The AMSAT® Journal

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Friends! Fun! Fest!

[Joe Kornowski, KB6IGK, photo]

in this issue ...

AMSAT-NA
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AMSAT Announcements

The AMSAT Journal Needs Your Words and Wisdom

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

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

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

After your article lands in members' mailboxes, and the kudos start arriving for your narrative payload, you can enjoy the satisfaction of knowing you've elevated the collective wisdom of AMSAT to a higher trajectory.

Send your manuscripts and photos, or story ideas, to: **journal@amsat.org**.

Our editors are standing by!

AMSAT's Mission

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

AMSAT's Vision

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

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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.

Dateline Dayton – Notes from Hamvention 2016

Joe Kornowski, KB6IGK
Editor
Photos: Keith Baker, KB1SF/ VA3KSF
Treasurer

AMSAT achieved resounding success at Hamvention 2016, from the satellite demonstrations outside Hara Arena and the action at the AMSAT booth to the AMSAT/TAPR dinner and the AMSAT Forum presentations. AMSAT delighted, informed, educated and added a number of new members to its ranks in Dayton.

This year AMSAT's booth generated approximately $38,892, including 41 new memberships, 121 renewals and 4 life memberships. That represents something of a record, at least compared to the last several years.

AMSAT/TAPR Banquet

The tenth annual AMSAT/TAPR dinner was held at the Kohler Presidential Banquet Center in Kettering, Ohio.

Michelle Thompson, W5NYV, AMSAT's Team Leader for the design and execution of the AMSAT Ground Terminal, presented the keynote, "It's Just Software, Right?"

She discussed highlights of the Ground Terminal project, including who, what, when, where, why and how the team is designing open source radio solutions for the next generation of AMSAT satellite payloads. She reviewed the project goal of creating a 5 and 10 GHz ("Five and Dime") digital SDR transceiver that will support both data and voice modes usable both for general amateur radio contacts and for emergency communications purposes.

The Ground Terminal is intended for the Phase 4B satellite as well as the next generation of AMSAT satellites. The design focus is to develop a relatively inexpensive amateur radio ground terminal that would cost tens of thousands of dollars, if developed commercially, for less than $1,000.

Michelle described some of the complexities of designing radios for highly capable digital communications as part of AMSAT's microwave strategy that includes projects such as Phase 4B, Phase 3E, the Cube Quest Challenge and similar missions. These radios need to permit sharing of text, voice, voice memo, images, data and perhaps video.

This new generation of microwave radios also must meet the needs of a diverse amateur radio community, from those operators who want to build their own to others who prefer an off-the-shelf solution. Whether through comprehensively documented recipes for do-it-yourselfers, kits or plug-and-play commercial rigs, the radio is intended to work for both satellite and terrestrial microwave operations that would use a "groundsat" on a mountaintop or tower instead of a satellite. Michelle noted that the team already has had several discussions with FlexRadio Systems, which has expressed interest in building the commercial radio.

The design and development team actually is working two projects simultaneously: the radio(s) and the satellite payload. To avoid encumbering the radio/ground team members with the discussion restrictions imposed by ITAR controls, Michelle described how they creatively decided to split the teams. While the satellite team adheres to the strict ITAR controls, the ground team can pursue a non-ITAR open process. The two teams communicate and collaborate through a common air interface document that specifies the waveforms recognized by both the radio on the ground and the orbiting payload.

The team already has begun to define the system and identified a framework for Phase 4 Ground using Digital Video Broadcasting (DVB) standards, specifically adaptations of DVB-T2 for terrestrial and DVB-S2 for satellites, to ship data. Another standard, Generic Stream Encapsulation, offers a method to turn IP packets into data streams

that easily can be handled by DVB.

Michelle explained that the team expects to provide a variety of designs for the various intended uses envisioned. As an example, while some fixed location stations may prefer a two-antenna dish solution for "five and dime" full duplex, a portable solution intended for emergency communications will require a single antenna.

Michelle expressed appreciation for the dedicated help of high-quality teams at Virginia Tech, led by Bob McGwier, N4HY, and Rincon Research in creating the Phase 4B payload. She referred anyone who is interested to volunteer, noting that all software and documents are hosted at **github.com/phase4ground**.

Following Michelle's remarks, the other highlight of the evening was the Dayton Amateur Radio Association's (DARA) presentation of a $5000 donation to AMSAT. Mike Kalter, W8CI, DARA's Treasurer presented AMSAT President Barry Baines, WD4ASW, with the donation check, for which Barry expressed sincere appreciation.

AMSAT Forum

Barry Baines, President

AMSAT President, Barry Baines, kicked off the forum presentations, recognizing the current members of the board of directors in attendance and announcing the upcoming election for directors' positions. Barry described the nomination and election process, noting that Tom Clark, K3IO, Lou McFadin, W5DID, and JoAnne Maenpaa, K9JKM, would be up for re-election to the board this year, though JoAnne announced that she would not be running.

After introducing the senior leadership team, Barry turned next to AMSAT's purpose, "Summarizing our vision statement," Barry stated, "it is keeping amateur radio in space." He explained that the organization has evolved since it was started in 1969.

"The key to our success as we see it right now is partnerships, opening opportunities, collaborating with groups and organizations, with corporations, with universities, with other non-profits. That's how we are able to come up with our ability to keep amateur radio in space," Barry explained.

As an example, Barry cited last October, the launch of AO-85, which was AMSAT's first CubeSat launch initiative, and the opportunity to work with NASA. It contained university student experiments that provided NASA with the justification to provide us with a free launch.

The spacecraft is working well, he noted, adding that there are some lessons learned that Jerry Buxton, V.P. Engineering, N0JY, would talk about.

Barry outlined the upcoming launch of Fox-1Cliff and Fox-1D, which involves collaborators -- Virginia Tech, Penn State, Vanderbilt, Rochester Institute of Technology and the University of Iowa. He described the diversity of launch opportunities. NASA gives us a free launch as part of the CSLI [CubeSat Launch Initiative] program, but it may take three, four or five years until actual launch depending upon the queue and the orbit that they're offering.

Barry explained that the other option is to buy your way to space and cited the contract with Spaceflight Industries, Inc., noting that Fox-1Cliff and Fox-1D will be flying on one of their launches later this year. AMSAT is paying for that launch and needs funding to cover that cost. While the cost already has been paid, AMSAT needs to replenish its coffers from members and outside sources to pay for future projects down the road.

In terms of other satellites, Barry also highlighted future launches, including the RadFxSat (Fox-1B) that has been designated for launch, hopefully in January of next year. That would be followed by a fifth CubeSat launch opportunity with Fox-1E. One difference with that satellite, unlike the other CubeSats, is that it will carry a linear transponder with SSB and CW modes.

Other examples of collaborative relationships include a memorandum of agreement with Virginia Tech. That has opened the door to new payload opportunities in geosynchronous orbit. Under the arrangement, Virginia Tech will pay for the payload itself, its integration into the spacecraft and the launch fee. The win for Virginia Tech is that students get involved in the design and development of that payload. AMSAT benefits because Virginia Tech handles the government regulation part of it in terms of spacecraft development.

AMSAT is responsible to pay for the combination study that determines whether to place that payload in the spacecraft. AMSAT already has paid the $100,000 for that study, completed earlier this year.

AMSAT also has responsibility for developing the ground terminal. AMSAT is building the amateur radio transceiver that will allow communication through that payload. AMSAT will also be the control operator for that payload once in orbit.

AMSAT additionally is responsible for IARU frequency coordination, as well as notifying the FCC of AMSAT's intent to place that payload in orbit, providing the API used to notify the FCC and the ITU of this project.

"One of the reasons for building the terminal is not just for P4B," Barry explained. "We see potential opportunities to use that in other possible projects down the road." Among those, he mentioned the Cube Quest Challenge that Ragnarok Industries is involved in. AMSAT has been working with them to provide the communications package to be placed on their satellite. Also, AMSAT has had conversations about placing a 6U CubeSat in high-elliptical orbit that would have to use a similar technology to be successful given the size and distance used in that potential idea.

Barry proceeded to highlight the significant transition of ARISS over the past two years in terms of roles and responsibilities of what AMSAT, the ARRL and NASA are responsible for. That was codified with the Space Act Agreement signed back in February. Among the three justifications for placing amateur radio onboard the International Space Station, Barry observed, the last, the capability of ISS for crew communications by amateur radio. While NASA originally downplayed the idea, it now recognizes the value of having an amateur radio emergency communications backup if required.

Among the other changes, Barry explained, NASA is no longer selecting the schools that

are involved in the ARISS program; AMSAT and the ARRL are collaborating on the school selection process. Also, NASA is no longer the lead on funding for ARISS operations. Now, an additional funding requirement is putting new equipment aboard the ISS. NASA will not pay for the equipment or the space qualification of that equipment. So, we'll need to do some fundraising if we want to see some upgrades to the equipment that is onboard.

Barry touched on the collaboration occurring with ISS between the U.S., Russia, Japan and Europe activities and the celebration in March of ARISS' 1000th school contact since ARISS was initiated in 2000, showing the strength and impact that ARISS has had on students, teachers and parents throughout the years. Also, the first Ham TV contact occurred with a school contact in February with equipment that will continue to operate down the road.

Barry described the editorial change at The AMSAT Journal in the last year with a new editor, Joe Kornowski.

"Joe is the guy who keeps *The AMSAT Journal* going," Barry stated. "Joe certainly has a professional background that makes him well qualified to help us provide a quality product – something that I consider to be the finest amateur satellite magazine available anywhere today. He has certainly done a lot of work to enhance the quality. If you are an AMSAT member, and you've been receiving the *Journal* since the last November/December issue, you've seen his mark in what's being published today."

Barry went to explain that the *Journal* needs people to submit articles, photos and other content. The goal is to create a pool of material for the Journal that includes people talking about their experiences, their interaction with contests, equipment and stories associated with amateur satellites because we learn from one another. Members may not think their ideas are of interest, Barry noted, but he encouraged them to contact Joe and tell him what you're considering writing about. And he'll give you some feedback on how you might go forward on that particular idea.

"And, of course, the more people who are writing," Barry commented, "the more we spread the workload around. So, it's not just Barry writing the 'Apogee View' or Jerry writing about engineering. We've got a variety of articles that are of interest to our membership."

In terms of membership, itself, Barry noted an uptick in membership this year from last year. Maybe it's because of the launch of Fox-1A, he speculated. Maybe it's because people are starting to see what we do and want to become part of the team. But we've seen an increase to 3,177 members. Barry explained that, while the membership increase was good news, AMSAT needed to have a much higher membership count if we wanted the membership to be the basis for keeping the organization going, and therefore use donations for projects and the like, we need to have a much higher membership count to equalize the expenses we have. If we don't, then either we take reserves out of our bank account to pay the operational expenses, or we take unspecified donations that could go to a project and use them to help keep the organization functioning. Barry stated that he would much rather use the membership dollars from a larger membership base to keep the organization functioning and members benefit from getting the *AMSAT Journal* and supporting the organization versus spending money to keep the organization running on a day-to-day basis.

In terms of financial trends, Barry highlighted the real concern of how to draw in the younger generation as members, speculating about possible reasons why they may not be joining. He questioned whether new launches in 2016 would bring in new members. Barry urged those in attendance to help AMSAT recruit new members, explaining that word of mouth was the most effective way to bring in members.

Barry shared that member dues do not support satellite launches and urged members to help support AMSAT's satellite projects through donations. Members should think of AMSAT as a charity organization worthy of member support.

AMSAT also needs volunteer support, Barry stated. Specific areas where volunteer help is needed usually appears on the back page of the Journal.

Barry concluded his comments with a description of the AMSAT Space Symposium at Sea, November 10-14, the itinerary and how to make reservations.

Jerry Buxton, V.P. Engineering

Jerry began his comments by describing the AMSAT Engineering team that is all-volunteer, and that is why he is looking for anyone who is interested to join the team.

Jerry reviewed the Fox-1A launch from the

P-Pod and showed a video of its deployment. He shared how the family of the late Tony Monteiro, the previous V.P. of Engineering, attended the launch and that the voice of Tony's daughter, Veronica, is the "voice" of all the Fox satellites' voice ID, which transmits after the transponder has been idle for two minutes.

With about eight months on orbit, everything looks to be working very nicely. The battery is very good; we're getting good power from the solar panels. The temperatures are much warmer than predicted; our thermal modeling indicated we would be somewhere around zero C. But the range has been 8 C to about 50 C. And we're very happy that we don't have to use the battery heaters.

Jerry next reported on the Vanderbilt radiation experiment, one of the experiments on Fox-1A/AO-85. They provided two boards to passively study radiation effects. They are very excited with the data they're getting from it. It exceeded their modeling expectations. They use it to compare against ground based models that are used to determine the suitability of various commercial, off-the-shelf semiconductor chips and such that are used in satellites.

The MEMS [Micro-Electro-Mechanical Systems] gyros – we have three MEMS gyros provided by Penn State University students as part of an experiment to measure our x, y and z axis rotation, and that is providing some exciting information about the attitude of the satellite. The satellite is passively magnetically stabilized so that it generally points to the north magnetic pole. The spin is induced by the sunlight, Jerry explained, by the offsetting of our solar panels. The MEMS gyro experiment, because the bar magnet is offset and not in the center of the satellite, is going to wobble a bit. We're taking a good look at that to determine exactly how the thing is pointed.

The downlink strength is very strong, if any of you have heard it. I often go in the backyard with my HT, take the cats for a walk, and I'll just tune in if there is an AO-85 pass. I can't work it with my rubber duck, but I can sure hear it very well.

There's a wonderful amount of telemetry being processed by all of you hams who are using the FoxTelem program. That telemetry is extremely helpful to us. And the fact that it is Data Under Voice, along with the FM signal, I think helps in the amount of telemetry being gathered because you can work the satellite and get data at the same time.

"That stuff is a gold mine," Jerry asserted. "All of that information."

