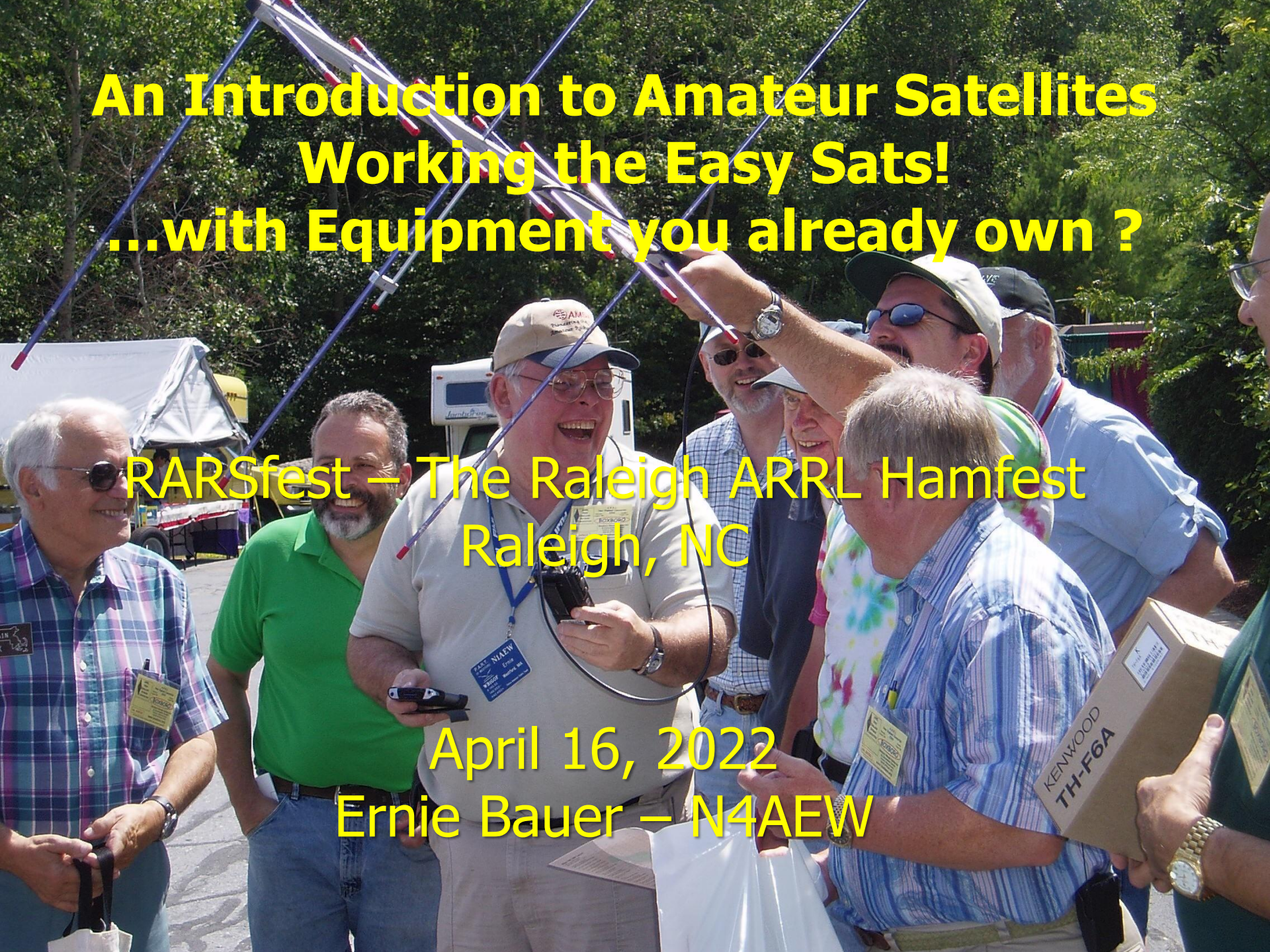


An Introduction to Amateur Satellites Working the Easy Sats! ...with Equipment you already own ?

