The AMSAT® Journal

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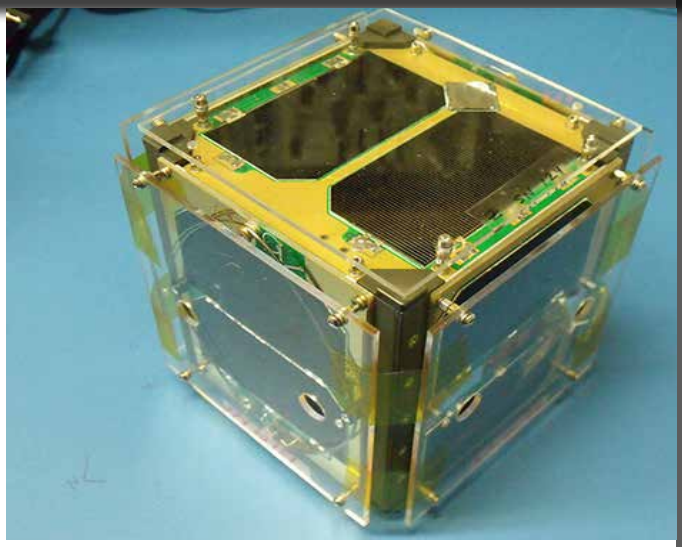
AMSAT at 50!



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AMSAT Announcements

AMSAT-NA Board of Directors Nomination Notice

It's time to submit nominations for the upcoming AMSAT Board of Directors election. Four directors' terms expire this year: Jerry Buxton, N0JY; Clayton Coleman, W5PFG; Drew Glasbrenner, KO4MA; and Paul Stoetzer, N8HM. Also, up to two Alternates may be elected for one-year terms.

A valid nomination requires either one Member Society or five current individual members in good standing to nominate an AMSAT member for Director. Written nominations, consisting of the nominee's name and call, and the nominating individual's names, calls and individual signatures should be mailed to:

AMSAT
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nominations, which is the preferred method, the intent to nominate someone may be made electronically. This includes e-mail, fax, or electronic image of a petition. Electronic petitions should be sent to martha@amsat.org or faxed to (301) 822-4371.

No matter what means is used, petitions MUST arrive no later than June 15th at the AMSAT office. If the nomination is a traditional written nomination, no other action is required. If it is other than this, i.e., electronic, a verifying traditional written petition MUST be received at the AMSAT office at the above address within 7 days following the close of nominations on June 15th.

ELECTRONIC SUBMISSIONS WITHOUT THIS SECOND, WRITTEN VERIFICATION ARE NOT VALID UNDER THE EXISTING AMSAT BYLAWS.

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.

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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

Joe Spier, K6WAO
President

50 years of AMSAT! Which begs the questions. What were you doing in 1969? What amateur radio equipment were you using? It was indeed a different time. According to Forbes magazine and Yale University's Richard Foster, most organizations when founded in the 1920s, expected to be around for 60-70 years. Today, the majority last only about 15 years. What gives our organization the ability to endure three times and longer over the average organizational lifetime?

The first reason is the investment in volunteers – and the investments by the volunteers in AMSAT – is fully returned, in both directions. What does this mean? This mutual respect and investment produce a character and principle-based organization that is replete with the traits that make for a lasting organization and lasting relationships. These traits include Respect, Belief, Loyalty, Commitment, Trust, Courage and Gratitude. Volunteers are fully engaged. Leaders are fully leading. Miraculous successes have and do occur.

The second reason is that relationships and partnerships with amateur radio communities and space agencies are rock solid, and produce tremendous returns. Trust and dependability abound.

The third reason is having good leadership. Leaders have to be proactive and involved. I can tell you that leadership in AMSAT can be, and often is, a full-time job. Good leaders also must have the opportunity to grow in seniority, to gain additional skills, and to become truly great. This is especially challenging in a volunteer organization.

The fourth reason is AMSATs' value and unique strengths are clear and focused. While AMSAT does not do marketing and sales very well (Help Wanted: Volunteer with Marketing and Grant Writing skills), project focus and fundraising are much more efficient when an organization doesn't need to be concerned with "reinventing itself," rebuilding a reputation or regaining awareness every 2-3 years. In fact, this may be a key reason for AMSAT's longevity. While most organizations only last 15 years, AMSAT's projects have a timetable of 10-15 years, so in essence, AMSAT has the ability to adapt to the changing focus of the space marketplace, to deal with the ebb and flow of government budgets and regulations, and when successful, have fundraising over a longer period of time. This means that AMSAT still must be diligent in fundraising, and responding to government regulatory actions that affect AMSAT, such as the recent Federal Communications Commission's Notice of Proposed Rule Making, FCC Docket#18-159A1 on Mitigation of Orbital Debris in the New Space Age.

Finally, long term organizations are financially stable. They experience fewer ups and downs and endure less stress and worry about the possibility of financial ruin. This means having conservative financial practices. That produces better financial cycles to create capital reserves that AMSAT can call upon in the leaner cycles.

Right now, costs are increasing for AMSAT, including launch costs, regulatory compliance, and space hardware certifications. AMSAT is experiencing the reality of being a product of its own success. Launch costs and competition for those launches are increasing because of the space marketplace realization that smaller, less expensive CubeSats do work and work well. While in the past, AMSAT rode as ballast on missions, now extreme competition exists for that physical space. And, yes, AMSAT still applies for CubeSat Launch Initiatives (CSLI), but this is not a free ride; instead, the benefit is a subsidy of up to $300k for a launch opportunity.

The point is that access to space is now going to require real dollars and funding that may be beyond the resources of what the amateur radio community of any one nation can provide. International cooperation will be necessary. This cooperation will

also require compliance with U.S. federal law and the associated cost. New AMSAT compliance and monitoring policies will need to be developed and implemented. Once completed, agreements with individual foreign organizations will need to be pursued. Only then will AMSAT be truly international again. AMSAT will also continue to find partnerships with the university community.

At the end of April, I'll be attending the CubeSat Developer's Conference in Southern California. Current planning is to have Vice-Presidents of Engineering and Operations, Jerry Buxton, N0JY, and Drew Glasbrenner, KO4MA, conduct the business of interfacing with the CubeSat community, freeing me to attend the majority of presentations that I seemed to have missed last year.

The 2019 Hamvention planning is proceeding very well with Phil Smith, W1EME, performing a fantastic job as AMSAT Chairman again this year. The TAPR/AMSAT Banquet has been scheduled along with the AMSAT Academy, and AMSAT's evening at Tickets Pub in Fairborn. The Banquet and Academy admissions are available on the AMSAT Store website. This year ARISS will conduct a separate forum on Friday, while AMSAT's Forum will be on Saturday as usual. AMSAT's Hamvention 2019 will feature a 1969 theme and an "OSCAR Park" display. The tentative lineup for the park includes appearances by OSCAR-1, AO-7, Phase-3A, ARISSat, Fox, and GOLF.

I am trying to have a little fun for those working in the AMSAT booth this year for Hamvention, so I've come up with a non-binding dress code. Dress code for gentlemen is a suit, think Mad Men, not Woodstock, or an AMSAT Polo shirt or T-Shirt with slacks. For ladies (directly from the film "Hidden Figures"): "Skirts must be worn past the knee. Sweaters are preferred to blouses. No jewelry. A simple pearl necklace is the exception." Or ladies may also wear an AMSAT polo shirt or t-shirt with slacks. I am trying to have some lab coats available with the AMSAT logo on the back.

Please make your plans now to attend Hamvention at the Greene County Fairgrounds in Xenia, OH, May 17-19, 2019. There is nothing like spending the weekend with thirty thousand of your closest friends.

Our 50th Anniversary Symposium for 2019 will be held at the Arlington Hilton in Arlington, Virginia. Hilton Arlington is located in the heart of Arlington's Ballston neighborhood. Connected to the Ballston Metro Station, the hotel offers easy and effortless access to Washington D.C.'s top tourist destinations like the National Mall, Smithsonian Museums and historic monuments.

The hotel is six miles from Reagan National Airport and the National Mall. The 50th Anniversary Symposium will be held October 18-20. The AMSAT Board of Director's Meetings will be held on October 16th and 17th at the same hotel. The current plan for tours of Washington DC/Baltimore area will be on Sunday and Monday, October 20-21. The Banquet speakers will celebrate AMSAT's long history, so please plan on attending the 50th Anniversary. You would be glad you did.

A final item is that ARISS is in the middle of a major fundraising campaign to get the new radios to the ISS. Recently, the ARISS-US team (Amateur Radio on the International Space Station) auctioned two very unusual items in its first-ever auction. Congratulations to the winning bidder and proud owner of a unique JVC Kenwood TS-890S signed by astronauts! JVC Kenwood, a proud supporter of ARISS, generously gave a brand new TS-890S for ARISS to auction. They first offered the radio for sale in the U.S. in the last half of 2018. Kenwood has been a super supporter of ARISS for years, and it was the company's idea for this radio, with astronaut signatures, to be an exclusive that just one ham operator could own! The company hopes you'll want to support ARISS, too.

And congratulations also to the top bidder on a special astronaut signed 6-volume boxed set 2019 ARRL Handbook. The limited edition 2019 ARRL Handbook for Radio Communications sold out fast once ARRL posted their ad. It was the first time that ARRL divided the Handbook into volumes, which nestle in a hard slipcase. ARRL, an ARISS sponsor along with AMSAT and NASA, saved back one boxed set to give ARISS for the fund-raiser auction. I wish I could have the auction's winning bidders names to announce, but I am writing this article in March. ARISS will have more fundraising ideas on the horizon.

I encourage you to do your part, whether that's operating the satellites, giving AMSAT or ARISS support, or bringing dollars or new members to our organization. See you at Hamvention -73!

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.

Sometimes we are getting rid of our old equipment, sometimes selling something new. In any case, please consider giving a piece of the pie to a new satellite and choose AMSAT for your eBay Charity.

Smile for AMSAT at Amazon.com

When making purchases from Amazon, you can select a charity and Amazon will donate .5% of a qualified purchase towards that charity. Select smile.amazon.com when making your Amazon purchases and make Radio Amateur Satellite Corporation (AMSAT) your chosen charity.

Having selected a charity, when you go to amazon.com, you will be prompted to go to smile.amazon.com. However, you can put everything you want in your cart at the original amazon.com site, then leave the site and go to smile.amazon.com and all your items will still be in your cart.

Engineering Update

Jerry Buxton, N0JY
Vice President, Engineering

As this issue celebrates AMSAT's 50th anniversary, I think back to when I started working with satellites around 1974, when I got my General Amateur Radio License. I don't have my first logbook as far as I know, and I'm not sure what the catalyst for the idea of working satellites was, but I'm pretty sure it was AMSAT or perhaps ARRL news and articles. For an 18-year-old child of the space era what could be more provoking than the thought of making QSOs with amateurs by "bouncing your signal off of a satellite"! With some science activities required to know your AOS/LOS times and track the "birds," the hook was set deep because of the possibilities of doing something that was ahead of anything else available to hams for exploring beyond your shack. Having just started my career with the railroad, my home base was my parents' house. But most of my time was spent in hotels and motels across eastern Iowa and Illinois, working what's known as the extra board – basically relief for whoever was up for their vacation. Even when I became more established at a location such as Des Moines, IA, or Highland, CA, my home was an apartment.

The AO-7, AO-8, and other Mode A birds were attractive and pretty easy to work, and were my first pick. With my Heathkit SB-104 for the 10m downlink and a thin stealthy wire hung or strung from a balcony hotel window or covertly placed on the roof at sunset and taken down before sunrise. A Ringo Ranger 2-meter antenna which was pretty easily broken in two to lay out of sight until sunset was quite effective, given the limitations of apartment living. It easily could be mounted on top of a couple of pieces of good old 5-foot Radio Shack mast "Jerry-rigged — to a balcony or patio rail. In less accommodating locations like a hotel, a simple 2-meter dipole worked. The oldest logbook I can find has OSCAR 7 and OSCAR 8 all throughout and at various QTHs.

I'm sure that many of you got started similarly, and the equipment available here 45 years later certainly facilitates the opportunity to make satellite contacts and join the fun! Although I will argue that my OSCARLOCATOR plastic overlay never locked up just before or during a pass.

The opportunities I had and we all have had over the past 50 years to make amateur radio contacts via our own satellites and learn and play with the science that goes with that have always been provided by a group of hardworking, dedicated, enthusiastic, and knowledgeable hams. Hams that are, because amateur radio is the hobby that it is, just like the rest of us. They choose to have their fun building spacecraft that feature amateur radios, and we all benefit from their fun. Many things about spacecraft radios add complexity to these amateur radio projects, and as far as I know, they have all come with a do-or-die deadline known as "launch." Not one amateur radio satellite has had the luxury of specifying their launch date.

I cannot provide a good history of AMSAT Engineering here, just because I was not part of most of it. Other members and officers of AMSAT do have either hands-on or firsthand knowledge and, both in this issue and through the symposium, I am sure that they will entertain us with the fun and foils they experienced. I believe that I can say, though, that each AMSAT Engineering team through the decades has similar experiences with the ideas, concepts, requirements, planning, construction, testing, and hold-your-breath minutes to hours time periods after launch to first confirm that we have succeeded.

Why does anyone volunteer to spend hundreds or even thousands of hours doing this? Either they are all smart, or they are all completely nuts. Personally, I think I fit the latter category.

The closest thing in amateur radio that I can think of as an analogy to what goes on to get a satellite to orbit would be a DXpedition. I am no expert, but I chase DX so I have read or viewed quite a bit about various expeditions and they are all well planned, well organized, well run, personally financed by the DXpedition operators to a notable extent, and have inherent risks and dangers that are a big part of the challenge. In the long run, the operators put in a lot of time, effort, and money that is targeted solely at the pleasure it brings other hams worldwide. The reward for a successful DXpedition or a successful satellite merely is satisfaction in a job well done. Maybe all of us are nuts, but if you have fun doing it,...

Since its inception in 1969, AMSAT has orbited 13 amateur radio satellites ranging from early telemetry/science beacons to store and forward packet mail systems to hemispheric coverage with an apogee that changed position each orbit, giving the entire world an opportunity for that type of coverage. Some were collaborations with AMSAT branches in other countries such as Australia, Germany, and the United Kingdom. One more awaits her launch in this our 50th year. Some were solely the original AMSAT(-NA), especially of the last decade due to export restrictions. Putting a successful satellite into orbit on an average of one about every 4 years is a remarkable and fantastic feat when you consider that each complete project from A-Z is accomplished by hobbyists, in their "spare time"!

I can personally relate most of the history of AMSAT's most recent (in orbit) satellite projects, the Fox-1 CubeSats. After early years of membership and much later years of President's Club donations, I wondered if I could "do anything to help" and that brilliant idea landed me the job of Systems Engineer for the new Fox program in September 2011. I consider that the point when I became an "insider."

Looking back to our beginnings, even back to OSCAR 1, you can see evidence in the design of the satellites that indicates their innovative shapes, which were often a result of the launch vehicle on which they rode. Our ability to orbit small yet robust satellites arguably opened the door to affordable access to space, and as worldwide interest grew, we now have an industry spanning amateurs to governments who are taking advantage of the low(er) cost of smaller satellites and launch opportunities. With the number of interested riders and the variety of launch vehicles joining in to make a buck on some of their excess propulsion/mass, it quickly became clear that creating satellites to fit various launch vehicle nooks and crannies as we had been doing was very inefficient. The CubeSat standard brought the same type of satellite designs to a deployer that could be fit on a variety of launch vehicles and offered the ability to choose or move between launch vehicles if necessary, with relative ease. And so, as we have done since the beginning, we now design satellites that fit the available space – CubeSats.

