transmissions with not affect your SV, nor will your SV be emitting any RF in those bands to affect the LV. Since all of our satellites are by design and requirement "dead" when integrated, it is usually pretty simple to determine whether anything can be overloaded and to document that we won't be transmitting anything.

Day-In-The-Life Report – One of my favorites, the basis for this is to demonstrate the ability of the SV to remain powered off while integrated on the LV in a small variety of simulated pre- and post-launch situations. The main points are the aforementioned "chatter" of one or both separation switches being briefly opened and meeting the requirement for timing after being deployed from the dispenser. Photos, spectrum monitoring, and timings are the data gathered in performing tests to show that our satellite meets or exceeds the requirements (Figure 6). While the test is successful once those timings have been demonstrated, we always carry on through the actual deployment of antennas and "First Veronica," as was the catchphrase with the Fox-1 FM birds, officially known as the first RF transmission from the SV. That continuance shows both the launch provider and ourselves that our "50-minute" timer does prevent IHU (full) start-up and subsequent deployments and transmissions until a minimum of 50 minutes after deployment (Figure 8). Most requirements are for timings of 15 to 30 minutes; our 50 minutes was based on the Fox-1A design to meet that mission requirement of 45 minutes of delay with a reasonable margin of added "feel good" for the launch provider. (NASA advised me during that mission that they all feel better if the payloads do not just go for 46 minutes and call it good, given the way things aren't always that simple.) And rather than adjust the RC circuit for each specific mission, keeping the 50 minutes gives us a good margin that also allows more time for the solar panels to recharge the battery after being out of our hands for (typically) a month or two. If you consider the fact that it took some years to get to orbit, another 50 minutes of safety and charging time is nothing at all.

Thermal Vacuum Bakeout Test and Report – this is the final action with our satellites before we bag them up and declare them ready to be delivered. (We do quick "aliveness" tests after vibe, shock, and bakeout to verify we're still functioning on site.) This is the "cleanup," which is also directly related to the outgassing item. The thermal bakeout typically exposes the satellite to a temperature above 60C at a pressure of 1.0x10^-4 Torr. The process removes extraneous handling contaminants such as skin oil and substances in components encapsulation and epoxies/fasteners ("outgassing") by essentially baking them and dispersing them into the vacuum before the same is done on orbit. These substances tend to collect on other, cooler things when they outgas, such as a camera lens or contaminating the works in nearby systems (see Figures 8, 9).

Figure 8 — View inside the chamber during test, illuminated by heater lamp during pulse.

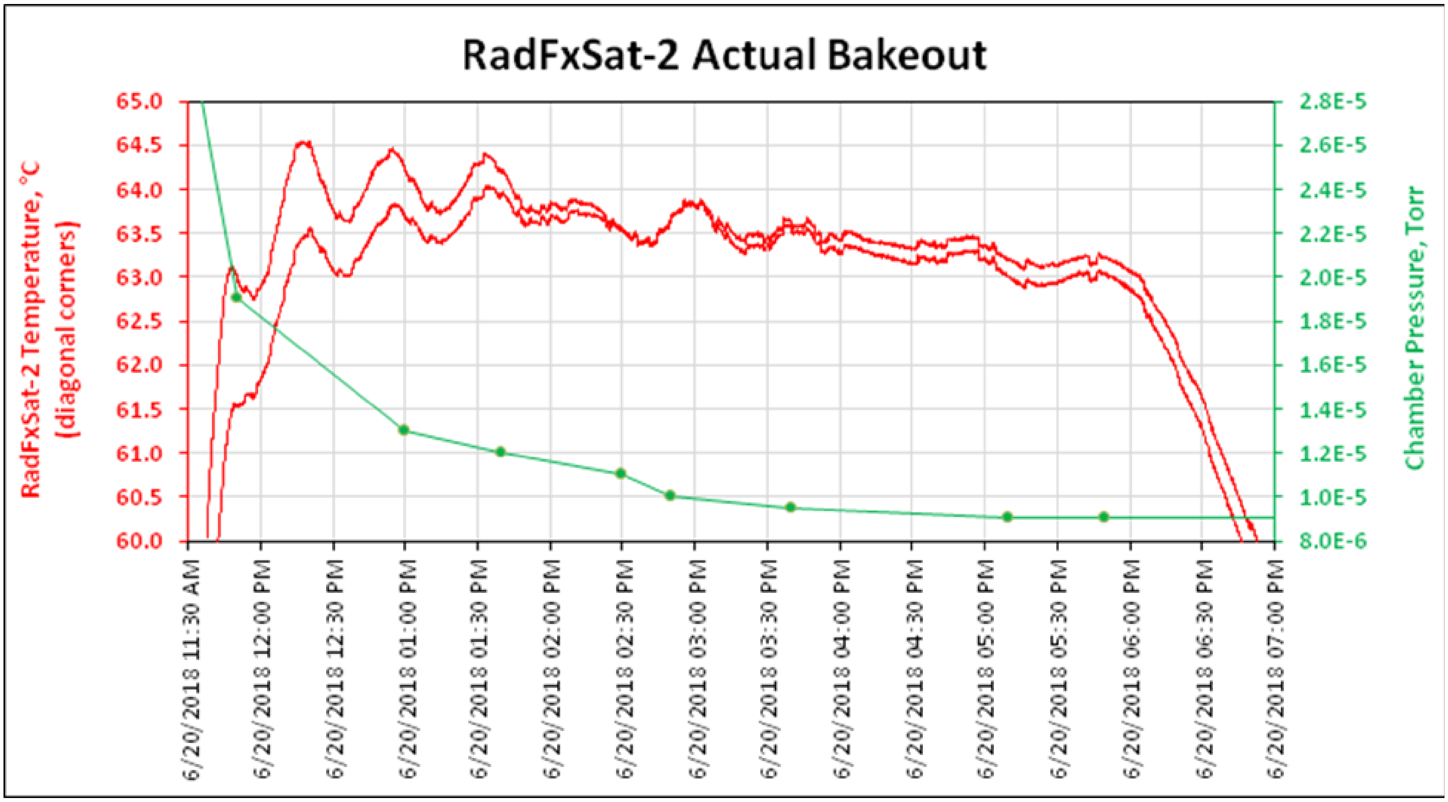

Figure 9 — RadFxSat-2 Actual Bakeout.

The list appears to have some duplication by accident and similarity, for example, the Environmental Test Plan and Vibration and Shock Test Report. While they are often in the same package deliverable, they are sometimes broken out. In many cases, the integration manager likely wants to see the environmental test plan to validate both their needs and your procedures before you go smashing your satellite project due to a misunderstanding. Thus they can be two different deliverables.

Items I omitted here are simply for time and space, and I would like to talk more about them and the whole devilishly detailed integration process. The Orbital Debris Assessment Report alone is a monster reaching way out as far as the ITU in processing. Not surprisingly, launch documentation comprises a tremendous amount of work in addition to what is typically seen in designing and building a satellite. I get my hands dirty doing my part of the "manual labor" during the launch process. It is typically a year or more, weekly calls and deliverable deadlines, walking the course from the first deliverable to ultimately putting our CubeSat into the dispenser. Always fun and enlightening. And so far, five for five is the hairiest experience you could ever want to encounter (or to avoid!) during the inevitable dash in the last three months.

Speaking of Building

Much hard and exciting work goes on continuously, from GOLF-TEE to SDR Plan B and Fox-Plus to Pacsat. Selection and acquisition of the ADCS (Attitude Determination and Control System) will bring us some of the system flight computer boards to begin working on our interface between the GOLF-TEE RT-IHU/LIHU systems with the ADCS for EM just awaiting further definition of our spaceframe and subsequent information for the choice of ADCS system options. The deployable solar panels will be doing design testing with real solar cells of the type we will use. Many systems boards are in production or have been produced and evaluated in a "flat-sat" type engineering model. The Radiation Tolerant Internal Housekeeping Unit (RT-IHU) software and radio development continue, and we are currently tracking toward a first-quarter 2025 delivery for launch. Note we do not have a particular launch yet, but this means that we will be seeking one soon, which wraps right back to the start of this update because it brings those things into the picture now.

