



WARC  
29 April 2017

# Amateur Satellites and



Patrick Stoddard



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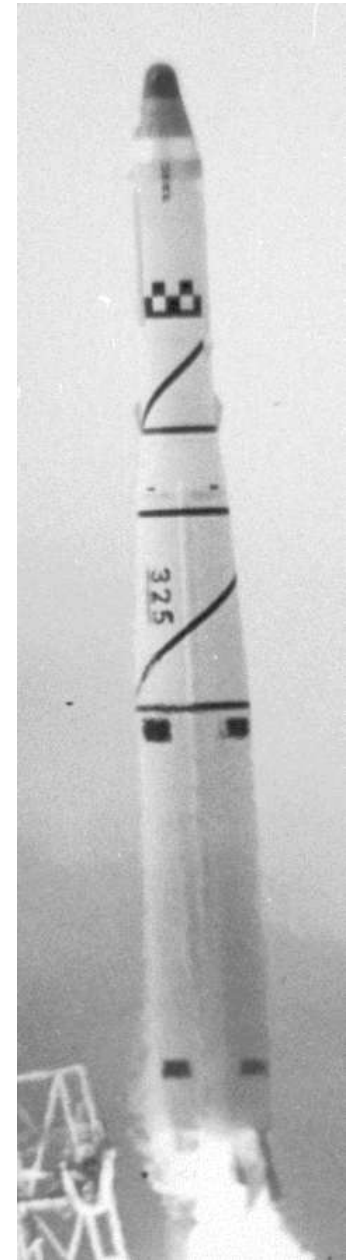
Area Coordinator, Radio Amateur Satellite Corporation (AMSAT)

...as adapted by Brent Taylor, W1PJ / VY2HF



# 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
- Transmitted until 3 January 1962, heard by over 570 radio amateurs worldwide
- Transmitted CW beacon – “HI” – on 2m
- Reentry on 31 January 1962



# 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

# Working satellites, now...

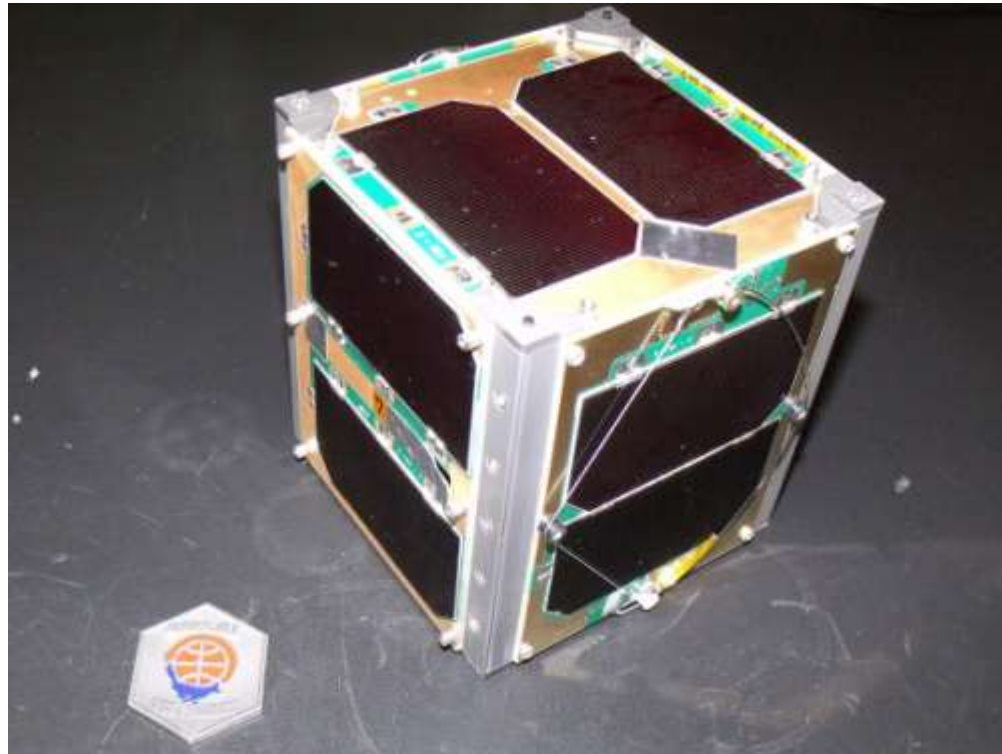
- More multiband satellite-ready transceivers available
- Monoband all-mode transceivers still an option
- HF/VHF/UHF all-mode transceivers also useful for satellite work
- SDR – transceivers, receivers, even USB dongles!
- For FM satellites, many 2m/70cm FM transceivers (HTs and mobiles) are suitable 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
- Although DXCC is difficult, many other awards available, including:
  - ARRL VUCC, WAS
  - AMSAT awards
  - CQ magazine awards

