



WARC
29 April 2017

Amateur Satellites and



Patrick Stoddard



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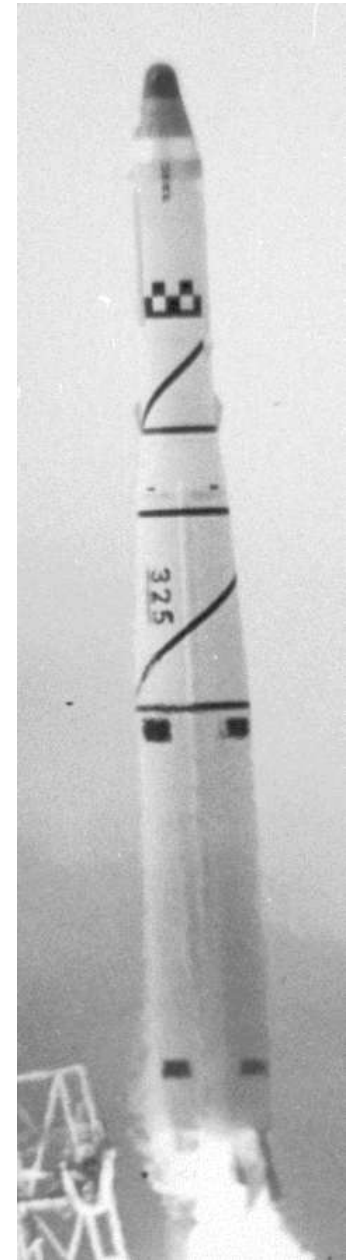
Area Coordinator, Radio Amateur Satellite Corporation (AMSAT)

...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...

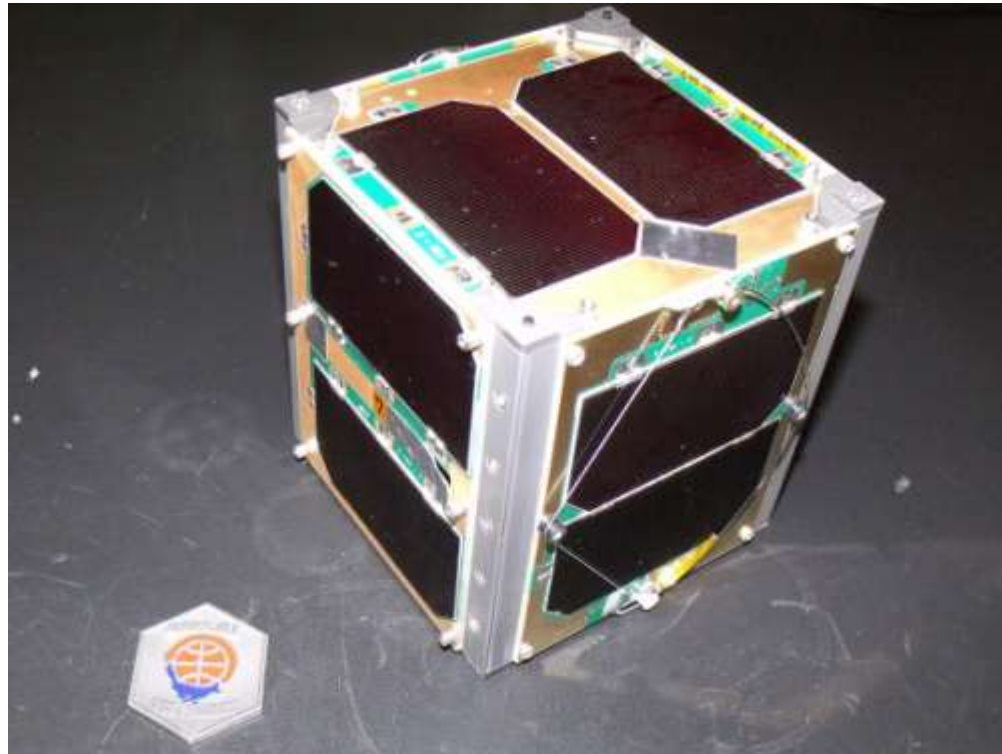
- More multiband satellite-ready transceivers available
- Monoband all-mode transceivers still an option
- HF/VHF/UHF all-mode transceivers also useful for satellite work
- SDR – transceivers, receivers, even USB dongles!
- For FM satellites, many 2m/70cm FM transceivers (HTs and mobiles) are suitable 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

