Amateur Radio Satellites

- Ogden Amateur Radio Club
- January 16, 2016

Satellites for Beginners

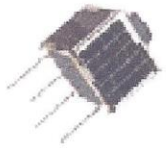
- Overview of Satellites
- Types of Orbits
- Orbital Mechanics
- Keplerian Elements
- Satellite Tracking
- Antenna Basics
- Simple Transmitters/Receivers
- Satellites for Beginners

What Is An OSCAR

- An OSCAR is an **O**rbiting **S**atellite **C**arrying **A**mateur **R**adio
- Built for non-commercial purposes
- Originally built by Project OSCAR members in garages in Silicon Valley
- Now built by and/or funded by members of AMSAT and AMSAT affiliates
- Originally a “bleep sat” but now carry sophisticated repeaters or transponders
- Are encouraged to carry sensors and other scientific experiments

Chuck Towns K6LFH in his garage with OSCAR-II

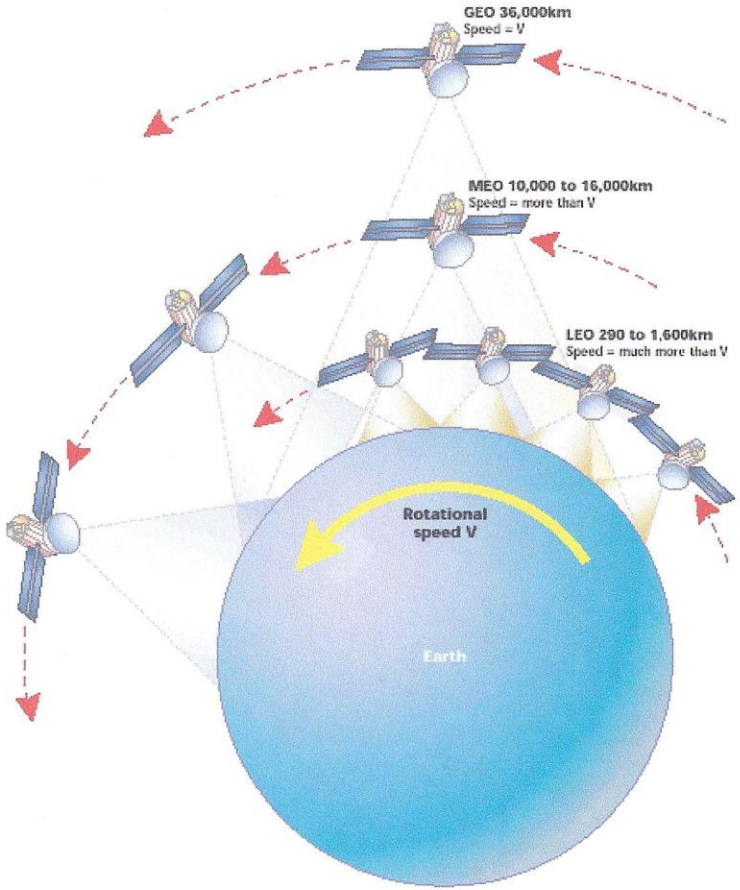
Some Important Terms



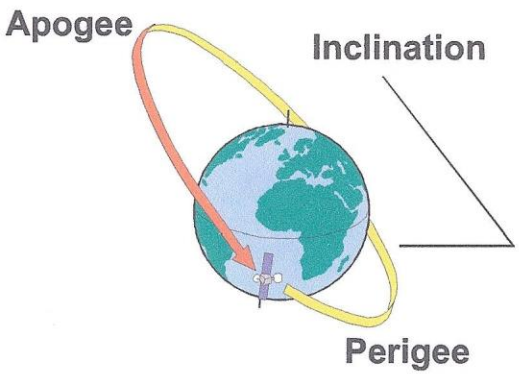
Orbit	⇨	The **path** a satellite travels around the earth
Doppler	⇨	A **shift** in frequency caused by satellite motion
LEO	⇨	A satellite in **L**ow **E**arth **O**rbit (400-2000km)
HEO	⇨	A satellite in a **H**igh **E**arth **O**rbit (> 20,000km)
GEO	⇨	A satellite in a **Geo**synchronous orbit (35,680km)
Uplink	⇨	The frequency used to **transmit** to a satellite
Downlink	⇨	The frequency used to **receive** a satellite
Footprint	⇨	A circular area where the satellite is **line of sight**
Apogee		When the satellite is at it's **highest** alititude
Perigee		When the satellite is at it's **lowest** altitude
Inclination		The **angle** of the satellite where equator = zero