In terms of the satellite's operation, Jerry revealed, "The satellite reception, we have noted, is being reported as not being as sensitive as we had advertised so that you could work it with an HT and an Arrow antenna. We believe the problem that caused that is that the receive antenna actually was broken when we had the flight modeling." The receive antenna came out of the solder that holds it on. We used a conductive epoxy to repair it, but the epoxy got on both the tip and the root of the antenna, and one of the solar cells was slightly overlapping one of the antenna traces – all of which changed the impedance to a large degree, and effectively detuned the antenna.

The receive frequency at the satellite is about 10 kilohertz lower than it was designed to be. That's a temperature effect because it's running warmer.

Looking to future missions, Jerry shared that the current launch date for Fox-1Cliff and Fox-1D will be no earlier than July 28, 2016. It is going to be from a Spaceflight "SHERPA," which is a big ring that has several CubeSat deployment mechanisms, "quad packs," that will hold 90U of CubeSats. Ours will be one of five CubeSats to be launched. It is the maiden flight of the SHERPA. This is the launch that Barry mentioned that already has been paid for.

Jerry explained, "We initially paid for Fox-1Cliff. We originally intended Fox-1D as the flight spare. It came up that some other customers were not able to deliver to Spaceflight, so we negotiated with them to fly the spare as well. That is why we're getting two for one here."

This will be an exciting launch from Vandenberg, Jerry asserted, and the satellites will be placed in a polar orbit, a sun-synchronous orbit.

The Fox-1Cliff payload will include the first MPPT, which is designed for "maximum power point tracking" for the power supply, originally intended to fly on Fox-1A. The MPPT will take every bit of power it can get from the solar panels and put it into the bus and the battery.

We also have onboard the Penn State "MEMS" gyro experiment. That is something that is integral to the IHU, and it will fly on every Fox satellite. It's very useful, and that is a good reason to want it on every flight.

Vanderbilt has the radiation experiment, which is the flight spare for Fox-1A. So, it is the same two experiment portions that we'll fly on Fox-1Cliff.

"The Virginia Tech camera will be the 'new kid' in town here," Jerry noted. "Virginia Tech has designed an experiment that is a VGA camera that will be 640 by 480 pixels. And it will be able to take images of the Earth and send them down in a high-speed downlink, about 9600 bits per second. And FoxTelem is capable of decoding that," Jerry continued, "and you'll be able to see pictures on your PC from that camera."

Jerry explained, "We're only able to take images of Earth because of license issues with NOAA, and all of the three-letter agencies of the government because we can't encrypt them, and anybody can receive them. So, you will only see images of Earth and it will only likely be active over North America or possibly Western Europe."

Next, Jerry talked about the L-band downshifter, which was the subject of an article in a recent issue of The AMSAT Journal. A team of engineers worked on an upconverter, and they created a 70-centimeter to 23-centimeter uplink in order to be able to access the L-band downconverter. The L-band reception that we have on Fox-1Cliff and –D is adapted for the board on the satellite; it uses the UHF antenna for receiving, which seems very well matched for L-band. And it will simply downconvert it to a 70-centimeter typical input frequency of 435.xx. Now, we'll be able to command that on, at will, and put it into that mode. That will offer some different opportunities for people to exercise this band. And if you don't have any equipment, Jerry stated, we're working on producing the plans, and possibly the parts, for you to make your own L-band upconverter.

Fox-1D will have many of the same experiments as in previous ones. It will have the MPPT, the Penn State gyro, a Virginia Tech camera – this one we have set Fox-1D to be 320 by 240 pixels because, in testing the Fox-1C, with the 640 by 480, we noticed that the frame buffer had to take two pictures to get a full frame. If the satellite is moving, that can cause some distortion in the pictures. So, they scaled this one down to 320 by 240. FoxTelem will automatically receive and decode that for you.

The L-band downshifter also will be there. Fox-1D also has a new experiment from the University of Iowa, which they call HERCI, which is the "High Energy Radiation CubeSat Instrument." Their students did a project to recreate what Dr. Van Allen did back in the '50s, when he discovered the Van Allen belts. And they are going to use the experiment to map the radiation belts. Some of the data will be available in the DUV [Data Under Voice], so you'll see that in FoxTelem. But they will occasionally, when over the U.S., enable it in high-speed data mode in order to downlink all their data. You will be able to see that as well in FoxTelem.

We also have Fox-1B, the active project right now. This is an entirely Vanderbilt radiation experiment. In fact, it is their satellite, RadFxSat. They submitted the CSLI for it. The flight model is under construction right now. January 20, 2017, is the estimated launch date for that.

RadFxSat-2 is another CSLI submitted by Vanderbilt. They are extremely pleased with what we're capable of doing. We've already been offered a launch by NASA, which we've accepted. Jerry averred, "I can't say any information about that just yet because they haven't lined everybody up for that, and they want to make a public announcement, but my guess is 2018 for the launch."

He announced that Vanderbilt will fly a new experiment that is the same kind of thing that they have done in the past but with new "FinFET" chips. AMSAT is going to fly a new radio; we're working on a 30 kilohertz-wide linear transponder that will fly on Fox-1E. It will provide VHF uplink, UHF downlink – a mode J, and 1200 bit per second telemetry beacon that will contain the experiment data as we have done with Data Under Voice, except that it will be on a separate channel in this case because of the transponder. So, it's a Fox-1 1U with some new avionics.

University of Washington contacted us a couple of years ago. They have a CubeSat project they are working on, and they wanted to know if we wanted to fly a radio on it. So, we're working with them, planning on flying

a Fox-1E-type transponder. We will have another opportunity to have a 30-kilohertz wide transponder, mode J again, flying on a satellite that they expect to launch also in the 2018 timeframe. Theirs is going to be a 3U flying in a LEO type orbit.

CQC, Cube Quest Challenge, is something that NASA has issued for people to come together and see what they can do with a 6U CubeSat orbiting the Moon. Ragnarok Industries contacted us about providing communications for that. We agreed to do that in return for their agreement, that once the satellite is orbiting about the Moon, it will become an amateur radio satellite. So, we're expecting that somewhere around 2019. If they are able to complete all of the hurdles to get to launch, we would have the opportunity to put a Phase 5 satellite around the Moon.

A Phase 4 ground station, the AMSAT ground terminal, is being designed to be able to work that, as well as for us to be able to command and perform the mission. The AMSAT ground terminal is a 5 gigahertz uplink, 10 gigahertz downlink – or "five and dime," based on SDR. It's an open design. It's not ITAR. There are many countries working on it. It is open source and everything is on the GitHub.

Elaborating on the ground terminal, Jerry said, "We're very excited about it because it's applicable to many satellites we'll do in the future. It's something we can finally do with other countries because it's entirely ground-based. So, we don't have to worry about ITAR. The idea is that we'll be able to use it with future satellites that we're planning and that it will be able to be produced for $1000 or less by vendors we've already talked to about it. They're doing some testing in Southern California, with software development underway everywhere. If you're interested, you can also help participate.

We're planning a HEO satellite of our own, a 6U, learning from all of these current projects that are going on because the technology and the five and ten gigahertz gives us an opportunity to finally get back to HEO. I see that, within the next three years, it could be possible to launch our own 6U HEO satellite again.

We'll also pursue LEO. Lots of universities are coming to us looking for opportunities. They've heard of the success of Fox; they've seen it. With all of this, we're building tons of great relationships.

Jerry concluded his remarks by stating, "What all of this work is doing is that we're at a great point with AMSAT Engineering, and there are lots of great opportunities ahead of us."

Bob McGwier, Director of Research, Hume Center for National Security and Technology, Virginia Tech

Bob addressed the forum about the Highly Elliptical Spacecraft project. He referenced Dr. Karl Meinzer who, with AMSAT OSCAR-7, put a single payload in orbit.

"My trajectory at Virginia Tech is nearly identical to Karl's," Bob confided, "in that it is he who I have wanted to emulate most. He took seven years to get from his first major payload on AO-7 to the HEO spacecraft AO-10 up, and I'm trying to do it in less than seven years. But I'm now believing it will take me more than seven years from the time I came to Virginia Tech to get a HEO or a GEO up."

So, the original target was to launch in 2018. Bob explained that we needed $15 million to do that launch. That was from the U.S. government because he was going to do things on it that they wanted him to do. The $15 million was solely determined by the short amount of time it was going to take to get the P3E from Germany, bring it to the U.S., make sure that nothing secret had been hidden in it, put everything they wanted on it, put AMSAT's payload on it. We could not integrate it by next summer, which is when it had to be integrated. And, if they were going to do it, it is $15 million. They actually raised $6 million for this program. So, $15 million was too much; $6 million is not too much. That is a lot of money. So far, ownership of most of the vehicle was an issue because it is sitting right now on a closet in Germany.

"Lack of trust and doing integration in time was an issue," according to Bob. "Virginia Tech has no flight heritage with that entity in the U.S. government building a spacecraft. We are working as quickly as we can to gain their trust."

"HEO funding and proposal underway for launch after 2018. Now, you cannot ask me a question because the answer is classified, not ITAR."

Bob asserted that the schedule does not now drive the cost, and P3E does not drive concerns. Sufficient funding is available, but the question now is will they be interested after 2018. "And the only answer I'm allowed to give you is, so far, yes," Bob said. "They want me to do something unique, and I would like to do it."

Among the goals and attributes:

- Test software defined radio capabilities and survivability;
- Do a Hohmann Transfer from one elliptical orbit to another with no plane change;
- The initial orbit will be attained as a secondary satellite carried directly to a 12-hour Molniya orbit without need for propulsion and then change the orbit to a new target HEO orbit for experiments;
- Characterize the environment in the new orbit because no vehicle has ever flown there;
- Use Rincon Research Corporation AstroSDR already known to be radiation-hardened; and
- U.S. government pays for the entire thing from beginning to end.

In terms of the GEO mission, with Millennium Systems, Bob described the orbit and what will be in that box. With an inclined orbit, it will draw a figure eight over the Earth because it will be inclined to the equator. A Rincon AstroSDR, radiation tested so hard it can fly to any orbit, period, will be capable of tuning from 50 megahertz to 6 gigahertz. "Whatever we want to do with this, we can," Bob noted.

Bob indicated on a slide the reset-receiver input providing the capability of the spacecraft to do "control-alt-delete." He explained, "On occasion you want to do control-alt-delete on a spacecraft to get it to restart or if you want to change the software for any reason, you'd fire the reset receiver and hit control-alt-delete, and then load a new operating system. So, that's how you reload a spacecraft if you're smart enough to include control-alt-delete."

Bob next described the initial software load developed by Rincon, which may or may not be what actually flies in the spacecraft. Bob stated that sufficient time likely existed for this not necessarily to be the initial software load.

As for funding, Bob announced, "An anonymous donor, Mike Valentine W8MM, and Franklin Antonio N6NKF, have donated the necessary $150,000 to VT for us to complete the preliminary design. So, we thank them!"

Bob reported that FEMA has said on its blog, "If you build it, we will use it." They will request ARRL to put 100 units in their go-kits. They will also request ARRL to support training using the units. They will make specifications available to us to incorporate our communications satellite capabilities into their communications infrastructure. "That is a big deal!" Bob declared, because it means that they trust us enough that they will use it.

"We can go according to the USG. We can build it. We can staff it. We can operate it. And people will use it," Bob asserted.

"And what is the bottom line of every talk you've heard this morning?" Bob asked the attendees. "We, AMSAT and Virginia Tech, have done our job. They will let us go. FEMA will use it. It will work as we have said it will work. What do we need? We need 7 million more dollars."

Bob went on to say that he would continue, personally, to try to raise the money any way he can, but that without community involvement, it will not fly. Bob described several high net-worth individuals are likely to support this project.

Bob apologized for the restrictions the federal government has placed on him in terms of what he can disclose, feeling that he has kept the AMSAT community ill-informed and hated every second of it.

Drew Glasbrenner, V.P. Operations

Drew, KO4MA, described three things he wanted to share:

1. highlights of some of the things that have occurred in the past year in amateur satellites and amateur satellite operations
2. some of the resources AMSAT provides, primarily on the website to help users become aware of those activities, and
3. a brief update on some of the satellites that will be launching within the next year or so.

AO-85 has worked very well with the exception of the sensitivity issue. It's in a great orbit: 500 by 800 kilometers, 65-degree inclination. We were making contacts on the second or third pass. There wasn't much to check out. There was not a whole lot of tweaking that needed to be done to it.

The satellite is easy to be heard, Drew emphasized. With an HT, you can turn the squelch down, tune it to 145.980, and you'll hear it.

Drew talked about the sensitivity issue on the uplink and that one of the ways to get around that is to be very aware of the polarity issues. Both antennas are linear whips on the same plane, one out of one end, and one out of the other end. Generally, with mode J satellites, we're used to twisting the Arrow antenna to peak on receive. Well, if we peak it for receive, your transmit is 90 degrees out of phase. So, you're 20 db down. Drew explained, "The one little trick that will make you happy is that, when you transmit, turn 90. If you peak on your receive, turn 90, talk, then go back. It makes a world of difference."

Drew showed slides of twitter posts from pleased AO-85 users, including an operator who made contacts as low as 2 degrees elevation with an Elk antenna. "The current distance record for AO-85 is 5751 kilometers," Drew reported, "almost 200 kilometers more than on AO-51. This satellite works. The footprint covers the entire U.S. on the mid-passes."

Next Drew highlighted the XW-2 Chinese satellites launched on September 19, with a 500 by 550 kilometer orbit. Nine satellites that were part of that launch carried amateur radios on board, with six mode B transponders at once in orbit, and one FM repeater that was active for awhile.

The satellites did not pass through the IARU coordination process completely. Some of them did. Some of the satellite frequencies chosen were outside of the agreed-upon band plan for 2 meters. But in general, people have been using them and there have not been any issues with it.

Drew described the six transponder satellites, with sizes ranging from CubeSats to something a bit bigger than AO-51. And there is LilacSat-2, or CAS-3H, which is the FM repeater. Drew also highlighted the footprint of these cluster satellites, which often is overlapping, sometimes allowing multiple QSOs over a short period of time, such as every ten minutes.