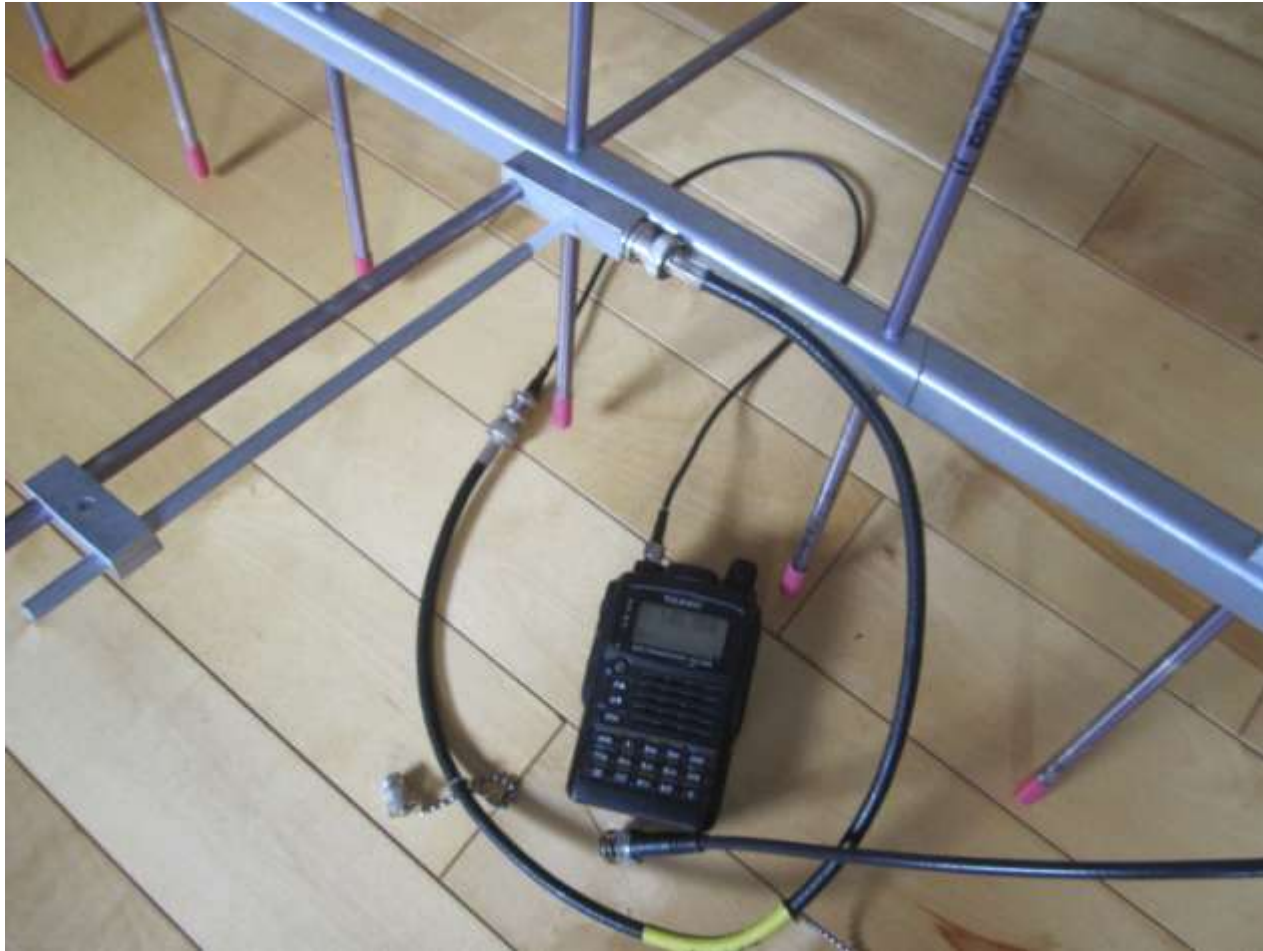
Arrow Antenna



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

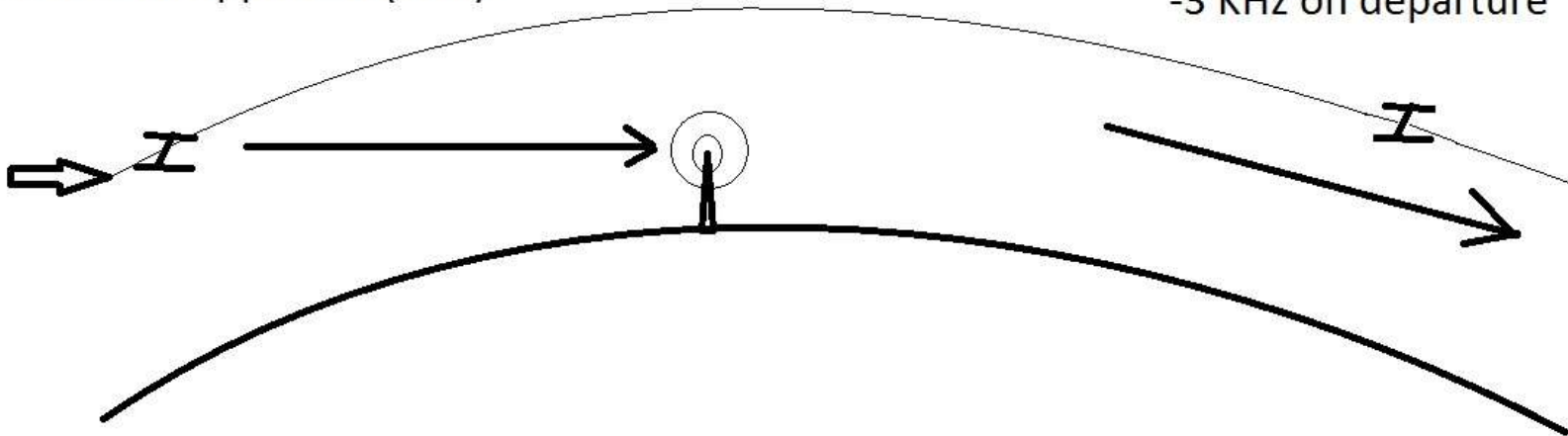