# 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)
  - Narrow FM on uplink & downlink may make for better receiving
  - Slow-speed telemetry sent w/FM downlink, sometimes replaced by high-speed telemetry – both readable with Fox telemetry software

# Fox-1A (AO-85)

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



# 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 like AO-85 (Wouxun KG-UV8D, KG-UV9D)
  - More options with mobile transceivers (TM-D710, TM-V71A, FT-8800, 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, FT-100, FT-817, FT-857, FT-897 etc. usable with split-VFO operation
- Separate 2m and 70cm FM transceivers



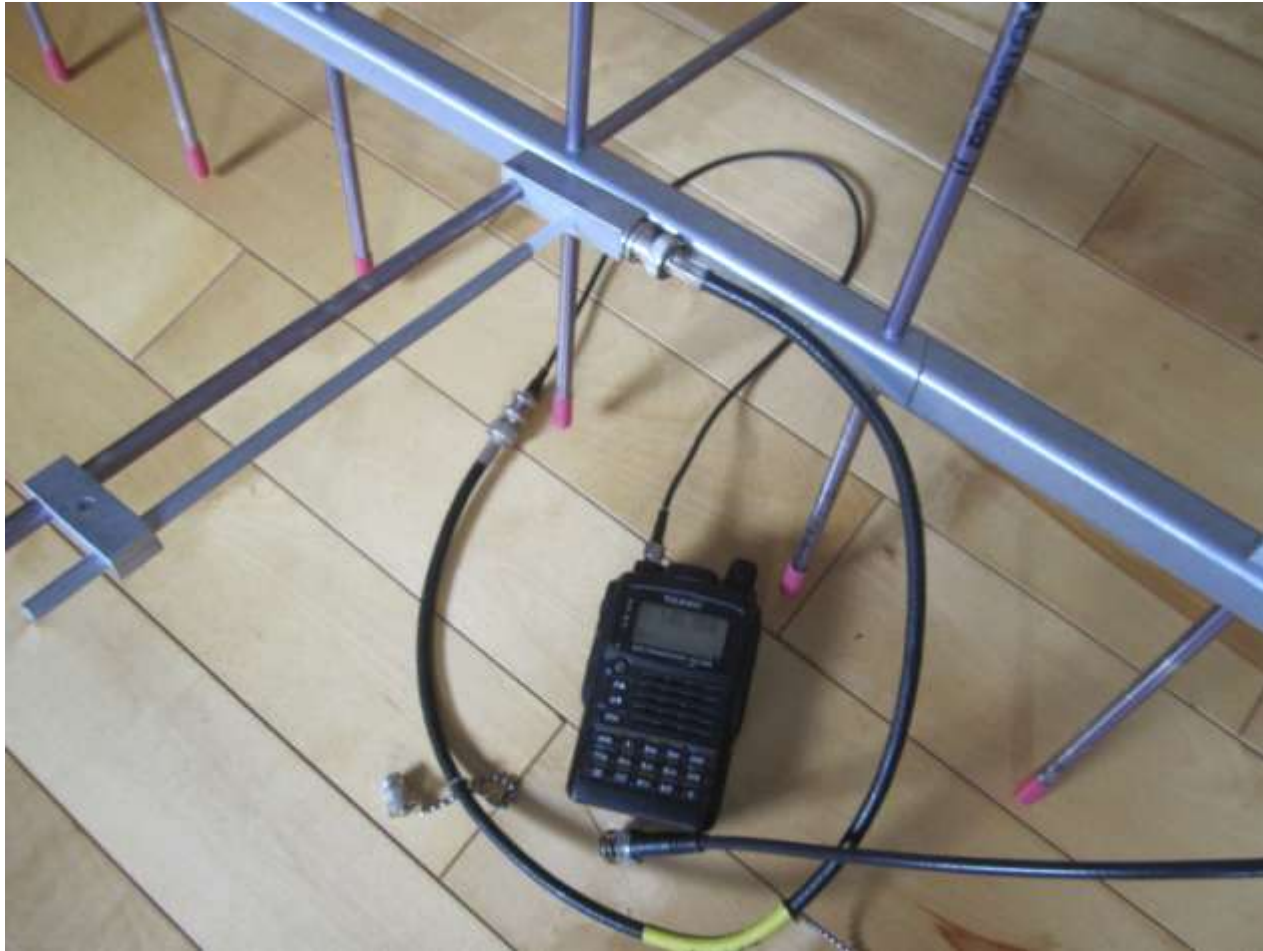
# Arrow Antenna



# Yaesu VX-3 (receive)



# Yaesu VX-8G (transmit)



# ELK Antenna

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



# 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, due to battery failure in 1981
- FO-29, launched in 1996, 2m uplink/70cm downlink
  - Originally had other functions including “digitalker”, now operates as 100 kHz transponder
- AO-73, launched in 2013, 70cm uplink/2m downlink
  - “FUNcube-1” – first of a series of UK/Dutch CubeSats
  - 20 kHz transponder
  - Sensitive uplink receiver, workable with 500mW to directional antenna, or 5W to long whip – easy to hear!
  - 2m digital telemetry beacon at 145.935 MHz (+/- for Doppler), can be decoded using FUNcube Dashboard software

