The AMSAT® Journal

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Volume 38, Number 5a **Fox-1A Launch Special Issue • October 2015**

in this issue ....

AMSAT Journal Special Issue

Launch of NROL-55 with AMSAT's Fox-1A aboard on October 8, 2015

Satellite Deployed & 145.980 MHz Downlink Telemetry Copied

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

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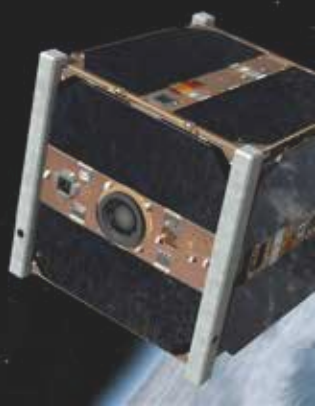
At Kensington, MD
and at additional
mailing offices

Commit to the Future of AMSAT

- **AMSAT has committed to launching Fox-1Cliff and Fox-1D in the 1st quarter of 2016.**
- **We teamed with SpaceFlight, Inc. for integration and launch utilizing SpaceFlight's SHERPA System to sun-synchronous orbit in first quarter of 2016 and we have already paid the launch fee.**
- **AMSAT must now raise the funds to recover those funds to re-establish our reserves.**
- **Along with serving as a "rainy day fund", these reserves provide the "seed money" for future satellite projects.**
- **It takes real dollars to develop real satellites.**
- **As a result, AMSAT has initiated a $125,000.00 campaign to raise the capital needed to provide the resources to maintain our ability to initiate future projects.**

Please consider these donation options

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



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

Welcome to the AMSAT Journal Special Issue

Welcome to the *AMSAT Journal* Fox-1A Launch Special Issue. We're making this special issue available as a free download ...

- If you're new to amateur satellites, welcome aboard. We hope to show you enough information for you to get started with amateur radio equipment you may already own.
- We'd also like to invite you to join AMSAT. So we'll tell you a little about ourselves and we hope you'll understand why many members say AMSAT is the most exciting amateur radio club in the world.

This special issue is being made available as a free download to enable the fastest distribution with the news of the Fox-1A launch. AMSAT members receive a 32 page print version of the *Journal* in the mail, sent six times per year.

See our advertisement on the last page of this issue for a new member deal!

AMSAT's Mission

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

AMSAT's Vision

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

Radio Amateur Satellite Corporation (AMSAT-NA)
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The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPEG formats. Kindly do not embed graphics or photos in your manuscript - we prefer receiving those as separate files. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time and efforts to produce *The AMSAT Journal*.

Congratulations to AMSAT's Fox Program

For AMSAT, this fall represents the "harvesting" of our efforts with the Fox-1 Program, with the scheduled launch of Fox-1A on October 8, 2015 from Vandenberg AFB as part of the ELaNa-XII group of satellites.

In addition, Fox-1Cliff and Fox-1D are now scheduled to fly together under contract with Spaceflight, Inc., which is expected to launch in first quarter 2016. Lastly, RadFXSat/Fox-1B has been assigned a launch that is currently expected to take place in November 2016 from Vandenberg Air Force Base as part of ELaNa-XIV.

The next 14 months will be rewarding ones for our volunteers, who spent countless hours designing, documenting, collaborating, fabricating, testing and integrating our Fox-1 design into flight hardware. There is a significant sense of pride in completing a spacecraft that will be used by amateurs, students, and scientists who will benefit from amateur radio capabilities on board, educational opportunities that our spacecraft can provide to the classroom, and the scientific data that will be available from payloads on board provided by university students and faculty.

Organizationally, AMSAT has benefited tremendously from the Fox-1 program as it provides the basis for training a new generation of satellite builders who are now seasoned veterans capable of tackling more complex and challenging projects. AMSAT's reputation as a satellite innovator is enhanced as the Fox-1 design allows seamless integration of scientific payloads that can benefit from a reliable communications downlink capable of low speed and high-speed data transmissions. Fox-1A will be the first FM repeater satellite in a 1U cubesat form factor, capable of sending low speed telemetry (satellite parameters as well as payload data) while the FM repeater is in normal amateur service. Volunteers have developed ground station software for use by amateurs and others to monitor the health of the satellite and receive and display the data from the scientific payloads that can then be forwarded to a central server. The software will also be capable of handling the imagery that will be made available on Fox-1Cliff and Fox-1D provided by the camera developed by Virginia Tech. The FoxTelem software is available through the AMSAT website.

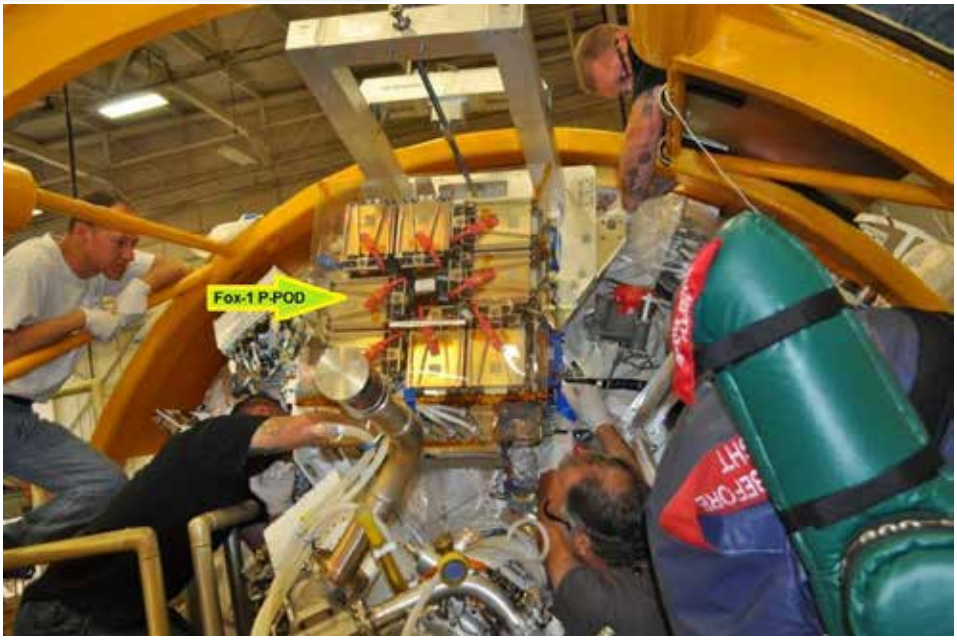
Liftoff of the United Launch Alliance Atlas-Centaur rocket at Vandenberg Air Force Base's Space Launch Complex 3-East pad. Launch of NROL-55 with AMSAT's Fox-1A aboard on October 8, 2015. United Launch Alliance photo.

Recognizing AMSAT's Fox-1 Team!