Around 2009, Vice President – Engineering Tony Monteiro AA2TX (SK) began working the idea of a CubeSat with the engineering team. The goal was to be able to get back into the affordable launch opportunities that we had virtually given away by our success, and so it was really just another look at a design shape that would fit the available space. We build CubeSats now because CubeSats are what we can get launched. But there was a barrier to our opportunities at that time, in that the cheapest launches (a.k.a. free) were offered through the NASA CSLI (CubeSat Launch

Initiative) program and that program was limited to (primarily) educational institutions only, e.g., universities. Tony had the idea and the determination to make CubeSats happen, so he set out and successfully petitioned NASA to add non-profit corporations, i.e. AMSAT to the list of candidates for a CSLI. That in itself is the significant contribution that kept AMSAT in the game for launches.

Upon opening the door, a CSLI proposal was submitted based on the design work underway, in a joint mission with Vanderbilt University. Including educational partners and experiments on the satellite was not only in line with our Bylaws, but also added a solid educational piece to the proposal for a better chance of selection.

In the beginning, Fox was imagined to be more complicated than the Fox-1 we are all familiar with now, having a software-defined radio and deployable solar panels among other "desirements It became clear that attaining all of those design goals in the amount of time given, having now been selected for launch and because of the demise of AO-51, was not possible. An alternative course was set which would split the original plan, with a descoping of the original plan for an immediate Fox-1 and the expectation to continue the bigger plan later, with Fox-2.

AO-51 had offered a robust platform of transponders that could be linked into various up/down modes using the VHF, UHF, 23 cm (1.2 GHz), and 13 cm (2.4 GHz) amateur radio satellite bands. The receiver and transmitter were very good, and AO-51 was so easy to work, that it became known as an "EasySat." The goal for Fox-1 was to produce a similar "EasySat" albeit with scaled back modes and get it to orbit ASAP in order to continue what was found to be a very popular type of satellite to operate.

This is where it gets complicated. If you have done design and prototype work for a new system be it a receiver, power supply, or IHU (integrated housekeeping unit), you know that it just isn't as easy as it should be. With satellites, or at least I can speak for CubeSats, the challenges are several times what you might typically see as a result of size, cost, space tolerance, and launch qualification. Throw in a hard deadline, integration into the launch vehicle dispenser, and the mandatory testing and qualification that you must make lest you waste a few years of the team members' lives now spent building a paperweight, and you have a lively time that can result in even more descoping to make the schedule.

The Fox-1 design, in general, was descoped because of such challenges and difficulties, initially with the plan to be able to include them back in future Fox-1s but eventually, some of the descoped was carried throughout the Fox-1 program because of the rapid succession of launch opportunities. Understand that a launch opportunity does not necessarily mean a closely following launch, but does set that hard deadline for integration. While launch dates move to the right as regularly as the sun rises, we cannot build that into any planning because we might get lucky and hit one that is close to the initial schedule – and come up empty at integration. In that Fox-1C and Fox-1D, which were now destined to fly on a commercial launch that AMSAT purchased, were produced hot on the heels of the delivery of Fox-1A and ready for integration just a year after Fox-1A's integration. However, their launch went south (but not in the sense of the SSO we were looking for), and it was two to two and a half years before they left the ground. Oh, what we could have incorporated if we knew we had that amount of time!

We are also fortunate that our partner in Fox-1A, Vanderbilt University, is pleased to work with us and they were the ones who successfully submitted the CSLI for Fox-1B and Fox-1E. That put Fox-1B on the list of deadlines and Fox-1E soon after. That put all of the planned Fox-1s into the production chute, and our amazing and dedicated Engineering team continued to plug away for another 3 years after the launch of Fox-1A, to get five spacecraft built and delivered.

The successful rush of Fox-1 CubeSats was very taxing on the Engineering team, but we were able to bring a few items back into scope thanks to their hard work. All of the Fox-1s were designed to have a MPPT (maximum power point tracking) power supply. That system ran into difficulty during design and was delayed, so at the last minute, I reverted to flying our fallback power supply design. The "LDO" power supply as we call it (referring to the Low Drop-Out regulators) is a simple regulated voltage supply. This was designed for lab use and testing and early engineering models only, but with difficulty with the MPPT Tony dubbed the LDO design as the fallback choice. Thanks to the efforts of a couple of recent Rochester Institute of Technology graduates, we had our MPPT "just in time" to fly on Fox-1C/D, and subsequently B and E. That system is an excellent illustration of the hard work and dedication that our AMSAT Engineering team puts forth. We were also able to do some very quick thinking of what might have been the reason for Fox-1A's (by then AO-85) receive problem. Of the candidate ideas that we had, only two could be implemented on Fox-1C/D due to the timeline. The antenna connection to the solar panel was a big one and turned out to be the correct one, and the option to disable the AFC on one of the two satellites was the other. Because both Fox-1C and Fox-1D were scheduled to be on the same launch, the thought was that having both in the same orbit and similar range at the same time after deployment might give us a chance to evaluate whether the AFC could be a cause or not. Unfortunately, they turned out to be far apart in time and space, of course, and in the meantime, the antenna solution was verified – but you cannot go back and make changes to a satellite that you have completed for delivery unless you have a lot of time and money to re-qualify for launch after you make your changes. Fox-1Cliff flies with no AFC and of course, we may never know how it would have worked or even if it might have somehow wound up being the cause of AO-95 being as deaf as a post.

Only Fox-1E had the benefit of having a little more time for some upgrades. Only four Fox-1s were planned, and I honestly don't know why that was determined, but it has merit, so Fox-1E is the result of leftover parts, the popularity of the Fox-1 platform, and input from both Operations and Engineers wanting to build and fly a linear transponder. Fox-1E was finished, as were all of the others, just in time and just as all of the others currently is still sitting in a Pelican case in Fox Labs waiting for delivery. How we did on her design I guess, will be something for our 100th-anniversary history reflection!

I would like to point out a unique piece of the Fox-1 development that has caught the attention of many and as far back as the day of the launch of Fox-1A with people throughout the CubeSat world starting at Cal Poly, where all of the missions on ELaNa XII gathered on launch day evening to listen for our birds. I am sure that you all have noticed, but not much has been said or at least not very often, about the voice ID of the Fox-1 FM satellites.

The original design called for an ID in Morse code, kind of the traditional thing for an FM repeater. With the passing of Tony Monteiro and the passing of the torch to me, when we came to the point of writing the ID into the IHU software, the software engineers, always starved for a challenge, brought up the idea of making it a voice ID instead. We agreed that it would be achievable and desirable, and that led to the discussion of who to use for the ID. It was suggested that perhaps Veronica Monteiro, Tony's daughter, might be interested in recording some ID-like phrases and that it would be a fitting memorial to

Tony as well. Careful coaxing and coaching during the recording session brought forth some pretty good audio, and once we tried it out, we decided to go all in and have Veronica record an ID for the three other satellites. I will admit that I did some editing of the later three to give it some zing and make it much easier to hear than Fox-1A, but Veronica did an excellent job and a great favor to AMSAT to spend the time recording the various phrases that now make up the Fox-1 IDs. Not many (then) college freshmen get to have their voice played for the whole world from orbit by four satellites, day after day and year after year! I am especially proud of the fact that we had such a unique opportunity to honor Tony and to interest so many in what we had done. At the listening gathering that first night at Cal Poly, several perked up when they heard Veronica and asked or remarked how cool it was to have a voice ID like that.

There is one thing about Veronica, though that I would like to clear up. The ID is often referred to as "the little girl" or similar, not so much now as it was at first, which I believe is because I did a better job of editing. If you were to hear the original recordings you would know that Veronica is a young woman, but thanks to our DUV (data under voice) telemetry on the Fox-1 FM satellites I had to put a brick wall high pass filter at 300 Hz in order to keep any of the voice ID audio from interfering with the telemetry. As a result, the ID does make her sound younger, but I hope that the later Fox-1s sound a little better.

The Fox-1 program can be summed up as being a significant step for AMSAT in transforming our engineering process and capability from satellites ranging from a few to tens of times the size of Fox-1, and the desire to keep amateur radio in space with the "EasySat" concept. Both were very successful in my opinion. Our engineering has developed with and learned from Fox-1, and I believe that there are a large number of hams for whom "the hook was set deep" in the world of amateur satellites. Now we continue to challenge ourselves with our next CubeSat program, GOLF.

I wrote extensively about GOLF in the Sep/Oct 2018 Journal, so I will not go into the detail that I have with the Fox-1 program. While the name (letter) is different, GOLF is a descendant of Fox-2 and the original Fox program idea. Knowing that the Phase system (1-5) is the overall and original goal of where to go with amateur satellites (aside from the progression in capability of AO-10, AO-13, AO-40, and having no idea where that might have gone had AO-40 kept chugging along), I believe that the Fox and GOLF programs are perhaps the longest running planned sequence of satellite development that AMSAT has undertaken in succession. The CubeSat platform will be around for some time, and we have no desire to go to less than 1U sizes as, of course, we want to pack as many radios and as much power into a satellite as we can get! I expect to step up through 3U to 6U, and I won't speculate beyond that at this time. There are many challenges to the GOLF concept and our desire to go higher in both the engineering, but perhaps more difficult, in the regulation and available low-cost launches that we hang our hat on. AMSAT has done an amazing job of putting highly capable and long-lived spacecraft into orbit for a miniscule fraction of the commercial world and the way we operate now the free launch is easily a 50% reduction in the cost of a satellite to orbit. That is helped by our carefully stepped progression in our satellites because we can watch the opportunities and weigh the options for a ride to orbit.

However, for GOLF-1 and even for GOLF-TEE we are pushing into territory where the free launch opportunities are dwindling. Because of the supply and demand as many of the launch candidates seek lower altitudes and lower costs as in ISS deployments as well as restrictions being drawn up in order to limit "space junk", we at least so far have not had CSLI selection quickly turning to launch offers that I became used to with the Fox-1s. The constraints that will require us to be able to de-orbit ourselves within 25 years of the end of the mission will make for difficult maneuvering through the regulatory agencies. We will need to prove that our missions last more than the one year that all CubeSats are lumped into these days because most do not have a mission of more than a few months. Reaching an altitude of an AO-7 or FO-29 has been nearly impossible due to current restrictions and does not look like it's going to get any easier. Perhaps we are again a victim of our own success, having had several CSLI selections with long-lived missions that go up against the (all-important, to the regulators) statistics and sheer numbers of the others that is the basis for the regulations that are made for the good of all.

AMSAT Engineering's next 50 years is not bleak by any means, and the advances in technology along with the innovation and talent of radio amateurs who have fun building satellites will no doubt bring us some pretty cool stuff, likely to limits that we can hardly imagine now. Perhaps similar to what those engineers who built the first beacon amateur radio satellites 50+ years ago might have wondered. Much of our past was primarily engineering, that is the nature of hams, and it pushed amateur radio satellites forward in technology and capability to spacecraft and communications that we are now working to regain in a sense in this whole new playing field for getting to space.

A look back over our 50 years tells us that AMSAT satellites are primarily a product of what the engineers want to do, not what Radio Amateur Satellite Corporation, the users, or even I want to do. As we move on with GOLF and beyond we, the engineers, officers, directors, and the amateur radio satellite community, must work together as fellow hams just as we would with any project or undertaking at home or at our clubs. We must understand and overcome the regulatory challenges, and very likely confront and get behind the fact that it is going to cost money on at least some scale of the past satellite triumphs we have had. "Space is hard" is a cop out, like saying "I'm afraid to do it because I might screw up or look dumb." I'm not about to hang it up for myself or AMSAT Engineering because Fox-1Cliff is hanging around waiting to hear something she may never hear. We had one failure out of 4 (so far), but it's certainly not because "space is hard." It is because something happened whether it was by us (Engineering) or in the integration and launch environment, and that is just another fun challenge to figure out and move forward.

"Space is expensive," I think we might all have to get behind that one if we want to continue to play. Are new, better, exciting amateur satellites for you and the kids of the next 50 years worth it to you?

Educational Relations Update

Alan B. Johnston, KU2Y
Vice President, Educational Relations

With still two months before Hamvention, lots of work is underway to get ready for the official launch of the AMSAT CubeSat Simulator Program!

Here are some of the recent activities. We are up to our third revision of the printed circuit board (PCB), version vB3. Recent improvements include moving the Remove Before Flight switch and DC input power connectors to the circuit board, saving having to wire them and mount them on the frame. The use of JST connectors, popular in Remote Control (RC) vehicles, is also an improvement. We also have a beta version of our 3D printed frame, thanks to Villanova CubeSat Club member's efforts.

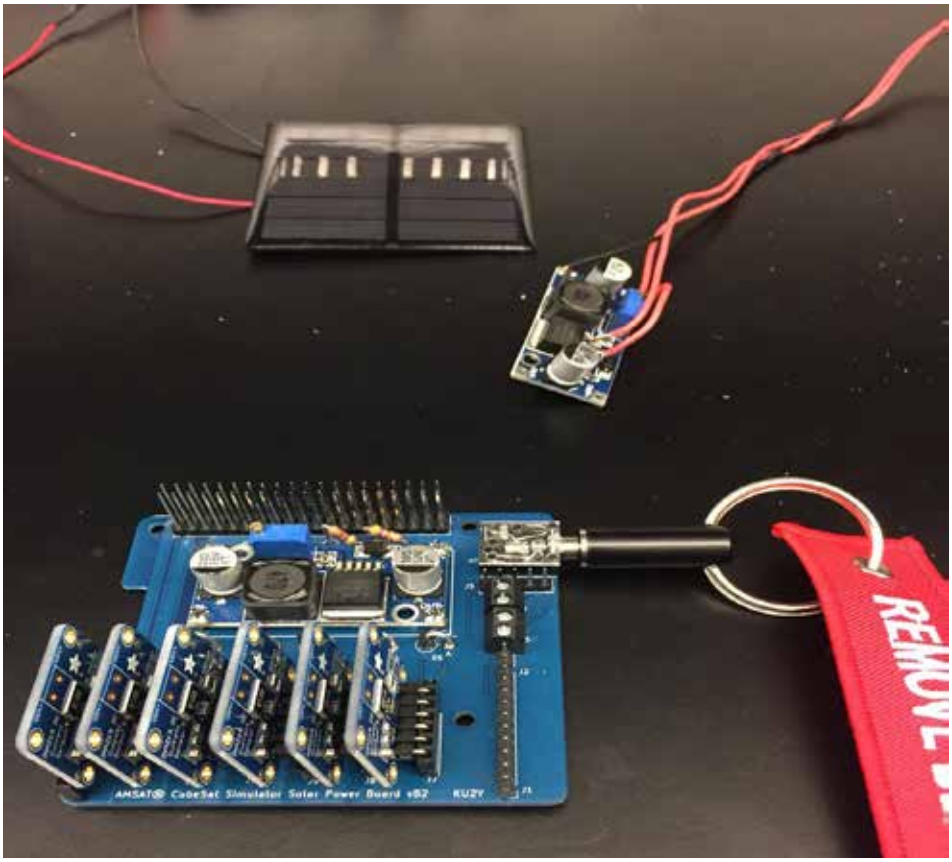
I've been enjoying learning how to make 3D prints. See your ideas and thoughts made real in front of you (a few hours later) is addictive!