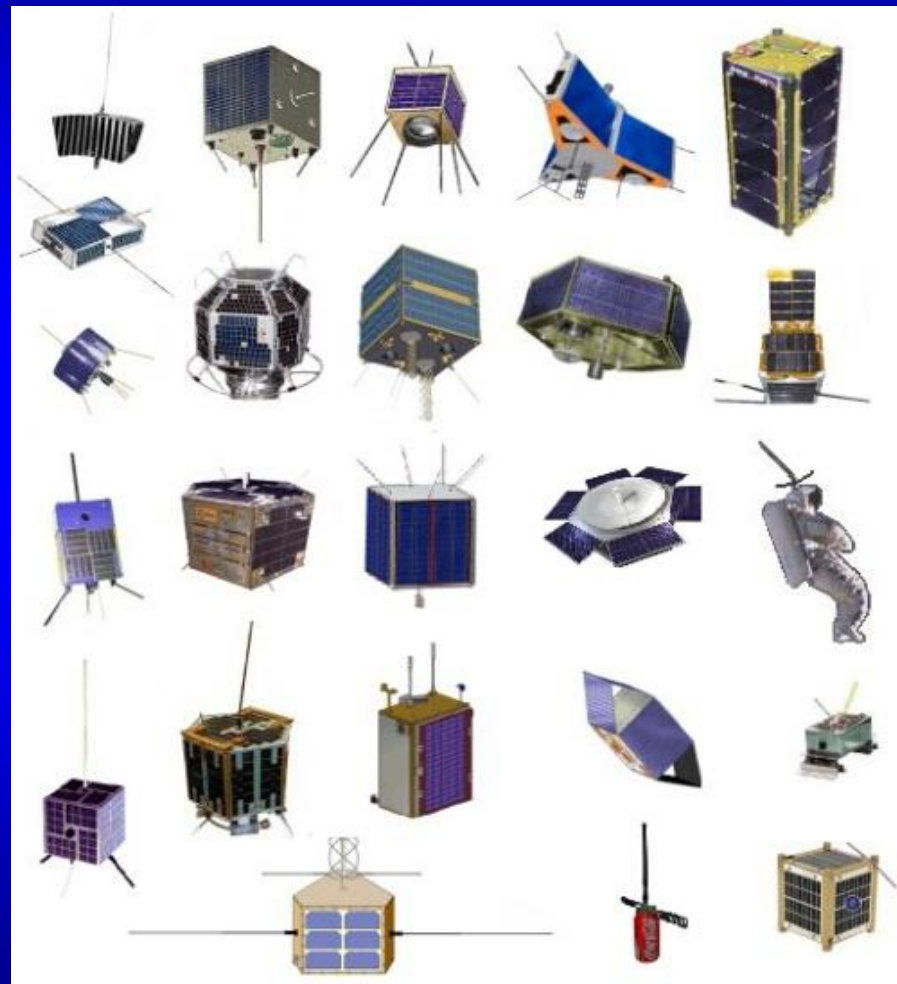
RARSfest – The Raleigh ARRL Hamfest
Raleigh, NC

April 16, 2022
Ernie Bauer – N4AEW



Satellite Characteristics Differ

- Size and mass
- Digital/Analog
- Orbital Parameters
- Frequencies Utilized
- “Payload”



