Introduction to Amateur Satellites

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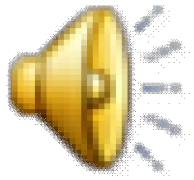
South Bay Amateur Radio Association

One of the core aspects of Amateur Radio is that, as we become proficient at our current skill level, we tend to challenge our self with the next big thing !

Working with Amateur Satellites is quite exciting; it combines many aspects of Amateur Radio…



[click icon to play audio file]

Satellite Types

- Commercial
  - Communication, Television, Radio, etc.
- Government / Military / Educational / Other
  - Weather, Observation, Research, GPS, etc.
- Amateur
  - Amateur Service, Experimentation

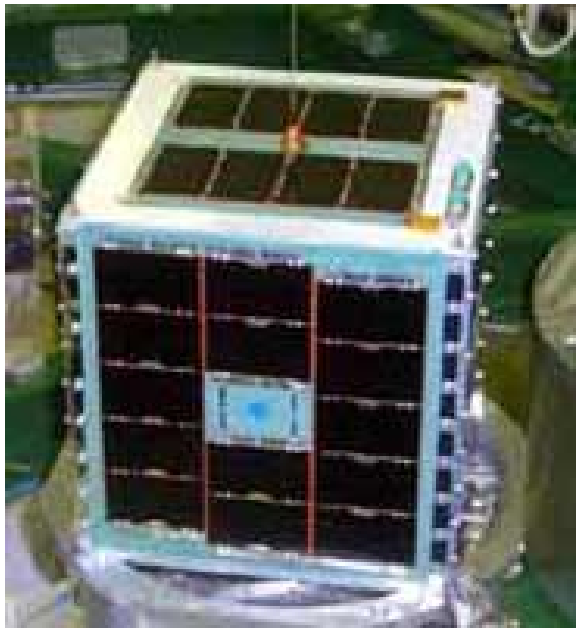
Satellite Orbits

- LEO - Low Earth Orbit (move fast)
  - 290 to 1600 kilometers
- MEO - Medium Earth Orbit (move slowly)
  - 10,000 to 16000 kilometers
- GEO - Geosynchronous Earth Orbit (stay)
  - 36000 kilometers

(Distance to Moon ~384,400 kilometers)

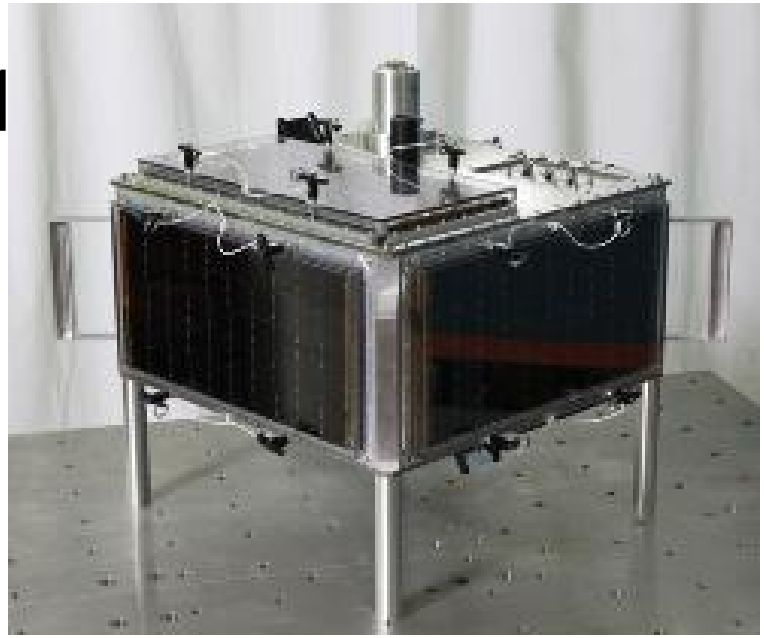
Amateur Satellite AO-51

- Dimensions: ~25cm cube
- Weight: 11.14 Kilograms (~24 lbs)
- Altitude: 435 miles
- Launch Date: June 28, 2004



Amateur Satellite ARISSat-1

- Dimensions: 55 x 55 x 40 cm
- Weight: 30 Kilograms (~ 68 lbs)
- Altitude: 300+ miles
- Launched: Jan 28, 2011



Satellite Pass Terminology: ***(IMPORTANT)***

- AOS - Time of acquisition of signal
- LOS - Time of loss of Signal
- AOS Azimuth - Azimuth at AOS
- LOS Azimuth - Azimuth at LOS

* RELATIVE TO OBSERVER *

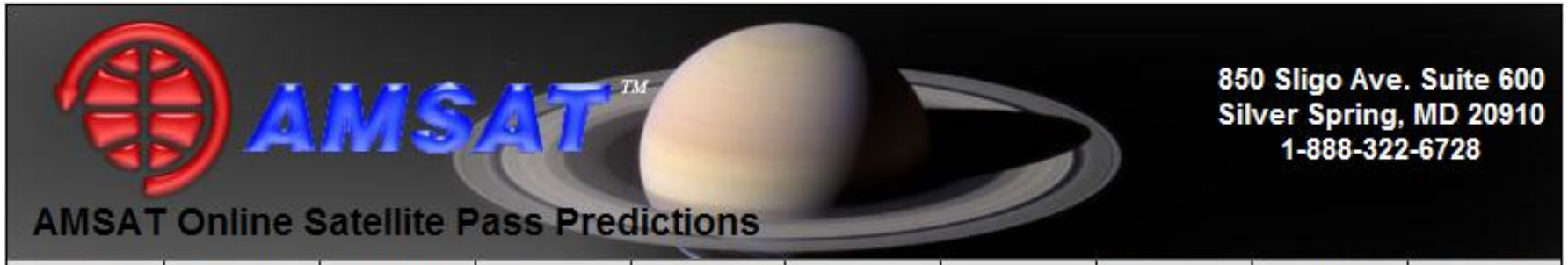
…contd.