At Villanova University, my freshman electrical and computer engineering students will start building CubeSat simulators next week. If all goes well, we will have at least three to demonstrate at Hamvention. I have seen pictures of CubeSat simulators constructed at the University of Tennessee under the supervision of Gould Smith, WA4SXM, author of the famed *Getting Started with Amateur Satellites* book sold by AMSAT!

Later this year, AMSAT CubeSat Simulators will be available as loaners. If you want to use one in your classroom or presentation or demonstration, contact me.

As always, we look forward to your feedback. Feel free to contact me via email **ku2y@amsat**.org or tweet at me **@alanbjohnston.**

As this issue of the *Journal* is a 50th anniversary special, I would be remiss to not tip my hat to all of the excellent educational activities undertaken by AMSAT over the past 50 years. I look forward to your help in fulfilling our educational mission!



CubeSat Simulator solar power board, photo by Mike Light, electrical engineering student at the University of Tennessee, from Twitter, used with permission.

Member Footprints: Share Your Experiences as an AMSAT Member

As a way to better serve our readers, *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**).

Past Presidents' Retrospectives

Perry Klein, W3PK [1969-1980]

The early AMSAT Directors and officers in June 1969 with Australis-OSCAR A. Left-to-right: Jim Puglise, George Kinal, Cap Petry, Chuck Dorian, Bill Tynan, Jan King and Perry Klein. Chuck Dorian and Bill Tynan were added to the Board in June.

The idea to create an "OSCAR East" was proposed by George Jacobs, W3ASK at a meeting of the COMSAT Amateur Radio Club on January 9, 1969, at which he was the guest speaker on the topic, "The Status of Project OSCAR." George pointed out that the expertise existed on the East Coast to continue the impressive work of Project OSCAR and suggested that the COMSAT Amateur Radio Club help form such a group. I was president of the club and agreed to explore the possibility. Less than two weeks later, I held a meeting at my apartment in Southwest Washington, DC with Bill Tynan and Jim Puglise of the Applied Physics Lab. Radio Club, George Kinal of the Communications & Systems Radio Club and Denny Avers of the IBM Radio Club, to see if there was enough interest to move forward. We concluded that there was.

By the end of the month, we were circulating a draft "Charter of the Amateur Satellite Corporation" and had met with Jan King, Frank Briden and Seth Williams of the NASA Goddard Space Flight Center Radio Club. Jan had recently graduated from college and, at 21 was the youngest of our group (I was 26.)

The following month (Feb. 1969) we held several organizational meetings at COMSAT, APL, and Goddard and drafted articles of incorporation to file as a non-profit scientific corporation in the District of Columbia. An interim Board of Directors was agreed upon consisting of Jim Puglise of APL, George Kinal of C&S, Cap Petry of ARINC, Jan of NASA and myself of COMSAT. We filed the incorporation papers with the District of Columbia on Feb. 27 and were officially incorporated on March 3, 1969, as the Radio Amateur Satellite Corporation, having added "Radio" to our name.

In March we held several organizational Board meetings, including one lasting from 5 PM to nearly 4 AM to finalize the bylaws. Officers were elected by the Board on an interim basis: myself as President, Jan as Executive VP, George Kinal as VP Engineering, Cap Petry as VP Operations, Jim Puglise as Secretary and Dick Mostow as Treasurer. We designed a membership form and dues were set at $5.00.

We started out to study satellite components and design, including even sophisticated subsystems such as nuclear power (which APL had flight experience with), but George Jacobs advised us to start small. He pointed out that the Project Australis group had delivered a satellite to Project OSCAR that had never flown, and a good first project would be to arrange its launch.

Project Australis and Project OSCAR agreed to turn over the Australis-OSCAR A to AMSAT, and we decided to try to arrange for NASA to launch it as a piggyback payload. Jan worked at Goddard and with his connections there, they were able to identify a TIROS weather satellite mission with spare payload space and weight margin to accommodate Australis-OSCAR. Jan agreed to be Australis-OSCAR project manager and arranged some upgrades, including replacing the batteries, and to use the test facilities at Goddard for thermal-vacuum, vibration and other tests to qualify the satellite for launch. It was launched from the Western Test Range on a Thor-Delta rocket on January 23, 1970, with TIROS-M (ITOS-1). The early AMSAT Directors and officers in June 1969 with Australis-OSCAR A (which became Australis-OSCAR 5 after launch.)

Our Status Now

Fast-forward fifty years to 2019. Qatar-OSCAR 100, launched Nov. 15 is now operational in geostationary orbit, capable of digital and analog modes, including TV, thanks to AMSAT-DL and the Qatar Amateur Radio Society and others. It's truly a dream come true, and hopefully, there will additional rideshare opportunities to geostationary orbit. CubeSats are very popular now, made possible by more efficient solar cells and increased microminiaturization of components. But our responsibility today is to assure that we pass down the capabilities and know-how to the younger generations and to encourage and facilitate their participation. Many universities and even a few high schools are building CubeSats now, and this is an excellent way to do this.

Jan King with Australis-OSCAR A in 1969.

Bill Tynan, W3XO (SK) [1991-1998]

In the Beginning

It all began in early January, 1969 when George Jacobs, W3ASK, then the writer of CQ's propagation column and professionally associated with the Voice of America, spoke at a meeting of the Communications Satellite Corp. (COMSAT) Radio Club. In his talk on the Status of Project OSCAR, George noted that the west coast group, that had pioneered Amateur Radio satellites, had not been able to orbit any new spacecraft for about five years. He observed that the Washington area included many industrial, university and government laboratories employing hams who should possess the technical capability to construct spacecraft. Therefore he urged that a Washington-based organization be established to carry on the fine work begun by Project OSCAR.

A young Ph.D. in the audience named Perry Klein, K3JTE (now W3PK), was so inspired by George's talk and its challenge that he resolved to take action. And take action, he did. Wasting no time, Perry called a meeting at his apartment in southwest Washington, DC. To that meeting he invited representatives from various Amateur Radio clubs associated with DC area organizations and government agencies. Included was the club at the Johns Hopkins Applied Physics Laboratory where I was employed. Answering Perry 's call, another JHU/APL Amateur Radio Club member, Jim Puglise, W3CBJ (now K9CQ), and I journeyed one cold winter evening from our homes in the Maryland suburbs down to southwest Washington - having no idea what we were getting ourselves into.

Attending, in addition to Perry, Jim Puglise and me, were George Kinal, K2MBU (now W3HPE), who worked for Communications and Systems Inc. and Cap Petry, W3AWN, from Aeronautical Radio Incorporated (ARINC). Perry's enthusiastic recounting of George Jacobs' challenge inspired us to the point that we immediately agreed to form the organization which is now known as the Radio Amateur Satellite Corporation, or AMSAT.

Getting Organized

Regular meetings were held to draft a set of bylaws and an application for a charter from the D.C. Government. More people soon came aboard; among them, Jan King, K8VTR (now W3GEY and VK4GEY), of the Goddard Space Flight Center, Dick Daniels, WA4DGU (now W4PUJ), of NASA Headquarters, Ray Soifer, K2QBW (now W2RS), then serving with the U.S. Maritime Administration, Bob Carpenter, W3OTC, of the National Bureau of Standards, and Dick Mostow, W3YAV, publisher of Forecast FM magazine. With their help, work began to set up a formal organization and, by March 3, the Radio Amateur Satellite Corporation was officially incorporated in the District of Columbia as a non-profit educational scientific organization. Thus from George Jacobs' original talk before the COMSAT Amateur Radio Club to incorporation, less than two months elapsed. Obviously we were enthusiastic to get started.

AMSAT's original concept was that it would be made up of Member Societies or clubs and members of these groups would participate through these Member Societies. That changed almost immediately as many individuals, not associated with any particular club, clamored to join.

AMSAT's interim Board of Directors was composed of the five who signed the articles of incorporation: Jim Puglise, George Kinal, Cap Petry, Jan King and Perry Klein. In June, two more were added to this interim Board: Capt Charles (Chuck) Dorian, W3JPT, of the U.S. Coast Guard and this author. These same people were elected by the members attending the first AMSAT Annual Meeting held at the Goddard Space Flight Center the following November. This board reaffirmed Perry as President, Jan as Executive Vice President, George Kinal Vice President for Engineering, Cap Petry as Vice President for Operations and selected Harry Helfrich as Treasurer. The original bylaws called for board nominations by one or more AMSAT Member Societies. This provision was later changed to also allow nominations by any five individual members as well as by Member Societies.

Telling Our Story

How to inform the amateur community of the new organization and its intention to serve the hobby? QST was obviously the best vehicle to make such an announcement. So Perry and I set out to write an article for that publication. When we had completed our first draft, I showed it to my friend Vi Clark, W4KFC, ARRL Roanoke Division Director and a fellow Potomac Valley Radio Club member. (Vic later became ARRL President.) He suggested that what we had written needed a little more " pizzazz," as he put it - and offered a few suggestions. Taking his good advice, I added a few paragraphs and the article announcing the birth of AMSAT was submitted.

In addition to announcing the formation of AMSAT to the amateur community as a whole, the organization needed a publication of it own to keep its member ship informed and tell its story to others who might be in a position to help the cause. So, the AMSAT Newsletter was born. Its first editor was a non-ham Ph.D, who Perry knew at COMSAT, by the name of Sajjad Durrani. Sajjad did a fine job of documenting those early days. (It is from some of the forty year-old copies of the AMSAT Newsletter that I obtained much of the information for this article.)

Various suggestions were received for a logo that would convey AMSAT's mission in an eye-catching manner, but none of the submission received seemed to be quite what we were looking for. So Dick Mostow went to a graphic artist friend at Washington's Channel 9 TV station who came up the familiar globe and arrow design, which marks our organization today.

Let's Get Technical

For AMSAT's first technical endeavor, we fell into the trap so typical of Washington - generating paper rather than actually accomplishing something. What did we do? Why of course, we set up study groups to research various aspects of spacecraft design and submit reports on our findings. I drew two assignments . One involved gravity gradient stabilization and the other, nuclear isotope power systems. My task was to determine if either or both of these technologies would be suitable for use on Amateur Radio spacecraft. I received these particular assignments, not because I knew anything about the subjects, but because

my employer, JHU/APL, had been active in both fields. Though my professional work involved missiles, not satellites, I knew a number of people in the Lab's Space Department, so it was assumed I would be able to pick brains for information.

An interesting aspect of these assignments is that none involved anything having to do with computers. Apparently none of us then dreamed of using computers in satellites. Possibly, if Tom Clark, WA3LND (later W3IWI) now K3IO, had been involved at the time, the major role computers would play in all types of spacecraft would have been recognized.

At a meeting called for presentation of the reports, I submitted mine and the others came with theirs. George Jacobs, who had been the inspiration for AMSAT, put us on the right course admonishing us for our typical Washington bureaucratic approach. He told us of the existence of an Australian amateur satellite sitting in a garage in California that had been sent by its builders at the University of Melbourne to Project OSCAR in hopes of a launch. Why should not our first project be to prepare this spacecraft for launch? Everyone agreed George was right. Amateur Radio needed a new satellite soon, not a stack of visionary reports on what might be - years in the future. So, thanks again to George Jacobs, AMSAT was off and running - this time, in the right direction.

Agreement was reached with Project OSCAR and the students and faculty members at the University of Melbourne for AMSAT to obtain the satellite and prepare it for launch. Jan King was given the responsibility for the technical work necessary to prepare the Australian spacecraft for launch.

In view of the key role Project OSCAR had played in getting Amateur Radio started in space, it had earlier been agreed that all AMSAT satellites would bear the name OSCAR. This policy would begin with the Australian spacecraft. Thus, it would be known as Australis OSCAR-A prior to launch and Australis OSCAR-5, or AO-5, once in orbit.

Australis OSCAR-5

Thanks to the dedicated work of Jan and his team, Australis OSCAR-A was ready for launch by the end of 1969. Jan and a co worker at Goddard, Harry Helfrich, W3DWF (later W3ZM), were able to arrange a ride for it as a secondary payload on a Delta vehicle scheduled to put a weather satellite into orbit.

AO-5 roared into orbit in January 1970, carrying beacons on 2 meters and 10 meters. In addition to getting Amateur Radio back into space, this satellite had two principal objectives. The 10 meter beacon was to prove the utility of that band for space use, and the command function would furnish the first demonstration of ground command of an Amateur Radio satellite. Bill Dunkerley, WA2INB, arranged for the Talcott Mountain Science Center in Connecticut to set up the necessary equipment to successfully command AO-5.

The ability to command amateur satellites would become increasingly important in later years as AMSAT, and similar organizations in other countries, endeavored to convince their governments and other launch authorities that amateurs could control their spacecraft. Permission for launches would often hinge on being able to furnish such assurance.

AMSAT Helps Launch Careers as Well as Satellites

A young Englishman attended some AMSAT meetings, apparently to learn what this amateur satellite business was all about. Eventually he established a spacecraft construction facility at the University of Surrey, near London. It was this university group that later launched UoSat OSCAR-9 (UO-9), UO-11 and a number of other amateur and research satellites. Later, he formed Surrey Satellite Technology to commercialize the work done at the university. For his satellite work, and the importance it has represented to Great Britain; this now, not-so-young-anymore Englishman Dr. Martin Sweeting, G3YJO, was knighted. I like to think that AMSAT played a role in Sir Martin's success.

I believe that Jan King will agree that his association with AMSAT helped him vocationally in later years in gaining several space-related positions with various organizations. There are others who will be mentioned in future articles chronicling our organization's later decades.

AO-6 , AMSAT's First Wideband, Multiple-user Transponder Satellite

Once the AO-5 mission was complete, design and construction began on our first from-the-ground-up project. In orbit, it would be AMSAT OSCAR-6, or AO-6. This satellite contained a 2 meter up/10 meter down transponder, a 21-channel command decoder, a 435.1 MHz beacon and a Morse code telemetry system.

Since no information existed on how a multiple-user transponder would behave when exposed to many signals in its passband simultaneously, a prototype of the 2 to 10 meter transponder was built and flown in a light plane. With Jan occupying the rear seat monitoring the transponder on a small HF receiver and a pilot and copilot at the controls, the plane took off one Saturday morning from Friendship Airport, now called Baltimore Washington International Airport (BWI).

The route took them up the East Coast to near Boston, then west over New York state and across the Niagara Peninsula of Canada. They landed late that afternoon at Pontiac, Michigan - a logical place to stop as Jan's parents lived in the area, thus providing the plane crew a free place to stay overnight. The following day they resumed the flight, proceeding to near Chicago and making it a point to fly over Kokomo, Indiana, where AMSAT already had several loyal members who were eager to participate in the experiment. The flight ended Sunday afternoon where it had begun.

A group of ground-based volunteers tracked the plane, communicating with Jan via 2 meter FM and relaying the aircraft's position and other information to me on 40 meters. I then reported the information to the other AMSAT folks in the DC area via one of the local 2 meter FM repeaters. It was a thrill when I suddenly heard Jan's voice as the plane crossed the Allegheny mountains.

Two unfortunate events occurred during OSCAR-6 's construction and testing. In conducting a thermal test on the flight transponder in his wife's oven, Dick Daniels inadvertently left the oven on too long and burned the thing to a crisp - necessitating construction of another unit. Worse was the sudden death of Harry Helfrich, who had been such an inspiration and great help to AMSAT in arranging for environmental testing and obtaining a launch for AO-5. Harry died suddenly while jogging one very cold January morning.

