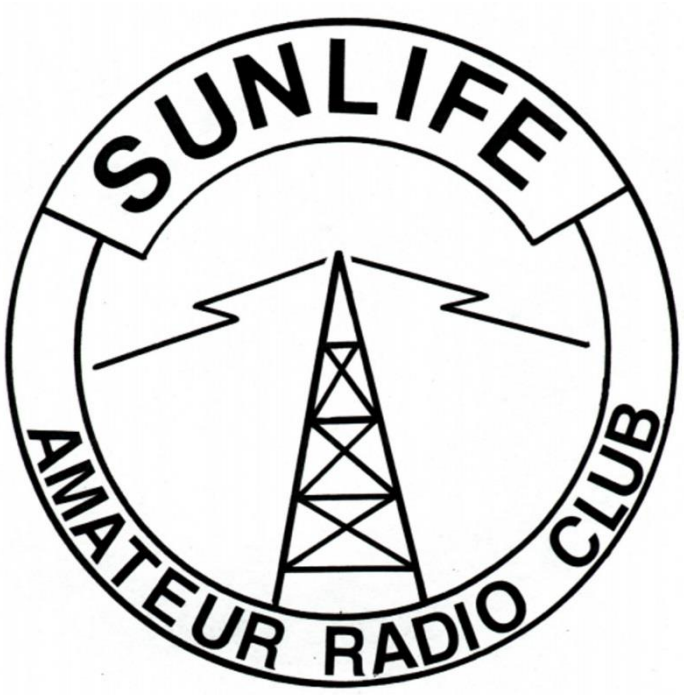


5 November 2018

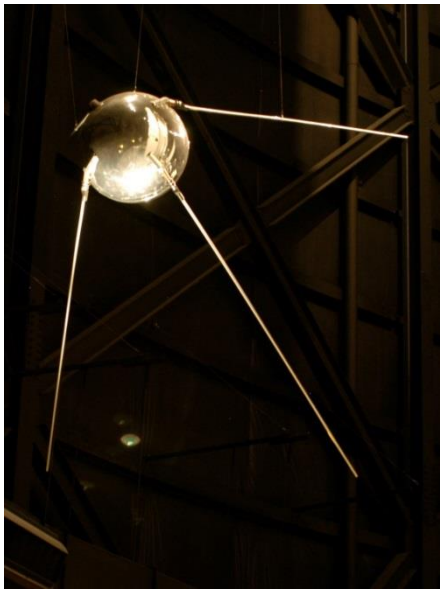
Amateur Satellites and AMSAT

by Patrick Stoddard 

/ 

AMSAT Ambassador, Radio Amateur Satellite Corporation (AMSAT)

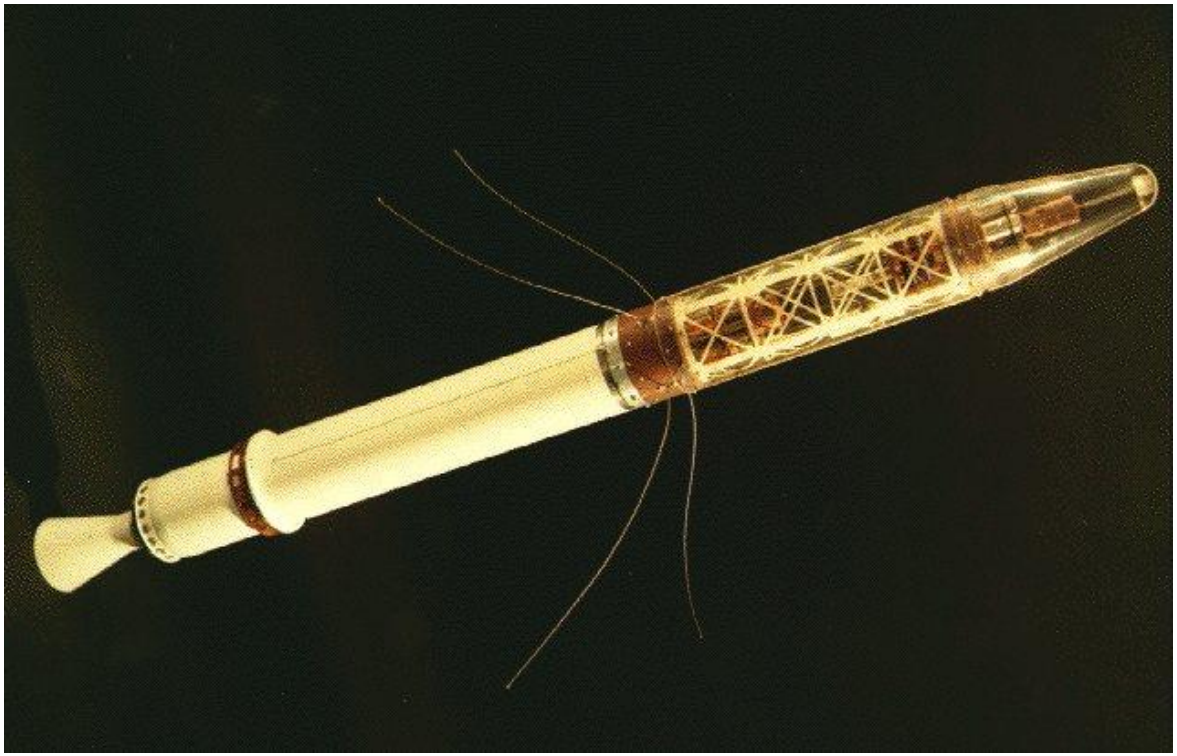
The beginning of the Space Age: Sputnik-1 (Спутник-1)



Launched by USSR on 4 October 1957, reentry on 4 January 1958, orbiting at 223 x 950km (139 x 590 miles), 1440 orbits before reentry.

