North Richland Hills ARC

Working the Low Earth Orbit Satellites III

NRHARC 10/26/15

Why Satellites?

- **All Ham Classes can use.**
- **Limited HOA impact**
- **Relatively inexpensive (FM)**
  - **Dual Band Wouxon/Baofeng Handheld $30 - $150**
  - **Homemade antenna $50 (or less)**
- **Minimum RFI**
- **All modes (digital, FM, SSB, SSTV)**
- **Challenging (17,000 mph)**

Working the Amateur Satellites

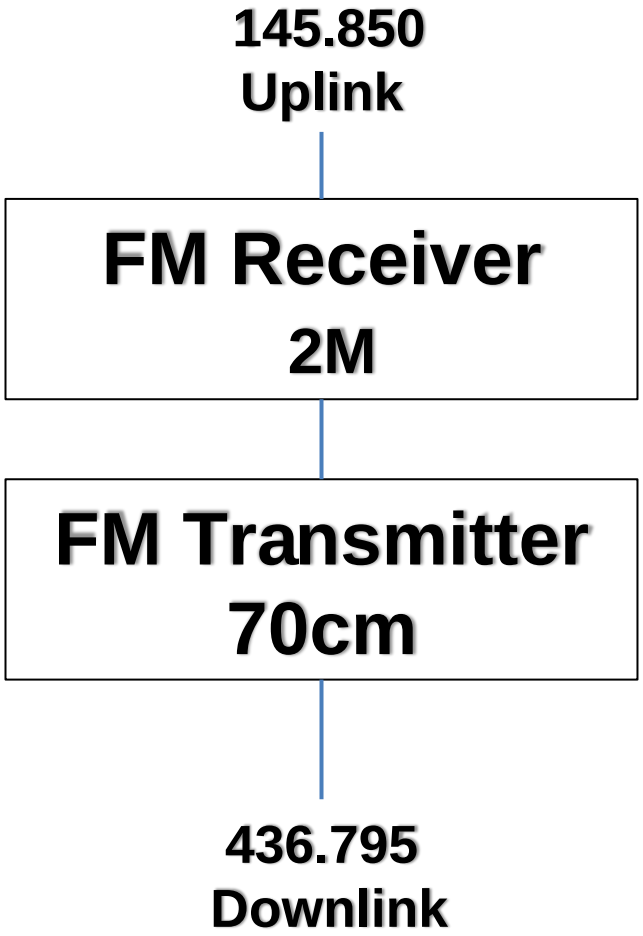
- FM satellite(s) easiest to work.
- SSB/CW satellites are similar to repeaters, but retransmit range of frequencies with many simultaneous contacts possible.
- Activity on almost every pass. DX possible? WAS?
- ISS – talk to crews (rare), access packet mailbox, use packet digipeater to make keyboard contacts with other ground stations or crews, use repeater to talk with other stations or crews, receive slow-scan TV pictures.

FM Satellites

- Low Earth Orbiting Cross-band Repeaters (LEO)
- Uplink (talk) on 2 Meters / Downlink (listen) on 440
- AMSAT – Amateur Satellite Corp. – currently 2 FM "Birds"
- Oscar1 1961
- Sub-Bands
  - 144.3-144.5, 145.8-146.0
  - 435.0-438.0
- "Easy" to work –
  Except on Field Day

FM Repeter (SO -50)

Single Channel Cross Band NFM Repeater



Radios for Satellites

Working the satellites - Radio

- Radios that have 1 VFO but can accept memory channels with RX and TX in different bands OK.
- Any dual-band FM radio can be used, with extra manual steps (channelizing RX and TX frequencies)
- Some use Separate 2m and 70cm radios
- Not necessary to run high power (except Field Day) – FM satellites have good Receivers.

Working the satellites - Radio

- HTs: IC-W32A, TH-D7, TH-79, FT-470, FT-51, FT-530, VX series, Wouxun, Baofeng, etc.
- Mobile rigs: IC-2820, FT-7800, FT-8800, TMD710, TM-V71A, and many others
- SSB All Mode Rigs: **FT-847**, TS-2000, IC-821H, IC-9100, FT-991 (?)
- Can use combination of FT-817, 857 and 897 in Half Duplex SSB mode using software.
- Transceivers that can work as 2m/70cm full duplex, multi-mode cross-band repeater are ideal for satellites (FT-847, TS-2000)

Working the satellites - Radio

- Full-duplex operation nice when starting out, but not mandatory on FM.
- Is “necessary” for SSB.
- Can work with as little as 100mW, many use 1-5W from HTs, some work mobile with 25-50W
- Must compensate for Doppler on 70cm.
- Antenna, antenna, antenna…

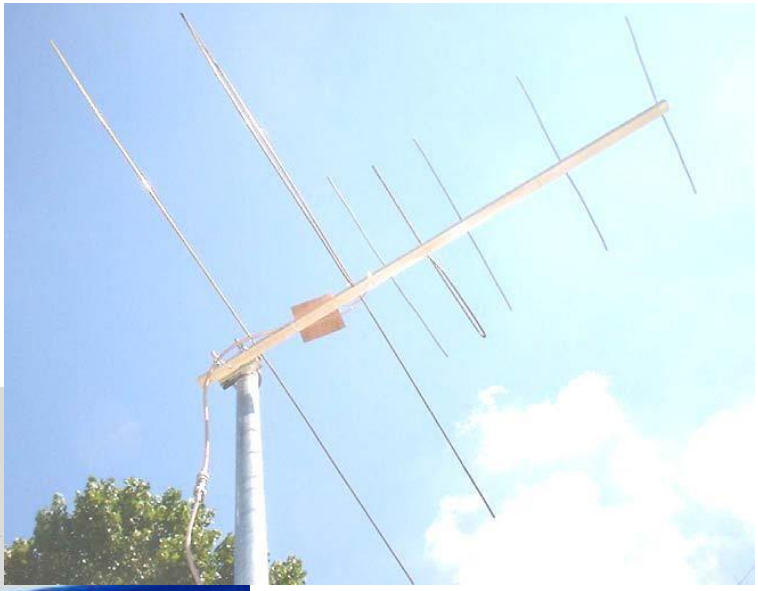
Working the FM satellites - Antenna

- Ideal antenna is a directional antenna – Yagi, quad, log periodic, etc.
- Circular polarization ideal, but not essential
- Omnidirectional antennas without gain also useful for satellite work
- Portable stations typically use handheld Yagis, log periodics, telescoping whips, or long duckies with HTs
- Sometimes antennas need to be tilted from vertical or rotated to hear satellites better

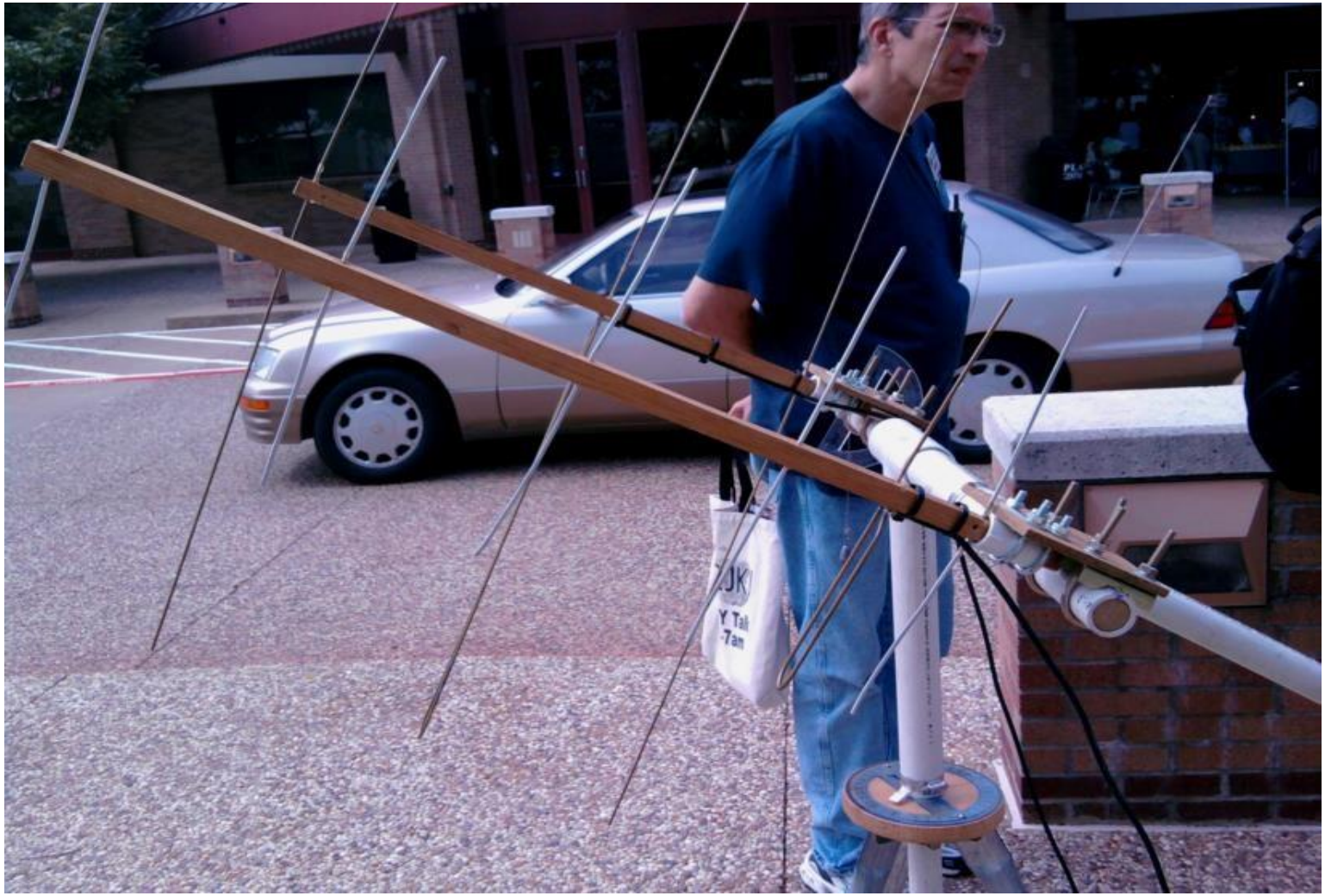
Antennas

Homebuilt Antennas

“Cheap Yagis”
WA5VJB



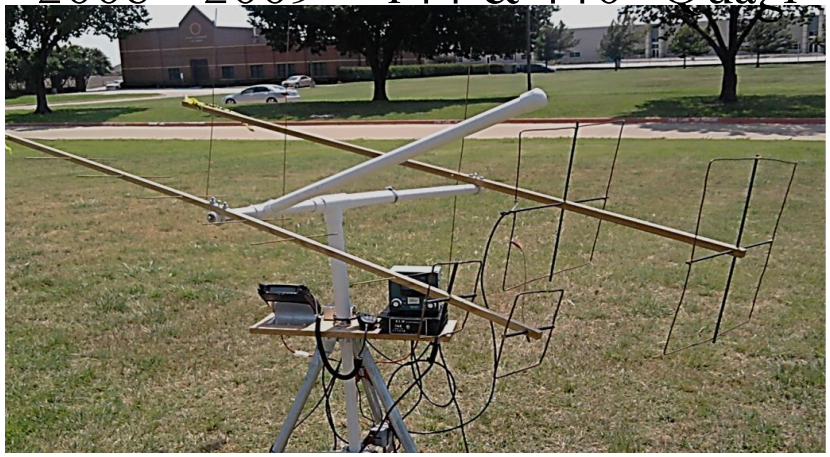
Homebuilt Antennas



2011 - 2 Meter LFA (G0KSC) & 10 element 440 Yagi Azimuth Rotor

Field Day – Satellite Antennas

2008 - 2009 – 144 & 440 “Quagi”



2010 - Arrow


DEG. X 10°
ELEVAT REMOTE PROGRAMMABLE ANTENNA ROTATOR VH126N
CHANNEL
ANT. POSITION
SENSOR
DEG. X 10°
AZIMUTH REMOTE PROGRAMMABLE ANTENNA ROTATOR
INITIAL
MEMORY
145.949.930
432.146.57
YAESU
RX
TX
TRACK
N-R

Field Day – Satellite Antennas

2016?

