

AMSAT Fox-1 CubeSat Series

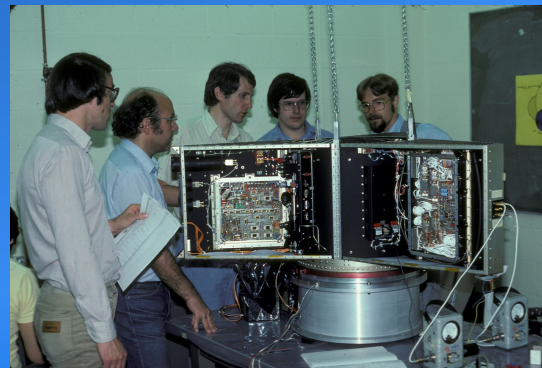
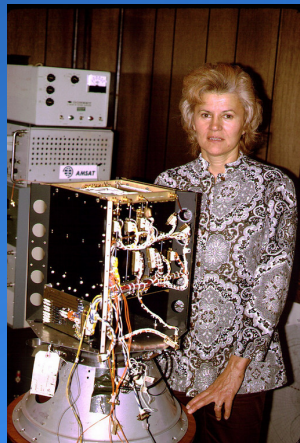
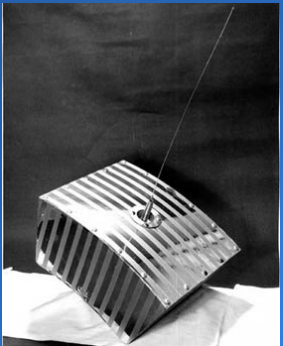
JERRY BUXTON

VICE PRESIDENT - ENGINEERING



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

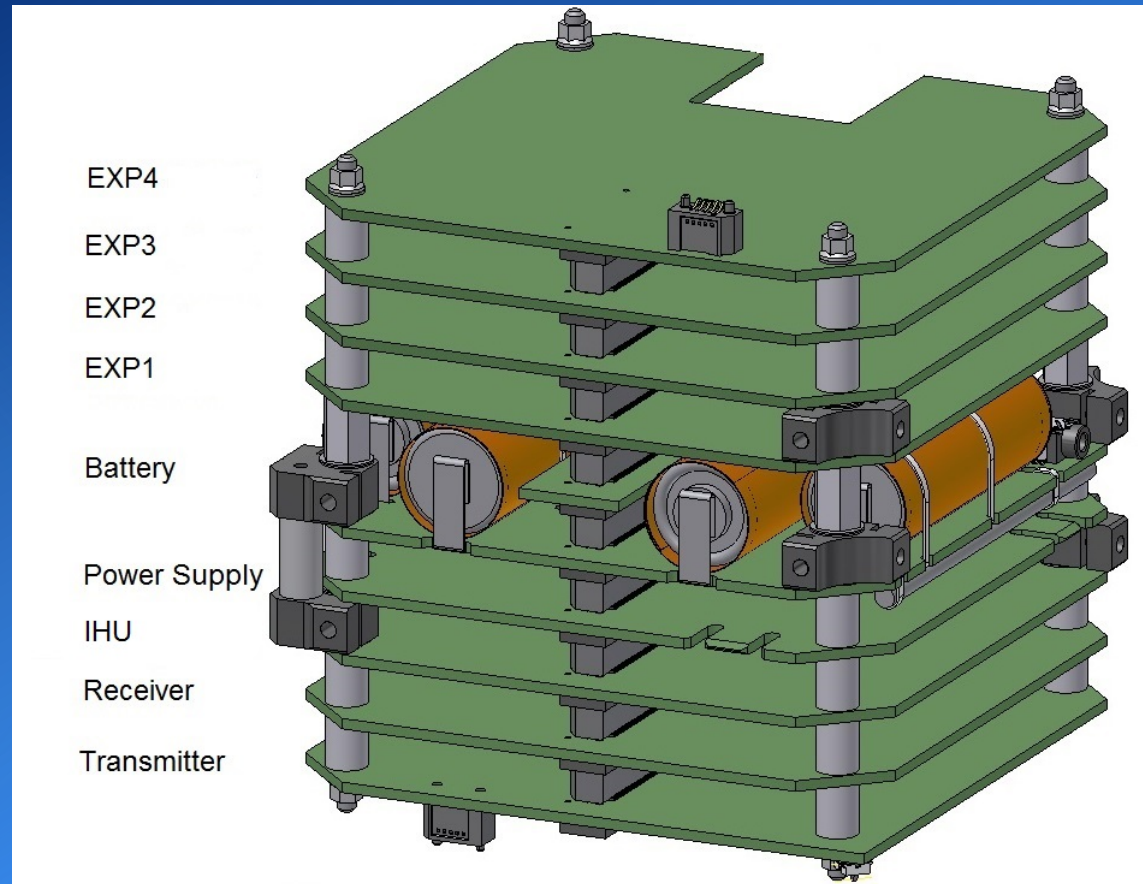


Fox-1 Program Status

- ▶ 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”!