First recordings outside USSR made by RCA engineers in New Jersey and Columbia University radio club (W2AEE), copying beacons on 20.005 & 40.002 MHz

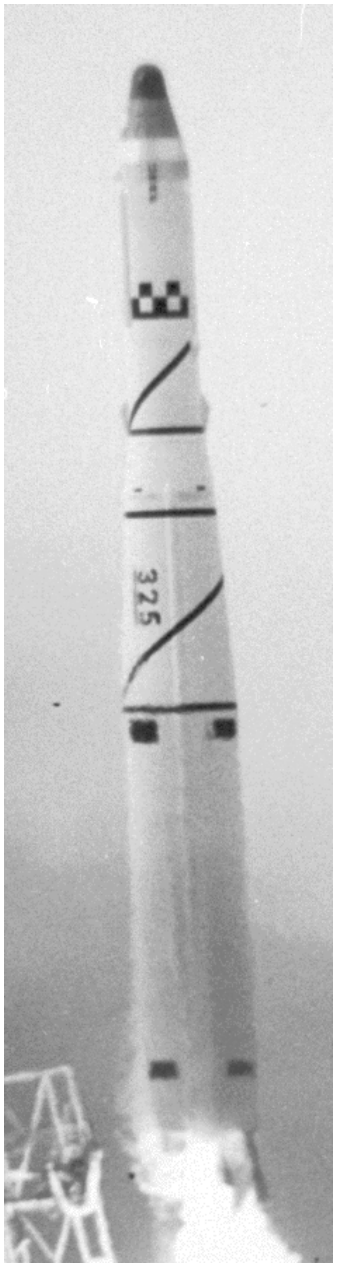
The beginning of the Space Age: Explorer 1



Launched by USA on 31 January 1958, reentry in 1970, orbiting at 358 x 2550km (222 x 1580 miles)

The beginning of the Space Age: OSCAR I

- Launched on Thor-Agena with Discoverer XXXVI on 12 December 1961, from Vandenberg AFB in California
- First non-government satellite
- First launch of > 1 satellite on 1 launcher
- Transmitted until 3 January 1962, heard by over 570 radio amateurs worldwide
- Transmitted CW beacon – “HI” – on 2m
- Reentry on 31 January 1962
- Decades later, confirmation that Discoverer XXXVI was a spy satellite



Working satellites...

- More multiband satellite-ready transceivers available
- Monoband all-mode transceivers still an option
- HF/VHF/UHF all-mode transceivers also useful for satellite work
- SDR – transceivers, receivers, even USB dongles!
- For FM satellites, many 2m/70cm FM transceivers (HTs and mobiles) are suitable for satellite work
- Current satellites in low orbit, 15 to 20 minutes per pass, many modes (FM, SSB, CW, SSTV, packet/APRS, other digital modes)
- Some DXpeditions now include a satellite station, once again
  - K1N & CY9C during 2016, HC8LUT in late 2017, VY0ERC in 2018
- Although satellite DXCC is difficult from many locations, other awards available, including:
  - ARRL VUCC, WAS
  - AMSAT awards
  - CQ magazine awards

Equipment for FM satellites

- Satellite-ready transceivers like IC-9100, TS-2000, etc.
- 2m/70cm FM transceivers with two VFOs capable of cross-band repeat ideal for FM satellite operation
  - One HT capable of cross-band full-duplex operation for all current FM satellites (Kenwood TH-D72A); a couple of others work full-duplex with FM satellites using a 70cm uplink (Wouxun KG-UV8D, KG-UV9D)
  - More options with mobile transceivers (TM-D710, TM-V71A, FT-8900, IC-2730A, DR-635 currently in production)
- Other 2m/70cm FM HTs and transceivers with “odd-split” memory channels can also be used with FM satellites, but not recommended
  - Most Kenwood and Yaesu 2m/70cm transceivers, including several Yaesu HF/VHF/UHF transceivers in current production (FT-817, FT-857, FT-991); some older Icom 2m/70cm transceivers
- IC-706Mk2, IC-706Mk2G, IC-7000, IC-7100, FT-100, FT-817, FT-818, FT-857, FT-897, FT-991, etc. usable with split-VFO operation
- Separate 2m and 70cm FM transceivers

Equipment for SSB/CW satellites

- Satellite-ready transceivers
- Pair of monoband all-mode transceivers
- Pair of multiband all-mode transceivers
- One all-mode transceiver, with one wide-band all-mode receiver
  - TH-F6A & TH-D74A HTs include all-mode receiver up to 470 MHz
  - All-mode receivers also includes SDR devices
    - FUNcube Dongle Pro+ - http://www.funcubedongle.com/
    - SDRplay receivers (all models) – http://www.sdrplay.com/ or at HRO stores
- One multiband all-mode transceiver, with computer control
  - Laptops, even some tablets, capable of running satellite-tracking software that controls the transceiver(s)

Equipment for digital/packet satellites

- VHF/UHF FM transceivers with built-in TNCs
  - Kenwood: TH-D7, TH-D72, TH-D74, TM-D700, TM-D710, TM-D710G
  - Yaesu: FT-1DR, FT-2DR, FTM-400XDR (**NOT** FTM-100DR)
  - PicoAPRS
- VHF/UHF FM transceivers with software
  - AGW Packet Engine, UZ7HO SoundModem for 1200bps packet
  - UZ7HO HS-SoundModem for higher speeds (i.e., 9600bps)
- VHF/UHF FM transceivers with external TNCs
  - Kantronics KPC-3+ or KPC-9612+, Mobilinkd, TNC-X, lots of old TNCs

Antennas

- Portable operation
  - Directional antennas
    - Handheld Yagis or log periodics are popular options, homebrew or commercially-made
  - Replace stock “duckie” on HTs
    - Telescoping whip or longer “duckie” may work with some FM satellites & ISS
- Fixed operation
  - Directional antennas
  - 1/4-wave verticals
  - Horizontal loops, 1/4-wavelength over ground plane
  - “Eggbeater” omnidirectional antennas
  - Computer control of antenna rotator desirable, preamps may be necessary for omnidirectional antennas

Antennas

Tim Lilley N3TL, about to work an FM satellite with an HT and an Elk Antennas 2m/70cm log periodic antenna

WD9EWK’s small ground station!

Yaesu FT-817ND, SDRplay software defined receiver, 8-inch Windows 10 tablet with HDSDR, & Elk Antennas 2m/70cm handheld log periodic antenna = small, very portable, all-mode ground station!

FM satellites

- SO-50, launched in 2001
  - uplink on 145.850 MHz (67.0 Hz CTCSS required)
  - downlink on 436.795 MHz (+/- 10 kHz for Doppler)
  - activate satellite for 10 minutes by transmitting on 145.850 MHz with 74.4 Hz CTCSS for 1-2 seconds

- AO-85 (Fox-1A), launched in October 2015
  - uplink on 435.170 MHz (+/- 10 kHz, 67.0 Hz CTCSS optional)
  - downlink on 145.980 MHz (may need to tune to 145.975 MHz near end of passes)
  - Slow-speed telemetry sent w/FM downlink, sometimes replaced by high-speed telemetry – both readable with Fox telemetry software

FM satellites

- AO-91 (Fox-1B), launched in November 2017
  - Uplink on 435.250 MHz (+/- 10 kHz, 67.0 Hz CTCSS optional)
  - Downlink on 145.960 MHz
  - Slow-speed telemetry sent w/FM downlink, sometimes replaced by high-speed telemetry – both readable with Fox telemetry software
  - Larger footprint than other FM satellites, very popular!