# OSCAR 7

AO-7

Mode A

145.850    ↑    145.950  
29.400    ↓    29.500

Non-inverting

Mode B/C

~~432.125    ↑    432.175~~  
~~145.975    ↓    145.925~~

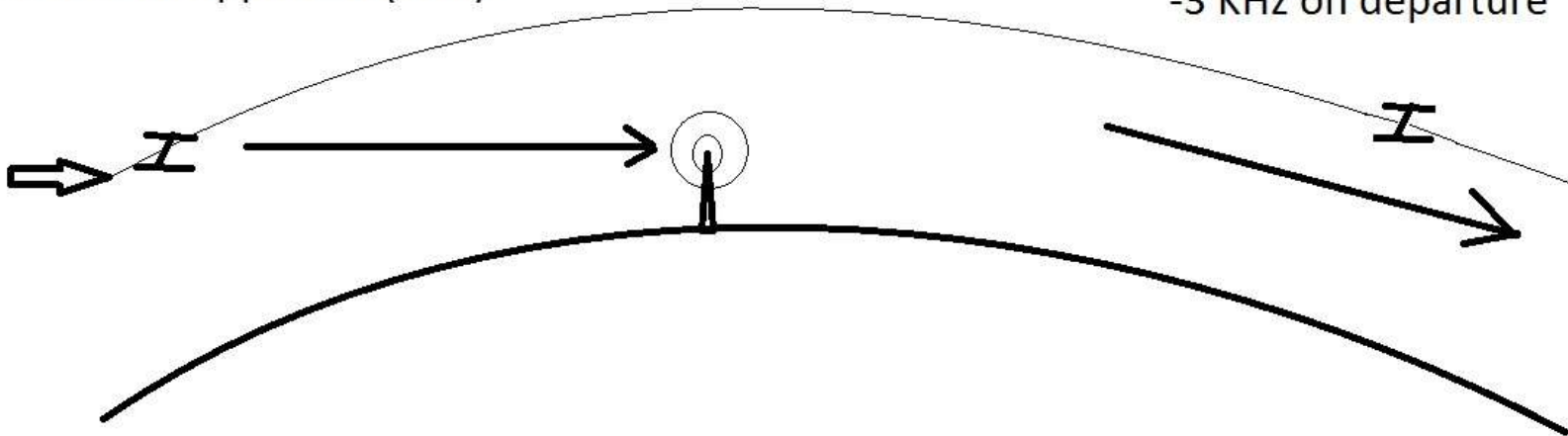
Inverting

# Watch for Doppler

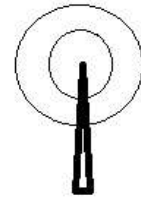
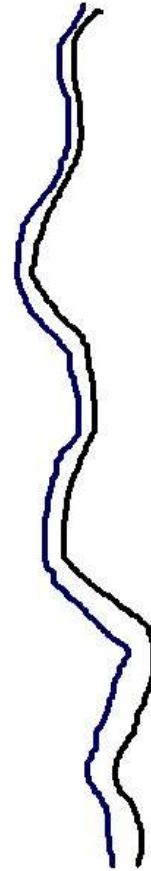
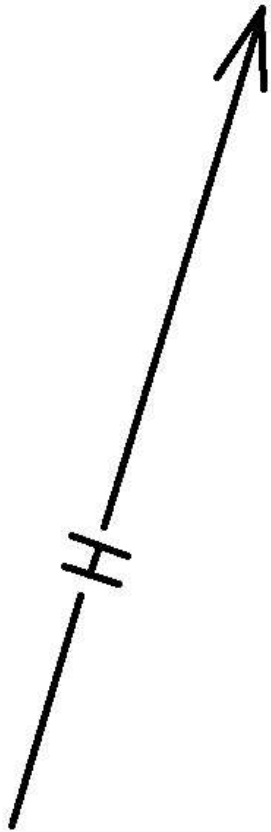
## Doppler

+10 KHz on approach (UHF)  
+3 KHz on approach (VHF)

-10 KHz on departure  
-3 KHz on departure



# Less Doppler

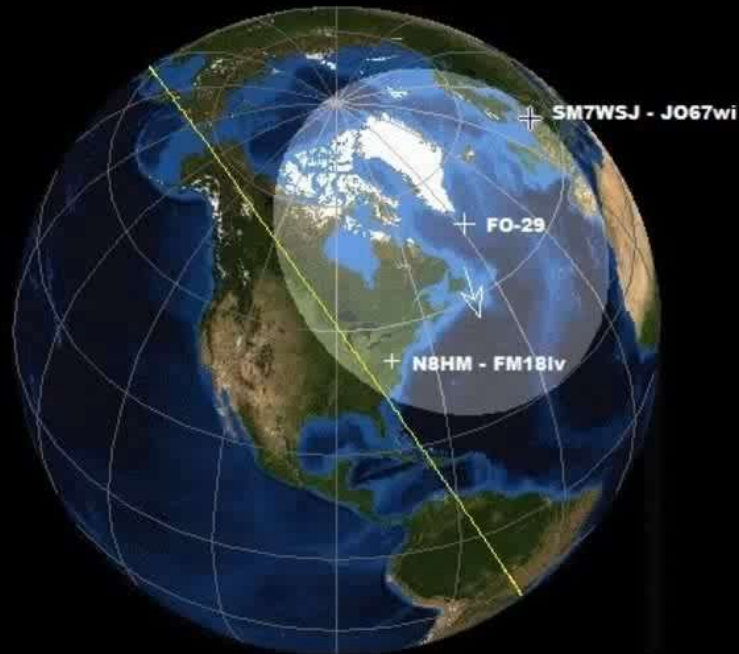




# N8HM and SM7WSJ

uploaded in HD @ TunesToTube.com

**N8HM to SM7WSJ - 1012Z 14-Jun-2014 - 6,516 km (4,049 mi)**



# More SSB/CW satellites

- Ukube-1, launched in July 2014 (“FUNcube-2”)
  - 3U CubeSat, carrying FUNcube system similar to AO-73
  - 20 kHz transponder, 70cm uplink/2m downlink
  - 2m digital telemetry beacon at 145.915 MHz (+/- for Doppler), can be decoded using FUNcube Dashboard software
  - Additional telemetry beacon at 145.840 MHz
- EO-79, launched in June 2014 (“FUNcube-3”)
  - 2U CubeSat, carrying FUNcube system similar to AO-73
  - 20 kHz transponder, 70cm uplink/2m downlink
  - CW/digital telemetry beacon at 145.815 MHz