Claimed record for distance: 4645 kilometers. While not the highest satellites out there, they are very strong and good opportunities to get on the air.

This year, with the ARRL National Parks on the Air event, we've seen a lot of participation with satellites, Drew reported. One of the coolest ones is Paul, N8HM. He lives in D.C. and went to the National Mall with his totally-portable station – Elk antenna, and a couple of FT-817s in a bag – and worked a couple of FO-29 passes, and activated that one. Doug, N6UA, operated from Rocky Mountain National Park and a bunch of other ones, and he did it off of his motorcycle.

4U70UN was active on satellites this year. The U.N. station in New York City counts as a separate DXCC entity. This effort has been ongoing for a long time by Mike, N1JEZ. They made quite a few contacts on FO-29 in tough conditions – drizzling rain and tall buildings all around them.

KG5CCI, in Arkansas, set a lot of records this year on our LEO satellites. He has achieved 8000 kilometers on AO-7 – a long ways – all the way to PY2RN down in Brazil. Drew indicated, "This pass was particularly interesting in that this pass did not go between the two stations. It was leaving one and coming to the other one – a very short window." They also have worked into central France on FO-29 from Arkansas. Of course, the ace up his sleeve is that he operates from a mountaintop in Arkansas. He does everything portable.

Drew next turned to the AMSAT resources that can help users get active on satellite. Drew showed a slide of the AMSAT website that included the pass predictor, as well as the live satellite status page, which allows users to report what they've heard. Users can go to this page, enter in their callsign, pick a time, and pick a report.

Upcoming satellite operations is a page that Paul Stoetzer is maintaining right now that lists all the known trips that are coming up, links to Twitter feeds and where you can go to get more information.

Drew advised, "All you have to do is drop Paul an email, and he'll put your information in there and publicize your grid expedition."

If you are participating in a grid expedition or DXpedition, and you need some equipment or technical advice or publication, AMSAT has two full-size satellite loaner rigs: an ICOM-910 and FT-847. We will be happy to loan to a member doing an activation of some sort of DXpedition. We have antennas, 817s – the same equipment that K1N used last year. We're also happy to publicize on email lists, Facebook or Twitter any information about your operation.

New satellites coming soon – Jerry already talked about Fox-1Cliff and Fox-1D. We should expect these things to be operational nearly as soon as AO-85 was. It will be interesting to see if they are in a similar orbit and how long it takes them to drift apart. Drew emphasized that AMSAT would have four satellites operating by next year.

NUSAT will be launched by AMSAT Argentina no earlier than May 30. It's going to a 500-kilometer sun-synchronous orbit and will have a linear transponder onboard. It will be roughly equivalent to an AO-73 type transponder.

Nayif-1 is the United Arab Emirates first CubeSat, and they are doing it collaboration with a Dutch company, Innovative Solutions in Space, AMSAT-UK, and AMSAT-NL. Nayif-1 will be launched along with Fox-1Cliff and D on the Spaceflight SHERPA launch. It's very similar to the other FunCube satellites except that the transponder has a little stronger of an output. It's 500 milliwatts, 30-kilohertz wide mode B.

Frank Bauer, V.P. Human Spaceflight

Frank, KA3HDO, began by describing ARISS' focus and station locations. "Our primary goal is amateur radio and human spaceflight promotion, backup communications, experimentation and astronaut relationships. We're in three different locations in the Space Station. The U.S. segment is the Columbus Module area. And then in the Russian segment we have the Service Module and the ATV [Automated Transfer Vehicle]. We have antennas in all those areas. Our primary stations are in the Columbus Module and in the Service Module."

Frank explained that ARISS does both VHF and UHF in the two primary locations, as well as Slow Scan Television. The astronauts have been absolutely critical in everything ARISS does. From Expedition 1 in 2000 to Expedition 48 today, ARISS has been continuously operational.

In terms of accomplishments from an operations perspective, ARISS currently has done about 1020 contacts since December 2000, when ARISS did its first amateur radio contact. Frank reported, "Since I was here last year, we've done 61 contacts, 21 countries and 17 states."

He mentioned that ISS astronaut, Tim Peake, from the U.K. has been doing a phenomenal job in his Principia Mission. They had 10 U.K. contacts as part that project.

Frank highlighted an ARISS milestone this past year – completion of ARISS' 1000th contact in March. It was with one of the new states, Frank noted, the North Dakota Space Grant Consortium. They had a phenomenal set of educational activities going on. They did it with Tim Copra, KE5UDN, through a telebridge station W6SRJ in Santa Rosa, California. Charlie Sufana, AJ9N, was the mentor for this 1000th contact. Charlie was not only the mentor for this historic contact but also the operator for the very first contact, "so it was a very interesting – and actually, for Charlie, an emotional – opportunity," Frank explained.

NASA even produced three videos honoring ARISS' achievement that included both astronauts and students talking about their experiences with ARISS contacts. The first video Frank showed was astronaut Sunni Williams, KD5PLB, who volunteered the impact ARISS contacts had on her:

So, you have the questions [from students] a little bit beforehand to help you through it. And then you go through it and get a report about how many people were at that event, and how long and how much preparation those kids took to actually understand ham radio and work with it. And I felt myself getting choked up every time I would read one of those reports and it was like, 'Oh my God, this is great!' I didn't realize that maybe a thousand kids are at an event.

In one of the first HamTV videos, U.K. astronaut Tim Peake, GB1SS, responded to a lighter question from a student at Norwich Schools, Norwich/East Anglia, U.K.:

Student: Hi, this is Austin. Are there any protocols or guidance in place if George Clooney comes knocking on the front door, as he did in the film 'Gravity,' over.
Peake: Hi, Austin. Well, as far as I'm aware, we're the only six human beings in space up here. So, if anyone comes knocking on our hatch, I'm not opening it, over.

Frank went on to describe other significant accomplishments over the past year, including the first-ever formal agreements between ARISS and NASA, as well as ARISS and the Center for the Advancement of Science in Space (CASIS). The NASA agreement – the first bi-lateral agreement between NASA and ARISS in ARISS' 20 year history -- lays out key elements of the relationship: identifying Space Communication and Navigation, NASA's program office for space communications, as ARISS' primary benefactor; defining NASA and ARISS roles and responsibilities; partially funding ARISS' payloads and operations support; and enabling AMSAT/ARISS to channel support funding into NASA. The CASIS agreement: defines the CASIS/AMSAT-ARISS roles and responsibilities; promotes ARISS at CASIS events and as STEM activity as a part of the ISS National Laboratory; and partially funds ARISS payload and operations support.

This past year also saw the first HamTV operations with schools, with the ARISS contact between U.K. astronaut Tim Peake and the Oasis Academy Brightstowe, Bristol, GB1OAB, which took place on February 19, 2016. In order to support HamTV, Frank said that ARISS-NA needed "chained" ground stations – three to five stations in various parts of the U.S. aligned to the ISS ground track.

Additionally, ARISS undertook development of a vitally needed upgrade to the hardware system on the ISS to support future contacts with schools. The new interoperable radio and power supply system is intended to: improve the Columbus Module downlink signal reception with a higher power radio; develop a standardized VHF/UHF radio and power supply system that will be interoperable across all ISS segments and modules; and certify, launch, install and operate a JVC Kenwood D710GA radio system with an ARISS/AMSAT-built interoperable power

supply and supporting cabling.

These enhancements will improve the audio during voice contacts, as well as reduce HamTV downtime through a dedicated power supply. The more robust radio software/firmware will help prevent accidental programming and reduce repeater mode command steps, while the new JVC Kenwood D710 fan will support continuous repeater mode operations.

To help make these upgrades a reality, Frank explained, ARISS was kicking off a substantial fundraising initiative – the On-Orbit Hardware Capital Campaign -- and appealed to attendees for support. The fundraising effort already received a jumpstart from JVC Kenwood, which has donated D710GA radios and the required engineering modifications.

ARISS will celebrate its 20th Anniversary of the first international ARISS meeting held in Houston, Texas, in November 1996. To commemorate this anniversary, ARISS will hold its next ARISS International meeting in Houston November 15-18, just after the AMSAT Symposium Cruise. Special tours of NASA Johnson Space Center and a special operations event are planned.

Frank concluded by noting that this has been a transformative year for ARISS. ARISS now has proven the utility of HamTV and is developing new and robust hardware and software systems to expand and improve ISS contacts. And, in order to sustain this momentum and continue growing, ARISS needs to expand its volunteer team and achieve sufficient funding to support hardware development and sustain its operations.

Joe Spier, V.P. Educational Relations

Joe, K6WAIO, began his remarks noting that both ARISS and university experiments reflect AMSAT's educational mission and that amateur radio helps bridge the gap between what is taught in schools and the reality of STEM (Science Technology Engineering and Math).

He explained that the goal of the education community has been to integrate STEM and what is called "common core" – or Common Core State Standards – which is a list of goals that the educators must tick off that have to be met for that year. The common core subjects include English language and Mathematics. Where is the science? Where is the engineering? Where is the technology?"

"The technology piece comes in under that English part," Joe explained. "That's been our focus and we need to reach out to educators to let them know that."

In terms of where amateur radio fits into Math, Joe stated, "we can do a little bit of calculation, so everybody remembers Ohm's Law; that's where we first learn mathematics. So, we have to get back to that 'Ohm moment.'"

Joe explained, "it also is in terminology and media. So, one of the thoughts we've had, to provide more opportunities, is that we've been focusing on ground stations," such as the Phase 4B and ARISS ground stations.
"Where is the next generation 'crystal radio set' going to come from?" Joe asked. "Well, maybe it's going to come from a little antenna and a FunCube-type dongle in the classroom that becomes a ground station for telemetry that they can use in the future for their own experiments to fulfill some of these obligations for common core."

Where we are being successful, Joe shared, is at the university level. "In the K through 16 goal, we're reaching people at 12 through 16," said Joe. "And this is because we get experiments on the spacecraft that the colleges and universities actually produce."

Joe discussed the challenges with student-designed experiments, citing the use of MPPT 1 and MPPT 2 to maximize power on the Fox satellites. Rochester Institute of Technology did the design. One challenge is that the design teams have graduated already, Joe explained, "so some of the results you get back by the time the spacecraft flies, we no longer have the support mechanism to do some of the analysis."

"This is especially true at Penn State," Joe continued. "Our folks at Penn State developed the MEMS gyros. They've graduated and moved on. There's no one doing the analysis of the altitude determination experiment, which is what the MEMS gryos are."

"Vanderbilt has been fantastic! They have some chips that they have put on the radiation experiments. These chips are basically high-end DRAM like what you would use in your computers. These memory chips run a subroutine over it and look for a single event upset or SEU."

Their design team has been really great, said Joe. "In fact, Vanderbilt in this design team said that one of the things that is key to AMSAT and how we can get launches to space. " When AO-85 went up, there were three CubeSats that were launched together, including AO-85, Joe stated. Of those three satellites that deployed, one failed immediately and another lasted only a few days.

Joe described the tremendous benefit universities like Vanderbilt derive from working with AMSAT:

At Vandenberg [during the AO-85 launch], Robert Reed and Robert Weller said that 'we get to do what we do at universities well. We get to design experiments. We get to collect the data. We get to benefit from that worldwide telemetry network of amateur radio operators to get our information back. We don't have to worry about building a spacecraft frame, designing a solar panel system, using non-conforming materials that fail in space immediately because we don't have the experience with it. We rely on AMSAT as a partner for that platform.' So, that's been our best success so far.

Next, Joe described AMSAT's collaboration with Virginia Tech, which has been building two cameras along with ground stations. The benefit of the two cameras on two different satellite missions is that we will now have the benefit of two different resolutions, plus they are command-switchable, on Fox-1Cliff and Fox-1D, to change the configuration depending on what we want to see out of those cameras in the future.

Bob McGwier, Zach Leffke and their team are building their own ground station at Virginia Tech. "So, my goal," Joe stated, "is to get another one on the west coast, a couple in the middle of the states and combine some of these ground team elements that we're trying to patch together."

"University of Iowa is conducting another radiation detection experiment," Joe continued. "This goes back to the days of Explorer 1 because the University of Iowa was involved in that program. It's called the High Energy Radiation CubeSat Instrument or 'HERCI.'" Joe described, "This is going to be a radiation-mapping experiment to map the location of impulses of higher radiation so that they can determine what may be

better orbits sometimes for these types of components."

Notice how many amateur radio operators with new callsigns are part of these university experiments. They go get their licenses because they are involved with amateur radio in space.

Vanderbilt's newest experiment is the Low Energy Radiation Detection 2 experiment. It is similar to the memory chip experiment for SEU but using a new chip called FinFET. It is able to increase the computing power of today and increase Moore's Law by up to 40 percent. "That's a fantastic software defined radio that you can fly if you have those chips in it," Joe asserted. "It alleviates a lot of these performance problems that we have in chips."

Joe presented a slide listing what experiments are on which spacecraft. He noted that, where open experiment slots existed on various missions, the AMSAT Engineering team was ready and able to fill those slots with their own experiments.

Joe highlighted the challenge of "where we can get that 'ARISS-contact' type of joy that we see on students' faces to meet the common core initiatives for the K through 8 grades. That's something we need to focus on. And how do we develop that telemetry data into a spreadsheet that the educators can use to sort of grab them."

"And the next is that we take that information and put it into some kind of modeling software that actually graphically displays this. So, we don't view the educational resources as developing lesson plans for teachers. What we do is give them some tools so that they can pick and choose where they need to meet it in the common core standards."

Joe elaborated on the idea of what he referred to as "next generation crystal radio," for which students don't need a license because it's just a receiver, a dongle that plugs in and attaches to an antenna on the roof of the school or nearby outside. "We get to use the telemetry from that," Joe explained, "and they get to use their own data for experiments or app into the server to pull the data that way."

In terms of opportunities, Joe urged attendees to write articles for The AMSAT Journal. As one of the rotating editors for the AMSAT News Service, Joe indicated that they are always looking for other editors to help. For those who are in education or like teaching, get involved with the educational relations department or ARISS. As his parting thought, Joe shared, "Remember the choices you make today because they determine your tomorrow."