For the first iteration, Fox-Plus is looking at an ISIS Space 1U frame to build on. Given our loss of Bob Davis and his extraordinary contributions to mechanical engineering, our new mechanical volunteers are working and getting familiar with the type of things we do in building pretty much everything from the ground up because – it's fun. I don't imagine anyone is doing it just for the pay, anyway. Jonathan is doing a great job bringing open access and new engineers to ASCENT, where work on the SDR Plan B, Pacsat, and our reaction wheels are underway. SDR Plan B relates to our need and desire to produce our SDR and a better way of mounting one in GOLF-n rather than the "transverse stack" we used to fit the Ettus radio in GOLF-TEE. That work will likely include other great ideas for the use cases for SDR and microwaves in future satellites. The reaction wheels project seeks to and has done some excellent development on building our reaction wheels for use with future ADCS, whether our own or perhaps commercially available ADCS. On the Pacsat project, we are looking forward to some new-age designs and robust pacsat capabilities on the Fox-Plus birds. FalconSat-3 and the ISS digipeater seem to have brought some new fun to the many newer satellite hams who were perhaps initially drawn into the fun through the Fox-1 series. (That is entirely my opinion only, for the record.) Whatever the source, we have digital thinkers thinking about fun stuff in ASCENT.

Speaking of thinkers in ASCENT, if you have an idea and interest in pursuing the design and building of that idea on your own or with other like-thinkers, please contact Jonathan Brandenburg via the volunteer contact links on the AMSAT web page. I am, and we all are excited to have people working on new ideas within ASCENT – which is the acronym for Advanced Satellite Communications and Exploration of New Technology – where the basic principle is to encourage work without specific bounds or ties to any existing satellite project so that they can be done in an open sharing of thought, designs, and hardware. Ultimately we will look to incorporate the things created in ASCENT into our satellite missions. Previous ASCENT work from the CQC project microwave SDR and SSPA development that are being adapted into the GOLF and Fox-Plus projects to the RT-IHU, which we hope to allow us to fly with a more mission-critical IHU function in both LEO where the South Atlantic Anomaly (SAA) was known to cause resets to the Fox-1 IHU on up to higher LEO orbits, as far as we can go using the ubiquitous "low-cost off-the-shelf (COTS)" style that has been AMSAT's staple for as long as I can remember.

2023 AMSAT Board of Directors Election

The nomination period for the 2023 Board of Directors Election ended on June 15, 2023. The following candidates have been duly nominated and their candidate statements can be viewed at the link below:

- Barry Baines, WD4ASW
- Jerry Buxton, N0JY
- Drew Glasbrenner, KO4MA
- Frank Karnauskas, N1UW
- Zach Metzinger, N0ZGO

As four seats on the Board of Directors are up for election this year, four of these candidates will be seated on the Board, along with one alternate when the voting period concludes on September 15th. The election will be held via AMSAT's Wild Apricot membership system. Voting is now open and will close on September 15, 2023.

When you click on the poll link, you will see your ballot (poll question). After choosing from the possible options, click the Submit button to cast your vote. Unlike many online polls, the results of all votes cast, up to the point of your vote, will not be displayed. AMSAT members can only vote once. If you click the poll link again after already voting, a vote submitted message will be displayed. The four candidates receiving the most votes will be seated on the Board concludes on September 15, 2023. The candidate placing fifth will be seated as an alternate.

73,

Jeff Davis, KE9V
Secretary
AMSAT

Barry A. Baines, WD4ASW, LM1971
Keller, TX

I am a former Board Member of AMSAT (1998-2017) and served as President from 2009-2017. I ask for your vote for this year's Board of Directors election.

When I previously retired as a Board Member and AMSAT President, AMSAT had accomplished much during my tenure including successful ARISSat-1 and Fox programs and taking steps for the next generation of AMSAT satellite development. Organizationally, AMSAT provided membership services through an excellent printed AMSAT JOURNAL and a variety of items for membership support such as books and software available.

Six years following my active involvement with AMSAT, much has changed in terms of the world around us and its impact on AMSAT. The COVID-19 pandemic resulted in a reformation of AMSAT as a web-based membership organization where the AMSAT JOURNAL is now distributed electronically, membership services are provided online via the AMSAT Store and the Membership Portal. The retirement of Martha Saragovitz as our Office Manager (following 42 years of service), and the closing of the AMSAT Office in Kensington, MD were necessary steps, but these changes also altered the nature of AMSAT's presence to our membership.

My interest in supporting AMSAT as a Board Member is based upon several considerations. First, my long involvement with AMSAT (Life member since 1982 and holding leadership positions starting in 1992) has provided me with personal experiences within AMSAT and "corporate knowledge" that can be useful to AMSAT leadership. Second, having been away from AMSAT leadership for six years offers an opportunity to view/evaluate AMSAT with a fresh perspective combined with a level of experience that will help me serve as an effective Board Member. Third, the BoD sets the strategic direction of AMSAT. As a BoD member, I see my role as encouraging further work in developing relationships with other organizations that are willing to support AMSAT's activities, as AMSAT must continue to broaden its base of support both inside and outside the amateur radio community. This includes attracting enthusiastic volunteers willing to use their time and talent to help AMSAT achieve our goals as well as develop support from donors willing to provide significant funding to make our vision of "Keeping Amateur Radio in Space" a reality.

If you have any specific questions, please e-mail me at wd4asw@amsat.org.

Jerry Buxton, N0JY

First licensed in 1972, I soon discovered amateur radio satellites. My first satellite work was around 1975, and I was hooked. It was thrilling to reciprocate nearly 40 years later, as I watched a new generation of hams and even some "old-timers" discovering satellites with the new Fox-1 birds.

AMSAT is growing fast, but not without some growing pains.

As membership grows member participation and member input for new possibilities and operating desires grow. We have had a much-needed increase in volunteers; appreciated and necessary are the new engineering volunteers that allow us to expand the missions needed to meet membership desires. New volunteers are coming on board in our other teams as well.

The growth in volunteers and projects also creates a need for more volunteers to manage the work being done. Managing dozens of people working on a dozen projects is beginning to saturate our officers, many working 40 hour weeks, and that will degrade our capability to take advantage of this growth.

Opportunities will require new financial resources beyond the gracious and ongoing contributions from our members. Fortunately, our access to other capital resources is growing as well.

Satellites face harsher space environments beyond our LEO missions; new and challenging regulatory requirements require maneuvering capability; launches to altitudes and orbits rather unique to AMSAT. These are some of the items that raise our costs. "Why would you want to go THERE?"

is a question I never heard before seeking orbits for GOLF-1. There is no doubt that we will need to pay a portion or all of the cost of launches, soon. This includes plans to keep LEO Fox-Plus birds in orbit to fill the void between larger, higher missions as well as to provide us with a way to test new developments in orbit before putting them into a more costly mission.

AMSAT provides benefits through educational outreach that extends beyond the amateur radio community providing valuable, visible results such as use of the CubeSat Simulator in classroom education. Higher-level education in carrying high school and university student-built STEM education experiments are on all of our mission,s from Fox-1 on to GOLF and Fox-Plus, an opportunity well known in the educational community. Supporting STEM and space education also comes with the Linear Transponder Module (LTM) that we provide partners who wish to add amateur radio to their CubeSat project.

All of these activities demonstrate the value of our corporation. Sustained financial support for these activities and to allow for their growth is a necessity.

I am blessed to have discovered AMSAT and amateur radio satellites, growing up with them to eventually become a financial contributor, a volunteer as Fox-1 Systems Engineer in 2011, and ultimately being voted VP of Engineering in 2014. I was elected to the Board of Directors in 2014 for one year, and have happily served our membership and the corporation as a Director since that time.

Your vote is a statement of confidence in my intentions and abilities for AMSAT. Thank you!

Andrew Glasbrenner, KO4MA

Thank you AMSAT members for the nomination to serve on the Board of Directors. I am excited to have the opportunity, if elected, to serve AMSAT. As you decide who should guide the organization forward, I would like to share with you some of the work that was accomplished as part of my previous and ongoing efforts both as Director and VP Operations.