# Still more SSB/CW satellites

- XW-2 satellites, launched in September 2015
  - **Six** satellites launched with LilacSat-2 (XW-2A through -2F)
  - XW-2E failed a couple of months after launch, others are OK
  - 20 kHz transponders, 70cm uplink/2m downlink
  - Separate 2m CW and digital telemetry beacons
- EO-88 (Nayif-1), launched in February 2017
  - 30 kHz transponder, 70cm uplink/2m downlink
  - Based on FUNcube design, very similar to AO-73
  - 2m digital telemetry beacon at 145.940 MHz (+/- for Doppler), can be decoded using free software
  - Like AO-73, sensitive uplink receiver & strong downlink

# 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 RSP1 & RSP2 – <http://sdrplay.com/> (available 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)

# Fred AB1OC & Anita AB1QB



# Drew, KO4MA 2 FT-817s, Arrow



# 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!



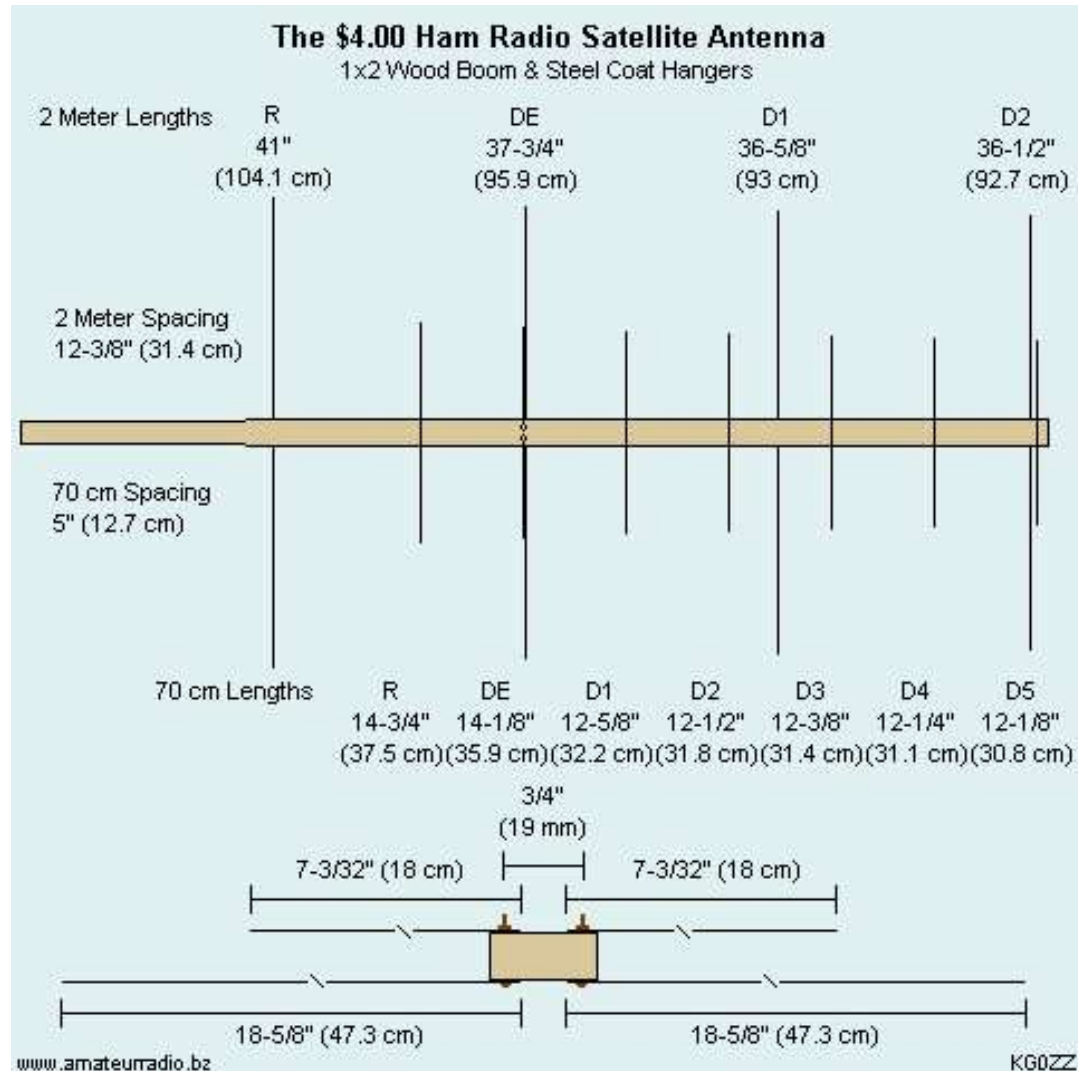
# The \$4 Antenna



KG0ZZ  
[www.amateurradio.bz](http://www.amateurradio.bz)



# The \$4 Antenna



# Digital/packet satellites

- NO-84 (PSAT)
  - built by US Naval Academy (NO-44, PCSAT2)
  - launched on 20 May 2015
  - 10m uplink/70cm downlink PSK31/FM transponder – uplink on 28.120 MHz PSK31, downlink on 435.350 MHz FM (+/- 10 kHz for Doppler)
  - 2m packet digipeater (145.825 MHz, simplex) – use ARISS or APRSAT in packet path (UNPROTO) when digipeater is active
- International Space Station
  - 2m packet/APRS digipeater (145.825 MHz simplex)
