A Brief History of AMSAT (Radio Amateur Satellite Corp.)

- Founded in 1969
  - To continue the efforts, begun in 1961, by Project OSCAR
- 501(c)(3) non profit corporation
  - All volunteers, one paid employee
- Satellites in orbits from LEO (ISS deploy) to HEO (1046 x 58775 km)
- Hams in over 20 countries have launched 80 OSCAR satellites
Fox-1 Overview

- ConOps in 2009
- 1U format as “first step”
- Custom bus design
- Common design allows multiple CubeSats with the same power, RF, and housekeeping systems
- Primary purpose – Amateur Radio FM repeater “EasySat”
  - Accessible with a hand held transceiver and hand held yagi antenna
- Secondary purpose – STEM education
- Designed to accommodate up to four experiments from partners
Fox-1 Program Status

- Fox-1A delivered and integrated March 25, 2015
  - August 2015 ELaNa XII launch
- Fox-1B “RadFxSat” accepted for ELaNa in 2012
  - Tentative November 2016 launch
- Fox-1C will launch on Spaceflight Sherpa in late 2015
  - SpaceX Falcon 9 launch
- Fox-1D flight spare for Fox-1C
  - If not needed will apply for CSLI
- All four of the planned Fox-1 CubeSats have STEM experiments and are “booked up”!
Fox-1 Avionics Stack
Fox-1A Flight Unit
Experiments on Fox-1B “RadFxSat”

Penn State - Erie
MEMS Gyros
(on IHU board)

Vanderbilt Radiation EXP
Sensors
Sensors
Sensors
Controller
Experiments on Fox-1C

- Virginia Tech Camera
- Filler/Lens Hole
- VT Camera
- Pennsylvania State - Erie
- MEMS Gyros
  (on IHU board)
- Vanderbilt Radiation EXP Sensors
- Controller
Experiments on Fox-1D

Virginia Tech Camera
Filler/Lens Hole
VT Camera

University of Iowa “HERCI”
Flexi-DPU and detector

Penn State - Erie
MEMS Gyros
(on IHU board)
Fox-1 Details

Communications

- **UHF FM Receiver**
  - 70 cm Amateur Radio Satellite Band
  - Sensitivity -120 dBm for 12 dB SINAD
  - Automatic Frequency Control (AFC) ±6 kHz
  - Omni whip antenna

- **VHF FM Transmitter**
  - 2 meter Amateur Radio Satellite Band
  - Up to 800 mW output (400 mW nominal)
  - Omni whip antenna
  - 200 bps sub-audible FSK telemetry (data under voice)
  - 9600 bps FSK high speed telemetry
Fox-1 Details

Power

- 12x Spectrolab UTJ Solar Cells
  - Two cells on each panel (face)
  - Approximately 27 cm² surface per cell
  - Approximately 2 Watts per panel
- Sanyo Cadnica KR-1400AE NiCd Cells
  - 3x pairs for nominal 3.6V
  - Matched cells
  - NiCd have proven space heritage with tens of thousands of cycles
- Maximum Power Point Tracker Power Supply
  - 6 channels - one for each solar panel
Fox-1 Details

Internal Housekeeping Unit (IHU)

- STM Micro STM32L161 MCU
- Gathers telemetry from spacecraft
- Controls power and gathers telemetry from experiments
- Generates slow speed and high speed telemetry
- Processes voice on FM uplink
  - High pass filter strips CTCSS
  - DUV telemetry added via low pass filter
  - Voice + telemetry audio sent to transmitter
- Provides voice ID to transmitter
Fox-1 Hosted Experiments Interface

- Battery bus power (3.6V nominal)
- 2x serial communications bus
- I²C communications bus
- SPI communications bus
- Experiment Enable control line (logic high/low)
What next?

BOTTOM LINE – WE’RE ALWAYS LOOKING FOR WAYS TO “KEEP AMATEUR RADIO IN SPACE”
More CubeSats

- “Design the Next AMSAT Satellite”
- Desire to continue STEM education partnerships
- We build excellent radios
- We have a worldwide population of “telemetry gatherers”
- We design and give away ground software to capture telemetry
  - All fed via internet (participation optional by user) to AMSAT servers
  - Available to anyone for research
- Your satellite or ours
More Opportunities

- AMSAT's **ASCENT** Program exploring long distance (i.e. high orbit) high speed data using microwave communications
  - Many voice and data channels
  - GTO or highly elliptical orbit
  - **Good opportunities for attitude control and propulsion experiments**
Providing CubeSat Communications

- “Mode J” linear transponder for 1.5 - 3U CubeSats
  - VHF uplink, UHF downlink
- Initial testing in Fox-1E, prospective launch in 2016
- Provides 1200 BPSK telemetry downlink in UHF band
- Amateur radio use involves amateurs worldwide and attracts telemetry ground station participation
- Payload to be available for primary or backup
  - Question: what CubeSat format is most used? (Pumpkin, ISIS, ?)
Amateur Radio Operators as a Telemetry Ground Station System

- ARISSat-1 deployed from ISS Aug. 2011, about 6 months on orbit
- FUNcube-1 (AO-73) launched Nov. 2013, still active

### ARISSat-1 KEDR Top submitters list

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### FUNcube1-Flight Model

#### Navigation
- Real Time Data
- High Resolution Data
- Whole Data
- Filter Messages
- Amateur Radio Info
- Satellite Position

#### Upload Ranking

We should like to thank all the groups and individuals who have uploaded data to the FUNcube data warehouse.

The following list gives the site names of those who have uploaded the most data frames:

**Key:** Within 1 week, within 2 weeks, greater than 2 weeks

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