- AO-92 (Fox-1D), launched in January 2018
  - Two uplinks, one operational at any time
    - 70cm uplink on 435.350 MHz (+/- 10 kHz, 67.0 Hz CTCSS optional)
    - 23cm uplink on 1267.360 MHz (+/- 30 kHz, 67.0 Hz CTCSS optional)
  - Downlink on 145.880 MHz
  - Camera experiment from Virginia Tech; pictures transmitted from AO-92 on 145.880 MHz downlink using 9600bps data
  - Slow-speed telemetry sent w/FM downlink, sometimes replaced by high-speed telemetry – both readable with Fox telemetry software

SSB/CW satellites

- AO-7, launched in 1974, resumed operation in 2002
  - Two possible modes of operation
    - 50 kHz transponder, 70cm uplink/2m downlink (Mode “B”)
    - 100 kHz transponder, 2m uplink/10m downlink (Mode “A”)
  - Powered only by solar panels, after battery failure in 1981
  - Largest footprint of current amateur satellites, supporting QSOs spanning over 8000km (almost 5000 miles)
- FO-29, launched in 1996
  - Built in Japan for JARL, following up on FO-12 & FO-20
  - Originally had other functions including “digitalker”, now operates as 100 kHz transponder with 2m uplink & 70cm downlink

More SSB/CW satellites (FUNcube)

- AO-73 (FUNcube-1), launched in 2013
  - 1U CubeSat
  - 20 kHz transponder, 70cm uplink/2m downlink & telemetry
- EO-79 (FUNcube-3), launched in June 2014
  - 2U CubeSat
  - 20 kHz transponder, 70cm uplink/2m downlink & telemetry
- EO-88 (Nayif-1), launched in February 2017
  - 1U CubeSat
  - 30 kHz transponder, 70cm uplink/2m downlink & telemetry

Still more SSB/CW satellites (China)

- XW-2 satellites, launched in September 2015
  - **Six** satellites launched
  - XW-2E failed a couple of months after launch, other 5 are OK
  - 20 kHz transponders, 70cm uplinks/2m downlinks
  - CW and digital telemetry on 2m downlinks
- CAS-4A and CAS-4B, launched in June 2017
  - 20 kHz transponders, 70cm uplinks/2m downlinks

Digital/packet satellites

- International Space Station
  - 2m packet/APRS digipeater (145.825 MHz simplex) – use ARISS for packet path (UNPROTO)
  - 1200bps AX.25 packet
- NO-84 (PSAT)
  - 10m uplink/70cm downlink PSK31/FM transponder – uplink on 28.120 MHz PSK31, downlink on 435.350 MHz FM (+/- 10 kHz for Doppler)
  - 2m 1200bps AX.25 packet digipeater (145.825 MHz, simplex) – use ARISS or APRSAT for packet path when digipeater is active
- FalconSAT-3
  - 2m uplink/70cm downlink packet/APRS digipeater and BBS
  - 9600bps AX.25 packet
  - Use PFS3-1 for packet path (UNPROTO) to use digipeater

Digital/packet satellites

- Use packet/APRS-capable transceivers
  - Transmit beacons with position (like calling CQ)
  - APRS messages used to complete QSOs
- TNC/software with transceiver, and software
  - Popular software for packet satellites is UISS

International Space Station

- Current amateur activity from two ISS ham stations
  - Russian Zvezda service module
    - 2m FM voice/SSTV on 145.800 MHz using TM-D710G
    - FM cross-band repeater (2m uplink/70cm downlink or 70cm uplink/2m downlink), rarely used since late 2000s
  - European Columbus module
    - 2m packet on 145.825 MHz, using GE/Ericsson VHF HT
    - Backup radios for voice & packet operations
- Most ISS voice activity connected with scheduled contacts, but occasional random QSOs with hams
- New TM-D710G for Columbus module in 2019
- Call signs used from ISS: NA1SS, RS0ISS, OR4ISS
  - Packet/APRS: use **ARISS** in packet path (UNPROTO)

International Space Station

- Random voice contacts are happening!!!!
  - Two Saturday mornings in October, plus last Saturday (3rd)
- Split-frequency operations, can use a memory channel
  - Receive on 145.800 MHz FM
  - Transmit on 144.490 MHz FM
  - (or 145.800 MHz memory channel with -1.31 MHz offset)
- Rapid-fire QSOs, as ISS is over USA for 10-15 minutes
- NA1SS QSL manager is Bruce W6WW in California
- http://www.ariss.org/

NO-84 (PSAT)

- Built by US Naval Academy, launched in May 2015
- 10m/70cm PSK31/FM transponder
  - Primary amateur payload, operational all the time
  - 28.120 MHz PSK31 uplink, 435.350 MHz (+/- 10 kHz) FM downlink
- 1200bps AX.25 packet digipeater on 145.825 MHz
  - Activated periodically by command stations
  - Packet path (UNPROTO) is **ARISS** or **APRSAT**
  - Telemetry beacons

FalconSAT-3

- Built for US Air Force Academy, launched in 2007
- Retired from military service in 2017, now operated by AMSAT with non-amateur payloads disabled by USAF
- 9600bps AX.25 packet mailbox/BBS and digipeater
  - 145.840 MHz uplink, 435.103 MHz (+/- 10 kHz) downlink
  - BBS requires software like PB/PG or WiSP to access
  - Digipeater uses **PFS3-1** as packet path/UNPROTO

When are satellites available?

- Use AMSAT website or tracking programs to know when satellites are in view of your location
- Some programs can control antenna rotators and transceivers
- AMSAT has tracking programs for sale (i.e., **SatPC32**)
- Free programs can be downloaded
  - Windows, Mac OS X, Linux, other operating systems
  - Mobile phones
  - Tablets – iOS, Android, and even small & inexpensive Windows tablets

Before you transmit…

- Do you hear the satellite?
  - Open squelch all the way
  - Satellites usually have activity on any daytime or evening pass over North America
  - Move antenna around, if satellite is not audible or is weak
  - If you do not hear the satellite, **DO NOT TRANSMIT**!
    - **One exception**: Transmitting on 145.850 MHz FM with 74.4 Hz CTCSS tone to activate SO-50 for 10 minutes, when satellite should be in view
    - **Another exception**: Transmitting to AO-85/AO-91/AO-92 with 67.0 Hz CTCSS tone. These downlinks shut off 60 seconds after satellites stops hearing the 67.0 Hz CTCSS tone