• AO-51 command station and leader of the international scheduling committee
• Conceived and negotiated AO-92 and AO-95 commercial launch contract
• Developed AMSAT's first online crowdsourcing for Fox-1Cliff and Fox-1D launch
• Developed Membership drives featuring free digital "Getting Started" books timed around our satellite launches.
• Led AMSAT into social media across several platforms
• Initial contact and negotiations to fly a Fox-1E linear transponder copy on Huskysat-1
• IARU satellite frequency coordination panel member, including advising university cubesat teams on frequency coordination and licensing issues
• On -orbit checkout and general operation of AO-85, -91, -92, -95, -109 as licensee and command station.
• OSCAR Number Administrator
• Reassignment and operation of Falconsat-3 satellite BBS and digipeater from Air Force Academy to general amateur use
• Moved AMSAT to PayPal Here for secure electronic credit processing and sales tracking for Dayton and large hamfests.
• Interfaced with equipment manufacturers for AMSAT discounts and web site sales (Arrow, M2, Gigaparts)
• Created and managed loaner gear program for DXpeditions and gear donations for unique DX stations.

I also try to remain an active operator, which is important to remain connected with the membership needs. 31 years of activity have resulted in 130 entities for Satellite DXCC and 1900+ grids worked via satellite for VUCC.

With your support and vote, I would be honored to continue to grow and diversify AMSAT's membership, missions, and opportunities as Director. Questions and concerns are welcome to ko4ma@amsat.org.

Frank Karnauskus, N1UW

Please cast your ballots for the other candidates: Messrs. Jerry Buxton, N0JY; Zach Metzinger, N0ZGO; Drew Glasbrenner, KO4MA; and Barry Baines, WD4ASW. These four gentlemen have the necessary experience and long histories of service to AMSAT that make them the most qualified to serve on the Board of Directors.

My only interest in appearing on the ballot (and asking to receive no votes) is to serve as an Alternate in the event one is necessary.

My limited qualifications include serving as a rotating editor for the AMSAT News Service Weekly Bulleting for three years; as Vice President – Development for two years with some limited success in fund raising and building the foundation for future revenue generating activities; and as the architect of the Youth Initiative which is in its early development phase. I have been handling some of the basic administrative office duties since AMSAT's changeover to a virtual office environment. I am a retired sales and marketing executive and small business owner. I have been licensed for 61 years, hold an Extra Class license, been an ARRL members for nearly as many years, and am an AMSAT Lifetime Member.

Who is Zach Metzinger (N0ZGO)?

My first ticket was Technician Plus class, granted in 1993, followed by an upgrade to Advanced class in 1995, and to Amateur Extra in 2019. I have held my original call since it was first issued in Wichita, KS. I also hold a General Radiotelephone Operator License, granted in 1994.

I'm active on HF and UHF/VHF, both terrestrial and satellite, with recent interest in the microwave bands. However, I am more of a builder and experimenter than an operator.

My first real interaction with amateur satellites was during Field Day in 1994. Hearing my own voice come back on the downlink was magical, just as it was the first time I heard inter-continental HF. I was hooked, but it took many more years before I was able to operate on satellites again.

During the last four years, I've been a volunteer for the AMSAT GOLF project, working on the Radiation Tolerant IHU (RT-IHU) board. This board is the "brains" of the satellite: sending telemetry, accepting commands, and controlling payloads such as the transponder and experiments. The first flight of the RT-IHU, on GOLF-TEE, will provide valuable reliability data on the use of common off-the-shelf (COTS) components for this critical function.

I fully believe in the path toward HEO; We'll achieve this goal through the diligent work of our volunteers on GOLF, perseverance in our leadership, and support by the membership as a whole.

It is also my hope that we'll reduce our dependency on the commercialized Internet. Rather, we should focus on creating an amateur digital network in space for bulletins, efficient digital voice, and high-speed data, while preserving low-cost-to-entry analog transponder options.

If elected, I intend to work constructively with fellow AMSAT directors to develop and deploy new technology, increase our membership through educational outreach, and "Keep Amateur Radio in Space".

AN INTERVIEW WITH CUBESAT SIMULATOR BUILDER BRUCE SEMPLE, WA3SWJ

Paul Graveline K1YUB
Asst. Editor, *The AMSAT Journal*

While speaking with Eastern Mass Section Coordinator, Jon McCombie, N1ILZ, about my new appointment as EMASS Section Youth Coordinator, he mentioned a ham on Cape Cod that had constructed an AMSAT CubeSat Simulator and was demonstrating it to non-ham groups on the Cape. His name is Bruce Semple, and his call is WA3SWJ.

As a member of the AMSAT CubeSatSim Education Materials Team led by Dr. Alan Johnston, of Villanova University, KU2Y, and including Mark Samis, KD2XS, Fredric Raab, KK6NOW, and David White, WD6DRI, we have been developing the latest generation of the CubeSat Simulator (CubeSatSim) and planning to provide materials to aid in promoting it. With his experience in building and promoting the CubeSatSim, WA3SWJ seemed like just the right ham to provide a road map from initial planning through construction and public promotion of the CubeSatSim.

I contacted Bruce and asked him to share his experience with readers of *The AMSAT Journal*. He was very willing to discuss his multi-year CubeSatSim experience with the AMSAT community, so I asked him to respond to some questions about his journey.

PG: Did you work in a technical field before getting your ham license? What got you involved in ham radio?

WA3SWJ: Like many hams, I was very involved in my teen years, but during my college years I was distracted by the usual: dating, college, marriage, and parenthood. Once my kids graduated from college and struck out on their own, the OM had some time and money to resume his 2nd favorite hobby. When I returned to my ham shack in 2010, I was amazed at the integration that had taken place between the radios and computers and the resulting plethora of ham radio-related software that was now available, much of it for free.

PG: Who/What got you interested in amateur radio?

WA3SWJ: My grandfather, K1AZR, introduced me to Amateur radio. His shack was in the basement of his house, and he had worked with a priest from the local church to build CW/AM transmitter based on an 813 tube. Frequency determination was done via a bank of 10 "rocks" selected by a rotary switch on the front panel. My grandfather had acquired a used Halicrafters receiver to complete the station.

I got my novice license when I was 17, in 1972. I was surprised that my father was comfortable enough to let me, a relatively new driver, drive alone 10 miles into downtown Wahsington, D.C. to the FCC headquarters, where I passed the 5-wpm code test and technical elements. A year or so later I returned to that same FCC office to pass the 13-wpm code test and got my Advanced ticket.

PG: How did you get interested in ham radio satellites?

WA3SWJ: My interest in satellites started in college during a work study co-op program in my junior and senior years. My industry rotations took place at the U.S. Naval Research Laboratory (NRL). My assignments had me working on various aspects of ground stations that received data from satellites. I started my career at IBM working on the ground station for the Satellite Business Systems joint venture between IBM, Comsat, and Aetna. When I got back into ham radio in 2005, I was very interested in working with the amateur radio satellites and the technical challenges involved in building a working ground station.

At my previous QTH in Potomac, MD, I had a roof arrangement such that when the antennas were parked at zero elevation, they could not be seen from the front yard; this was a key requirement. I had M2s 2 m and 440 antennas mounted on a 5' roof tripod on the back side of the roof. I had the RHCP/LHCP feature on the 2 m antenna and a mast preamp on the 440 downlink antenna. I was utilizing separate Yaesu azimuth and elevation rotors with a homebrew rotor interface to the computer. The transceiver was a Kenwood TS-B2000, without a front panel and all computer controlled. I used HamRadioDelux's Satellite Tracker and SatPC. Back then, the GO-32 satellite carried a bulletin board system. For those passes, I also ran the WISP software to coordinate the upload and download of bulletin board files. One of my key resources for getting on the birds was K8YSE John S. Paypay's satellite recordings. John had designed and developed a system to automatically record the audio passband on the various satellite passes. His recordings (www.papays.com/sat/general.html) are key to allowing new satellite operators to hear how their signal is being received on the birds. Two significant challenges of working with Low Earth Orbit (LEO) satellites is dealing with the Doppler shifts and aiming the antennas as the satellites move from horizon to horizon in about 15 minutes depending on the elevation of the pass. Again, the software comes to the rescue as it controls both the azimuth and elevation of the antennas as well as the transmit and receive VFOs. Getting all these various systems integrated and working together was a technical challenge that I enjoyed.

PG: Why did you build the CubeSatSim ?