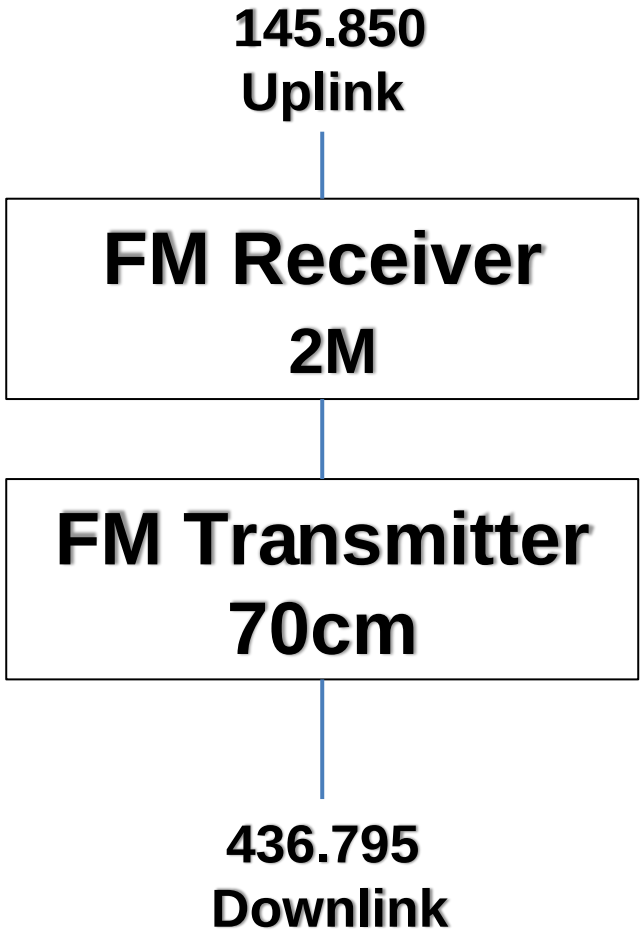

ELEVAT REMOTE PROGRAMMABLE ANTENNA ROTATOR VH128N
AZIMUTH REMOTE PROGRAMMABLE ANTENNA ROTATOR
145.950.070
432.146.17
acer

30 degrees elevation & 270 degrees azimuth

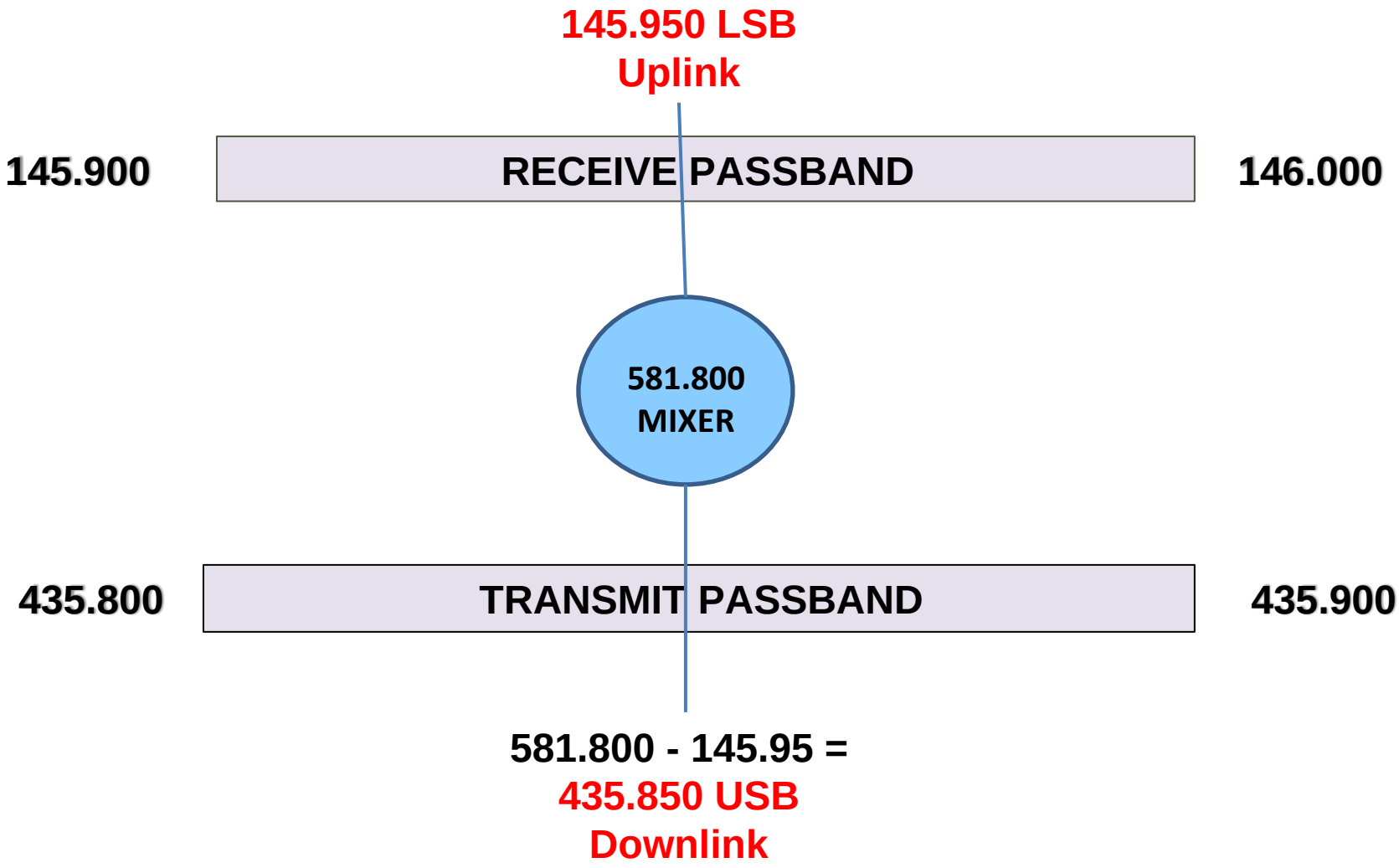
SSB Satellites

FM Repeater (SO-50, AO-85)

Single Channel NFM Repeater



SSB AO-07, FO-29, XW-2D-2F
Inverting Linear Transponder



SSB AO-07, FO-29, XW-2D-2F
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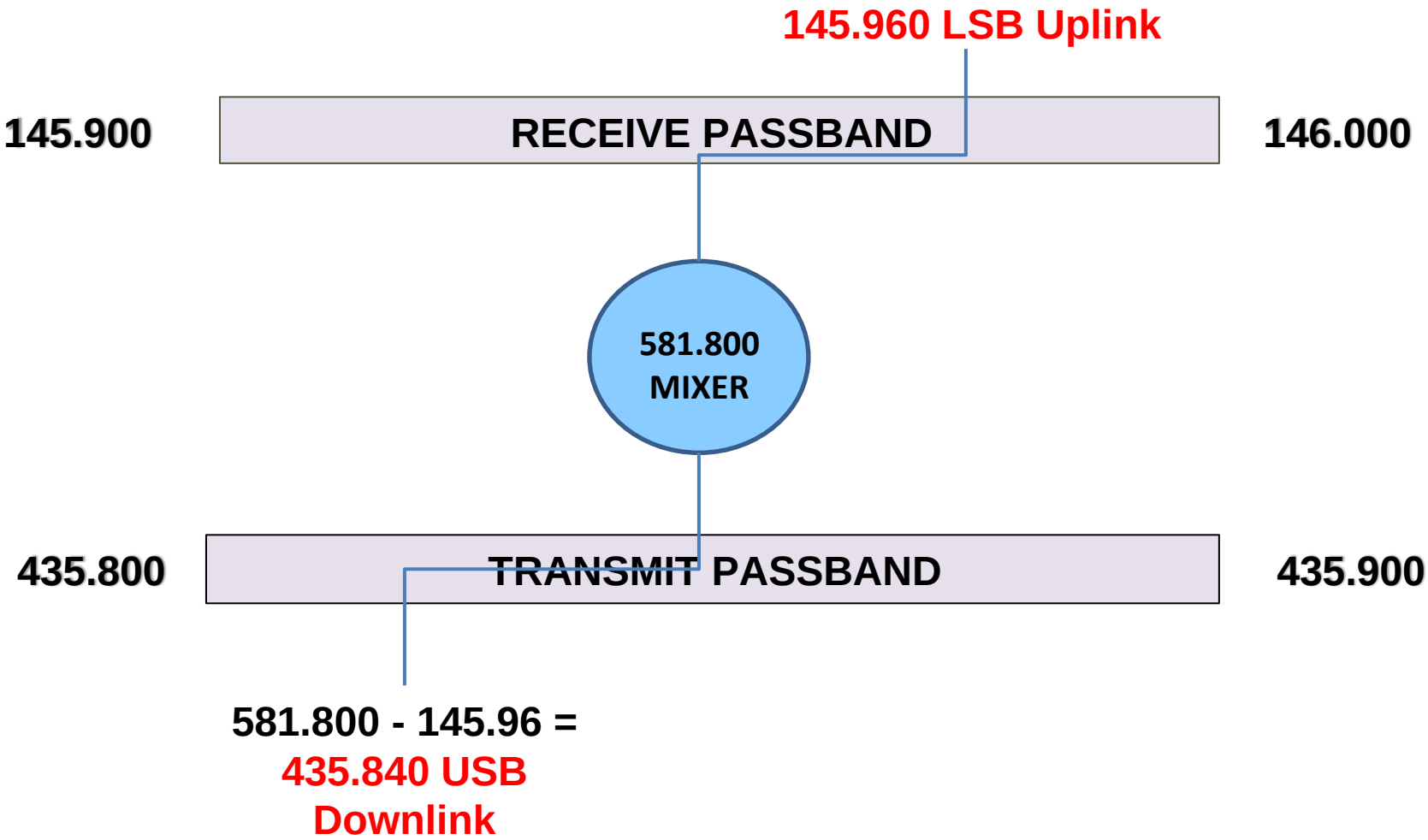


Operating Procedures – Linear Transponder (SSB – Digital)

- **<u>Monitoring your uplink is a necessity – not a nice to have</u>**
- **Adjust only the higher frequency (UHF) during your QSO. • If not you end up chasing each other around the dial**
- **Use the minimum power necessary**
- **Also remember you are moving through the usable bandwidth while the QSO is in progress**

here to Start Listening on SSB Birds

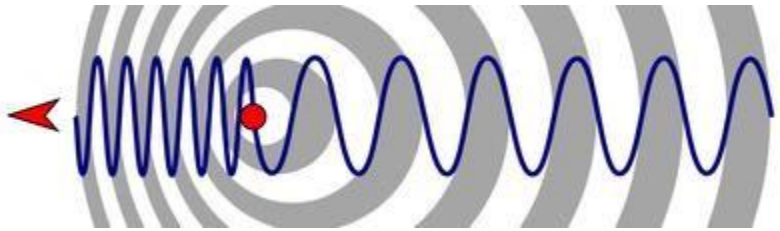
- **Generally in center of Passband**
- **AO-07 (145.925 – 145.975) 145.950**
- **FO-29 (435.800 – 435.900) 435.840**

Doppler Effect on Satellites
Doppler Shift

- **Not a big factor on VHF**
- **Bird is moving at ~17,000 mph**
- **2.5 kc shift on VHF**
- **Shift becomes significant on UHF – up to 10 kc**

Doppler Effect

- Change of wavelength caused by motion of the source or hearer
- Locomotive, Ambulance, etc.
- Same is true of satellites

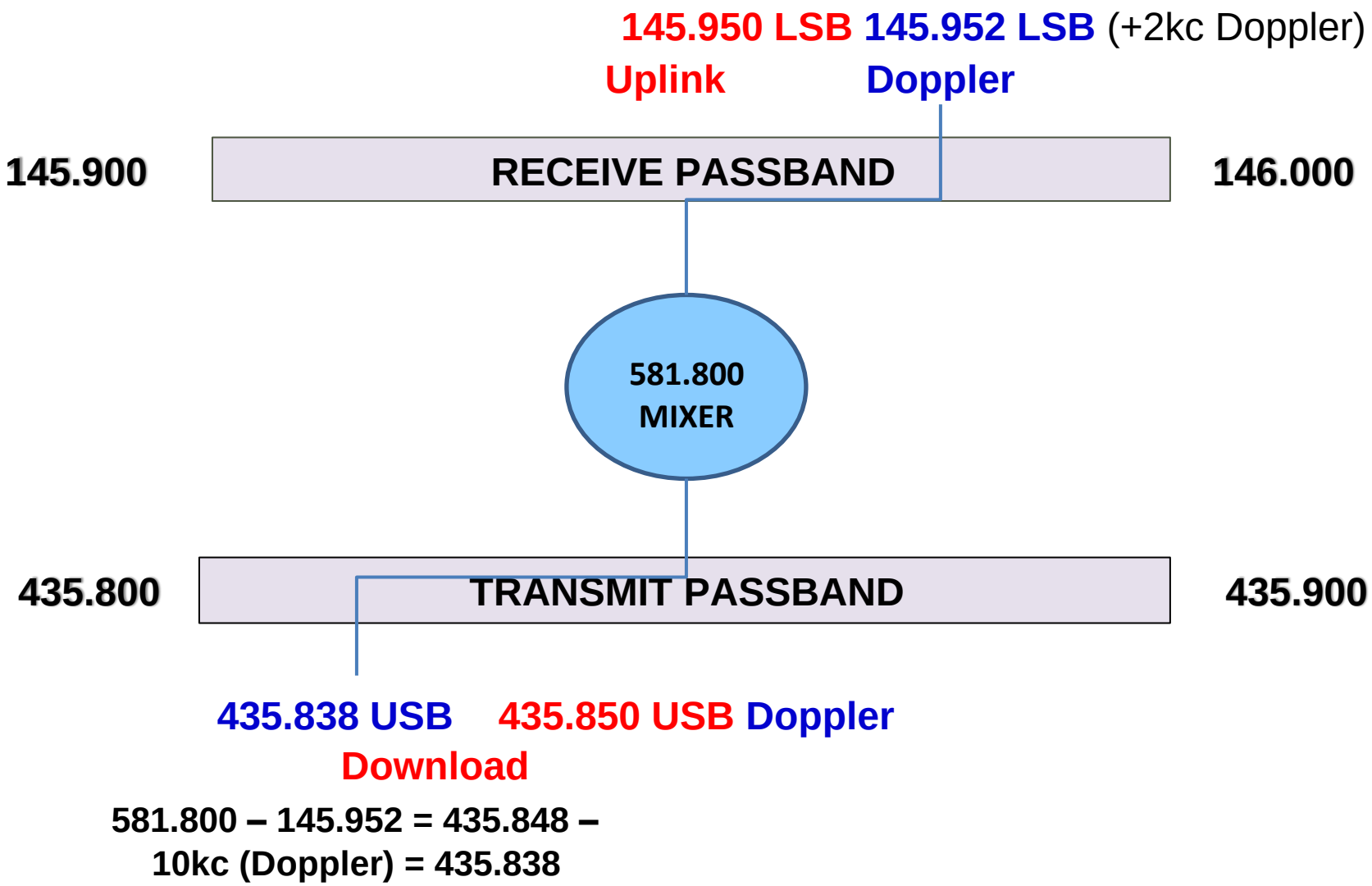


- As the satellite approaches us, the frequency is higher
- As it passes, the frequency becomes lower