Making contacts

- Listen to the satellite, pick out some call signs
- On FM satellites, call a specific station, or just transmit your call sign and possibly your grid locator. **DO NOT CALL CQ!**
- Calling CQ on an SSB/CW satellite **is** encouraged, as these satellites are retransmitting a band of frequencies instead of just one frequency. (similar to working HF, except you can hear yourself)
- Contacts on FM satellites are usually quick – call sign, grid locator, maybe your name & city/state (similar to HF contests & DXpeditions)
- Contacts on SSB/CW satellites can be similar to FM satellites, or longer chats – multiple conversations can take place simultaneously
- Contacts can even be made via orbiting APRS digipeaters – use APRS messaging to make QSOs, even from APRS-ready radios
- Regular operators can recognize new operators, and are happy to make contacts and help with operating advice
- Work **full-duplex** (hearing the satellite's downlink while you transmit) when possible

Logging contacts

- Many satellite operators use audio recorders or software on computers/mobile phones/tablets to record audio for logging
  - Especially for portable operating; almost impossible to log in real time if holding a radio/microphone and antenna
  - Play back recordings later to make log entries
  - Keep copies of memorable contacts
  - Be able to give others copies of contacts (MP3 or WAV files)
  - Digital recorders are small, inexpensive; many mobile phones and tablets have voice recorder apps – or use a computer
    - TH-D74A has audio recorder function, with a microSD card
  - Many are looking for confirmations for contacts using QSL cards, Logbook of the World, eQSL, etc. to earn awards

More satellites are coming…

- AMSAT Fox-1 satellites
  - 70cm or 1.2 GHz uplink/2m downlink, FM
    - Fox-1C, to be launched on SpaceX Falcon 9 from Vandenberg AFB in late 2018 or early 2019
  - 2m uplink/70cm downlink, SSB/CW
    - Fox-1E (RadFxSat-2), to be launched by Virgin Galactic from Mojave CA in late 2018 or early 2019
- AMSAT GOLF project
  - Greater Orbits, Larger Footprints
    - announced during 2017 AMSAT Symposium
    - Two 3U CubeSats in the works for future NASA launches with 5 GHz uplink/10 GHz downlink transponders
      - GOLF-TEE
      - GOLF-1

More satellites are coming…

- European ESEO satellite, coming in 2019
  - Includes FM repeater, 23cm uplink/2m downlink
- A geosynchronous amateur satellite payload coming…
  - **Phase-4A**, by AMSAT-DL - tentative launch in 2019
    - Coverage includes Europe, Africa, much of Asia, eastern tip of Brazil
    - Two transponders, SSB/CW & digital (2.4 GHz uplink/10 GHz downlink)
- More amateur satellites from China
  - Several FM satellites scheduled for launches, others may come with little or no advance notice

AMSAT

- Organization dedicated to supporting and promoting amateur satellite activity
- Founded in 1969, continuing pioneer work by Project OSCAR
- All-volunteer organization, except for office manager
- Operates AO-7, AO-85, AO-91, and AO-92; 2 more Fox-1 satellites coming in late 2018 or early 2019
- Supports Amateur Radio on International Space Station (ARISS)
- GOLF (Greater Orbit, Larger Footprint) project for more options beyond small CubeSats at LEO, announced in late 2017
- Always open to new proposals for amateur satellites
- http://www.amsat.org/

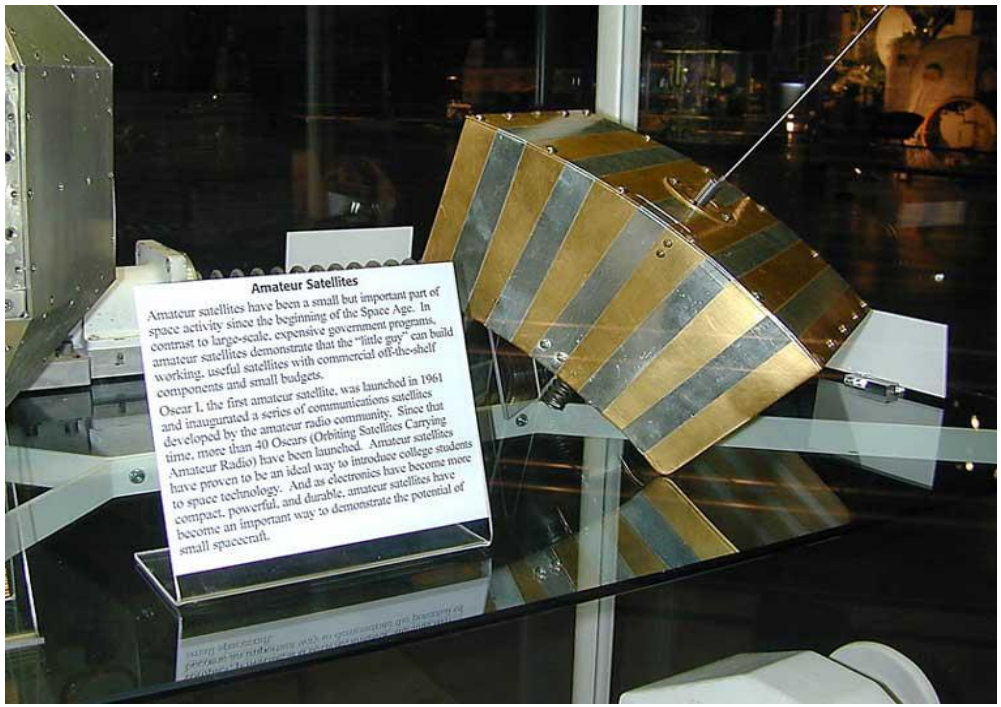
Questions?

Additional Slides

Working satellites, in the past...

- Multiple radios required to work satellites
  - All-mode monoband transceivers
  - HF transceivers with transverters or up/downconverters
- Satellite-ready transceivers available since 1980s – expensive!
- SSB/CW, maybe SSTV and RTTY
- Satellites in low and high orbits
  - High-orbit satellites provided intercontinental DX for hours at a time
  - Low-orbit satellites also available, 10 to 30 minutes per pass
- No real easy and inexpensive starting point
  - i.e., no equivalent to used transceiver and dipole for HF

The beginning of the Space Age: OSCAR I



Model donated by Project OSCAR to Smithsonian, on display at Udvar-Hazy Center (National Air and Space Museum annex, at Dulles Airport). ARRL also has an OSCAR I model, which transmits!