Jerry Buxton	N0JY	Program Manager	Keith Packard	KD7SQG	IHU card
Tony Monteiro	AA2TX (SK)	Original driving force	Dan Passaro	AK4PX	Mechanical
Corey Abate	K8SPN	Solar panel design	Ben Pearson	KD7UIY	Systems engineering
Andrew Abken	KN6ZA	Structure machining	Tracie Perez	KF5UYL	PhD student; LED thruster
Joseph Armbruster	KJ4JIO	Assenbly; ground software	Larry Phelps	K4OZS	RF
Bryan Baker	N4DTV	Command and Control RF uplink	Fred Piering	WD9HNU	RF
Jacob Beningo	KD8FAX	Software	David Ping	WB6DP	Antennas
Steve Bible	N7HPR	RF card	Douglas Quagliana	KA2UPW	Ground software
Alan Biddle	WA4SCA	Radiation	Bill Reed	NX5R	Software
Kevin Bishop	KG7NSD	Project Management	Robert Reed		ISDE experiment
Jonathan Brandenburg	KF5IDY	Experiment control software	Chuck Reynerson		Software; Orbital Mechanics
Darell Brehm	WA3OPY	ICM Crystals - RF	Ed Rhodes	WA1LEI	Mechanical construction; AutoCAD
Larry Brown	W7LB	Model program	Brent Salmi	KB1LQD	MPPT
Kevin Burns	KJ4SYL	VT Camera	Bryce Salmi	KB1LQC	MPPT
Steve Christie		Mechanical	Tony Scalpi	N2VAJ	Statek Cyrstals
Bill Clark	KK4EWQ	VT Camera	Jay Schwartz	WB8SBI	Software
Arlen Cordoba		Flight unit structure machining.	Dan Schultz	N8FGV	Test documents and equipment
Don Corrington	AK2S	Power supply; test	Kelley Shaddrick	W0RK	LiIon battery study
Taylor Crisp	KF5SKQ	Mechanical	Brian Sierawski		ISDE software
Bronson Crothers	AA1ZB (SK)	Power Supply	Mark Spencer	WA8SME	ARRL Education Liason
Bob Davis	KF4KSS	Mechanical, Environmental	Kevin Stewart	NF6H	Software
Mitch Davis	WQ3C	VT Camera	Bruce Sutherland	KO4IN	Software
Randy Dawson	KF7CJW	RF	Ron Tassi	N3AEA	Power system
Paul Finch	WB5IDM	RF testing.	Ken Tatebe	KF5IGK	Physics and algorithms
Burns Fisher	W2BFJ	Software team co-lead	Nick Teti		Thermal
Joe Fitzgerald	KM1P	IT support and management	Chris Thompson	AC2CZ	Test documents
Bob Fitzpatrick	KB5SQG	Transponder testing	Al Vasso	KB1UKV	Systems engineering
Marc Franco	N2UO	RF	Marcus Wagnborg	KJ4YTA	Power system
Bdale Garbee	KB0G	IHU and command and control hardware	Brad Walker	KG6MDU	Software
Larry Garvin	KB1QQM	Project management	Kevin Warren	AK4TX	ISDE Radiation Experiment
Braddock Gaskill	W3BCV	IHU card	Damon Wascom	KC5CQW	Test planning; SMD construction
Dan Habecker	W9EQ	RF design and testing	Melanie Wascom	KF5TNK	PCB SMD construction
Mark Hammond	N8MH	STEM Education	Fred Weiser	WQ3M	Software
Alex Harvilchuck	N3NP	University Programs	Dan Welch	W6DFW	Mechanical machining
Bruce Herrick	WW1M	PCB Design	Bob Weller	AK4RO	ISDE
Bryan Hoyer	K7UDM	Battery Card	Aaron Young	KF5SKO	RF
Dick Jansson	KD1K	Thermal	Everett Yost	KB9XI	Batteries
Jim Johns	KA0IQT	Software	Jerry Zdenek	N9YTK	Consultant
Phil Karn	KA9Q	Software	**Fox-1 Advisors**		
John Klingelhoeffer	WB4LNM	RF card	Keith Baker	KB1SF	Project Management
Bryan Klofas	KF6ZEO	Systems engineering	Tom Clark	K3IO	Technical Advisor
Taylor Klotz	K4OTZ	RF	Andrew Glasbrenner	KO4MA	AMSAT VP Operation
Dale Kubichek	N6SJX	Test documents	Chuck Green	N0ADI	Electronic Hardware
Chris Lee	NT6D	RF	Lou McFadin	W5DID	Chief Engineer, ARISS
Zach Leffke	KJ4QLP	VT Camera	Bob McGwier	N4HY	Technical Advisor
Rich Lewis	KG6ZVC	Materials engineer	Stan Wood	WA4NFY	Antennas
Steve Lubbers	KE8FP	Software	**AMSAT's Future in Space**		
Joshua Lynch	KD0OPN	Command software	**What's next? Fox-1Cliff and Fox-1D in the first quarter of 2016 aboard Spaceflight's maiden flight of the SHERPA system on a SpaceX Falcon 9. Additional donor support is needed to offset the costs associated with the launch of Fox-1D in addition to Fox-1Cliff. RadFxSat/ Fox-1B** will fly with the Vanderbilt University radiation experiments expected in 2016. **Fox-1E** "Evolution" will carry a Mode J linear transponder. The transponder is planned to be 30 kHz wide and will also have a 1200 bps BPSK telemetry beacon. Launch opportunities are being developed. **Please visit www.amsat.org to support this launch, and help keep amateur radio in space.**		
Gilbert Mackall	N3RZN	Ground software			
Beau Martin		CNC machining			
Mike McCann	KB2GHZ	Software			
Brian McCarthy	N1ZZD	Software			
Norm McSweyn	N3YKF	NiCad Study; SMT assembly			
Dave Mynatt	KA0SWT	Assembly			
Bob Nelson	K2QPN	Power Supply Unit			
Kyle Owen	KK4ANG	RF			

3...2...1... Fox1-A Liftoff From Vandenberg!

Main payload of NROL-55 ready for launch. NRO Photo.



The P-POD containing Fox-1A and co-passengers have been mated with the Centaur upper stage of the Atlas V in preparation for launch from Vandenberg Air Force Base on October 8.

AMSAT Vice-President Engineeing Jerry Buxton, N0JY was on the panel at a NASA prelaunch briefing on Wednesday, October 7.

Watch the replay on-line at:

https://www.youtube.com/watch?v=b6duPV3BwcY&feature=youtu.be

NROL-55 Mission Logo

NROL-55 loaded into fairing

Replay of the launch is posted at:

https://www.youtube.com/watch?v=drTslV7nR3w&feature=youtu.be

... more photos on page 18

Photo of Vandenberg Air Force Base's Space Launch Complex 3-East pad

The AMSAT Fox-1A cubesat is flying aboard the GRACE (Government Rideshare Advanced Concepts Experiment) mission as part of the NRO auxiliary payload that will carry a total of 13 CubeSats, nine sponsored by the NRO and four sponsored by NASA, to space. A United Launch Alliance Atlas 5 rocket, designated AV-058 lifted off from Vandenberg Air Force Base, CA. on October 8, 2015 from Vandenberg Air Force Base, California.

The NASA ELaNa Cubesats

- This launch will include the first launch of a CubeSat from Alaska and a tribal college.
- **ARC (Alaska Research CubeSat)** - University of Alaska Fairbanks -- Fairbanks, Alaska. The Alaska Research CubeSat (ARC) mission is a technology demonstration mission to increase the technology readiness level of the ARC subsystems and to provide NASA relevant data of the launch environment. Beyond validating the basic platform, two critical subsystems will be tested, (i) a novel low-power attitude control and determination system, and (ii) a communication system capable of high bandwidth data transfer. ARC is the first satellite designed, built, tested and operated by engineering and science students from Alaska.
- **BisonSat** - Salish Kootenai College, Pablo, Montana. The BisonSat mission is an Earth Science mission that will demonstrate the acquisition of 100-meter or better resolution visible light imagery of Earth using passive magnetic stabilization from a CubeSat. The science data, 33 km x 33 km color images with a resolution of 130 m, a few of which will be images of the Flathead Indian Reservation in northwest Montana, will be used primarily for engaging tribal college students and tribal communities in NASA's mission. BisonSat is the first CubeSat designed, built, tested, and operated by tribal college students.
- **Fox-1** - AMSAT, The Radio Amateur Satellite Corporation -- Silver Spring, Maryland. The Fox-1 mission is an education mission that will host a two-way FM communications transponder and an experiment payload allowing students to relay messages from Earth to space and back to other students somewhere on the planet requiring

Photo of the ELaNa XII mission patch

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

A premium collectable is available for qualifying donations to the Fox satellite program. AMSAT has commissioned a unique challenge coin for donors who have contributed at the $100 level or higher. This challenge coin is shaped as an isometric view of a Fox-1 cubesat, complete with details such as the stowed UHF antenna, solar cells, and camera lens viewport. Struck in 3mm thick brass plated with antique silver, and finished in bright enamel, the coin is scaled to be approximately 1:4 scale, or 1 inch along each of the six sides. The reverse has the AMSAT Fox logo.

Donations may be made via the:

- AMSAT website at **http://www.amsat.org**
- FundRazr crowdsourcing app at: **http://fnd.us/c/6pz92**
- AMSAT office at (888) 322-6728

only a simple walkie-talkie style radio combined with a small hand-held antenna.

- **LMRST-Sat (Low Mass Radio Science Transponder - Satellite)**; Jet Propulsion Laboratory -- Pasadena, California. The LMRST-Sat mission is a technology demonstration mission to provide a calibration source in Earth orbit to provide an order-of-magnitude improvement in X-Band deep space navigation (DSN) solutions and raise the technology readiness for a developmental model of the X-Band LMRST exciter. It will consist of a prototype X-Band LMRST and support bus electronics for purposes of calibrating the DSN X-Band navigation equipment. Current calibration methods are performed using sources in deep space that are limited by interplanetary media and ground based calibrations are limited by being in the near–field, too close to the ground, or expensive to replicate if airborne.

The NRO Cubesats

NRO's CubeSat Program Office partnered with the U.S. Army's Space and Missile Defense Command, NRO'S Communication Systems Directorate (COMM), NRO's Advanced Science and Technology (AS&T) Directorate, and the Aerospace Corporation to manifest and launch nine NRO-sponsored CubeSats.

Similar to NRO's previous CubeSat rideshares, GRACE will reach orbit on an ATLAS V rocket, mounted to the Aft-Bulkhead Carrier, located on the aft (or back) end of the Centaur-upper-stage.

The GRACE NRO-sponsored CubeSats were developed by Aerospace Corporation (AeroCube-5c and AeroCube-7), the Army's Space and Missile Defense Center (SNaP-3), Tyvak (PropCube) and SRI International (SINOD-D). These cubesats are:

- **AeroCube-5c and AeroCube-7** – technology pathfinders that weigh 1.5 kilograms each and will demonstrate tracking technologies, optical communications, and laser communication.

- **SNaP-3** – A total of three CubeSats, weighing 4.5 kilogram each, whose mission is to develop user software-defined radios to provide beyond-line-of-sight communication for disadvantaged users in remote locations.

AMSAT's Fox-1A application to the NASA CubeSat Launch Initiative was announced via an AMSAT News Service bulletin during November, 2011.

SB SAT @ AMSAT $ANS-324.06
AMSAT Submits Proposal to NASA for Fox-1 Satellite

AMSAT News Service Bulletin 324.06
From AMSAT HQ SILVER SPRING, MD.
November 20, 2011
To All RADIO AMATEURS
BID: $ANS-324.06

On Monday, Nov. 14, AMSAT submitted a proposal to NASA for their CubeSat Launch Initiative, also known as the "Educational Launch of NanoSat" (ELaNa) program. NASA selects projects that they deem to have merit in support of their strategic and educational goals. Projects that are selected will be able to enter into a collaboration agreement where NASA will cover the integration and launch costs of the satellite.