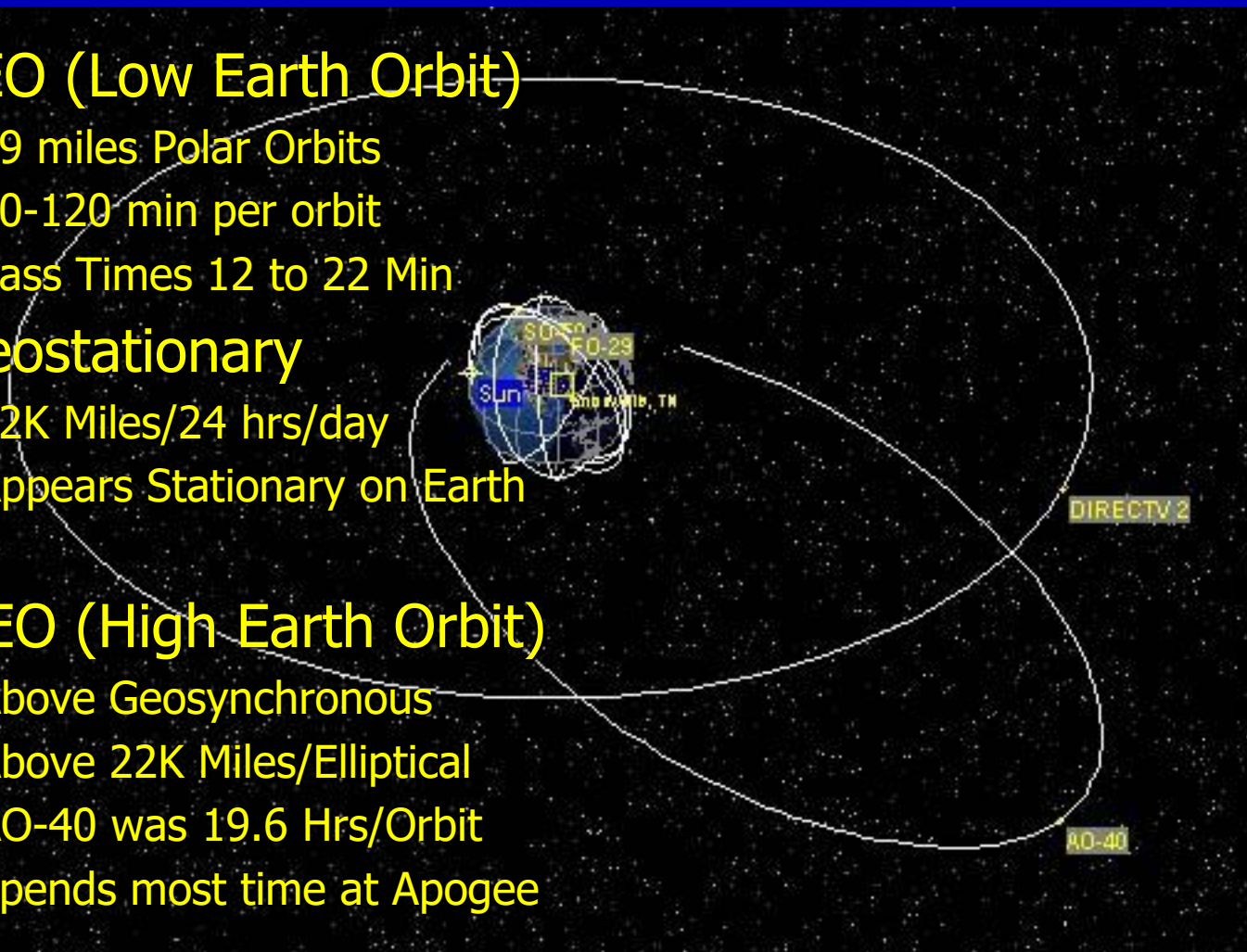
Available Satellite Bands



- Bands Exist from 15 Meters to 24 GHz
 - Set by International Convention
 - Not all Amateur Bands allocated for Satellites (e.g. 6 Meters, 220 MHz)
- 70 cm/2M Most Often Used
- Various 'Modes' (Analog/Digital/Voice/Data)
- Shift towards Microwave (2.4GHz/10.45GHz)
- Oscar-100 on board Qatar TV Sat Uses S/X Bands

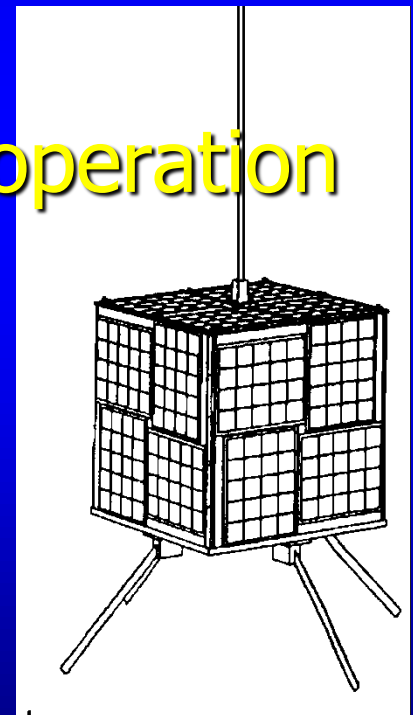
Satellite Orbit Overview

- **LEO (Low Earth Orbit)**
 - 99 miles Polar Orbits
 - 90-120 min per orbit
 - Pass Times 12 to 22 Min
- **Geostationary**
 - 22K Miles/24 hrs/day
 - Appears Stationary on Earth
- **HEO (High Earth Orbit)**
 - Above Geosynchronous
 - Above 22K Miles/Elliptical
 - AO-40 was 19.6 Hrs/Orbit
 - Spends most time at Apogee



