The AMSAT® Journal

Volume 38, Number 3 May/June 2015

in this issue ....

Fox-1A on the Road to Vandenberg

AMSAT-NA Geosynchronous Opportunity

AMSAT-NA
10605 Concord St., Suite 304
Kensington, MD 20895-2526

Periodicals
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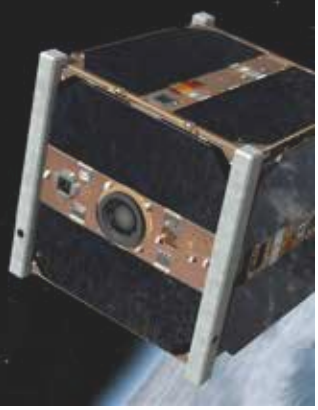
At Kensington, MD
and at additional
mailing offices

Commit to the Future of AMSAT

- **AMSAT has committed to launching Fox-1C in 3Q 2015.**
- **We teamed with SpaceFlight, Inc. for integration and launch utilizing SpaceFlight's SHERPA System to sun-synchronous orbit in third quarter of 2015 and we have already paid the launch fee.**
- **AMSAT must now raise the funds to recover those funds to re-establish our reserves.**
- **Along with serving as a "rainy day fund", these reserves provide the "seed money" for future satellite projects.**
- **It takes real dollars to develop real satellites.**
- **As a result, AMSAT has initiated a $125,000.00 campaign to raise the capital needed to provide the resources to maintain our ability to initiate future projects.**

Please consider these donation options

- **Donate to the AMSAT President's Club**
- **Cash gifts with your credit card, PayPal, or check**
- **Gift of life insurance by naming AMSAT as a beneficiary**
- **Gift of stocks or other securities**
- **Bequest to AMSAT in your will or trust**
- **AMSAT is a 501(C)(3) non-profit organization**
- **Call the AMSAT-NA office at 301-822-4376 for questions on any or all of these ways to keep Amateur Radio in space.**



Support AMSAT-NA http://www.amsat.org

AMSAT Announcements

Long-time ARISS team member Nick Lance, KC5KBO, SK

On behalf of the ARISS-International team, it is with great sadness that we announce the passing of long-time ARISS team member Nick Lance, KC5KBO, SK. Nick passed away on May 24 from an aneurism of the aorta.

Nick was a smart, caring, considerate and helpful person that loved the amateur radio hobby. As the primary amateur radio license trainer for the ISS astronauts, Nick played an integral role in encouraging and training countless astronauts (US, Canada, Japan and Europe) to pursue their amateur radio license and become active on ARISS. He inspired and trained dozens of NASA's aerospace education specialists (who talk to schoolteachers nationwide) to get their ham tickets. He also taught a "Hamster" course to middle schoolers, inspiring them to pursue careers in technology through Amateur Radio and ARISS activities.

Personally, I enjoyed working with Nick both as a NASA engineer and an amateur radio operator. I will miss his quick wit and sense of humor. Nick will be deeply missed by many.

Our deepest sympathy goes out to all that knew Nick, especially Renee, his wife, and all his family members.

Frank H. Bauer, KA3HDO,
ARISS International Chairman

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 JPEG formats. Kindly do not embed graphics or photos in your manuscript - we prefer receiving those as separate files. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time and efforts to produce *The AMSAT Journal*.

As I write this column the week following Memorial Day, there is much to highlight that has taken place in the past six weeks. Needless to say, these are exciting times for AMSAT!

Much of what I'm including below was discussed at the AMSAT Forum at Hamvention on May 16, 2015. So please allow me to note some of the takeaways from my presentation and others as I summarize where things stand…

Potential Amateur Payload on a Geosynchronous Orbit (GSO) Satellite

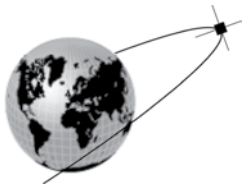
ANS Special Bulletin 116.01 released on Saturday, April 25, 2015, announced that "we have accepted an opportunity to participate in a potential rideshare as a hosted payload on a geostationary satellite planned for launch in 2017. An amateur radio payload, operating in the Amateur Satellite Service, will fly on a spacecraft which Millennium Space Systems (MSS) of El Segundo, CA, is contracted to design, launch, and operate for the US government based on their Aquila M8 Series Satellite Structure." (Note: the correct term is "geosynchronous" as the satellite is not expected to be positioned over the equator.) Details on the meeting that took place at Millennium Space Systems (MSS) on April 13, 2015 can be found in that ANS special bulletin, as well as on the AMSAT website. Millennium Space System's website can be found at:

http://www.millennium-space.com

Here is some updated information:

1. AMSAT has re-signed a Collaborative Agreement with Virginia Tech that is the basis for our relationship to work on satellite projects. The original agreement, signed in February 2013 resulted in the development of the VT camera that will now fly on Fox-1C later this year. This new agreement, signed on May 5, 2015, is an updated document to replace the one that expired. It forms the basis for future collaboration on joint projects.

2. An AMSAT Board of Directors meeting took place on Tuesday, May 5, 2015, to formally approve AMSAT's participation in this project. Note that while the ANS Bulletin preceded formal BoD endorsement, this action was taken to express the Board's support of the Executive Team's initial acceptance of the invitation extended by Virginia Tech.



3. Justification for placement of an amateur secondary payload on the MSS space frame is based upon a key amateur radio purpose: Emergency Communications. AMSAT is seeking the ability for amateur radio operators using this payload to support Federal, State, and local disaster first-responders during times of national disasters**.** This potential space-borne asset will be of significant benefit with 24 x 7 availability over the northern hemisphere. You will recall that ARRL and FEMA (Federal Emergency Management Agency) signed a "Memorandum of Agreement" during the 2014 ARRL Centennial Convention last July; having an amateur radio asset available anytime will certainly enhance amateur radio's ability to support emergency communications.

4. MSS has informed Virginia Tech that a "Payload Analysis" will be required to assess the feasibility of adding an amateur payload to their spacecraft, including analysis of power requirements, size and weight, antennas, etc. MSS estimates that the cost of this one-month effort is $100,000. Consequently, we have initiated fund-raising to pay for this analysis, as it will determine the practicality, from the spacecraft vendor's perspective, of adding an amateur payload to their spacecraft design.

   I announced at Dayton that as of the day of the AMSAT Forum, we have raised $63,000 of that amount. Since then, we've raised another $10,000. That still leaves a $27,000 gap to cover the payment that we expect to make in June. If you're interested in seeing a GSO amateur payload fly, please consider designating your gift NOW so that we can keep the momentum going.

5. Roles and Responsibilities of the various partners are still being developed. Given that the MSS has yet to agree to integrate an amateur payload on the spacecraft and the spacecraft owner (the US Government) has yet to agree to allow this payload to be flown on their spacecraft, it would be premature to discuss the details of the inter-relationships that are developing. If this project materializes, this will be a unique

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Apogee View - continued from page 3 ...

partnership between an educational institution (Virginia Tech), an all-volunteer not-for-profit scientific and educational organization (AMSAT), an aerospace company (MSS), a spacecraft owner (US Government), and other potential partners who may contribute equipment to the effort.

At this juncture, the areas of AMSAT involvement include:

- Participate in the development of the Ground Station.
- Serve as the control operator of the amateur radio payload, including frequency coordination with IARU Satellite Advisor and filing FCC notice.
- Serve as the conduit for fundraising for this project. At this time, we've announced the need to raise funds for the payload analysis. Should this project move forward after the payload analysis is completed, additional funding will be needed to cover spacecraft equipment and launch costs, but a public campaign will not be announced until after an initial capital campaign strategy is completed (e.g. discussions and potential commitments with potential major donors).
- Provide technical consultation to Virginia Tech on the development of the amateur payload.

Virginia Tech will be the payload developer and serve as the primary interface with MSS and the US Government. VT's participation is critical given the resources and talent that they bring to the project, including:

- Paid technical staff including project managers.
- Student opportunities for involvement in design/construction.
- Will handle ITAR/EAR Compliance Issues (Office of Export & Secure Research Compliance)
- Their existing relationships within the Aerospace Industry and US Government
- Education outreach involving STEM and other educational programs utilizing this payload. VT's Hume Center has educators on staff interested in developing programs for the public schools to engage students.

Technical discussions taking place to date suggest that the amateur payload will feature:

- C-band receive (5.8 GHz) / X-band (10.45 GHz) transmit
- Amateur satellite service band
- Frequency division multiplex up
- Time division multiplex down
- Operating on principles of trunk mobile radio.

6. Given that this payload will be an entirely new amateur RF design that incorporates the microwave bands and digital modes, an affordable ground station must be developed. In addition, AMSAT is actively partnering in the development of a 6U spacecraft that will also utilize the microwave bands (see below). Our intention is to develop a "common core" scheme as the basis for the GSO opportunity that will be adapted to other flight opportunities so that an investment in a ground stations by users can be adapted for use with other missions.

7. As the MSS spacecraft is already under development, we don't have much time to get the amateur payload built once we know that MSS is agreeable to incorporating it into their design. VT will likely need to deliver the payload in Summer, 2016.

8. At this point, we expect that the amateur payload will be operational for at least two years once placed in service. As the primary payload drives the spacecraft mission, we don't know what the spacecraft owner's intentions are regarding future operations or whether such operations would permit operational use of the amateur payload after two years.

We must also recognize that developing this partnership with Virginia Tech and establishing recognition by Millennium Space Systems of AMSAT's capabilities and desire to provide amateur communications from GSO could provide opportunities for future missions down the road. A key component of successful future flight opportunities is establishing the initial relationship. Even if it turns out that this particular flight opportunity is not feasible, both VT and AMSAT will benefit from the establishment of this relationship. We all know that there will always be future GSO satellites that will be built and flown; the key is to gain a foothold that will allow AMSAT to participate in future missions that provide mutual benefit. Just as scientific payloads provide the justification for NASA to support our cubesat initiatives, we believe that amateur radio's ability to support emergency communications using satellite operators willing to support such efforts will be the justification for placing an amateur radio payload on board a spacecraft placed in GSO or even GTO orbits.

NASA CubeQuest Challenge: to Lunar Orbit or Deep Space

Late last year, NASA announced a competition to fly 6U cubesats to either a lunar orbit or deep space. The winning entries will be flown on the Space Launch System (SLS) EM-1 mission in 2018 with two different potential goals:

- Place 6U cubesats in lunar orbit or heliocentric orbit -- "Lunar Derby;" and
- Placement in deep space (> 4 million kilometers) -- "Deep Space Derby."

A total of $1.5 million in potential prize money spread across different interim and flight goals will be awarded to registered competitor teams that meet or exceed propulsion or communications objectives. In addition, competing teams must participate in a "Ground Tournament" of four ever-increasing difficult design reviews conducted by NASA. Three of the winning ground tournament 6U spacecraft will be dispensed by SLS on a trans-lunar injection (TLI) orbit. Other satellite competitors would have to secure their own launches, but the competition period will allow these non-SLS cubesats to compete under the same terms as the SLS winners.

Along with the ground tournament, there is a competition in space regarding the ability of these 6U spacecraft to send data to the ground as part of either the deep space or lunar derbies. Evaluation is based upon such criteria as best burst data rate, largest aggregate data volume sustained over time, and spacecraft longevity. In addition, the deep space competition has a prize for farthest communication distance from Earth, while the Lunar Derby has a prize for "Achieve Lunar Orbit" (which requires propulsion to alter the cubesat's trajectory to be placed in lunar orbit). Thus, there is both a spacecraft development component as well as a ground station component to this completion.

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AMSAT-NA Opportunity for Rideshare to Geosynchronous Orbit

AMSAT is excited to announce that we have accepted an opportunity to participate in a potential rideshare as a hosted payload on a geosynchronous satellite planned for launch in 2017. An amateur radio payload, operating in the Amateur Satellite Service, will fly on a spacecraft which Millennium Space Systems (MSS) of El Segundo, CA is contracted to design, launch, and operate for the US government based on their Aquila M8 Series Satellite Structure.

A meeting to discuss this potential rideshare took place on April 13 at Millennium Space Systems that included Dr. Bob McGwier, N4HY; Franklin Antonio, N6NKF, co-founder of Qualcomm; Jerry Buxton, N0JY, AMSAT Vice President of Engineering and member of the board for AMSAT-NA; Dr. Tom Clark, K3IO, Director and President Emeritus of AMSAT-NA; Phil Karn, KA9Q; and Michelle Thompson, W5NYV.

(L-R) Sonya Rowe, KK4NLO; Jerry Buxton, N0JY; Bob McGwier, N4HY; Franklin Antonio, N6NKF; Tom Clark, K3IO; Michelle Thompson, W5NYV; and Phil Karn, KA9Q standing next to the Aquila M8 Bus flight article.

Hosting the meeting for MSS were Stan Dubyn, founder and Chairman of MSS, Vince Deno, President of MSS, Jeff Ward, K8KA, of MSS, VP for Product Development (formerly with SSTL and University of Surrey Space Centre), and Ryan Lawrence of MSS as Project Manager on the spacecraft mission. Attending by telephone were Dr. Jonathan Black, Associate Research Director of Hume Center for Aerospace Systems and Associate Professor of Aerospace and Ocean Engineering and Dr. Michael Parker, KT7D, founder of RINCON Research Corp.

Following the meeting, Dr. Bob McGwier, N4HY, Director of Research at the Hume Center for National Security and Technology of Virginia Tech, and former director and former VP Engineering of AMSAT, described this as an opportunity to go forward with "AMSAT-Eagle" which, in the 2006-2008 timeframe, evolved into a microwave payload to be flown to geosynchronous orbit as a hosted payload. It would have provided digital communications to small terminals on the ground and a linear bent pipe transponder had it flown. This failed to go forward in part due to lack of an affordable flight opportunity.

Dr. McGwier outlined the next steps toward developing this mission:

1. To organize an effort at Virginia Tech to make a firm proposal to MSS and its US government sponsor, and organize an effort to raise sufficient funds to pay for development of the mission.
2. Enable Dr. Jonathan Black to lead the construction project at Virginia Tech in the Space@VT Center. Sonya Rowe, KK4NLO, Project Manager at the Hume Center will be the project manager.
3. Work for development of a low-cost microwave ground station for amateur radio still needs to be determined.
4. Dr. Michael Parker, KT7D, will solicit the cooperation of the Rincon Research Corp. for development of the software radio technology for this payload.

The AMSAT Board of Directors has accepted the invitation to participate in this potential rideshare payload opportunity. AMSAT expects to be involved in the development of the ground station and the payload RF development, and will serve as the amateur radio (hosted) payload operator once the satellite has been launched.

Dr. McGwier summarized, "The launch is currently scheduled for 2017 and the payload must be delivered for testing and integration by spring of 2016. It is an ambitious schedule and all involved will have to gain and maintain a serious level of commitment to that which they agree to undertake." AMSAT President, Barry Baines, WD4ASW, said, "The AMSAT leadership is excited to fly a Phase-IV geosynchronous amateur satellite payload. This is an evolving development as we collaborate with the VT Hume Center with a project that provides technical challenges to create a new amateur radio capability in space that will provide a variety of benefits not only for amateurs but also for emergency communications and STEM educational outreach."

The transponder is expected to support a wide range of voice, digital, and experimental advanced communications technologies. A decision is expected soon specifying the microwave uplink and downlink bands.

Additional information on the Aquila M8 series satellite can be viewed on-line:

http://www.millennium-space.com/

http://www.millennium-space.com/platforms#aquila

You're invited to find more information about AMSAT on our web at:

http://www.amsat.org

Apogee View - continued from page 4 ...