AMSAT, working with ARRL, highlighted the educational merit of the project including the incorporation of Fox-1 into the ARRL Teacher Institute seminars. ARRL also provided a letter of support for the project that was a key component of our proposal.

The Clay Center for Science and Technology at the Dexter and Southfield schools in Brookline MA, also provided a letter of support that was an important part of our proposal. The Clay Center noted that they use AMSAT satellites such as ARISSat-1 in their educational activities for K-12 students and that they look forward to making use of Fox-1.

The completed proposal, at 159 total pages, required a significant effort that was all done by volunteers. NASA will select from all of the submissions and announce the winning projects by January 30, 2012.

[ANS thanks AMSAT Vice-President of Engineering, Tony Monteiro, AA2TX for the above information]

AMSAT's Fox-1A acceptance into the NASA CubeSat Launch Initiative was announced via an AMSAT News Service bulletin during February, 2012.

AMSAT NEWS SERVICE
ANS-041 Special Bulletin

SB SAT @ AMSAT $ANS-041.01
ANS-041 AMSAT Fox-1 Cubesat Selected for NASA ELaNa Launch Collaboration

AMSAT News Service Bulletin 041.01
From AMSAT HQ SILVER SPRING, MD.
February 10, 2012
To All RADIO AMATEURS
BID: $ANS-041.01

Project ELaNa, NASA's "Educational Launch of NanoSat" managed by the Launch Services Program at the Kennedy Space Center, announced on February 10 that the AMSAT Fox-1 cubesat has been selected to join the program.

NASA will work with AMSAT in a collaborative agreement where NASA will cover the integration and launch costs of satellites deemed to have merit in support of their strategic and educational goals.

AMSAT President Barry Baines, WD4ASW said, "The ELaNa Launch opportunity marks AMSAT's return to space after the conclusion of the successful ARISSat-1/KEDR flight. We need to get the flight Fox-1, along with an operational flight backup satellite, built, integrated, tested, and delivered. Our ability to provide a spacecraft and get it launched is dependent upon the active support of our donors who wish to see Fox-1 fly."

AMSAT Vice-President of Engineering, Tony Monteiro, AA2TX noted this will provide a launch opportunity for AMSAT's next generation of FM repeater satellites with features and operation beyond the experience
of AO-51.

[ANS thanks AMSAT President Barry Baines, WD4ASW, AMSAT Vice-President of Engineering, Tony Monteiro, AA2TX and AMSAT's Project Fox Engineering team for the above information]

- **PropCube** – Two 1-kilogram CubeSats performing dual frequency ionospheric calibration measurements.

- **SINOD-D** –Two 2-kilogram CubeSats demonstrating software defined radio communications.

Earlier NRO-sponsored rideshare missions:

- **OUTSat** (Operationally Unique Technology Satellite) on NROL-36, in August 2012.

- **GEMSat** (Government Experimental Multi-Satellite) on NROL-39, in December 2013.

- **ULTRASat** (Ultra Lightweight Technology and Research Auxiliary Satellite) on Air Force mission, AFSPC-5, in May 2015.

The GRACE CubeSat Fact Sheet is available at:

http://nro.gov/WhatsNew/GRACE_CubeSat_FactSheet.pdf

Some History ... How We Got to Today

Fox-1A was designed to take advantage of large and growing interest in CubeSats. AMSAT developed a strategy to create a family of CubeSats that would be attractive for flying science missions which would enable partnerships with universities and apply for free launches as science missions. This provided a solution for being unable to fly due to exponentially increasing launch costs.

After the science mission, or even during the science mission, the satellite is capable of running its amateur radio transponder. The Fox Engineering Team arrived at a design which enables simultaneous amateur radio and scientific operations. The two operating modes for Fox-1 are:

- **Transponder Mode**, including
  - FM repeater
  - Telemetry/experiment data sent as sub-audible, low-speed FSK simultaneously

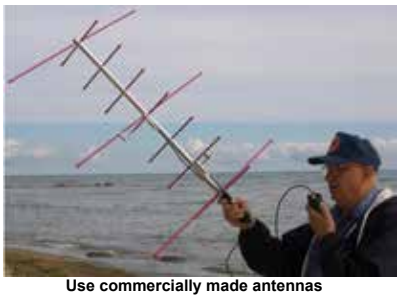
- **Data Mode**
  - High-speed data (9600 bps)
  - Science missions with high data/power requirements

Tony Monteiro, AA2TX (SK) led the Fox-1 Engineering Team from inception in 2009 and led AMSAT's efforts to apply for acceptance of Fox-1 in the NASA Education Launch of NanoSat (ELaNa) in 2011 and Fox-1B in 2012. He established relationships with several universities to secure scientific payloads for Fox-1A and Fox-1B, including student experiments. It was Tony that convinced the NASA ELaNa program to modify their qualification criteria to add "not for profits" to those that could apply for launch grants. Universities that were looking for ways to fly their payloads but didn't have the experience to build satellites, were encouraged into collaborations that would benefit both AMSAT and the university.

During Tony's tenure as VP Engineering AMSAT applied for launch opportunities with NASA's Educational Launch of Nanosatellites (ELaNa) as a "not for profit" organization which included collaboration with university projects. AMSAT announced our application in November, 2011. In February, 2012, NASA selected Fox-1A for an ELaNa launch. See the sidebar to the left for a copy of the AMSAT News Service bulletins.

In March, 2014, AMSAT President Barry Baines, WD4ASW appointed Jerry Buxton, N0JY, as AMSAT's VP-Engineering. Jerry had served as the Fox Team Systems Engineer since 2011. Barry noted, "When it became clear that Tony was not likely to recover from his medical issues, I started asking various AMSAT officers and several Fox Team members who should be considered to take the reins of AMSAT Engineering. The only feedback I received was that I should consider Jerry Buxton, N0JY."

The Fox-1 Cubesats are designed for amateur radio operation using low power and simple antennas ...



Use commercially made antennas
Photo credit: KB1SF

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

Fox-1 Operating Hints

- Use a small beam like the Arrow Antennas Yagi or Elk log periodic, clear of obstructions.
- Select the 67. 0 Hz PL/CTCSS for transmit
- AMSAT recommends to use no more than 5 watts with a modest gain antenna
- Open your Squelch all the way
- Use a combo headphone/boom mike to reduce feedback/echo (and give you a free hand)
- Use a printout or your laptop, smartphone or tablet to track the satellite path over your QTH
- Apps include Satellite Explorer Pro (iOS) and AmsatDroidFREE (Android)
- Have an audio recorder to log the QSO (it is difficult to talk, point the antenna, do PTT operation, remember the callsign, and think - all at the same time)
- Set your transmit and receive frequencies in memories to make tuning easier
- Twist the antenna as the pass progresses to improve signal strength

The CubeSat concept was originally proposed by Stanford University Professor and AMSAT member Bob Twiggs, KE6QMD. He and Professor Jordi Puig-Suari of Cal Poly collaborated and published the CubeSat Design Specification. Their main purpose was to try to reduce launch costs so that university students could participate in the development and operation of a real, albeit tiny, satellite.

Tony Monteiro, AA2TX, in an article, "AMSAT Fox CubeSat Program Update", published in the July/August 2011 AMSAT Journal wrote, "While AMSAT has pioneered the development of small, low-cost satellites, the CubeSat concept takes this idea even farther (and smaller!). Our AO-51 satellite is a relatively tiny 10-inch cube that weighs less than 25 pounds. A basic CubeSat on the other hand is an even smaller 4-inch cube and weighs less than 3 pounds. AMSAT has adopted the CubeSat idea for our next satellite project to take advantage of the low launch costs. The small size however, does pose some interesting design challenges. The AMSAT Board of Directors approved the Fox satellite project in late 2009, but with ARISSat-1 development still in full swing, it had to be deferred."

Tony continued, "Just a few days after completion of ARISSat-1, the Fox program was started. Several of us met at the 2010 Space Symposium and got together to discuss ideas. Over the next several weeks, these ideas were further developed and finally formalized in a System Requirements Specification document in January of this year [2011]. The spec incorporated many ideas that had never been tried before on a (1-Unit) CubeSat. These included deployable solar panels, an advanced power system, a high-performance processor, a LINUX-based operating system, a software upload capability and a software-defined transponder (SDX) that could support linear and digital modes. Since the battery in AO-51 was known to be having problems, the specifications also included a hardware, analog FM transponder so the Fox satellite could be flown as an eventual replacement for AO-51."

Thermal issues needed to be overcome and were handled by Dick Jansson, KD1K, and Bob Davis, KF4KSS. The Internal Housekeeping Unit (IHU) design was based on the TI OMAP-3 processor, which was developed for use in new smart cell phones.This chip specifically designed for battery power operation. The IHU was to handle control functions and a software defined transponder (SDX) capability. It soon became clear that due to the radiation, error-correcting RAM would be required to make this work. This adds significant complexity to an already challenging design but Bdale Garbee, KB0G, and Keith Packard, KD7SQG, agreed to take on this challenge. In May, 2011 Alan Biddle, WA4SCA also joined the radiation effects analysis team.