There are Three Types of Amateur Satellites

- Analog FM Repeater operation
- Analog SSB/CW Transponder operation
- Digital Operation





How satellites operate like single channel repeaters

- Retransmit what they “hear”
- Have Optimized Receivers, Transmitters, Antennas
- Great Location!
- Allows Communications Over Great Distances

How satellites differ from Repeaters

- **Have a Moving Footprint!**
 - Location Changes / Availability Varies
 - Frequency Changes due to Doppler Shift
- **Full Duplex**
 - Simultaneous Uplink and Downlink on Different Bands
 - Multi-mode (CW/SSB/Digital/SSTV/PSK31)
- **“World Wide” Coverage**

Operational FM Repeater Satellites



<u>Satellite</u>	<u>Uplink/Downlink</u>	<u>Mode/Comments</u>
SO-50	145.850/436.795	FM repeater*/74.4/67.0
AO-91/Fox 1	435.170/145.980	RadFxSat/Fox-1B (In Sun Only)
CAS-3H	144.350/437.200	Lilac-2 Check beacon 437.2
PO-101 FM	437.500/145.900	141.3 PL Check Sked
AO-27	145.850/436.795	4 min limited passes
ISS/FM	145.990/437.800	67 PL (Check ARISS Status)

Some satellites are “Transponders”



- Receives a SEGMENT of one band (50-200 kHz)
- Retransmits EVERYTHING it hears on another band
- Inverting & Non-inverting Transponders
 - FM Sat Retransmit one station (up 2m/dwn 70cm)
 - Inverting retransmits low receive frequency at high transmit frequency (and inverts USB to LSB)

Example for FO-29:

Vu Uplink: 145.900 – 146.000 MHz LSB/CW
(Mode JA)Dwnlnk: 435.800 – 435.900 MHz USB/CW
Beacon= 435.795/CW/12wpm and 435.910/PSK

Operational Transponder Satellites



<u>Satellite</u>	<u>Uplink/Downlink</u>	<u>Mode/Comments</u>	
AO-7B	432.125-432.175 145.975-145.925	SSB/CW	50Khz/Inv
FO-29	145.900-146.000 435.800-435.900	LSB/CW USB/CW	100 kHz/Inv
XW-2A	435.030-435.050 145.665-145.685	USB LSB	30Khz/Inv
CAS-4A	435.210-45.230 145.860-145.880	LSB USB	20Khz/Inv
CAS-4B	435.270-435.290 145.915-145.935	LSB USB	20KHZ/Inv 20KHZ/Inv
HO113	145.885-145.855 435.165-435.195	LSB USB	30KHZ/
JO-97	435.100-435.120 145.855-145.875	LSB USB	20KHZ/Inv