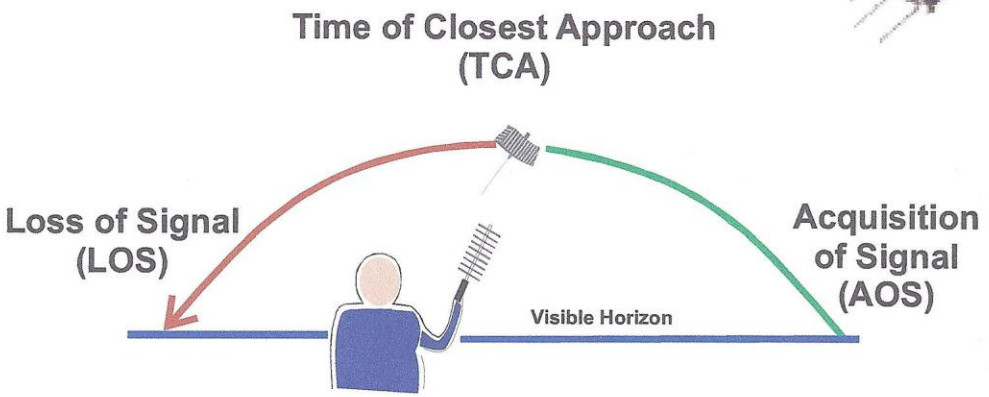
Types of Orbits

FIGURE 71: SATELLITE ORBITAL DISTANCES



Satellite Orbit Tracks

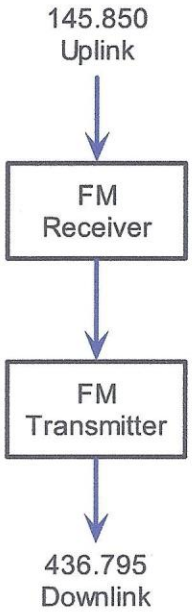




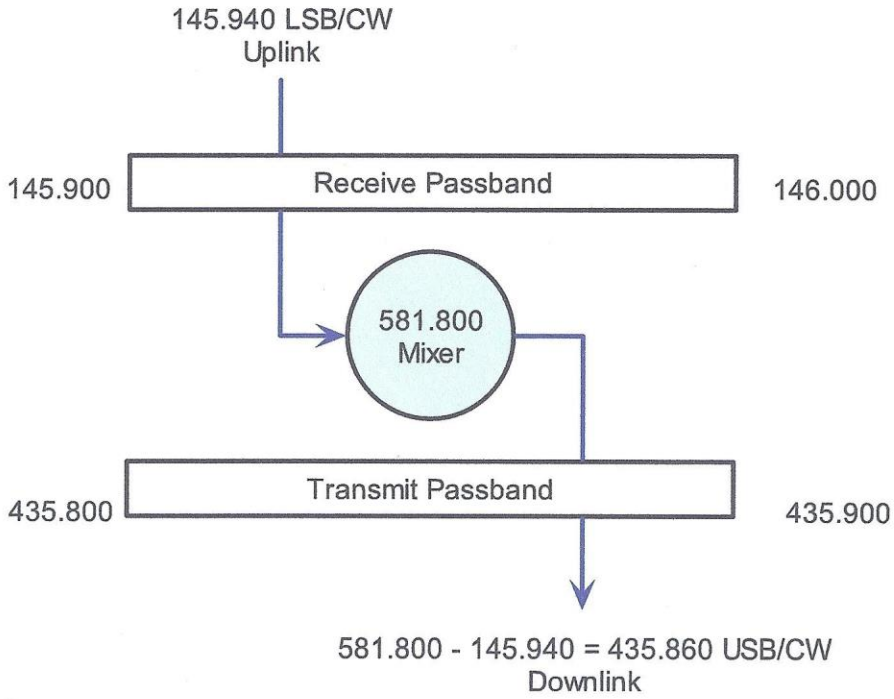
- Artificial satellites travel in an arc determined by height, eccentricity, and inclination.
- **Inclination** can range from 0° (equitorial) to 90° (polar)
- The time the satellite is visible (in range) to an observer is called a satellite "**pass**". During the pass, you are in the "**footprint**"
- The altitude of the satellite above the earth determines the length of the orbit and pass or "**time on station**" and mutual coverage

FM Repeater vs Linear Transponder

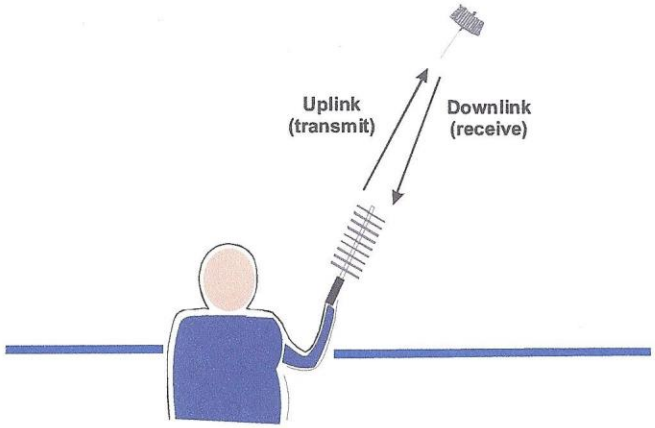
Single Channel NFM Repeater



100 KHz Wide Linear Transponder



Operating a Satellite



Satellites don't have the physical space to separate receive and transmit antennae a great distance, so they use different bands