Speaking of Satellites – FlexRadio Systems®

The *Journal* caught up with Gerald Youngblood, CEO of FlexRadio Systems, and Steve Hicks, V.P. of Engineering, to talk about Flex's involvement in some of the satellite issues trending at Hamvention.

Gerald: I think one thing that's very important about satellite operations is all FLEX-6000s are now full duplex enabled – the 6300, etc.

Journal: You've had that since last year, right?

Gerald: Right. So that, in itself, is a key piece of the puzzle.

The second thing is that the Maestro provides a very user-friendly operating environment for SDRs. Historically, SDRs have been mainly PC-based.

Journal: If you didn't have a laptop or desktop, you're kind of in trouble.

Gerald: You are kind of in trouble. So, what we've now done is that all of our radios are servers – they are radio servers. Think about that for just a moment. That means that the radio has a Linux operating system that is running the radio. So, we're digitizing the antenna port, and we're in bits now. And then everything is mathematics.

And all of our radios have a high-end ARM processor, a high-end DSP running it, like 1.2 to 1.4 gigahertz. They have very a large FPGA, Xilinx FPGAs. They have about four other processors and another DSP. That's all in the box. Effectively, it's like a Cray computer of maybe 10 or 12 years ago that is in that box. So, we have enormous processing power in the radio that we can update with just a download. So, that's a server.

In my house, I've got a rack -- actually, my radio, a PC server, and all of those things in the rack. It rolls under the desk all neat and clean. And then I have a choice of how I operate.

I can use a Maestro. Maestro is a portable, wired or wireless control surface for our FLEX-6000 series.

Journal: It's currently wireless.

Gerald: Yes. You can use it either way; it has a gigabit Ethernet port and a dual-band Wi-Fi built into it, 5 gigahertz or 2 gigahertz Wi-Fi, and Bluetooth. The Bluetooth would be for headsets, keyboards, etc., like that. So, basically, when I'm in the station, I can plug it into Gigabit Ethernet and DC power, and run it right there by the radio.

Journal: So that can be your knob radio if you want to go that way, right?

Gerald: Exactly.

Journal: You can do away with the whole computer interface if you want to.

Gerald: You do not need a computer if you have a Maestro. It completely runs the radio.

Now, if you want to run logging software, Fldigi, satellite tracking software – all of those kinds of things – they still run on a PC or a laptop, or a Microsoft Surface, or whatever. So, you can still do that. And all of those things are clients to the server.

I want to give you an example of a client that you might not think of. We have something called Digital Audio Exchange – DAX – that can connect some third-party piece of digital, like Fldigi. Fldigi talks to DAX; DAX talks to the radio. It doesn't go through Maestro. It's a client.

Another might be CW Skimmer. There's a third party applet that was written by somebody to talk to our application programming interface, and Skimmer talks through that to the radio. So, you can have Skimmer running on a PC. You can have four instances of Skimmer running on four bands over here, with Maestro running the radio. They're both talking to the server.

So, here's another example. Now, notice I'm not talking all about satellites here. Last night, we had a dinner. We had a Maestro that was talking 5 gigahertz Wi-Fi across the room to a box on a Raspberry Pi that was talking to LTE, to a cell phone gateway that was running a contest super-station, K9CT, in Peoria, Illinois, with full waterfall – real-time panadapter waterfall – and audio, and I'm holding it in my hand.

Journal: So Maestro is now fully remote access?

Gerald: Today, from VPN. In the future, we're going to embed that so that it's plug and play.

From a satellite standpoint, there will come a day when you can sit by your pool, and operate satellite on your station that's in the shack, and rotate the antennas, and all that, from Maestro. That's where we're going. In other words, totally integrated station

automation in that interface. It could also be on an iPad. There's an iPhone app right now – all of those things because it's a server.

Journal: And today, you can operate that station. You just don't have that full integration to do all the things that are now handled by third party applications?

Gerald: That's right. You'll see in our booth Ethernet-based antenna switching and control. We partnered with Sky Sat [Communications] 4O3A for station integration and control using Ethernet as the backbone. We're just announcing a new kilowatt-and-half amplifier that has Ethernet on the back port. It will be totally integrated, so when you use Maestro remotely, it will show 1500 watts, SWR coming out of the amplifier. It will show the voltage and current – all coming out of the amplifier. Eventually, you'll see that my rotor is pointed at 90 degrees.

Journal: So, you'll have the full view of what's going on?

Gerald: You'll have the full view of what's going on – singular station integration. And that can apply to satellite operation as well. Why be tied to the shack if you want to operate satellites?

Journal: Without getting out your Arrow antenna and your handheld.

Gerald: Yeah. So, that's kind of the vision. It's taking complex things and making them simple so you can operate.

Journal: With a lot of math.

Gerald: With a lot of math, that's right.

Journal: Okay, so tell me a little bit about the radio that you are developing with the Phase 4 Ground folks. [See Michelle Thompson's article, "AMSAT Phase 4 Ground Project Update," *The AMSAT Journal,* March/April 2016.]

Gerald: Okay, N4HY, Bob McGwier, is a long-time colleague and friend of FlexRadio, and we've been working on projects for years. And he's now at Virginia Tech. He approached us not too long ago because they were working on this project. And it really is a SDR in the sky, if you think about it. And there needs to be a ground station that is, I guess you'd say, that takes advantage of all the things SDR can do, and we share kind of a common vision of how that could happen. And it needs to be something that … And we really need to have Steve in this conversation, too … We're just talking about the Phase 4 …

Journal: Yeah, the Phase 4 Ground station for which you're building the commercial radio for people that use that ground station. Which parts are you handling and which parts are being handled by the software, if you can talk about that?

Steve: We haven't made a final decision about what we're going to do yet. We've made an offer that we would be interested. As a hobbyist, my personal interest is I want to see devices somebody can buy off the shelf to use the satellite without building it. And I recognize that there are a lot of hams that want to go build their own thing. But for a lot of hams, they want to go buy what they're going to use and get the capability to do it. And I would like to be the company that does that, that offers that. And so, we've talked with the folks that are working on the ground station effort.

Journal: Michelle Thompson, Bob McGwier…

Steve: Michelle Thompson, Bob McGwier, and those guys, and offered to go do that. And they asked us a bunch of questions about how actually you would go do it if you were going to do it? What components would you use and all that. So, we had a detailed conversation about how we thought the hardware architecture should flush out. And I think they liked all those answers. And we agreed that we were interested in working together.

The major issue, if you will, for us is around funding because if we go invest a bunch of money in this, and then the project falls apart -- there's not a ride, or the rocket explodes on lift-off …

Journal: All of those things that can happen.

Steve: Then we're concerned that the investment we've made won't pay off. And we're a pretty small company, and it's a substantial investment. We've talked about all that, and there's been discussions about how we're going to fund the project. So, this is kind of the phase we're in right now is figuring out how we're going to fund it.

Assuming we get funding, and all that happens, we'd like to go build the hardware.

Journal: And you envision that hardware playing with the other Flex products, or would it be a standalone 5 and 10 gigahertz radio?

Steve: We haven't talked a lot about that. I think it would be a standalone device. I told Michelle that, if I had my druthers, what it would be is something that every ham would look at and say, "I've gotta have one of those." So, it would be a James Bond-style briefcase that you open up, that has the nickel and dime hardware in there with a collapsible antenna that you can point at the satellite. So you could carry this thing out there – the site of a hurricane or something, lay it out on the ground, and you're on the air.

Journal: I could see the ad in the *Journal* now!

Steve: Yeah, it's a complete solution.

Journal: That's great!

Steve: So this is what I'd like it to be. I know they have a lot of folks that have a lot of ideas already about the software architecture. The ideas are different than how we're doing things on our radio. So, I tentatively told them that my thinking was that they're responsible for the software. We would do the hardware, but we would do the software required to make the thing boot up and all that sort of thing. So, we would provide them a hardware platform that had Linux, and it would boot, and it would have space to store things, and all that, and then they would worry about all of the control software and stuff like that. It's yet to be seen how all that's going to pan out, but that's the idea.

Journal: But that's the concept, and these are the early stages, and stay tuned for more?

Steve: Yeah.

Journal: And do you have any other thoughts about the future of Flex and satellites, or is that what you've bitten off for now?

Gerald: That's the biggest thing right there.

Steve: Yeah, if we get involved in this project, we won't have time to think about any other stuff. Incidentally, the other thing about the hardware is, because it's using Digital Video Broadcasting signal format, there's discussion about using the "S" [satellite] and the "T" [terrestrial] variety, and that these devices could also be used for terrestrial use. So, that's also part of it.

Hamvention 2016 Volunteers

Volunteers are the lifeblood of every membership organization. A deeply appreciative handshake and tip of the hat go to the following dedicated volunteers who made Hamvention 2016 a tremendous success for AMSAT. *You made it happen!*

Don Agro, VE3RW
Barry Baines, WD4ASW

Keith Baker, KB1SF
Frank Bauer, KA3HDO
Steve Belter, N9IP
Alan Biddle, WA4SCA
Tim Bosma, W6MU
Alan Bowker, WA6DNR
Jonathan Brandenburg, KF5IDY
John Brier, KG4AKV
Kent Britain, WA5VJB
Jerry Buxton, N0JY
Tom Clark, K3IO
Ed Collins, N8NUY
Steve Coy, K8UD
Daniel Cussen, EI9FHB
Wyatt Dirks, AC0RA
Dave Dull, WB9BRX
Burns Fisher, W2BFJ
Drew Glasbrenner, KO4MA
Jeff Griffin, KB2M
Mark Hammond, N8MH
Debra Johnson, K1DMJ
Dave Jordan, AA4KN
Steve Kenwolf, WH6BSZ
Michael Kirkhart, KD8QBA
Taylor Klotz, K4OTZ
John Kludt, K4SQC
Joe Kornowski, KB6IGK
Ed Krome, K9EK
Sean Kutzko, KX9X
Chet Latawiec, W2NHA/VE3CFK
Hope Lea, KM4IPF
JoAnne Maenpaa, K9JKM
Nancy Makley, KC8GYW
Lou McFadin, W5DID
Bob McGwier, N4HY
Ciaran Morgan, M0XTD
Ken Nichols, KD3VK
Doug Papay, KD8CAO
John Papay, K8YSE
Art Payne, VE3GNF
John Pinkham, K3PER
Keith Pugh, W5IU
Douglas Quagliana, KA2UPW
Bill Reed, NX5R
Martha Saragovitz, Ofc Mgr
Jay Schwartz, WB8SBI
Mike Seguin, N1JEZ
John Shew, N4QQ
Gould Smith, WA4SXM
Phil Smith, W1EME
Joe Spier, K6WAO
Paul Stoetzer, N8HM
Dave Taylor, W8AAS
Bob Thompson, VA3RD
Michelle Thompson, W5NYV
Stefan Wagener, VE4NSA
Bill Watt, K4BLL
Rosalie White, K1STO
Mike Young, WB8CXO

AMSAT Hamvention Photos

A large crowd was on hand for the Friday evening AMSAT/TAPR banquet.

TAPR President Steve Bible, N7HPR, addresses the gathering at the AMSAT/TAPR Banquet.

Just before opening Friday at the AMSAT booth.

Joe Spier, K6WAO, Vice President, Educational Relations shows Dhruv Rebba, KC9ZJX, a mockup of the radio/headset used for ARISS contacts aboard the ISS.

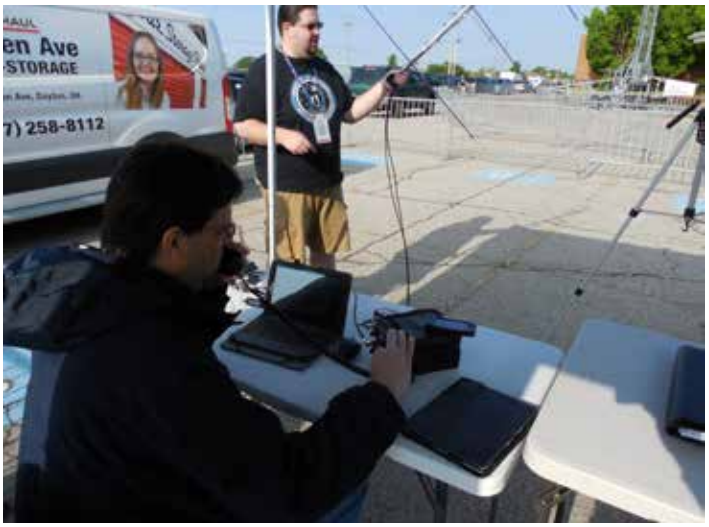
From Left, Lou McFaddin, W5DID, Michelle Thompson, W5NYV, and Paul Williamson, KB5MU, chat in the Engineering Area.

Office Manager Martha (L) shares a moment with Art Payne, VE3GNF, in the Beginner's Corner.

Frank Bauer, KA3HDO and Rosalie White, K1STO, share a moment at the ARISS display.

AMSAT Treasurer Keith Baker, KB1SF/VA3KSF (L) and Stefan Wagener,VE4NSA (R) explain the inner workings of the Fox-1B Engineering Model to Glenn MacDonell, VE3XRA, President of the Radio Amateurs of Canada.

Hope, KM4IPF (L) along with her sister and brother check out the AMSAT booth just after opening on Friday.



AMSAT Secretary Paul Stoetzer, N8HM, holds the antenna while a visitor to the outdoor AMSAT Demonstration Area makes a contact.

Working the birds in the demo area: Paul Stoetzer, N8HM, Wyatt Dirks, AC0RA, Doug Papay, KD8CAO, and John Brier, KG4AKV.

The AMSAT Demonstration Area station.

An engineering model of the ARISS Packet Radio interface model was on display in the ARISS area of the AMSAT booth.

AMSAT Vice President for Operations, Drew Glasbrenner, KO4MA, demonstrates the proper portable antenna technique to successfully work through AMSAT's Fox 1A

The Fox 1-B Engineering Model was on display in the Engineering Area.