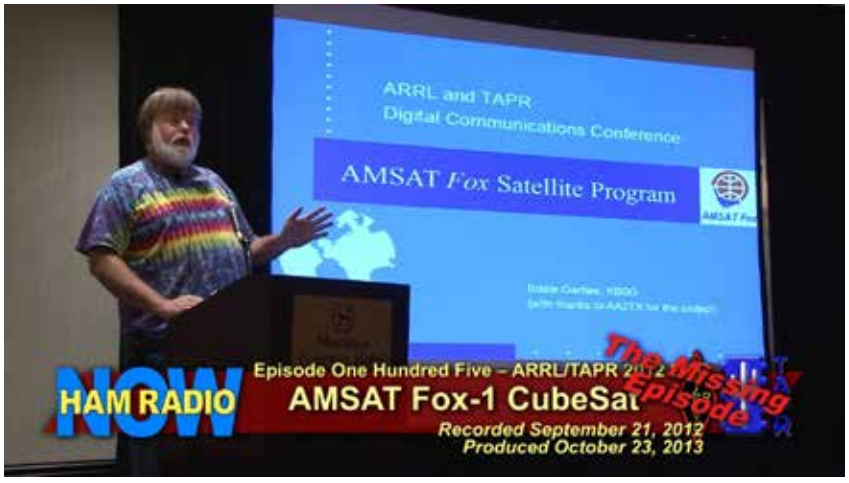
The primary mission of the Fox-1 satellite was to provide a wide-area, Amateur Radio communications capability that can be accessed using very simple ground station equipment such as a handheld FM transceiver paired with a small, handheld beam antenna. This is our intended replacement for AO-51.

Tony wrote,"In our power baseline analysis, we found that we would have enough power to run a basic FM transponder without requiring deployable solar panels. Eliminating the panels significantly simplifies both the mechanical design of the structure as well as the power system electronics."

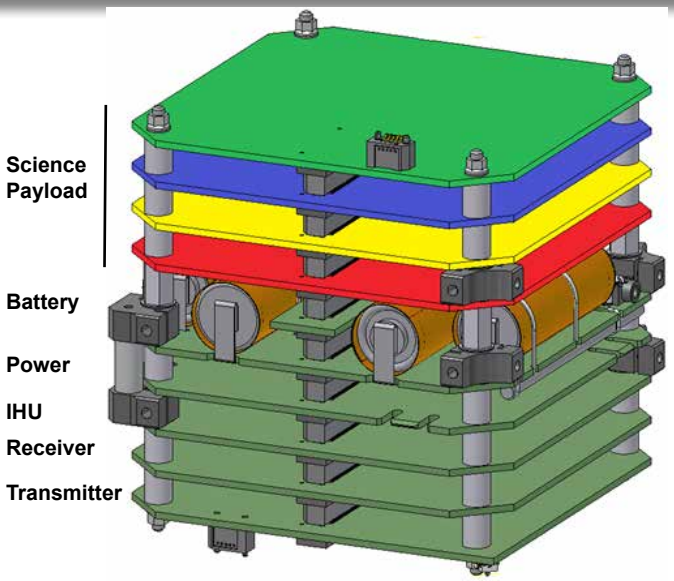
Other key design decisions included:

- To maximize the effectiveness of the power available, Fox-1 will use 2 m for the downlink and 70 cm for the uplink. The lower path loss on 2 m will make the satellite quite a bit easier to receive than if 70 cm were used and the uplink will still be sensitive enough to allow access with only an HT driving a hand-held beam.
- Providing only an FM transponder will allow the use of a high-efficiency, class-C, RF power amplifier and further optimize the use of the limited power available.
- We expect to be able to provide at least 400 mW EIRP on the downlink.

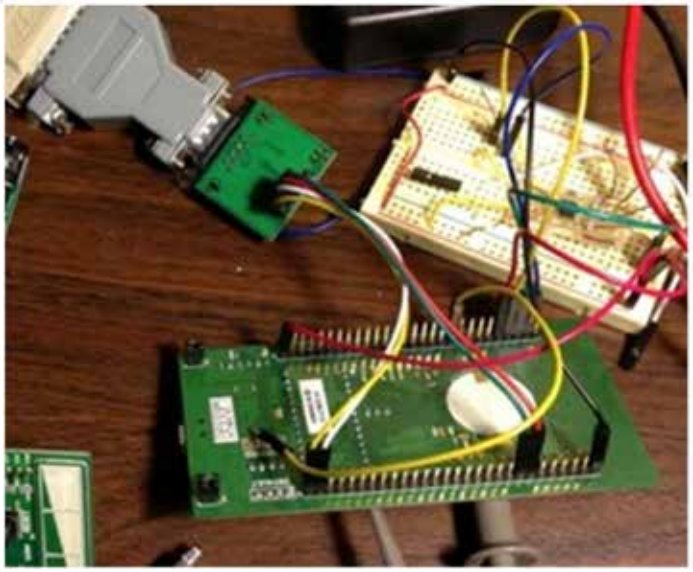
Watch the Fox-1 Status Update, by Tony AA2TX presented at the 2013 Dayton Hamvention
https://www.youtube.com/watch?v=Gub5182mowg



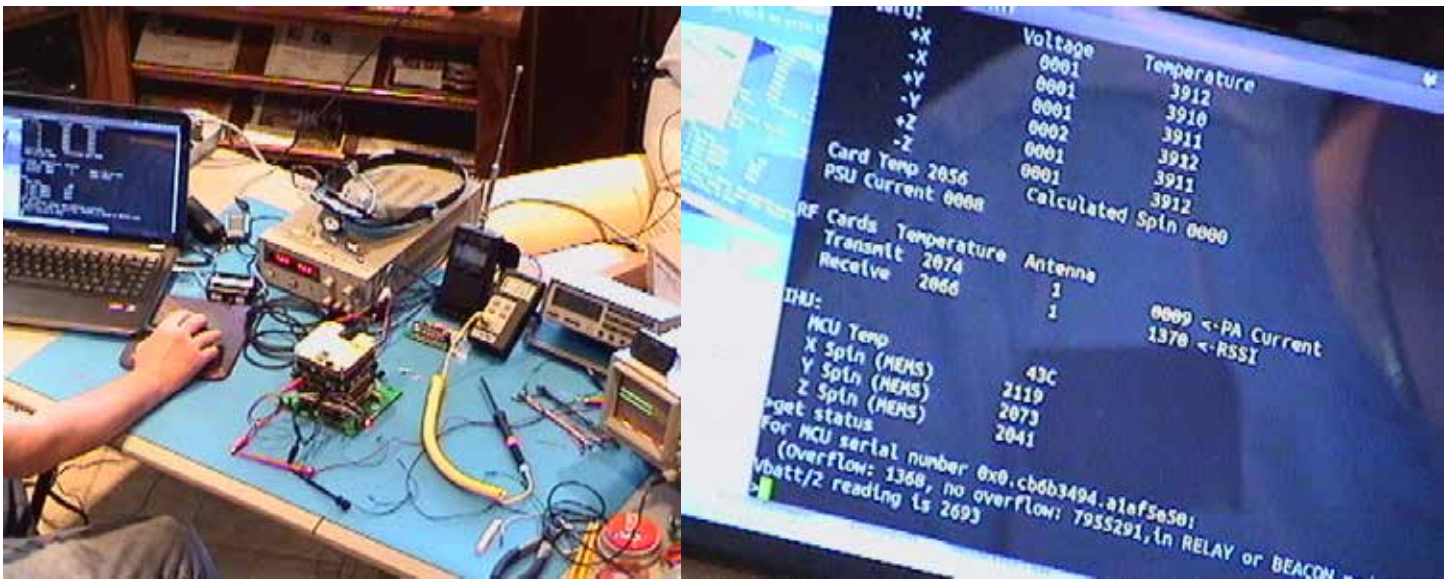
Watch Bdale Garbee, KB0G talk about Fox-1 at the 2012 ARRL/TAPR Digital Communications Conference
https://www.youtube.com/watch?v=14eVqY96uZk



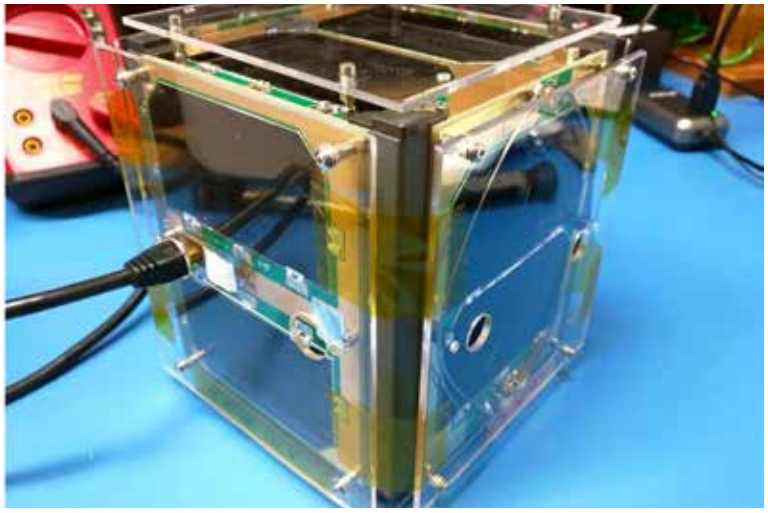
Fox-1 Stack: 400 mW TX downlink on 2M, 70 cm RX, IHU with 32-bit processor, 128K program memory, 16K RAM, 128K MRAM to store telemetry and experiment data.



Board design and prototyping proceeded from rat's nest testing to PC boards to a build up of the Fox-1 stack for the Engineering Prototype.