Details about the NASA CubeQuest Challenge may be found at:

http://www.nasa.gov/directorates/spacetech/centennial_challenges/cubequest/index.html#.VWaVnGC-XS8

This competition has generated a significant amount of "buzz" in terms of "being the first" to accomplish these goals with a 6U spacecraft. At a NASA briefing that took place at NASA's Ames Research Center this past January that outlined the competition, a number of organizations were present, including aerospace firms, universities, and others (such as AMSAT). Given the degree of competition and the relatively short time frame for development, collaborative teams are being established to participate in this competition.

AMSAT has been approached to join such a team. In our case, Ragnarok Industries-Satellite Company -

http://www.ragnarokindustries.com

is the lead organization. We've been asked to develop the communications package hardware and software for a 6U cubesat that will compete in this selection process and, if selected, provide the RF capability needed to communicate with the spacecraft and compete in the data transmission exercises. Other team members will focus on other aspects of satellite design and construction; AMSAT will focus on the RF package.

Given the relatively small size and limited power budget of a 6U cubesat, a digital microwave system will be used to transmit data. Considering the distances involved with deep space or lunar orbit, we anticipate using relatively large dishes to serve as the receiving points for these data transmissions. We do not anticipate that amateurs with their backyard systems will be able to receive/demodulate the spacecraft signals.

During the same BoD meeting that took place on May 5, 2015 when the GSO opportunity was endorsed, the Board also approved AMSAT's partnering with Ragnarok Industries Nano-Satellite Company, focusing on developing the communications package hardware and software.

So why is AMSAT interested in participating? First, since we'll be flying an amateur RF package, amateur radio offers unique capabilities that might provide a competitive advantage in the competition. We have our own allocated bands in the Amateur Satellite Service. There are large arrays in the US and elsewhere operated by amateur radio organizations that would be excited to collaborate on such a project. And there are those in the amateur microwave community who are interested in addressing this kind of challenge. Lastly, we had previously announced our desire to support the development of new technologies for future spacecraft, and this opportunity fits within that definition.

We believe that there will be future opportunities to fly 6U cubesats to GTO orbits, which in turn means potential DX coverage that we enjoyed with the Phase-3 birds. This competition provides an opportunity to develop a 6U RF package for such future opportunities where we would expect amateurs to be able to fully utilize with ground stations in their backyards.

In addition, we're looking for synergies between the GSO opportunity and the NASA CubeQuest Challenge in terms of developing ground stations that can potentially handle both types of satellites; a low power 6U in GTO as well as a higher power hosted amateur payload on a much larger and more robust GSO satellite using the same set of uplink/downlink bands and modes. Thus, any development effort by AMSAT in support of the NASA CubeQuest Challenge will not be a 'wasted effort' as we expect to take advantage of this development for future designs even if our team is not selected to fly on the SLS mission.

That said, we need a team of AMSAT engineers to engage in this 6U cubesat RF development effort. It turns out that a group of AMSAT volunteers are willing to work on such a project that is separate from the Millennium Opportunity. The GSO amateur payload will be managed by Virginia Tech while the 6U cubesat RF package will be managed by AMSAT.

Bryan Klofas, KF6ZEO has agreed to serve as the AMSAT Team Leader for the CubeQuest Challenge RF package. If you're interested in learning more about their team's efforts, please contact Bryan (bklofas@gmail.com).

2015 is "The Year of the Fox"

As summer approaches, we're also getting closer to the anticipated launches of two Fox-1 class satellites later this year. Fox-1A was delivered to CalPoly in March, 2015 for integration. The satellite features experiments from Penn State-Erie and Vanderbilt University's Institute for Space and Defense Electronics (ISDE) plus our FM repeater capability that includes both a low speed data transmission of payload data and spacecraft telemetry plus a high speed data downlink (9.6 KBaud). Launch of our satellite as part of the ELaNa-XII mission is now scheduled for late September, 2015. Meanwhile, work continues on Fox-1C that AMSAT has contracted with Spaceflight, Inc. to fly under a launch services agreement and which we expect to deliver later this summer for launch in late 2015. This spacecraft will feature some new capabilities, including:

- The Virginia Tech Camera which will take images of the Earth to be downloaded using the 9.6 KBaud downlink.

- A new Maximum Power Point Tracker (MPPT) that will provide improved power generation.A single channel FM U/V Transponder with L/V capability. If you were at Dayton this year and visited the AMSAT Engineering Area, you would have seen the Fox-1C Engineering model as well as images being taken by the VT Camera Engineering Model. Visitors to the booth also had an opportunity to use the HTs to transmit through the Fox-1C FM uplink and hear themselves on the downlink.

We still need to raise a significant amount of money to pay for the Fox-1C launch. To date, we've received $22,838 in designated gifts for the Fox-1C Launch while our goal is $125,000. We need to raise this money in order to be able to complete RadFxSat/Fox-1B, Fox-1D and Fox-1E (a fifth 1U cubesat). Details on donating to AMSAT for the Fox-1 program can be found on page 23 of this issue.

Our 'publicity campaign' is ramping up in anticipation of these launches. Dave Jordan, AA4KN has written an article for *QST* on Fox-1A that we anticipate will be published by ARRL prior to the Fox-1A launch. AMSAT's VP-User Services (and AMSAT Journal Editor) JoAnne Maenpaa, K9JKM developed a Fox-1A handout for Dayton that was widely distributed. This issue of the *AMSAT Journal* includes "Getting on the Air With Fox-1A" (page 9) that is an update to that handout. It includes the planned frequencies (assigned or pending IARU coordination) for the Fox-1 FM series satellites.

Partnerships are Key to Keeping Amateur Radio in Space

I trust you've noticed a pattern concerning how AMSAT is moving forward in developing flight opportunities. Future success depends upon developing appropriate partnerships that provide the impetus for keeping amateur radio in space. We are dependent upon creating collaborative efforts that create successful missions:

1. The Fox-1 series satellites include scientific payloads that provide the justification for NASA's ELaNa program to pay for our cubesat launch opportunities as these payloads support NASA's mission. Amateur radio provides the communications vehicle for supporting scientific payloads while also allowing amateurs to communicate with each other.

2. The GSO opportunity involves partnership with Virginia Tech that in turn provides a venue for student involvement and where Emergency Communications ("EmCom"), a key amateur radio capability, provides the justification for placement of an amateur payload on a satellite. VT's connections to aerospace firms and government are key to establishing this amateur payload on a MSS spacecraft. During normal operations, we expect amateurs to benefit from using a wide area footprint amateur payload that brings significant STEM potential as well. In times of emergency, amateur satellite operators can help lead the effort to establish effective communications in affected areas.

3. Partnering on the NASA CubeQuest Challenge provides the impetus for AMSAT's development of new technology in support of a partner's desire to compete in the Challenge, but which lays the foundation for eventual implementation on future AMSAT 6U spacecraft that may go to GTO.

   Amateur radio's future in space depends upon establishing these kinds of relationships because we don't have the resources to do it alone.

One (or Two) "Last Thing"…

With summer rapidly approaching, I do want to remind you that the AMSAT ballots will be mailed by July 15, 2015. Ballots must be received back at the AMSAT office in Kensington, MD, no later than September 15, 2015 in order to be counted.

This year we have four seats up for election for two-year terms along with two alternates who are selected annually. As I write this column, there is one incumbent who will not be standing for re-election (Alan Biddle, WA4SCA). One of the benefits (and corresponding obligations) of AMSAT membership is your opportunity to vote for those who are willing to serve on the AMSAT Board of Directors. The BoD sets the strategic direction of the organization and oversees the work of the Executive Team that is responsible for the day-to-day tactical management of the Corporation.

This is your opportunity to help decide the future of AMSAT by selecting those individuals who will serve on the Board of Directors. When you receive your ballot in July, please take the time to review each Candidate's Statement. I also encourage you to send e-mail directly to the candidates with any questions or feedback you 'd like to receive about their candidacy. Please complete the ballot and mail it back early enough so that it will be received on or before September 15, 2015 at the AMSAT office in Kensington, MD, in order to be counted.

Second, included with the Ballot will be information about the upcoming 33rd AMSAT Space Symposium that takes place October 16-18, 2015 in Dayton, OH. We'll be at the Crowne Plaza in downtown Dayton. The weekend features:

- The Symposium with presentation of papers that will be published in this year's Proceedings
- AMSAT General Membership Meeting
- Annual banquet with keynote speaker, door prizes, and an opportunity to interact with the AMSAT Leadership Team and AMSAT Engineering Team, and,
- A gathering of the Field Operations Team (FieldOps) at their traditional FieldOps Breakfast on Sunday morning.

Tours and other events are being scheduled for Sunday afternoon and Monday (after Symposium), including a special tour of the National Museum of the United States Air Force. Details will be posted on the AMSAT website.

One of the key advantages of holding the Symposium at Dayton is the central location. Dayton is easy to reach via interstate or airline. About 2/3 of the US population resides within 12 driving hours of Dayton. For those of us that attend Hamvention and don't have time to "see" Dayton's attractions in May, this will be an excellent opportunity to take the time to see the Air Force Museum, Historical Carillon Park, Mendelsons in downtown Dayton (as well as MCM Electronics in Springboro), and America's Packard Museum.

With all of the activities taking place within AMSAT, I'm sure this will be a busy and enlightening weekend for you at Symposium. Starting in mid-June, you may register via the AMSAT Store. Hotel reservation information will also be on the AMSAT website under "Events->AMSAT Symposium and General Meeting". You must make your own hotel room reservation directly with the Crowne Plaza.

See ya at Dayton (in the fall)!

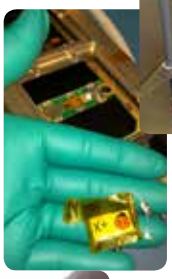
Collection of AMSAT Journals and Other Publications - 1969 through 1993

This DVD contains a collection of AMSAT Newsletters, Orbit Magazine, Satellite Report, and the AMSAT Journal, ranging from 1969 through 2013. An incredible source of both history and technical information, much still applicable. The archive is nearly complete for the various publications, though a few older issues are missing.

Price is $30 + $5 shipping on-line at:

http://store.amsat.org/catalog/

Fox-1A and flight companions in the shipping container for delivery to Vandenberg.



The "Remove Before Flight" pin was pulled by Jerry at the completion of his work on system integration and prior to closing all of the side panels on the P-POD.

Fox-1A and flight companions will be delivered to Vandenberg Air Force Base in California for launch. We are planning for a launch scheduled for late September, 2015. Photo: http://www.vandenberg.af.mil

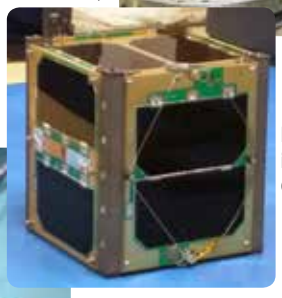
Jerry Buxton, NØJY with Fox-1A during system integration at Cal Poly.

On March 25, 2015 AMSAT Vice-President of Engineering, Jerry Buxton, NØJY, reported on the achievement another milestone leading to the launch of Fox-1A.

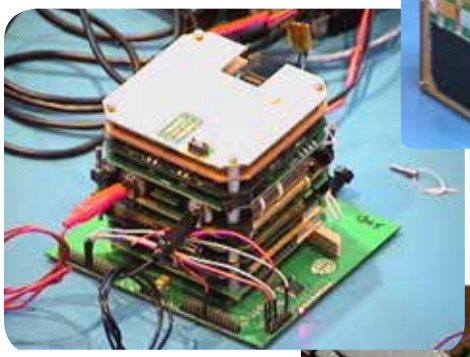
Fox-1A, having passed all integration and environmental testings, and successfully completed a Mission Readiness Review, was delivered by Jerry to the launch integration team at Cal-Poly in San Luis Obispo, California.

Fox-1A was integrated with the P-POD cubesat deployer in preparation for being loaded on the launch vehicle.

The Fox-1A Flight Model passed all of its pre-flight environmental testing in Orlando, Florida during the week of January 19. Shown above are the Fox-1A test team (L-R) Bob Davis, KF4KSS; Burns Fisher, W2BFJ; Jerry Buxton, N0JY (not pictured). Also shown are Lou McFadin, W5DID; Dave Jordan, AA4KN, and Ed Krome, K9EK, who supported the test team.



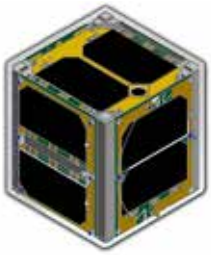
Fox-1A Flight Unit in the clean room at Cal Poly.



Fox-1A hardware and software development.

Fox-1 cubesat mission concept and design. Tony Monteiro, AA2TX (SK) presenting Fox-1 at the 2012 AMSAT Symposium in Orlando. During this time the Fox-1 engineering team developed board prototypes leading to an engineering model.

AMSAT Fox-1 Challenge Coin Available for Donations at $100 or Higher



Donations may be made via the:

- Paypal and credit card payment on the AMSAT website at http://www.amsat.org
- Donation link in the AMSAT store: http://store.amsat.org/catalog/
- Call the AMSAT office at (888) 322-6728

How to Find the Satellite

Orbital predictions are needed to tell you when to listen and where to point your antenna. You'll need to tell the web site your location:

- Grid square, or
- Latitude and Longitude, or
- For some, selecting the nearest major city is enough to start with for manual tracking.
- Select the satellite you want to track.
- If using a computer tracking program, you'll need to load tracking data, called Keplerian elements, into the software. Initially, we'll recommend the web until you have had a chance to learn more.

Your tracking program can now tell you the basic parameters of the satellite pass:

- AOS/LOS - the time of the Acquisition of Satellite (beginning of the pass) and Loss of Satellite (end of the pass).
- Azimuth - this is the compass direction (such as north, south, east, or west) which updates as the satellite flies through your view of the sky.
- Elevation - this is how many degrees above the horizon the satellite will be flying (0° is the horizon and 90° is directly overhead), which updates as the satellite flies through your view of the sky.

Tuning for Doppler Shift

Tune the right frequency. The UV frequency plan used by Fox-1A makes tuning for Doppler shifts no harder than the VU configuration, but it does require some change of technique to decide when to tune. With UV, each station needs to tune their uplink based on their specific location with respect to the satellite. How do you do this?

While the satellite's receiver AFC will help minimize the needed transmission Doppler correction, you must be prepared to make adjustments when using an HT or similar equipment. Some HTs may be set for 2.5 KHz channel spacing, but 5 KHz spacing with the satellite AFC should be adequate. For a typical HT with 5 KHz spacing, the following memory frequencies are suggested:

If Fox-1 is heading directly toward you, the Doppler shift will be greatest, but except for passing overhead, it will change relatively slowly. Passes well to the east or west will have smaller maximum shift, but it will change continuously throughout the pass. Learning to compensate for this is a necessary operator skill. Using the recommended full-duplex operation will allow you to hear if you are tuned on-frequency.