Harry's death left both a technical and administrative voids in AMSAT's activities. Since he had been serving as Treasurer, that position had to be filled immediately. Bill Hook, W3QBC, of the National Institutes of Health Radio Amateur Club, an early member, stepped up and took over this vital post. Tom Clark, K3IO, replaced Harry on the board and took over as Executive V.P.

Despite the magnitude of the job and these setbacks, AMSAT OSCAR-6 was launched on October 15th, 1972. But a problem with the new satellite became apparent almost immediately. Although it was heard by European stations soon after launch, when it first came over Australia, the down-under command station reported no signals. Jan quickly flashed word to send an ON command, whereupon the spacecraft immediately again came to life. It didn't take long to conclude that AO-6 had a mind of its own. Even though it contained no on-board computer, only logic control circuitry, its transponder would turn on and off for no apparent reason. To overcome this pesky situation, Jan initiated what he termed, "intensive use of ground command." To maintain the bird in the desired mode, commands had to be sent by the various command stations around the world at every opportunity. Several dedicated volunteers, around the world, including Randy Smith, VE2BYG (later VE3SAT), and Larry Kayser, VE3QB, automated their stations to accomplish this arduous task even when they could not be present.

The first DXpeditions involving amateur satellite operation took place during AO-6's lifetime. One such DXpedition was to Penrhyn Island (also known as Tongariva) in the North Cook chain. Though HF operation was the group's main objective, some among them wanted to try the new satellite as well. Thanks to Chip Angle, N6CA, they had the appropriate equipment. But, the on-again/off-again nature that AO-6 continued to display represented a real challenge to their success in making satellite contacts.

By the time of the AO-6 launch, I had been designated as Vice President for Operations and therefore had the responsibility to coordinate the various command stations around the world. In that position, I endeavored to support the Penrhyn Island DXpedition by having the satellite on when it was in the vicinity of the Cook Islands. To accomplish this, I depended principally on our New Zealand command station operated by Bruce Rowlings, ZLlWB. Bruce came through and the Penrhyn group was able to work a couple of US West Coast stations via AO-6, thus demonstrating that satellite operation could be a useful addition on future DXpeditions.

During AO-6's lifetime, a request came from the Boeing Amateur Radio Club. They asked us to make AO-6 available so that they could attempt to command a radio controlled model airplane through it - an interesting experiment indeed, with all sorts of implications applicable to the present-day world.

Two Twin City hams, John Fox, W0LER, and Ron Dunbar, W0MJS, reported an odd effect on reception of AO-6's 435.1 MHz beacon. As the satellite traveled away from them toward the south, they noted that, at one point in the pass, that the Doppler shift became inverted. (The frequency rose rather than falling, as one would expect for a departing object.) They did not observe this effect on AO-6's lower frequency beacons, or on other satellites, but did note it on some U.S. Navy navigational spacecraft with beacons in the vicinity of 400 MHz. John's and Ron's observations elicited much speculation in scientific circles as to the cause of the strange phenomenon.

AO-6 supported the first satellite WAS. Jack Colson, W3TMZ, had worked diligently to put all fifty states into his log and finally lacked only Hawaii. KH6 is about a 4,400 mile hop from Maryland - close to the limit of the range afforded by AO6's 900 mile high orbit. That, plus the fact that the satellite was often not on when it was supposed to be, made completing of that last contact seem doubtful. Many times, when the bird was in the right spot, the transponder was silent. But one evening the satellite gods were with Jack. The satellite was in the right position. The transponder was on. W3TMZ, and Butch Miller, KH6HLK (now NN2T), the Hawaii station he had been scheduling, were both on deck. The first satellite WAS went into the record books. Some dozen more joined Jack before AO-6 ceased to function in June 1977.

AO-7 and DJ4ZC

Following AMSAT OSCAR-6 , came AO-7. This spacecraft, built in an improvised clean room in Jan's basement, carried two transponders. One was a 2 meter to 10 meter unit like the one on AO-6. This combination of bands had been dubbed, Mode A. The other transponder was supplied by a German group led by Karl Meinzer, DJ4ZC, of the University of Marburg. Karl had earlier provided an in-band 2 meter transponder to Project OSCAR, which had never flown. The 70 centimeter to 2 meter transponder on AO-7 proved very successful. The design employed HELAPS (High Efficiency Linear Amplification through Parametric Synthesis) which had been the subject of Karl's doctoral thesis. Although signals from AO-7's Mode A transponder were not as robust as those from the one on AO-6, its Mode B transponder produced very strong downlink signals , making AO-7 very popular with hams throughout the world.

Inter-satellite Relaying Demonstrated

The overlapping lifetimes of AO-6 and AO-7 provided amateurs an opportunity to accomplish something never before achieved with any other satellite, government or commercial - relaying signals from one satellite to another. This satellite-to-satellite mode of communication has since found application in non-amateur spacecraft , including NASA 's Tracking and Data Relay Satellites (TDRS).

Satellite-to-satellite link-up became possible when AO-6 and AO-7 were within line-of sight of each other so that the 2 meter signals from AO-7s Mode B transponder could be received by AO-6's Mode A transponder and thus sent back to Earth on 10 meters. A number of satellite operators took advantage of these opportunities to complete QSOs via this cross-satellite route. The first to do so were Ray Soifer, K2QBW (now W2RS), and Ben Stevenson, W2BXA. Incidentally, Ben later became the first to earn a satellite DXCC. While Ben, W2BXA, was the first to actually receive the Satellite DXCC award, Pat Gowen, G3IOR (SK), was the first to work the required l00 countries. But Pat was notoriously slow to collect QSLs, so he eventually received Satellite DXCC Number 4. Incidentally, G3IOR was elected to the AMSAT Board in October, 1976, the first non-US citizen to serve. Over the years, other non-US board members have been Haruo Yoneda, JAlANG, Junior deCastro, PY2BJO, John Henry, VE2VQ, Larry Kayser (VE3QB) and Randy Smith (VE3SAT)

Satellites Come to the Rescue

An experiment conducted using both AO-6 and AO-7 involved sending a signal through each satellite, then computing the location of the station sending that signal by the Doppler shift. Confirmation of the utility of this technique to locate ground-based transmitters eventually led to initiation of the international SARSAT (Search And Rescue SATellite) Project to locate downed aircraft and lost mariners.

Back from the Dead

Incidentally, though AO-7 was launched in November, 1974, and went silent in the summer of 1981, its signals were suddenly and unexpectedly received again one evening in June, 2002, by G3IOR. The reappearance of long-departed AO-7 produced much excitement and many theories as to why and how it had happened. It has been surmised that, though the satellite 's batteries had long since ceased to furnish power, its solar

cells still provide power when in sunlight. Apparently AO-7's original demise was caused by a short circuit in one or more battery cells and that opening of the short made the solar panel power available to run the transponders - bringing the old bird back to life after so many years. But, since AO-7 can no longer be easily commanded, one can never be sure which transponder will be active. Many satellite enthusiasts make a special game of using this derelict spacecraft.

AMSAT Membership Swells

By the end of 1973 our membership had reached the one-thousand mark. Two who joined by that time, and made notable contributions to the organization were Tom Clark, WA3LND (later, W3IWI now K3IO) and Joe Kasser, G3ZCZ. Tom became very active in AMSAT activities and was elected to the board in 1974 and named executive VP in 1976. Joe Kasser, G3ZCZ, who had who had emigrated to the U.S. from England several years before joining AMSAT, took over the editorship of the AMSAT Newsletter in late 1974. Joe was also responsible for making a number of technical contributions, especially in the then new field of microprocessor based computers.

ARRL Does Its Part

To replace the by-then dead AO-6 and provide a Mode A capability superior to that offered by AO-7, the League funded AMSAT to build AO-8. In addition to a Mode A transponder , AO-8 carried a 2 meter up/70 centimeter down transponder built by the Japanese AMSAT group called JAMSAT. As a result of its Japanese origin, this combination of bands was dubbed Mode J. AO-8 was launched in March, 1978 and performed well under stewardship of ARRL volunteer controllers for five years.

The Soviets Contribute to Amateur Space

In October, 1978, AMSAT's and ARRL's efforts to provide satellites for the world's licensed amateurs , was augmented by hams from the Soviet Union. Radio Sputnik 1 (RS I) and Radio Sputnik 2 (RS-2) were sent into orbit simultaneously on a single launch vehicle. Both of these satellites carried Mode A transponders and remained popular for a number of years.

Martha Arrives

By 1978, AMSAT membership had grown such that Perry Klein was no longer able to keep up with the administrative paperwork by himself. From a couple who lived in the same building, he learned that their daughter, though employed as a teacher in the Headstart program, was willing to work part time. That's how Martha Saragovitz came to AMSAT. Martha remains our only full time paid employee. Incidentally, she met her husband, John Shew, N4QQ, as a result of her association with AMSAT. So AMSAT can be credited with fostering a romance. Of course, over its 50 years, AMSAT has come close to fostering a few divorces as well!

The Phase 3 Era

During the mid-l970s, work began on a cooperative project with Karl Meinzer and his German associates on a new high altitude amateur satellite. All of our previous spacecraft had been in relatively low orbits, thus affording only limited DX potential. This new type of spacecraft was referred to as Phase 3. The first OSCARs, including OSCAR-5, carrying only beacons , were referred to as Phase I, and the low-orbit transponder-equipped satellites, such as OSCARs 6, 7, 8 as well as the RS birds, were termed Phase 2. Phase 3A, the first of the Phase 3 satellites, was to provide worldwide coverage from a Molniya orbit. This kind of orbit, first developed by the Soviets to provide coverage across their very wide northerly country, involves a high latitude (approximately 64 degrees) inclination to the Equator, with apogee occurring at the northern-most point in the order of 36,000 kilometers (23,000 miles) and a relatively low perigee, which of course falls in the southern hemisphere. The low perigee enables the use of on-board electromagnets to orient the satellite in the higher strength Earth's magnetic field existing at the lower altitude.

Much hard work by volunteers from a number of countries went into the design, construction and testing of Phase 3A. In addition to the human labor expended to construct this spacecraft, AMSAT raised approximately a quarter of a million dollars in support of the project. Of course the German group had expended considerable labor and financial resources to complete Phase 3A as well.

The Phase 3A spacecraft was built mostly at the Goddard Space Flight Center, with much of the work being accomplished by volunteers in the "Fish Bowl," a small plywood building with the large windows erected in 1978 near the Goddard Visitors Center.

As AMSAT's first decade came to a close, the satellite, which promised worldwide long distance communication for amateurs in many countries around the globe, was ready to be shipped to Kourou in French Guiana

Barry Baines, WD4ASW [2008-2017]

I've been asked to reflect upon AMSAT's history during my tenure as President (October 2008 – October 2017) and make some remarks regarding AMSAT's future.

It has only been 18 months since my retirement from AMSAT as President as well as having the privilege of serving on the Board (1999-2017). I'm proud of the accomplishments that AMSAT achieved during my 18 years on the Board, but I will primarily focus on some key achievements during my nine years as President. Organizations are "living and breathing organisms"; what preceded my time as President directly impacted/influenced the issues that we addressed during my tenure as well as created the foundation for the next stage of AMSAT's evolution. Likewise, the "State of AMSAT" as I retired is the basis for the next stage that AMSAT is now experiencing.

During my time as President, I wrote "Apogee View" columns for every issue of *The AMSAT Journal* documenting key accomplishments, concerns/challenges, and future plans. My goal in writing these articles was to explain AMSAT's focus, build support with the membership for the strategic direction of AMSAT. Keeping amateur radio in space is very difficult, time-consuming, and expensive. The fact that AMSAT has been successful in making a difference over 50 years is remarkable that is not only reflected in the longevity of AMSAT, but how well AMSAT has evolved in response to changes in technology,

regulatory environment, political and social norms, and the costs of doing business.

For example, less than 20 years after AMSAT was incorporated in 1969, who would have imagined that AMSAT's efforts to expand amateur radio in space would start to encompass collaboration with the Soviet Union with the first US amateur station two-way communication with a Russian crewed spacecraft (MIR)? This took place at the 1988 AMSAT Space Symposium in Atlanta, GA during the Cold War. Later, following the establishment of the Russian Federation, came the creation of ARISS International in 1996, the launch of Echo (AO-51) in 2004 by a former Russian ICBM launch vehicle repurposed for commercial launches, the deployment of SuitSat in 2006 and later ARISSat-1 from the ISS by Russian Cosmonauts in August 2011.

Likewise, who would have foreseen in 1969 that the size/mass of a Fox-1 class amateur satellite first launched in 2015 (AO-85, a 1U 10cm x 10cm x10cm CubeSat weighing about 1.33 kg) would be 1/9th the size and 1/8th the weight of the first amateur satellite (OSCAR-1) yet have significantly greater amateur capabilities and provide important scientific data? This is a design that has now flown four times already with a fifth one yet to be flown. Such success was unimagined in 1969 when AMSAT was incorporated.

As I've repeated over the years, "Keeping Amateur Radio in Space" is the vision that keeps us focused. However, how that commitment is met considerably evolved during my watch.

That evolution is reflected in the proposal developed during the first year of my Presidency to build 1U CubeSats where the basic FOX design has subsequently proven itself, with four Fox-1 class satellites already launched and a fifth one (Fox-1E) ready for launch. At the AMSAT Board meeting inat the October 2009 (held at BWI just prior to the AMSAT Space Symposium celebrating AMSAT's 40th Anniversary), AMSAT VP-Engineering Tony Monteiro (SK) convinced the board that partnering with universities would provide the justification for NASA to cover the launch costs of amateur satellites by meeting NASA mission objectives, which included education. Noting that AMSAT possessed limited resources at that time to build and launch amateur satellites, Monteiro explained that some university researchers were interested in flying their scientific payloads. Fox-1A (AO-85), RadFXSat-1/Fox-1B (AO-91), and RadFXSat-2/Fox-1E are ELaNa launches because of the science as well as student involvement in these projects.

AMSAT announced at the ARRL Centennial Convention in July 2014 that a contract had been signed with Spaceflight, Inc. to launch Fox-1Cliff (AO-95) as a way to diversify our launch opportunities in the hope of securing launches more quickly. This agreement was later amended to include Fox-1D (AO-92). Fox-1Cliff was subsequently placed in orbit in December 2018 on a SpaceX Falcon 9 launcher that had a reusable first stage. Elon Musk's company was formed in 2002 and with their first flight (Falcon-1) only 10 years ago, highlights the changing dynamics of commercial involvement in space. Fox-1D (AO-92) was launched from India in January 2018 on an Indian Space Research Organization (ISRO) Polar Satellite Launch Vehicle (PSLV), another reflection of the dramatic changes taking place in space launch opportunities.

An exciting evolution of the Fox program is that universities are coming to AMSAT to establish relationships because they see that AMSAT is a viable partner. Along with placement of university experiments on AMSAT spacecraft, we're starting to see situations where a university wants to incorporate our space hardware into their satellite design. Consequently, the University of Washington has integrated AMSAT's linear transponder design (designed for Fox-1E) into their CubeSat mission. This is an excellent example of "putting an OSCAR into every CubeSat" approach.