The Fox Engineering Team developed the ability to do the work in a virtual engineering environment with the team having access to multiple PCs, telephones, GoToMeeting online teleconferencing, and file sharing, and the FoxCam allowing a view into the Fox Labs located in N0JY's shack in Texas.



Fox-1A sporting her final set of solar panel covers ready for the P-POD.

AMSAT Vice President Engineering, Jerry Buxton, N0JY with the Fox-1 model.

Fox-1C Named Fox-1Cliff

Cliff Buttschardt, K7RR (SK)

Long time Project OSCAR and AMSAT member Cliff Buttschardt, K7RR, passed away on July 30, 2006 at age 75. Project OSCAR awarded Cliff their Lifetime Achievement Award (their highest honor) to him just days before his passing for his contributions to amateur radio.

Cliff served as an advisor/mentor to students building cubesats at Cal Poly. Cliff also served as an Area Coordinator as part of the AMSAT Field Operations Team.

Cliff's wife, Mable Vierthaler passed away in 2013. Both AMSAT and ARRL were notified that they were designated as beneficiaries of the Trust that they had established. Both organizations received similar amounts from the Trust, with AMSAT receiving the initial distribution in mid-July. The initial distribution to AMSAT was around $270,000.00.

Given Cliff's interest in cubesats, the consensus of the Board is to change the designation of Fox-1C ("Charlie") to "Fox-1C ("Cliff") and to have the voice identification of the satellite utilize the new designation. Veronica Monteiro, the "voice" of Fox-1A and daughter of former AMSAT VP-Engineering Tony Monteiro, AA2TX (SK) recorded a voice identification announcement for the satellite, "Hi. This is amateur radio satellite Fox-1 Cliff".

When Fox-1 Cliff is placed in orbit, it will be a fitting recognition of an avid AMSAT member and generous husband and wife team who took steps to help provide the resources to keep AMSAT moving forward. AMSAT is humbled by Cliff and Mable's generosity.

Support AMSAT

New Version!

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.

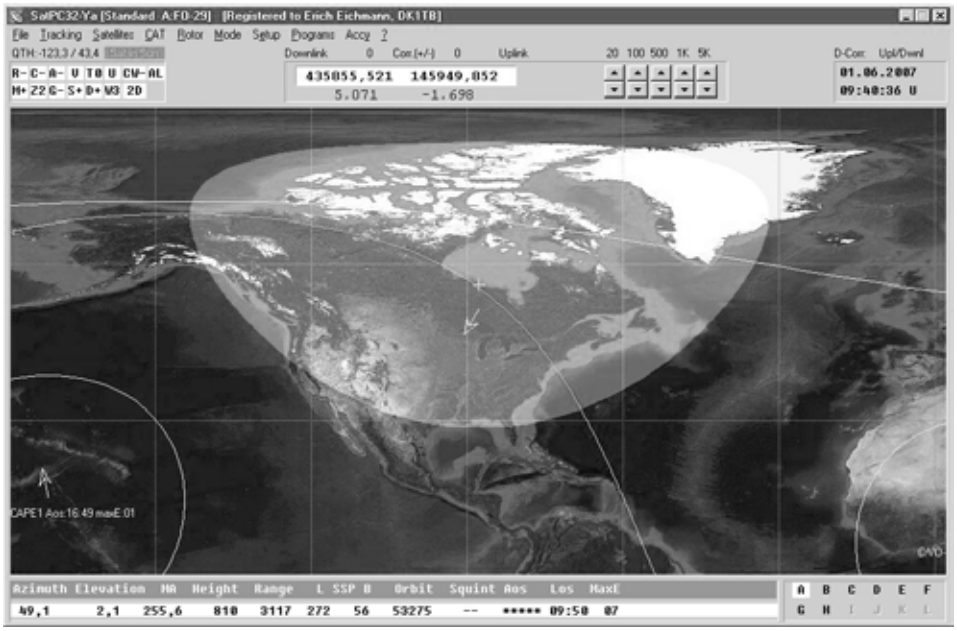
Version 12.8c is compatible with Windows 7, 8/8.1 & 10 and features enhanced support for tuning multiple radios.

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.



Environmental testing was the final step of the actual construction and testing of the Fox-1 flight unit and it took place the week of January 18 in Orlando, FL. Team members Bob Davis KF4KSS (mechanical engineer), Burns Fisher W2BFJ (software engineer) and myself with Fox-1 in tow were all involved in the final measurements, preparations, testing, and post-testing over a 5-day period. It started Tuesday morning in a hotel room where the necessary measurements and steps were performed to put Fox-1 in the TestPOD, a 1U P-POD type device designed for use in the vibration testing. Arriving at the facilities of Qualtest that afternoon we found that another customer was still underway on the vibe table so we spent the afternoon getting to know the Qualtest folks and the facility. Wednesday morning we were back and performed the vibration tests. Fox-1 had to be subjected to vibrations of up to a little over 22G and in all three X, Y, and Z axes in order to satisfy the CubeSat to P-POD ICD requirements that our little CubeSat would not fly apart during launch and harm the primary payload or launch vehicle. The photo shows the brief celebration when Fox-1 passed her Short Function Test and Aliveness Test after that major shakedown!

Once vibe testing was done the Thermal Vacuum Bakeout began on Thursday with a 12 hour pre-soak bringing the temperature to 50° C. at a vacuum of less than 50 milliTorr which is as low as the roughing pump would handle. This was necessary to remove any major contaminants prior to performing the ICD required bakeout to avoid damage to the ion pump, which is used to bring the vacuum chamber pressure down to the level needed for qualification. Fox-1 was not in the Test POD for this procedure. After coasting overnight we began the required bakeout very early Friday morning and brought Fox-1 up to 60° C. and the pressure below $1x10^{-4}$ Torr for six hours to bake out any contaminants in and on the components and structure so that they would not become a problem when Fox-1 hits the vacuum of space. Friday night it was done. We performed the Short Functional Test and Aliveness Test one final time then put Fox-1 "in the bag" to come home with me – an anti-static bag where she will remain except for occasional battery charging until delivery and integration, to keep her "generally clean."

The Fox-1 Mission Readiness Review (MRR) was held February 24 at the SRI facility in San Luis Obispo, CA. With NASA, NRO, SRI, Cal Poly, and Tyvak representing the review board, AMSAT and the four other ELaNa XII satellites each underwent about a two hour review. The purpose of the review is to present the evidence and documentation that shows that each of the requirements of the CubeSat to P-POD ICD (interface control document) are satisfied. These requirements are designed to protect the primary payload, launch vehicle, and other CubeSats on the mission. The flight readiness and operations plan are also reviewed to look at the mission success of the individual satellite, and significant anomalies are reviewed to understand the challenges faced by each team.

NASA requires their ELaNa satellite teams to be on site for the MRR and it is a good opportunity. Being in the same room with your mission sponsors and the launch service provider teams and having the opportunity to ask as well as answer questions makes for a very comfortable and complete review.

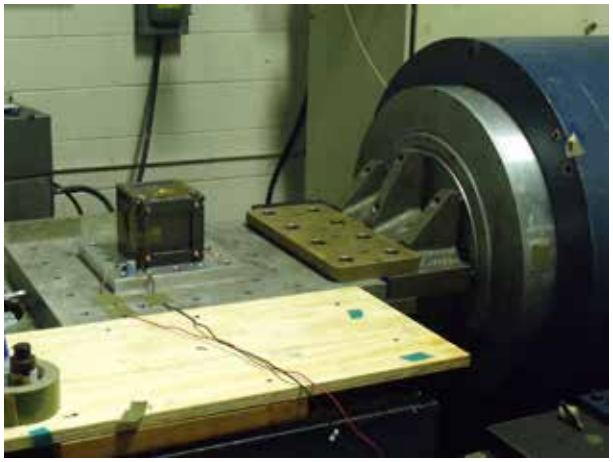
There is no "final outcome" from the review. As the word implies it is an opportunity to go over all of the requirements and each team, as well as the review teams, came away with action items to take care of in order to submit a final review. That will then be passed up the chain to the launch provider so that they can be aware of the status of their "hitchhikers."

The Fox-1 environmental test team: Jerry, NØJY; Bob, KF4KSS; and Burns, W2BFJ, celebrate passing the Short Function Test and Aliveness Test at the conclusion of 3-axis vibration testing with acceleration up to 22 G. The five day test period also included thermal-vacuum testing to very low pressure and high temperature in order to remove any contaminants left over from construction and handling.

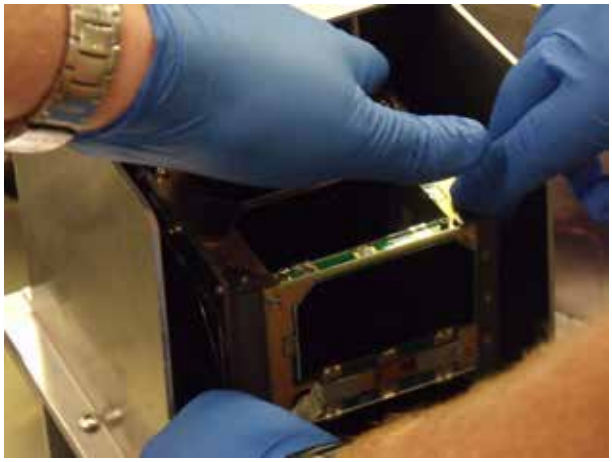
Jerry Buxton, N0JY presenting Fox-1 during the Mission Readiness Review (MRR) which was held February 24 at the SRI facility in San Luis Obispo, CA.