A Directional Antenna is Recommended for Best Results

The Arrow Antenna. Photo credit: KB1SF

The ELK Antenna. Photo credit: elkantennas.com

Learn how easily you can make your own satellite antenna
Photo credit: VE2ZAZ.net

Fox-1A Doppler Shift Correction		
	Your Transmit Frequency (with 67 Hz tone)	Your Receive Frequency
AOS (Mem.1)	435.170 MHz	145.980 MHz
Approaching (Mem.2)	435.175 MHz	145.980 MHz
Passing (Mem.3)	435.180 MHz	145.980 MHz
Departing (Mem.4)	435.185 MHz	145.980 MHz
LOS (Mem.5)	435.190 MHz	145.980 MHz

Planned Frequencies for the Fox-1 FM Series Cubesats		
	Uplink FM (67 Hz tone)	Downlink FM
Fox-1A	435.180 MHz	145.980 MHz
RadFxSat Fox-1B *	435.250 MHz	145.960 MHz
Fox-1C*	435.300 MHz / 1267.300 MHz **	145.920 MHz
Fox-1D*	435.350 MHz / 1267.350 MHz **	145.880 MHz

* Pending IARU Coordination, Changes will be announced
** Switchable by command station, not operational simultaneously

Download the Fox-1A Operating Guide from the AMSAT Station and Operating Hints page: http://www.amsat.org/?page_id=2144

Suggested Fox-1 Basic QSO Tips

A very busy single channel FM satellite is like any FM repeater and you do not call CQ. Exchanges will be crisp and very short, so do not expect to have a lengthy conversation about the weather or your station configuration. Most importantly listening is important: if two other stations are in the middle of the exchange, let them finish. Even though a pass is short, the exchanges are even shorter. You will get a shot so please be patient and respectful of others.

- Listen for others
- Listen for yourself using full-duplex operating technique "W4ABC" (make sure you have your PL switched on!)
- You hear "K9XYZ"
- You say "K9XYZ W4ABC EM74"
- You hear "W4ABC K9XYZ QSL EN52"
- You say "K9XYZ W4ABC QSL 73"
- Please do not call "CQ Satellite" on the FM birds

Minutes of the AMSAT-NA Board of Directors Teleconference

AMSAT-NA Board of Directors Telecon Meeting, 2 December 2014.

The formal meeting was called into session by AMSAT-NA President Barry Baines, WD4ASW at 2033 EST.

Attending:

Directors:
- Barry Baines, WD4ASW
- Lou McFadin, W5DID
- Alan Biddle, WA4SCA
- Tom Clark, K3IO
- Mark Hammond, N8MH
- JoAnne Maenpaa, K9JKM
- Jerry Buxton, N0JY

Others:
- Martha Saragovitz, Officer Manager
- Keith Baker, KB1SF/VA3KSF, Treasurer
- Frank Bauer, KA3HDO, Vice President-Human Spaceflight
- EMike McCardel, KC8YLD, Vice President-Educational Relations

Before the planned business items, Barry introduced Tom to discuss his view that AMSAT needed an advanced research function; a sort of "Skunk Works." Tom began his presentation by referencing issues raised during the recent "HEO Group" effort to develop a proposal on short notice for an advance analog and digital CubeSat. He reported that some of the HEO team did not feel that adequate support was provided by AMSAT Engineering and the Board in general. He expressed concern that both old and new AMSAT contributors who were excited by the challenge of revolutionary amateur technology might drift away unless a proactive effort was made to assure them that AMSAT would value and support such efforts in the future. Prior to the meeting, Tom had provided a list of identified "tall poles" which need to be addressed in the near future to launch the desired class of satellites in a 2018-2020 timeframe. He suggested that to address these issues AMSAT should have a research group, completely separate from the existing "production" Engineering team and management, with a separate budget to insure the needed flexibility, innovation, and support. He suggested that some dedicated funding be available to support such an enterprise on those terms.

The response from the Board and Officers was somewhat mixed. While the desire to encouraging innovation and innovators was unanimous, there were serious concerns expressed with the proposed structure. Jerry pointed out a complete separation is inappropriate because our interests and resources are in fact shared rather than separate. Martha and Keith mentioned administratively there is already a "Future Projects" item in the Engineering budget.

Barry pointed out that from his and others' viewpoint, the problems in the recent effort were more due to the lack of an existing structure rather than lack of flexible thinking and support. This was exacerbated by the unrealistically tight schedule to develop a compelling proposal (including reviews required by NASA) for submission to the AMSAT Board by 14 NOV 2014 that, if approved, would be submitted to NASA ELaNa. He emphasized that while a "Skunk Works" is an excellent idea and needed, it must be something which is more than a support structure for one particular effort. Keith suggested having a group leader within the Engineering department. This would provide flexibility in researching issues not connected with current projects while ensuring the necessary coordination of resources.

Tom said that AMSAT had historically been involved with innovative amateur technologies, and that was not currently the case. He specifically cited the lack of high-speed digital communications, which will be needed for future projects to be viable. Barry objected, saying that in fact the equipment in ARISSat-1 included software defined communications (SDX) and while this was not practical for the Fox-1 series, it has always been planned for the upcoming Fox-2 series. Jerry added that the current Fox-1 launch campaign was reaching its culmination and understandably was currently the primary consumer of technical and financial resources.

After discussing the technical aspects of the new research initiative, Keith asked about mending fences with those who were disappointed in the recent outcome of the HEO effort. Frank reminded us that perception had largely become reality, and that it was in everyone's interest for the AMSAT leadership to reach out to others. Barry agreed, but suggested that allowing passions to cool for a period of time is much more likely to have a positive result. JoAnne suggested that Tom could at least informally serve as a bridge.

In the course of the discussion, there were various references to both funding to the research group, but also the potential financial benefits. Keith reminded us again that AMSAT must develop revenue streams for long term viability. Tom pointed out that for most CubeSat users communications is one of the last things that they consider. A cheap, capable, and reliable digital orbital radio would be attractive to other groups and a potential source of both revenue and contacts. Barry finished by restating that the money would be in the budget, and the Board just needed to approve it.

At this point, the discussion ended, and Barry brought up the approval of the AMSAT operating budget that had been refined over the past few months.

It was moved by Lou, seconded by Mark, and unanimously approved that the "The 2015 AMSAT budget be approved as submitted."

Barry and Martha moved on to report that the 2015 General Meeting and Symposium will be held in Dayton, Ohio this year and the hotel contract has been signed. The Board meeting will be on 15-16 October, and Symposium 16-17 October.

The second scheduled item of business was the approval of the minutes of the 2014 Board meeting held at the BWI airport. A few last minute updates were received, and these will be merged with the existing minutes.

It was moved by Jerry, seconded by Mark and Lou, and approved unanimously that "I make a motion to approve the minutes as amended."

Barry asked if there were any more items. Tom moved to implement the research mechanism: "In recognition of opportunities for innovative technologies in future amateur spacecraft, AMSAT will budget "seed money" for new technology development."

The motion was seconded by Jerry, and unanimously approved by the Board.

There being no further business, it was moved by Barry, seconded by Jerry, and approved unanimously that the meeting adjourn at 2151 EST.

Alan Biddle, WA4SCA
AMSAT-NA Corporate Secretary

Delfi-C3 Notes 7th Year On-Orbit

Wouter Weggelaar, PA3WEG
pa3weg@amsat.org

Congratulations to the Delfi-C3 team at Delft University of Technology (TU Delft) in the Netherlands on the 7th anniversary of Delfi-C3 in orbit. Delfi-C3 was launched on April 28, 2008 from India by ISRO on the PSLV-C9 mission.

Wouter Weggelaar, PA3WEG, wrote, "The satellite still remains healthy and strong. We are delighted to still get the support of the ham radio community. In all seven years there have been very few days where no telemetry was decoded and submitted. Thank you very much to those still decoding and sending in telemetry and also to those still signing up for new accounts."

Wouter continued, "Delfi-C3 has been praised numerous times as the ideal example of cooperation of radio amateurs and a university. The team Delfi-C3 is very proud of that. Together we have demonstrated the first successful Distributed Ground Station Network (DGSN) built around radio amateurs. We as a community can be very proud of this achievement! Without your continued support, this would not have been possible. 73 on behalf of the team."

In reply, Stefan Wagener, VE4NSA, wrote, "Delfi-C3 truly is and was an inspirational satellite. It broke new ground from a CubeSat perspective and allowed many of us to share in the science and amateur radio part. Congratulations to the team for a job well done!"

Delfi-C3 Primary telemetry downlink: 145.870 MHz, 1200 Baud, BPSK, AX.25, 100mW

For more information on the program see:

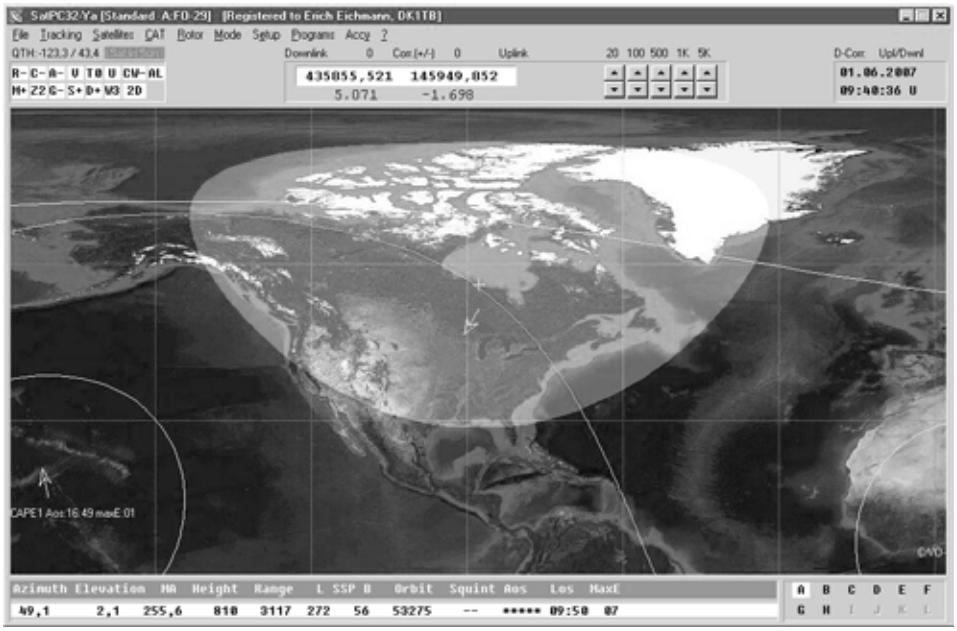
http://www.delfispace.nl/

Information for amateur radio operations can be found at:

http://www.delfispace.nl/operations/radio-amateurs

The RASCAL telemetry decoding software is available at:

http://www.delfispace.nl/operations/delfi-c3-telemetry-reception



CNCTRK - A LinuxCNC Based Satellite Tracking System

Bob Freeman, KI4SBL
uwaveguy@gmail.com

This paper presents a new approach to antenna positioner control and introduces a new azimuth (AZ) and elevation (EL) positioner designed for use in satellite tracking. The prototype positioning units have been integrated for use with the well known open source satellite tracking programs, Predict and GPredict, to enable tracking of LEO satellites.

A complete ground station with tracking system, called CNCTRK, is shown in Figure 1.

The block diagram shown in Figure 2 illustrates the simplicity of the CNCTRK system.

The initial design intent of the overall system is to enable satellite tracking using small- to medium sized (Arrow- and Elk-like) antennas. The system provides portable 12 VDC operation and can be mounted on a camera tripod.

This paper describes the prototype AZ/EL antenna positioning system (APS), the motion control approach and the integration of the APS unit with tracking software, and touches on design considerations for the system.

Figure 1. Complete Ground Station Using CNCTRK System

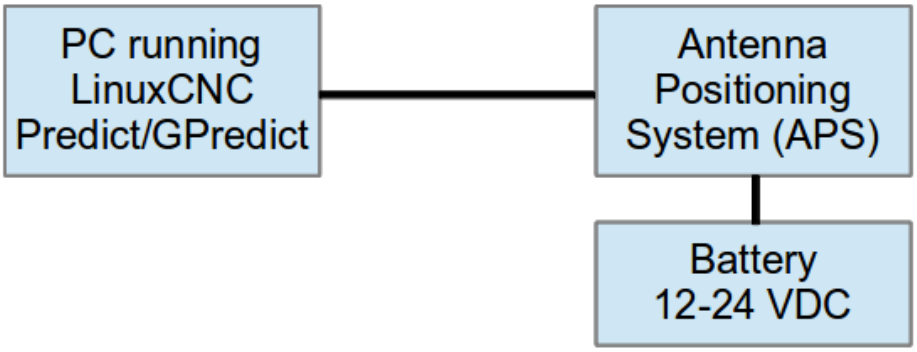


Figure 2. CNCTRK System Block Diagram

Prototype Hardware

A custom low-cost gearbox has been designed for use in the new APS. The basis of the gearbox is a rigid CNC-machined aluminum housing. Starting with the housing, the assembly is built up using heavy duty ball bearings, a worm gear drive, and 1/2" steel shafting. Stepper motors are used to drive the system as they are economical and provide simple, repeatable performance. Motor drivers are integrated into the system.

Modular Assembly

There is only one gearbox design for the APS. In order to achieve dual-axis operation, two gearbox units are ganged together with a 90 degree angular offset using a configuration adapter. For the initial prototypes, the axes are configured as an elevation-over-azimuth positioner as shown in Figure 3, on the right.

Figure 3. APS in EL-Over-AZ Configuration

Motion Control Concept

Motion control for CNCTRK is achieved without building a new rotor interface circuit. Instead, the motion planning and execution is provided via the open source LinuxCNC software: http://linuxcnc.org running on the host computer (i.e. the same computer running Predict or GPredict). LinuxCNC is used worldwide for control of computer numeric controlled (CNC) machinery in both professional and home shop environments.

Note: Installation of the LinuxCNC system is a great way to re-purpose your old Windows machine.

LinuxCNC (previously known as the Enhanced Machine Controller) was originally developed by National Institute of Standards and Technology. The program has been revised, enhanced, and maintained

through community effort. A wealth of information is available on the project website at, linuxcnc.org.

Key features of the LinuxCNC program employed for the CNCTRK project are:

1. Motion planning and control - the system provides soft start/stop of the positioner using profiled velocity and acceleration, simultaneous in all axes. Configuration options are available for user customization.

2. Flexible machine interface to motor controls - several different types of motor drives are supported, including steppers and servos.

3. Graphical user interface (GUI) - provides both interactive and programmed position control.

LinuxCNC Installation

Instructions for installing the LinuxCNC are available on the linuxcnc.org web site.

http://linuxcnc.org/

The web site also contains a Wiki to aid users with installation. Basically, the latest LinuxCNC ISO image is downloaded and burned to DVD or USB flash drive. The media is inserted into the candidate computer and the system is booted. (Note that for CNCTRK, a computer with a parallel port is required.) Following the instructions for installation will result in a bootable LinuxCNC system. Thanks to the software's developers at linuxcnc.org, the process can be just that simple.

Live versions of the LinuxCNC are available that allow testing the candidate computer before installing the operating system. Further, it is very important to test the candidate machine's latency before installation to verify the computer is able to adequately run the real time software. See the following site for more information regarding the latency test:

http://wiki.linuxcnc.org/cgi-bin/wiki.pl?Latency-Test.

For reference, the laptop used in the development system exhibited latency measured at less than 25 micro-seconds.

LinuxCNC Setup

Setting up LinuxCNC the first time is done by selecting the program from the applications menu. Select a generic stepper configuration to start and have the program make a Desktop icon or Shortcut for the system. The specific information needed for control of the CNCTRK system is achieved using an .ini file. An initialization file is provided with the CNCTRK system for this purpose - it need only be copied to the generic stepper configuration directory and referenced by the desktop icon in order for the system to start.