Operational Transponder Satellites

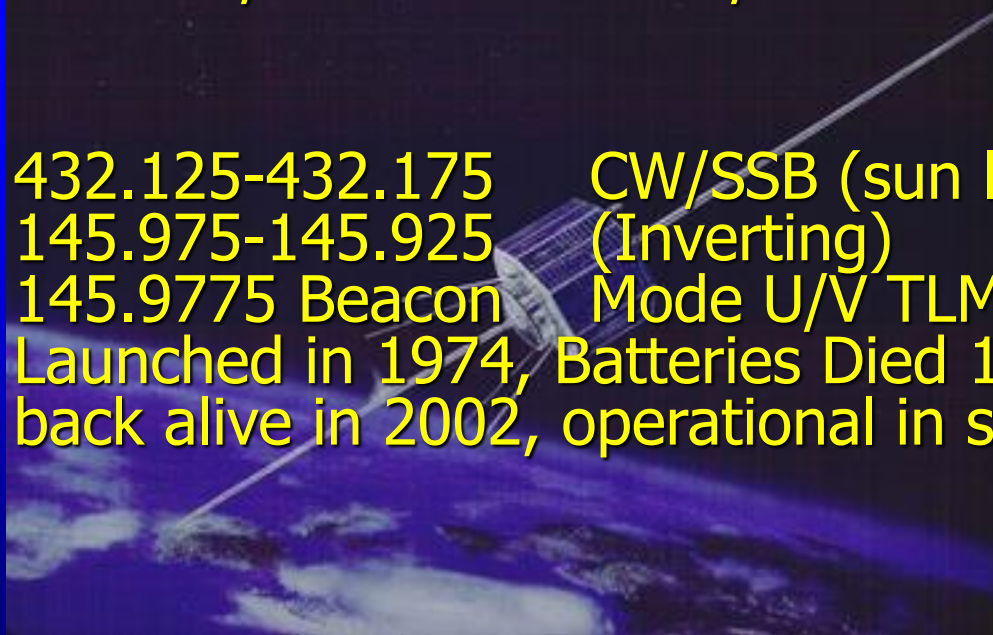


<u>Satellite</u>	<u>Uplink/Downlink</u>	<u>Mode/Comments</u>	
RS-44	145.935-145.995 435.610-435.670	LSB/Inv USB	60KHZ
TO-108 (CAS-6)	435.270-435.290 145.915-145.935	LSB/Inv USB	20KHZ

OSCAR Satellites Semi-Operational



<u>Satellite</u>	<u>Uplink/Downlink</u>	<u>Mode/Comments</u>
ISS	145.200/437.800 145.800 144.490/145.800	2m FM Voice Rpt SSTV Imaging Crew/Schools Region 2&3
AO-7B	432.125-432.175 145.975-145.925 145.9775 Beacon	CW/SSB (sun light ops only) (Inverting) Mode U/V TLM Beacon/CW Launched in 1974, Batteries Died 1981, came back alive in 2002, operational in sunlight only.





Getting Started

EASY 'sats' FM Birds (Low Earth Orbit)

- **FM Satellite: SO-50, AO-91**
- **Human Spacecraft (ARISS)**

Minimum Ground Station:

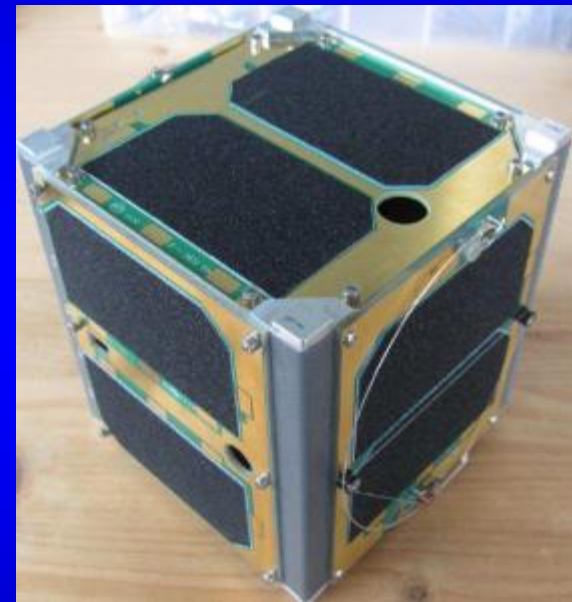
- **Dual Band Handheld (2m/70cm) full duplex mode**
- **Dual Band Arrow, Elk, or yagis**
- **Google Cheap Yagis – (find cheapyagi.pdf)**
Articles by WA5VJB Kent Britain in CQ Mag
- **Mobiles listen on Vertical Antennas**

SSB & CW Sats (Upgrade rig to SSB)

- **SSB/CW AO-7B**
- **SSB/CW FO-29 100 Khz Bandwidth**
- **Longer, multiple QSOs because 50 Khz bandwidth**
- **SSB/CW CAMSATS XW-2A CAS-4A & 4B 30 Khz BW**

AO-91 (AMSAT Fox-1B)

- Uv (Mode B) FM repeater
 - Up Link: 435.240 Mhz 67 Hz
 - Down Link: 145.960 Mhz
- 67 Hz tone turns on the transmitter
- Low Earth Orbit/Non Polar, orbits change each day
- 400-800 mW transmitter



SO-50 (SaudiSat 1-C)