Fox-1A Flight Model Passes Pre-flight Environmental Testing
Ready for Launch!

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



The Fox-1A Flight Model mounted to the vibration table for the X-axis phase of the 3-axis vibration testing. The test produces high G force vibrations that emulate the expected accelerations that will be experienced during launch.



Fox-1A shown under preparation for thermal-vacuum testing to very low pressure and high temperature in order to remove any contaminants left over from construction and handling.

Fox-1A shown under preparation for thermal-vacuum testing with (L-R) Steve, the Qualtest operator, and Jerry Buxton, N0JY.

Shown monitoring the Fox-1A thermal-vacuum testing are (L-R): Lou McFadin, W5DID; Bob Davis, KF4KSS; Burns Fisher, W2BFJ; and Steve, the Qualtest operator.

Fox-1A has passed all tests and is literally in the bag, ready for launch!

Fox-1A Delivery and Integration

And this is not so much an end but also the beginning of the rest of the Fox-1 Project. Fox-1 delivery and integration took place the week of March 23.

The AMSAT Engineering Team is already busy working on Fox-1Cliff and her flight spare Fox-1D for launch later this year. Fox-1D will be fully tested and ready to step in right up to launch integration should Fox-1Cliff suffer a mishap. And Fox-1D will also be truly "on the shelf" ready for handover on other launch opportunities that are on our radar. That saves AMSAT money not only on the Spaceflight launch of 1Cliff (as standard practice, we have to pay whether we launch a satellite or they launch a mass simulator in our place) but on the testing which can take place for both in one trip, reducing travel expenses. We will then have three fourths of the Fox-1 series done 3Q this year with only Fox-1B "RadFXSat" left to finish for a launch which is tentatively on the calendar for July 2016.

Fox-1A waits for the October 8, 2015 launch. Please remember that the launch is an NRO/OSL classified mission so they're not giving detailed information. It will be likely that Keplerian elements will not be available until just prior to, or perhaps even after, the launch. We will make them available as soon as we are given permission!

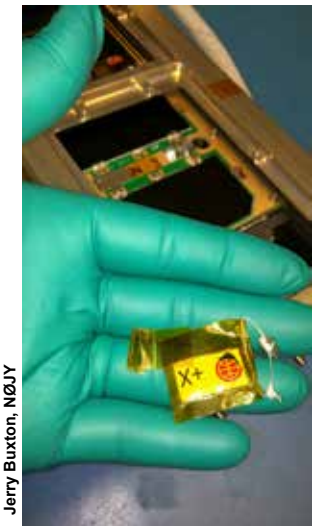

Justin Foley, KI6EPH

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

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

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

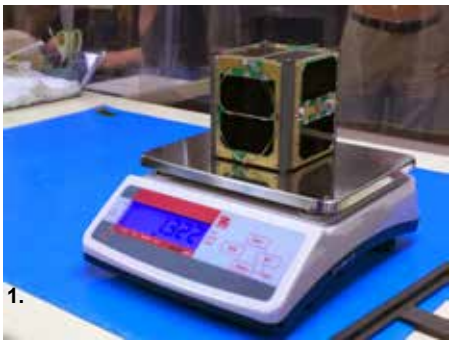

Jerry Buxton, NØJY


Jerry Buxton, NØJY

(left) Fox-1A integrated with the P-POD deployment canister.

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

AMSAT Vice President Engineering, Jerry Buxton, N0JY in clean room gear during Fox-1A integration.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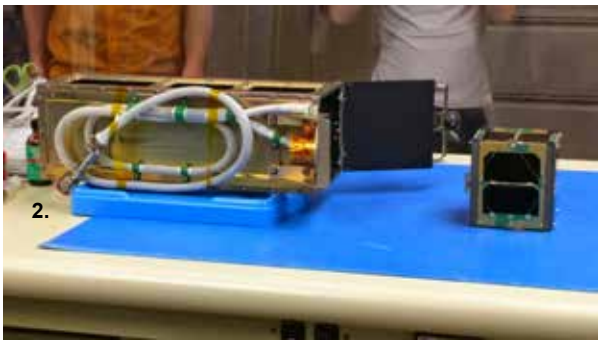
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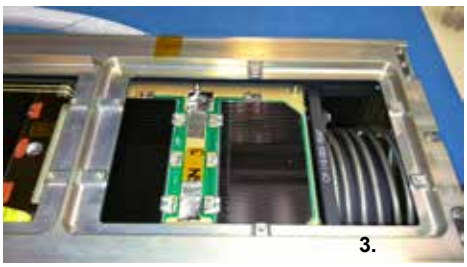

3.

More photos from the Fox-1A cubesat integration at Cal-Poly in San Luis Obispo, California during the week of March 23, 2015.

Photo 1. Acceptance testing included meeting mechanical specifications such as weight, length, width, height.

Photo 2. Fox-1A ready to be loaded into the P-POD cubesat deployer.

Photo 3. When a control signal releases the trap door on the front of the P-POD the internal spring pushes the cubesats out into space.

Operating Tips When You Operate on Fox-1A

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

- Grid square, or
- Latitude and longitude, or
- If using a computer tracking program, you'll need to load tracking data, called Keplerian elements, into the software. Initially, we'll recommend the web until you have had a chance to learn more.

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

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

Fox-1A Characteristics	
NASA catalog number	TBD post launch
Launch	Atlas 5, NROL-55, Vandenberg AFB, CA
Orbit	LEO (Low Earth Orbit)
Inclination	64°
Eccentricity	0.200
Period	97 minutes
Estimated orbital lifetime	5+ years
Altitude	~470-780 km (~295-490 miles)
Size	10 x 10 x 10 cm (4 inch cube); 1.3 kg (~3 pounds)
Transmit power	400-800 mW
Downlink	145.980 MHz FM voice FSK digital data up to 9600 bps
Uplink	435.180 MHz FM voice 67.0 Hz PL (CTCSS)

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

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

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

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

Tuning for Doppler Shift

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

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

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

Suggested Fox-1 Basic QSO Tips

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

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

FoxTelem Software for Windows, Mac, & Linux

Chris Thompson, AC2CZ/G0KLA
g0kla@arrl.net

The Fox Telemetry Decoder is being released to demodulate, store and analyze telemetry data from AMSAT's Fox series of CubeSats. We hope that you will also upload the telemetry you receive to the AMSAT server so that it can be used by other Amateur Scientists and our research partners, whose experiments fly with the Fox satellites.

FoxTelem is experimental. We are sure it can be improved. Please send me your feedback and suggestions.

Fox-1 satellites include two telemetry formats:

- Slow Speed, also called Data Under Voice (DUV) is 200 bps FSK data sent at the same time as the transponder audio. Whenever the transmitter is on, data is being sent. This happens during beacons and during live QSOs.
- High Speed is 9600 bps FSK sent instead of the transponder. This is used for data intensive experiments such as the Virginia Tech Camera and the University of Iowa HERCI experiment. This is only active when commanded from the ground. You can recognize High Speed because it sounds like an old school computer modem.
- FoxTelem will receive and store both formats assuming you can feed it audio that does not have the frequencies below 200 Hz filtered. For High Speed, the audio must also extend to include the full 9600bps bandwidth of the FM signal. For both modes this is best achieved from a Software Defined Radio or from the 9600 bps packet port of some radios. See the user guide for more details.

Downloading the Program

You can download FoxTelem from the AMSAT web page:

http://www.amsat.org. Select Fox Project –> FoxTelem Software for Windows, Mac, & Linux

from the menu at the top of the page for access to these versions

- FoxTelem for Windows
- FoxTelem for Mac
- FoxTelem for Linux

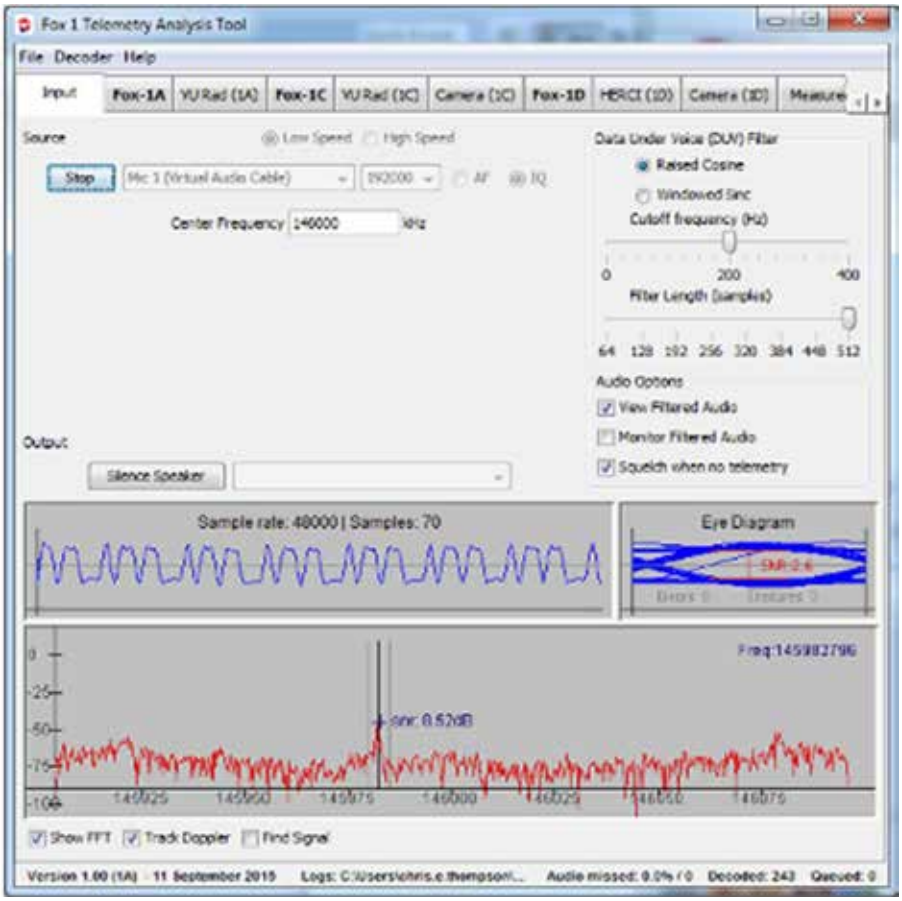


Figure 1: FoxTelem IQ screen

The User Guide for all versions is also available from the download page. This contains instructions regarding interfacing the program to your radio, software setup, operation, and troubleshooting..