Traditional LEO Modes:

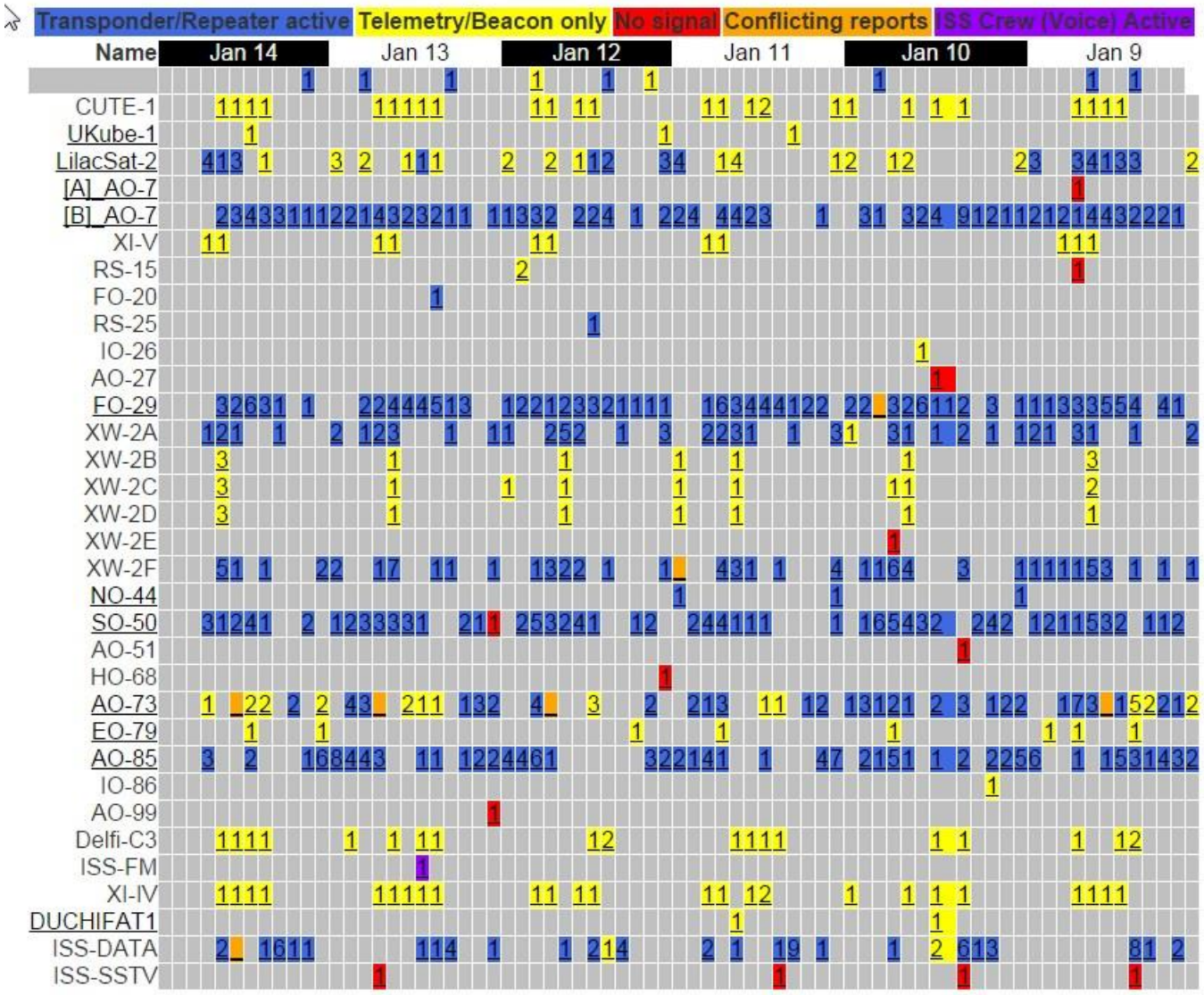
Mode A = 10m/2m

Mode B = 2m/70cm

Mode J = 70cm/2m

New satellite band designations are paired letters, eg U/V, L/S, etc.