Our coming to grips with ITAR (International Traffic in Arms Regulations managed by the Directorate of Trade Controls, Department of State) in the 2008-2009 timeframe cleared the way for our engineering volunteers to dedicate their time and effort on future satellites under a new appreciation of what is required to 'play in space' given that communications satellites were classified as "munitions". I wrote a paper for the 2010 Proceedings of the AMSAT Space Symposium ("AMSAT and ITAR: Lessons Learned") that outlined the steps that were taken by AMSAT under the ITAR self-disclosure process that allowed our volunteers to continue their engineering work with AMSAT without concerns for past "sins". I also gave a presentation at the 2010 AMSAT-UK Colloquium that explained how ITAR impacted AMSAT-NA's ability to collaborate on international projects. In 2014, Congress passed the National Defense Authorization Act (NDAA) that allowed the President to re-classify specific technologies such as communications satellites that were below certain thresholds as export items under EAR (Export Administration Regulations) managed by the Department of Commerce rather than ITAR that significantly eased the regulatory burden of export control.

The successful deployment of ARISSat-1 in August 2011 from the International Space Station (ISS) opened the door on using Software Defined Radio (SDR) technology in amateur spacecraft, demonstrating the versatility of a single system to provide a variety of operating modes including slow scan TV as well as telemetry downloads. The creation of worldwide data collection with forwarding of telemetry from ARISSat-1 to a central server has now been incorporated into the Fox-1 series spacecraft with scientific research directly benefiting from the efforts of amateurs worldwide to provide data to a central server. I wrote a paper for the *2012 Proceedings of the AMSAT Space Symposium* that summarized the significant benefits of ARISSat-1 on educational outreach as well as general amateur impact as documented by those that collected SSTV imagery and telemetry packets ("An Overview of the ARISSat-1 Mission").

As I noted in a 2017 "Apogee View" column as my service as AMSAT President was ending, ARISS (Amateur Radio on the International Space Station) in the US has evolved considerably in the past few years, responding to a variety of new challenges and relationships. SAREX (Shuttle Amateur Radio Experiment) was started in 1983 with the flight of STS-9 and Owen Garriott's first onboard use of amateur radio from space. SAREX established the viability of placing amateur assets on human spaceflight platforms and was the precursor of expanded opportunities that a space station could provide. ARISS International was established in 1996 before the first International Space Station segment was placed in orbit to develop a formal relationship between amateur radio organizations and the space agency's managing ISS: NASA (US), ESA (Europe), Rosaviakosmos (Russia), Canadian Space Agency (CSA), and Japan Aeronautics Exploration Agency (JAXA). Before the first crew arrived in November 2000, there was amateur radio equipment onboard.

Now, 20+ years after the establishment of ARISS there continues to be an amateur presence on the ISS. However, in today's environment AMSAT has assumed an even more prominent role in leading ARISS than ever before with these changes taking place in 2016-2017. AMSAT VP-Human Space Flight Frank Bauer, KA3HDO also

leads ARISS-International, the body that serves as the "voice" of amateur radio to the space agencies in terms of both the operational and technical aspects of amateur radio's presence onboard the ISS. ARISS volunteers in the US are engaged in US school selection after review of submitted proposals, providing educational guidance to the schools in preparation for their contacts, and documenting the impacts of those contacts.

An added responsibility is finding the funds to support the costs of keeping ARISS sustained and thriving here in the US. This includes the development of new onboard hardware systems that are employed for school contacts and by amateurs on the ground. This has led to new relationships with CASIS (Center for Advancement of Science in Space) which manages the International Space Station US National Laboratory. Frank also secured funding from SCAN (Spacecraft Communications and Navigation) at NASA HQ to keep ARISS going. Meanwhile, ARISS is moving forward to replace aging and failing equipment currently onboard the ISS. The replacement of failed equipment is critical, but it is also time-consuming and expensive as any system that is to be placed on the ISS must meet NASA safety certification standards. This means more funding is needed to fund the hardware development and safety certification process.

I continue to be impressed by the dedication, ingenuity, and technical tenacity of the ARISS-US team as they tackle an ever-changing environment. The overall impact of ARISS on students and educators at all levels is remarkable. The human spaceflight program that started under the leadership of Bill Tynan, W3XO (SK) in the early 1980s continues 36+ years later in response to changing circumstances and opportunities. As human space flight evolves into new missions, I'm sure that ARISS will be invited by NASA to submit proposals to participate in those missions.

Administratively, AMSAT continues to evolve and develop services in response to changing membership expectations. *The AMSAT Journal* is a key member benefit being published on time every other month containing articles developed by our members and the senior leadership team. Likewise, the AMSAT News Service continues to provide a weekly release full of useful information that helps to bind the amateur satellite community together as it is distributed worldwide.

Social media, the AMSAT website, and online membership support are areas where AMSAT is evolving. Membership expectations today are different than what was expected and provided in the 1970s. "Information Technology" was something outside of AMSAT when it began in 1969. During my tenure, AMSAT retained an outside firm to develop the new AMSAT website and the AMSAT Store which went online in 2017. Efforts to enhance AMSAT's online presence continues, but it is fair to say that IT infrastructure is a challenge that requires significant management attention and resource allocations that are not easy to implement.

While AMSAT takes great pride as a volunteer organization, I see similar trends in paying for someone's time to focus in areas involving significant deadlines and significant workload. For example, as we become more engaged with outside organizations that provide funding support for AMSAT programs, they will want AMSAT to provide metrics and reporting of significant developments. It makes sense to pay for the services of someone to handle these tasks to ensure timely and appropriate information. In certain situations, we've also paid individuals to complete satellite systems due to testing or delivery deadlines that must be met. As we move forward, I wouldn't be surprised to see an increasing trend towards paying for services to produce a quality product by stipulated deadlines.

Of course, the ability to cover such expenses is dependent upon AMSAT having the necessary resources. Expanding membership to cover administrative and operational costs related to maintaining AMSAT's presence is important, but so is raising funds for the projects that we want to see built. AMSAT members are the ones most familiar with our vision, project goals, and track record. As AMSAT seeks outside donor support, those donors are looking at the degree of support our members are providing as a barometer for measuring AMSAT's internal support. After all, if AMSAT is unable to build donation support from within, is it reasonable to expect success in gaining support from donors outside the organization?

What about the future? I'm confident that the successes during my tenure while serving as AMSAT President are leading to new opportunities in AMSAT's future:

- Our university relationships developed under the Fox program are strong and could lead to future collaboration.

-The ASCENT program is developing innovative technology that could be used in a variety of projects.

-AMSAT's relationship with Ragnarok Industries as they pursued NASA's CubeQuest Challenge has resulted in serious engineering development work applicable for future opportunities.

-AMSAT has developed a strong relationship with NASA's ELaNa program based upon our overall Fox-1 mission success that will continue to provide opportunities for future launches that meet NASA mission goals.

-AMSAT's collaboration with Virginia Tech on the (canceled) Phase 4-B project has created new relationships that will hopefully lead to new opportunities.

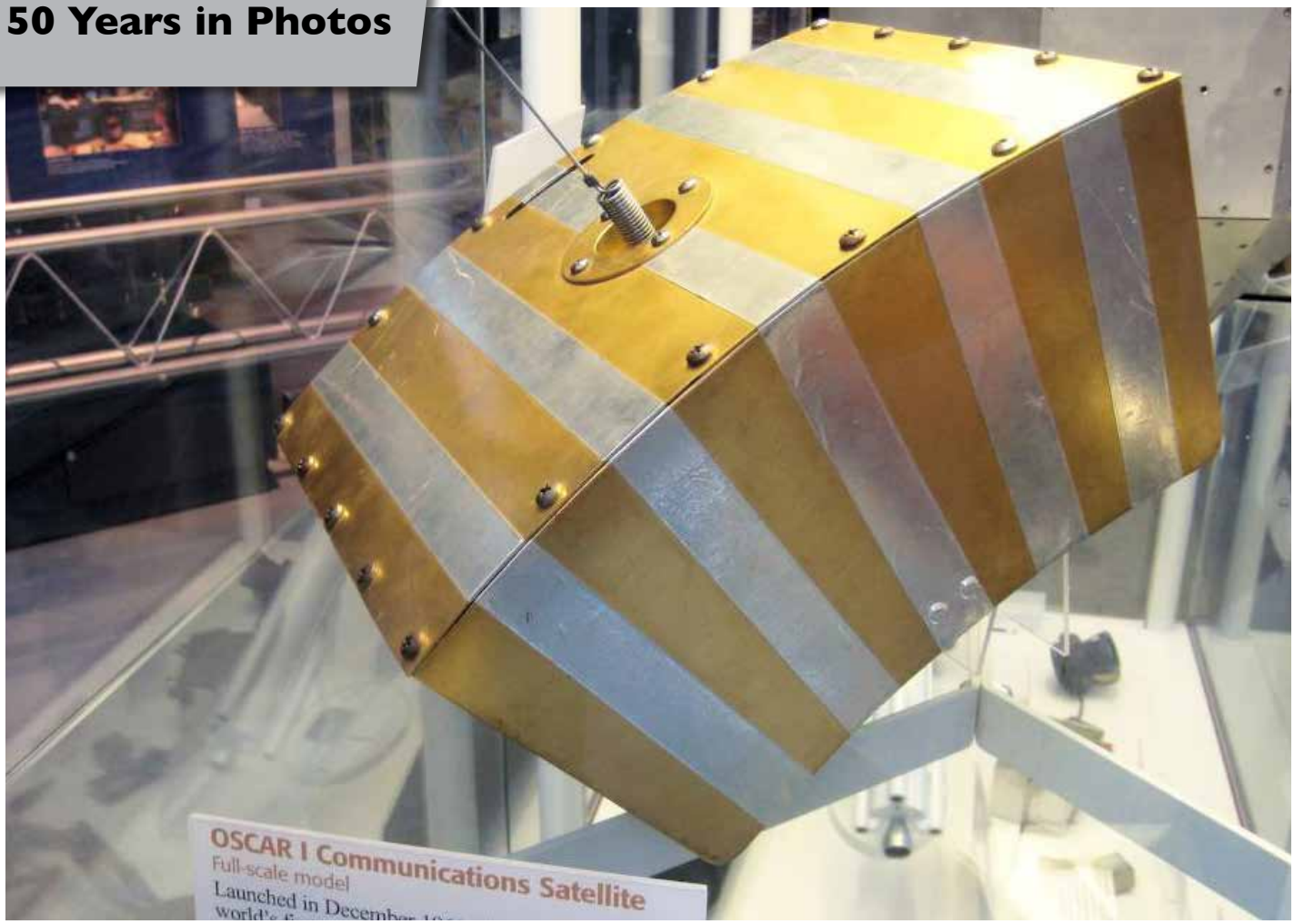
-Understanding how the regulatory environment has evolved considerably since 2014 now potentially opens the door for collaborative relationships with AMSAT organizations in Western Europe should such an opportunity arise.

-A key benefit of ARISSat-1 is incorporating SDR into payload development and the creation of a ground station network for collection of data that has been adopted by the Fox program; this work has potential application in a variety of scenarios such as the Golf program.

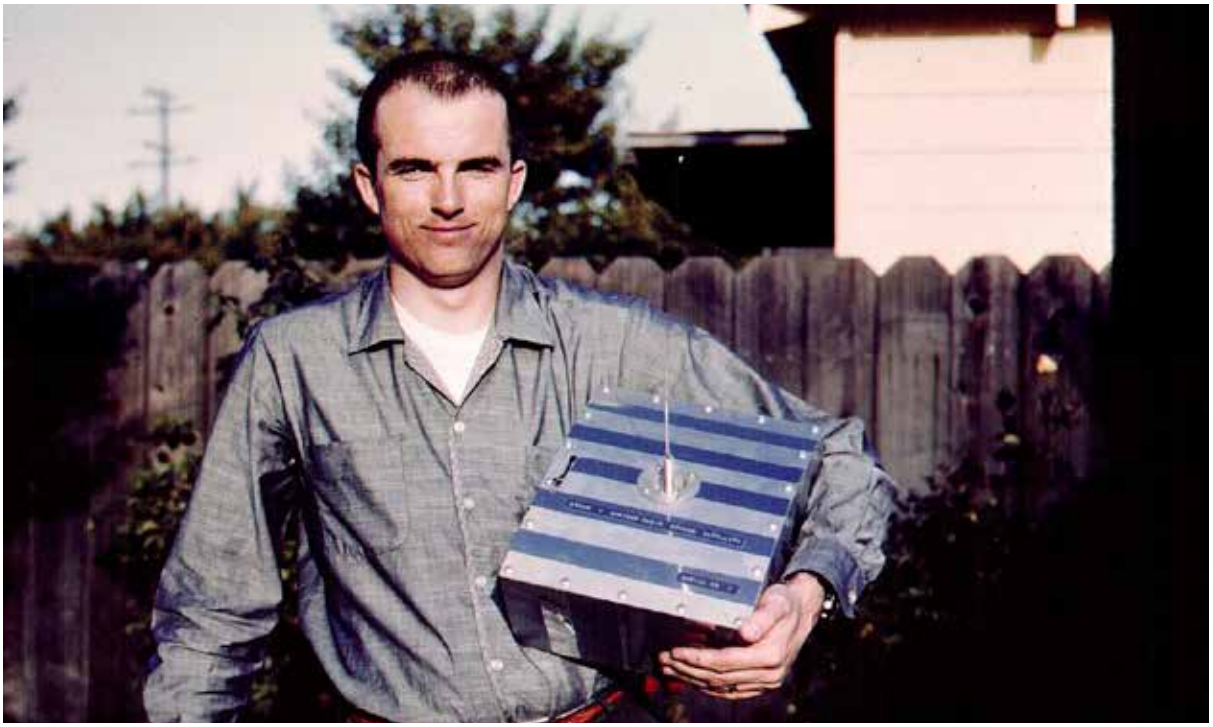
-ARISS will continue to provide a unique education and amateur radio program as human spaceflight evolves.

I cannot predict the future, but I do know that AMSAT will be positioned to take advantage of opportunities that may arise because of the relationships that have been established within industry, NASA, educational institutions and the amateur radio community.