Satellite Pass Terminology: ***(IMPORTANT)***

- Max Elevation – highest elevation during the pass
- Max Elevation Azimuth - Azimuth at observer at Max Elevation
- Ground Track - Projected location on the earth
- Footprint - Area of illumination of the satellite's signal

Pass Predictions

- Calculated from Keplerian Data published for each Satellite
- Online prediction programs - AmSat.org, Heavens-Above.com, CalSky.com, SeeASat.com, SpaceFlight.nasa.gov, etc.
- Computer Programs for Linux (Predict), Windows (SatPC32), Mac (OrbiTrack), Handheld Devices (PocketSat), etc.



850 Sligo Ave. Suite 600
Silver Spring, MD 20910
1-888-322-6728

AMSAT Online Satellite Pass Predictions - AO-51

View the current location of AO-51

Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)
12 Nov 11	00:53:12	00:10:35	222	9	264	320	01:03:47
12 Nov 11	11:21:10	00:14:32	24	30	109	168	11:35:42
12 Nov 11	13:00:01	00:14:19	1	30	306	221	13:14:20
12 Nov 11	14:42:36	00:03:17	322	1	309	297	14:45:53
12 Nov 11	22:33:06	00:13:23	139	29	81	359	22:46:29
13 Nov 11	00:11:57	00:13:18	195	26	255	335	00:25:15
13 Nov 11	10:42:28	00:12:13	36	13	95	144	10:54:41
13 Nov 11	12:20:13	00:15:17	9	70	306	200	12:35:30
13 Nov 11	14:00:31	00:10:24	345	8	304	257	14:10:55
13 Nov 11	21:55:02	00:11:18	115	12	74	10	22:06:20