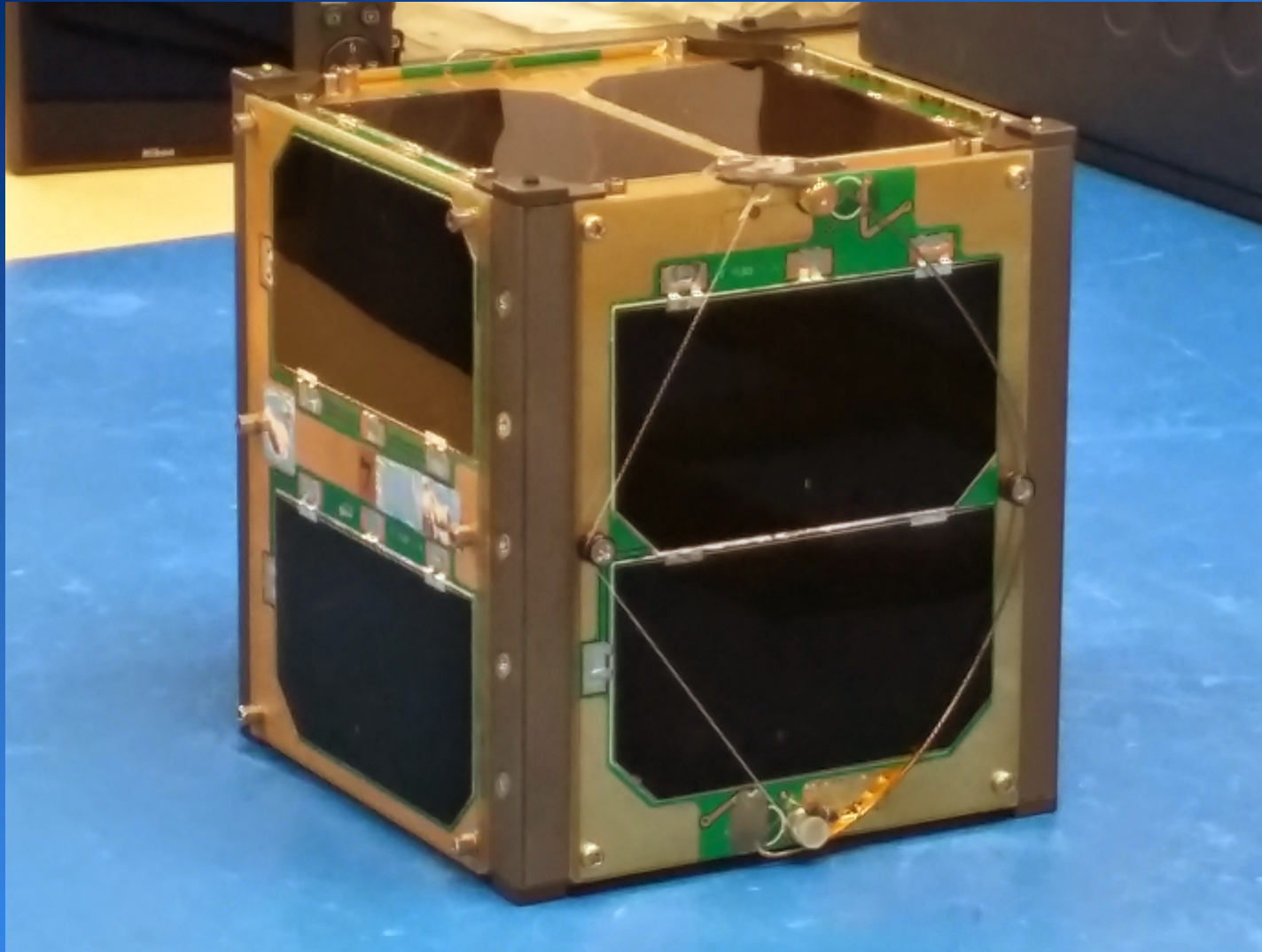


Fox-1 Avionics Stack

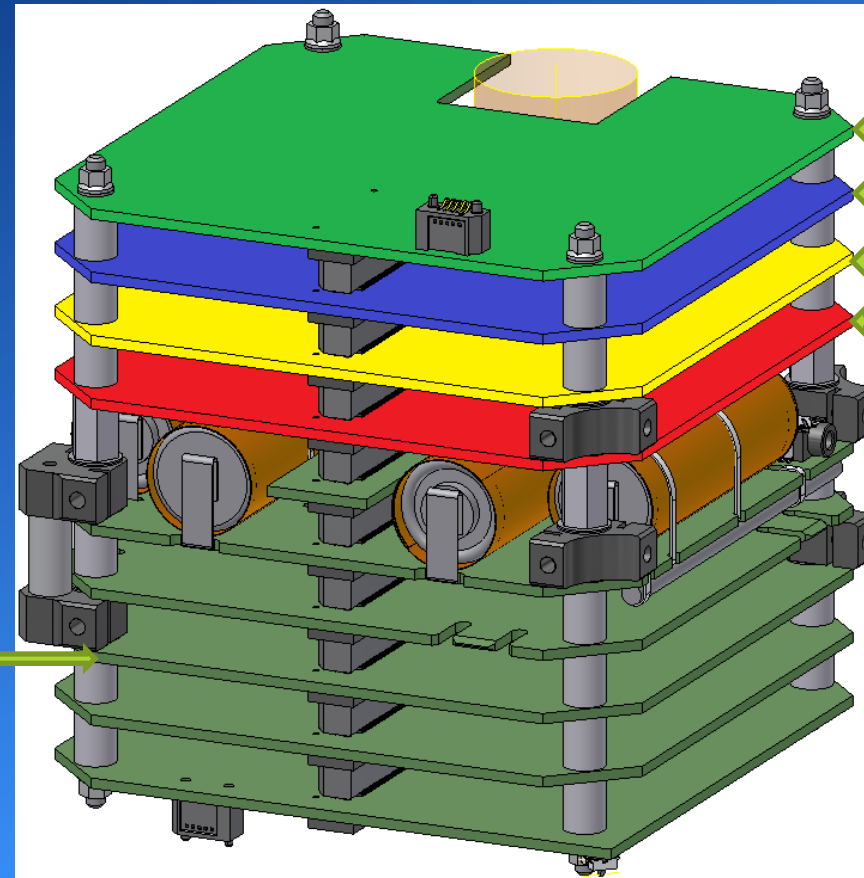


Fox-1A Flight Unit

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Experiments on Fox-1B “RadFxSat”



Vanderbilt Radiation EXP
Sensors
Sensors
Sensors
Controller

Penn State - Erie
MEMS Gyros
(on IHU board)