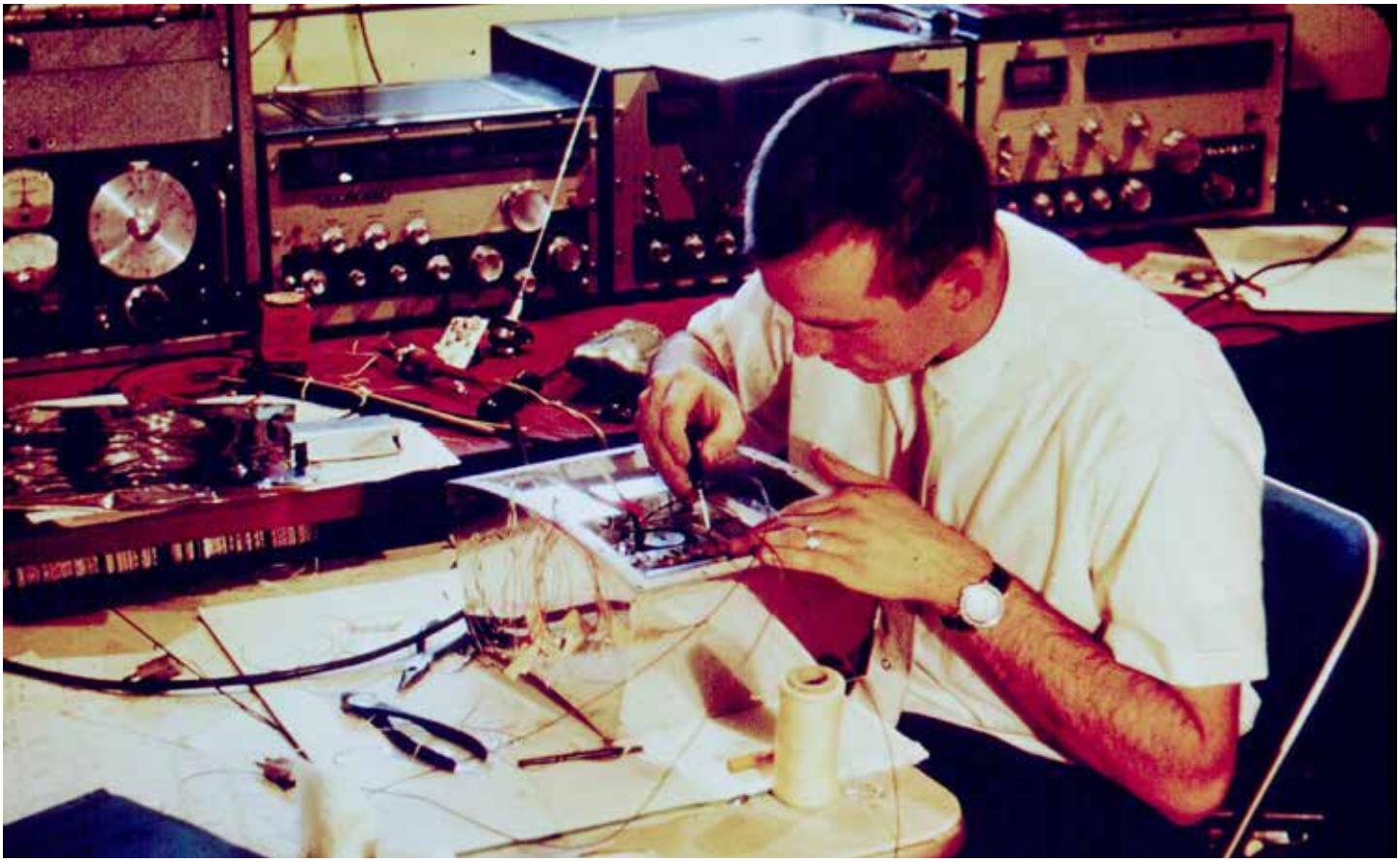
After 50 years of AMSAT volunteers making a difference in growing amateur radio's presence in space, education outreach, and technical development, I look forward to supporting this unique and capable organization's next levels of success.



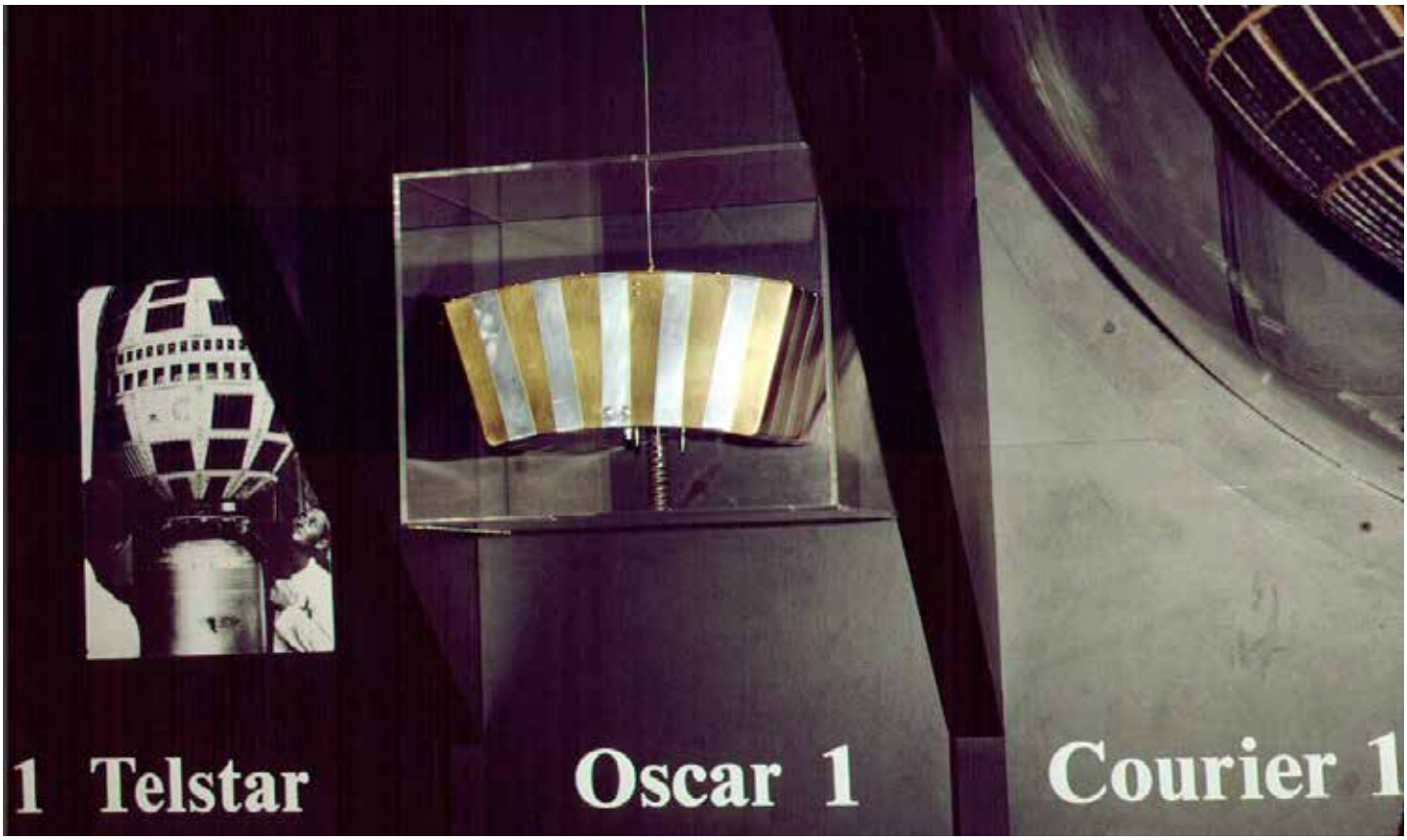
OSCAR 1 Communications Satellite model, Steven F. Udvar-Hazy Center (Courtesy: AMSAT).



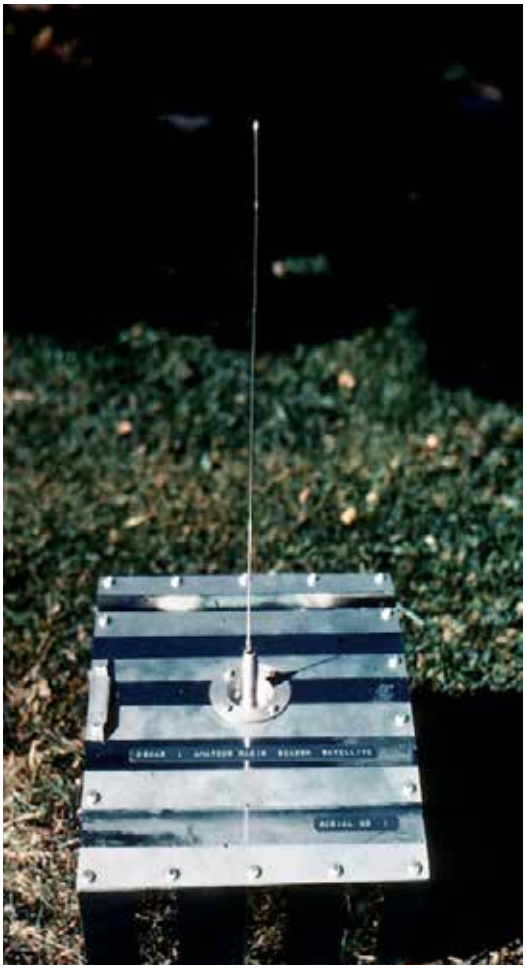
Lance Ginner holding OSCAR 1 (Courtesy: AMSAT).



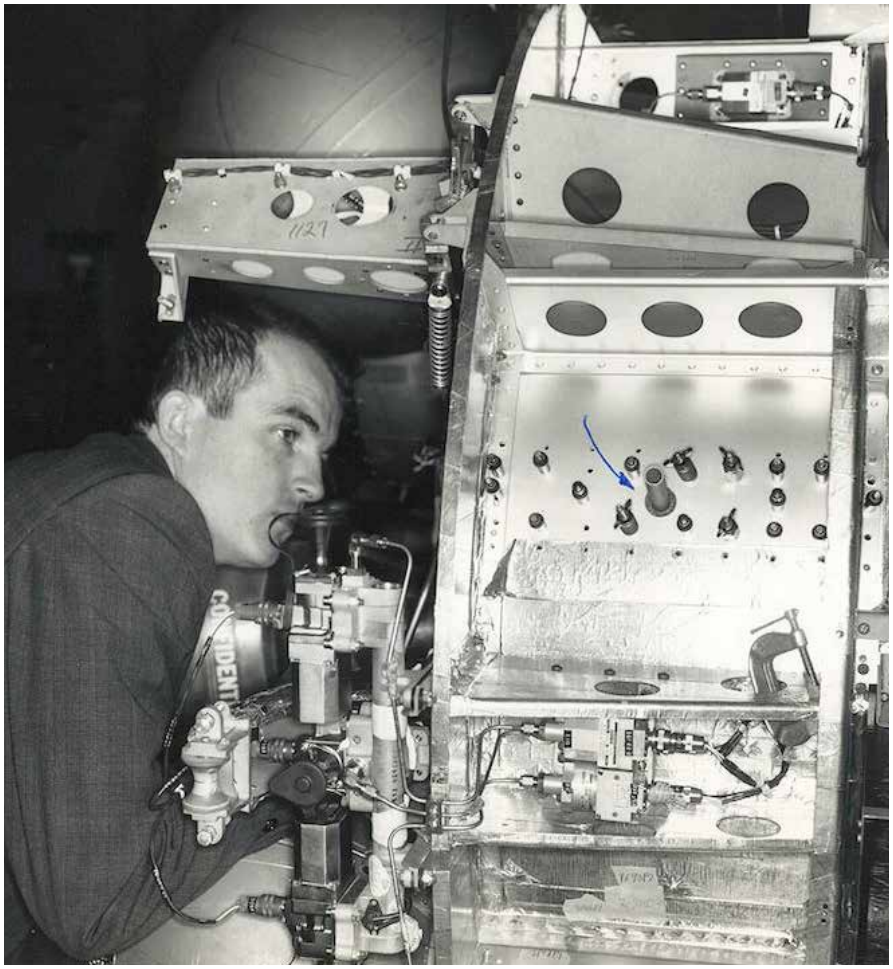
Lance Ginner working on OSCAR 1.



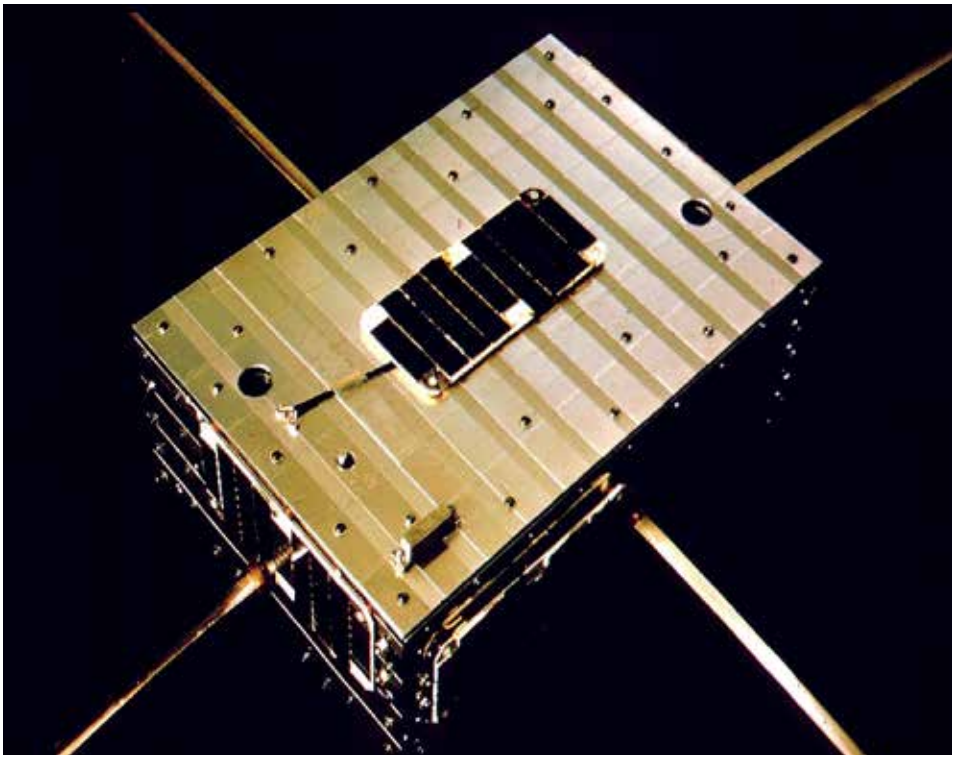
OSCAR 1



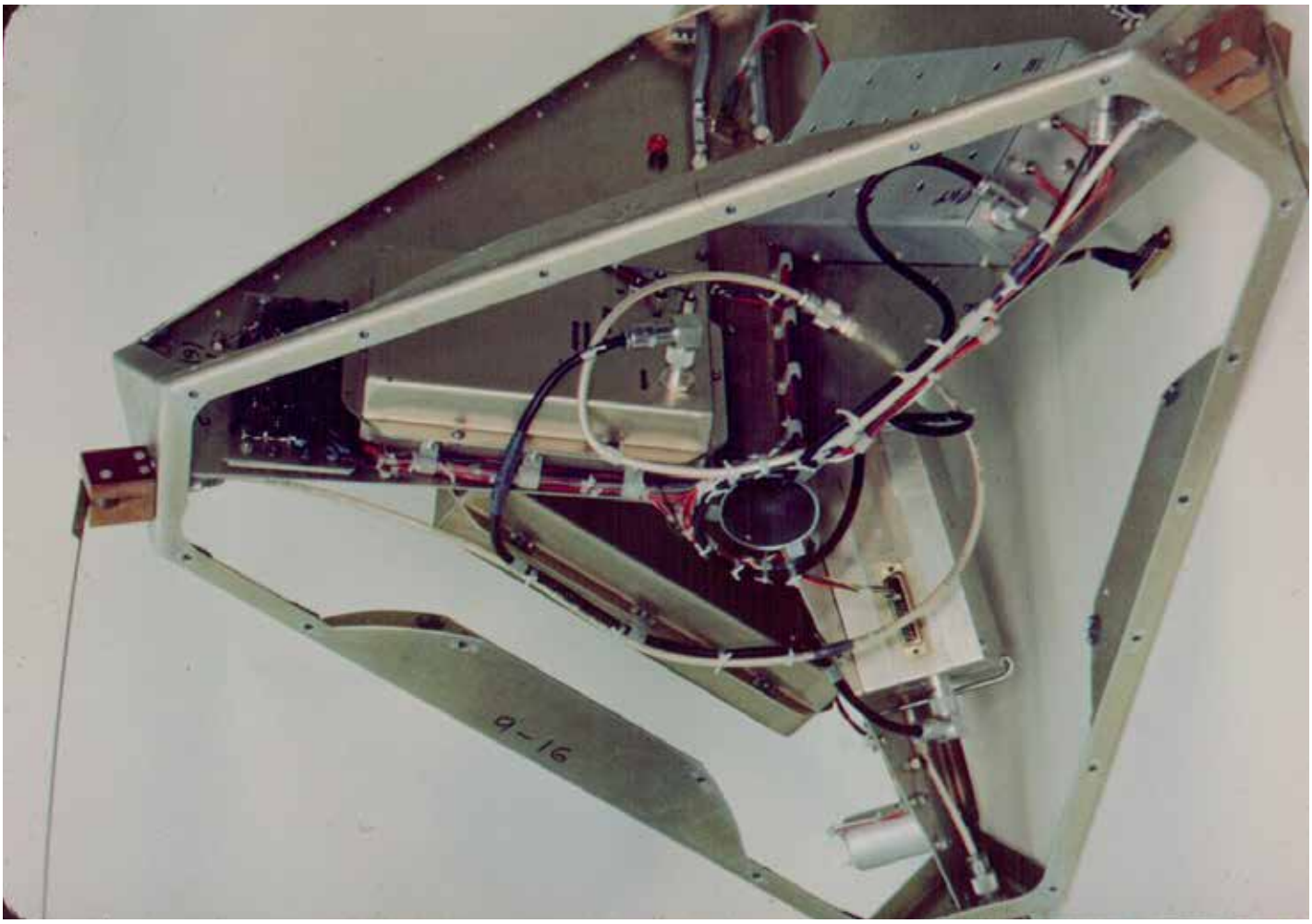
OSCAR 1 (Courtesy: AMSAT).