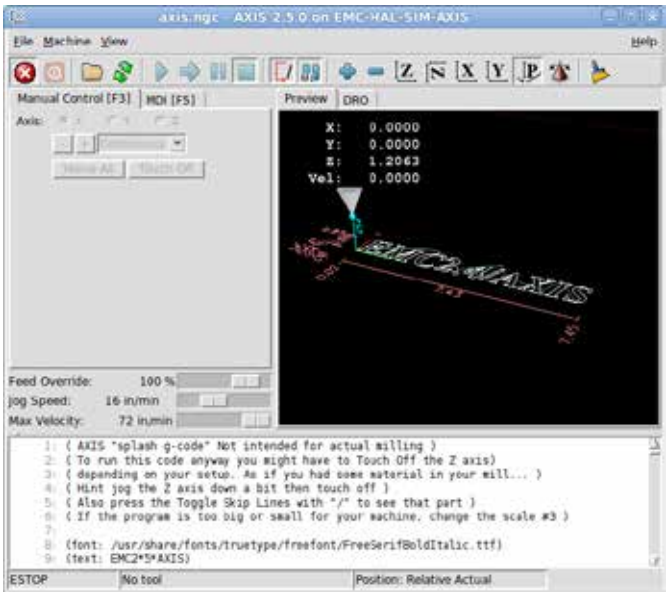


Figure 4. LinuxCNC running AXIS GUI

Axis GUI

The initialization file will direct the LinuxCNC to start the Axis GUI; an example of the resulting window is shown in Figure 4. The Axis GUI is also required for the CNCTRK system to function.

Once the GUI has started, press F1, press F2, and press the "Home All" button on the interface. These actions take the machine out of ESTOP, turns on the servos, and homes the axes, respectively. With power applied to the APS, the cursor keys will provide manual control of the positioner. At this point you will now have a CNC-based antenna positioner!

With the APS working, the satellite tracking program(s) can now be configured for use with the system.

Satellite Tracking Options

Initial development of the CNCTRK system employed the satellite tracking program, PREDICT:

http://www.qsl.net/kd2bd/predict.html

This approach employs the use of a small piece of C code, cnctrk.c, to query the Predict program for azimuth and elevation values and then send these to the positioner controller. Use of CNCTRK with Predict is the easiest system to set up and less resource intensive.

The Predict program does not provide a radio interface to enable computer control of the user's radio. However, the CNCTRK concept was extended for use with GPREDICT for this purpose:

http://gpredict.oz9aec.net/

This required a new rotator back-end be written for Hamlib so the GPredict system could be set up in the normal fashion:

http://sourceforge.net/projects/hamlib/

Descriptions of the setup and use of each of these two tracking approaches are provided as follows.

Tracking using Predict

The Predict program is a relatively small application, it is the easiest to set up, and is preferred for cases where manual radio control is used. Predict provides a text mode display for tracking either a single satellite or multiple satellites, among other things. For use with the CNCTRK system the program is started in server mode from the command line, using:

```
predict -s
```

Select option "M" for multiple satellite

tracking display mode (highlighted entries are within view) or select option "T" to display tracking data for a single satellite. Once in track mode, the predict server is available for use by client programs (such as the CNCTRK system). A screenshot of Predict in single satellite "T" mode is shown below, for reference.

Similar as before, power the APS and start the LinuxCNC program (press F1, F2, "Home All") and verify the system is operational via the cursor keys. A technique for aligning the system with earth coordinates is provided later.

Open a terminal window and enter following command to initiate satellite tracking:

```
cnctrk (A-Z designator for satellite)
then press Enter
```

The designator for the desired satellite, A to X, is found in PREDICT's Track screen "T." You may also enter a "Y" or "Z" to track the sun or moon, respectively.

Once the designator (A to Z) is entered the APS will swing into position and the system will begin to track the target with position updates every second. The commanded azimuth and elevation values are displayed on the terminal as long as the unit is tracking. To stop the process, enter Ctrl-C in the same terminal window or tracking will also stop if Predict is removed from track mode using "q" or "ESC."

Tracking using GPredict

Setup of GPredict is done in the normal fashion, as described in the GPredict documentation. Follow the instructions in the manual to setup radios, if needed. Gpredict employs the Hamlib library for control of multiple radios and rotators. A new positioner (rotator) interface has been introduced for inclusion into Hamlib for the CNCTRK system. The software is not yet included in the current release of Hamlib so the sources must be compiled using the provided patch to the current release (presently, Hamlib-1.2.15.3.tar.gz).

Compiling Hamlib with CNCTRK Patch

Download the current release of Hamlib from the above web site then unpack using

```
tar xzf  hamlib-1.2.15.3.tar.gz
```

Figure 5. PREDICT in single satellite mode

Copy the provided patch file to the Hamlib directory, change to the directory, and apply the patch using:

```
patch -p1  < hamlib-1.2.15.3_cnctrk.
patch
```

Compile the sources as usual using

```
./config
make
sudo make install
```

To get started, power the APS and start the LinuxCNC program (press F1, F2, "Home All") and verify the system is operational via the cursor keys. To verify the APS interface is working through Hamlib use the function "rotctl" to start an interactive session. From the command line, proceed as follows:

```
rotctl -m 1501
```

(the Hamlib model number for the APS is 1501)

```
P
```

(enter azimuth and elevation data desired)

When finished, press Ctrl-C to stop the rotctl interactive program.

In order to use the APS with GPredict, the "rotctl" program must be run in the operating system as a daemon; open a terminal and use the following command to run the daemon process in the background:

```
rotctld -m 1501 &
```

At this point the LinuxCNC and Hamlib processes are ready to accept position commands from the tracking software.

GPredict Setup

Again, setup of GPredict is done in the normal fashion. Follow the instructions in the GPredict manual to setup the rotator and position limits under the **Edit>>Preferences>>Interfaces>>Rotators** pull-down menu. Select either "Add" or "Edit," as needed to configure the parameters. For more information see the user manual at:

http://sourceforge.net/projects/gpredict/files/Gpredict/1.3/gpredict-user-manual-1.3.pdf/download

Open the "Antenna Control" from the pull-down menu (small icon located at the top right of the main GPredict screen). Initiate control of the APS by clicking on the "Engage" button. The APS can also be manually jogged using the up/down arrows on the numerical position display. The "Track" and "Engage" buttons will remove manual control and place the APS under control of the GPredict program, as needed for satellite tracking. A screenshot of of the Antenna Control window during active tracking of satellite AO-27 is shown in Figure 6.

Field Alignment of Coordinate System

To align the system in the field, a tripod mount and sunny day is assumed. Start the LinuxCNC program, the tracking program

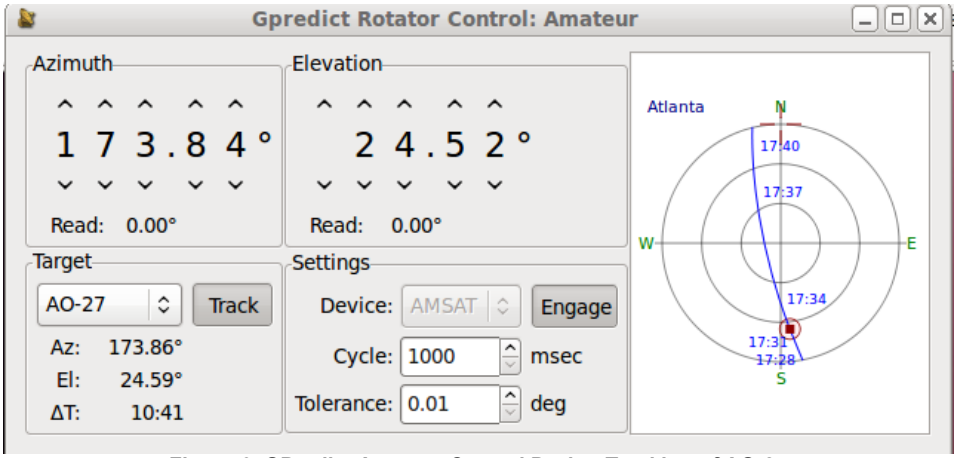


Figure 6. GPredict Antenna Control During Tracking of AO-27

Predict, and proceed as follows:

1. Level the Azimuth axis

2. Initiate sun tracking in Predict (this steers the Azimuth and elevation axes to the correct angle)

3. Unlock the tripod mount and rotate about the vertical axis until the Sun is in alignment with the antenna beam. Once aligned, a dual band antenna will produce a shadow that resembles an "X" or cross on the ground.

4. The system is now aligned; lock the tripod vertical axis in place.

If the Sun is obscured then use of a compass or other means may be employed to align the azimuth axis.

Prototype Hardware Characteristics

As mentioned previously, a custom gearbox is made from a rigid CNC machined aluminum housing, heavy duty ball bearings, worm gear drive, and 1/2" steel shaft-ing used throughout. Stepper motors and generic motor drivers accepting step and direction signals from the LinuxCNC computer provide the drive for the system. Finally, the range of azimuth axis rotation is made greater than 360 degrees through the use of a wrapped power/control cable.

Mechanical and electrical characteristics of the prototype system were measured. Since the drive settings for the motor drivers were set to conservative values. The rotation velocity is a function of the computer used with the system; the values listed are for reference only. A summary of measured characteristics data from one of the prototype units is provided in Table 1.

Cost Considerations

Several factors were considered in the APS design to reduce cost of the units. Some of these are listed below.

1. To take advantage of the economies of scale, the positioner employs a modular design and reusable parts. The gearbox design, including the drive system, is re-used for each axis in the system. Connecting parts are used in multiple applications, where possible.

2. The worm gears used in the system are commodity gear kits; they will provide long service life and are inexpensive to replace. The positioning accuracy achieved using the worm drive system is entirely sufficient for amateur satellite operation where antenna 3 dB beamwidths are in excess of 20 degrees.

3. Stepper motors are used to drive the assembly. These are widely available and can be purchased with a range of characteristics for torque, voltage, and current. A NEMA-23 standard motor size is used in the CNCTRK system.

   Note: The first prototype unit used stepper motors from old printers with excellent results.

   It should be noted that the LinuxCNC is capable of controlling a wide range of motor controls, including servos. See the linuxcnc.org Wiki for a list of known working motor interfaces.

4. The free, open source, LinuxCNC program provides the motion control logic for the CNCTRK system. This is a flexible and stable real time platform with proven performance. Use of LinuxCNC reduces tracking system cost by eliminating the need for a separate track box assembly and associated cabling or other proprietary interface to commercial antenna rotators.

5. The CNCTRK system, shown in the previous block diagram, employs only three major components: 1) a laptop or other computer with printer port and cable, 2) a DC power supply, and 3) the APS. Power for the APS may be provided from any available DC source in the range of 12 to 24 VDC, including battery power.

Flexibility and Future Enhancement Opportunities

The CNCTRK system provides a suitable platform for its intended purpose of tracking amateur radio satellites. Enhancements to the system are always possible, as are alternative uses for the system. Some ideas along these lines include:

Azimuth or Elevation Axis	
Holding Torque	48 in-oz
Velocity	15 deg/s default setting
Backlash	2 deg
Theoretical Resolution	0.007 deg at 1/16 microstep
APS Assembly	
Weight	8.5 lb
Finish	Bare aluminum
Azimuth Range	-90 deg < AZ < 450 deg
Elevation Range	-20 deg < EL < 90 deg
Position Accuracy	+/- 2 deg
Dimensions	Approx. 7 x 7 x 8 inches
Power Consumption (Idle)	0.25 A x 12VDC = 3 Watts
Power Consumption (AZ/EL Steering)	2.00 A x 12VDC = 24 Watts (default)

Table 1 System Characteristics

Home/Limit Switches - The LinuxCNC program can easily accommodate the use of limit switches wired to the 25-pin I/O connector. This enhancement provides repeatable position location from one session to the next. The aluminum housing provides ample area for addition of this and other custom features.

Raspberry Pi - The LinuxCNC program has been demonstrated to run on the Raspberry Pi (RPi). For an example see:

http://www.youtube.com/watch?v=Kz02FxYAvC4

A Raspberry Pi based system has been successfully implemented using Predict. An additional circuit board is employed to generate step pulses; the PCB is an open source design and may be found at:

http://github.com/kinsamanka/PICnc-V2

The RPi solution requires much less power than the laptop system and no changes to the APS hardware are needed.

Use of the RPi with CNCTRK may also serve as an avenue of interest for young operators that are already familiar with programming the platform.

Modular Approach - The modular characteristic enables two or more axes to be assembled, as needed. These units may be configured as a mast mounted system, polarization rotators, azimuth table for antenna range measurements, and so on. Or, how about a Roll-Over-Elevation-Over-Azimuth configuration for AZ, EL, and polarization control? The LinuxCNC will control at least four axes using a single parallel port.

Solar Tracking - The system can be made to track the Sun. This is already enabled when using the Predict program interface, cnctrk.c, and is a feature that is quite useful for system alignment in the field. An alternate application might include positioning of photovoltaic (i. e., solar electric) panels for maximum energy collection.

Education - Educational opportunities exist through the exploration and use of this project. In addition to the diverse offerings that come with amateur radio and satellite communications, there is much to learn in the area of mechanical systems, motor and motion control, and the concepts of CNC machinery. The CNCTRK ground station approach may be beneficial to the student by providing relatively low cost hardware to enable the exploration of the concepts and practices of CNC and mechanical systems.

Performance - The mechanical performance of the basic gearbox may be improved through the addition of a custom worm gear set. A gear set with finer pitch could achieve lower backlash, improved self-braking (through higher gear ratios), and overall improved position accuracy. Note that slower speeds will result with higher gear ratios, assuming the control computer is held constant.

Dual Antenna Mounting - The length of the elevation axis shaft is made purposely long and extends on both sides of the APS. This enables one to adapt shaft extensions on the APS unit to provide separation distance between antennas that may be mounted on both sides of the APS. For example, one might mount a 2m crossed Yagi-Uda on one side and a 70 cm beam on the opposite side.

Counterweight - A counterbalance may be employed for antennas that require greater torque than is readily available with existing motors and gearing.

More Power! - The motor driver circuits employed in the prototype system were adjusted to approximately 1.0 A per driver at 12 VDC. The motor driver circuits provided with the system are based on the Toshiba TB6600 and are actually capable of driving up to 4.5 A at 24 VDC. While use of the drivers at these levels has not been tested by the author, it does offer the potential for much greater delivered torque from the APS with the existing motors.

Weatherproofing - The initial APS design is meant for portable operation and is not weatherproof. Additional parts or features could be added to the unit to increase survivability in the outdoor environment.

Kits and Assemblies

Supply of APS kits is a possibility, depending on the level of interest. Mechanical assembly and wiring of the APS is required but the motor driver electronics are furnished as fully assembled modules.

Kits would include the following items:

- CNC aluminum parts and components for two gearboxes (AZ + EL)
- Configuration adapter
- Stepper motors and drivers
- Assembly instructions in electronic form
- CD-ROM or DVD with Linux-CNC distribution
- CD-ROM or Flash Drive with setup file and cnctrk.c

Note that since custom-machined parts are used, there may be significant lead times for the APS kit components. All RF equipment and cables needed to complete a ground station are to be provided by the user.

Summary and Conclusion

A new low-cost approach to antenna positioning for satellite tracking has been described. The approach employs existing open source motion control software in the form of the LinuxCNC to handle the hardware layer mechanical control. A new APS has been designed, built, and tested. Further, the prototype units are integrated with open source satellite tracking programs, thus enabling tracking of LEO satellites.

The design intent of the system is to enable satellite tracking using small-to medium-sized (Arrow and Elk) sized antennas. The system provides portable DC powered operation and, weighing about eight pounds, is suitable for use on a camera tripod.

This article has described the CNCTRK system, the prototype APS, integration of the unit with available tracking software, and has touched on the design approach and possible enhancements of the system.

Questions, suggestions, and inquiries regarding the CNCTRK system are welcomed by the author. Additional information may be found at:

http://ki4sbl.dodropin.org/CNCTRK/

Biographical information for Bob Freeman, KI4SBL

Bob is a career microwave antenna engineer with several years experience in antenna design and measurement. Interests include microwave engineering, amateur radio, hobby CNC, RVing, tree climbing and other outdoor activities. Bob and wife Cathy, KI4SBK, currently reside in Cumming, GA or somewhere along a scenic highway in the USA.