VX-5 PROGRAM MEMORIES 249 - 255

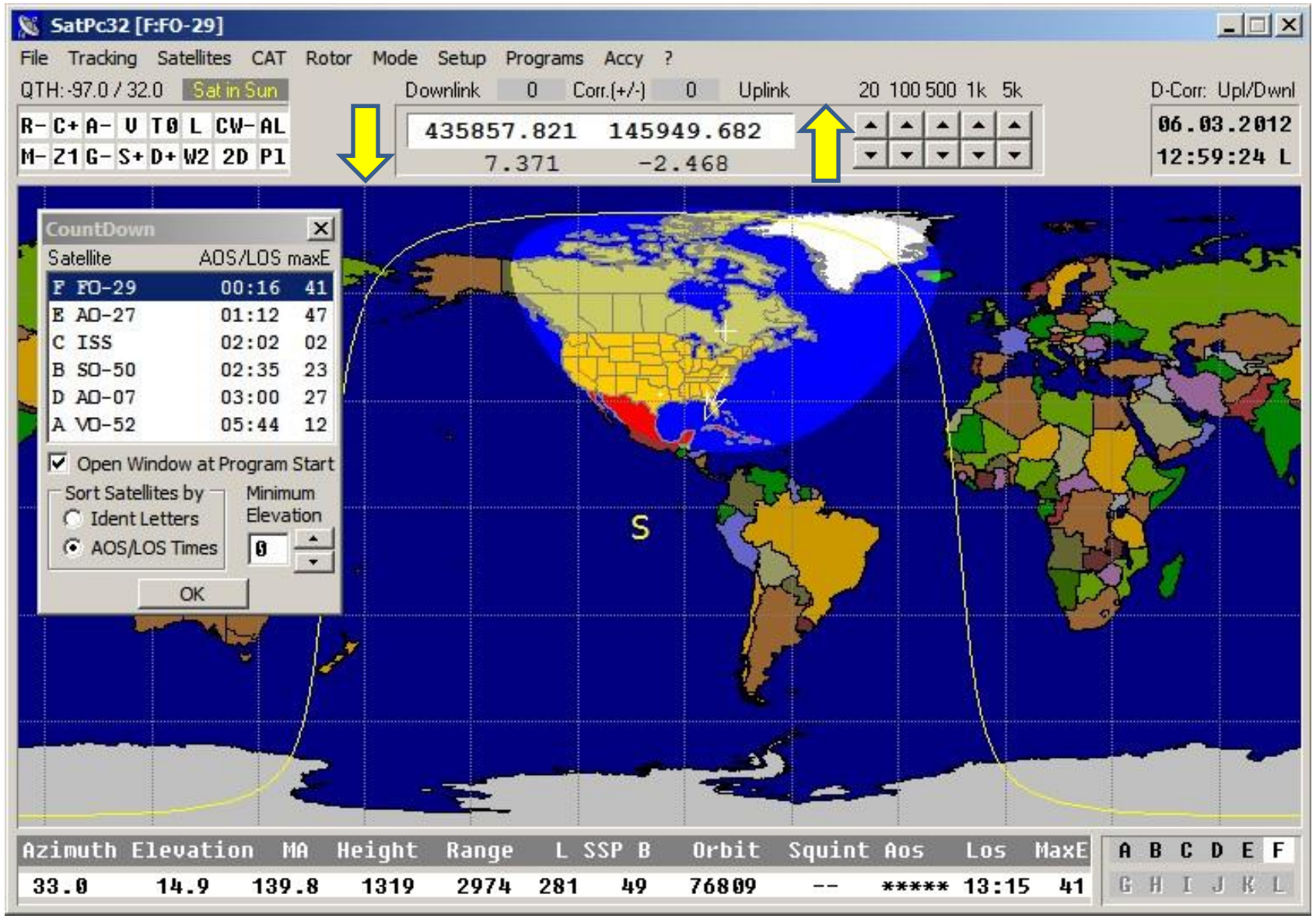
249 - 436.8100 67.0	FM	Split	145.8500	Enc	Name SO50AO	HIGH
250 - 436.8050 67.0	FM	Split	145.8500	Enc	Name SO50-2	HIGH
251 - 436.8000 67.0	FM	Split	145.8500	Enc	Name SO50-3	HIGH
252 - 436.7950 67.0	FM	Split	145.8500	Enc	Name SO50MI	HIGH
253 - 436.7900 67.0	FM	Split	145.8500	Enc	Name SO50-4	HIGH
254 - 436.7850 67.0	FM	Split	145.8500	Enc	Name SO50-5	HIGH
255 - 436.7800 67.0	FM	Split	145.8500	Enc	Name SO50LO	HIGH