Your results are shown above

Use the form below to request more pass predictions

Show Predictions for: AO-51 for Next 10 Passes

Calculate Latitude and Longitude from Gridsquare: CM97an Calculate Position

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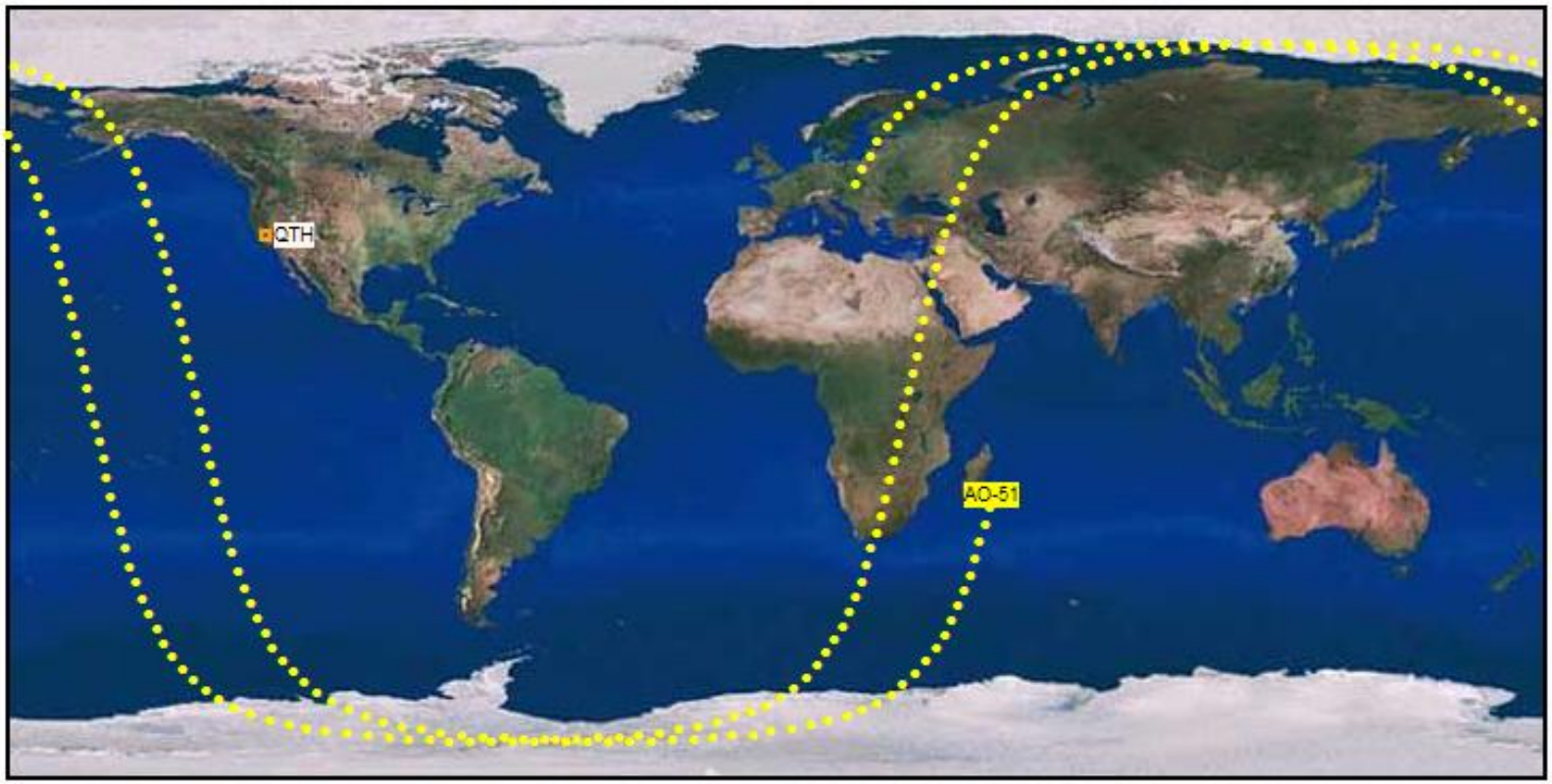
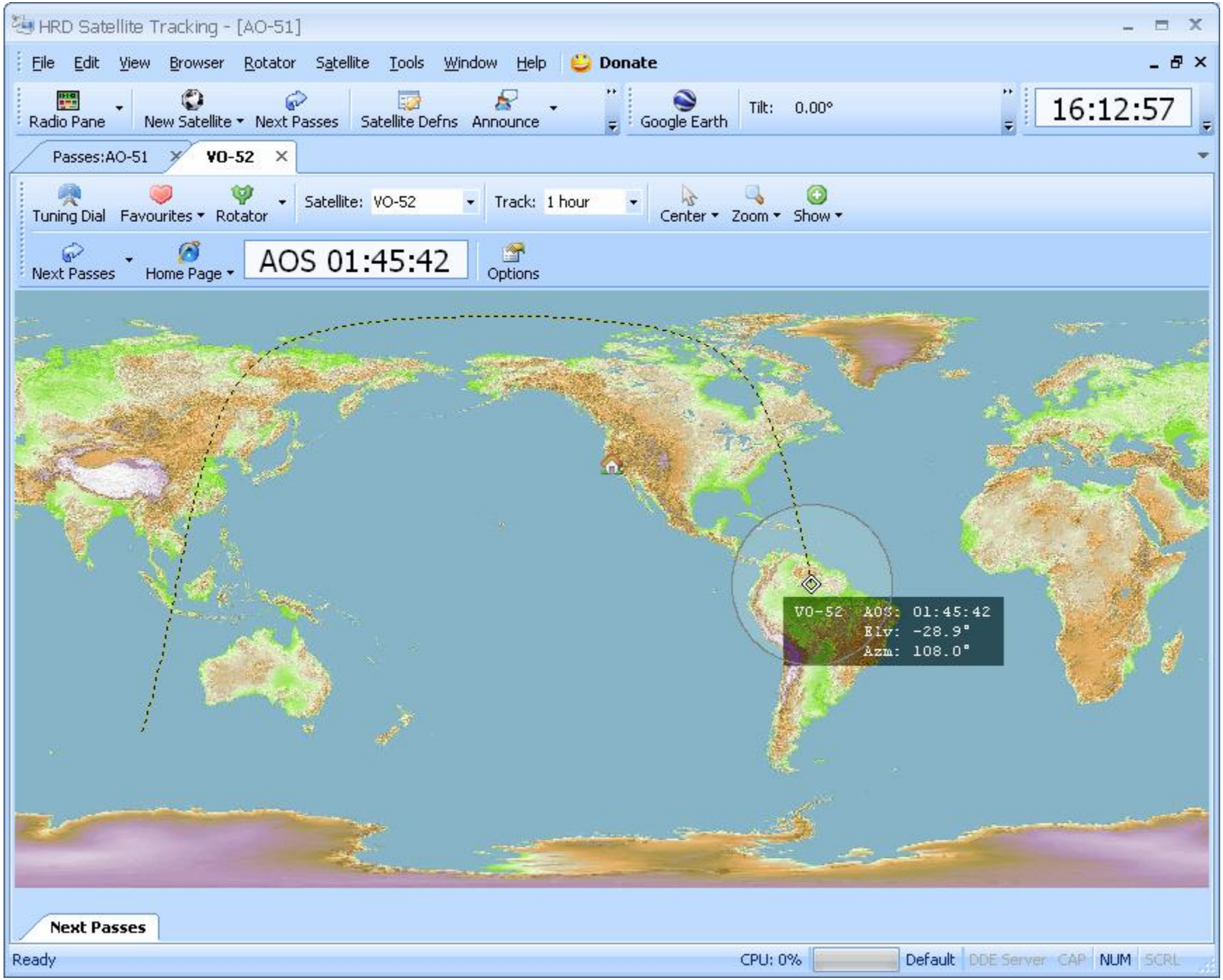
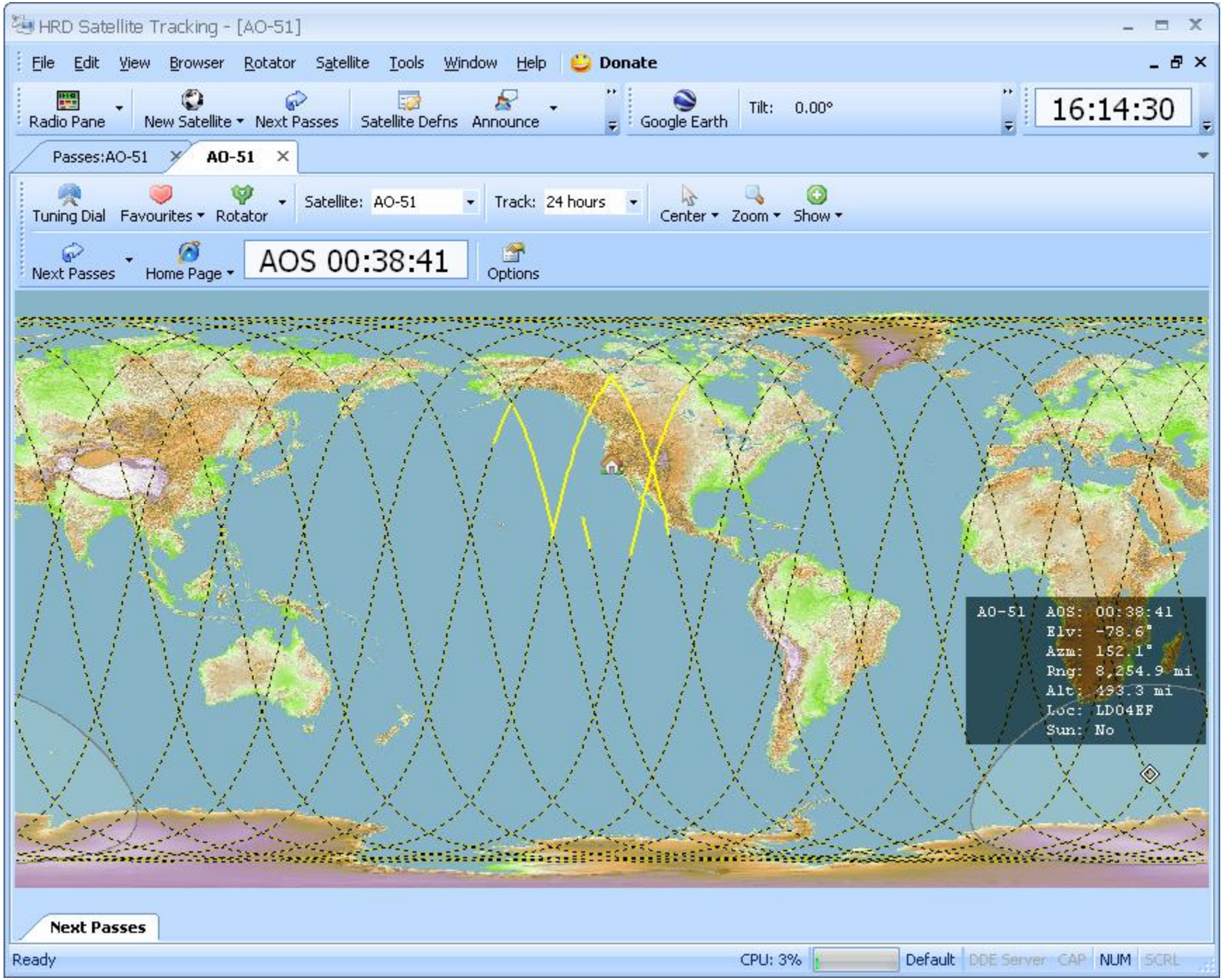
Satellite Tracking for AO-51