Tom Clark, K3IO, Receives ARRL President's Award

The ARRL announced earlier this year that it had honored AMSAT Board Member, Tom Clark, K3IO, "veteran AMSAT personality and Amateur Radio digital pioneer ..., with its President's Award. ARRL President Kay Craigie, N3KN, presented the award plaque to Clark at a January 10 meeting of the Potomac Valley Radio Club in Blacksburg, Virginia."

Former AMSAT President and current AMSAT Board Member, Bob McGwier, described Tom's key contributions to AMSAT. "There would be no AMSAT to inspire all of this work without Tom Clark," he said, noting that the organization was in serious trouble after the Phase 3A satellite launch failure.

McGwier credited Tom with reviving AMSAT during that difficult period:

Tom took over as president of AMSAT, and he saved the organization and inspired all of us to look to the future and aim for the stars. All that has followed, including PACSAT and microsats, CubeSats, AO-13, all the way through AO-85, are a direct result of Tom Clark saving AMSAT and providing it leadership as president from 1980 to 1987 and continuous leadership on the Board of Directors of AMSAT from 1976 until today.

McGwier shared that it was Clark who convinced him in 1985 that the future lay in digital signal processing (DSP). "We started the TAPR/AMSAT DSP project, and it was announced in 1987," he said. "We showed in our efforts that small stations with small antennas could bounce signals off the moon, and, using the power of DSP, we could see the signals in our computer displays. Tom is now and always will be a leader, mentor — the chief scientist for all of Amateur Radio," McGwier said.

Tom's pioneering work on Software Defined Radio led to the development of AMSAT's SDX, the Software Defined Transponder, included in ARISSat.

Tom currently is serving as an advisor to Virginia Tech as adjunct professor of aerospace and ocean engineering and of electrical and computer engineering. He is performing a crucial role in the Phase 4B geosynchronous satellite opportunity on the U.S.A.F. Wide Field of View spacecraft, in which Virginia Tech is a partner.

Tom Clark, K3IO (right) with ARRL President, Kay Craigie, N3KN (left). [Bob McGwier, N4HY, photo.]

Tom Clark, K3IO, Rick Hambly, W2GPS, and Bob McGwier, N4HY, after the first successful test of the SDX.

AMSAT 2016 Space Symposium Cruise

The 2016 AMSAT Space Symposium will be held aboard the Carnival Liberty on November 10-14. Your family, friends, or significant other will want to join you at the Symposium this year!

2016 Highlights

Cruise Departure
Galveston, Texas, near both Houston airports (IAH & HOU)

Two full days at sea
Symposium presentations and annual meeting while at sea

One day in port
Sightseeing and other activities in Cozumel, Mexico

Fun for everyone
Great food, activities and fun for family and friends

This year's cruise ship venue offers an environment for significant others, families, and friends to attend the AMSAT Space Symposium with you. Many activities are available on a cruise ship, including musical and theatrical performances, comedy, dancing, and casino gaming. During the stop in Cozumel there are many onshore activities and excursions available for your pleasure.

The Space Symposium will include detailed presentations on current and future AMSAT satellites, the Five and Dime Ground Terminal, satellite design and construction, satellite launch and deployment, operating experiences, Amateur Radio on the International Space Station, and ideas for future projects. The annual meeting will highlight recent activities within AMSAT and discuss some of our challenges, accomplishments, projects, and any late breaking news.

The approximate cost of the cruise is $389 per person for an inside cabin, double occupancy, for 3 nights and meals, plus tax. You can upgrade your accommodations for an additional cost. Reservations require a $150 deposit; make your reservations soon as there are a limited number of cabins set aside for AMSAT. The telephone number to book is (800) 438-6744, ext. 70005. International number is +1 (305) 599-2600, ext. 70005. The group name is AMSAT and the group code is 8Z0FR5. Please utilize the group code as this directly benefits the Symposium and the amenities we are able to offer the attendees.

For additional information, an FAQ, and up-to-the minute details on the AMSAT 2016 Space Symposium Cruise, visit the AMSAT website at www.amsat.org.

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GNU Radio Companion Prototype for a Dual Analog/Digital Transponder System for the AMSAT GEO Mission

Dr. William C. Headley, KM4KAL
Dr. Robert McGwier, N4HY
Dr. Tom Clark, K3IO

1. Introduction

The AMSAT GEO mission is a joint effort between AMSAT and the Virginia Tech Ted and Karyn Hume Center for National Security and Technology in order to place an amateur radio payload into orbit. The primary goal of this mission is to enable critical new capabilities to amateur radio operators in emergency response scenarios. More specifically, this amateur radio payload will allow for resilient, and continuous, coverage for amateur radio communications, aid trained operators in mobilizing disaster areas to provide emergency communications support, and support coordination between FEMA and the American Radio Relay League (ARRL).

In order to deploy this amateur radio payload, a rideshare is being established onboard the U.S. Air Force Remote Sensing Program Office Wide Field of View (WFOV) geosynchronous satellite being designed by Millennium Space Systems. The payload itself is a software-defined radio (SDR) payload being developed by Rincon Research Corporation. The partners for this mission are: Virginia Tech, AMSAT, ARRL, Millennium Space Systems, U.S. Air Force, and Rincon Research Corporation.

While the AMSAT GEO mission is principally a digital mission, it will be extremely beneficial to have a payload that supports both a digital transponder and a linear bent-pipe analog transponder. This setup will allow for the use of newer technologies through the digital uplink, while also allowing for the use of legacy amateur radio uplinks utilizing traditional analog voice communications. The digital transponder is intended to support up to 100 digital PSK channels using an FDMA based uplink protocol and either a TDMA or CDMA downlink protocol. For the linear bent-pipe transponder, it is intended to support 90 voice-grade channels using single side-band (SSB) or a single digit number of voice grade channels using narrow-band FM. Given these intended specifications, at present the design of the payload is envisioned to consist of separate linear and digital downlink paths.

The goal of this paper is to provide an alternative to these dedicated downlinks by proposing a dual analog/digital communications system for the payload. More specifically, this work prototypes a communications system in which the linear bent-pipe transponder signal is added to the digital transponder signal at a frequency some distance from the main lobe of the digital signal. These signals would then be combined and hard-limited by the payload's final amplifier and transmitted synchronously. At a receiver, a filter can be utilized to recover the intended digital or analog signal with minimal interference from the other signal.

To test this proposed design, GNU Radio was used in order to prototype the transmitted digital BPSK transponder signal, the transmitted AM transponder voice signal, and the AM signal receiver. Analysis of this prototype system demonstrates that the receiver reproduces the voice signal with sufficient fidelity to likely make dedicated digital and analog downlink paths unnecessary.

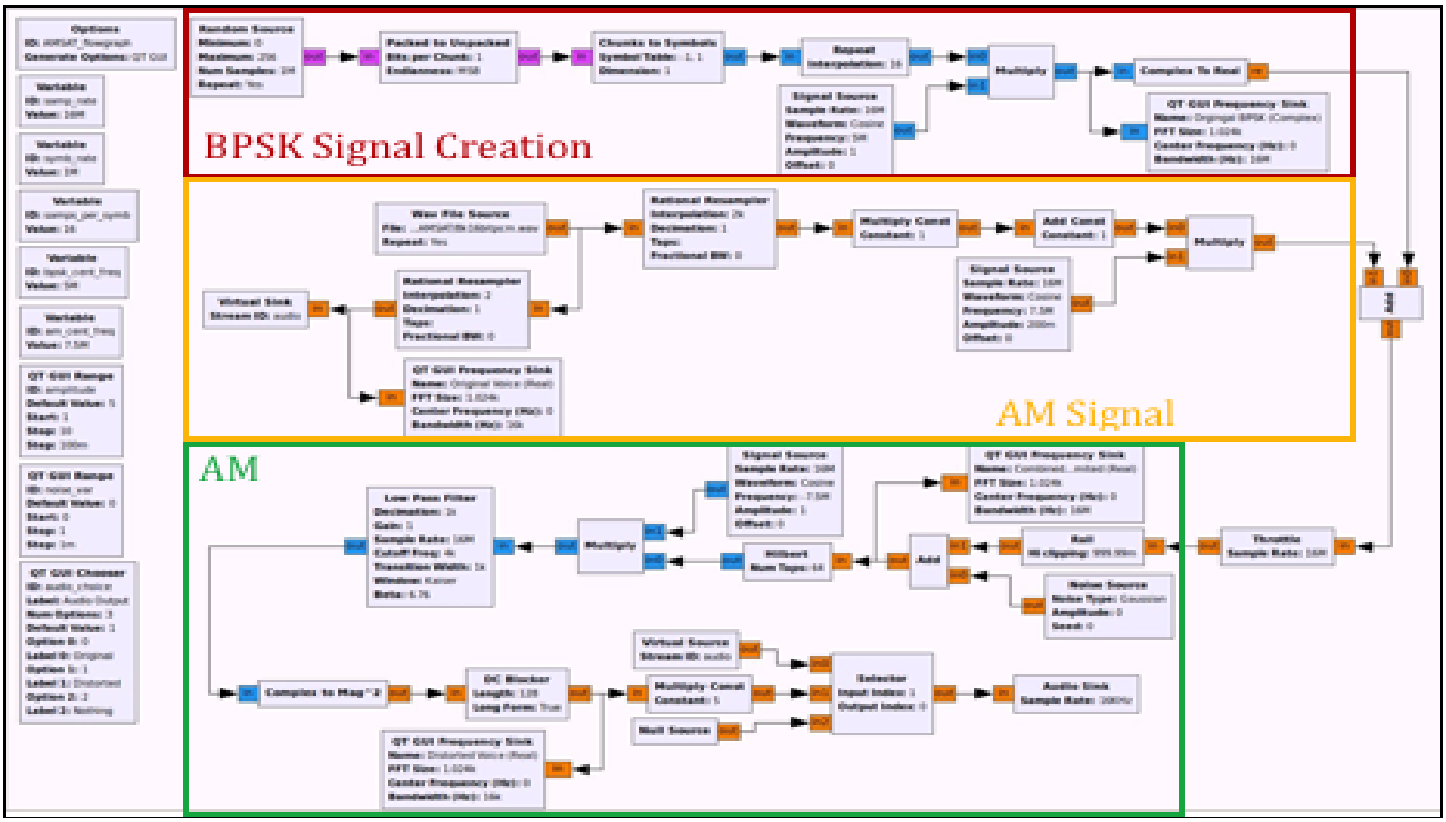

Figure 1 - GNU radio companion flowgraph for the proposed dual analog/digital communication system. The digital signal is BPSK modulated and the analog signal is AM modulated. The receiver is designed for the AM modulated signal.

2. GNU Radio System Prototype

As stated on the GNU Radio project's website, "GNU Radio is a free software development toolkit that provides the signal processing runtime and processing blocks to implement software radios using readily-available, low-cost external RF hardware and commodity processors."[1] Included in this software development is GNU Radio Companion (GRC), a tool in which GNU Radio signal processing blocks can be connected, reconfigured, and initiated as flowgraphs in a user-friendly graphical interface. In Figure 1, the GRC flowgraph for the proposed dual analog/digital communications system for the AMSAT GEO mission is presented.

The flowgraph in Figure 1 consists of three main signal-processing chains. At the top of the flowgraph are the signal processing blocks that are used to generate a BPSK modulated signal. This signal represents a prototype for the payload's digital transponder downlink signal. For this work, the data transmitted by this digital signal is chosen to be random (given this paper's focus on the reception of the analog signal).

In the middle of this flowgraph are the signal processing blocks that are used to generate an AM modulated signal. This signal is used as a prototype for the payload's linear bent-pipe transponder downlink to be used on the payload for legacy amateur radio voice communications. The data transmitted by this analog signal is a sample voice recording found on the Internet.[2]

To simulate dual transmission of these signals, the AM modulated signal is up-sampled to the rate of the BPSK modulated signal and frequency shifted to its second side-lobe (which in this case is approximately 20 dB down from the primary lobe). The analog and digital signals are then added together and hard-limited to values between −1.0 and 1.0.

Finally, at the bottom of this flowgraph is the AM receiver for the generated dual transmission signal. Here, the signal is first frequency shifted so that the AM modulated signal is at complex-baseband. Next, a low-pass filter is applied in order to largely remove the impact of the BPSK modulated signal. Finally, an AM demodulator is applied to recover the analog voice signal. Note that this process can be replicated with respect to the BPSK modulated signal.

3. Prototype Analysis

The relevant frequency domain outputs for the various signals generated from the GRC flowgraph can be observed in Figures 2 and 3. Given the perfect noiseless channel assumed in Figure 2, the AM modulated signal can be clearly seen on the second side-lobe of the BPSK modulated signal. As previously stated, this side lobe is approximately 20 dB down from the main side lobe of the BPSK modulated signal. Also note that the frequency representation of the received analog voice signal is largely undistorted when compared against the original transmitted voice signal. For the AWGN channel assumed in Figure 3, the noise floor has been raised to the level of the BPSK modulated signal's second side lobe. Again note that the received analog voice

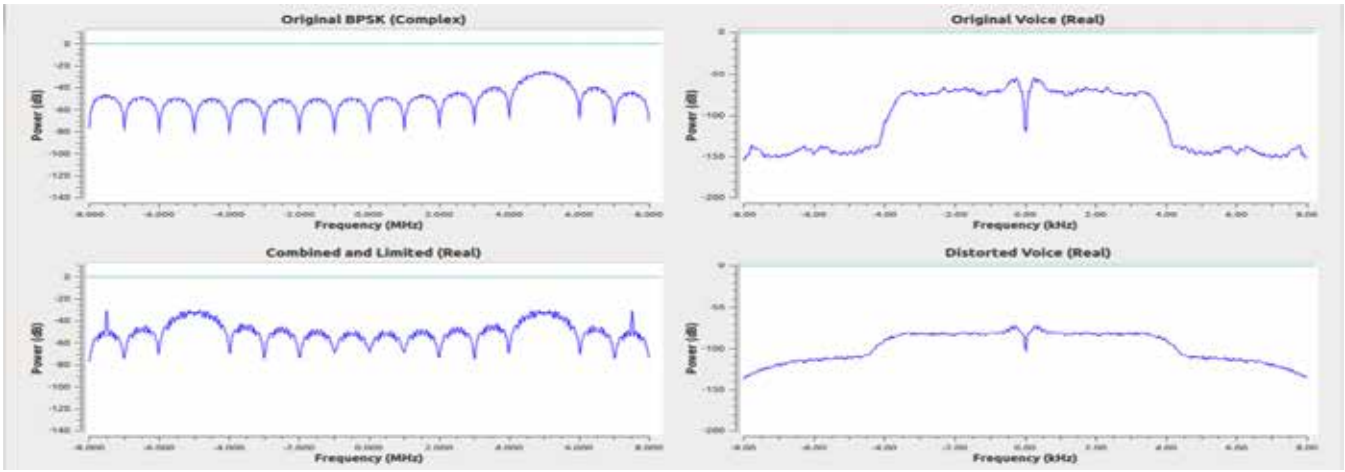

Figure 2 - Frequency spectrum of a few signals generated from the GNU Radio Companion flowgraph assuming a perfect noiseless channel. Counter-clockwise from top right: analog voice signal before AM modulation, BPSK modulated signal, combined AM and BPSK signals (after hard-limiting), received analog voice signal after AM demodulation.