Inverting

Watch for Doppler

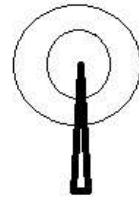
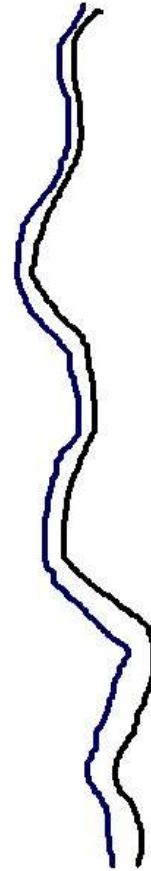
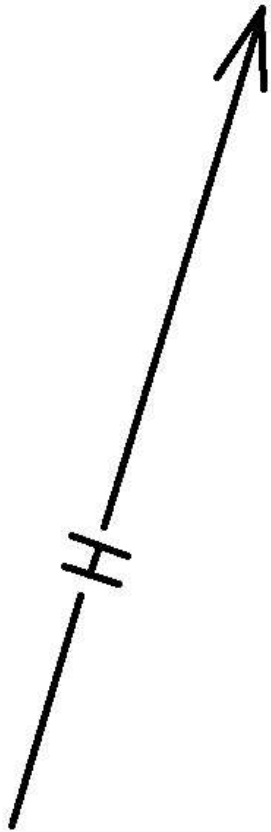
Doppler