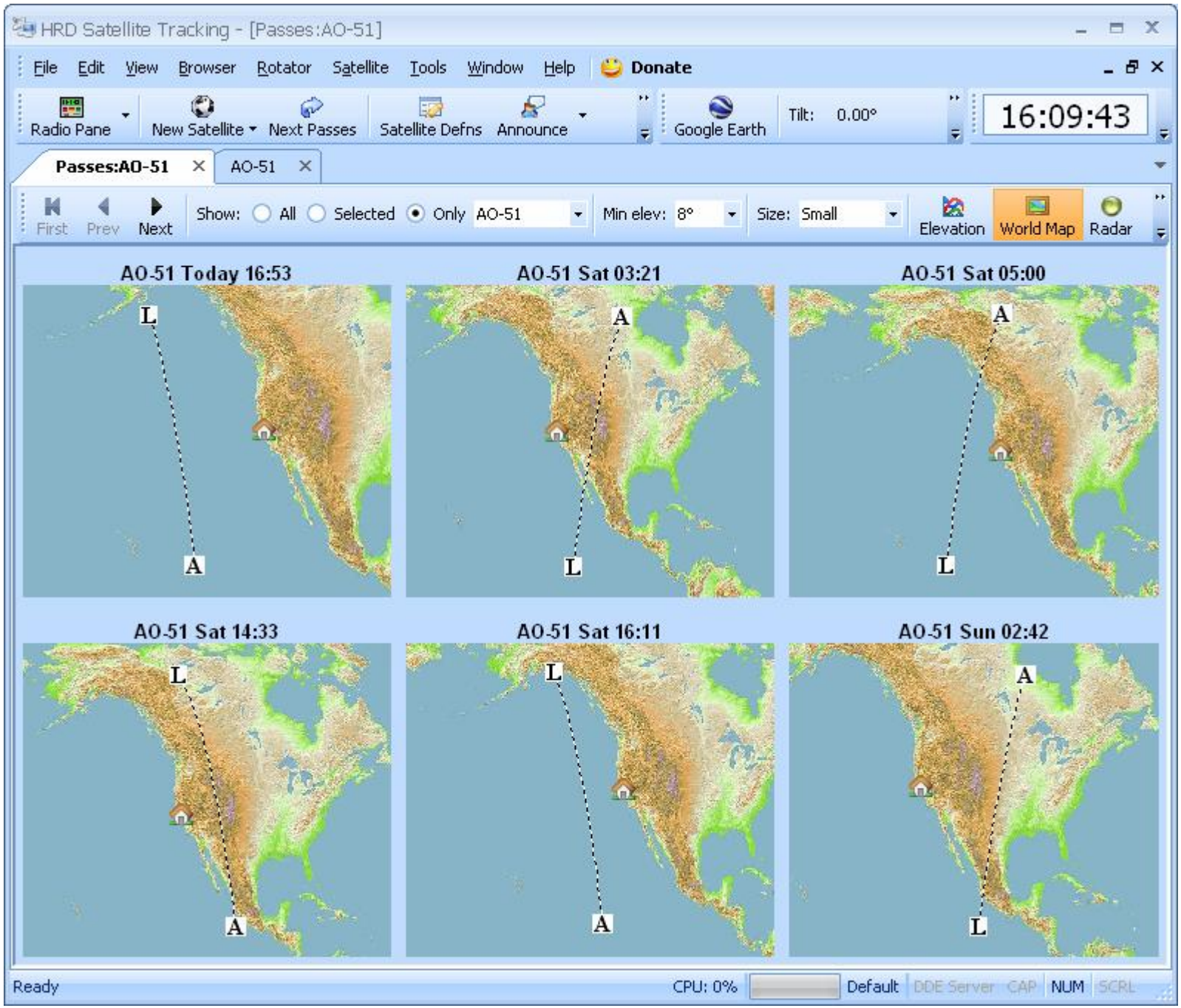
Current Position of AO-51

Sat, 12 Nov 2011 00:05:16 UTC (16:05:16 local time)
Current Location: 51.5E 24S




HRD Satellite Tracking - [AO-51]
File Edit View Browser Rotator Satellite Tools Window Help Donate
Radio Pane
New Satellite
Next Passes
Satellite Defns
Announce
Google Earth
Tilt: 0.00°
16:12:57
Passes:AO-51
VO-52
Tuning Dial
Favourites
Rotator
Satellite: VO-52
Track: 1 hour
Center
Zoom
Show
Next Passes
Home Page
AOS 01:45:42
Options
VO-52 AOS: 01:45:42
Elv: -28.9°
Azm: 108.0°
Next Passes
Ready
CPU: 0%
Default
DDE Server
CAP
NUM
SCRL