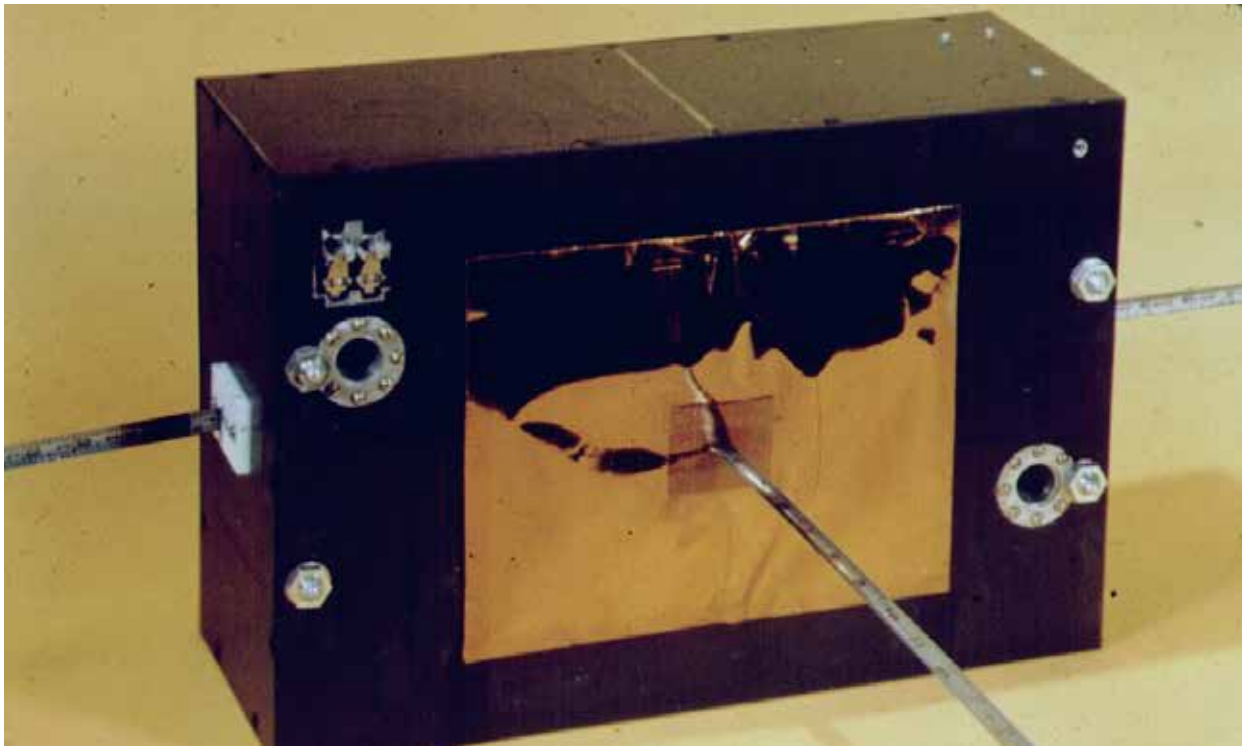
Lance Ginner inspecting OSCAR 2 ejection mechanism (Courtesy: AMSAT).



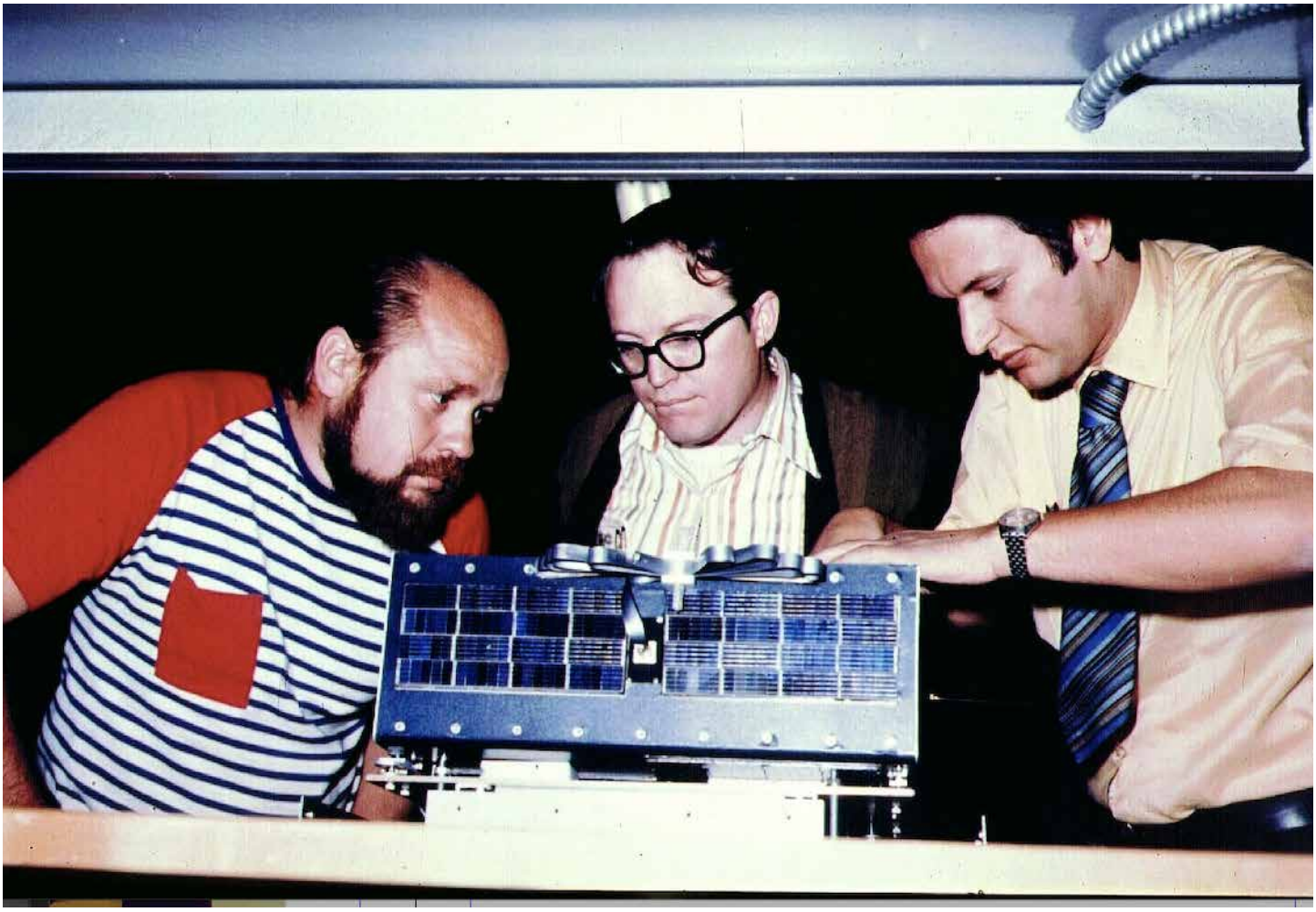
OSCAR 3



OSCAR 4 inside systems (Courtesy: AMSAT).

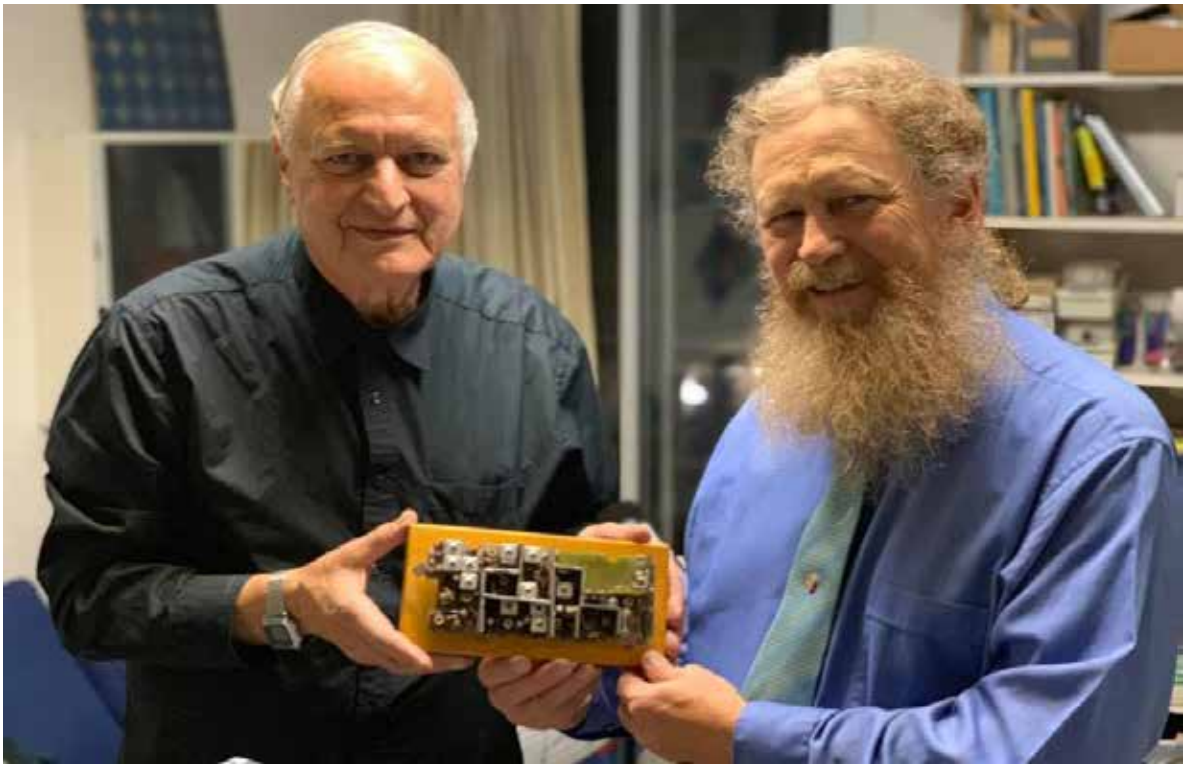


OSCAR 5 (Courtesy: AMSAT).

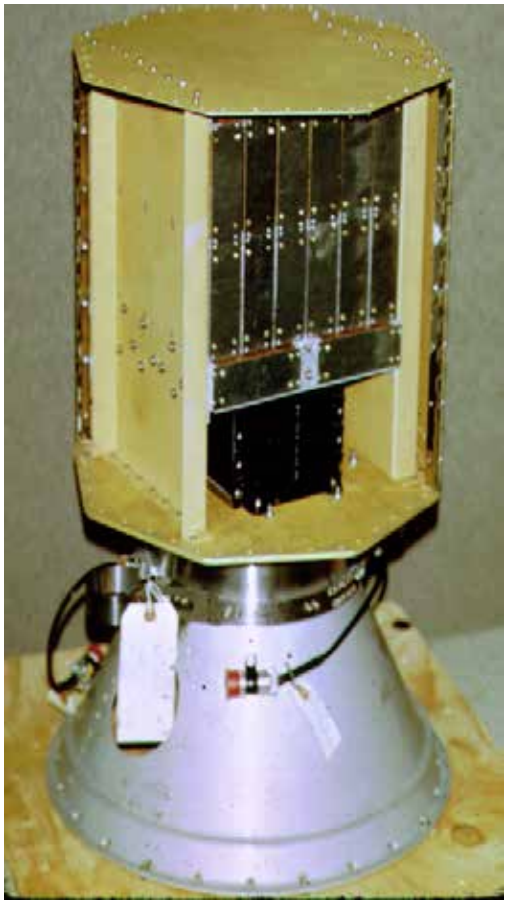


OSCAR 6 - Perry Klein with others (Courtesy: AMSAT).

OSCAR 6 complete. Note the tape measure antennas on the sides for the 29 MHz half-wave dipole.



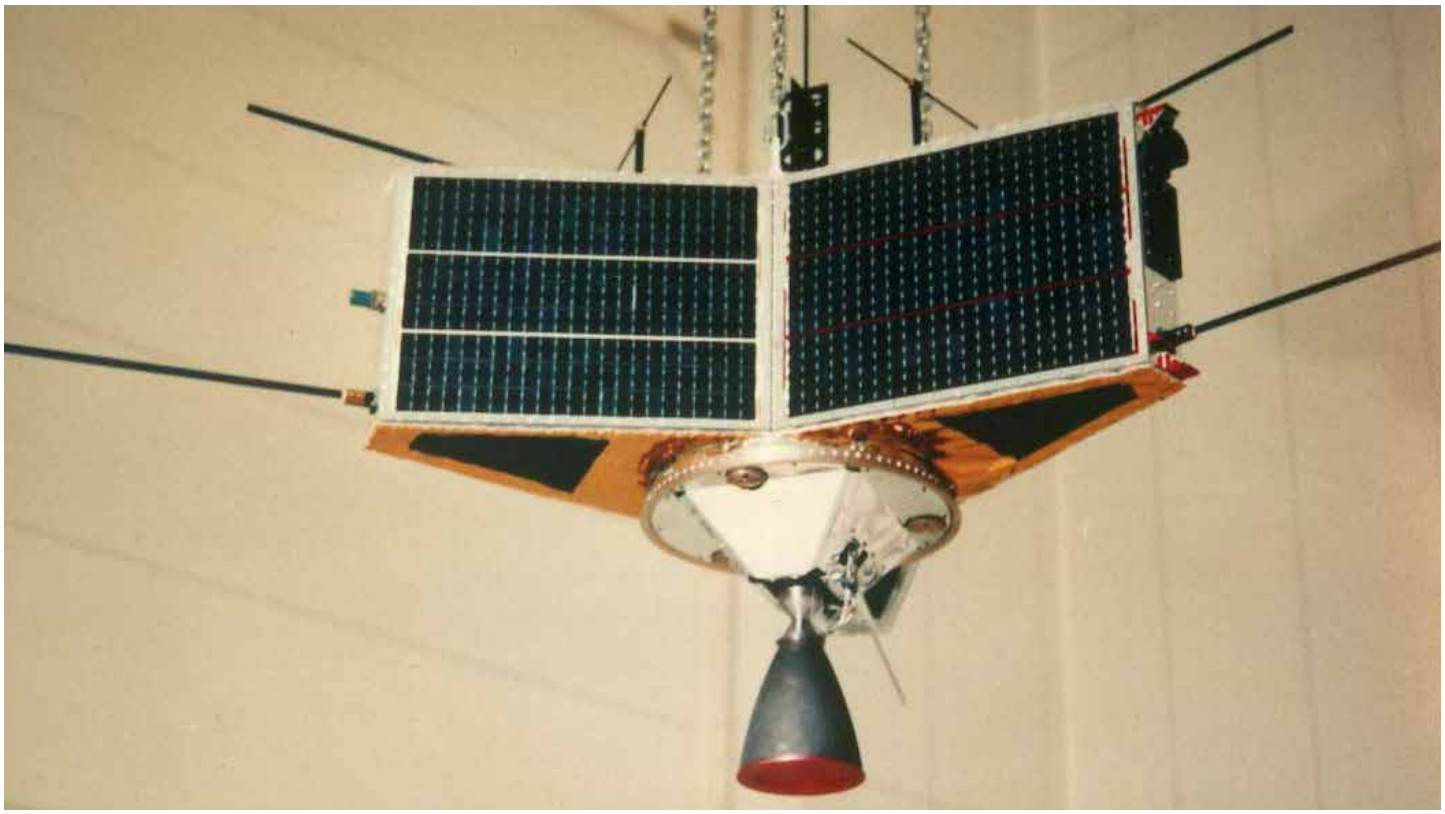
Perry Klein and Joe Spier with burned-out AO-6 transponder.