International Space Station

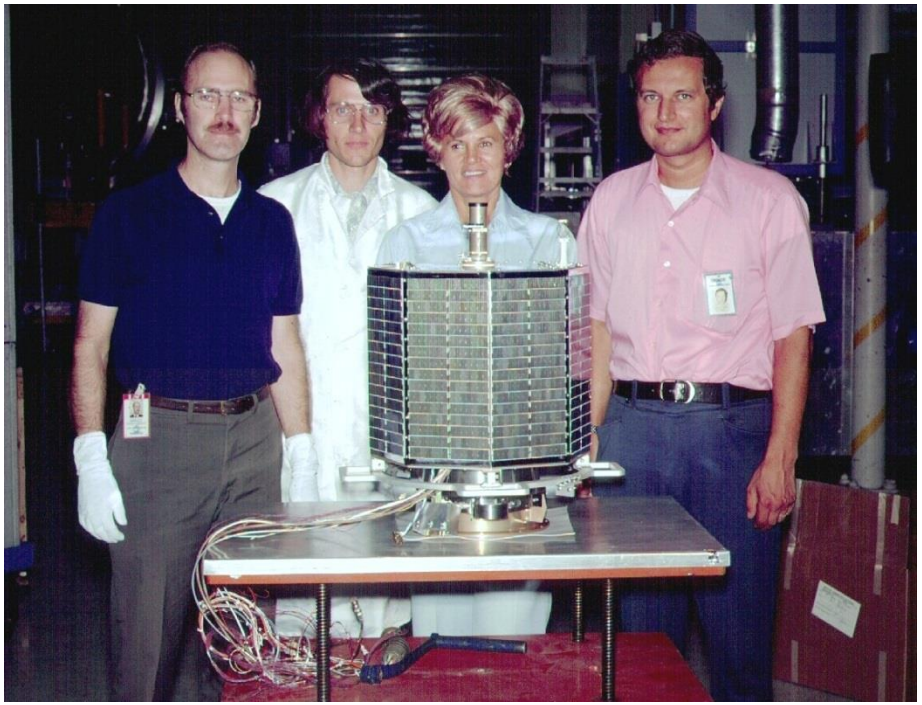
NASA astronaut Reid Wiseman, operating from European Columbus module as NA1SS, on 28 June 2014 (Field Day)

International Space Station

Slow-scan television (SSTV) picture, received on 145.800 MHz by WD9EWK, 2 February 2015

AO-7 (OSCAR 7)

- Constructed by AMSAT, launched 15 November 1974 from Vandenberg AFB
- Went silent in 1981, but resumed operating in 2002
- Still operational today, 40+ years after launch

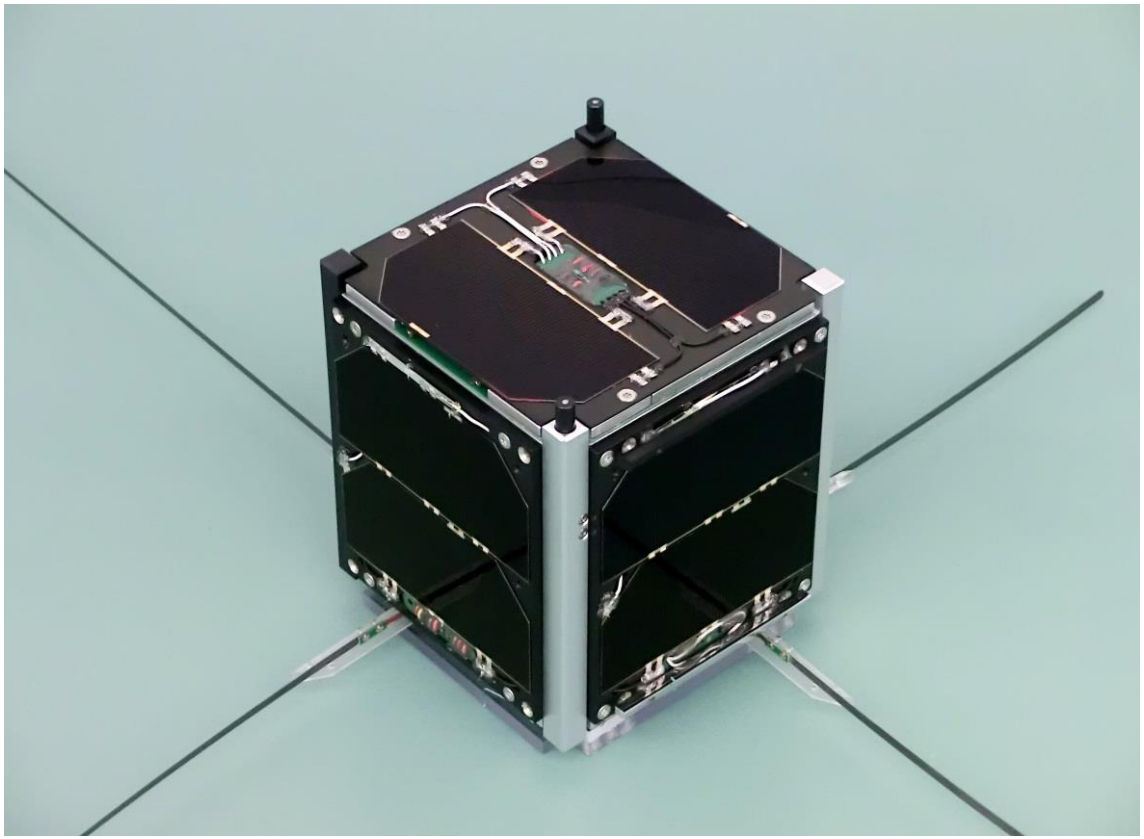


AO-7 (OSCAR 7)

- Radio amateurs demonstrated satellite-to-satellite communications in 1975, with OSCARs 6 and 7
- EKG transmitted via OSCAR 7 from California to Washington DC
- Tests validating methods of locating transmitters using OSCAR 7 (without GPS-type system) leads to COSPAS-SARSAT satellite system & UHF locator beacons still in use today
- Radio amateurs continue to use this satellite daily