WA3SWJ: I had worked with Pat Kilroy, N8PK (AMSAT Area Coordinator), while I was working and living in Maryland. I was following his work as co-founder of the CubeSat Simulator project. Upon retirement in 2020, we relocated to Cape Cod. I felt that building a CubeSat Simulator would be a good warm-up activity for re-engaging with the amateur satellite aspect of our hobby. I had a 3D printer, so printing the CubeSatSim frame was not going to be an issue. I was amazed to find on GitHub the necessary files that you could upload to a website (www.pcbway.com) and back would come beautifully labeled, plated holes through PC boards for about $5.00. The CubeSatSim team had provided a very specific bill of materials as well as illustrated instructions that included steps to check out and verify each component as it was assembled. Dr. Alan Johnston, KU2Y, was quick to answer any questions I had.

PG: How Long did it take?

WA3SWJ: I think the project took me about one or two months at a very relaxed pace, including ordering and waiting for parts. Everything went very smoothly. I had one issue that I believe was caused by getting caught in a version update from V1 to V2. I opted not to try surface mounting the SMT components that made up the bandpass filter for the transmitted output signal, opting instead to use an external bandpass sub-component. I also wanted to use the newer 440 vertical antenna arrangement instead of the measuring tape antenna. These two minor changes resulted in some challenges when it came to routing the signal coax from the output board to the bandpass filter, and then to the mounted antenna.

PG: What was the easiest and hardest part?

WA3SWJ: Some time has passed since I built my CubeSatSim, and nothing comes to mind as being particularly difficult.

The instructions included several pictures of assemblies in various stages of completion. As you build the various sub-assemblies, you are taken through a checkout of the sub-assembly, which is very helpful. You know right away if you have a problem that you need to resolve before going on to the next step.

There are a lot of soldering headers on small sensor boards, so a steady hand is a must. You have the option of downloading the disk image for the SD card that runs the Pi Zero, the main microcontroller of the CubeSatSim. You need to download the Arduino SDK and install it on an available Windows, Linux or Mac computer to compile and download the firmware for the microcontroller for the payload or STEM board. Nothing difficult here, just steps that need to be followed.

Some ideas for future versions:

- more engaging visualization of the telemetry data – gauges, bar graphs, x-y plots, etc.;
- animation/visualization of CubeSatSim motion;
- interpret telemetry data to show location of the sun;
- explore ways to interact with the mathworks library www.mathworks.com/help/aeroblks/model-and-simulate-CubeSats.html;
- an uplink with some basic commands to turn on/off the payload power; and
- a mini FM repeater 2m up 440 down with a doppler simulator so that the CubeSatSim would shift the transmit and receive frequencies as if it was moving.

Events Worked

Lem, W1LEM, coordinates our club's (Barnstable Amateur Radio Club, www.barnstablearc.org) involvement in the various community events out here on Cape Cod. The various scouting activities are a key area of interest.

Our club set up a demonstration at the Boy Scout's 2022 Jamboree On The Air (JOTA) at Camp Greenough. We had set up several information stations for the scouts to visit as they moved through the demonstration area covering topics like Morse code, 2 m repeaters, HF transceivers and the CubeSatSim.

Another community event that we participate in is the Cape Cod Mini-Maker Faire (www.facebook.com/capecodmakerfaire/). Given the context of this event, we wanted to focus on the DIY/Homebrewing/kit-building aspects of the hobby. The CubeSatSim was a good fit for this venue because it utilized 3D printed components, micro-controllers, sensors, and assembly of circuit boards.

As one would expect, attendees to these Makers' Faires already have an interest in STEM-related projects. I display the CubeSatSim on a rotating platform with a simulated sun (an LED work light) shining on the solar panels (to charge the batteries) so as to provide some eye candy that would draw visitors to the display.

The Barnstable Amateur Radio Club (BARC) and the The Falmouth Amateur Radio Association (FARA) have teamed up to present a program at one of the STEM sessions on all the various aspects of amateur radio (including amateur satellites) to the Cape Cod Collaborative's Advanced Studies & Leadership program.

A common question I get at these events is "Did this unit go into space?" Or, even more common, "What's a simulator?" I've used the analogy of why one would go to a batting cage: to practice one aspect of the game of baseball. The CubeSatSim allows CubeSat developers to think about and practice some aspects of building and then interpreting data from a CubeSat.

Several attendees are usually homeschooled and ask how they can get involved.

PG: I understand that your club is in the process of building from scratch a new ham station at Camp Greenough which will include a satellite station.

WA3SWJ: The Barnstable Amateur Radio Club (BARC) applied for and received a grant from ARRL to build a ham radio station at Camp Greenough. What surprised and pleased us was how much interest it generated in the community, and how many significant donations we have received from local vendors and utilities. Our local power company has donated and installed telephone poles to support antennas, our ISP has donated fiber cable and associated equipment, and local businesses have donated building supplies. Our club is planning on donating the azimuth and elevation rotors as well as some antennas for the ground station once the new visitors' center is completed.

[*Ed.* — When the Boy Scout ham station is operational, *The AMSAT Journal* will provide a report on the satellite installation at the club. They have even engaged the local power company, National Grid, to raise some supports to hang antennas and Verizon is installing digital communication in the station. This is an amazing ham project!]

PG: What do you think is the best way to promote ham radio?

WA3SWJ: Often called "the hobby of 1,000 hobbies," I think it's important to talk about the depth and breadth of the hobby. The CubeSatSim is an example of that very statement. The fact that amateur operators can build a ground station to track and talk through the satellites or get involved with the actual building, testing, and operating one of these birds is testament to the dimensions of this hobby.

The explosion of new digital modes like FT8 and FT4 with their associated software that does some very sophisticated signal processing is yet another example of the wide ranging aspects of amateur radio. The amateur radio hobby is much more than "just talking on the radio," as non-hams might summarize it. As hams, we need to emphasize this multidimensional aspect of amateur radio when we talk to this next generation. They already can talk to one another over a "radio" that they all carry around in their pocket.

The *Journal* thanks Bruce for taking time to share his experience with its readers and, hopefully, this new Cape Cod installation will provide a model for other similar projects across the nation.

A SATELLITE ETIQUETTE PRIMER

Keith Baker, KB1SF/VA3KSF
kb1sf@amsat.com

[*Portions of this feature previously appeared in the December 2000 edition of The Spectrum Monitor magazine. Thank you, TSM!*]

Wow, it's been a wonderful satellite spring and summer with many new call signs appearing on our growing fleet of amateur radio satellites. However, sadly, I'm also hearing more and more of what can only be described as poor operating technique from some folks who may be new to the birds as well as from some other "interlopers" on our frequencies — frequencies that have been carefully set aside for satellite operation worldwide.

So, in this feature of our *AMSAT Journal*, I'll discuss some of the conventions and courtesies that make satellite operation more enjoyable for all of us. I'll also explain to our non-satellite and beginning satellite users why it's vital that they and their friends be conscientious about the frequencies they choose for other modes of amateur radio operation. That's because some of their current choices may be (perhaps unknowingly) causing harmful interference to satellite users.

Figure 2 — Manually shifting one's uplink frequency is easily accomplished on the TS-2000 by a quick flick of the RIT/SUB knob when a satellite's uplink frequency is programmed into the radio's sub-band VFO. (Courtesy: Author)

The Satellite Bands

As most of us already know, because satellites operate in various orbits worldwide, their "footprints" (both receiving and transmitting) can often take up entire continents…or even entire hemispheres. As a result, unless some international coordination is put in place, absolute chaos will most certainly result. This is why the International Amateur Radio Union (IARU) appoints a worldwide Satellite Frequency Coordinator responsible for assigning non-interfering uplink and downlink frequencies to all proposed amateur radio satellites before they are even approved for construction.

However, despite those efforts, there's now a host of other transmitters on our bands (particularly in our VHF and UHF bands) that can easily (and often unknowingly) cause harmful interference on those satellite frequencies. These activities run the gamut from various cross-band repeater links and simplex communications to those little "hotspots" many of us now use for our VHF and UHF digital activities.

And if you think all those low-powered devices can't be heard in space, think again. If a low-powered hand-held radio with a "rubber duck" antenna can be used to uplink to one of our low earth satellites reliably, then someone else using similar equipment (operating on what they think is an "empty" VHF or UHF simplex frequency) can do the same. And, unfortunately, that's precisely the kind of interference many of us are now hearing coming through some of our satellite transponders, particularly on our FM birds.