SSB FO-29 Inverting Linear Transponder

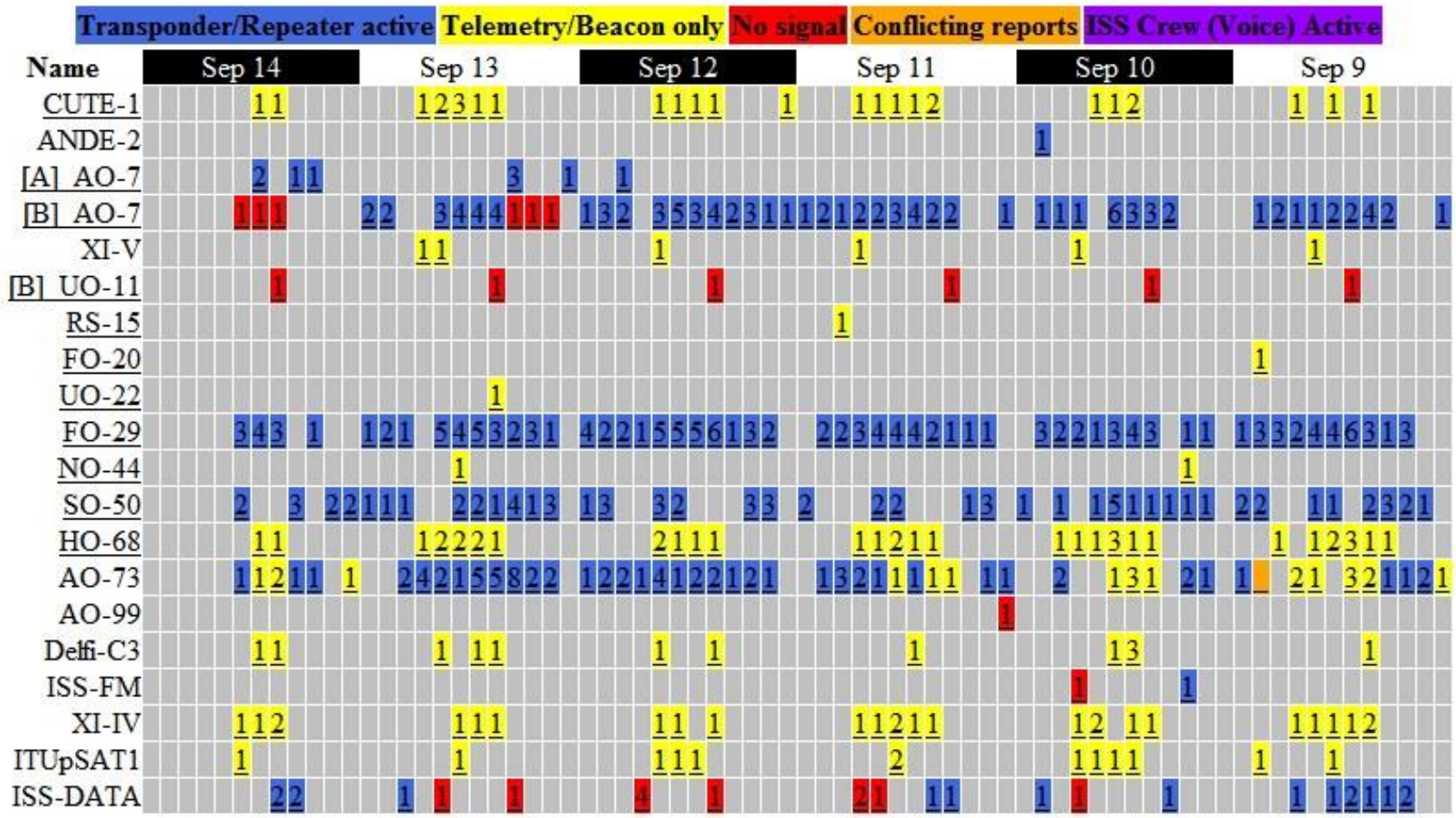


581.800 – 145.952 = 435.848 –
10kc (Doppler) = 435.838

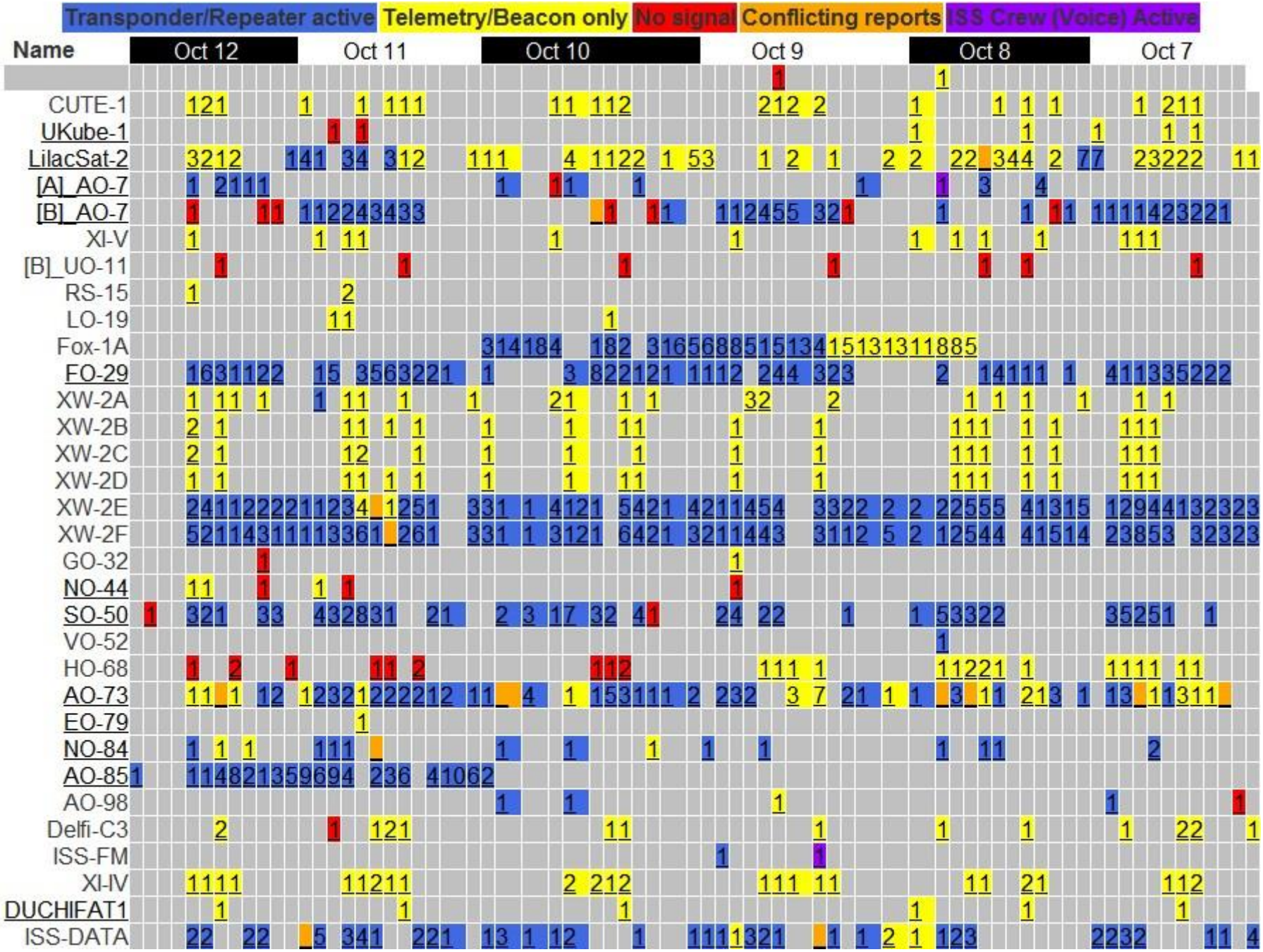
SATPc32


SatPc32 [F:FO-29]
File Tracking Satellites CAT Rotor Mode Setup Programs Accy ?
QTH: -97.0 / 32.0 Sat in Sun
R- C+ A- V T0 L CW- AL
M- Z1 G- S+ D+ W2 2D P1
Downlink 0 Corr.(+/-) 0 Uplink
435857.821 145949.682
7.371 -2.468
20 100 500 1k 5k
D-Corr: Upl/Dwnl
06.03.2012
12:59:24 L
CountDown
Satellite AOS/LOS maxE
F FO-29 00:16 41
E AO-27 01:12 47
C ISS 02:02 02
B SO-50 02:35 23
D AO-07 03:00 27
A VO-52 05:44 12
Open Window at Program Start
Sort Satellites by
Ident Letters
AOS/LOS Times
Minimum Elevation
0
OK
S
Azimuth Elevation MA Height Range L SSP B Orbit Squint Aos Los MaxE
33.0 14.9 139.8 1319 2974 281 49 76809 -- ***** 13:15 41
A B C D E F
G H I J K L

Satellite Status 9/15



http://oscar.dcarr.org

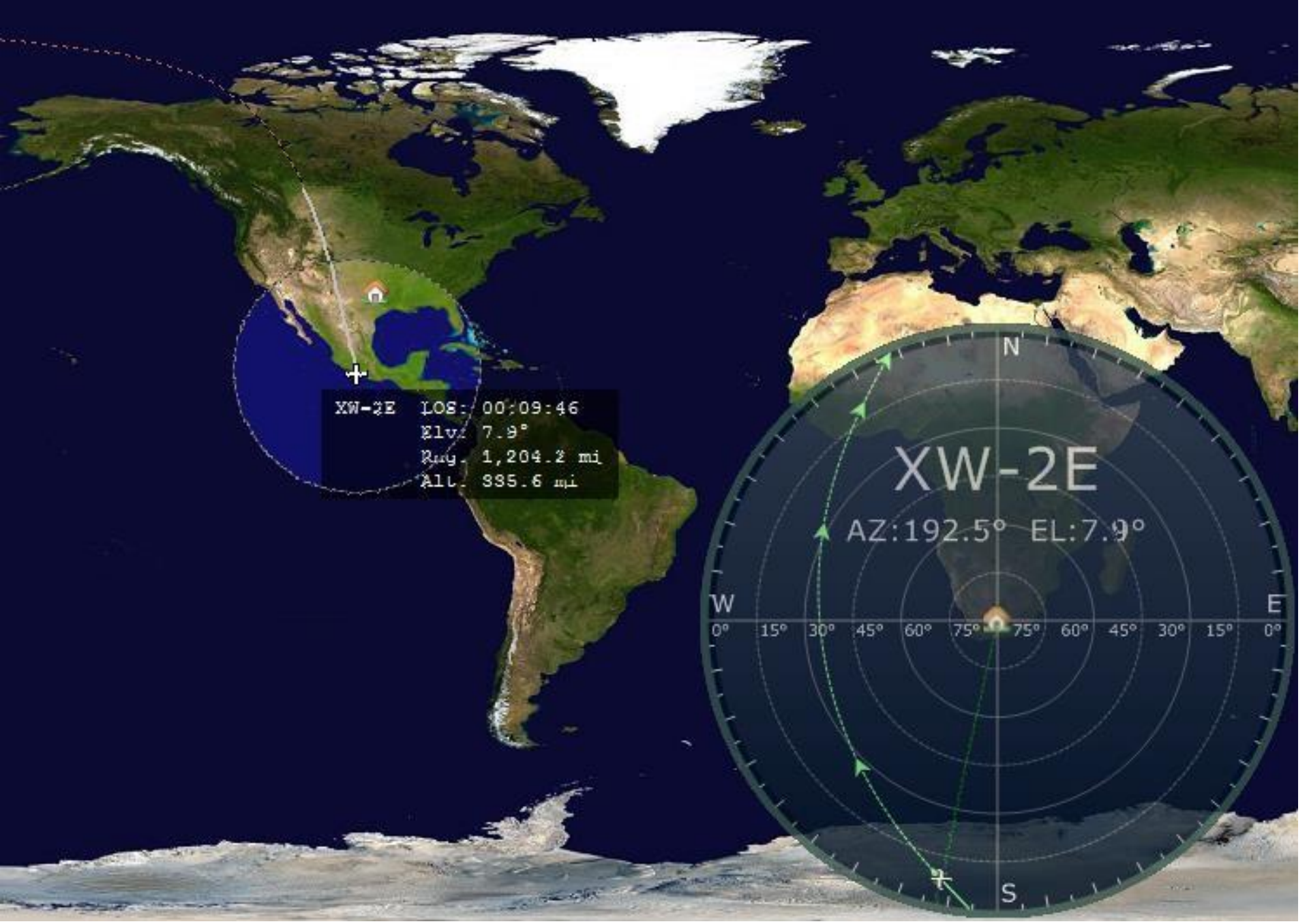

Transponder/Repeater active
Telemetry/Beacon only
No signal
Conflicting reports
ISS Crew (Voice) Active
Name
Oct 12
Oct 11
Oct 10
Oct 9
Oct 8
Oct 7
CUTE-1
UKube-1
LilacSat-2
[A]_AO-7
[B]_AO-7
XI-V
[B]_UO-11
RS-15
LO-19
Fox-1A
FO-29
XW-2A
XW-2B
XW-2C
XW-2D
XW-2E
XW-2F
GO-32
NO-44
SO-50
VO-52
HO-68
AO-73
EO-79
NO-84
AO-85
AO-98
Delfi-C3
ISS-FM
XI-IV
DUCHIFAT1
ISS-DATA

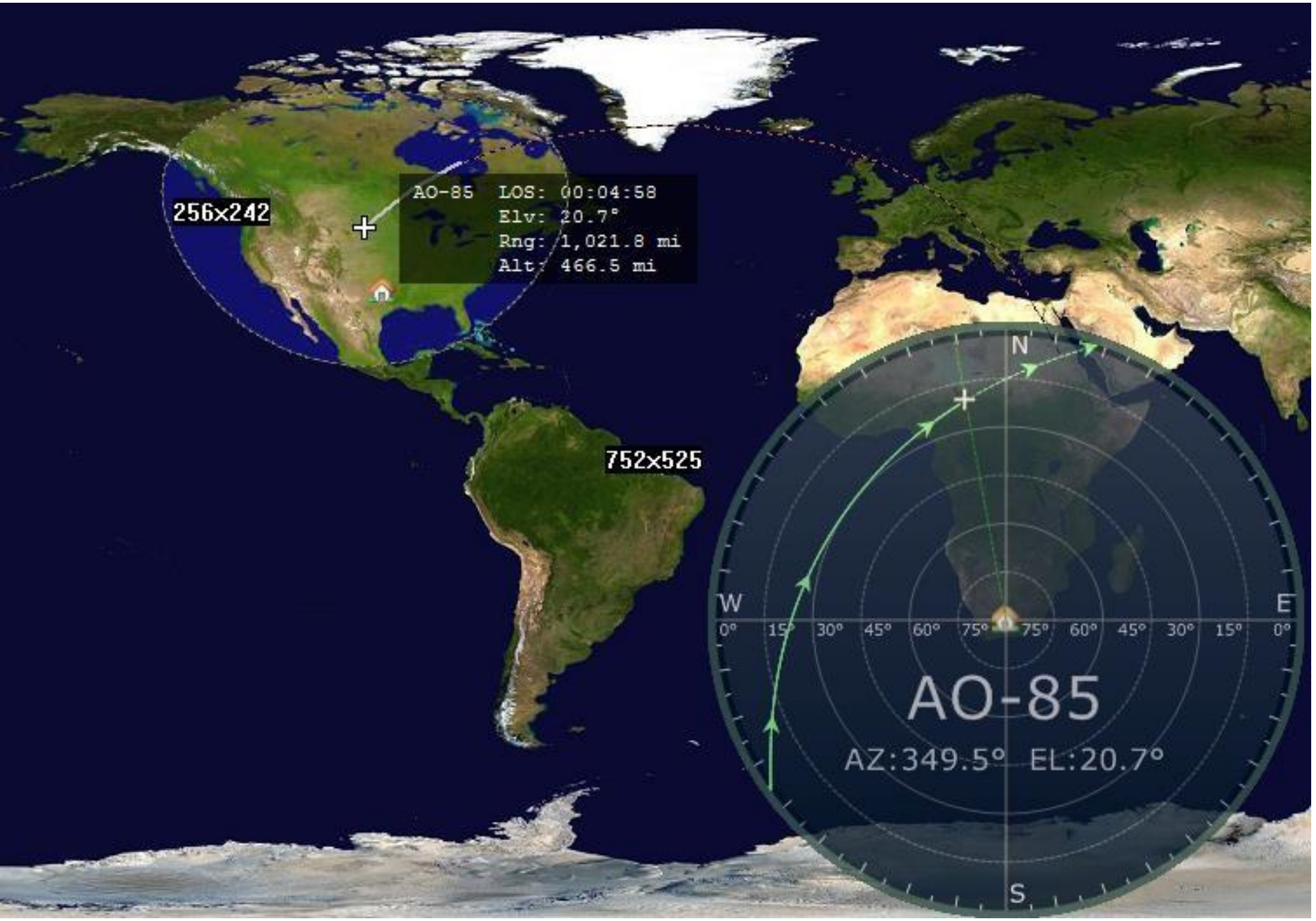
Current Primary LEO satellites

- **SO-50**
  - **launched in 2002;**
  - **145.850/436.795 MHz FM - PL 67.0**
- **AO-07**
  - **launched in 1974;**
  - **B Mode 432.125 – 432.175 uplink / 145.975 – 145.925 MHz SSB**
  - **A Mode 145.85 uplink/ 29.40 downlink SSB**
- **FO-29**
  - **launched in 1996;**
  - **145.90 – 146.00 uplink / 435.80 – 435.90 MHz SSB**
- **AO-73 – Operational 10/16/15**
  - **Uplink 435.130 – 435.160, 145.950 – 145.970 Mhz SSB**

Current Primary LEO satellites

- **AO-85 (Fox1A)**
  - **launched 10/9/15**
  - **Uplink 435.180 MHz FM, Downlink 145.980 MHz FM**
- **XW-2A-F**
  - **Chinese Launched 9/19/15**
  - **Uplink/Downlink various (435/145) SSB**
- **LilacSat-2**
  - **Chinese Launched with the XW birds**
  - **Inverting SSB/CW transponder 300 mW PEP**
    - **435.150 – 435.130 MHz Uplink LSB**
    - **145.950 – 145.970 MHz Downlink USB – - MWF only**


XW-2E LOS: 00:09:46
Elv: 7.9°
Rng: 1,204.2 mi
Alt: 385.6 mi
XW-2E
AZ:192.5° EL:7.9°
N
W
E
S
0° 15° 30° 45° 60° 75° 75° 60° 45° 30° 15° 0°


AO-85 LOS: 00:04:58
Elv: 20.7°
Rng: 1,021.8 mi
Alt: 466.5 mi
256x242
752x525
N
W
E
S
0° 15° 30° 45° 60° 75° 75° 60° 45° 30° 15° 0°
AO-85
AZ:349.5° EL:20.7°

When are Satellites Available?