FoxTelem is written in Java, so you need to have Java installed. Is is available from

http://www.java.com

Installation Instructions

FoxTelem is supplied as an archive file (.zip on windows or Mac, and .gzip on Linux). You can unzip the contents and put it in the directory of your choice. Right on the desktop works well, as does somewhere in your home directory or documents directory. If you install it into the Mac Applications folder or into the Windows Program Files folder (or any other folder that is not writable by the application), then you will need to choose a different directory to write the decoded data into. You can do this the first time you run the program.

Running FoxTelem

Run FoxTelem by double clicking FoxTelem.exe on Windows or the Application file on MacOs. On Linux, you should be able to double click FoxTelem.jar. If you can't, then right click, Properties, and change the Open With to be the Java runtime environment.

When FoxTelem starts then you should have the Welcome screen shown (Figure 2). The Simple install will use the installation directory to store the decoded data. This keeps everything in one place, but mixes the program with its data. If you want to write the data to another directory, choose **Custom**, click **Continue** and specify the directory on the next screen.

Further instructions are available in the manual, which is in the installation directory and accessible from the *Help* menu.

If FoxTelem does not start

FoxTelem will not start if you do not have java installed, or have a version before Java

6. You will get a message from the launcher telling you to download and install the latest version from java.com.

If you get an error message from Windows Smartscreen (Figure 3), then click "More Info" and then "Run Anyway". Windows gives this message for new or little known applications that have not established a reputation.

MacOS has similar security precautions and will give you a message as shown in Figure 4.

FoxTelem is not really damaged and it can in fact be opened. You can hold the "Command" key while you double click the application and it will run. After that it will run without the Command key. This message is displayed because your "Security and Privacy" settings do not allow applications that are not installed from the Mac App Store.

If you are on Windows and the program complains that it is missing MSVCR100. dll or something similar to that, then you need to install the Microsoft Visual C++ redistributable:

- Visual C++ for 32 bit windows **http://www.microsoft.com/en-us/download/details.aspx?id=5555**
- Visual C++ for 64 bit windows **http://www.microsoft.com/en-us/download/details.aspx?id=14632**

If you do not know if you have 32 or 64 bit windows then Open System by clicking the Start button, right-clicking Computer, and then clicking Properties. Under System, you can view the system type.

If you are using MacOS 10.7 or later and you get the message shown in Figure 5, then follow the instructions and install Apple's "legacy" version of Java.

FoxTelem is written and compiled with the latest version of Java (Version 8 in Sept 2015) but it is compliant with Java 6 so that it works on older Mac operating systems. On other platforms you can run FoxTelem with any versions of Java from Java 6, but Apple and Oracle have not made this simple on the Mac.

If FoxTelem still won't start, then see the troubleshooting section at the end of the manual or ask for help on the amsat-bb mailing list.

Figure 2: Welcome screen prompt to select installation directory

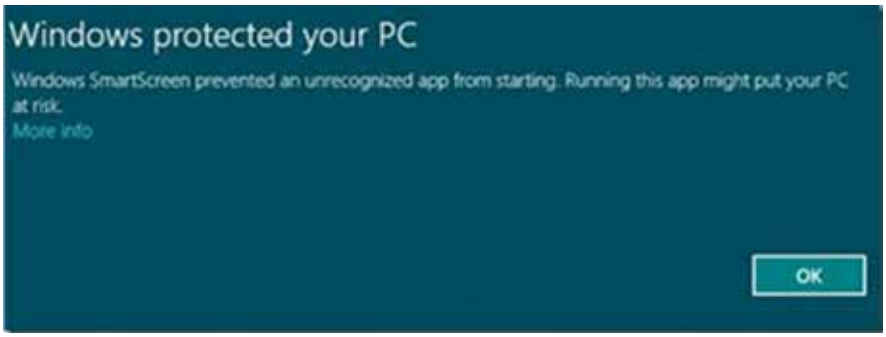


Figure 3: Windows Smartscreen message

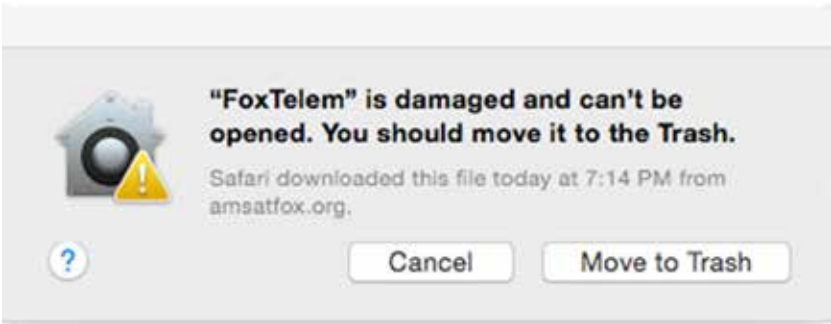


Figure 4: MacOS security message

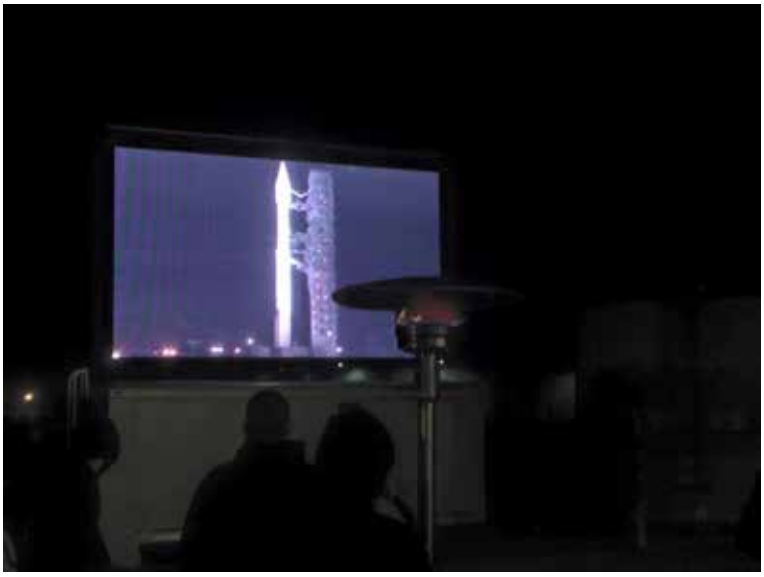
Figure 5: MacOS update Java message

The source code for FoxTelem is released under the GNU General Public License at: https://github.com/ac2cz/FoxTelem

... continued from page 5

Liftoff of the United Launch Alliance Atlas V NROL-55 mission with Fox-1A aboard. (ULA photo)

View of the liftoff from the ULA Hangar at Vandenberg AFB which hosted a viewing party for the flight participants. (N0JY photo)

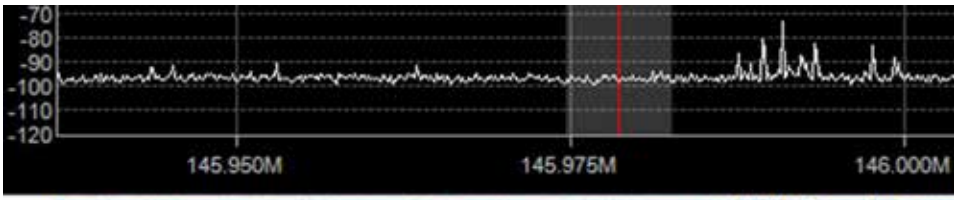


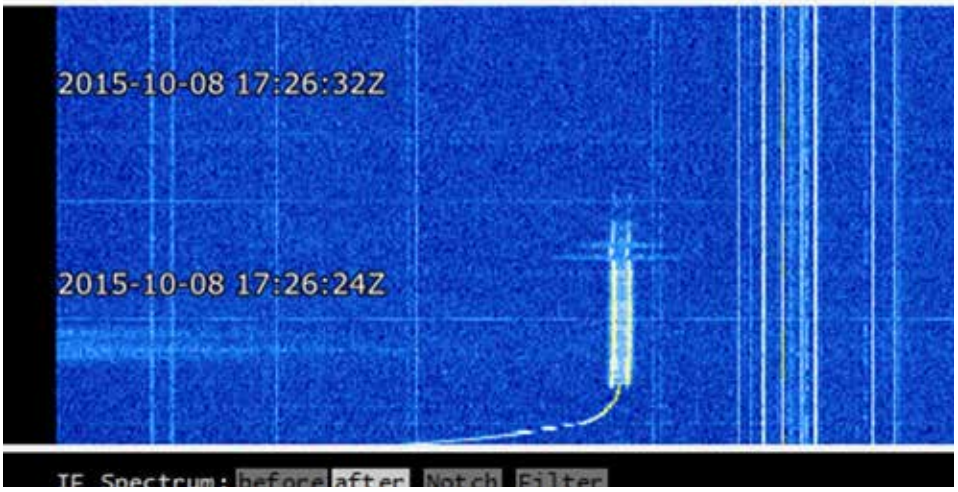
View of the liftoff from the ULA Hangar at Vandenberg AFB with the large screen TV. (KB1LQC photo)

(right) View of the launch pad just prior to liftoff. (NRO photo)

(below, right) James, WX4TV, posted this photo of his children watching the launch. Shown are: WX4TVJ, Zechariah; AE4FH, Faith Hannah; KM4IPF, Hope; and a sister who will be licensed soon. (WX4TV photo)

(below, left) The view below from a booster camera just after liftoff. (NASA Spaceflight photo)





Jan Gils, PE0SAT, reported that FOX-1A was active over Europe during the first orbit. (PE0SAT via Twitter)

What's next after Fox-1A?