US Naval Academy Launches PSAT, BRICsat, and USS Langley Cubesats

Bob Bruninga, WB4APR
bruninga@usna.edu

On May, 20, 2015, three satellites developed by students at the US Naval Academy were launched into a 55° inclination orbit from Cape Canaveral aboard the AFSPC ULA Atlas-5 mission. The cubesats from same P-Pods were PSAT on 435.350 MHz, BRICsat on 437.975 MHz and USS Langley on 437.475 MHz. BRICsat and USS Langely both transmit 9600 baud AX.25 packet telemetry. First packets were heard on the next orbit over the USA.

The US Naval Academy welcomes radio amateurs worldwide to tune into the downlinks and either IGate packets into the global APRS-IS system or email to bruninga at usna.edu.

After launch the PSAT PSK31 435.350 MHz FM downlink was received full quieting with 6 bars using a decent UHF Yagi antenna. The APRS digipeater on 145.825 MHz was turned off to allow maxiumum power for PSK31 operations.

Receiving the PSAT PSK31 FM downlink

Software for the PSK31 mode is needed for operation. Examples of this software include FLDIGI which is a digital modem program for Linux, Free-BSD, OS X, Windows XP, NT, W2K, Vista and Win7:

http://www.w1hkj.com/Fldigi.html

The Digital Master software in the Ham Radio Deluxe package also provides PSK31 capability.

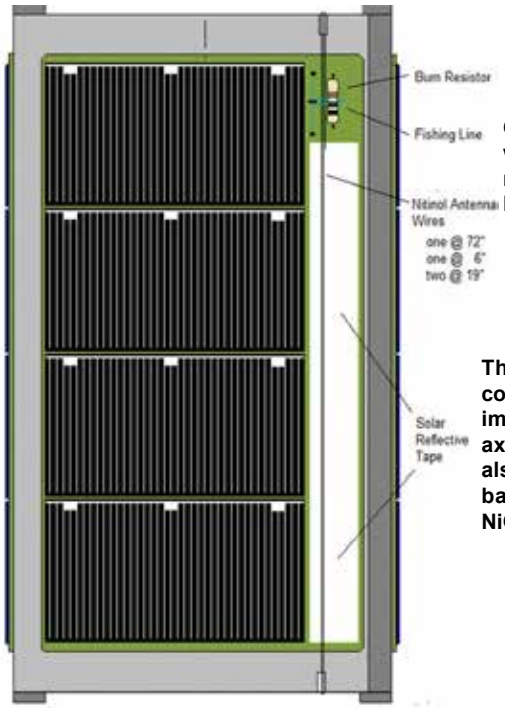
Although the PSK31 10 meter uplink is conventional SSB, the 435.350 MHz downlink is FM and can be received as simply as placing your PSK31 laptop microphone next to the speaker on your FM satellite UHF receiver and just watching the waterfall.

What you see is exactly what everyone else sees (its FM). There is no Doppler added to the tones due to your station's position relative to the satellite. But you DO have to retune your FM radio at least 3 times during the pass (+5 kHz, 0, -5 kHz) to stay in the FM passband.

User uplinks, however, will shift in the waterfall according to each user's position relative to the satellite. The shift can be as low as 1 Hz per second to as high as 6 Hz per second. This is because the uplink is on 10 meters where the Doppler rate is only 1/15th of what it would be on UHF.

The PSK31 channel at 315 Hz (PSAT) or 375 Hz (BRICsat) is FIXED with no Doppler since it is generated onboard into the FM downlink

Just turn on MULTI CHANNEL window and let the PSK31 decode everyone. The ones with the least Doppler at any instant may be decoded for a while.



On command to deploy the antennas, which are stowed for launch, the burn resistor heats, melting the fishing line holding the wire antennas.

The offset solar reflective stripe compared to the black solar panels imparts a slight spin about the Z axis for good thermal balance. It also assures equal charge on the batteries which are charged one NiCd pair per solar side panel.

Source: http://aprs.org/psat.html

US Naval Academy Launch - May 20, 2015			
Satellite	**Uplink (MHz)**	**Downlink (MHz)**	**Operating Mode, Satellite Status**
PSAT	145.825	145.825	Digipeater is secondary mission
PSAT (W3ADO-5)	28.120	435.350	SSB PSK-31 up; PSK-31 FM down (telemetry at 315 Hz offset); Satellite is operational
BRICsat-P		437.975	9600 baud telemetry every 20s
BRICsat-P (W3ADO-6)	28.120	435.350	SSB PSK-31 up; PSK-31 FM down (telemetry at 375 Hz offset); heard weakly, powers down due to low voltage.
USS Langley		437.475	9600 baud telemetry; satellite not heard yet.

Brno University in the Czech Republic provided the transponders for use in the PSAT and BRICsat satellites.

Prepare your station to transmit PSK-31 on 10 meters SSB and to receive the audio from an FM UHF rig on 435.350 +/- 5 kHz steps of Doppler. The UHF downlink signal is only 300 mW and so a UHF beam is needed on the downlink.

UPLINK RESTRICTIONS: Use of *NOTHING MORE THAN* a Vertical 1/4 wave or dipole is authorized on the 10m uplink with no more than 25 Watts until the link is well understood..

Remember a 1/4 wave vertical is the ideal antenna because it maximizes the signal at lower angles and tapers the signal as the satellite gets closer. This keeps user uplinks about the same during a pass. Strong stations just drive down the AGC and ruin it for everyone.

Use minimum power!! Remember, this is crossband FULL DUPLEX so you can see yourself in the downlink just like everyone else can see you. Act accordingly. And of course, the transponder will not come on unless someone is transmitting PSK31!.

FLDigi software window receiving on 435.350 MHz.

Extreme DXing on FO-29 with a Portable Station

Hector L Martinez, CO6CBF/W5CBF
co6cbf@amsat.org

As a former HF DXer, I became very interested in extreme DX on satellite. The orbits of the linear transponder satellites, such as AO-7 and FO-29, provide the best range, increasing the opportunity for working DX stations.

Unfortunately, operating via AO-7 Mode B is not legal for Cuban satellite operators because we cannot transmit on 432 MHz which is AO-7's Mode B uplink band. With the lack of AO-7 Mode B and the issues of Mode A downlink on 10 m, Cuban operators just have one option to try extreme DX on the birds: FO-29.

FO-29 is a great satellite with a 1300 km apogee, a very stable 1W downlink, and a very generous 100 kHz pass-band. In spite of its eighteen years in orbit, it is still providing an outstanding service to the amateur satellite community [1].

Photo 1: Hector, CO6CBF, at his home station working Dale, KL7R

Photo 2: Dale, KL7R at the Alaskan end of the DX contact

My first extreme DX

I set my goal to work an extreme DX station on FO-29. I also needed to work Alaska for my WAS award so I emailed Dale, KL7R, in BP54. He agreed to try a contact until we were successful! We knew that it could be difficult, but we did not know how difficult! We tried up to 10 times until our successful contact. All SSB attempts failed, but our first attempt in CW was successful. It was my first extreme DX on FO-29 (6720 km). Dale is a very persistent and dedicated operator. For each attempt at a contact with me in Cuba, he had to climb up a nearby hill even at nights and under freezing temperatures. Photo 1 shows me at my home station; Photo 2 shows Dale, KL7R contacting me from Alaska.

There were two potential reasons which frustrated our first attempts at my end. At that time, I was operating with my all-homebrewed satellite station. For receiving, I used my homebrewed HF receiver listening to the IF from my homebrewed W6IOJ 70cm down converter (Photo 3). To transmit, I used a homebrewed HF transceiver driving my homebrewed CX9BT 2 m transverter (Photo 4). I had tested all of my gear using homebrewed test equipment. This was the first gear I had built for VHF/UHF. I tried the best I could, but I was aware that the 70 cm downconverter's sensitivity and noise figure were not excellent [2].

Additional difficulties arose due to my home station not having a clear horizon in any direction except south. There are some tall buildings which shield down 5 degrees on every north and west pass. Due east is totally blocked by a 45 meter tall building (Photo 5)

My first transatlantic DX

I was still looking for more fun and my first transatlantic DX on the birds. I emailed Juan, EA4CYQ in Spain (IM78cx) for a schedule. This contact looked even more difficult! We almost made a contact on our first attempt. He heard me and came back but, because I just barely heard him during a few seconds, I was not able to get his full callsign.

I tried to improve my 70 cm reception but I already had done the best I could with my test equipment and homebrewed 70 cm converter. I thought about operating portable to overcome the bad location but this idea was discarded due to the high volume and weight of my SSB satellite gear. We had to wait for a mutual visible pass to try again.

Two months later, after that failed transatlantic attempt, I had the high honor of attending the AMSAT 30th Annual Space Symposium. At the Symposium I received a lot of donated equipment to improve my satellite station. I became a proud owner of a FT-817ND and ELK dual-band log periodic antenna. Once again, I thank everyone who has made my trips possible and who generously donated equipment to improve my station!

Photo 3: CO6CBF homebrew UHF downcoverter

Photo 4: CO6CBF 2M/10M Homebrew transverter

Back in Cuba with my new ham radio gear, I could not wait to get on the air again. I combined some of my homebrewed gear (30 W PA and 70 cm LNA) with my new setup. My first goal was the transatlantic contact with Juan, EA4CYQ. We set another schedule and I decided to operate portable from a tall building's rooftop utilizing my new toys. We had a great 7189 km contact! It was the first time I got a solid downlink from FO-29 at my horizon [3].

Half – duplex portable setup

With the new gear, working the satellites has never been easier for me, My new FT-817ND and ELK antenna solved all my limitations to work FO-29 from AOS to LOS. Now, I can choose the best location for the pass I want to work. I can go and operate portable from everywhere. The FT-817ND and ELK antenna are very light, making the easy to carry and ready to hear very weak signals. Photo 6 shows my new portable setup. Yes, I realize that it is not a full duplex radio, but operating half duplex is not terribly hard. In fact, in extreme contacts which have a very limited footprint you may not have time to look for yourself on the downlink. You could waste valuable seconds of a short window trying to do that.

Taking advantage of the great FO-29 stability, my technique is to attain frequency accuracy. I run calculations based on the great feature implemented on SatPC32 V12.8b which allows an option of seeing

Photo 6: Hector's portable satellite station

the frequency you are appearing at the satellite receiver at any time during a pass. Photo 7 shows an example screen shot from. SatPC32.

Doppler shift is always in play so your dial frequencies will be different between your station and the DX station. If you use the satellite receiver frequency as common reference point, you will transmit exactly or very close to where your desired station is listening, and vice versa.

Another important factor is antenna positioning. When FO-29 is over the horizon, I almost always get the best signal using vertical polarization. The 100 mw beacon is very helpful to track the satellite. I have the beacon's frequency stored in a memory channel while I set the receive frequency in VFO A and the transmit

Photo 5: The obstructed horizon at CO6CBF's home satellite station. The 45 meter tall building blocks the horizon to the east.

frequency in VFO B. This makes it easier to switch between the beacon's frequency and the QSO frequencies. On the FT-817ND this can be done with just two touches of the V/M button. You will be able to track the satellite's beacon until the last second before or after both stations get into the footprint.

Good visibility to the horizon is essential. After all, I have some benefit from that 45 m tall building which blocks the east of my home station; it is a great place to work satellites below the horizon. It is my favorite place to work extreme DX on FO-29.

More Fun

I have continued looking for extreme DX and have been enough lucky to find some adventurous operators who have committed all their efforts to archive an extreme contact with me. A huge thanks to all of them! Each extreme contact on FO-29 is an exciting story!

Following my first extreme DX with Dale, KL7R and Juan, EA4CYQ; I have had other long contacts up to 6000 km. I worked Spain, contacting David, EA4SG in IN80cp (7330 km) and Jose Elias, EB1FVQ in IN52pe (6900 km). On Canary Island I contacted Hugo, EA8HB in IL18bp (6383 km).

My first contact with Ireland was with Joe, EI5EV in IO62kg (Photo 8). We were successful at our second attempt. It was a 6955 km contact! I was operating from a tall building at my university and was using my usual portable station with a homebrew Arrow antenna (Photo 9). My second contact with Ireland was with Michael, EI3GYB in IO53ot (6840 km). He uses vertical antennas for satellite operation.

Wet Grids

Yuri, UT1FG/MM has sailed across the Atlantic, around South America, through the Panama Canal, into the Caribbean and up the Atlantic coast to the St. Lawrence Seaway. I have worked him up to 6000 km away several times. In most cases, I was operating with my portable gear from that tall building.

UK

After six months of work, I achieved a 7286 km contact with Peter, G4DOL in IO80so. We tried several times but Peter never could hear below one degree. I suggested that he assemble a portable station to operate from a better spot. He did so, loaded his car with antennas, radio, and a battery and drove five miles from his home looking for a good spot in the windy and dark coast. Photo 10 shows me at my operating position on the tall building; Photo 11 shows conditions at Peter's end for the contact. As a great friend and mentor in satellite told me: "A good ham radio operator is one that looks at a problem as a challenge rather than a show stopper."

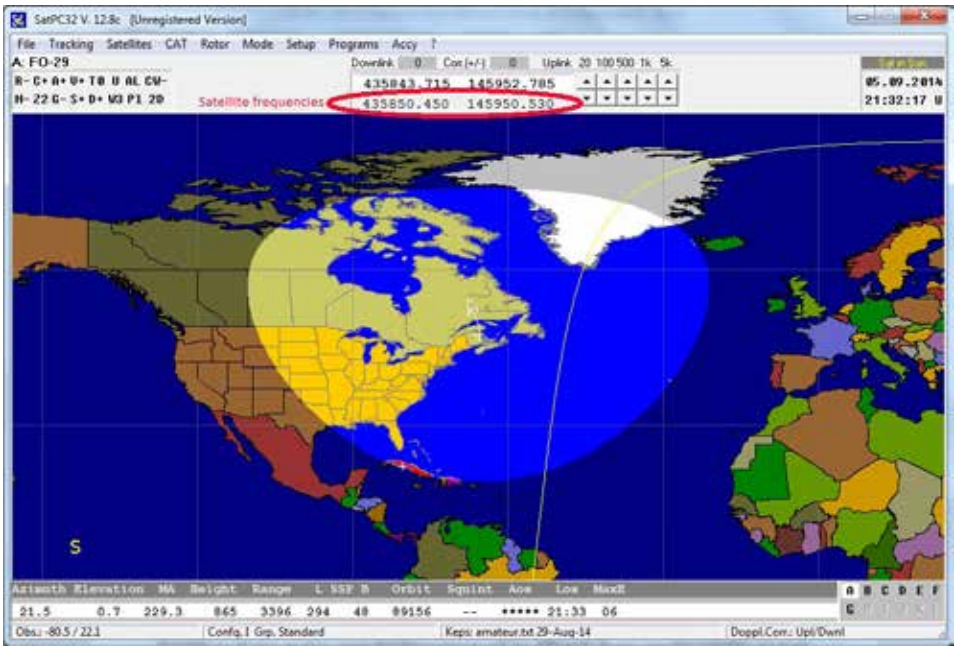


Photo 7: SatPC32 includes a feature showing your Doppler shifted frequency at the satellie

(left) Photo 8: Joe, EI5EV working Hector on FO-29

(below) Photo 9: Hector at his operating position on the tall building for his contact with EI5EV

Alaska again

Dale, KL7R was operating from some very rare grids. We made a schedule for each grid he activated. He did a great effort to be on the very early FO-29 passes. It was a very exciting week for me. I had to go to the tall building top, every day. We were successful in all attempts: BP41, BP42, BP51, BP52, BP61, BP62 and BP83 (all over 6500 km) [4].