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

-10 KHz on departure
-3 KHz on departure



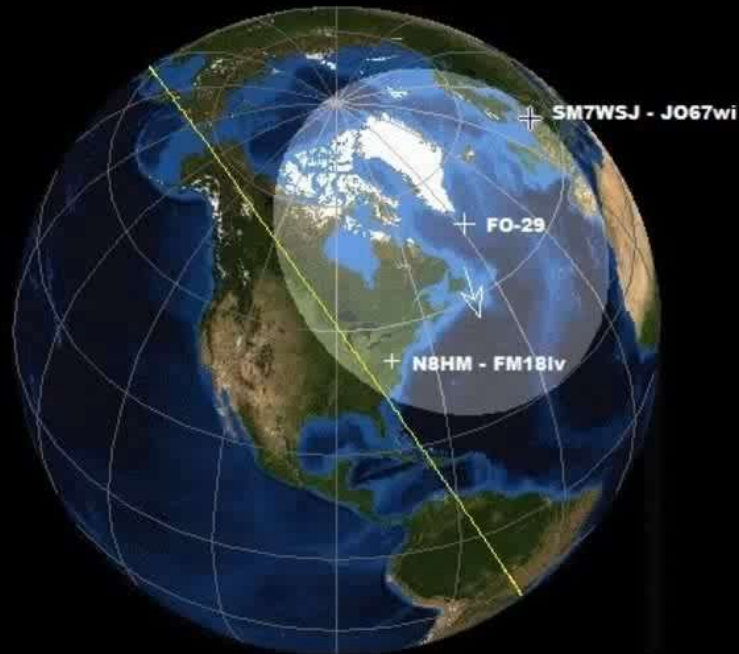
Less Doppler



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!

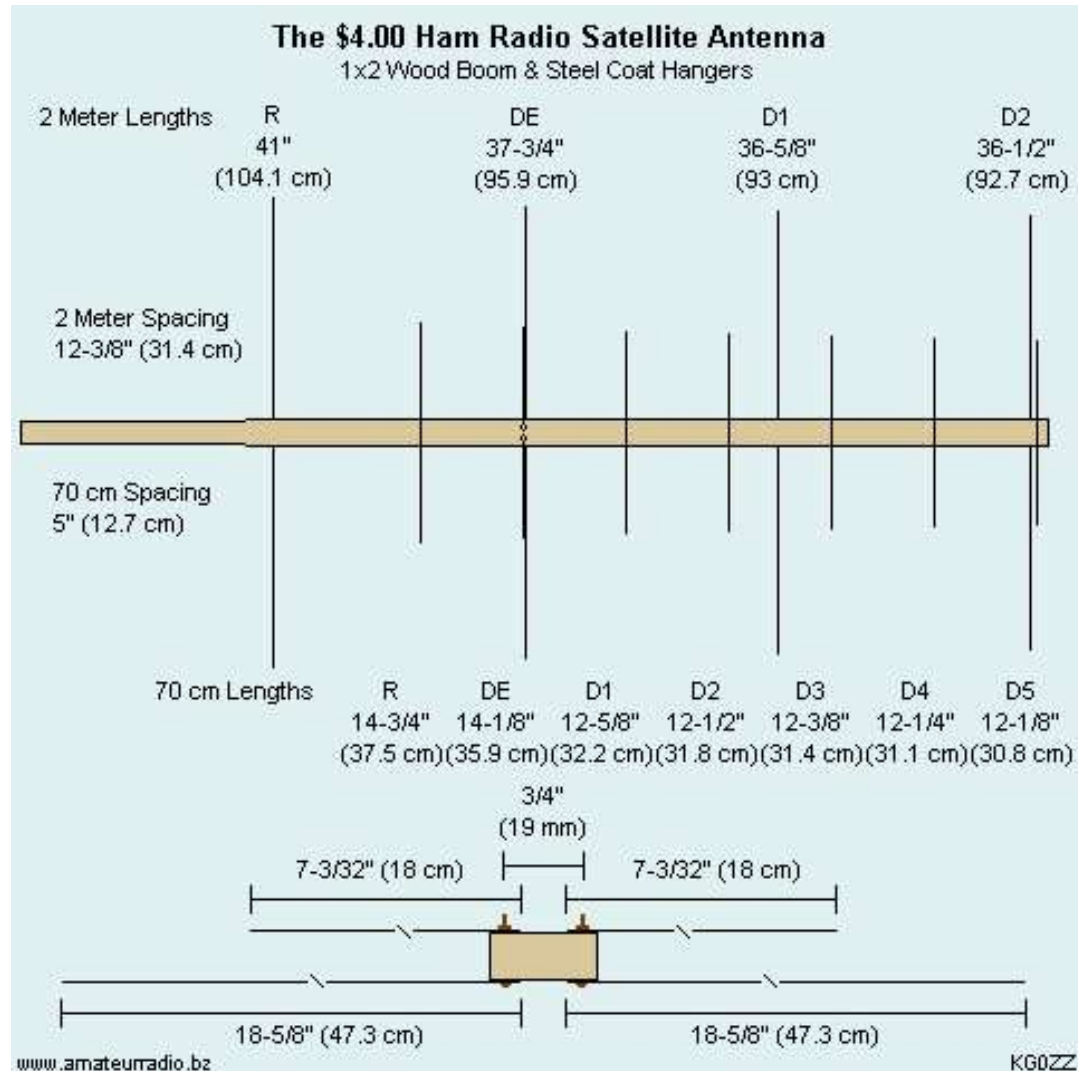
Yaesu FT-817ND, SDRplay software defined receiver, 8-inch Windows 10 tablet with HDSDR, & Elk Antennas 2m/70cm handheld log periodic antenna = small, very portable, all-mode ground station!