Figure 1 — The author's Kenwood TS-2000S is a 1990s-era, HF/VHF/UHF satellite-capable radio that, while allowing for computer input to compensate for Doppler shifts, still works very well with manual tuning. (Courtesy: Author)

By worldwide agreement, the IARU has set aside (admittedly by "gentlemen's agreement") the primary satellite frequency sub-bands of 145.800 to 146.000 MHz on 2m and 435.000 to 438.000 MHz on 70 cm. Similarly, other allocations are set aside for satellites on different frequency bands, including allocations on 10 m and 15 m, 23 cm, 13 cm and 9 cm. So, if you (or your local repeater group) are planning any activity to use these satellite frequency bands for something other than satellite operation, please consult your country's band plans for alternate frequencies to use, lest the seemingly "empty" frequencies you have chosen fall within spectrum expressly set aside for satellite operation.

Figure 3 — When connected between your computer and satellite antenna rotator box, a tracking interface, such as the AMSAT LVB Tracker, does a superb job of un-complicating many of the tasks required to use our satellites. While no longer in production, LVB Tracker boxes can still be found on the used market. (Courtesy: Author)

FM Satellite Etiquette

In a previous feature, I noted that our analog satellites usually have much room to spread multiple conversations over an entire pass band of frequencies. Within the parameters of available satellite power, this approach allows for simultaneous "rag chew-type" conversations to occur in the pass band. However, such is not the case with our FM satellites!

Imagine for a moment the absolute chaos that would ensue if your local club's single-channel 2 m or 440 MHz FM repeater were mounted on a 350-mile high tower giving it essentially continental coverage! Indeed, the situation with an FM satellite (with a single uplink and downlink frequency) is very similar.

At any one time, tens (or even hundreds!) of operators may be within range of a satellite, all trying to "work the bird," each using varying amounts of uplink power and antenna configurations. Toss in the added limitations caused by a satellite tumbling in orbit with its (often linearly polarized) antenna arrays continually moving into and out of phase along with multiple ground stations trying to get into the satellite simultaneously. And then there's the "capture effect" naturally inherent in all FM transmissions. So, clearly, without some informal operating conventions on these satellites, chaos would reign supreme.

Over the years, (a largely unwritten) set of protocols has emerged for efficiently and effectively working thru these FM, single channel satellites. Those protocols include lots of listening combined with short, crisp conversations with minimal information being exchanged. So, on the FM birds, once you are sure that the satellite is within range of your station, you should wait for a clear channel, come up on the satellite's uplink, and announce your call sign along with your Maidenhead Grid Square locator.

For example, I would come up on frequency and say, "KB1SF, EN-83," and then patiently wait for another station to respond to my call. Likewise, if I wish to call another station I've heard, I say their call sign, followed by my call sign and my grid square locator. That exchange might be: "W8XYZ, KB1SF, EN-83". If conditions are poor, I might give my call sign and grid square locator in phonetics.

But, as you can see, the goal is to keep your conversations as short as possible to allow others to use the satellite. Long-winded conversations on the FM birds are most unwelcome. And, like on your local repeater, calling "CQ" on these FM satellites is a definite "no-no"!

In addition, it's just common courtesy to allow other stations to complete their QSOs before you call another station. It's frustrating when you call a station to complete a QSO,

Figure 4 — As it's possible to work our satellites with a small hand-held radio and a "rubber duck" antenna, it's also possible for these seemingly low-power devices operating on satellite frequencies for non-satellite purposes to interfere with ongoing satellite communications. Here, my wife, Kate, KB1OGF, talks through one of AMSAT's FM satellites from the shores of Lake Huron in Michigan. (Courtesy: Author)

and another station starts calling before your own QSO is finished. Someone else calling you (or another station) while your QSO is in progress is rude. It's the amateur radio equivalent of being interrupted by another person during a face-to-face conversation over dinner. So, if you hear a QSO already in progress, please let that other QSO finish before you make your call!

In addition, you will often hear stations on an FM satellite pass that you have already worked several times. If others are calling, it is common courtesy to refrain from calling a station you have already contacted numerous times. If you think about it (and even if everyone is cooperating), only so many QSOs can be made during a given FM satellite pass. Each QSO between two stations that have already contacted each other prevents another QSO from happening…one that might be in a new grid square for that other station or even that station's very first satellite QSO!

Analog Satellite Etiquette

As with the FM satellites, all the voice satellites in our fleet operate as cross-band repeaters in "full duplex" mode. That's because if you hear yourself on the downlink, others should be able to hear you as well. But, admittedly, finding your signal on the downlink for the first time on an analog satellite can be difficult.

However, if it's also not done correctly, one's first attempts to find their downlink signals can annoy others on the passband. Sadly, I can't begin to count all the whistles, "helloooooooos," and other verbal emanations I now hear swishing back and forth across our analog satellite passbands, often landing right on top of one of my ongoing conversations!

Over the years, I've perfected a simple manual operating technique to find my downlink that works beautifully while minimizing QRM to others in the passband. That is, once the satellite pops over the horizon, I first do a quick check to see if the satellite's beacon is operating. Once I confirm that the satellite is operational, I'll then set my uplink frequency to the middle of the transponder's passband, and then send just a few very widely spaced "dits" (in CW!) while tuning my downlink VFO until I hear my own "dits" coming back at me. This confirms that I'm "in the ballpark" with the right combination of uplink and downlink frequencies.

This simple technique very effectively prevents all that annoying "swishing" of one's uplink and downlink signals (often in broad SSB) across the passband of the satellite in a desperate search to find one's downlink. It also prevents me from causing copious amounts of QRM to others already in QSO. That's because CW "dits" are not nearly as offensive to others as broad SSB signals are, and they are just as effective while manually hunting for my downlink.

Which Sideband?

One of the other QRM generators I've noted with newcomers to our analog birds needs clarification regarding which combination of sidebands should be used on voice contacts. Often, newcomers have difficulty finding their voice downlink signals because they are attempting to communicate through the satellite using the wrong sideband.

In short, the convention on all of our analog satellites is to use whatever combination of lower or upper sideband emission results in your downlink being on the upper sideband. This means that your signals going up to the satellite should be on the lower sideband on an inverting satellite transponder. Conversely, your uplink signals on a non-inverting satellite transponder should also be on the upper sideband. Fortunately, a CW uplink signal will always result in a CW downlink, regardless of the "flavor" of the transponder. Compensating for Doppler.

Another problem many newcomers encounter while operating on analog satellites is compensating for the Doppler shift. Back in the amateur radio satellite "dark ages," when veteran satellite operators (yours truly among them) first became active on the analog satellites, we didn't have tracking software connected to computer-controlled radios to do our antenna tracking and Doppler tuning. Indeed, many of us (like me) had to use two separate, manually tuned radios…one for the uplink and one for the downlink to make our contacts. This meant that we were continually manipulating two VFOs plus manually moving our antennas to keep up with the satellite as it moved across the sky.

Many of us developed our own set of (admittedly ambidextrous!) tracking and tuning techniques that have served many of us well over the years, including what came to be known as the "One True Rule" for tracking the Doppler shift on our satellites.

Briefly, "The Rule" suggests that, when manually tuning for Doppler, you should keep one frequency steady while tuning the other. It also indicates that you should manipulate the higher frequency while keeping the lower frequency constant. So, on a Mode U/V satellite (the old Mode B), you should hold your VHF downlink steady while manipulating your UHF uplink to keep up with the Doppler shift. The reverse is valid on a Mode V/U satellite (such as RS-44 and FO-29).

I've found that simply moving my uplink frequency while trying my best to steady my downlink frequency on both types of satellite transponders works reasonably well. Granted, while the other person is talking, their (and my) uplink frequency will shift. However, a quick flick of the uplink VFO will soon bring my signal in line with theirs once the other person hands the conversation over to me. Again, the goal should be to prevent your conversations from drifting into someone else's in the passband as much as possible.

Alan Biddle, WA4SCA, wrote a very detailed article about the "One True Rule" in an AMSAT Journal a while back. Those of you who might want to investigate a more detailed explanation of this whole subject can find his article at:
www.amsat.org/wordpress/wp-content/uploads/2015/02/FDT-WA4SCA.pdf.

The Bottom Line

I hope this little primer on some of the satellite operation customs and courtesies that have evolved over the years has proven helpful. As a disclaimer, I freely admit some of the techniques I've outlined here may not be suitable for all situations. However, most have worked well for me and, hopefully, have made me a "popular camper" on our satellites. But, as one of my university professors once said of his classroom offerings, "Take it all in, but only swallow what fits."