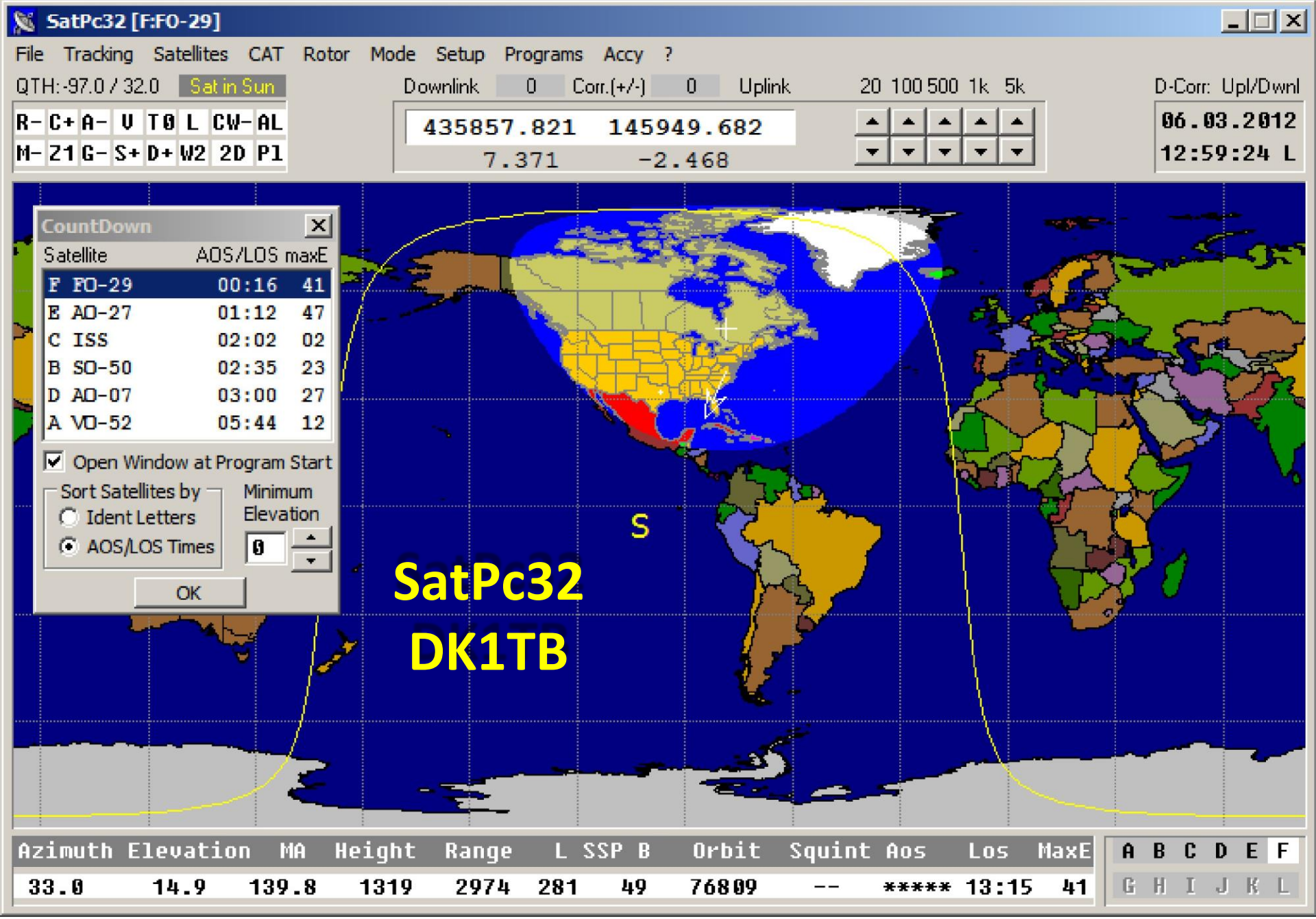
- **Use AMSAT website or tracking programs to know when satellites are in view at our location**
- **AMSAT and ARRL have tracking programs for sale**
- **Some programs can control antenna rotators and radios. Some are free (Orbitron). HRD 6.0 & SatPC32 cost $**
- **Schedules: http:www.amsat.org**
- **KEPS**

What the heck is a “Kep”?

- **Keplerian elements - standard mathematical model of spacecraft orbits**
- **FO-29 1 24278U 96046B 12116.90282700 .00000016 00000-0 18403-4 0 8264 2 24278**

  098.5816 224.4066 0350742 164.5498 196.6683 13.52981591774881 SO-33
- **Most Satellite programs either download Kep elements automatically or must be loaded manually (except frequency)**
- **Based on a given point in time**
- **PC clock must be correct**

Software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M- Z1 G- S+ D+ W2 2D P1
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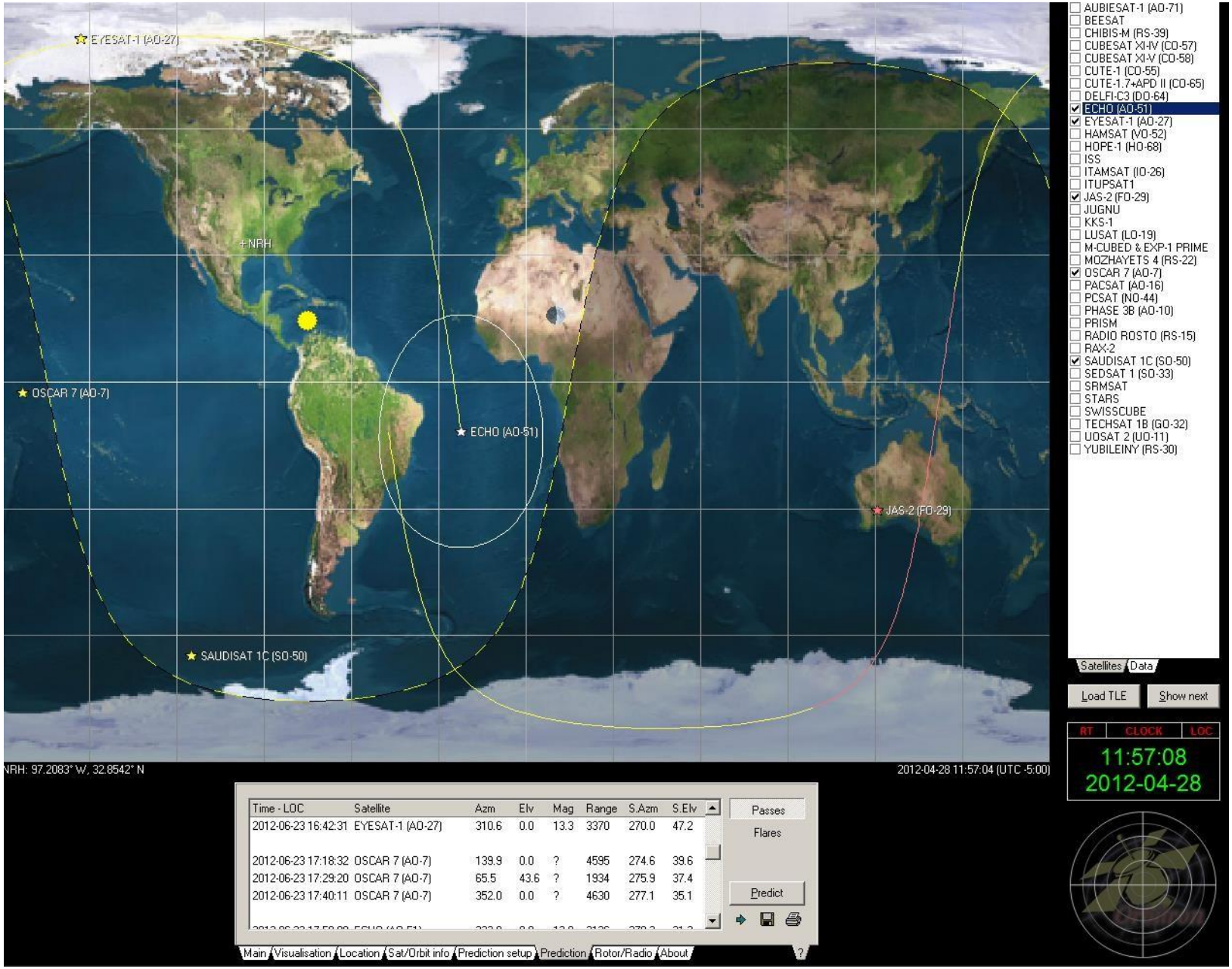
D AO-07 03:00 27
A VO-52 05:44 12
Open Window at Program Start
Sort Satellites by
Ident Letters
AOS/LOS Times
Minimum Elevation
0
OK
S
SatPc32
DK1TB
Azimuth Elevation MA Height Range L SSP B Orbit Squint Aos Los MaxE
33.0 14.9 139.8 1319 2974 281 49 76809 -- ***** 13:15 41
A B C D E F
G H I J K L

Orbitron


EYESAT-1 (AO-27)
NRH
OSCAR 7 (AO-7)
ECHO (AO-51)
JAS-2 (FO-29)
SAUDISAT 1C (SO-50)
AUBIESAT-1 (AO-71)
BEESAT
CHIBIS-M (RS-39)
CUBESAT XI-IV (CO-57)
CUBESAT XI-V (CO-58)
CUTE-1 (CO-55)
CUTE-1.7+APD II (CO-65)
DELFI-C3 (DO-64)
ECHO (AO-51)
EYESAT-1 (AO-27)
HAMSAT (VO-52)
HOPE-1 (HO-68)
ISS
ITAMSAT (IO-26)
ITUPSAT1
JAS-2 (FO-29)
JUGNU
KKS-1
LUSAT (LO-19)
M-CUBED & EXP-1 PRIME
MOZHAYETS 4 (RS-22)
OSCAR 7 (AO-7)
PACSAT (AO-16)
PCSAT (NO-44)
PHASE 3B (AO-10)
PRISM
RADIO ROSTO (RS-15)
RAX-2
SAUDISAT 1C (SO-50)
SEDSAT 1 (SO-33)
SRMSAT
STARS
SWISSCUBE
TECHSAT 1B (GO-32)
UOSAT 2 (UO-11)
YUBILEINY (RS-30)
Satellites
Data
Load TLE
Show next
RT
CLOCK
LOC
11:57:08
2012-04-28
NRH: 97.2083° W, 32.8542° N
2012-04-28 11:57:04 (UTC -5:00)
Time - LOC
Satellite
Azm
Elv
Mag
Range
S.Azm
S.Elv
2012-06-23 16:42:31
EYESAT-1 (AO-27)
310.6
0.0
13.3
3370
270.0
47.2
2012-06-23 17:18:32
OSCAR 7 (AO-7)
139.9
0.0
?
4595
274.6
39.6
2012-06-23 17:29:20
OSCAR 7 (AO-7)
65.5
43.6
?
1934
275.9
37.4
2012-06-23 17:40:11
OSCAR 7 (AO-7)
352.0
0.0
?
4630
277.1
35.1
Passes
Flares
Predict
Main
Visualisation
Location
Sat/Orbit info
Prediction setup
Prediction
Rotor/Radio
About
?