- Vu (Mode J) FM repeater
 - Up Link: 145.850 Mhz 67 Hz
 - Down Link: 436.795 Mhz
 - 145.850 Mhz. 74.4 Hz 2 Sec ON
- Uplink needs 67 Hz tone
- Not a polar orbit, so pass times change day to day
- 250 mW transmitter



Minimal equipment needed to operate the FM Sats (Drew KO4MA Demo)



- Dual band handheld
- Arrow antenna

Hardware Store Special with Armstrong Rotators



Fixed Station Example

- Small yagis, fixed elevation, TV rotor
- 70 cm preamp at the antenna
- Satellite radio or two radios
- Low power
- Optional computer control of rotor and Doppler





AMSAT Online Pass Predictions



AMSAT Online Satellite Pass Predictions

PO Box 27
Washington, DC 20044-0027
1-888-322-6728

AMSAT Online Satellite Pass Predictions - AO-91

[View the current location of AO-91](#)

Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)
15 Apr 22	02:19:14	00:07:32	57	4	83	124	02:26:46
15 Apr 22	03:52:59	00:13:44	15	67	103	187	04:06:43
15 Apr 22	05:30:20	00:10:18	344	11	302	243	05:40:38
15 Apr 22	14:47:32	00:10:15	144	27	81	1	14:57:47
15 Apr 22	16:24:39	00:08:47	212	11	276	322	16:33:26
16 Apr 22	02:37:21	00:10:16	44	9	86	140	02:47:37
16 Apr 22	04:12:15	00:13:49	9	74	290	198	04:26:04
16 Apr 22	05:50:18	00:08:28	336	6	293	257	05:58:46
16 Apr 22	15:06:31	00:10:43	157	50	50	354	15:17:14
16 Apr 22	16:45:06	00:06:49	230	5	274	310	16:51:55

AO-91 Doppler Shift Correction

AO-91 Doppler Shift Correction		
Memory	Your Transmit Frequency(With 67 Hz Tone)	Your Receive Frequency
Acquisition of Signal (AOS)	435.240 MHz	145.960 MHz
Approaching	435.245 MHz	145.960 MHz
Time of Closest Approach (TCA)	435.250 MHz	145.960 MHz
Departing	435.255 MHz	145.960 MHz
Loss of Signal (LOS)	435.260 MHz	145.960 MHz