IO-117 ANTENNA TESTING

Dave Fisher, KG0D

[*Note: The following article is a continuation of Dave Fisher's work as described in "Operating Low Elevation DX via GreenCube" in the March/April 2023 of* The AMSAT Journal.]

Antennas and antenna configurations testing for IO-117 continues. The summary of 148 tests is shown in (Figure 1). The base station comparison summary has been expanded from 30 passes to 126 passes. Data from these passes (Figure 2) has been separated into ten-degree increments for Reception Quality review. Passes higher than 41 degrees do show better overall Reception Quality. Of course, those between 11-20 degrees beg to differ! The base station is the IC-9700, M2 Leo-Pack 8+8 RHCP, S.A.T., 24 dB ULNA. I've included more tests using motors to remotely axial rotate these antennas to any polarity needed to improve Reception Quality.

The OZ9AAR Terminal program continues to evolve. A Signal Quality graph (0 to 100%) with a continuously updated redline average was an important addition. It provides signal strength for each received packet, noted by each decode line. This data also fills the graph in real-time with the X-axis for elevation and the Y-axis for signal strength. UZ7HO added a feature to his SoundModem program so it would pass a "signal quality value" for each packet received. The "signal quality" is a value that indicates how many bytes it had to correct to construct a valid packet from the incoming audio stream. This value is forwarded to the OZ9AAR Terminal program and shown live on screen while receiving packets. OZ9AAR also included my T.L.M. Receive Quality percentage math. It is updated constantly during a pass based on the number of received telemetry packets. Some passes are near 100% Signal Quality for most of the pass (Figure 3). Other passes follow the fading signal pattern shown in (Figure 4). We should be receiving a Telemetry decode about every 49 seconds on average. Any missed T.L.M. packets aren't counted, and the Receive Quality percentage decreases. This fading affects some of my test results. I'm sure some of my polarity chasing learning curves with polarity adjustments is affecting Receive Quality, too.

Only three antenna types are being used for testing – In many configurations. The Base Station tests use the M2 LeoPack UHF 8+8 RHCP with a bit higher gain ULNA. The Yaesu G5500DC rotator and S.A.T. controller determine the AZ/EL changes as needed. The other two are the seven-element Arrows and the homebrew 11-element WA5VJB Yagis. All were tested near the house Wi-Fi, so the system could also report data to SatNOGS. All portable tests used the Italian-made JG-ULNA70VOX preamp hung near the antenna(s).

The Arrow Yagis were tested in three ways (Results in Figure 1):

(1) A single Arrow (Figure 5) that I manually rotated from vertical to horizontal, or anywhere between, for the best-received signal. This required a loud radio setting while outside making changes and listening.

(2) Two Arrows (Figure 6), one fixed vertical and the other fixed horizontal, with a coax relay mounted at the Yagis. I could switch polarization back at the shack while watching/listening for the best-received signal.

(3) A single Arrow Yagi (Figure 7) with a drive motor set to remotely change the Yagi's polarity while watching/listening for the best-received signal. A small variable frequency drive (VFD) with a switch for clockwise/off/counterclockwise controlled this drive motor. What if the signal was best at a 45 or 135-degree angle? I wouldn't know with just the vertical/horizontal test. This axial motor-driven antenna let me test all polarity possibilities.

KG0D June 28, 2023 at CN88ka Master Summary Greencube IO-117	Satellite Passes	Total Decodes (GetKISS+)	Total Telemetry to SatNOGs	Decode Minutes	SORT Reception Quality Percentage
Portable IC-9700, Single Arrow 7 El Yagi Manual V to H or Between (?? dBi), 20dB ULNA	1	49	49	58	69.0%
Portable IC-9700, Single Arrow 7 EL COAX RELAY V or H (?? dBi), 20 dB ULNA	1	428	56	60	76.2%
Portable IC-9700, Dual Phased WA5VJB 11 EL DUAL AXIAL Motors (13.8+2.5 dBi), 20 dB ULNA	3	1,560	146	152	78.4%
Base station IC-9700, M2 LeoPack 8+8 RHCP only (13.3 dBi), 24dB ULNA	126	60,626	6,641	6,769	80.1%
Portable IC-9700, Single WA5VJB 11 EL Manual V to H or Between (13.8 dBi), 20 dB ULNA	4	2,108	205	190	88.1%
Portable IC-9700, Dual Phased WA5VJB 11 EL Manual RHCP or LHCP (13.8-3.0 dBi), 20 dB ULNA	3	1,380	127	115	90.2%
Portable IC-9700, Single WA5VJB 11 EL COAX RELAY V or H (13.8 dBi), 20 dB ULNA	3	1,263	182	164	90.6%
Portable IC-9700, Single Arrow 7 El Yagi AXIAL Motor (?? dBi), 20dB ULNA	1	606	56	50	91.5%
Portable IC-9700, Single WA5VJB 11 EL Single AXIAL Motor (13.8 dBi), 20 dB ULNA	3	1,674	188	166	92.5%
Portable IC-9700, Dual Phased WA5VJB 11 EL Manual V or H or Between (13.8+2.5 dBi), 20 dB ULNA	3	1,893	172	144	97.5%
	148	71,587	7,822	7,868	

Figure 1 — Master Summary of 148 IO-117 passes data.

CN88ka — IC-9700, 24 dB ULNA, LeoPack 8+8 RHCP Yagi

126 Passes

Date	Elevation	DK3WN GetKISS+ Decodes Count	Unique Calls Count	Telemetry Frames to SatNogs	Minutes (First to Last decode)	Decodes/ Minute	Reception Quality Percentage
(14 Passes)	1-10	3,084	531	261	349	8.8	61.1%
(5 Passes)	11-20	2,159	269	208	204	10.6	83.3%
(8 Passes)	21-30	3,179	382	341	391	8.1	71.2%
(7 Passes)	31-40	3,637	399	335	380	9.6	72.0%
(26 Passes)	41-50	13,538	1,206	1,489	1,486	9.1	81.8%
(25 Passes)	51-60	12,782	1,198	1,447	1,461	8.7	80.9%
(14 Passes)	61-70	8,224	651	898	853	9.6	86.0%
(15 Passes)	71-80	7,226	745	968	922	7.8	85.7%
(12 Passes)	81-90	6,797	556	694	723	9.4	78.4%
126 Passes		60,626	5,937	6,641	6,769	9.0	80.1%

Figure 2 — Elevation versus Reception Quality percent.

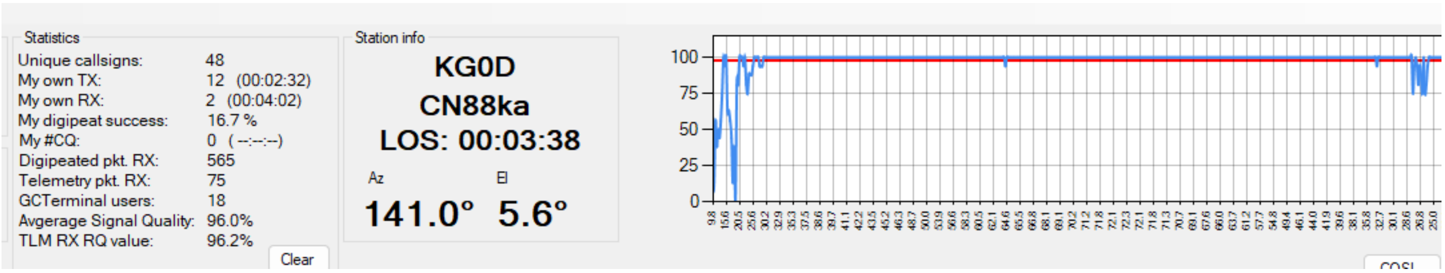

Figure 3 — Signal Quality graph 96%.

