

ENGINEERING UPDATE

Jerry Buxton, NOJY VP Engineering



FOX-1 PROGRAM

5 built: 4 launched, 1 ready



AO-85 (FOX-1A) LAUNCHED 8 OCTOBER 2015

- Orbit:
 - 504 x 796* km @ 64.8 degrees inclination
- Radio:
 - FM repeater, 600 mW average output
- Experiments:
 - Vanderbilt University radiation effects 1 EXP slot
 - Penn State Erie designed MEMS gyro spin/wobble
- Status:
 - Off, activation likely only during full sun orbit periods (AMSAT Operations team)
 - Battery failing, likely due to high temperatures from full sun orbit periods and overstressed conditions during construction



AO-91 (RADFXSAT/FOX-1B) LAUNCHED 18 NOVEMBER 2017

• Orbit:

- 461 x 824* km @ 97.7 degrees inclination
- Radio:
 - FM repeater, 600 mW average output
- Experiments:
 - Vanderbilt University radiation effects primary all 4 EXP slots
 - (Penn State Erie designed MEMS gyro spin/wobble)
- Status:
 - Nominal, continuous operation



AO-92 (FOX-1D) LAUNCHED 12 JANUARY 2018

• Orbit:

- 490 x 505* km @ 97.5 degrees inclination
- Radio:
 - FM repeater, 600 mW average output
- Experiments:
 - University of Iowa HERCI (partial operation)
 - Virginia Tech jpg Camera, 320 x 240 pixels
 - AMSAT L band Downshifter mode L/v operation (AMSAT Operations team)
 - (Penn State Erie designed MEMS gyro spin/wobble)
- Status:
 - Nominal, continuous operation



AO-95 (FOX-1CLIFF) LAUNCHED 3 DECEMBER 2018

• Orbit:

- 560 x 582* km @ 97.8 degrees inclination
- Radio:
 - FM repeater, 600 mW average output
- Experiments:
 - Vanderbilt University radiation effects 1 slot (Fox-1A flight spare)
 - Virginia Tech jpg Camera, 640 x 480 pixels
 - AMSAT L band Downshifter mode L/v operation (AMSAT Operations team)
 - (Penn State Erie designed MEMS gyro spin/wobble)



AO-95 (FOX-1CLIFF) LAUNCHED 3 DECEMBER 2018

- Status:
 - Stone deaf downlink transmission nominal but unable hear commands
 - Reason for failure unknown
 - Telemetry nominal
 - RSSI is the only clue, it is flat and indicating minimum (no signals, noise)
 - Several possibilities
 - Antenna doubtful, should still hear high power signals
 - Receiver front end
 - IF
 - Downshifter doubtful, nothing heard on L band uplink either



AO-95 (FOX-1CLIFF) LAUNCHED 3 DECEMBER 2018





RADFXSAT-2/FOX-1E LAUNCH SUMMER 2019

- Orbit:
 - 500 km @ 90 degrees inclination
- Radio:
 - 30 kHz V/u transponder, 450 mW nominal
 - Separate 1200 bps BPSK telemetry downlink
- Experiments:
 - Vanderbilt University radiation effects primary all 4 EXP slots
 - (Penn State Erie designed MEMS gyro spin/wobble)
- Status:
 - Last of the Fox-1 series



GOLF PROGRAM

<u>Greater Orbit, Larger Footprint</u>

GOLF PROGRAM

- Two projects underway, GOLF-TEE and GOLF-1
- Common elements:
 - 3U CubeSats
 - Deployable solar panels
 - 3 axis attitude control
 - SDR (software designed radio)
 - RT-IHU (radiation tolerant IHU design)
 - VHF (144 MHz), UHF (435 MHz), X (10 GHz) bands
 - Options for L (1.2 GHz), S (2.4 GHz), C (5.6 GHz) uplink bands
 - Selected for NASA ELaNa launch program



GOLF PROGRAM GOLF-TEE

- Target approximately 600km orbit
- "Rapid deployment" to test, qualify, and gain experience with deployable solar panels, attitude control, and new avionics (RT-IHU, SDR)
- Target integration date early 2020
 - Would mean possible launch as early as late 2020
- PDR (preliminary design review) underway
- Some flatsat Engineering Model construction underway



GOLF PROGRAM GOLF-1

- Target approximately 1200km orbit
- Elements of system design being developed/expanded on GOLF-TEE designs
 - GOLF-TEE experience and performance to provide important design information and adjustments
- High speed telemetry downlink on X band
- Five & Dime transponder (5 GHz uplink, 10 GHz downlink)
 - Other band/modes as well, variety of options
- Will fly Vanderbilt radiation effects and Albuquerque Public Schools camera experiments
- Target integration date early 2021