France, my longest DX on the birds

I emailed Michael, F6GLJ for a schedule. He agreed but we had to wait almost a month for a mutually visible pass. We just had three mutual visible passes during the next six months. Our first attempt was on July 18, 2014, but Michael was not able to get a solid copy of my signal. Fortunately, FO-29 offered us another opportunity and we scheduled again. I decided to use the Elk

antenna instead of the Arrow which I used in the first attempt. I had my first contact on satellites with France. It is a 7509 km contact, very close to the FO-29 maximum footprint (Photo 12).

I operated from my usual spot on the 45 m tall building, running half-duplex with my portable gear: FT-817ND, a homebrew 50 W power amplifier and a homebrew 70 cm LNA. Everything was powered by a 12 V, 7 A gel battery.

Michael, F6GLJ was running around 80 W with an ICOM IC-910 without preamplifier (Photo 13). His antennas included an 11 element Yagi for 2 m and a 19 element Yagi for 70 cm at 7 m on his roof. Fortunately, he has a good horizon visibility.

Looking South

I have a good visibility to the south from my full-duplex home station. South American DX has been easier but not less exciting. I have worked some stations up to 6000 km there, too:

- Uruguay - Juan Miguel, CX1TH in GF25vi (6892 km)
- Argentina - Juan Carlos, LU2DPW in GF05gi (6683 km) and Mario, LU2HAM in FF78up (6190 km)
- Brazil- Luciano, PY5LF in GG54gm (6271km)
- Chile - Joel, CE2JLB in FF47jg (6130 km)

You could be the next one

I am always looking for new stations, grids, and countries on the birds. If we have a mutual visible pass, we can make a contact. If you cannot work down to the horizon from your home station, you always can go to a better location and use a portable setup. There is nothing wrong with using a portable setup to work DX. Just do the best with what you have, and you will have FUN!

(left) Photo 10: Hector's view from the roof while working Peter, G4DOL

(Right) Photo 11: The antenna at the dark coast at G4DOL

Notes

[1] NASDA (National Space Development Agency of Japan). August 1996.

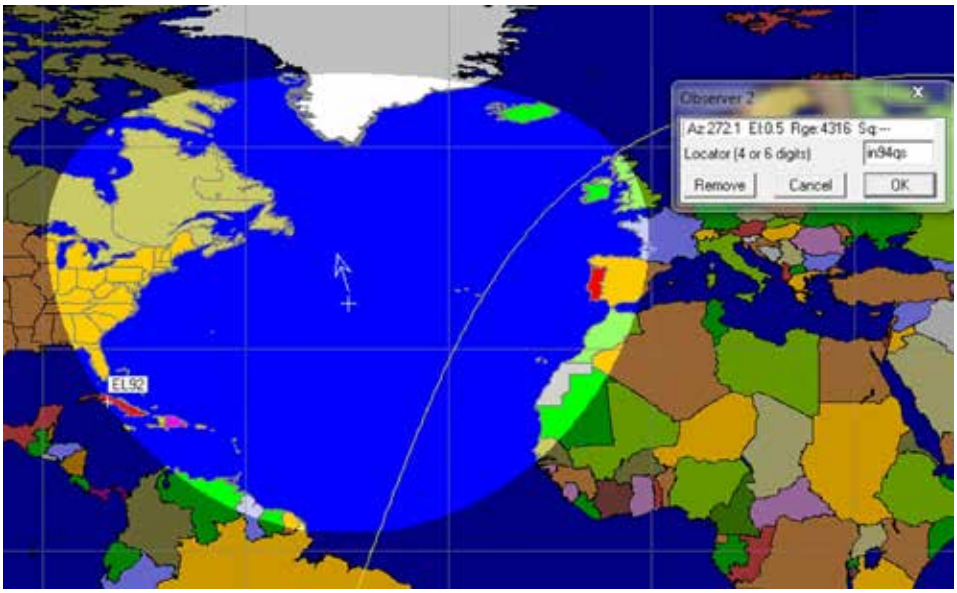
[2] Proceedings of the 2012 AMSAT-NA 30th Space Symposium, pp 111-117..

[3] http://www.papays.com/sat/general.html.

[4] https://www.youtube.com/watch?v=R29nW1tepFs

DX Distance Update

Since this article was completed, Hector reports that, in April 2015, he and Peter, G4DOL, have had another successful extreme DX contact via FO-29. Distance calculation for this contact is approximately 7537 km, making this possibly the longest QSO ever reached on FO-29.



(above) Photo 12: Michael, F6GLJ, and Hector, CO6CBF in the FO-29 footprint.

(right) Photo 13: F6GLJ's home station

Rotor Controller Box/Boards Available

LVB Tracker Box

- Reasonably priced and all profits go to AMSAT
- Serial interface standard
- USB interface may be easily added by user
- Open software
- Open architecture
- Built-in rotor interface cable with DIN connector
- Power supplied via the rotor controller cable
- Bi-directional interface allows the unit to read the rotor position
- LCD position readout
- Front panel manual control
- Self-programmable, allows for easy software upgrades
- Supported by the major tracking programs
- Uses GS-232A or Easycomm I/II protocols

Contact Martha at the AMSAT office 301-822-4376 to order.

The complete units will be built in groups, so get your orders in early. Units will be shipped as they become available.

Minimum donations requested for various configurations:

1) Bare board - $20 + S&H – no parts kits available
2) Custom Enclosure powder coat, silk-screened, drilled/punched - $50 + S&H
3) Complete unit - board, serial output, rotor cable, LCD, enclosure - $200 + S&H **our most popular

Documentation for the LVB Tracker can be found at: http://www.LVBTracker.com

Boards and complete units may be ordered from the AMSAT office at 301-822-4376 or from martha@amsat.org

Visit the AMSAT On-Line Store for details on the updated LVB Tracker Box: http://store.amsat.org/catalog

AMSAT Fox-1C $125,000 Launch Initiative Goal ... Your Help is Needed!

AMSAT is excited to announce a launch opportunity for the Fox-1C Cubesat. AMSAT has teamed with Spaceflight for integration and launch utilizing Spaceflight's SHERPA system to a sun-synchronous orbit in the third quarter of 2015.

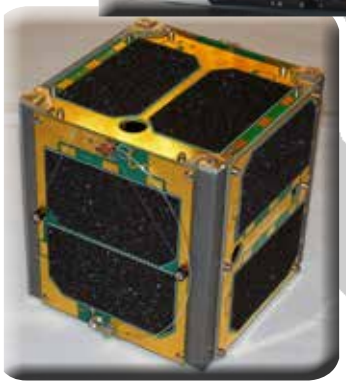
Fox-1C is the third of four Fox-1 series satellites under development, with Fox-1A and RadFXsat/Fox-1B launching through the NASA ELaNa program. Fox-1C will carry an FM repeater system for amateur radio use by radio hams and listeners worldwide. Further details on the satellite and launch will be made available as soon as released.

AMSAT has an immediate need to raise funds to cover both the launch contract and additional materials for construction and testing for Fox-1C. We have set a fundraising goal of $125,000 to cover these expenses over the next 12 months, and allow us to continue to keep amateur radio in space.

Spaceflight's SHERPA will deploy multiple cubesat payloads on-orbit

Spaceflight's SHERPA System

ISIS QuadPack Nanosatellite Dispenser



Your help is needed to get the AMSAT Fox-1C 1U Cubesat launched on the Spaceflight's initial SHERPA flight in 3Q 2015.

For the latest news on Fox-1 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.

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 Fox-1C ... Join Now!

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

Radio Amateurs invited to test APRS on Duchifat-1

Duchifat-1, the Israeli high school students 1U CubeSat launched June 19, 2014, is ready for its first public tests. People with the ability to send Compressed APRS location packets are invited to join the tests.

The satellite will collect these packets worldwide along its flight at 620 km high orbit, and will downlink them from time to time over our ground station in Herzliya/Israel.

Participants are kindly requested to register in advance in order to get their packet identified on the map.

The packets successfully received will be displayed on a map in our Internet site and QSL cards will be sent via Bureau to the stations registered and recognized. (unfortunately, there is no way we can recognize packets from unregistered stations because the packet is limited to 14 characters at the satellite, so we assign two unique characters to every registered station to enable us to identify them).

Registration can be done at

http://www.h-space-lab.org/php/duchifat1-en.php

Also available in that site are operational information about the satellite, and the following documents:

Configuring TT4 Explanation.doc – how to use the Byonics TinyTrak4 for generating Compressed APRS packets

Terms Of Use.doc – terms and techniques for making the best use of the satellite

There is also Ground station software available for download, written by our students around ISIS space Demodulator software.

We hope many people will find it interesting and enjoyable,

Duchifat-1 Frequencies and Operating Modes

Uplink	Downlink	Mode
435.220 MHz	145.980 MHz	Compressed APRS packet digipeater AFSK 1200 baud UHF uplink, BPSK 1200 baud VHF downlink.
	145.980 MHz	Morse beacon at satellite wake-up: Shalom de 4X4HSL Duchifat1- Herzliya Science Center sat Morse beacon every 1 minute (at speed of 15 words per minute): hi de Duchifat
	145.980 MHz	Telemetry every 20 seconds: 1200 baud AX.25 BPSK

Planetary Society Lightsail Launched

The Planetary Society's Lightsail-A satellite was also aboard the same AtlasV launch from Cape Canaveral which included the US Naval Academy's PSAT, BRICsat, and USS Langley satellites.

For the Planetary Society, the launch of LightSail marks the culmination of a six-year effort to send a solar sail CubeSat to space. The project began in 2009, but was temporarily sidelined by technical and funding challenges, as well as the need to find a sufficiently high-altitude flight. The spacecraft was originally built by San Luis Obispo-based Stellar Exploration, Inc. In 2014, Ecliptic Enterprises Corporation became the vehicle's prime contractor, and Doug Stetson joined the team as project manager. Boreal Space serves as a contractor to Ecliptic. Testing and integration for LightSail occurs at Ecliptic as well as Cal Poly San Luis Obispo.

Lightsail does not include two-way amateur radio communications on this mission. The telemetry data is sent on a downlink of 437.435 MHz using 9600 bps FSK.

Two ground stations for the Lightsail mission are located Cal Poly in San Luis Obispo, California and at Georgia Tech.

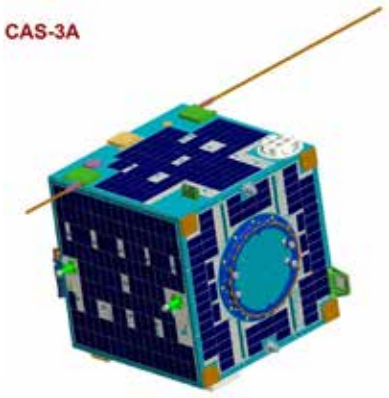
The latest satellite location and operational status is displayed on-line at:

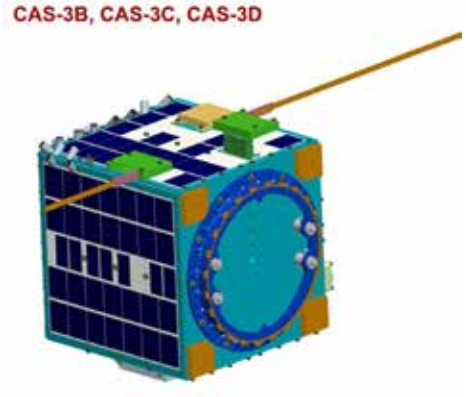
http://sail.planetary.org/missioncontrol

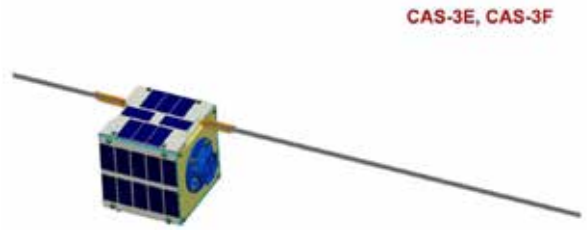
CAMSAT Press Release: Multiple Amateur Satellite Launch in July

Beijing, May 23, 2015 - The CAMSAT orchestrated CAS-3 amateur satellite system is now nearing completion Six Chinese amateur satellites will be launched in mid-July which includes a series of satellites, one 20 kg, three 10 kg, and two 1 kg sizes. All six satellites are equipped with substantially the same amateur radio payloads, a U/V mode linear transponder, a CW telemetry beacon, and an AX.25 19.2k/9.6k baud GMSK telemetry downlink. The amateur radio equipment on each of the six satellites shares the same technical characteristics, but will operate on different frequencies of 70cm band uplink and 2m band downlink.

CAMSAT worked closely with DFH Satellite Co. Ltd., a Chinese government aerospace contractor which provided most of the support for this project. All the satellites are currently conducting final testing and inspection.







CAS-3A Micro-satellite

- Dimensions: 400Lx400Wx400H mm
- Mass: 20kg
- Stabilization: three-axis stabilization system with its +Y surface facing the earth
- Antenna: Deployable antenna, one 1/4λ monopole VHF antenna with max.0dBi gain located at +Z side and one 1/4λ monopole UHF antenna with max.0dBi gain is located at –Z side, close to the each edge of satellite body
- Uplink: 70cm band
- Downlink: 2m band
- Amateur radio payloads:
  - Callsign: BJ1SB
  - CW Telemetry Beacon: 50mW, 22 wpm
  - U/V Mode Linear Transponder: 100mW, 20kHz bandwidth, inverting
  - AX.25 telemetry: 100mW, 19.2k/9.6k baud GMSK

CAS-3B, CAS-3C and CAS-3D Micro-satellite

- Dimensions: 250Lx250Wx250H mm
- Mass: 9kg
- Stabilization: three-axis stabilization system with its +Y surface facing the earth
- Antenna: Deployable antenna, one 1/4λ monopole VHF antenna with max.0dBi gain is located at +Z side and one 1/4λ monopole UHF antenna with max.0dBi gain is located at –Z side, close to the each edge of satellite body
- Uplink: 70cm band
- Downlink: 2m band
- Amateur radio payloads:
  - Callsign: BJ1SC (for CAS-3B), BJ1SD (for CAS-3C), BJ1SE (for CAS-3D)
  - CW Telemetry Beacon: 0mW, 22wpm
  - U/V Mode Linear Transponder: 100mW, 20kHz bandwidth, inverting
  - AX.25 telemetry: 100mW, 19.2k/9.6k baud GMSK

CAS-3E and CAS-3F Cubesat

- Dimensions: 110Lx110Wx110H mm
- Mass: 1.5kg
- Stabilization: Spinning stabilization using permanent magnet torquer
- Antenna: Deployable antenna, one 1/4λ monopole VHF antenna with max.0dBi gain is located at +Z side and one 1/4λ monopole UHF antenna with max.0dBi gain is located at –Z side, close to the each edge of satellite body
- Uplink: 70cm band
- Downlink: 2m band
- Amateur radio payloads:
  - Callsign: BJ1SF (for CAS-3E), BJ1SG (for CAS-3F)
  - CW Telemetry Beacon: 50mW, 22wpm
  - U/V Mode Linear Transponder: 100mW, 20kHz bandwidth, inverting
  - AX.25 telemetry: 100mW, 9.6k baud GMSK

This launch will use the brand new Chinese launch vehicle named as Long March - 6 (LM-6 or CZ-6) at Taiyuan Satellite Launch Center of China, CAS-3A will operate at about 450 km height sun-synchronous orbit, the other satellites will operate at about 530 km height sun-synchronous orbit.