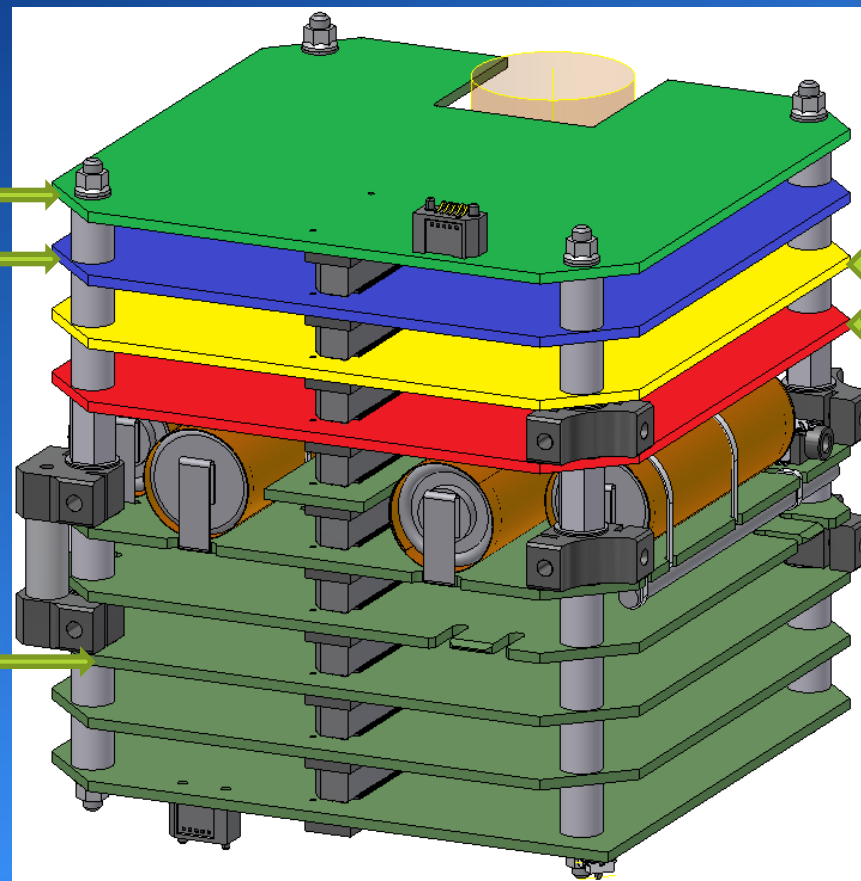


Experiments on Fox-1C

Virginia Tech Camera
Filler/Lens Hole
VT Camera

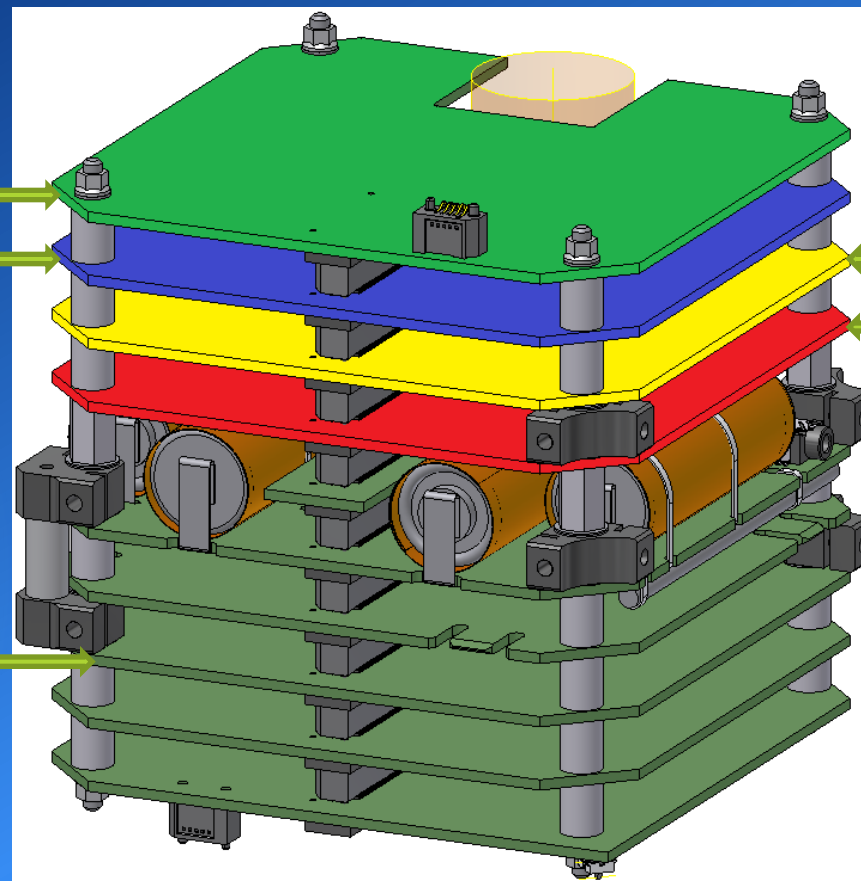
Vanderbilt Radiation EXP
Sensors
Controller

Penn State - Erie
MEMS Gyros
(on IHU board)



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 12dB 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

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- ▶ 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

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- ▶ 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

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- ▶ “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

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- ▶ 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

Call	Kursk	Spacecraft	Total
N8MS	3572	3869	7441
DK3WN	2955	3069	6024
NOJY	2472	2722	5194
ZL2BX	2180	2502	4682
VE6AXL	2266	2397	4663
JA0CAW	2114	2202	4316
JA5BLZ	1875	2079	3954