OSCAR 7

OSCAR 7 - Tom Clark (left) and Jan King.

OSCAR 8 - Dick Daniels



OSCAR 10

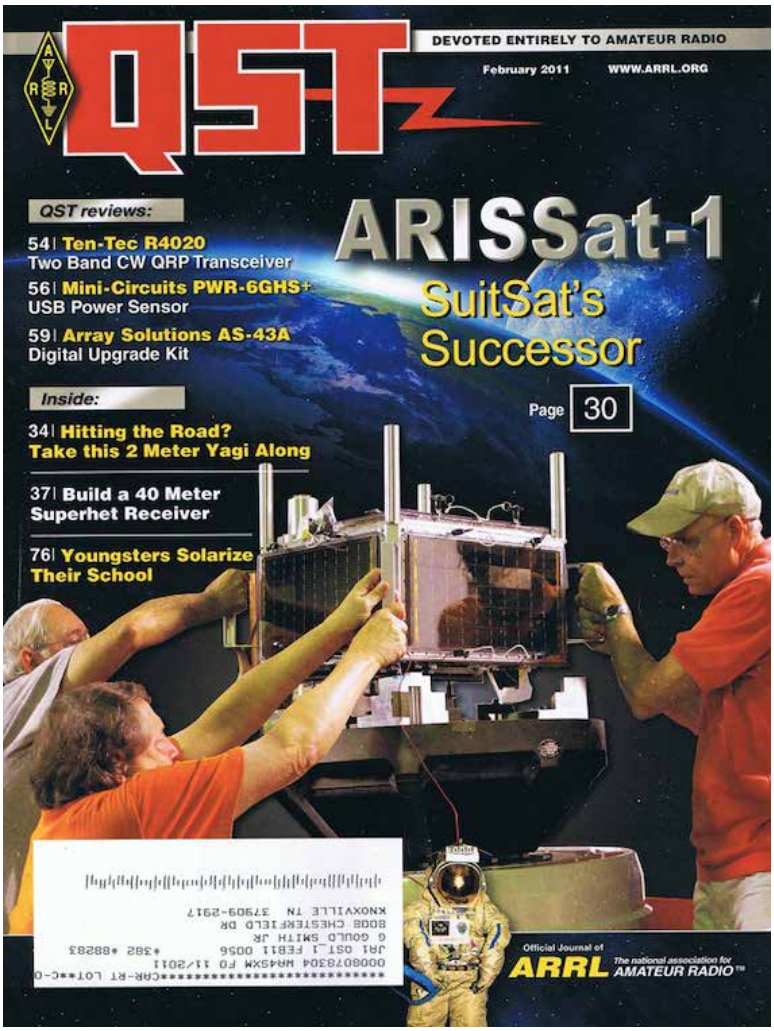
Bdale Garbee, KB0G, with the proposed flight spaceframe for P-3E in the AMSAT-DL Lab.

National Aeronautics and Space Administration

The Shuttle Amateur Radio EXperiment (SAREX)

Ron Parise, WA4SIR, was instrumental in bringing amateur radio equipment to the Shuttle and operated on the air during his own missions.

ARISSat on ISS. The silver "top hat" structure on the right is the KURSK experiment.

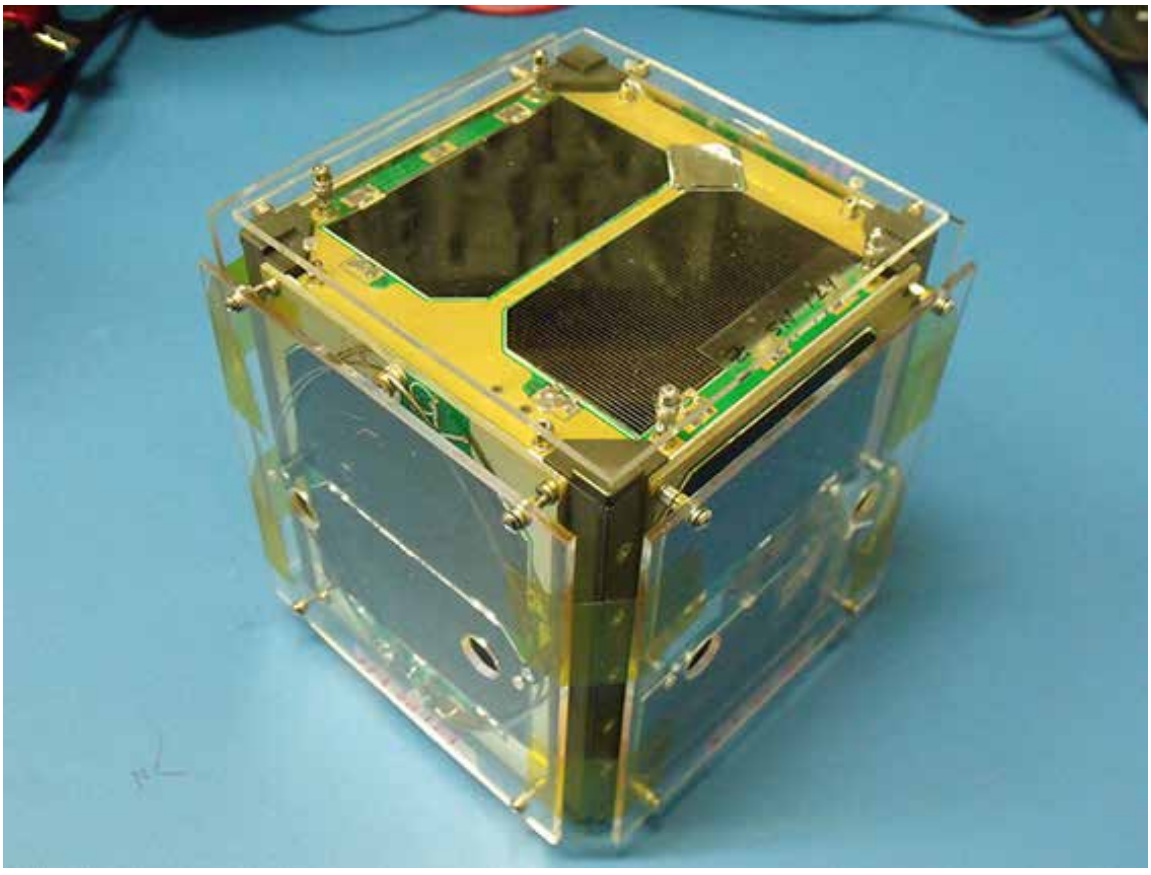


ARISSat on *QST* cover.

FO-29.

Astronaut Owen Garriott with Gould Smith, WA4SXM, and an early model of SuitSat at the Dayton Hamvention.

Fox-1 P-POD



Fox-1

AMSAT Symposium @ Sea 2016

AMSAT Symposium at U.S. Space and Rocket Center, Huntsville, AL, 2018.

Faith Hannah Lea, AE4FH, Ruth Willet, KM4LAO, and Morgan Croucher, KD8ZLK, operating an FO-29 pass from the rooftop in Saba. [James Lea, WX4TV, photo.]

Patrick Stoddard, WD9EWK (left), with Endaf Buckley, N6UTC, in the W6RO Wireless Room of the Queen Mary, Long Beach, CA, December 15, 2018.

Fox-1A launch

Support AMSAT

AMSAT is the North American distributor of SatPC32, a tracking program for ham satellite applications. Version 12.8c is compatible with Windows 7, 8/8.1 & 10 and features enhanced support for tuning multiple radios.

Version 12.8c features:

- SatPC32, SatPC32ISS, Wisat32 and SuM now support rotor control of the M2 RC-2800 rotor system.
- The CAT control functions of SatPC32, SatPC32ISS and Wisat32 have been expanded. The programs now provide CAT control of the new Icom transceiver IC-9100.
- The accuracy of the rotor positions can now be adjusted for the particular rotor controller. SatPC32 therefore can output the rotor positions with 0, 1 or 2 decimals. Corrections of the antenna positions can automatically be saved. In previous versions that had to be done manually.
- The tool "DataBackup" has been added. The tool allows users to save the SatPC32 program data via mouse click and to restore them if necessary. •
- The rotor interfaces IF-100, FODTrack, RifPC and KCT require the kernel driver IOPort.SYS to be installed. Since it is a 32-bit driver it will not work on 64-bit Windows systems.
- SuM now outputs a DDE string with azimuth and elevation, that can be evaluated by client programs. Some demo files show how to program and configure the client.

Minimum Donation is $45 for AMSAT members, $50 for non-members, on CD-ROM.
A demo version may be downloaded from http://www.dk1tb.de/indexeng.htm

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.

AMSAT GOLF $125,000 Development and Launch Initiative Goal

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 for GOLF-TEE and GOLF 1. We have set a fundraising goal of $125,000 to cover these expenses and help us to continue to keep amateur radio in space.

GOLF-TEE (Technology Exploration Environment) will be a rapid deployment to LEO to establish/verify/learn ADAC, Deployable Solar Panel Wings, Radiation Tolerant IHU, SDR.

GOLF-1 is planned as an approx. 1300 km LEO, progression of GOLF-TEE technology, first STEM mission with VU and APS, AO-7/FO-29 supplement, and our first "High LEO" CubeSat.

Donations may be made through the AMSAT webpage at **www.amsat.org**, by calling (888) 322-6728 or by mail to the AMSAT office at 10605 Concord Street, Kensington, MD 20895, USA. Please consider a recurring, club, or corporate donation to maximize our chance of success with this mission.

AMSAT President's Club
Support GOLF-TEE and GOLF-1

Contribute to AMSAT directly through easy, automatic charges to your credit card. Since AMSAT is a 501(C)(3) organization donations may be USA tax deductible. (Check with your tax advisor.) To join contact Martha at the AMSAT Office by phone (888) 322-6728 in the US, or (301) 822-4376; e-mail **martha@amsat.org**.

Titanium Donors contribute at least US $400 per month	❒	$400 / month
	❒	$4800 one time
Platinum Donors contribute at least US $200 per month	❒	$200 / month
	❒	$2400 one time
Gold Donors contribute at least US $100 per month	❒	$100 / month
	❒	$1200 one time
Silver Donors contribute at least US $50 per month	❒	$50 / month
	❒	$600 one time
Bronze Donors contribute at least US $25 per month	❒	$25 / month
	❒	$300 one time
Core Donors contribute at least US $10 per month	❒	$10 / month
	❒	$120 one time

Your help is needed to get the AMSAT GOLF-TEE and GOLF-1 Cubesats launched.

For the latest news on GOLF watch our website at www.amsat.org, follow us on Twitter at "AMSAT", or on Facebook as "The Radio Amateur Satellite Corporation" for continuing news and opportunities for support.

AMSAT is Amateur Radio in Space ... and YOU are AMSAT!

Seize opportunities to launch your amateur radio experience to new heights!

AMSAT Ambassadors - NEW

AMSAT Ambassadors program is looking for satellite operators to share enthusiasm for Amateur Radio in Space with others by:

- Promoting AMSAT at in-person events, practical demonstrations, online, or in written communications
- Offering personal mentoring and coaching to new enthusiasts either in-person or via online means
- Connecting members and potential enthusiasts with proper resources at AMSAT.

To volunteer, send an e-mail to Clayton Coleman, W5PFG at: **w5pfg@amsat.org**

AMSAT Internet Presence

AMSAT's information technology team has immediate needs for volunteers to help with development and on-going support of our internet presence:

- Satellite status updating and reporting.
- Add/delete satellites to ANS and the web as needed.
- Research and report satellite details including frequencies, beacons, operating modes.
- Manage AMSAT's Facebook and Twitter presence.

To volunteer, send an e-mail to Robert Bankston, KE4AL at: **ke4al@yahoo.com**.

AMSAT Engineering Team

AMSAT Engineering is looking for hams with experience in the following areas:

- Attitude Determination and Control, and Thermal Engineering, to help in the design of high orbit CubeSats.
- Power systems, for CubeSats from 1U through 6U and LEO to HEO.
- Help with solar, power supply, and battery design for both LEO and HEO missions.
- Logistics, for parts procurement, inventory, and distribution.
- Documentation, for designs, tests, and public relations.

To volunteer, please describe your expertise using the form at **www.amsat.org/contact-amsat-engineering/.**

AMSAT User Services

AMSAT is looking for an on-line store co-manager with WooCommerce experience to update and refresh the AMSAT Store web page when new merchandise becomes available or prices and shipping costs change.

- Add new merchandise offerings
- Delete merchandise no longer available
- Update shipping costs as needed
- Add periodic updates for event registrations
- Interface with the AMSAT Office.

To volunteer, send an e-mail to Robert Bankston, KE4AL at: **ke4al@yahoo.com.**

AMSAT Educational Relations Team

AMSAT's Educational Relations Team needs volunteers with a background in education and classroom lesson development ...

- Engage the educational community through presentations of how we can assist teaching about space in the classroom.
- Create scientific and engineering experiments packaged for the classroom.
- Create methods to display and analyze experimental data received from Fox-1.

To volunteer send an e-mail describing your area of expertise to Alan Johnston, KU2Y at: **ku2y@amsat.org**.

ARISS Development and Support

AMSAT's Human Space Flight Team is looking for volunteers to help with development and support of the ARISS program:

- Mentors for school contacts
- Support for the ARISS web
- Hardware development for spaceflight and ground stations
- Help with QSL and awards certificate mailing.

To volunteer send an e-mail describing your area of expertise to Frank Bauer at: **ka3hdo@amsat.org.**

Find more information at amsat.org. Click Get Involved, then Volunteer for AMSAT.