Time	Satellite	Azm	Elv	Mag	Range	S.Azm	S.Elv
2012-06-23 12:03:25	SAUDISAT 1C (SO-50)	335.0	0.0	14.4	3120	110.5	68.5
2012-06-23 12:10:45	SAUDISAT 1C (SO-50)	59.3	58.6	13.2	769	113.0	70.0
2012-06-23 12:17:44	SAUDISAT 1C (SO-50)	143.5	0.0	17.0	2982	115.6	71.3
2012-06-23 12:13:25	JAS-2 (FO-29)	36.9	0.0	14.8	4078	114.0	70.5
2012-06-23 12:21:28	JAS-2 (FO-29)	92.4	14.5	16.9	2896	117.2	72.0
2012-06-23 12:29:54	JAS-2 (FO-29)	146.3	0.0	16.0	4358	121.1	73.6
2012-06-23 13:12:54	EYESAT-1 (AO-27)	112.7	0.0	13.8	3352	155.8	79.7
2012-06-23 13:18:41	EYESAT-1 (AO-27)	62.9	10.7	13.0	2329	163.0	80.2
2012-06-23 13:24:29	EYESAT-1 (AO-27)	13.4	0.0	12.7	3373	170.7	80.4
2012-06-23 13:45:05	SAUDISAT 1C (SO-50)	306.6	0.0	15.1	3089	198.8	80.1
2012-06-23 13:50:48	SAUDISAT 1C (SO-50)	253.9	11.7	16.2	1952	205.8	79.6
2012-06-23 13:56:21	SAUDISAT 1C (SO-50)	200.4	0.0	16.6	2973	212.0	79.1
2012-06-23 13:57:07	JAS-2 (FO-29)	11.5	0.0	14.3	4002	212.8	79.0
2012-06-23 14:06:50	JAS-2 (FO-29)	286.1	86.3	14.4	1246	222.0	77.7
2012-06-23 14:17:31	JAS-2 (FO-29)	196.2	0.0	15.6	4360	230.1	76.1
2012-06-23 14:39:00	ISS	209.3	0.0	6.7	2310	242.0	72.4
2012-06-23 14:44:12	ISS	131.3	36.7	2.4	615	244.2	71.4
2012-06-23 14:49:24	ISS	53.8	0.0	3.9	2314	246.2	70.4
2012-06-23 14:49:49	EYESAT-1 (AO-27)	169.1	0.0	13.1	3341	246.4	70.3
2012-06-23 14:57:30	EYESAT-1 (AO-27)	258.5	78.2	10.9	817	249.0	68.8
2012-06-23 15:05:15	EYESAT-1 (AO-27)	346.2	0.0	12.7	3372	251.5	67.3
2012-06-23 15:32:28	OSCAR 7 (AO-7)	81.7	0.0	?	4617	258.3	61.8
2012-06-23 15:38:45	OSCAR 7 (AO-7)	46.2	5.8	?	3980	259.6	60.5
2012-06-23 15:45:02	OSCAR 7 (AO-7)	10.9	0.0	?	4633	260.8	59.2
2012-06-23 15:43:31	JAS-2 (FO-29)	349.9	0.0	14.2	4002	260.5	59.5
2012-06-23 15:51:03	JAS-2 (FO-29)	297.4	14.2	15.3	2854	262.0	57.9
2012-06-23 15:59:07	JAS-2 (FO-29)	245.9	0.0	17.5	4326	263.4	56.3
2012-06-23 16:15:28	ISS	260.7	0.0	5.7	2312	266.0	52.8
2012-06-23 16:20:17	ISS	325.9	16.4	2.6	1084	266.8	51.8
2012-06-23 16:25:08	ISS	31.7	0.0	3.3	2315	267.5	50.8
2012-06-23 16:32:53	EYESAT-1 (AO-27)	231.2	0.0	13.6	3350	268.6	49.2
2012-06-23 16:37:41	EYESAT-1 (AO-27)	270.9	5.6	13.6	2743	269.3	48.2
2012-06-23 16:42:31	EYESAT-1 (AO-27)	310.6	0.0	13.3	3370	270.0	47.2
2012-06-23 17:18:32	OSCAR 7 (AO-7)	139.9	0.0	?	4595	274.6	39.6
2012-06-23 17:29:20	OSCAR 7 (AO-7)	65.5	43.6	?	1934	275.9	37.4
2012-06-23 17:40:11	OSCAR 7 (AO-7)	352.0	0.0	?	4630	277.1	35.1
2012-06-23 17:54:34	ISS	311.8	0.0	3.8	2316	278.8	32.1
2012-06-23 17:57:26	ISS	344.9	2.8	3.0	1989	279.1	31.5
2012-06-23 18:00:17	ISS	17.8	0.0	3.0	2310	279.5	30.9
2012-06-23 19:10:47	HAMSAT (VO-52)	107.9	0.0	11.2	2906	287.6	16.6
2012-06-23 19:15:12	HAMSAT (VO-52)	64.5	6.8	10.8	2205	288.1	15.7
2012-06-23 19:19:38	HAMSAT (VO-52)	21.2	0.0	11.6	2927	288.6	14.8
2012-06-23 19:11:23	OSCAR 7 (AO-7)	188.0	0.0	?	4593	287.6	16.4
2012-06-23 19:22:04	OSCAR 7 (AO-7)	260.7	36.1	?	2145	288.9	14.3
2012-06-23 19:32:55	OSCAR 7 (AO-7)	334.4	0.0	?	4627	290.2	12.2

AO-27 | SO-50 | AO-07 | FO-29 | VO-52 | ISS | OSCAR Satellite Status page by K... | AMSAT - Satellite Detail - VUSat O... | QTH.COM Ham Radio Classified Ad...

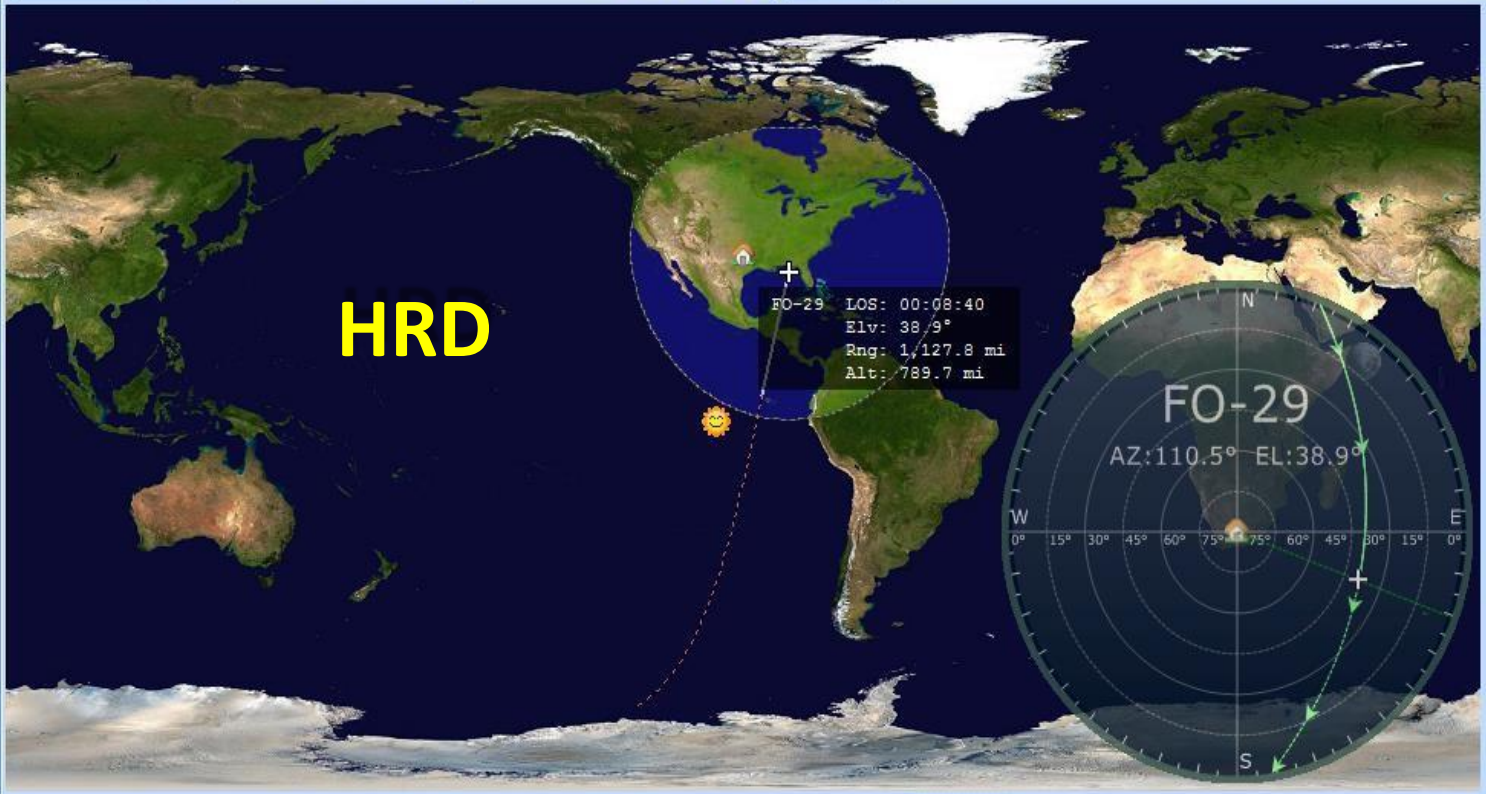
Tuning Dial | Favourites | Rotator | Satellite: FO-29 | Track: 30 mins | Center | Zoom | Show | Next Passes | Home Page | LOS 00:08:40 | Options

Manual Tuning
Enable

RX VFO-A 435.848.591 DOWNLINK 435.850.000
TX VFO-B 145.950.472 UPLINK 145.950.000

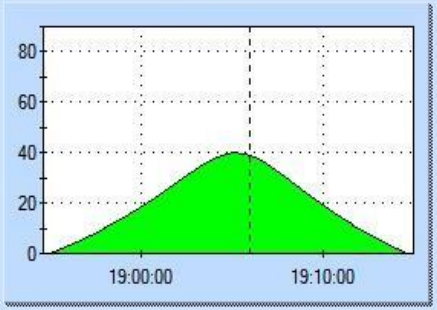
Transponder
Undo
Freq

TRX
XIT

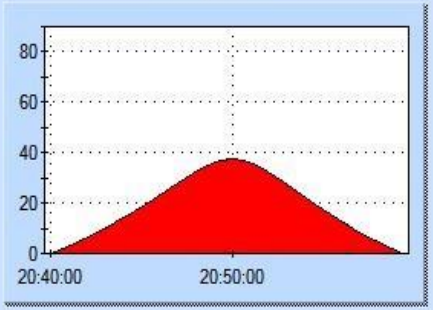


Next Passes

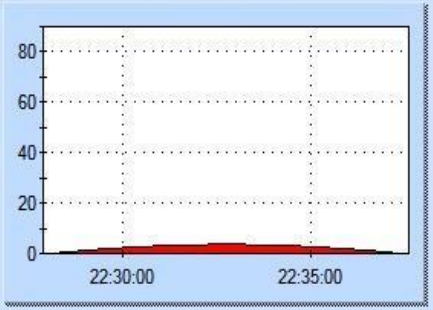
Today 18:54



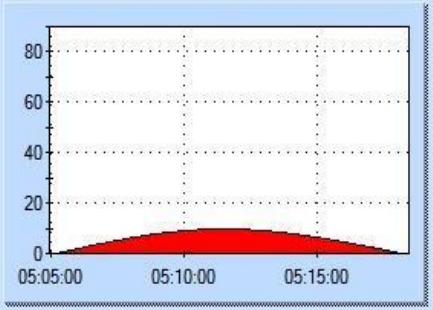
Today 20:40



Today 22:28



Wednesday 05:05



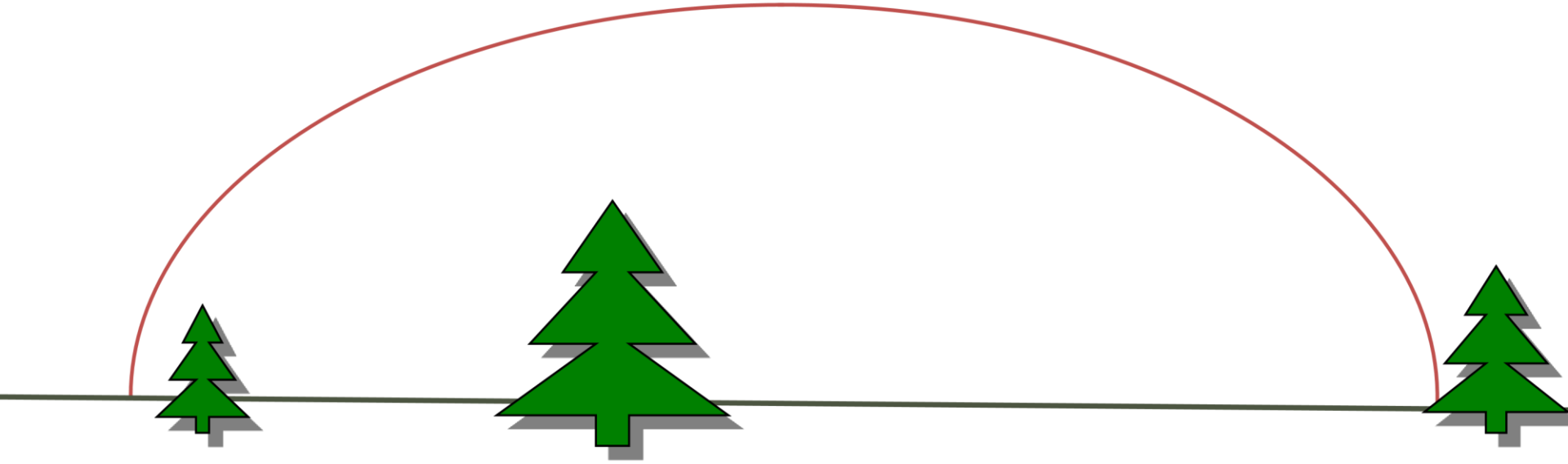
Tracks

The Pass

- Direction (landmarks)

The Pass

SO-50



LOS	TCA	AOS
436.780	436.795	436.810
168°	245°	355°
12:20	12:09	12:00
5°	45°	5°

- Frequency shift as satellite approaches and departs
- Acquisition of Signal, Time of Closest Approach, Loss of Signal

Before you transmit…

- **Do you hear the satellite?**
  - **– <u>Open squelch all the way</u>**
  - **– FM satellites usually have activity on any pass over North America**
- **If satellite is not audible or is weak, move antenna around– If you don't hear the satellite, don't transmit**
- **FM satellites have sensitive receivers, but weak transmitters**
- **SO-50 transmits at 250mW**
- **ISS transmits at 5W or 10W, depending on the radio being used (Ericsson/GE commercial VHF HT, Kenwood TM-D700)**