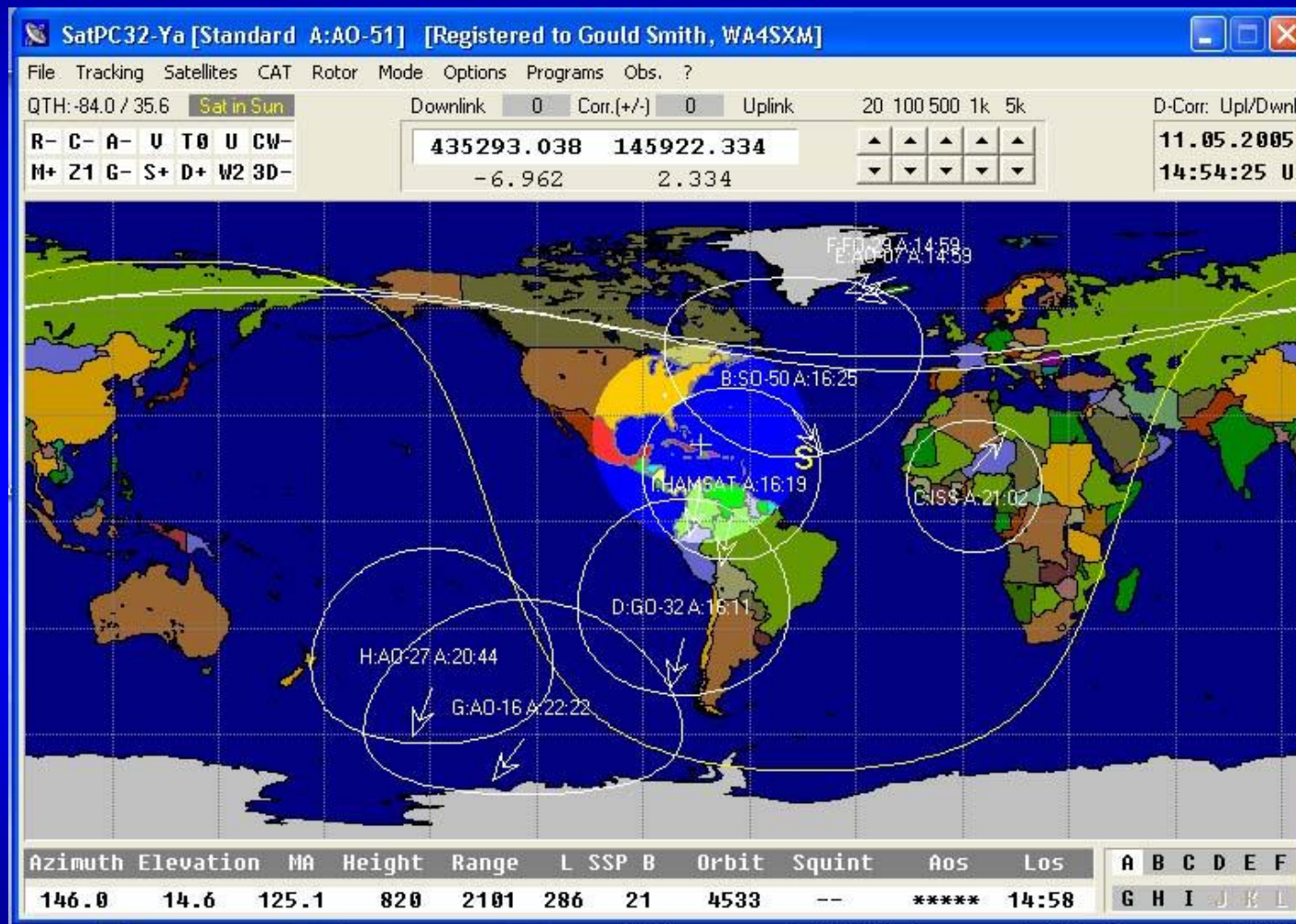
Operating Techniques During the Pass



- **Adjust for Doppler (Use 5 Khz Steps)**
- **Listen to who is talking - Note the call-sign**
- **Make a short call to this specific station**
- **Give your name, callsign, and grid square**
- **Have a means to record contacts**
- **Have patience-LEO satellites are busy, so it may take a few passes until you make a contact**