    - Use ARISS in packet path (UNPROTO)

# 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), not used in several years
  - European Columbus module
    - 2m packet on 145.825 MHz
    - Backup radio for UHF voice/packet operations
    - 2.4 GHz (S-band) DVB-S digital ATV
- Most ISS voice activity connected with scheduled contacts, but very occasional random QSOs with hams
- New TM-D710G for Columbus module in late 2017
- Call signs used from ISS: NA1SS, RS0ISS, OR4ISS
  - Packet/APRS: use “ARISS” in packet path, instead of paths normally used with terrestrial APRS (i.e., “WIDE1-1,WIDE2-2”)

# More satellites are coming...

- AMSAT Fox-1 satellites
  - 70cm uplink/2m downlink, FM
    - Fox-1B (RadFxSat), to be launched by NASA from Vandenberg AFB, 29 August 2017
  - 70cm or 1.2 GHz uplink/2m downlink, FM
    - Fox-1C, to be launched on SpaceX Falcon 9 from Vandenberg AFB, late 2017 or early 2018
    - Fox-1D, to be launched from India, late 2017
  - 2m uplink/70cm downlink, SSB/CW
    - Fox-1E (RadFxSat-2), to be launched by Virgin Galactic from Mojave CA, late 2017

# More satellites are coming...

- PSAT-2
  - Built by US Naval Academy midshipmen, to be launched in 2017 by SpaceX Falcon 9 from Cape Canaveral
  - APRS digipeater on 145.825 MHz
  - 10m/70cm PSK31 transponder – uplink on 28.120 MHz PSK31, downlink on 435.350 MHz FM (+/- 10 kHz)
  - DTMF “transponder” – send DTMF tones on 145.980 MHz FM, hear voice confirmation and see results on APRS digipeater