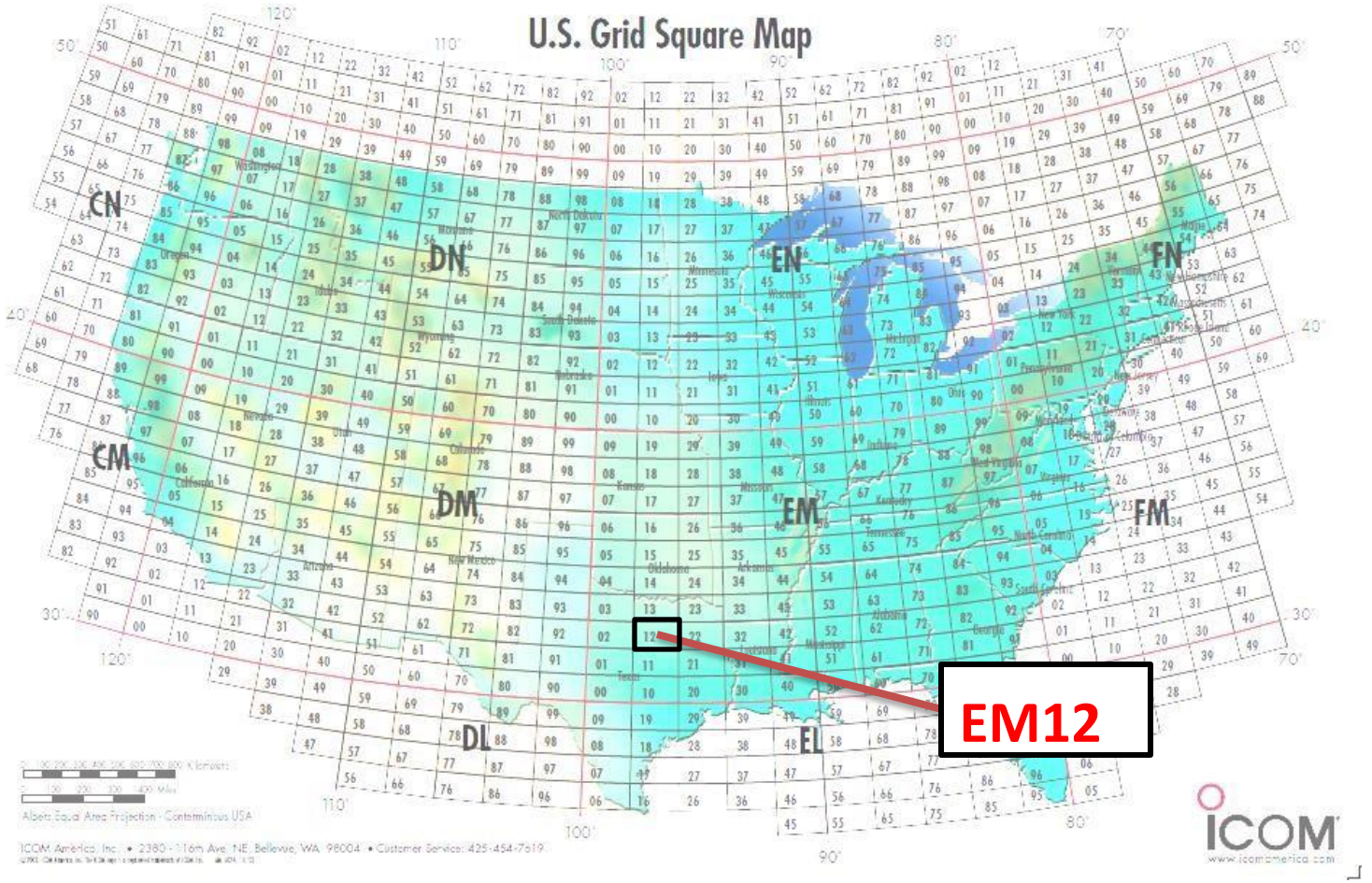
Making contacts

- **Listen to the satellite, pick out some call signs**
- **On FM satellites, call a specific station, or just transmit your callsign**
- **Calling CQ on an SSB/CW satellite is OK, as those satellites are retransmitting a band of frequencies instead of just one frequency. Similar to HF, you are hoping someone hears your CQ call and then calls you.**
- **Contacts on FM satellites are usually quick - callsign, location, maybe your name (similar to HF contests or Dxpeditions). More time to chat on SSB/CW satellites.**
- **Regular operators can recognize new operators, and are usually happy to make contacts and help with operating advice**
- **Satellite operators like to exchange “grids” for location**

What's a "grid"?

- 4- to 6-character identifier represents approximate latitude/longitude
- NRH is in grid EM12, this meeting is in grid **EM12sn**
- QRZ.com usually has grids for most US hams, based on licensee's address
- Web sites & Cell phone APS have converters to take latitude/longitude and calculate your grid:
  - http://www.arrl.org/locate/grid.html
  - http://www.amsat.org/amsat-new/tools/grids.php

Grid Squares



Logging contacts

- **Many people use recorders or computers to record audio for logging**
- **Especially for portable operating, almost impossible to log in real time if using a radio/microphone and holding 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)**
- **Tape recorders or digital recorders are small, inexpensive – or use your cell phone**

What's Next?

- AO-07 very old (1974). Having power issues. Still works…for now
- Cubesat "1u" approximately 4" square. 2u and 3u
- AO-73 FUNcube (SSB) May be in transponder mode soon (10/16/15). Having power issues? 1u
- AO-79 FUNcube (SSB) Transponder mode only. In orbit testing. 2u

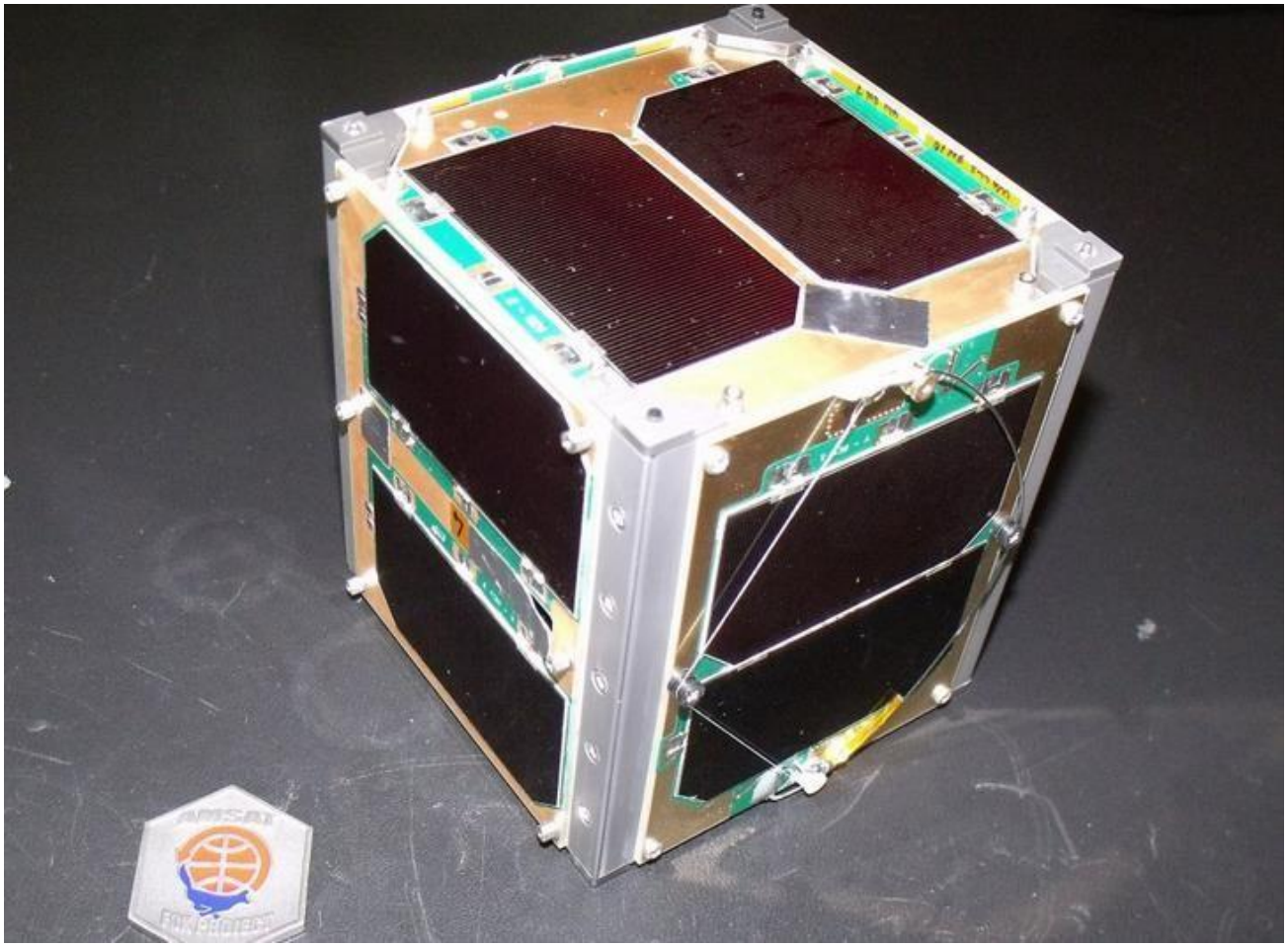
- EO-80 Cubesat (FM) In orbit and commissioning. Should be operational 2016
- EO-73 Cubesat (SSB) In orbit and commissioning. Should be operational 10/16/15
- UKube-1 FUNcube (SSB) In orbit and commissioning. Should be operational 2016. Telemetry only
- Chinese active. Launched 6 satellites (10/15). XW2E and XW2F active - all SSB
- LilacSat-2 Launched with the XW birds
- HEO Geostationary Satellites . Very expensive to launch ($10 Million). AO-13 in storage to be shipped to Virginia Tech for further development. Phase 3E

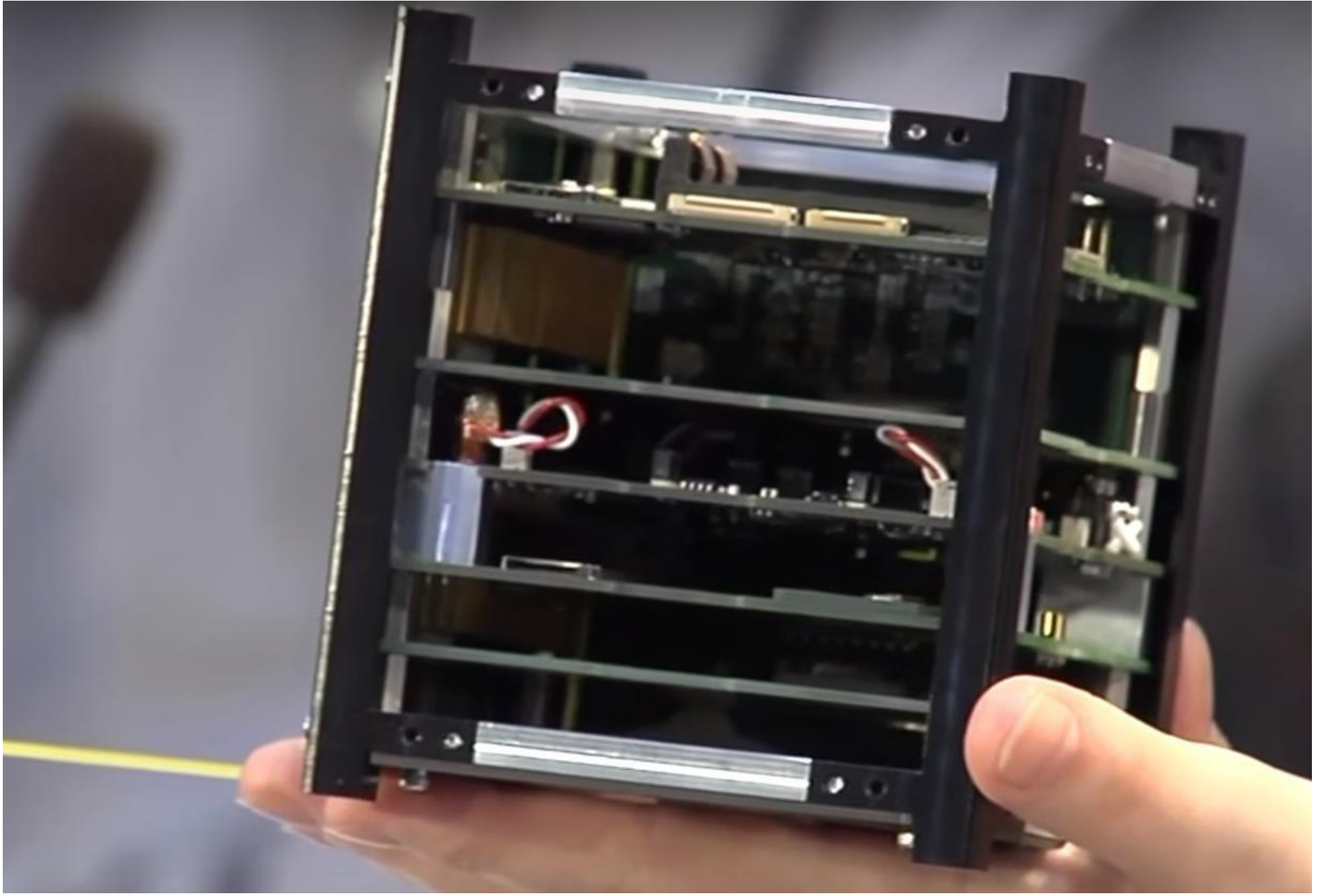
What's Next?