The \$4 Antenna



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

The screenshot displays the Orbitron 3.71 software interface. The main window shows a world map with satellite orbits and ground station locations. The map is centered on the Atlantic Ocean, with latitude and longitude coordinates visible. The ground station locations are marked with colored dots and labels: XW-2B, XW-2D, XW-2C, XW-2F, XW-2A, UKUBE-1, AD-85, AD-07, EO-79, EO-88, FO-29, SO-50, and ISS. The ISS is shown as a small grey sphere. The map also shows the Sun and Moon. The interface includes a sidebar on the right with a list of satellites and ground stations, a status bar at the bottom, and a control panel at the bottom center.

Orbitron 3.71

150 120 90 60 30 W 0 E 30 60 90 120 150 E 180 W

75
60
30
0
30
60
3

Stratford: 63.0417° W, 46.2292° N

2017-04-23 10:11:42 (UTC -3:00)

Mode
 Real time
 Simulation

2017-04-23 10:11:44
1 minutes

Time
 Local
 UTC

RT CLOCK LOC
10:11:44
2017-04-23

Orbitron

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

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

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)

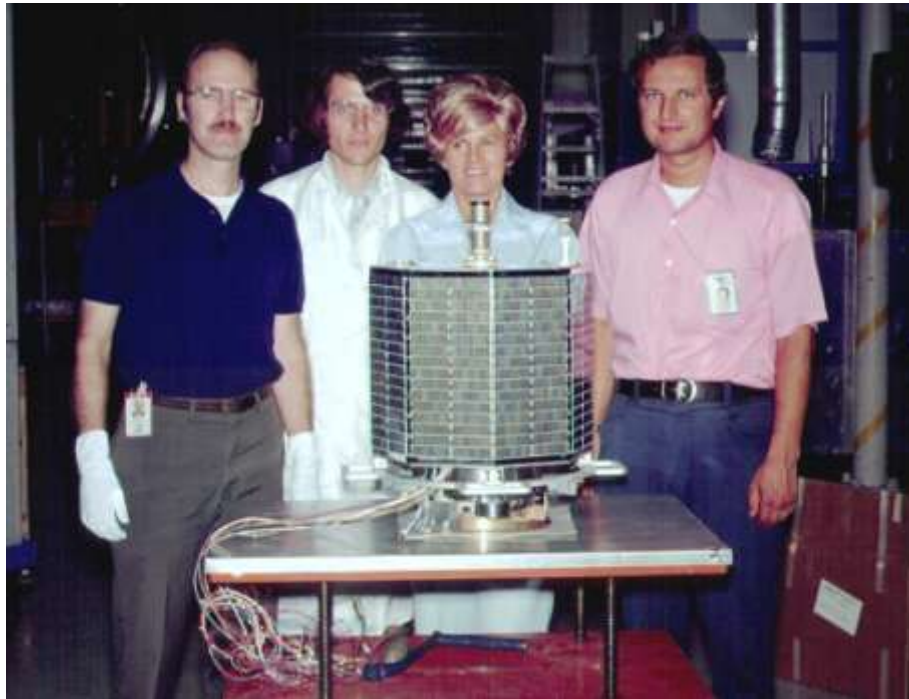
International Space Station



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