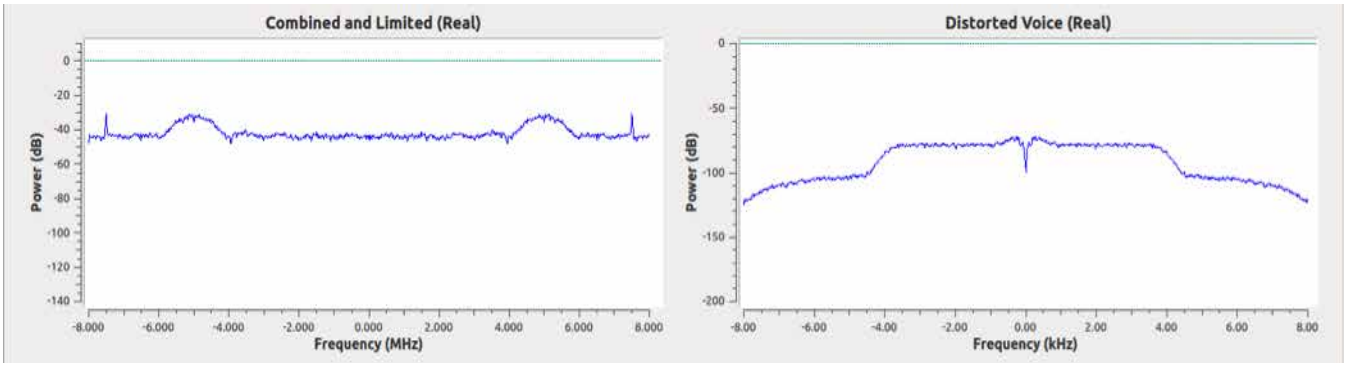

Figure 3 - Frequency spectrum of a few of the signals generated from the GNU Radio Companion flowgraph assuming an AWGN channel. On the left is the combined AM and BPSK signals (after hard- limiting and channel effects) and on the right is the received analog voice signal after AM demodulation.

signal is still clearly discernable above the noise floor and remains largely undistorted. In both cases, the audio signal can clearly be heard above the noise and the content can be clearly heard with minimal distortion.

4. Conclusions

Our results seem to indicate that it will be acceptable, especially at 10 GHz, to simply add the linear bent-pipe transponder signals to the digital modulated waveform on the downlink from the GEO mission payload so long as it is placed well away from the main lobe of the digital signal, even if run through a hard limiting amplifier, as long as the receiver is narrow-band as compared to the digital signal. In other words, the linear bent-pipe transponder can be carried on the same carrier as the digital signal, thus greatly simplifying the communications system on the payload. This is not a perfect solution by any means but could easily have better IMD performance then the Phase 3 HELAPS transponder.

Notes:

[1] **http://gnuradio.org/redmine/projects/gnuradio**
[2] **https://en.wikipedia.org/wiki/WAV**

Smile for AMSAT at Amazon.com

Select smile.amazon.com when making your Amazon purchases and default to Radio Amateur Satellite Corporation as your chosen charity.

Want to put a smile on a satellite? When you make your purchases from Amazon, you can select a charity and Amazon will donate .5% of a qualified purchase towards your selected charity. AMSAT (Radio Amateur Satellite Corporation) is registered with Amazon Smile and you can select it as your preferred charity, which in turn will put a smile on our satellite efforts.

Once you have selected your Amazon Smile charity, when you go to **amazon.com**, it will remind you to go to **smile.amazon.com.** However, you can put everything you want in your cart at the original **amazon.com** site, then leave the site and go to **smile.amazon.com** and all your items will still be in your cart and make the purchase there. Or, just go to **smile.amazon.com** all the time. Your choice, only thing is if you forgot to pay at **smile.amazon.com**, AMSAT gets a goose egg instead of help towards a new satellite. Remember, go to **smile.amazon.com** and select Radio Amateur Satellite

Orbital Debrief

Paul Stoetzer • N8HM
AMSAT Secretary

Satellite DXing is alive and well! While the lack of High Earth Orbit (HEO) satellites makes it a different game than it was during the days of AO-10, AO-13, and AO-40, many satellite operators still enjoy the thrill of working a new DXCC entity and working towards the AMSAT OSCAR Century Award or Satellite DXCC. Several rare entities have been active on satellite in 2016:

- Norm McSweyn, N3YKF, operated from Guyana (8R) in December and early January;
- Mel Vye, W8MV, operated from Grenada (J3) and St. Vincent & The Grenadines (J8) in late January and early February;
- Jens Held, DL7VTX, operated from Dominica (J7) and French St. Martin (FS) in February;
- Michael Lipp, HB9WDF, operated from Curaçao (PJ2) in March;
- Lee Imber, WW2DX, operated from St. Vincent & The Grenadines (J8) in late March;
- Bryan Green, KL7CN, operated from the Bahamas (C6) in late April;
- Tom Price, KP2E, operated from the U.S. Virgin Islands (KP2) in late April.

Readers will observe that many of these entities are very common on HF. However, in many cases, it had been years since they were active on satellite. Hams frequently visit these locations, and the amateur satellite community needs to better encourage satellite operations from these areas.

In late March, I sent a survey to several active satellite operators to gauge the most needed DXCC entities in the Western Hemisphere on satellite, which are listed on the accompanying charts. If you wish to contribute to improving the accuracy of these charts, please email **n8hm@amsat.org**.

If you are traveling to or know of any amateur radio operators traveling to any of the rarest entities, please help satellite DX chasers by bringing satellite gear and operating or encouraging those who are traveling to include satellite operations in their plans. AMSAT may be able to make loaner equipment available for DXpedition use. Please email **n8hm@amsat.org** for further details.

CY9C DXpedition to St. Paul Island Announces Satellite Operation

The CY9C DXpedition to St. Paul Island (#2 on the North America Satellite Most Wanted Chart), scheduled for August 19-29, 2016, has announced that Lee Imber, WW2DX, has joined the DXpedition team and will add satellite operations, as well as 2 meter EME and 6 meter operations, to the DXpedition plans.

St. Paul Island is located in grid square FN97 in the Cabot Strait between Cape Breton Island, Nova Scotia and Cape Ray, Newfoundland and is a separate entity on the ARRL DXCC list. It also counts as a country for the AMSAT OSCAR Satellite Communications Achievement Award, AMSAT OSCAR Sexagesimal Award, and AMSAT OSCAR Century Award. Most of Europe and North America should be easily workable from this location. St. Paul Island has not been activated on satellite since July 1998.

For further information about the DXpedition, please see the CY9C DXpedition website (**www.cy9dxpedition.com/**)

This operation and other planned amateur satellite grid/DX operations are posted on the AMSAT Upcoming Satellite Operations page (**amsat.org/?page_id=3921**). Please email **n8hm@amsat.org** with any additions to this page.

Grid Operations

2016 has also been active on the grid front. UT1FG/MM was active from wet grids until mid-May, crossing the Atlantic twice during his late 2015 to mid-2016 travels. Several other operators including DJ8MS, KA4H, KG5CCI, KL7CN, KL7R, NP4JV, PP2RON, W5PFG, WA7HQD, WD9EWK, XE1AO, and XE1AY operated from multiple grids.

A notable trip occurred in mid-May. Kevin Manzer, N4UFO, traveled to operate several grids in Nevada (and also operated from some grids, including DM54, DM63, DM64, DM73, and EM52 on the way). He activated several very rare grids such as DM07, DM08, DM16, DM17, DM18, DM19, DM26, DM27, DN00, DN01, DN10, and DN11. A few pictures from his expedition are included here.

Reader Submissions

We are always looking for good photos of satellite operating from rare grids, DXCC entities, or other locations. Please submit photos for publication to **n8hm@amsat.**

FDM19 facing West. Kevin Manzer, N4UFO, set up to operate from DM19 in Nevada.

Kevin Manzer, N4UFO, operating SO-50 from Tularosa, NM (DM73).

Kevin Manzer, N4UFO, operating on FO-29 from Roswell, NM (DM73).

Member Footprints
John Smith, K14RO

Grid: EM88xa

Lately, working VO1ONE in FO10 was a real exciting QSO for me – surprised at how far my little HT and a homebrew 2m/440m beam could actually reach.

My first satellite contact was on OSCAR-6 or -7 back in the 70s when I was stationed at March AFB in Southern California and using the call WA8WDZ. Jerry, WA6OWR, and I were neighbors and we put my Regency HR2A on a crystal controlled frequency, and we were both fascinated by the Doppler shift on the downlink through my Yaesu FT-DX560. We used a 2-meter beam mounted at a slight up-angle and a dipole.

My current setup is a couple of Baofeng UV5R HTs and, of course, an Arrow. Only 5 W or so but I've had success with SO-50, AO-85 and Lilacsat-2 when it was on the air.

I decided to support AMSAT because of all the fun I was having and all the knowledge that appears to be in the group. I find most of the "regulars" to be very friendly and ready to help at the drop of hat with recommendations and suggestions to help me improve my experiences with the birds.

My most interesting moment was learning that N8HM and I were practically neighbors back in Michigan. We grew up within about 20 miles of each other. Of course, Paul is a lot younger than I so it was probably his father I grew up next door – hi hi.

Being a low end user/buyer of radios I'm always interested in articles about low-end HTs like the Chinese rigs that have hit the market lately. Although I don't have a lot of test equipment, I do also enjoy seeing different antenna projects. My first antenna was modeled after KG0ZZ's design on his web page at **amateurradio.bz/4_dollar_satellite_antenna.html**. Although I've never worked Ted on any satellite, this design got me started on the satellites again, and I used it for the first 9 months I was on the air with great success. I'm also a DXer at heart, so whenever I see anything about rare grids coming on the air or DX stations coming on the air, I'm always interested.

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www.amsat.org/?page_id=4859

Support AMSAT

AMSAT is the North American distributor of SatPC32, a tracking program designed for ham satellite applications. For Windows 98, NT, ME, 2000, XP, Vista, Windows 7, 8/8.1 & 10.

Version 12.8c is compatible with Windows 7, 8/8.1 & 10 and features enhanced support for tuning multiple radios.

Version 12.8c features:

- SatPC32, SatPC32ISS, Wisat32 and SuM now support rotor control of the M2 RC-2800 rotor system.
- The CAT control functions of SatPC32, SatPC32ISS and Wisat32 have been expanded. The programs now provide CAT control of the new Icom transceiver IC-9100.
- The main windows of SatPC32 and SatPC32ISS have been slightly changed to make them clearer. With window size W3 the world map can be stretched (only SatPC32).
- The accuracy of the rotor positions can now be adjusted for the particular rotor controller. SatPC32 therefore can output the rotor positions with 0, 1 or 2 decimals. Corrections of the antenna positions can automatically be saved. In previous versions that had to be done manually.
- The tool "DataBackup" has been added. The tool allows users to save the SatPC32 program data via mouse click and to restore them if necessary. After the program has been configured for the user's equipment the settings should be saved with 'DataBackup'. If problems occur later, the program can easily restore the working configuration.
- The rotor interfaces IF-100, FODTrack, RifPC and KCT require the kernel driver IOPort.SYS to be installed. Since it is a 32-bit driver it will not work on 64-bit Windows systems. On such systems the driver can cause error messages. To prevent such messages the driver can now optionally be deactivated.
- SuM now outputs a DDE string with azimuth and elevation, that can be evaluated by client programs. Some demo files show how to program and configure the client.

Minimum Donation is $45 for AMSAT members, $50 for non-members, on CD-ROM.
A demo version may be downloaded from http://www.dk1tb.de/indexeng.htm
A registration password for the demo version may be obtained for a minimum donation of $40 for members and $45 for non-members.
Order by calling 1-888-322-6728.

The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.

An Arduino Controlled GPS Corrected VFO

Gene Marcus, W3PM/GM4YRE

A VFO that provides 1 to 112.5 MHz signals on two independent outputs. Use it as a stand alone unit or with a GPS receiver to improve frequency accuracy. UTC and six digit grid square locations are also displayed in the GPS Mode.

This project began with the purchase of a Si5351A clock generator breakout board for less than $8 from Adafruit Industries. Designed as a substitute for crystal oscillator clocks, it features three output ports for frequencies between 8 kHz and 160 MHz. Although the board is specified for a wider bandwidth, this project is limited to 1 through 112.5 MHz.

Figure 1 shows my project, built on a piece of perfboard. The Si5351 board is the top board on the right side of the perfboard. Just below that is the Arduino Nano board I used to control the oscillator. This version uses a rotary encoder to set the operating frequency. You can see the encoder off the left side of the board. Figure 2 shows a completed unit, packaged in a plastic project box. The Resolution, Band Select, and Reset pushbuttons are on the right, just below the rotary encoder.