HRD Satellite Tracking - [AO-51]
File Edit View Browser Rotator Satellite Tools Window Help Donate
Radio Pane
New Satellite
Next Passes
Satellite Defns
Announce
Google Earth
Tilt: 0.00°
16:14:30
Passes:AO-51
AO-51
Tuning Dial
Favourites
Rotator
Satellite: AO-51
Track: 24 hours
Center
Zoom
Show
Next Passes
Home Page
AOS 00:38:41
Options
AO-51 AOS: 00:38:41
Elv: -78.6°
Azm: 152.1°
Rng: 8,254.9 mi
Alt: 493.3 mi
Loc: LD04EF
Sun: No
Next Passes
Ready
CPU: 3%
Default
DDE Server
CAP
NUM
SCRL


HRD Satellite Tracking - [Passes:AO-51]
File Edit View Browser Rotator Satellite Tools Window Help Donate
Radio Pane
New Satellite
Next Passes
Satellite Defns
Announce
Google Earth
Tilt: 0.00°
16:09:43
Passes:AO-51
AO-51
First Prev Next
Show: All Selected Only AO-51
Min elev: 8°
Size: Small
Elevation
World Map
Radar
AO-51 Today 16:53
AO-51 Sat 03:21
AO-51 Sat 05:00
AO-51 Sat 14:33
AO-51 Sat 16:11
AO-51 Sun 02:42
Ready
CPU: 0%
Default
DDE Server
CAP
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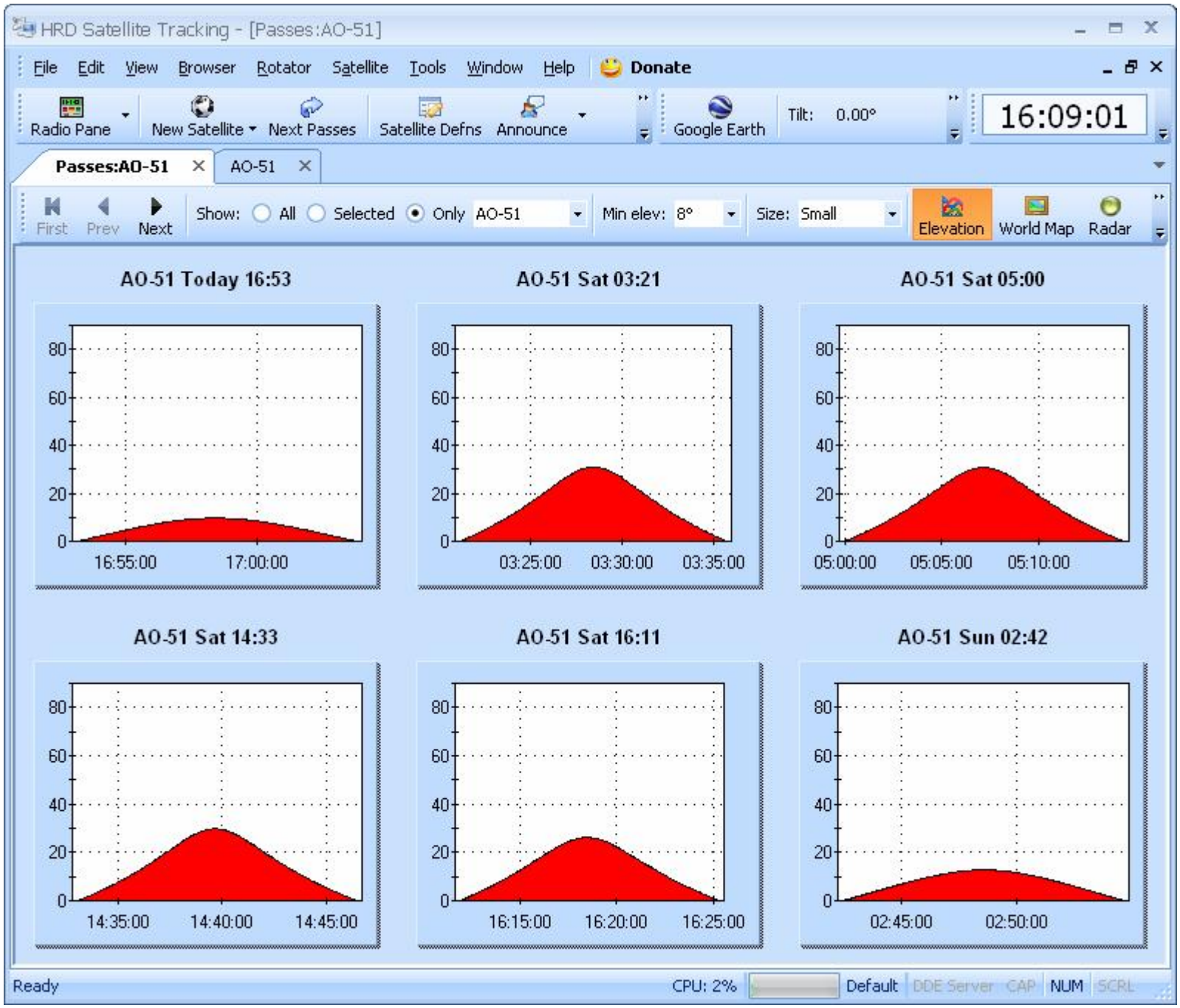
SCRL