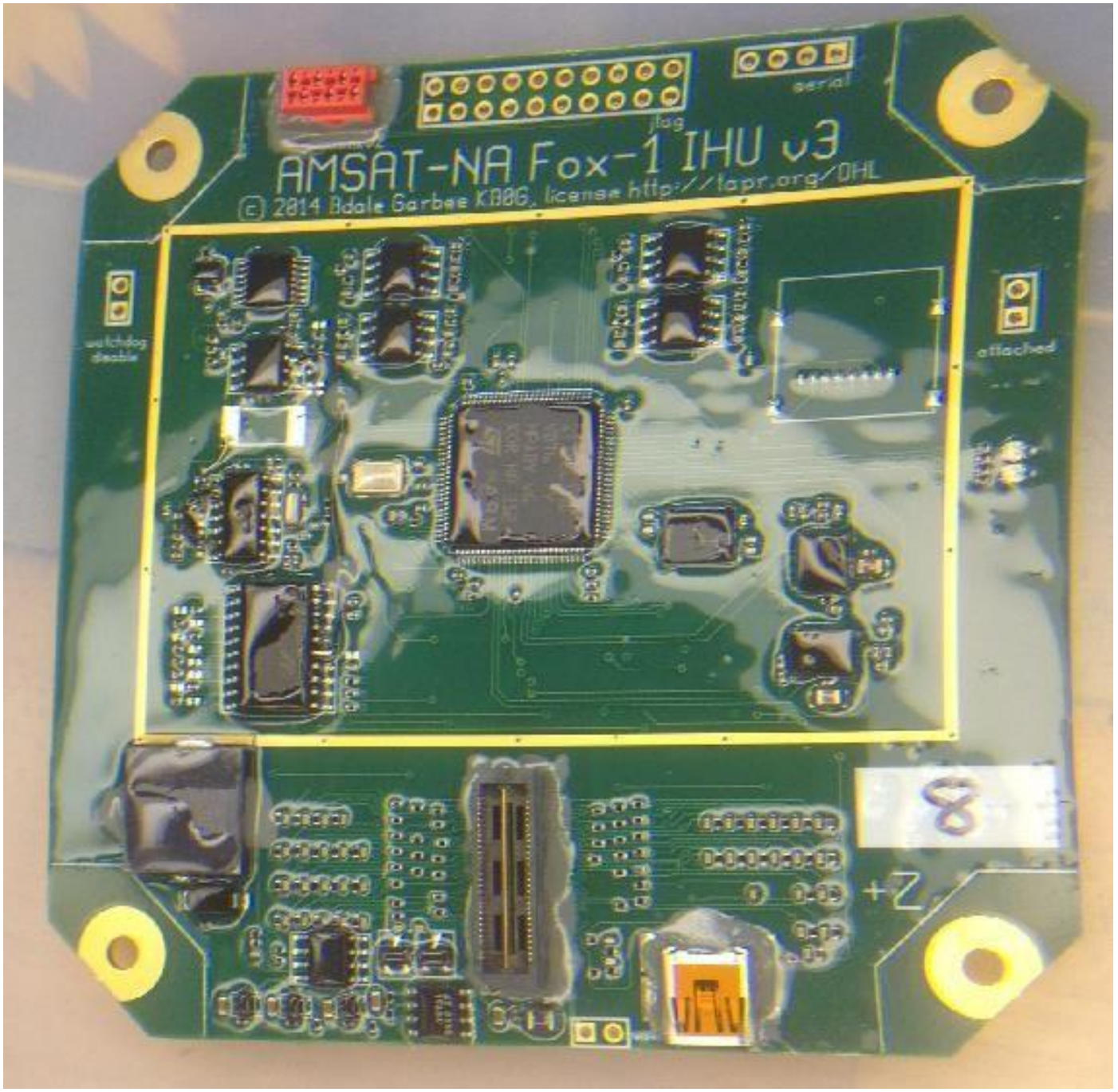
- **Fox1a - Fox1d (FM)**

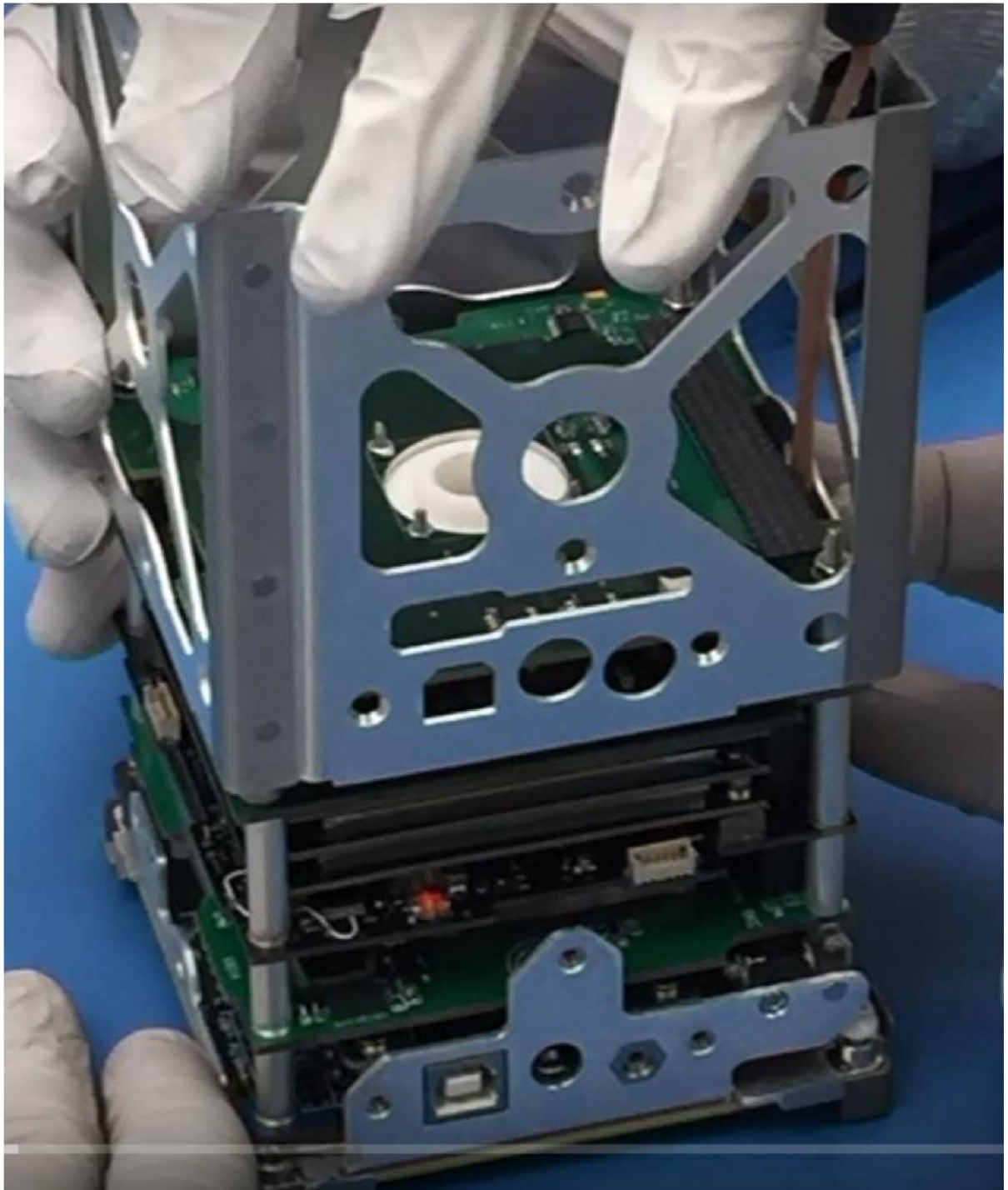
1. **Major AMSAT project.**
2. **4 satellites scheduled.**
3. **440 up 67 hz PL, 2 meters down. full duplex – can hear yourself with 2 handhelds.**
4. **Large "footprint" like FO-29. Coast-to-Coast coverage. DX?**
5. **Designed to work with handheld/Arrow type antenna**
6. **2015 and 2016 launch dates.**
7. **Fox1a (AO-85) Launched 10/09/15**
8. **Fox1c & d scheduled for 1Q16**
9. **Fox1b scheduled for 11/16**

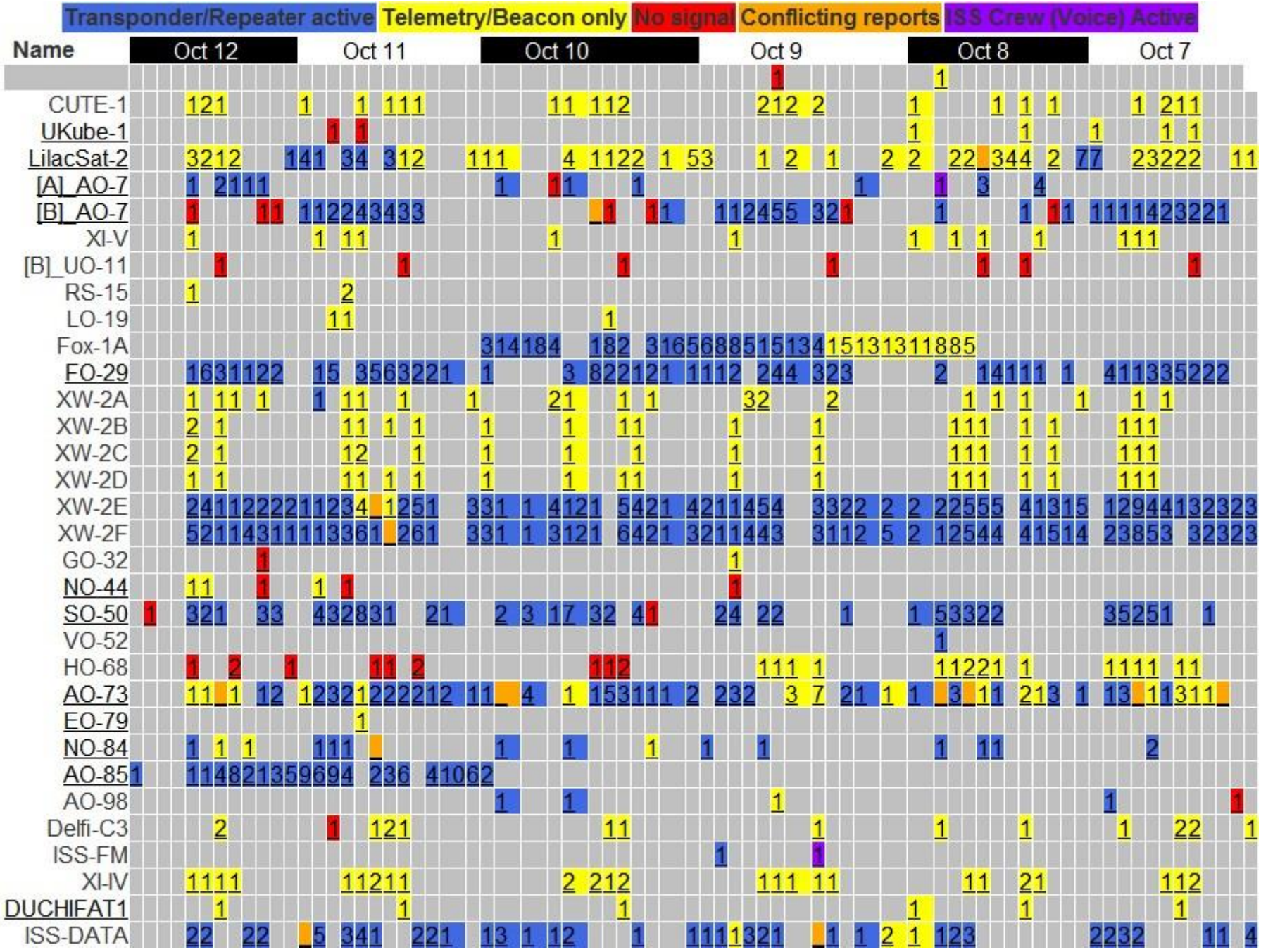
Fox1A (AO-85)






jtag
serial
AMSAT-NA Fox-1 IHU v3
(c) 2014 Adale Garbee KA0G, license http://tapr.org/OHL
watchdog disable
attached
8
+Z




Transponder/Repeater active
Telemetry/Beacon only
No signal
Conflicting reports
ISS Crew (Voice) Active
Name
Oct 12
Oct 11
Oct 10
Oct 9
Oct 8
Oct 7
CUTE-1
UKube-1
LilacSat-2
[A]_AO-7
[B]_AO-7
XI-V
[B]_UO-11
RS-15
LO-19
Fox-1A
FO-29
XW-2A
XW-2B
XW-2C
XW-2D
XW-2E
XW-2F
GO-32
NO-44
SO-50
VO-52
HO-68
AO-73
EO-79
NO-84
AO-85
AO-98
Delfi-C3
ISS-FM
XI-IV
DUCHIFAT1
ISS-DATA

Questions?