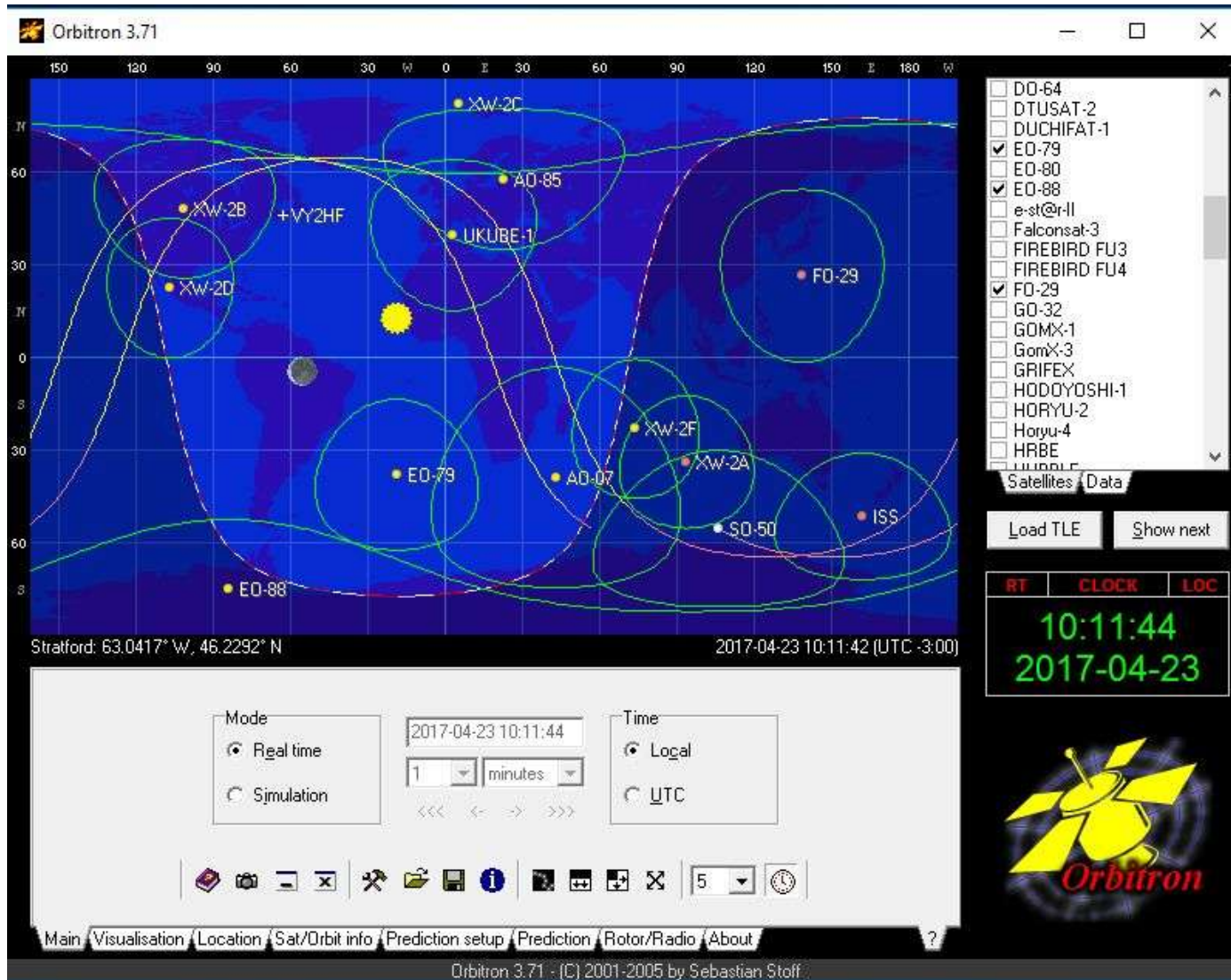
# More satellites are coming...