KD8CAO	1780	1874	3654
N8MH	1571	1699	3270
SM5SRR	1407	1454	2861
JH1BCL	1374	1448	2822
JA6PL	1329	1359	2688
K4OZS	1159	1408	2567
E21EJC	1036	1202	2238
PE0SAT	1053	1115	2168
ON5PV	999	1066	2065
G7WIQ	1004	1025	2029
F6CDZ	918	990	1908
RW3WWW	917	979	1896
N4ZQ	886	983	1869
G4BBH	854	899	1753
PY4ZBZ	782	924	1706
JA1GDE	800	895	1695
W5RKN	789	842	1631

FUNcube

UK Amateur Radio Educational Satellite

[Register]

FUNcube-1 Flight Model FC1 Engineering model UKube FC2 Payload

Navigation

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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

Site Id	Count	Position
g0mjw	298550	1
OM3BC	252401	2
KC0BMF	200861	3
HB9MFL	179371	4
VK5HI	178089	5
SP8CGR	172055	6
SP5ULN	154990	7
PB0AHX	150749	8
VK5GU	141295	9
wa6wvf	133611	10
n8mh	130582	11
Iu4eou	125502	12
K9CIS	118199	13
7J1ADJ	116699	14
ISIS	113075	15

Count
298550
252401
200861
179371
178089
172055
154990
150749



Contact AMSAT Engineering
vpe@amsat.org

<http://www.amsat.org>