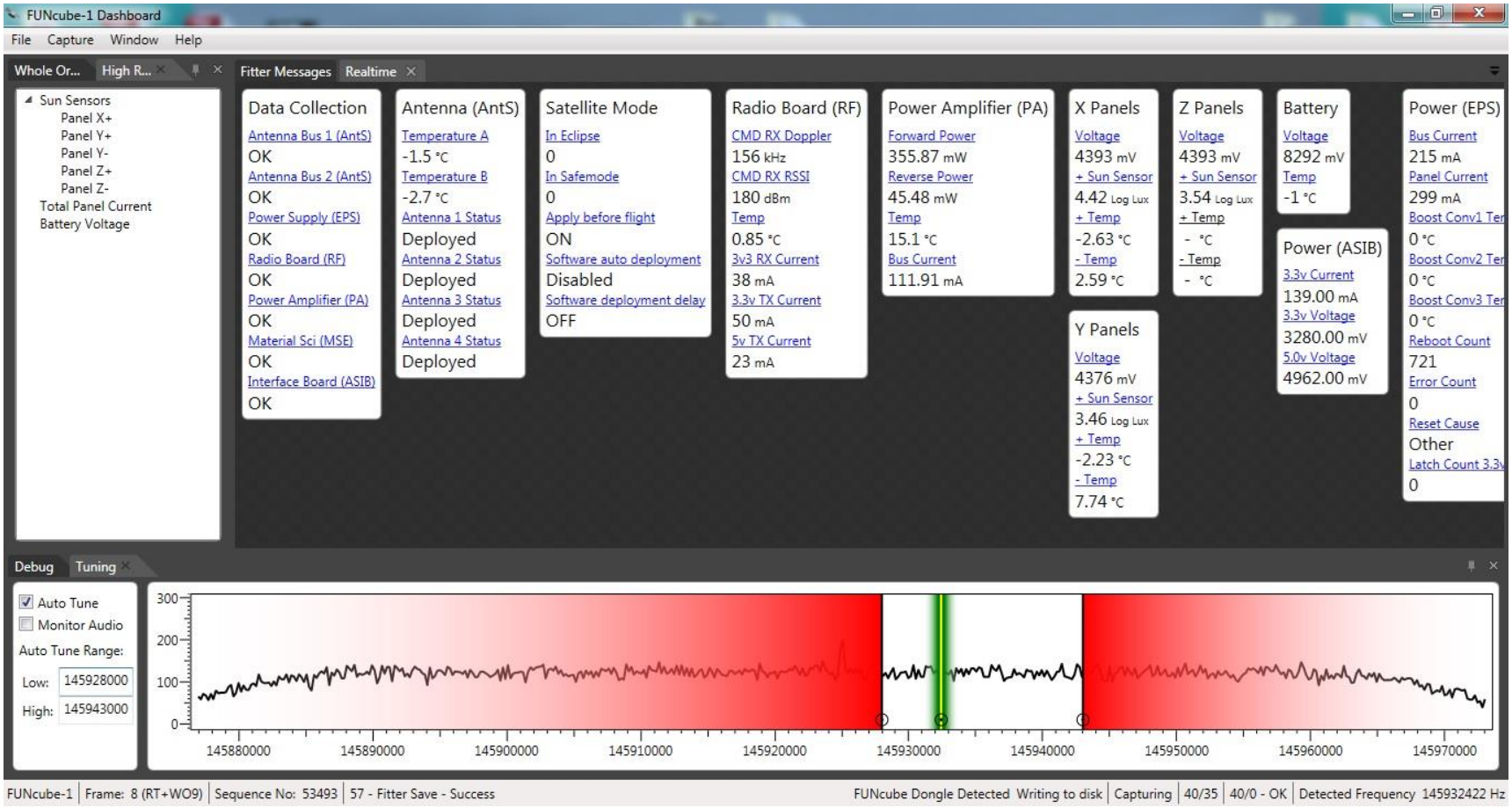
AO-73 (FUNcube-1)

Launched in November 2013, 70cm/2m SSB/CW transponder with 2m telemetry beacon, 4”/10cm cube



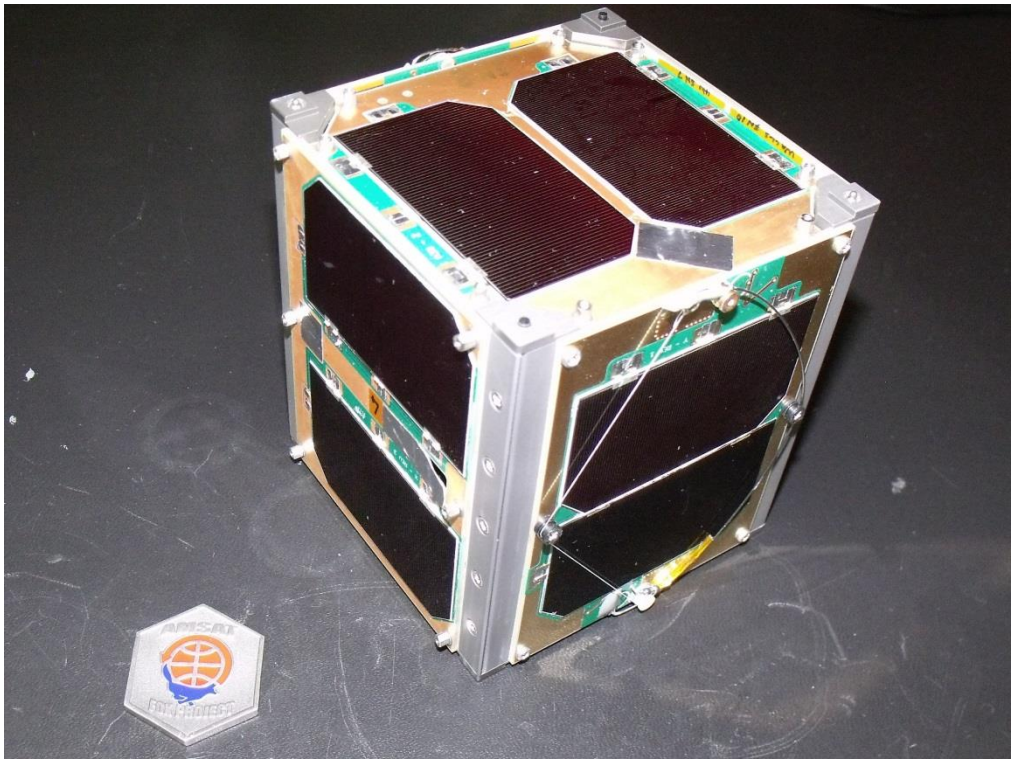
FUNcube Dashboard software

Available from http://funcube.org.uk/, Windows software can directly control a FUNcube Dongle Pro+ SDR receiver



AO-85 (Fox-1A)

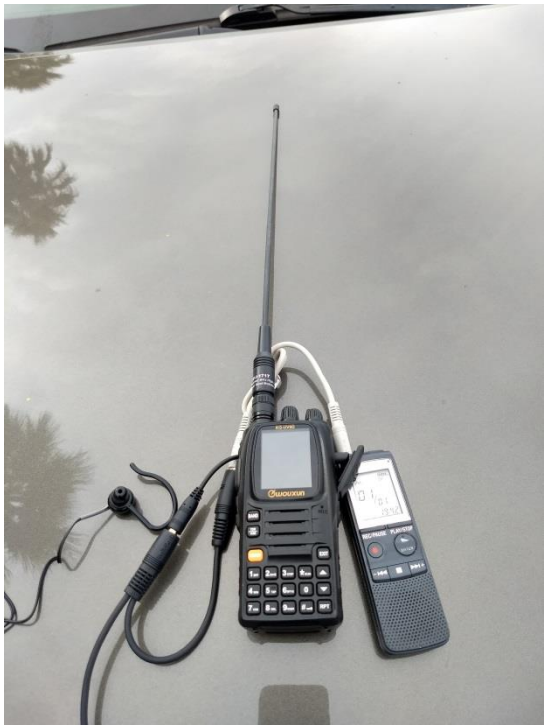
Launched in October 2015, 70cm/2m FM transponder with telemetry, in a 4”/10cm cube