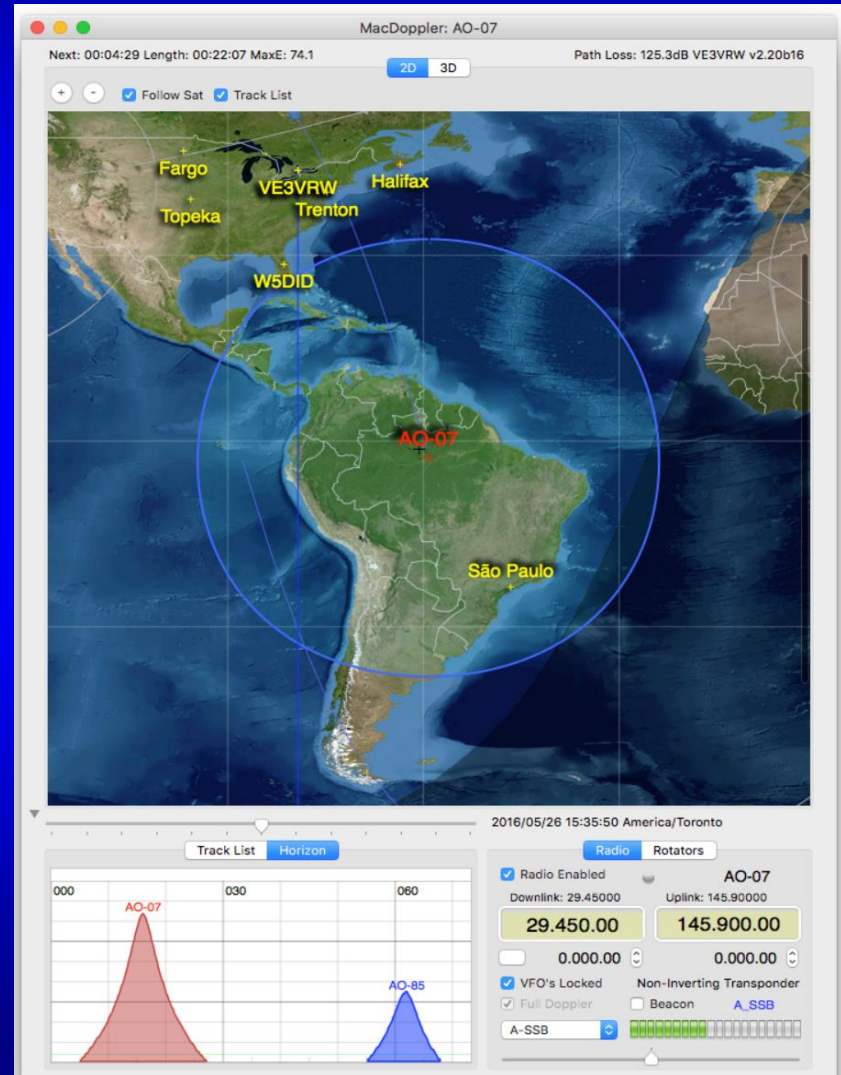
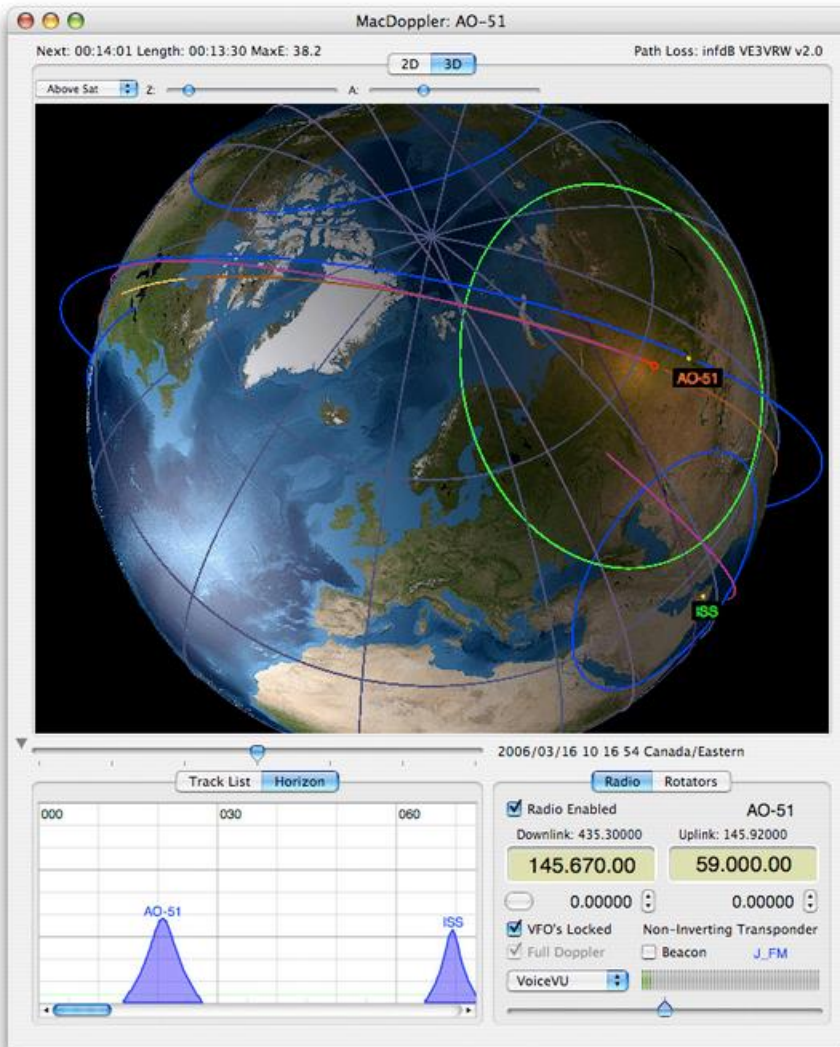


SatPC32 software



Will also do antenna and radio control

MacDoppler





Get started right now!

WWW.AMSAT.ORG

The AMSAT Web Site has it all!

Join AMSAT

Buy Getting Started books

Use Satellite positioning tools online

Easy Satellite status & Freq charts

Check it out!



For More Information

AMSAT

712 H Street NE, Ste 1653
Washington DC 20002

WWW.AMSAT.ORG

info@amsat.org