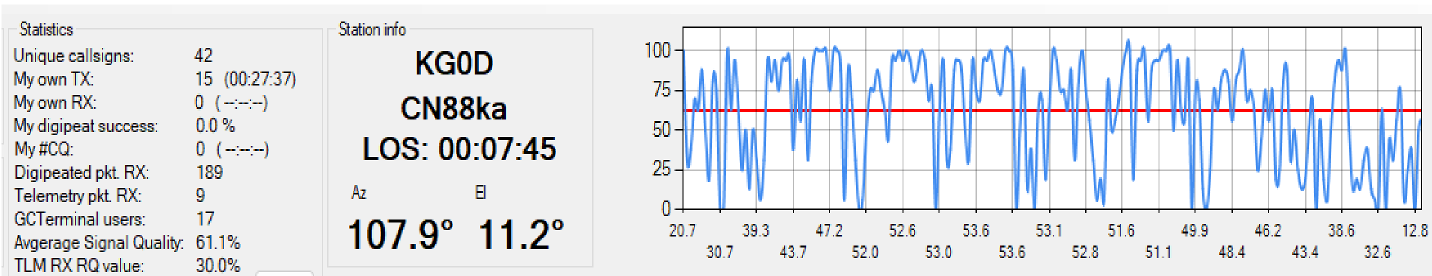

Figure 4 — Signal Quality graph 60%.

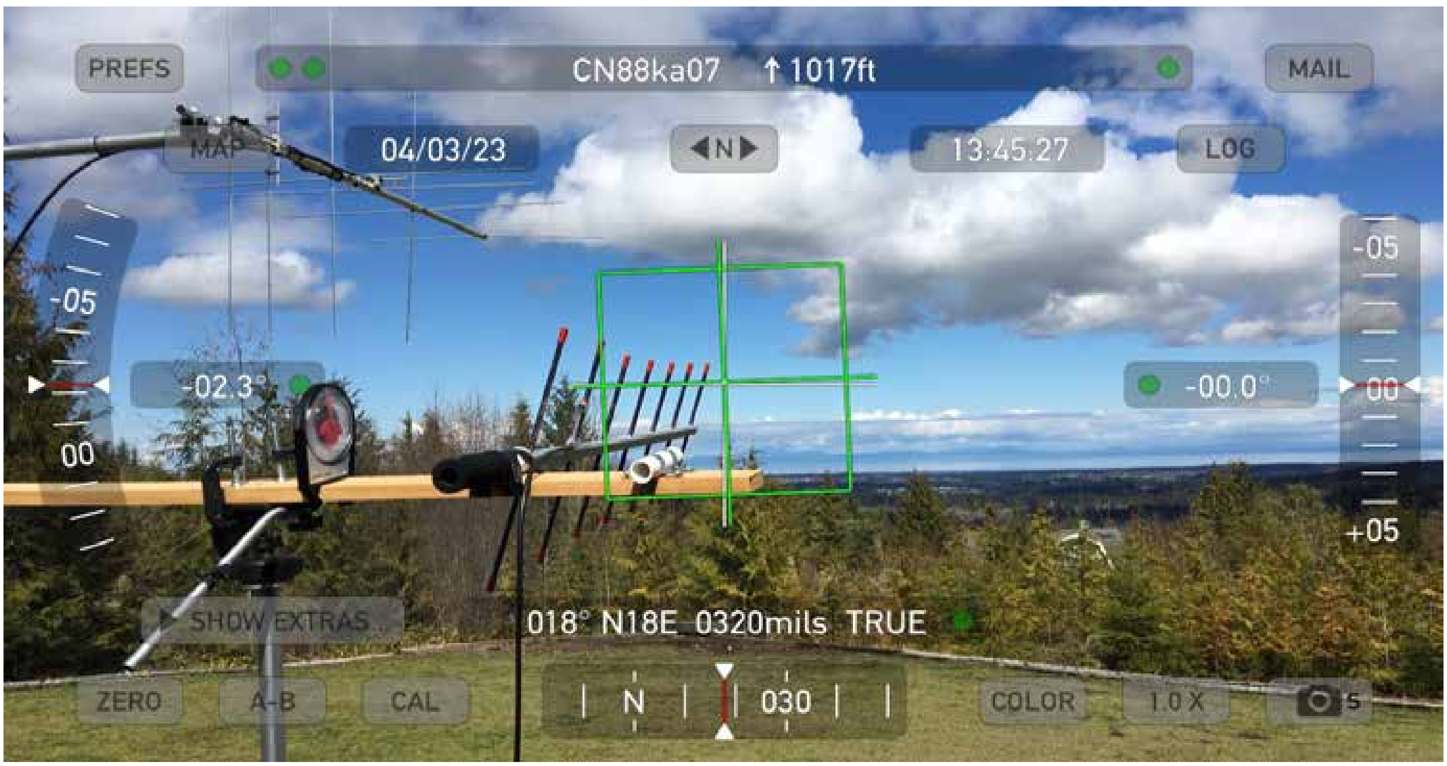

Figure 5 — Single Arrow manual vertical or horizontal or between.

The WA5VJB Yagis (~$10 each) were tested in six ways (Results in Figure 1):

(1) A single 11 EL Yagi (Figure 8), manually rotated from vertical to horizontal or anywhere between, while listening for the best-received signal. Again, requiring a loud radio volume setting while outside making changes.

(2) A single 11 EL Yagi (Figure 9) axial motor driven with remote VFD and direction control switch.

(3) Two Yagi's (Figure 10), one fixed vertical and the other fixed horizontal. A coax relay was hung near these Yagis with a remote switch back at the radio. Easy to change polarities while watching/listening for the best signal.

(4) Two Yagi's (Figure 11), coax phased and offset for RHCP or LHCP. Changes were made manually at the antennas while listening to the radio for the best-received signal.

(5) Two Yagi's (Figure 12), coax phased, manually rotated from vertical to horizontal or anywhere between while listening for the best-received signal.

(6) Two Yagi's (Figure 13), coax phased, both axial motors powered with a single V.F.D. and direction control switch. Electrically, this worked, but the Yagi's/motors needed

Figure 6 — Two Arrows, remote coax switched for vertical or horizontal.

Figure 7 — Single Arrow Remote controlled axial rotation.

to be more polarity-synchronized. I added a second V.F.D. to manually adjust each Yagi polarity as needed and keep the polarities similar.

(7) Similar to #6 but with two R.C. Servos and O.N.E. Servo Commander controllers (Figure 14) replacing the gear motors and VFDs. Success!! The Yagis stay synchronized with each other.

This discovery from Test #6 took me in another direction. I installed a second VFD and direction control switch and now am using both thumbs to control both those antennas while sitting at the radio remotely. Then I had the idea of loading in a VHF antenna to one of the motors and seeing if I could overcome the fades on RS-44. YES! This is a fourth antenna type – the four-element WA5VJB VHF Yagi (Figure 15). It slipped into the blue 3D printed part made by Matt, KC7EQO (Figure 16). The first test worked great. More testing/documentation will be done for RS-44.

The test platform/tripod is the Italian-made, Bogen, model #3011. I've had it for about 25 years. It weighs 3,120 grams (6.9 pounds). A single UHF-only Arrow Yagi weighs 384 grams (0.85 pounds). A single WA5VJB 11-element Yagi (including the coax) weighs 480 grams (1.1 pounds). The wooden crossbar, with a pair of gear motors, and the Deluxe Special cutting board with motor weighs 1,790 grams (3.9 pounds). All tripods are trained at birth to fall over! So far, I have balanced this one, left to right and front to back. Always give your tripod a carefully controlled nudge to test how "tippy" it might be. Raising it taller increases the tippy factor. Be aware! You will see the counterweight system made of vise grips and lead weight I am using in some pictures. Combined with adjustable friction in the tripod's elevation joint, these systems are balanced and easily adjusted as needed. The gravity-operated elevation angle indicator came from Harbor Freight. The electrical tape keeps it attached.

I'm using the tripod for portable operations, so component assembly needs to be quick and easy, preferably with no tools. PVC pipe is used to hold the antennas in place. The PVC also acts as the bearing surface, allowing Yagi rotation to any polarity needed. The goal is cheap and simple.

12 VDC Gear motors ($15), pulleys ($8 + $10), belts ($5), and VFD controller ($12) (Figure 17) came from Amazon (Danger!). I am using a 12 VDC SLA 1.2 Ah battery for this system. The Arrow cutting board

Figure 8 — Single 11 EL Yagi manually rotated vertical or horizontal or between.

Figure 9 — Single 11 EL Yagi remote controlled axial rotation with VFD.

used a two-rpm gearmotor. It was "in stock" here and waiting for use. The cutting board was from the Dollar Store. It worked great for the single Arrow Yagi rotation testing. It very easily slipped on an Arrow, into the PVC and over the two driver nuts attached to that motor.