- **Two** geosynchronous amateur satellite payloads coming...
  - **Phase-4A**, by AMSAT-DL - tentative launch in 2018
    - Coverage from eastern tip of South America, Europe, Africa, & much of Asia
    - Two transponders, SSB/CW & digital (2.4 GHz uplink/10 GHz downlink)
  - **Phase-4B**, by AMSAT – tentative launch in late 2018
    - Coverage includes North America, possibly parts of other continents
    - One transponder for SSB/CW & digital (5 GHz uplink/10 GHz downlink)
    - AMSAT will have ground station design & kits available in time for launch

# 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

# Orbitron





# Orbitron

Orbitron 3.71

Stratford: 63.0417° W, 46.2292° N      2017-04-23 10:13:06 (UTC -3:00)

Time - LOC	Satellite	Azm	Elv	Mag	Range	S.Azm	S.Elv
2017-04-23 10:36:16	EO-79	58.1	11.1	?	1880	123.3	43.4
2017-04-23 10:52:06	ISS	145.3	47.4	0.7	536	127.7	45.6
2017-04-23 10:52:08	AO-07	3.7	3.7	?	4175	127.7	45.6
2017-04-23 10:52:50	XW-2A	306.8	1.8	?	2279	127.9	45.7
2017-04-23 11:02:49	SO-50	337.3	11.7	12.8	1913	130.8	47.1
2017-04-23 11:13:50	EO-88	105.5	82.8	?	507	134.2	48.5

Passes  
Flares  
Predict

Main Visualisation Location Sat/Orbit info Prediction setup Prediction Rotor/Radio About

Orbitron 3.71 - (C) 2001-2005 by Sebastian Staff

# 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 with 67.0 Hz CTCSS tone. The AO-85 downlink shuts off 60 seconds after it 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** (hear 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

# 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 and AO-85
- **Fox satellites in development**
  - Fox-1 satellites – 4" x 4" x 4" cubes, various transponder configurations
  - Fox-2 satellites – 4" x 4" x 12" cubes, SSB/CW, frequencies TBD
- Phase-4B geosynchronous payload, riding with communications satellite
- Always open to new proposals for amateur satellites
- <http://www.amsat.org/>
- Other AMSAT organizations around the world developing satellites



Questions?

**Additional Slides**

# International Space Station



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



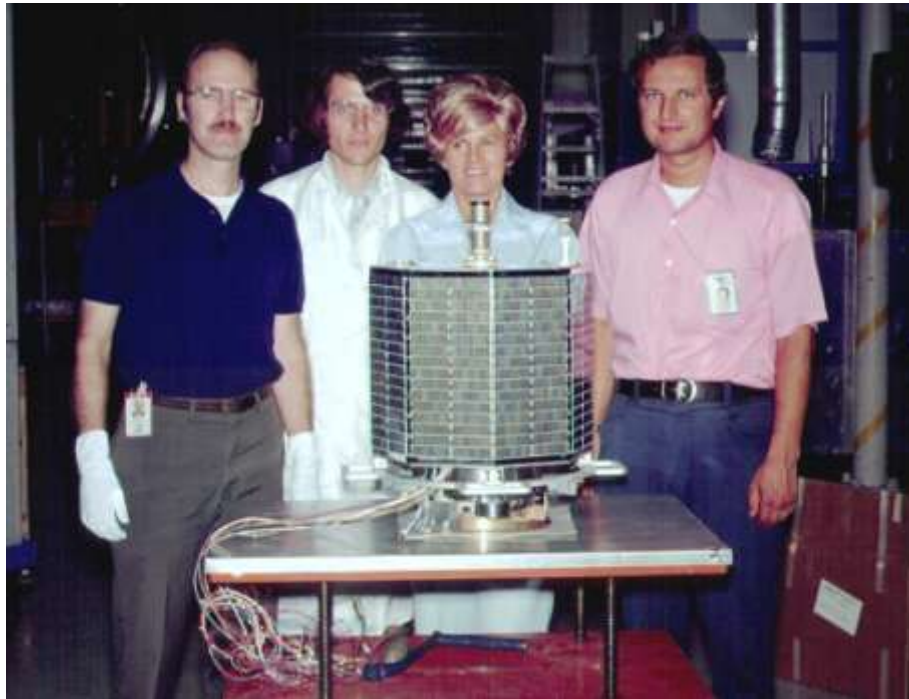
# International Space Station



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

# OSCAR 7 (AO-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



# FUNcube-1 (AO-73)

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