The Si5351A board does have limitations. Although it is a highly capable and stable board, the output is a square wave with odd harmonic frequencies present in the output. The square wave output does make a good source for some mixers. Phase noise is also higher than other popular programmable signal sources. A quick search of the Internet will yield a wealth of data concerning the performance of the Si5351A IC. Builders are urged to consider phase noise and crosstalk limitations before using this IC in their project.

A simplified version of the VFO can be built without the GPS module. Figure 3 shows the circuit for this configuration. Figure 4 shows the schematic diagram for the complete circuit, with GPS module, rotary encoder and pushbuttons.

Unlike a GPS disciplined oscillator (GDO) using a phased lock loop (PLL), this project uses a GPS 1 pulse per second (pps) output to act as a precision frequency countergate. An Arduino Nano (or Uno) is used as a frequency counter to calculate a correction factor to use when programming the Si5351 board. Although not as accurate as a GDO, this simple method provides a variable signal source from 1 to 112.5 MHz with an uncertainty of better than 1 part in 107.

The Arduino provides the processing power required to calculate the frequency, control the Si5351A board, serve as a UTC timekeeper, and as an added bonus, calculate your 6-digit Maidenhead grid square locator.

Favorite operating frequencies are stored in software and are accessed by the Band Select pushbutton. Each band may be configured in a VFO only or VFO/LO combination. The Si5351A CLK1 output port is the VFO, and CLK2 is used as an LO. The displayed frequency is arithmetically corrected when the VFO/LO configuration is used. Multiple bands can be configured in this manner. A programmable offset function allows you to

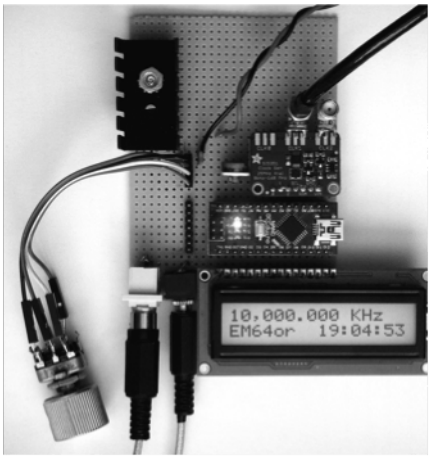


Figure 1 — I constructed the VFO on a piece of perfboard. The heatsink shown at the top left corner of the board is for the 7805 voltage regulator. The regulator is not required for the basic non-GPS configuration of the Si5351 VFO project, if used without the display backlight. The VFO output signals connect to the CLK1 and CLK2 connectors at the edge of the Si5351 board. The Arduino Nano is between the Si5351 board and the display board. At the bottom left of the perfboard are the GPS connections. Also note the rotary encoder to the left side of the perfboard. The pushbutton switches were not included on this version of the VFO.

Figure 2 — Here is a completed VFO project, housed in a plastic project box. The Resolution, Band Select, and Reset pushbutton controls are located just below the rotary encoder.

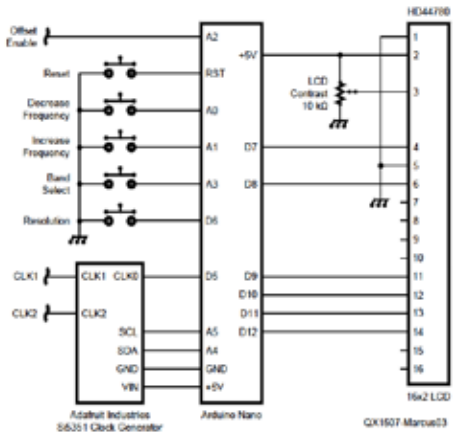


Figure 3 — This is the schematic diagram for the basic non-GPS configuration of the Si5351VFO project. Either an Arduino Nano or Arduino Uno can be used.

use the unit for transceiver operation.

Theory of Operation

The Si5351A is based on a PLL/VCXO and high resolution MultiSynth fractional divider architecture. The Si5351A board can generate any frequency up to 150 MHz on each of its outputs. System short and long term frequency uncertainties are attributed to the onboard 25 MHz clock. One of the three Si5351A outputs (CLKØ) is programmed to 2.5 MHz and routed to the Arduino's frequency counter input port (pin D5). The 1 pulse per second output from the GPS receiver is routed to the Arduino's interrupt 0 input port (pin D2) to act as a counter gate. The Arduino counts the 2.5 MHz input over a 40 second gate time, resulting in a 100 MHz total count. This count is used to recalculate the 25 MHz clock frequency. Total system uncertainty, including calculation resolution limitations and clock drift during counter gate time, is better than 1 part in 10 million. The VFO frequency is updated every 40 seconds, or when the frequency is changed. Typical frequency uncertainties versus time for GPS and non-GPS configurations can be seen in Figures 5 and 6.

When the unit is first turned on, the GPS processing routines are enabled to determinethe correct UTC and 6-digit Maidenhead grid square location. When the software determines that valid data has been received, the GPS processing routines are disabled. At this point, frequency accuracy and time is maintained by the GPS 1 pps signal. GPS NMEA processing is turned off to eliminate processing conflicts and resultant frequency counter errors.

Excellent library routines are available on the internet to simplify Si5351A frequency programming. Instead, I chose to program the Si5351A PLL and MultiSynth functions directly without the use of library routines. The resultant code is very simple compared to other routines, but works quite nicely in this application.

I found I could easily program the Si5351A board up to 150 MHz using PLL divider techniques. Unfortunately, PLL divider techniques create glitches each time the frequency is changed. Fixed PLL frequencies using MultiSynth division provide glitch-free tuning, but the frequency range is limited to 112.5 MHz using this method.

Options

The unit may be built without the GPS receiver and used as a stand-alone VFO (refer to the software installation instructions). If used in the stand-alone mode, you can expect a drift rate of approximately 1.6 Hz / °F (2.8 Hz / °C). Operating the VFO in standalone mode also provides an excellent means to test the project prior to connecting the GPS related hardware.

The frequency is controlled either by the rotary encoder or the frequency up/down pushbuttons. You may want to include either the encoder or pushbuttons, or both.

Construction

Construction of the VFO unit is not critical provided adequate RF layout techniques are used. Do not use long unshielded wires for RF and GPS 1 pps connections. I first built the system using a solderless breadboard without any problems. Later, I transferred the circuit to a RadioShack perfboard.

The Si5351A board and LCD may be directly powered from the 5 V pin of the Arduino. A separate 5 V DC source is required if you use the LCD backlight and/or GPS receiver.

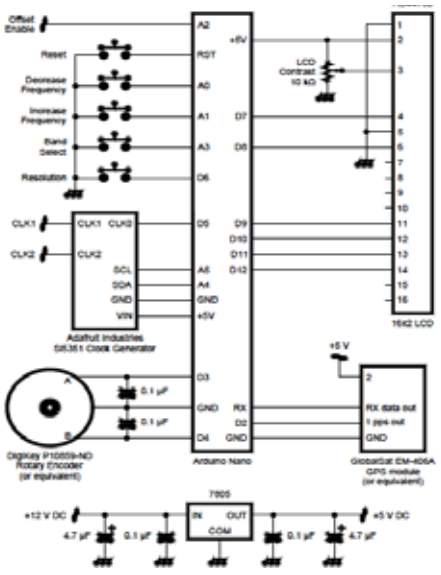


Figure 4 — The GPS corrected version of the Si5351 VFO project is shown in this schematic. The rotary encoder can be included to controlthe operating frequency. Either an Arduino Nano or Arduino Uno can be used.

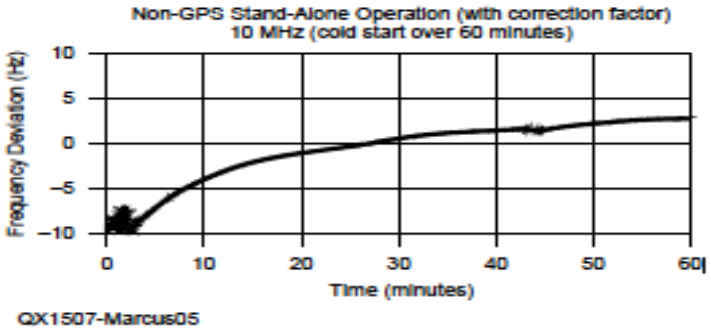


Figure 5 — This is a graph of the frequency versus time over the initial 60 minutes, for the output from the non-GPS version of the VFO project. A constant room temperature was maintained during the data collection. The drift rate is approximately 1.6 Hz / °F (2.8 Hz / °C).

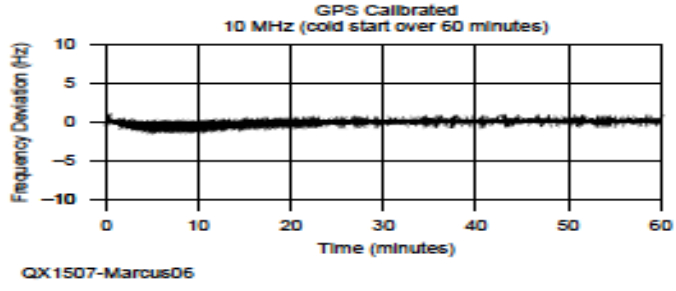


Figure 6 — Here is the graph of the frequency versus time over the initial 60 minutes for the GPS corrected VFO. A constant room temperature was maintained during this data collection. Frequency corrections to bring the frequency back to normal are shown during the early minutes of warm-up.

A 7805A voltage regulator with a small heat sink works nicely. LCD backlight current requirements vary by manufacturer, so circuit details are not included here.

GPS antenna location is critical. A solid GPS signal is necessary to ensure consistent system operation. You should try to locate the GPS antenna with a clear view to the sky, away from noise sources. The GPS receiver requirements are 5 V operation, 1 pps output, and 4800 baud NMEA data output in either $GPGGA or $GPRMC format.

Software Installation and Setup

The Arduino download website (http://arduino.cc/en/Main/Software) outlines installation instructions for the first-time Arduino user. My Arduino Si5351A_vfo.ino file is located at: (www.knology.net/~gmarcus/Si5351.html). This file, current at publication time, is also available for download from the ARRL QEX files web page.

Important note: The serial input port (pin 0) is used for both GPS and USB serial data. Do not attempt to upload software into the Arduino Nano while receiving GPS data. Disconnect the GPS NMEA data line before uploading software.

The software will allow the displayed frequency to be arithmetically corrected when both output ports are used in the VFO/ LO configuration. Multiple bands may be configured in this manner.
Near the beginning of the Arduino sketch, you will find the following variable that defines the Band Select configuration:

Depressing the Band Select pushbutton will step through the programmed frequencies. Each entry follows the format "{CLK1 frequency, CLK2 Frequency, math command}." You may modify, delete, or add to the Band Select list. The last entry in the list must be (0, 0, 0). The rotary encoder or frequency up/down pushbuttons will only control the CLK1 frequency.

All frequency entries are in Hz. The math command controls how the frequency is displayed. A "1" will add CLK1 and CLK2, and a "2" will subtract CLK1 from CLK2. A "0" results in no change.

For example: {5286500,8998500,1}, will result in:
CLK1 output: 5.286500 MHz
CLK2 output: 8.998500 MHz
LCD display: 14.285000 MHz.

The Offset variable controls the frequency offset. When the Arduino pin A2 is held low, the programmed offset in Hertz is added or subtracted. Any positive or negative value of Hertz can be used to program the frequency offset.

There are two ways to configure this project: either as a GPS corrected frequency source or as a stand-alone unit without GPS correction. Locate the variable GPSflag near the beginning of the Arduino sketch and set the variable to either "1" for GPS correction or "0" for non-GPS operation.

If you choose to use the project without GPS correction, you can enter a correction factor to allow for greater frequency accuracy. To calculate and enter this correction factor, perform the following steps:

1) Connect the VFO to a frequency counter
2) Set the VFO to 25 MHz

```
const unsigned long Freq_array [] [3] = {
{ 7030000,0,0 }, // CLK1=7.030 MHz, CLK2=0 MHz, Display=7,030.000 kHz
{ 1810000,0,0 },
{ 3560000,0,0 },
{ 7040000,0,0 },
{ 10106000,0,0 },
{ 14060000,0,0 },
{ 18096000,0,0 },
{ 21060000,0,0 },
{ 24906000,0,0 },
{ 28060000,0,0 },
{ 50060000,0,0 },
{ 5286500,8998500,1 }, // CLK1=5.2865 MHz, CLK2=8.9985 MHz, Display=14,285.000 kHz
{ 5016500,9001500,2 }, // CLK1=5.0165 MHz, CLK2=9.0015 MHz, Display=3,985.00 kHz
(0,0,0)
};
```

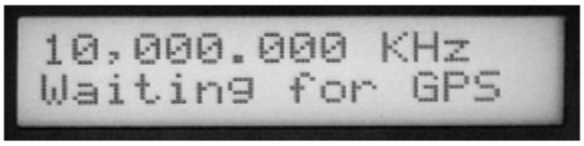


Figure 7 — When you first turn on the GPS corrected VFO, you will see the start-up frequency and the Waiting for GPS message on the display.

Figure 8 — If you build the non-GPS version, the initial display will show the start-up frequency and the initial frequency step size.

Figure 9 — When valid NEMA GPS data is received by the Arduino, the second line of the display will show your six-digit MaidenheadGrid Locator and the time, in UTC.

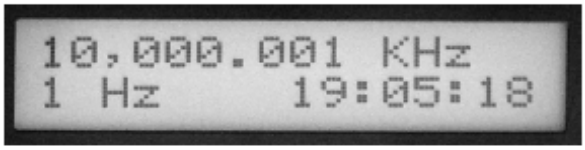


Figure 10 — When you change the frequency step size on the GPS version, the Grid Locator will be replaced by the step size on the display.

3) Note the measured frequency in Hz
4) Subtract 25 MHz from the counter reading
5) Note the difference in Hz (such as –245), and
6) Locate the variable CalFactor in the Arduino sketch and enter the value.