AO-91 (Fox-1B)

Launched in November 2017, 70cm/2m FM transponder with telemetry, in a 4”/10cm cube. Can be worked with 2m/70cm FM HT & long “duckie” or telescoping whip antenna

WD9EWK using a Wouxun KG-UV9D HT & MFJ-1717 “duckie” on AO-91, 6 Jan 2018



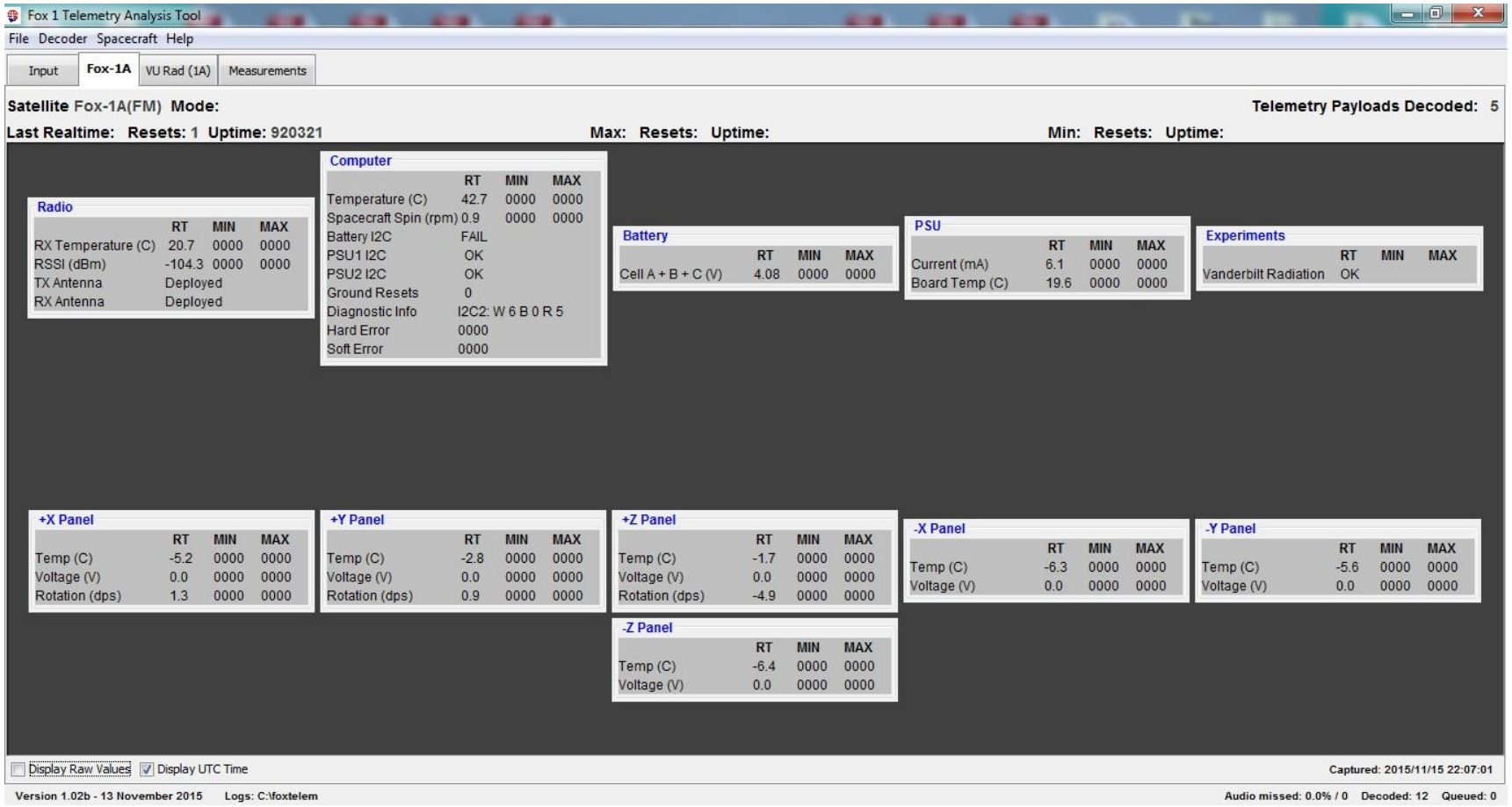
AO-92 (Fox-1D)

Launched in January 2018, FM transponder (70cm or 23cm uplink/2m downlink) with telemetry and camera