- Fox-1B will fly with the Vanderbilt University radiation experiments expected in 2016.
- Fox-1C will launch on Spaceflight's maiden mission of the SHERPA multi-cubesat deployer planned for the 1st quarter of 2016. U- and L-band uplinks with the VHF band downlink will be available.
- Fox-1D will launch with Fox-1C. It will include the University of Iowa HERCI experiment. IA Virginia Tech camera will also be included. U- and L- band uplinks with the VHF band downlink will be available.
- Fox-1E "Evolution" will carry a Mode J linear transponder. The transponder is planned to be 30 kHz wide and will also have a 1200 bps BPSK telemetry beacon. Launch opportunities are being developed.

Looking forward to what is next after the Fox-1 program AMSAT and Virginia Tech are engaged in two different potential payload opportunities that will have significant impact on the Amateur Satellite Service. The first is the Geosynchronous Orbit (GSO) opportunity to place an amateur radio payload on a US Government spacecraft. This will feature a 5 GHz uplink/10 GHz digital downlink signal that will provide up to 100 "channels" for the transmission of digital content, including voice and data. A ground station design will be developed in conjunction with the satellite payload.

AMSAT submitted a "Request for Proposal" (RFP) to Millennium Space Systems (MSS) on September 16, 2015 to conduct the "Payload Accommodation Study" which must be completed in order to determine the feasibility of adding the amateur secondary payload to the host spacecraft before the US Government will agree to allow an amateur payload to be placed on their spacecraft. The study will look at all aspects of placing an amateur payload on this spacecraft, such as the physical placement of the payload on the spacecraft, electrical accommodations including development of a preliminary Interface Control Document (ICD), and determination of technical risk with the addition of this payload to the spacecraft.

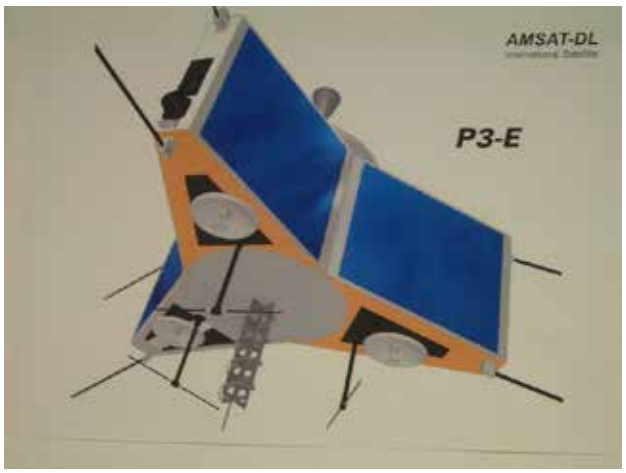
AMSAT has agreed to provide $100K in funding to cover the cost for MSS to conduct the Payload Accommodation Study. While AMSAT does have the funds on hand to cover this expense, we do need to raise additional funds to recover this amount in order to have funds available for other potential needs. Please consider a donation to AMSAT to help offset this outlay.

The other project that AMSAT and Virginia Tech are collaborating on is the Phase 3-E Highly Elliptical Orbit opportunity that was announced in July. Virginia Tech under the direction of Bob McGwier, N4HY Director-Research at the Hume Center for National Security and Technology, is in negotiations with a US Government agency to fly P3-E as a research satellite with an extensive amateur radio capability. While it appears that there is serious interest in conducting this mission, at this point it is too early to know whether the Government will be in a position to provide the funding to support their research and accommodate their requirements as well as provide the launch direct to HEO.

It does appear that funding to support the development of the amateur radio portion of the spacecraft will fall on the amateur radio community. While P3-E was substantially developed by AMSAT-DL, that development work was essentially halted around 2006. Given the advances in technology since that time and the likely obsolescence of major P3-E subsystems, it is appropriate to evaluate the need to replace what has been built previously with current designs and systems availability. The actual bands to be flown are yet to be determined since it is unclear at this point how much "real estate" will be occupied by the Government's equipment versus amateur radio, along with the associated power budget considerations and other constraints.

AMSAT and Virginia Tech met in Blacksburg, Virginia on October 2-4,to "kickoff" the P3-E project as well as discuss the GSO opportunity. I anticipate that the results of those meetings will be discussed at the AMSAT Space Symposium in Dayton. Having face-to-face meetings will enhance the level of cooperation between the two organizations, define respective roles and responsibilities, create an opportunity to initially define milestones and timelines, and initiate the statements of work. In addition, a discussion of the concepts of operations and look at the two projects from both a technical and satellite user perspective will be important. A key concern for both organizations is to understand the resource requirements of conducting both projects simultaneously and for AMSAT and VT to define how AMSAT engineering volunteers will interact with VT on these projects.

Geosynchronous Opportunity AMSAT is working on a potential rideshare launch with Virginia Tech and Millennium Space Systems



P3E - We're also working on a highly ellipcal orbit launch with Virginia Tech and a government partner.

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.

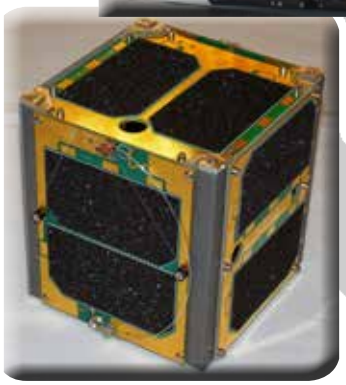
Fox-1Cliff and Fox-1D will provide selectable U/V or L/V repeater capabilities on separate frequencies once in orbit, and will be capable of downlinking Earth images from the Virginia Tech camera experiment.

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
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	❒	$2400 one time
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	❒	$1200 one time
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	❒	$600 one time
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	❒	$300 one time
Core Donors contribute at least US $10 per month	❒	$10 / month
	❒	$120 one time

We hope you've enjoyed this *AMSAT Journal* free special edition downloaded issue to celebrate the launch of Fox-1A

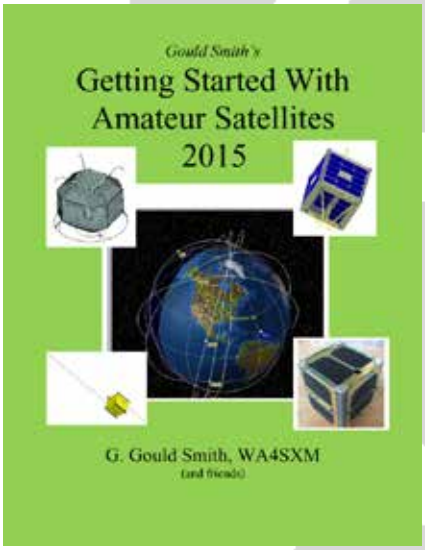
Are you a member of AMSAT?

We invite you to join amateur radio in space ... join AMSAT ...

AMSAT® is dedicated to keeping amateur radio in space. Its membership includes a worldwide group of radio hams who monitor amateur radio satellite signals and use satellites for QSOs. They also design and build the satellites, and control them once in orbit.

Since 1961, more than 80 amateur radio satellites have successfully reached orbit and begun operation. 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 Low Earth Orbiting satellites developed in cooperation with the educational community and other amateur satellite groups.

Both you and AMSAT will benefit when you join. You get the AMSAT Journal bi-monthly and support from AMSAT Area Coordinators. Member dues and donations provide AMSAT's primary support.



Fox-1A Launch New Member Special Offer

For a limited time new memberships received via the on-line AMSAT Store receive a free downloaded copy of our book, "Getting Started With Amateur Satellites 2015" ... a $15 value.

Join today at: http://store.amsat.org

Plus you'll also receive ...

Your membership includes the AMSAT Journal mailed to our members six times a year bringing you 32 pages of articles on satellite operation, news of amateur satellites, and technical data about current satellites. You'll also read about satellite development, satellite history, ground stations, antennas, hardware development, software defined radio, VHF, UHF, and microwave operating applicable to satellite operations. You'll also read about STEM activities, ARISS, and satellite operating photos.

The Radio Amateur Satellite Corporation - AMSAT

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