Frequency uncertainty without GPS calibration and without the calculated correction factor is normally less than 1 kHz.

Operation

When first turned on, you will see "Waiting for GPS" displayed on the LCD. See Figure 7. (If GPS correction is not used, the second line of the LCD will continually display the frequency step resolution, as shown in Figure 8.) It may take a few minutes for the GPS receiver to lock and obtain valid NMEA data. After the GPS receiver obtains valid data, the "Waiting for GPS" display will be replaced with the (UTC) time and your 6-digit grid square locator. The system is now ready for operation. See Figure 9.

Depress the resolution pushbutton to select the frequency step. When the button is depressed the selected resolution will be displayed for a few seconds on the second line of the LCD. See Figure 10.

Experimentation

This is an open source project. You are encouraged to experiment and improve upon the system operation. Simple system improvements such as using a 4 × 20 LCD to display additional data can be easily implemented. Variables containing latitude, longitude, and the number of satellites in view exist in the GPSprocess() subroutine. More complex updates such as varying the CLK2 LO frequency may also be incorporated.

Gene Marcus, W3PM/GM4YRE, was first licensed in 1963 as KN3YVP, and has held an Amateur Extra Class license since 1968. He was first licensed in Scotland as GM5AQM in 1969. He received a First Class FCC Radiotelephone license in 1977.

Gene completed an ASEE degree program at Penn State University in 1968. After a four-year tour as a Cryptologic Technician with the U.S. Navy, he began a 32-year career in the field of precision measurement equipment calibration. In retirement, he enjoys experimenting with various RF and microprocessor projects, and enjoys world travel with his wife, Phyllis.

[Editor's Note: This article was first published in the July/August 2005 issue of QEX.*]*

On the Grids: Working Satellites from Caribbean Islands

Melvin C. Vye, W8MV
w8mv@arrl.net

For several years, my wife and I have been able to escape Ohio winters by spending a couple of weeks in the Caribbean. Rather than go the cruise route, we choose a couple of islands, find some nice accommodations, fly there and relax. This year, our islands of choice were Grenada (FK92) and St. Vincent (FK93).

While I have operated from 27 DXCC entities including 3Y0X, going on DXpeditions recently got a whole lot easier. A handheld transceiver and an Arrow or Elk antenna are all you need to get on the FM satellites.

Caribbean islands, except U.S. and French islands, require a license costing around $20. I downloaded the Grenada license forms, completed them and returned them by email. The St. Vincent forms did not have an option for electronic return, so I sent them by regular mail.

In Grenada, I went to the telecommunications office only to find that they had not received my application. Fortunately, I had my application and FCC license with me. They accepted my money, told me that the license had to be signed by the Minister of Communication, but not to worry. I was authorized to operate as J3/W8MV.

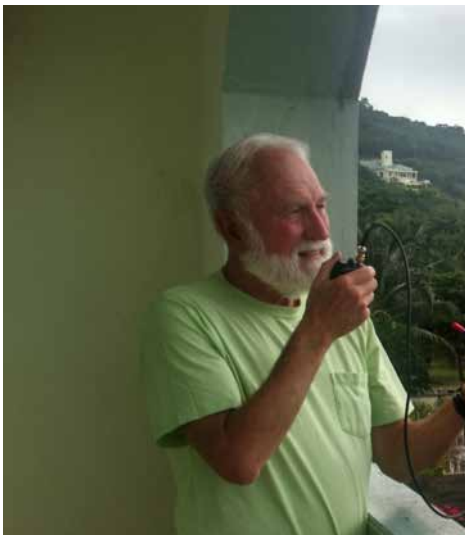
The process on St. Vincent went easier. My application had been received and the license was ready. I was authorized to operate as J8/W8MV.

The accommodation on Grenada was perfect. Our room included a balcony facing west over the Caribbean. With two or three SO-50 passes daily, I could work down to 0 degrees of elevation without ever leaving the room.

Operating on St. Vincent proved to be more challenging. Our hotel was in a valley, so I had to walk up a hill to get a shot to the west. Even there, mountains to the north blocked me. Although we had a rental car, the roads on St. Vincent leave much to be desired. I was not comfortable driving at night. Still, one day we drove up the west coast of the island to work one SO-50 pass, and returned just before sunset.

I logged 45 QSOs from Grenada and 14 from St. Vincent, all on SO-50. In the future, I'll choose my accommodations more carefully, making sure that I have a clear shot to the north or west.

Working satellites from Caribbean islands is fun and easy. Next year there will be more islands and hopefully more satellites. See you on the "birds."



W8MV Working SO-50 on Grenada.

W8MV Working SO-50 from St. Vincent.

AMSAT Activities at Greater Houston Hamfest 2016

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

AMSAT was well represented again this year at the Greater Houston Hamfest (GHH) held March 19, 2016, 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. It is sponsored by BVARC – The Brazos Valley Amateur Radio Club. Attendance at GHH this year was 1,350, setting a record high.

The 2016 GHH had 26,850 square feet of indoor exhibit space this year with approximately 200 tables for vendors and individuals, a large outdoor tailgate area with early access before the main hall opened, and an adjacent RV camping area with 36 spaces. Amateur radio license test sessions were administered to 16 candidates with an overall pass rate of 87.5 percent. Some of the featured speakers were Riley Hollingsworth, former FCC "top cop," Carl Luetzelschwab, K9LA, well known propagation expert, and Gerald Youngblood, K5SDR, President and Chief Executive Officer of Flex Radio Systems.

Carl Kotila, WD5JRD, staffed the AMSAT booth along with assistance from Bruce Paige, KK5DO, AMSAT Director of Contests and Awards. Bruce was also available at the AMSAT booth to check QSL cards for the ARRL VUCC award. Charlie Keng, K5ENG, Andy, W5ACM, and Allen, N5AFV, also filled in at the booth as needed.

Andy, W5ACM, and John Maca, AB5SS, teamed up to give a technical talk about high altitude balloons. Attendance at the 8:30 a.m. presentation was approximately 70, including 50 boy scouts. Following a brief talk hitting the high points of the South Texas Balloon Launch Team efforts since BLT-1 in 1990, and an excellent 12-minute video, they brought out balloons, payloads and helium for two launches from the fairgrounds.

Although it was quite windy, both balloons – one latex (BLT-44) and the other Mylar (BLT-43), made it into the sky without mishap. The latex balloon was just big enough to take two temperature sensor experiments to nearly 100,000 feet before bursting three hours later. The temp sensor units transmitted temperature in degrees Fahrenheit and Celsius via CW on three HF and VHF frequencies.

The payload for the Mylar "floater" balloon weighed in at 18 grams, including the Lithium Polymer battery and solar cells. Derived from a circuit design by Thomas Krahn, KT5TK, this pico-payload PECAN 5A included a GPS receiver, computer and frequency-agile, two-meter FM transmitter sending APRS location data and telemetry for global distribution via http://aprs.fi. It spent the day drifting east at about 27,000 feet until lost somewhere over central Georgia.

Scott Medbury, KD5FBA, using an Arrow antenna and HT, conducted a satellite demonstration via AO-85. Scott got into the bird and a station came back to him, but the intense congestion on the satellite did not permit the contact to be completed. Andy, W5ACM, and Allen, N5AFV, provided receiving stations using HTs with AL800 whip antennas. Approximately 35 people attended the satellite demonstration, including 20 boy scouts.

The Brazos Valley Amateur Radio Club, organizer of the hamfest, gave away four raffle prizes. The main raffle prize was a Kenwood TS-590SG all-band multimode transceiver, which was won by Gene Reichle, N5EBK, from Houston.

Figure 1 – BLT-1 Launched Dec-8-1990. [Allen Mattis, N5AFV, photo]

Figure 2 – AB5SS Ready to Launch BLT-43. [Hugh Burgess, K5HTB, photo]

Figure 3 – AB5SS Launches BLT-43. [K5HTB, photo]

Figure 4 – WA5TWT, K5SAF and W5ACM Filling BLT-44. [K5HTB, photo]

Figure 5 – W5ACM and WA5TWT Launching BLT-44. [K5HTB, photo]

Figure 6 – N5AFV, KK5DO and KD5FBA at the Satellite Demonstration. [K5HTB, photo]

Figure 7 – Scott, KD5FBA, Calling on AO-85. [K5HTB, photo]

Figure 8 – WD5JRD, N5AFV and W5ACM at the AMSAT Booth. [Thomas Matthews, K5SAF, photo]

GOTA Station Demos Satellites to Over 400 Students

Richard Siff, WA4BUE

In February 2016, the K4AMG Memorial Amateur Radio Club was invited by Dr. Linda Vahala, Associate Dean of the Batton College of Engineering and Technology at Old Dominion University, to host an amateur radio GOTA station (including satellites) and to give presentations demonstrating STEM concepts to over 400 visiting middle and high school students.

Our GOTA station was set up in front of Webb Center, the student union building. We operated HF and satellites. We provided information on satellites communications and demonstrated the AMSAT CubeSat simulator.

The following pre-teen and teen amateur radio operators spoke:

- Adam Nowak, KJ4NFL, "The Role of Amateur Radio in Emergency Communications,"
- William Ferguson, KJ4EYZ, "The History of Amateur Radio from the 1800s to Modern Times," and
- Zechariah, WX4TVJ, and Faith Hanna Lea, AE4FH, "Construction of Different Types of Two Meter Antennas."

Richard Dyer of local Chapter 54 of the Society of Broadcast Engineers spoke on "Careers in the Broadcast Engineering Industry"

A luncheon was held for all of the guests including many faculty members. The keynote speaker was Hope Lea, KM4IPF, age 9, speaking on "Fun Stuff on Satellite Communications, Using OSCAR Satellites."

Great Bridge High School is starting the paperwork process to contact the ISS.

President of K4AMG is John KW4CR (**john@KW4CR.com**).

eBay Sellers Donate to AMSAT

Are you an eBay seller? One item, ten items, or a full-time business you can donate a percentage of your winning bid to AMSAT. To do so, do not list your item with the basic listing tool, select advanced tools. eBay will give you a warning message that it is for large volume sellers, however this is where the eBay for Charity tool is found.

You can "select another nonprofit you love" and search for either AMSAT or Radio Amateur Satellite Corporation. Choose the percentage amount of the sale you would like to donate to AMSAT, and boom!. When your item sells and the winning bidder pays, eBay will deduct the percentage from your take and forward it to AMSAT.

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

Rotor Controller Box/Boards

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

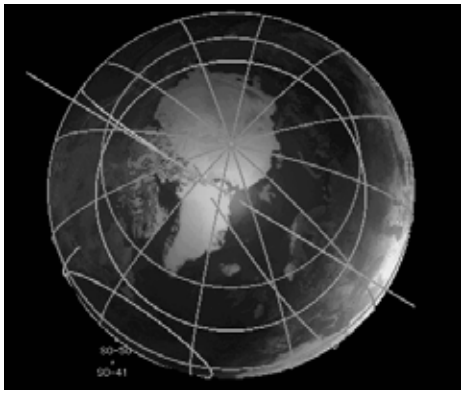
Documentation for the LVB Tracker can be found at: **http://www.LVBTracker.com**

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

MacDoppler

The premier Satellite tracking and station automation application for the Macintosh - OS 9 & OS X



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

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

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

Now available from AMSAT at a special member discount donation!

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Dog Park Software Ltd.
www.dogparksoftware.com

AMSAT Fox-1Cliff & Fox-1D $125,000 Launch Initiative Goal

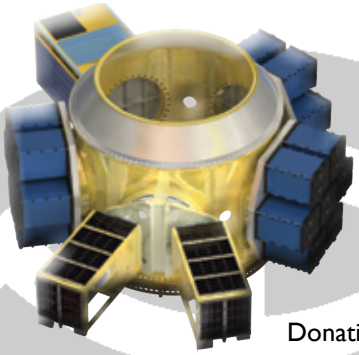
AMSAT is excited to announce a launch opportunity for **BOTH** the Fox-1Cliff and Fox-1D Cubesats. In response to a breaking opportunity, AMSAT and Spaceflight, Inc. have arranged for Fox-1D to accompany Fox-1Cliff on the maiden flight of the SHERPA system on a SpaceX Falcon 9 in the 1st quarter of 2016.

Fox-1Cliff and Fox-1D will provide selectable U/V or L/V repeater capabilities on separate frequencies once in orbit, and will be capable of downlinking Earth images from the Virginia Tech camera experiment.

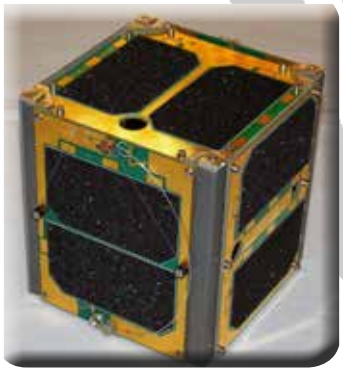
AMSAT has an immediate need to raise funds to cover both the launch contract and additional materials for construction and testing for Fox-1Cliff and Fox-1D. We have set a fundraising goal of $125,000 to cover these expenses over the next 12 months, and allow us to continue to keep amateur radio in space.

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-1Cliff and Fox-1D 1U Cubesats launched on the Spaceflight's initial SHERPA flight in 1Q 2016.

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-1Cliff and Fox-1D

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

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

Seize 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 Engineering Team

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

- Attitude Determination and Control, and Thermal Engineering, to help design high orbit CubeSats.
- Power systems for CubeSats from 1U through 6U, LEO to HEO. Help with solar, power supply, and battery design for LEO and HEO missions.
- Design and build hardware and software for the AMSAT Ground Station for P4B, CQC, P3E, and GTO/HEO.

To volunteer, please describe your expertise using the form at **ww2.amsat.org/?page_id=1121.**

AMSAT User Services

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

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

To volunteer, send an e-mail to Joe Kornowski, KB6IGK at: **kb6igk@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 Joe Spier, K6WAO at: **k6wao@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