HRD Satellite Tracking - [Passes:AO-51]
File Edit View Browser Rotator Satellite Tools Window Help Donate
Radio Pane
New Satellite
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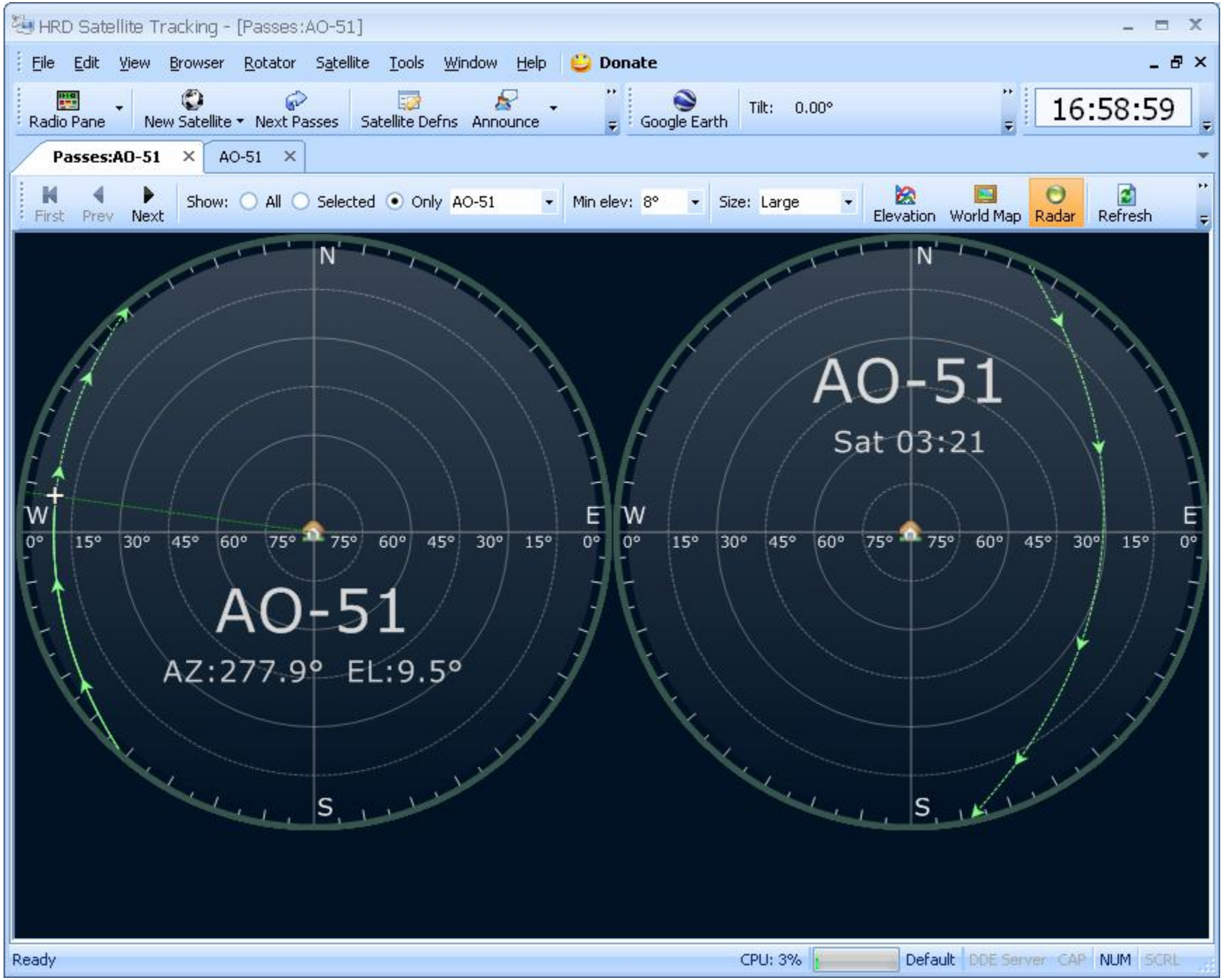
03:25:00 03:30:00 03:35:00
AO-51 Sat 05:00
05:00:00 05:05:00 05:10:00
AO-51 Sat 14:33
14:35:00 14:40:00 14:45:00
AO-51 Sat 16:11
16:15:00 16:20:00 16:25:00
AO-51 Sun 02:42
02:45:00 02:50:00
0 20 40 60 80
Ready
CPU: 2%
Default
DDE Server
CAP
NUM
SCRL


HRD Satellite Tracking - [Passes:AO-51]
File Edit View Browser Rotator Satellite Tools Window Help
Donate
Radio Pane
New Satellite
Next Passes
Satellite Defns
Announce
Google Earth
Tilt: 0.00°
16:58:59
Passes:AO-51
AO-51
First Prev Next
Show: All Selected Only AO-51
Min elev: 8°
Size: Large
Elevation
World Map
Radar
Refresh
N
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E
S
0° 15° 30° 45° 60° 75°
AO-51
AZ:277.9° EL:9.5°
AO-51
Sat 03:21
Ready
CPU: 3%
Default
DDE Server
CAP
NUM
SCRL

Modes & Frequencies

- Amateur Satellites typically use weak-signal or satellite sub-bands in the amateur bands from 10 meters and up
- Duplex for Voice
  - Separate Downlink & Uplink Frequency & Bands
- Simplex for Packet Digipeater & APRS

[Example, frequency set for AO-51]

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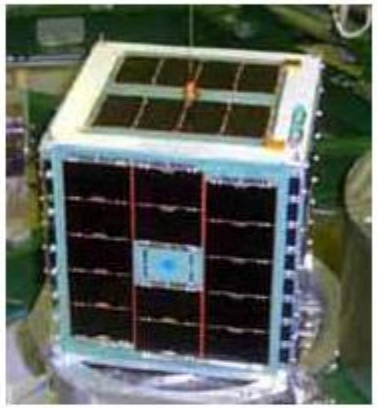
Satellite Detail - AMSAT-OSCAR 51

Launch Pad | Navigator | Sat Status | Keps | Passes | News | Store | Members | Contact Us | Return

AMSAT-OSCAR 51
(Echo)



Spacecraft Summary

OSCAR Designation:	AMSAT-OSCAR 51	**Oscar Number:**	AO-51
International Designator:	2004-025K	**Norad Number:**	28375
Common Name:	Echo	**Alternate Name:**	OSCAR-E
Satellite Type:	Microsatellite	**Launch Date:**	28 June, 2004
Launch Location:	Baikonur Cosmodrome	**Launch Vehicle:**	Dnepr
Apogee:	818.00	**Perigee:**	696.00
Inclination:	99.97	**Period:**	99.97
Dimensions:	~25cm cube	**Weight:**	11.140 Kg
Organization:	AMSAT-NA		

Frequency Information

Mode V/U (J) FM Voice Repeater: Semi-Operational
Uplink: 145.8800 MHz FM
Downlink 435.1500 MHz FM