The launch will carry total of 20 satellites, there are other three satellites named as CAS-3G, CAS-3H and CAS-3I involved in amateur radio from other agencies of China will share the same launch, CAMSAT was assisting Chinese government administration to coordinate and allocate their frequencies, more details will be announced later.

LilacSat-2, developed at the Harbin Institute of Technology, has been renamed as CAS-3H. (Uplink 145.825 MHz, 145.875 MHz; Downlink 437.225 MHz FM/APRS; Beacon 437.200 MHz) Two others satellites on the launch also carry amateur satellite service payloads and have been named as CAS-3G and CAS-3i.

CAMSAT with support from the Qian Youth Space Academy has been developing two satellites CAS-2A1 and CAS-2A2. These will not be on this launch, instead they may fly on a CZ-2 at a later date.

AMSAT Activities at Greater Houston Hamfest 2015

Allen F. Mattis, N5AFV, n5afv@amsat.org, and
Andy MacAllister, W5ACM, w5acm@amsat.org

AMSAT was well represented again this year at the Greater Houston Hamfest (GHH) held March 28, 2015 at the Fort Bend County Fairgrounds in Rosenberg, Texas, southwest of Houston. The GHH is the second largest and the fastest growing hamfest in Texas. Attendance at the GHH this year was 1,345. A search is underway to find a larger venue for next year's GHH.

The GHH had 18,000 square feet of indoor exhibit space with 114 tables for vendors and individual sellers, a large outdoor tailgate area with early buyer access before the main hall opened, and an adjacent RV camping area with 36 spaces. VE test sessions were administered to 20 candidates with an overall pass rate of 65 percent.

This year the GHH again hosted the American Radio Relay League (ARRL) South Texas Section Convention. Featured speakers were Dr. Joe Taylor, K1JT, Nobel Laureate and originator of many programs for amateur digital modes; Norm Fusaro, W3IZ, head of ARRL Membership and Volunteer Programs and Logbook of the World; Joe Eisenberg, K0NEB, CQ Magazine kit building editor; and Dr. Patricia Reiff, W5TAR, Professor of Physics and Astronomy, Rice University.

The AMSAT booth was manned by Carl Kotila, WD5JRD, along with assistance from Andy MacAllister, W5ACM, and Allen Mattis, N5AFV. AMSAT Director of Contests and Awards, Bruce Paige, KK5DO, was available at the AMSAT booth to check QSL cards for the ARRL VUCC award. Out-of-town visitors to the booth included Hector Martinez, W5CBF/CO6CBF, George Carr, WA5KBH, and Jack Wilson, KF5LOQ.

Andy W5ACM, and Allen N5AFV, teamed up to give a technical talk about CubeSats, the upcoming Fox program, and a high altitude balloon flight launched by the South Texas Balloon Launch Team. Over 40 persons attended the presentation.

Two satellite demonstrations were conducted on AO-73 by Andy, W5ACM, and Bruce, KK5DO. Andy worked the Yaesu FT-847 while Bruce kept the M-Squared Leo-Pack antennas aimed at the satellite. The antennas arrived just a few days before the hamfest, and worked extremely well. A lead-filled counter-balance pipe on the back of the array made it easy to aim the antennas. The first satellite demonstration was attended by 50 persons, and the second satellite demonstration had 30 observers. The high point of the satellite demonstrations was when Patrick Stoddard, WD9EWK, was worked at the Tucson Hamfest. It was easy for the attendees to hear the contacts through the use of external speakers aimed away from the rig and microphone. Knowledgeable satellite operators and balloon launch team members Charlie Keng, K5ENG, A.C. Spraggins, W5EZM, Tony Summerville, N5RPQ, John Maca, AB5SS, Ed Manuel, N5EM, and Tom Matthews, K5SAF, circulated through the crowd and helped answer questions.

The Brazos Valley Amateur Radio Club, organizer of the hamfest gave away four major raffle prizes this year. The main raffle prize was a Yaesu FT-991 all-band multimode transceiver which was won by Dennis Teal AA5DT. Many favorable comments from attendees regarding the AMSAT activities were received by the event managers.

(L-R) Carl Kotila, WD5JRD, George Carr, WA5KBH, Jack Wilson, KF5LOQ, and Hector Martinez, W5CBF/CO6CBF at the AMSAT Booth. Carl WD5JRD did the vast majority of "booth" time this year (Photograph provided by WA5KBH)

Allen, N5AFV, gave a presentation about Fox-1 satellites and also included discussion on current and future amateur radio satellites. (Travis Burgess, K5HTB photo)

Andy W5ACM discussed the South Texas Balloon Launch Team efforts with their "satellites on strings". (Travis Burgess, K5HTB photo)

(L-R) Charlie K5ENG, Bruce KK5DO and Andy W5ACM assemble Bruce's new M-Squared LEO-Pack antenna array for use during the two AO-73 passes. (Travis Burgess, K5HTB photo)

The M-Squared LEO-Pack antennas are carefully balanced for easy aiming, but that is certainly a long boom between the 2M and 70cm antennas. (Travis Burgess, K5HTB photo)

Bruce KK5DO rotates the antennas. Andy W5ACM works the radio. A good crowd showed up in the parking lot at the Greater Houston Hamfest for the AO-73 passes. (Travis Burgess, K5HTB photo)

Big antennas deserve a big radio. Andy used his Yaesu FT-847 for the two AO-73 passes. Speakers were carefully placed so everyone could hear both sides of the satellite contacts. (Travis Burgess, K5HTB photo)

Alex/"Happysat"
happysat@gmail.com

I'm Alex, also known in on-line satellite forums as Happysat. I live in the Netherlands about 25 km from Maastricht and I like receiving signals from satellites.

Many of these satellites transmit pictures using methods such as the analog Automatic Picture Transmission (APT) or the digital Low Rate Picture Transmission (LRPT) modes.

One of these satellites is Meteor M-N2. It was launched recently and is has been fully operational since November 10, 2014 with two visible channels and one infrared channel available [1]. Those signals are now readily accessible and people can receive its images both day and night. An example of what can now be received is shown in Figure 1.

Further information about the data format can be found in references such as [2].

Station Description

To receive those signals, I use an R820 T SDR-RTL USB dongle connected to my Windows XP computer together with a quadrifilar helicoidal (QFH) antenna located on top of my garage. The antenna is based on the design of John Coppens, ON6JC/LW3HAZ, and was built from leftover coaxial cable and waste sewer pipe (Figure 2). Details of this design are at:

http://jcoppens.com/ant/qfh/index.en.php

For software, I use WXtoImg for APT signals:

http://www.wxtoimg.com/

while for LRPT downlink:

http://meteor.robonuka.ru/soft/

In addition, I use SDRSharp for signal processing:

http://sdrsharp.com/

http://www.pe0sat.vgnet.nl/sdr/sdr-software/sdrsharp/

Meteor M-N2 Images

The first image that I received from Meteor M-N2 was amazing and is shown in Figure 3. A few weeks later, I used a simple 40 - 900 MHz TV pre-amplifier to improve the quality of the received signal with great success.

Figure 2. Monitoring station antenna

I made a gallery of WXtoImg images which I receive daily from Meteor M-N2. It also has images from people all over the world (stored with permission where possible) as

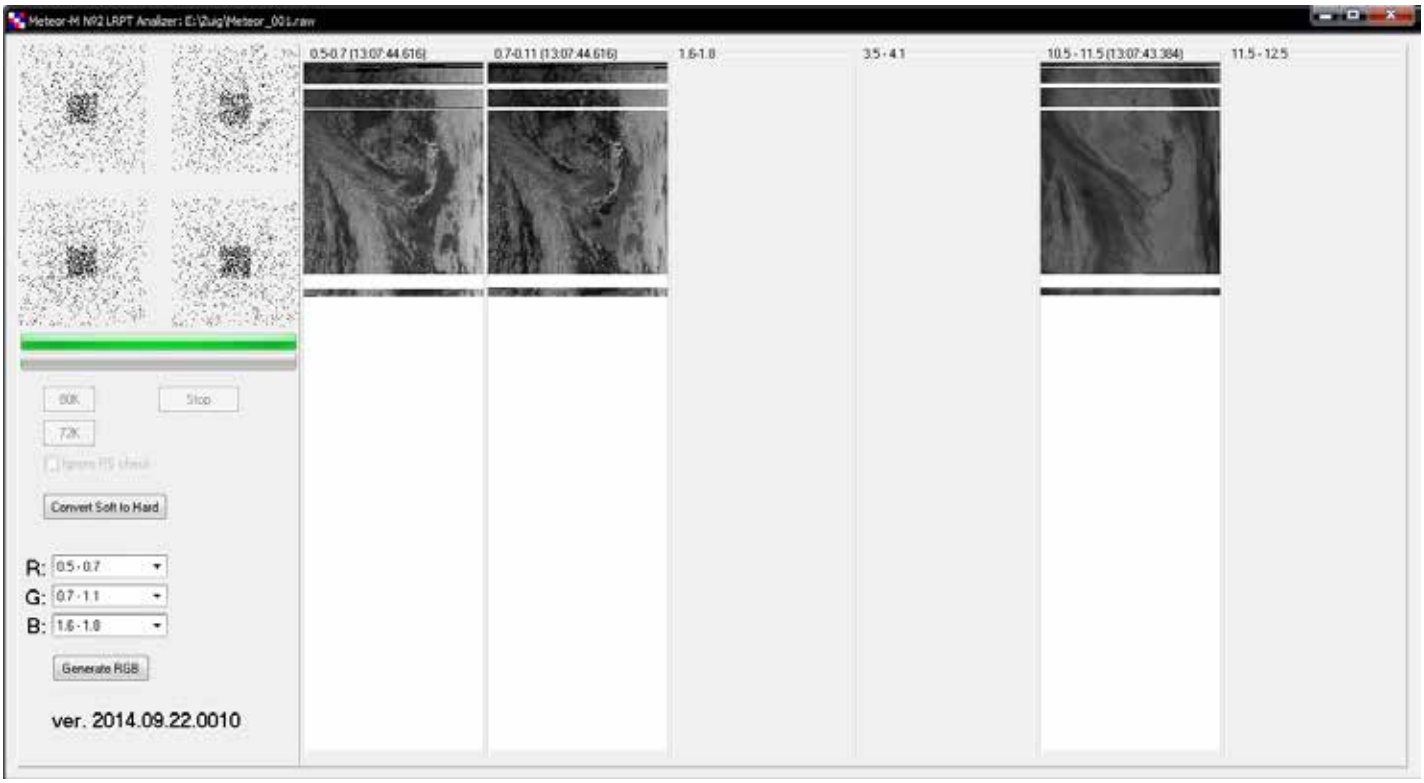


Figure 1. Example of images from Meteor M-N2. The two left images are in visible light (0.5 - 0.7 µm and 0.7 - 1.1 µm, respectively) with the third one in infrared (10.5 µm) [1], [2].

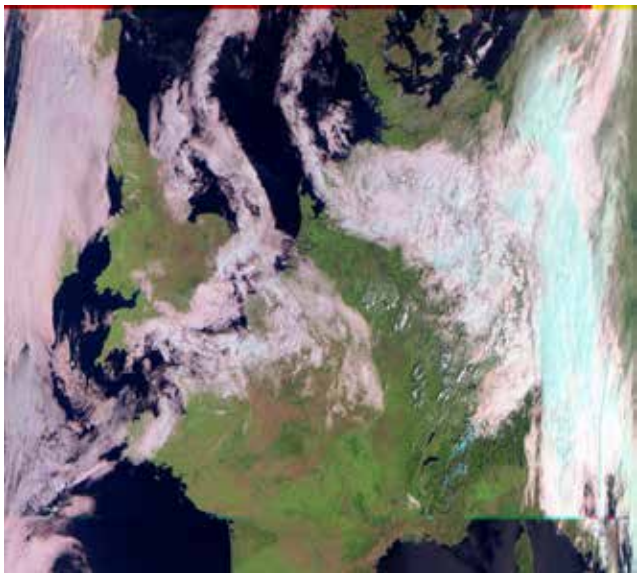


Figure 3. First image received from Meteor M-N2

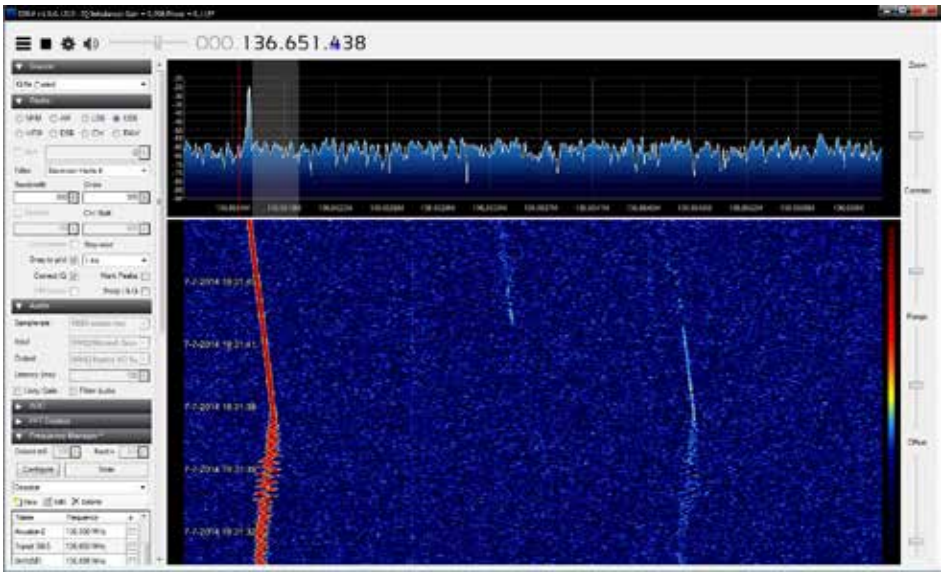


Figure 4. Waterfall displays for Transit 5B-5 downlink

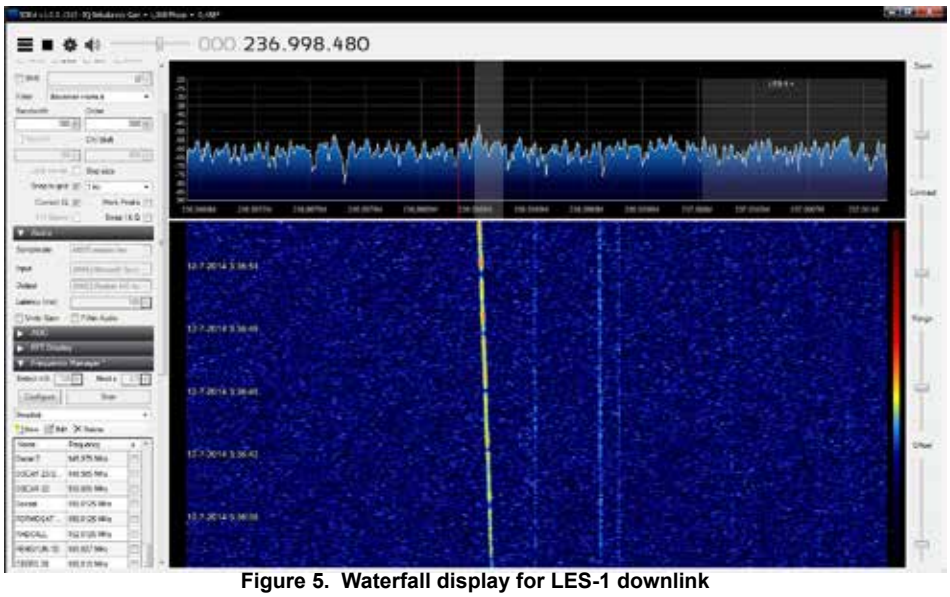


Figure 5. Waterfall display for LES-1 downlink

well as the current status of Meteor M-N2. It's located at:

https://dl.dropboxusercontent.com/u/124465398/Meteor/index.html

Updating this gallery with new images and information requires manually editing the HTML file. This is different than the automated updating process used by WXtoImg.