GOLF PROGRAM CHALLENGES

Orbital debris compliance

- Regulation enforcement is very strict
- Must re-enter within 25 years of launch
 - Yes, the regulations say 25 years after end of mission, but we don't own the rocket or enforce the regulations
- "25 year rule" is somewhat of a moot point as no approved de-orbit devices exist for CubeSat today
 - We can't be the ones to test anything because if it hasn't been tested we don't comply, so we can't get a launch to test anything anyway!
 - Testing would require demonstrating deorbit device(s) soon after launch and that defeats our desire to put up satellites that last a long time (i.e. very expensive gamble)



GOLF PROGRAM CHALLENGES

BUT...

- GOLF-TEE design was revised to carry a deorbit device that should be able to deorbit her in short order
- That gives us an option to demonstrate the device if we choose to accept a shorter orbit lifetime
- This <u>MIGHT</u> qualify that device for use on GOLF-, if we test it and it works
 - Discussion with NASA/FCC in progress

We are working with NASA and the FCC to find opportunities to get back to higher orbits. It's all part of the fun of doing amateur radio satellites.





CubeSat Developers Workshop Cal Poly – San Luis Obispo, CA



CubeSat Developers Workshop 2019

Presentation on IARU and FCC amateur radio licensing process





CubeSat Developers Worshop 2019

We talked at length with Karl Kensinger, Deputy Division Chief of the FCC International Bureau

We also talked at length with Scott Higginbotham, Mission Manager for NASA ELaNa program





CubeSat Developers Worshop 2019

We had a very nice conversation with Dr. T. S. Kelso (Celestrak) about tracking and identifying new CubeSats when several are deployed from one launch vehicle





CubeSat Developers Workshop 2019 (and other venues)

Fox-1E type Linear Transponder package – University of Washington (Engineering Model)

Three other university CubeSat teams interested in flying our radio, discussions underway





VPE ACTIVITIES - ARISS LUNAR GATEWAY

- AMSAT provides both financial and engineering support for ARISS
- ARISS International is working with NASA to bring amateur radio capability to the Lunar Gateway
 - AMSAT-UK, AMSAT-DL
 - Two way communication with astronauts
 - Note: Gateway will not be continuously manned
 - Amateur radio access and control of various ARISS experiments on Gateway
 - Amateur radio relay/transponder type communications
- Ambitious and exciting project!
- Follow ARISS news for ongoing updates

www.ariss.org





LUNAR GATEWAY AND AMATEUR RADIO EXPLORATION (AREx)

PRESENTED BY FRANK BAUER, KA3HDO AMSAT VP HUMAN SPACEFLIGHT

Deep Space STEAM Education & Exploration

- ARISS/AMSAT is poised to support human spaceflight endeavors beyond low Earth orbit, including the Lunar Gateway
- Gateway operations will be mostly autonomous (satellite-like) with occasional human operations
- Employ hardware, operations and education infrastructure demonstrated on ISS
- Weak signal, long path length challenges are achievable and have been previously demonstrated by ARISS/AMSAT team
 - AMSAT/ARISS team tracked & received data from Voyager, Cassini, Venus Radar and several Lunar missions
 - Chinese Radio Amateurs recently launched LongJiang 1 & 2 that are currently orbiting the moon
- Currently working with NASA on Gateway and excited to partner with other international space agencies and commercial entities on these efforts





AREX GATEWAY OPERATIONAL SEGMENTS





Space Segment Crew Tended | Autonomous



User Segment Educational Outreach | Amateur Ops | Experimental Scientific



Operations Control Segment Nominal | Contingency Ops



ON-ORBIT OPERATIONS (EARLY CONCEPT)





Crew Engagement 1-2 months/year

- School Contacts (Audio only & w/video downlink)
- SSTV (Picture up/downlink)
- Experiment setup & (optional) ops
- Random Voice Contacts

Uncrewed-Autonomous 24/7/365

- Ham Video downlinks (Earth, Moon, AREx Experiments)
- Packet/APRS & Robotic commanding via APRS
- Voice Repeater
- SSTV Pictures & Educational Puzzles
- Experiment & Ham Station Telemetry





EWAY OPERATIONAL SCENARIOS (EARLY CONCEPT)



Gateway



Users

Bond

- Schools, General Public - Amateur Radio Operators

9.5670 MHZI-Alternote

5-Band 12400-2450 MHD

- Experimental/Scientific

AREx Gnd Stations

- Cmd
- TLM
- Contingency



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