Callsign(s)

Broadcast: PECHO-11
BBS: PECHO-12

Doppler Effect

- LEO Satellites travel at very high speeds
- Doppler Effect shifts signal frequencies
  - higher when approaching the observer
  - lower when receding from the observer
- Doppler Shift depends on the speed and distance from observer as it travels from AOS to LOS

Compensating for Doppler Effect

- Fairly easy for FM satellites, but SSB/CW satellites need more work
- For FM, set the receiver 10 to 15 KHz higher than the center frequency
- Change the frequency 2.5 or 5 KHz (one step) lower when voices appear garbled
- Takes a minutes or two before the step down becomes necessary

Signal Polarization

- Amateur Satellite typically use quarter wave antennas
- The signal polarity may change as the satellites travels around the Earth
- Amateur Satellites typically tumble through space; they don’t have the capacity to reorient and always face the earth

Effects of Polarization

- Proper polarization between transmitting and receiving antennas is important, at very high frequencies
- Improper polarizations angles can cause up to 3dB loss (~ 50% loss)
- 3dB loss can bury weak signals in noise, especially bad for the FM (like the HDTV problem)

Compensating for Polarization

- We can't change the satellite, so we make adjustments in the Earth stations
- Circular polarized antenna would work very well
- People have used 2 high gain beams mounted at 90 degrees
- Simply rotate high gain beam for best signal strength (rotators, arm strong)

Antennas for Satellite Use

- High Gain Antennas Preferred
- VHF/UHF Dual Band Whip
- Quarter Wave Ground Plane Antenna
- Single band VHF beam
- Separate VHF and UHF beams
- Handheld operation will require a light antenna or tripod mount

DIY Antennas

- Cheap Yagi for 70cm – Jul Aug 06 Amsat Journal *** show & tell
- Cheap 2m Yagi for Uplink – Sep Oct 06 Amsat Journal
- Tape Measure Beam Optimized for Radio DF by WB2HOL *** show & tell
- Cheap Yagi by WA5VJB
- Cost under ($20)

Commercial Antennas

- Arrow Satellite Beam Antenna ($130+)
- Elk 2m 440 Dual Band Antenna ($???)
- Pryme AL-800H High Gain Whip ($25+)

Radios for FM Satellites

- A Full Duplex Radio or Two Separate Radios Preferred
- 5 watt HT is good enough for FM Satellites
- Dual band HT supporting split frequency operation (most Yaesu HTs, Icom 90A)
- Dual band Dual receive HTs (IC-91, IC-92)
- Full duplex radios (FT-857 etc.)

Duplexers or Diplexers

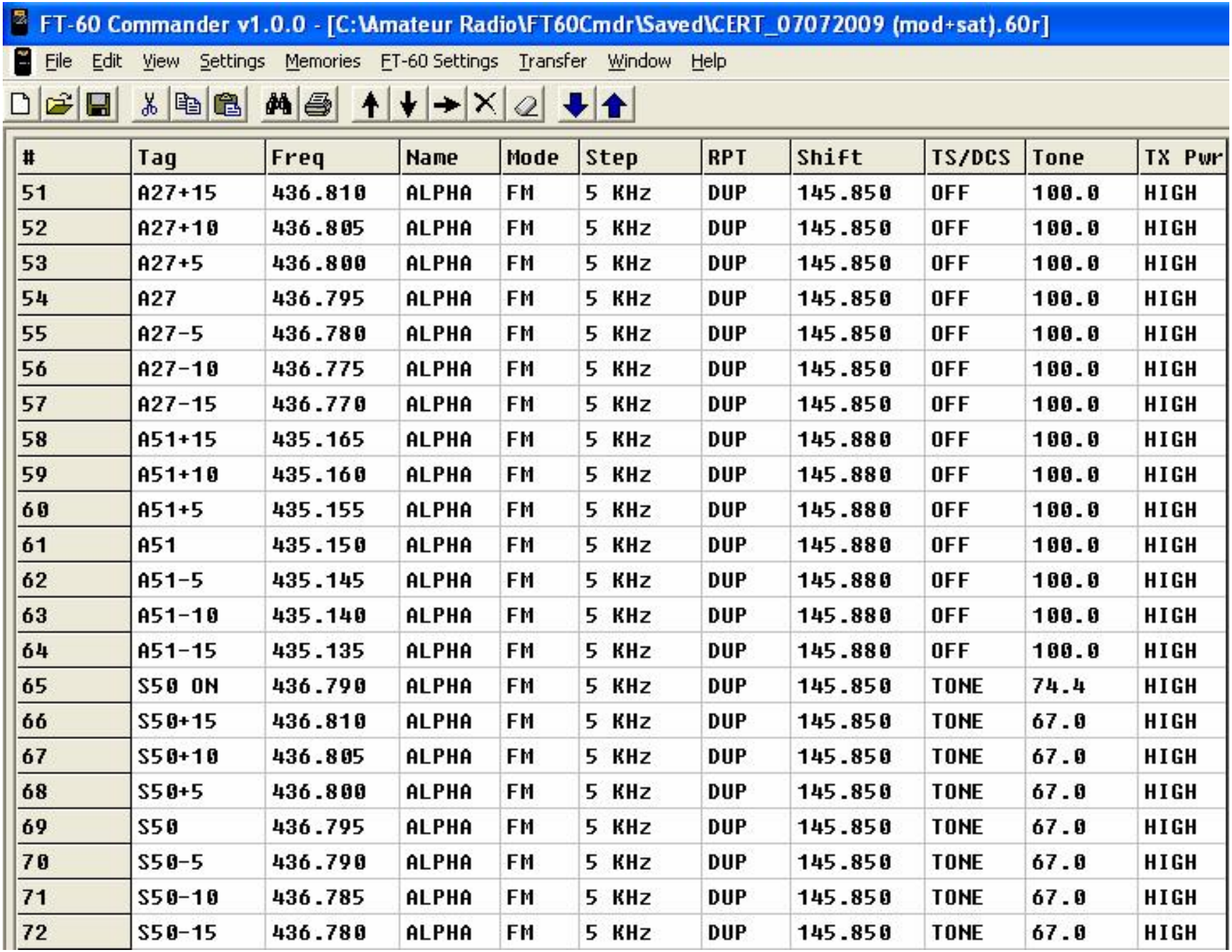
- Duplexer - connects a dual band antenna to 2 single band radios