Readers are permitted to use my images. They are not of the same quality or size as what other people have received, but I'm improving.

Decommissioned or Abandoned Satellites

A. Background

I also like to monitor satellites that are decommissioned, abandoned, or, simply, no longer in service, but which still transmit while in direct sunlight over my QTH. I've been told that they, like AO-7, resume operation due to the batteries becoming an open circuit, allowing the transmitter to be powered directly from the photovoltaic panels. It's amazing that many very old satellites are still functioning--one cannot say that they used bad hardware during the '60s.

There are many abandoned satellites which were originally launched by military and civilian users for applications including navigation, experimentation, and weather observation, as well as amateur radio. Most are no longer transmitting any useful telemetry or, for that matter, weather images, but they still use the original frequencies to send out an unmodulated carrier. These signals, however, interfere with those from currently operational satellites in the 136/138 MHz band.

When a satellite goes out of service, the last of its on-board fuel reserve is used to shift it into a graveyard orbit. This orbit is at a higher altitude than the one used during its operational life. Once there, the satellite is switched off and left on its own.

However, this doesn't always go as planned, sometimes due to solar radiation or other technical failures. Some satellites have a timer on board which is activated at the end of the scheduled operational life. This timer cuts the power to the transmitter so it will not broadcast again, but it can fail as well. The result is that the satellite will not respond again to the ground station

commands, which leaving it in its original orbit.

One of the oldest spacecraft still transmitting is the Transit 5B-5 military navigation satellite from 1964. It can be heard in either CW or USB and its signal has a somewhat melodic sound. An example of its downlink can be heard in a recording I made of it, which is at:

https://dl.dropboxusercontent.com/u/124465398/Transit5b_5_2014_09_06.rar

Figure 4, on the previous page, shows waterfall displays of its downlink.

Another is the Lincoln Experimental Satellite 1 (LES-1) from 1965. An audio example of its downlink is at:

https://dl.dropboxusercontent.com/u/124465398/LES1plainaudio.rar

Figure 5, on the previous page, shows waterfall displays for LES-1.

The downlink from certain other satellites is just a spooky howling sound like what's heard from LES-1. For example, the one from NOAA 9 is due to the voltage fluctuation from its photovoltaic panels.

Similar recordings are available elsewhere on the Internet. Matthias Bopp, DD1US, for example, has a very nice collection images and orginal sounds at:

http://www.dd1us.de/spacesounds%204b.html

B. Personal Experience

Spacecraft like these came to my attention while monitoring weather satellites. I noticed signals from what I later found out was NOAA 9 plus some from a few unidentified birds.

During a search with Google, I found additional information about them at the following websites run by, respectively, Mike Kenny, Maik Hermenau, and Mike Coletta, KG0UFO:

http://mdkenny.customer.netspace.net.au/emitters.html

http://www.satellitenwelt.de/satelliten_untot.htm

http://www.ufogeek.com/satwatch/les1.htm

After finding all the correct satellite TLEs a few months ago, I myself started by monitoring all of the frequencies from 136 - 138 MHz and a few between 150 - 400 MHz. These orbital elements, which are available for anyone to use, are listed at:

https://dl.dropboxusercontent.com/u/124465398/tle/deadsat.txt

and are updated weekly. These TLEs can be used by your favorite tracking software. I prefer Gpredict for this, which is available at:

http://sourceforge.net/projects/gpredict/

Figure 6 shows a typical screenshot.

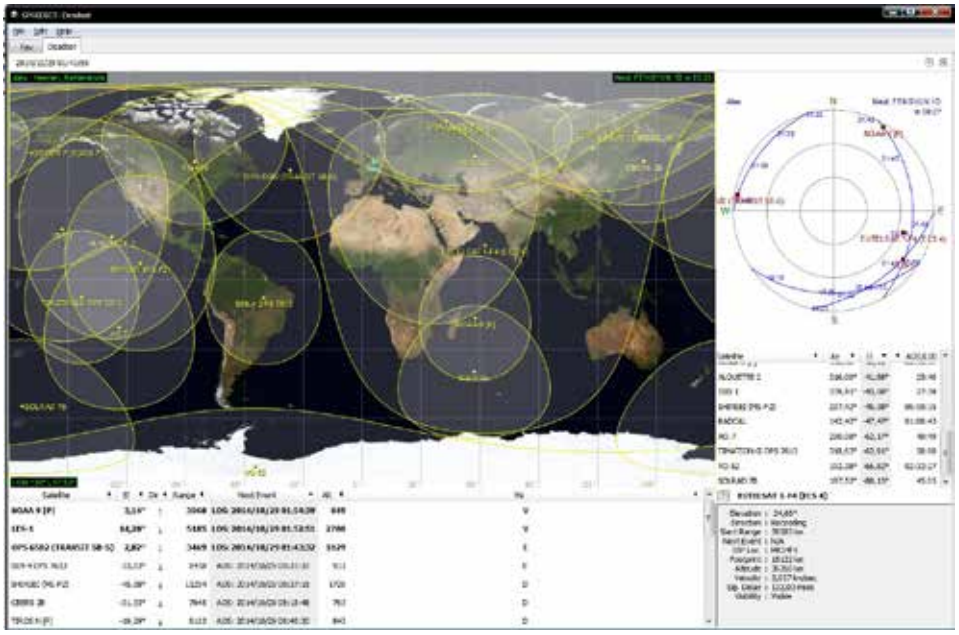


Figure 6. Typical Gpredict screenshot

Another is Orbitron, but the unstable frequencies and Doppler effects that these satellites have might not make it suitable for this purpose.

Using my receiver, I was able to see signals from the satellites mentioned. Most were weak but needed further definition by zooming in with SDRSharp. Figures 7 - 11 show screenshots for the signals from some of the decommissioned or abandoned satellites I've monitored. The spectra aren't of high resolution due to the performance of my computer.

Additional information is available at:

http://www.rtl-sdr.com/receiving-dead-satellites-rtl-sdr/

Concluding Remarks

Further information about receiving signals from Meteor M-N2, as well as information about the satellite itself, can be found in a tutorial which I wrote with the assistance of Raydel, CM2ESP. Its URL is:

http://www.rtl-sdr.com/rtl-sdr-tutorial-receiving-meteor-m-n2-lrpt-weather-satellite-images-rtl-sdr/

Keep in mind, however, that some time in the future, many satellites, such as the old NOAA birds, will go out of service and their analog APT signals will no longer be available. Their succesors will be digital only and word is this will not be easy for end users to receive in terms of hardware and software.

Acknowledgements

Many thanks to my friend Raydel Abreu Espinet, CM2ESP, who helped me with setting up my station and explained how to receive images from the Meteor M-N2 satellite.

Also, Oleg Bekrenev's requests for assistance from Roscosmos (the Russian Federal Space Agency) and Rosihydromet (Russian Federal Service for Hydrometeorology and Environmental Monitoring) in evaluating images during Meteor M-N2's testing phase was most valuable.

Thank you as well to Aleksandr Zhuravel, chief specialist-expert of Rosihydromet, for updates on the status of Meteor M-N2.

My thanks also to Phil Williams, G3YPQ for the recording of LES-1.

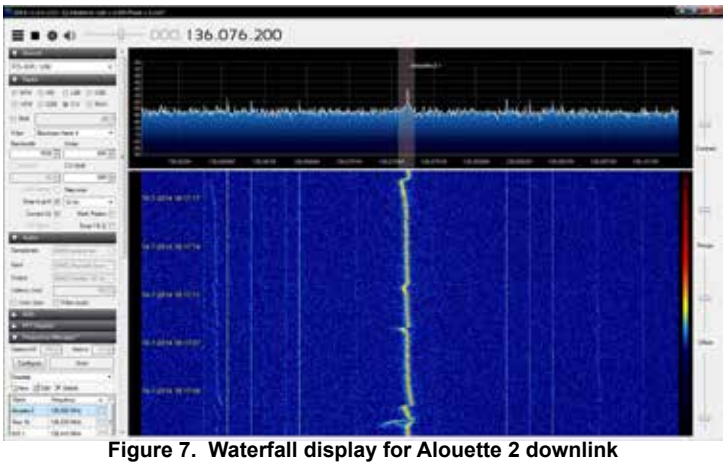


Figure 7. Waterfall display for Alouette 2 downlink

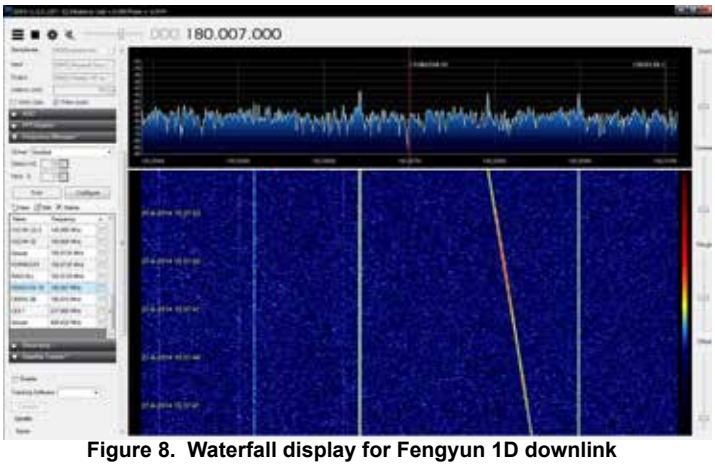


Figure 8. Waterfall display for Fengyun 1D downlink

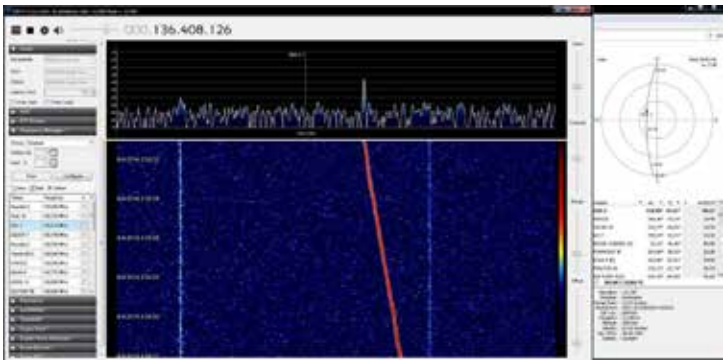


Figure 9. Waterfall display for ISIS 1 downlink

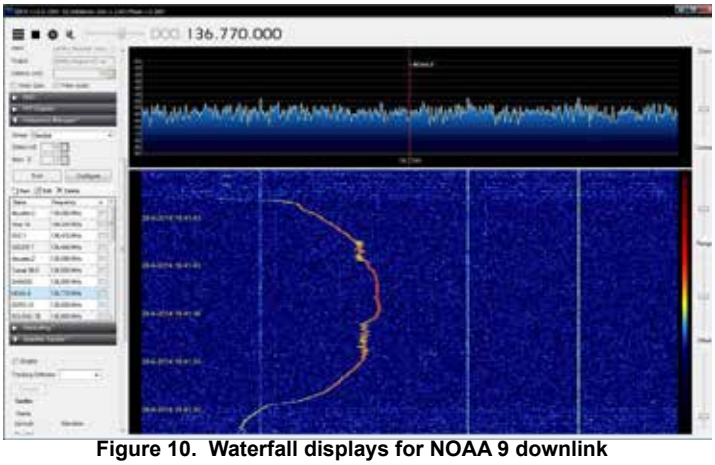


Figure 10. Waterfall displays for NOAA 9 downlink

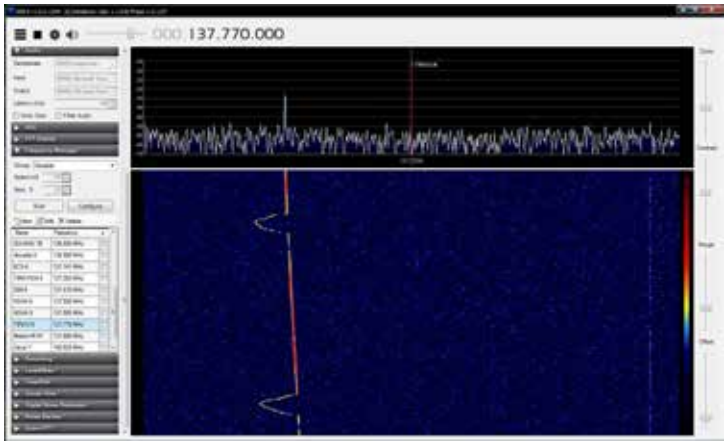


Figure 11. Waterfall display for TIROS-N downlink

References

[1] Private communication from Aleksandr Zhuravel, chief specialist-expert, Rosihydromet.

[2] Packet Telemtery Services, Consultative Committee for Space Data Systems, CCSDS 103.0-B-1, May 1996.

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

Here are opportunities to launch your amateur radio experience to new heights ...

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.

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 Drew Glasbrenner, KO4MA at: ko4ma@amsat.org.

AMSAT's web presence needs a site content editor and authors for content development for technical articles and feature development.

To volunteer send an e-mail to JoAnne Maenpaa, K9JKM at: k9jkm@amsat.org

AMSAT Engineering Team

AMSAT Engineering is looking for hams interested in developing spacecraft and ground station equipment for future satellites. Immediate needs include:

- Design of an inexpensive L-Band uplink converter for LEO satellites.
- Thermal engineering design for upcoming AMSAT CubeSats up to 6U in LEO and HEO, and larger spacecraft up to 150 kg. Sinda, Thermica, and Patran software experience would be helpful.
- Low-cost microwave ground station development for geosynchronous satellite.

If you are interested in helping, please contact AMSAT Engineering by completing the form on the website to tell Jerry Buxton, N0JY, the Vice President of Engineering, how you can volunteer your time and skills to help AMSAT engineering build satellites and other required hardware/software:

http://ww2.amsat.org/?page_id=1121

AMSAT User Services

AMSAT is looking for an Editor-in-Chief for the *AMSAT Journal.* This position is now open due to the expansion of opportunities in the User Services Department. Our current editor, JoAnne Maenpaa, K9JKM, is also the Vice President of User Services. The Officers and the Board have discovered that it is impossible for a single volunteer to accomplish management of the *AMSAT Journal* with the other pending User Services leadership requirements. Hence we are planning on a handover when a suitable candidate is found.

Experience with the Adobe InDesign CS6 publication system would be helpful. However this system resembles a word processor on steroids; while there is a learning curve it will not be impossible. The editor-in-chief will continue to lead the team of Journal assistant editors arranging for content to publish

To volunteer send an e-mail to JoAnne Maenpaa, K9JKM at: k9jkm@amsat.org

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 E. Mike McCardel, KC8YLD at: kc8yld@amsat.org.

AMSAT Field Operations

AMSAT's Field Operations Team is looking for satellite operators to promote amateur radio in space with hands-on demonstrations and presentations.

- Promote AMSAT at hamfests
- Setup and operate satellite demonstrations at hamfests.
- Provide presentations at club meetings.
- Show amateur radio in space at Dayton, Pacificon, Orlando Hamcation.

To volunteer send an e-mail to Patrick Stoddard, WD9EWK at: wd9ewk@amsat.org

You can find more information on the web ...
www.amsat.org ... click AMSAT ... then click Volunteer