The motor was loosely assembled to the cutting board with a pair of tie wraps (Figure 7). That assembly is easily removed from the test platform with two small bolts. The pair of 12 VDC gear motors are 23 rpm driver pulley has 10 teeth, driven pulley has 30 teeth. Belt tension was not too critical as the toothed belt prevented slippage. I learned later there was slightly varying motor speed, depending on load. Motor load differences quickly caused the two Yagis to stop polarizing, defeating the added ~2.5 dB gain from proper phasing.

7.4 VDC RC Servos ($32), the Servo Commander ($30), channel mount ($5), servo mount plate ($8), 8mm servo shaft extension ($8), and extension wires ($16) came from www.goBILDA.com (Figure 18).

The 7.4 VDC LIPO batteries came from Amazon – one at 850 mAh ($30 for two) and two at 5200 mAh ($27 for two). One battery is needed for operations (located at the Servo Commander). The smart do-it-all charger was $97. A different drive pulley is required, so I ordered the 20-tooth version (with an 8 mm bore) from Amazon ($9). With this setup, the Servo travel is limited to 300 degrees (default), so the antenna travel is limited to 180 degrees. These servos have an internal Pot that sends shaft location feedback to the Servo Commander. The Servo Commander knob is rotated at various speeds for antenna rotation/direction. It is designed to drive two servos. With slow speeds, there is no electronic noise. At higher speeds, there is a bit of noise (not a problem). The Type 61 ferrite material should eliminate this noise – on order!

The Yagi boom rotating systems, whichever type you choose, help keep the signal strength high and provide more decodes. Yes, there is a bit of a learning curve and some lucky guessing which way to rotate and chase the rotation as it is happening. With the R.C. Servos, I could peak the signal with very fast boom rotation during some of the longer packet transmissions. I recorded polarity as I made changes and saw no set pattern. Automating this polarity hunting for maximum signal strength and best SNR in the background will be the next logical step. Longer Yagi's mounted on the tripod could happen, but it will increase the risk of a "Gravity Event" – maybe guy wires? I hope this information and test results will encourage others to experiment and share the results. We are pushing the limits to communicate with a fantastic MEO satellite with our LEO antenna systems.

Figure 10 — Two 11 EL Yagi's remote coax switched for vertical or horizontal.

Figure 11 — Two 11 EL Yagi's coax phased for manual RHCP or LHCP.

Figure 12 — Two 11 EL Yagi's coax phased and manually rotated for vertical or horizontal or between.

Figure 13 — Two 11 EL Yagi's coax phased with gear motors and remote axial rotation control by VFD.

Figure 14 — Two 11 EL Yagi's coax phased with RC Servos and remote axial rotation control by Servo.

Figure 15 — Four EL Yagi for RS-44 remote axial rotation control.

Figure 16 — Blue 3D printed part by KC7EQO.

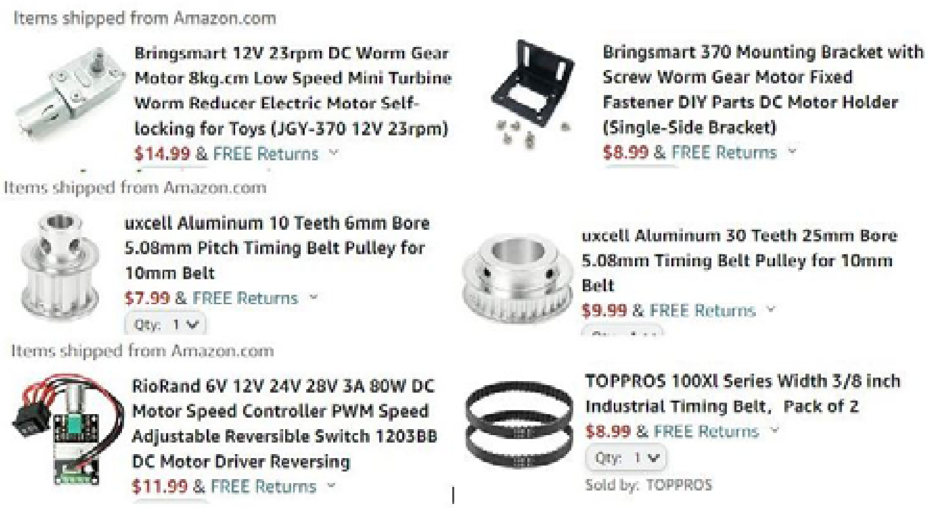

Figure 17 — GearMotor components list.

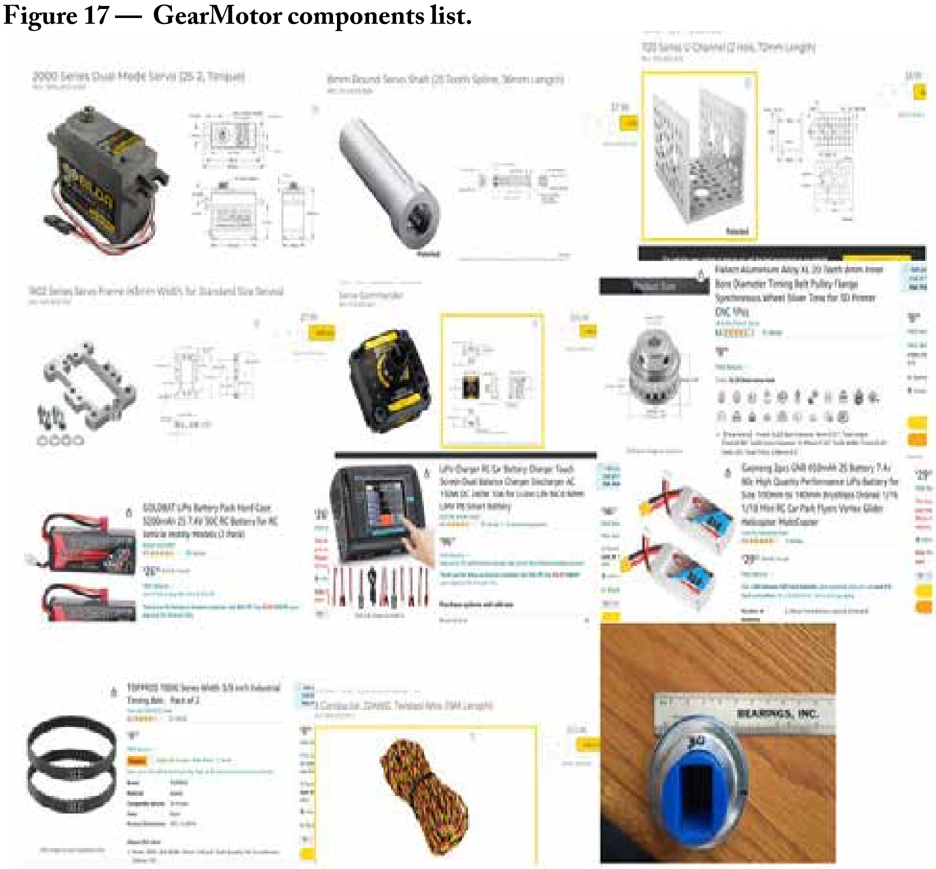

Figure 18 — RC Servo components list.

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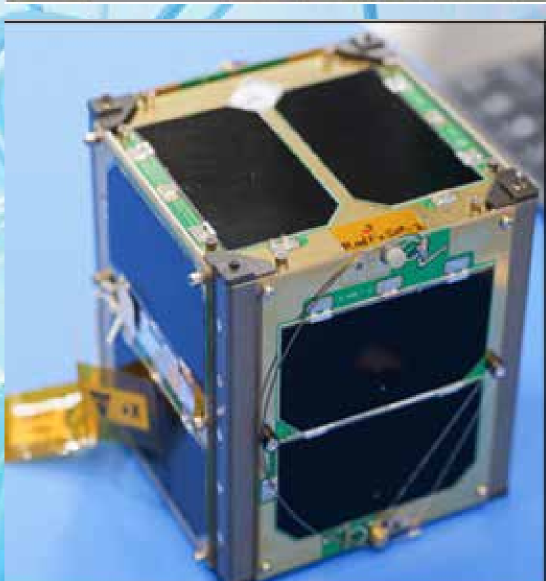

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