Pictures taken by AO-92 on 13 & 16 January 2018 over USA east coast

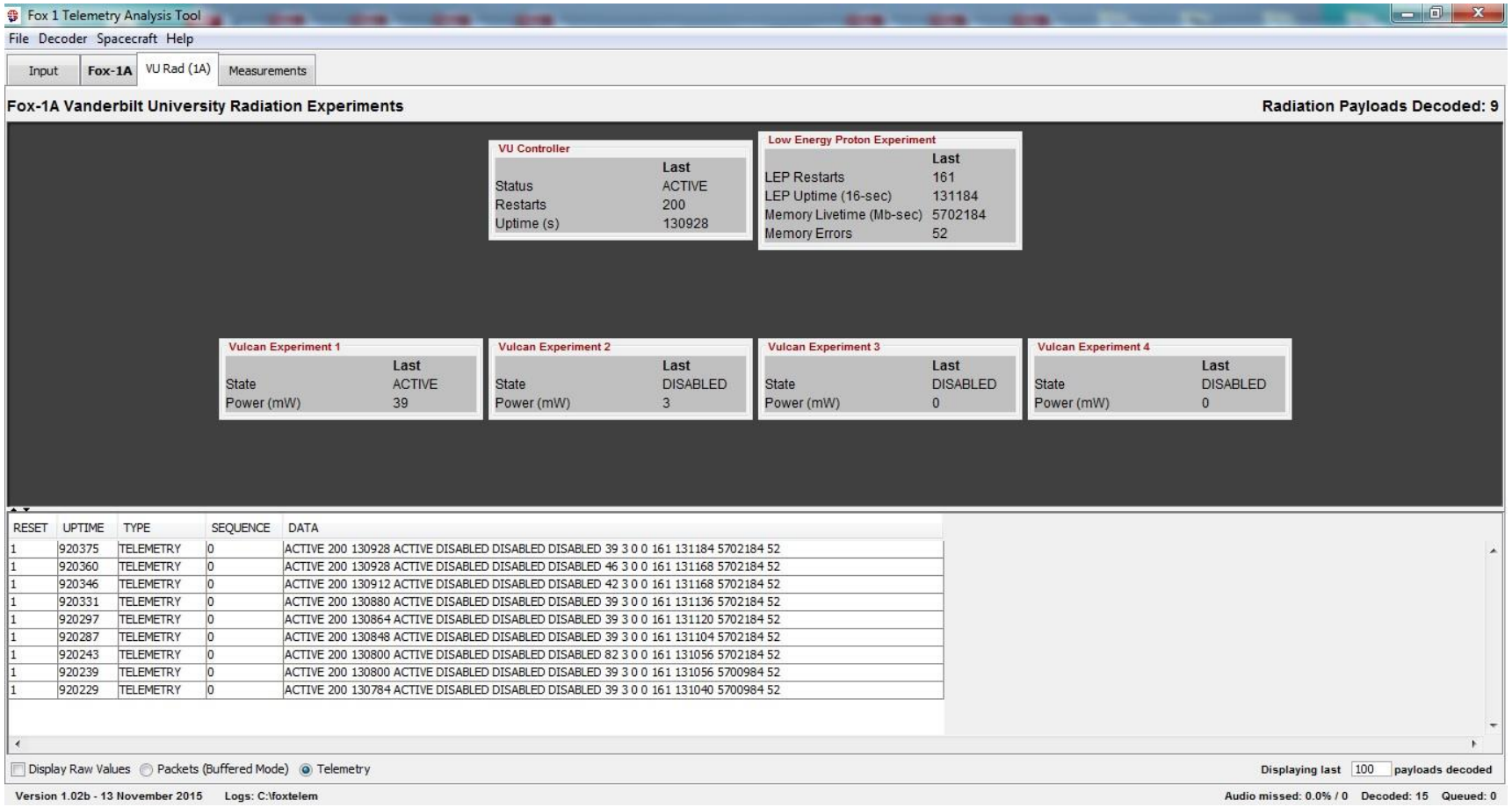
FoxTelem software

Free software available from AMSAT web site for Windows, Mac OS X, and Linux (requires Java)



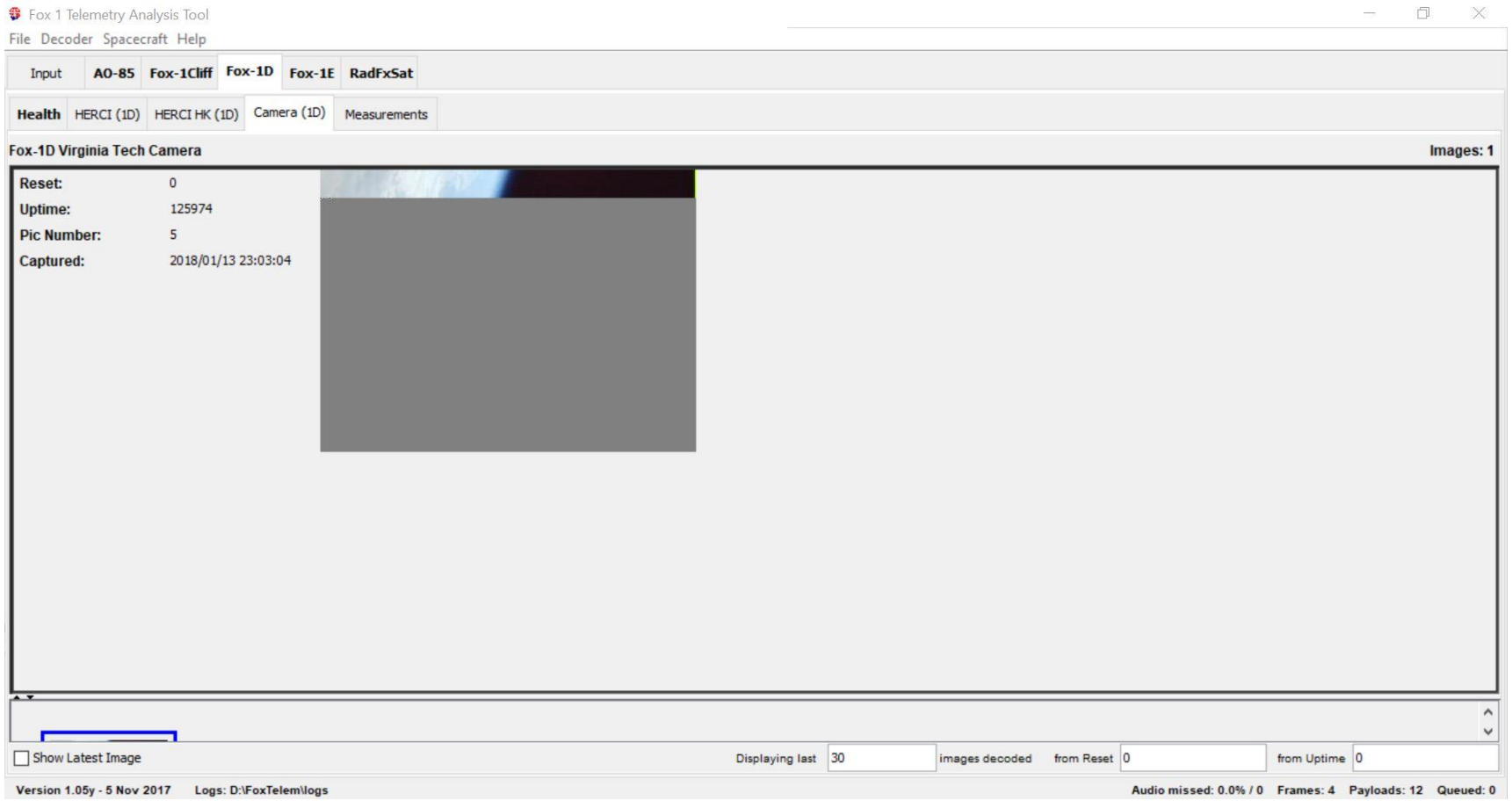
FoxTelem software

Telemetry includes data from university experiments, pictures from cameras on some Fox-1 satellites.



FoxTelem software

Can also decode pictures from cameras on AO-92 & Fox-1C



FoxTelem software

Partial picture (L) received from AO-92 by WD9EWK on 13 January 2018 at Thunderbird Hamfest, using SDRplay RSP1A, Elk Antennas handheld 2m/70cm log periodic, & 8-inch Windows 10 tablet at AMSAT table. Complete picture received by other stations on right.

FoxTelem software

Software can directly control a FUNcube Dongle Pro+, or process data from other SDR receivers or 9600bps data port on many radios