- Diplexer - connects a dual band radio to 2 separate antennas

Using Memory Channels

- Store frequency pairs for many satellites
- Convenience of storing different Doppler Shifted frequencies in adjacent channels

[show sample chart]



#	Tag	Freq	Name	Mode	Step	RPT	Shift	TS/DCS	Tone	TX Pwr
51	A27+15	436.810	ALPHA	FM	5 KHz	DUP	145.850	OFF	100.0	HIGH
52	A27+10	436.805	ALPHA	FM	5 KHz	DUP	145.850	OFF	100.0	HIGH
53	A27+5	436.800	ALPHA	FM	5 KHz	DUP	145.850	OFF	100.0	HIGH
54	A27	436.795	ALPHA	FM	5 KHz	DUP	145.850	OFF	100.0	HIGH
55	A27-5	436.780	ALPHA	FM	5 KHz	DUP	145.850	OFF	100.0	HIGH
56	A27-10	436.775	ALPHA	FM	5 KHz	DUP	145.850	OFF	100.0	HIGH
57	A27-15	436.770	ALPHA	FM	5 KHz	DUP	145.850	OFF	100.0	HIGH
58	A51+15	435.165	ALPHA	FM	5 KHz	DUP	145.880	OFF	100.0	HIGH
59	A51+10	435.160	ALPHA	FM	5 KHz	DUP	145.880	OFF	100.0	HIGH
60	A51+5	435.155	ALPHA	FM	5 KHz	DUP	145.880	OFF	100.0	HIGH
61	A51	435.150	ALPHA	FM	5 KHz	DUP	145.880	OFF	100.0	HIGH
62	A51-5	435.145	ALPHA	FM	5 KHz	DUP	145.880	OFF	100.0	HIGH
63	A51-10	435.140	ALPHA	FM	5 KHz	DUP	145.880	OFF	100.0	HIGH
64	A51-15	435.135	ALPHA	FM	5 KHz	DUP	145.880	OFF	100.0	HIGH
65	S50 ON	436.790	ALPHA	FM	5 KHz	DUP	145.850	TONE	74.4	HIGH
66	S50+15	436.810	ALPHA	FM	5 KHz	DUP	145.850	TONE	67.0	HIGH
67	S50+10	436.805	ALPHA	FM	5 KHz	DUP	145.850	TONE	67.0	HIGH
68	S50+5	436.800	ALPHA	FM	5 KHz	DUP	145.850	TONE	67.0	HIGH
69	S50	436.795	ALPHA	FM	5 KHz	DUP	145.850	TONE	67.0	HIGH
70	S50-5	436.790	ALPHA	FM	5 KHz	DUP	145.850	TONE	67.0	HIGH
71	S50-10	436.785	ALPHA	FM	5 KHz	DUP	145.850	TONE	67.0	HIGH
72	S50-15	436.780	ALPHA	FM	5 KHz	DUP	145.850	TONE	67.0	HIGH

Logging, QSLs

- Use a notepad
- Use a small sound recorder
- Use a logging program (like HRD, etc.)

- Mail Paper QSL Cards
- Electronic QSLs via LOTW, eQSL, etc.

Grid Squares

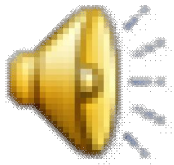
- World Map divided into squares of 1° latitude by 2° longitude (70 × 100 miles)
- A Grid Square is indicated by two letters and two numbers
- Typical Exchange involves a 4 character Grid Square
- Grid Square for Fremont is “CM97”
- Excellent Article on Wikipedia.com

Achievement Awards

- AmSat Awards
  - Satellite Communicators' Club Certificate
  - Oscar Satellite Communications Achievement Award Certificate
  - Oscar Century Award Certificate
- ARRL Awards
  - Satellite DXCC Award
  - Field Day

Courtesy, Phonetics, Efficiency

- FM Satellites offer a single channel like a repeater, shared by everyone
- SSB/CW satellites offer a 100KHz channel that can support several SSB/CW QSOs simultaneously



[click icon to play sample audio file 1]

Jump Start - Preparation

- Pick an easy to work FM Satellite like AO27, AO51, SO-50
- Get Satellite Pass Prediction Table
- Magnetic Compass with Azimuth Rose, Elevation Chart
- Notepad or Voice recorder
- Suitable Radio
- Suitable Antenna (Tripod if required)

Jump Start - Ready

- Prepare everything about 10 minutes before AOS time
- Set Receiver to correct channel and turn off any kind of squelch
- Point the compass to Magnetic North and identify the AOS and LOS Azimuths
- Identify the Max Elevation & its Azimuth
- Pick a good spot, clear of buildings & hills

Practice Recieving

- At AOS time, point the antenna in the direction of AOS Azimuth
- In a short time, you start to notice receiver quieting and may hear some faint voices
- Rotate the antenna to achieve the best signal.
- In a minute, the signals will get very strong and the receiver will be full quieting
- When noise increases re-point the antenna in the direction of the path
- When voice gets garbled changed the receive frequency one step down. [click icon file 2]

Making a QSO

- Practice writing down call signs & grid squares while keeping the antenna pointed to the satellite
- Call a known station and provide your call sign & grid square while listening to your own voice
- When the other replies, you have made a QSO. As a courtesy, thank him/her.
- Congratulations on your contact !!!

Internet References

- AmSat.org
- WB2HOL Tape Measure Beam
  www.west.net/~marvin/wb2hol.htm
- Cheap Yagi
  www.wa5vjb.com/yagi-pdf/cheapyagi.pdf
- SatPC32 by DK1TB
  www.dk1tb.de/indexeng.htm
- Ham Radio Deluxe v5
  www.ham-radio-deluxe.com/HRDv5.aspx

Thank You !