V=2m	C=7.5cm
U=70cm	X=3cm
L=23cm	K=1.5cm
S=13cm	Q=5mm


Transponder/Repeater active
Telemetry/Beacon only
No signal
Conflicting reports
ISS Crew (Voice) Active
Name
Jan 14
Jan 13
Jan 12
Jan 11
Jan 10
Jan 9
CUTE-1
UKube-1
LilacSat-2
[A]_AO-7
[B]_AO-7
XI-V
RS-15
FO-20
RS-25
IO-26
AO-27
FO-29
XW-2A
XW-2B
XW-2C
XW-2D
XW-2E
XW-2F
NO-44
SO-50
AO-51
HO-68
AO-73
EO-79
AO-85
IO-86
AO-99
Delfi-C3
ISS-FM
XI-IV
DUCHIFAT1
ISS-DATA
ISS-SSTV

AMSAT Online Satellite Pass Predictions - AO-85

View the current location of AO-85

Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)
15 Jan 16	00:01:17	00:14:35	183	32	102	42	00:15:52
15 Jan 16	01:41:22	00:15:16	233	40	313	28	01:56:38
15 Jan 16	03:24:57	00:11:59	282	10	320	22	03:36:56
15 Jan 16	05:10:11	00:08:10	325	4	350	29	05:18:21
15 Jan 16	06:52:29	00:10:46	338	8	17	68	07:03:15
15 Jan 16	08:32:54	00:14:17	334	30	52	118	08:47:11
15 Jan 16	10:13:32	00:14:16	321	41	245	169	10:27:48
15 Jan 16	11:57:12	00:05:31	285	2	273	240	12:02:43
15 Jan 16	22:49:19	00:10:52	148	9	109	57	23:00:11
16 Jan 16	00:26:37	00:15:30	205	71	97	35	00:42:07
16 Jan 16	02:08:15	00:14:12	253	21	308	24	02:22:27
16 Jan 16	03:52:57	00:10:07	302	6	341	22	04:03:04
16 Jan 16	05:37:23	00:08:38	334	4	359	42	05:46:01
16 Jan 16	07:18:31	00:12:37	337	13	33	89	07:31:08
16 Jan 16	08:58:52	00:14:48	329	59	33	139	09:13:40
16 Jan 16	10:40:05	00:12:29	312	17	257	193	10:52:34
16 Jan 16	23:13:15	00:13:59	174	23	119	45	23:27:14
17 Jan 16	00:52:40	00:15:31	225	53	300	30	01:08:11
17 Jan 16	02:35:43	00:12:43	274	13	330	22	02:48:26
17 Jan 16	04:21:00	00:08:36	319	4	344	27	04:29:36
17 Jan 16	06:03:54	00:10:03	338	6	17	60	06:13:57
17 Jan 16	07:44:27	00:13:47	335	23	53	109	07:58:14
17 Jan 16	09:24:56	00:14:35	324	58	259	160	09:39:31
17 Jan 16	11:07:28	00:08:35	296	5	272	222	11:16:03
17 Jan 16	22:02:07	00:08:48	136	5	111	65	22:10:55

Satellite Tracking Programs

PC

- Nova For Windows
- SatPC32 for Windows
- SCRAP

Available at the AMSAT web site!

- Satscape
- Orbitron

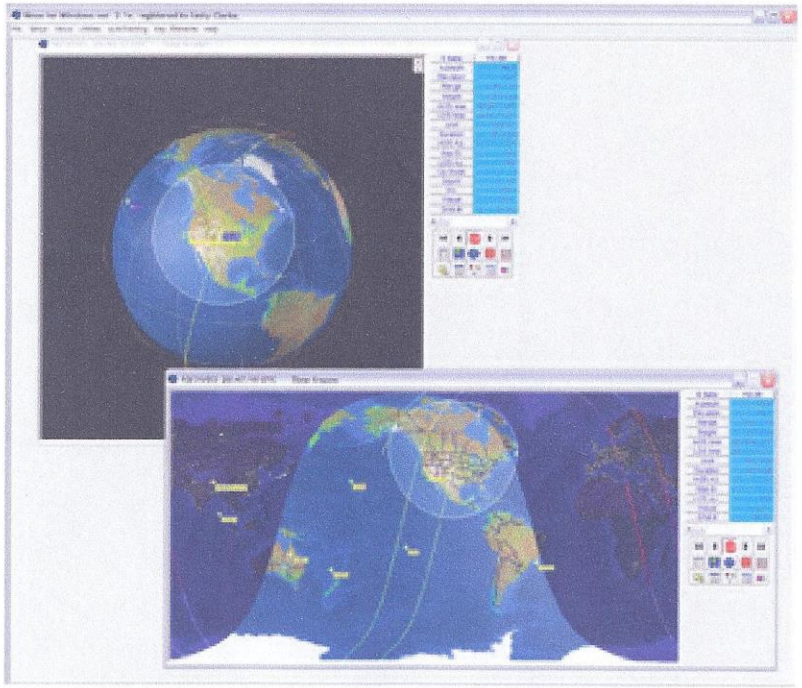
MacIntosh

- MacDoppler Pro

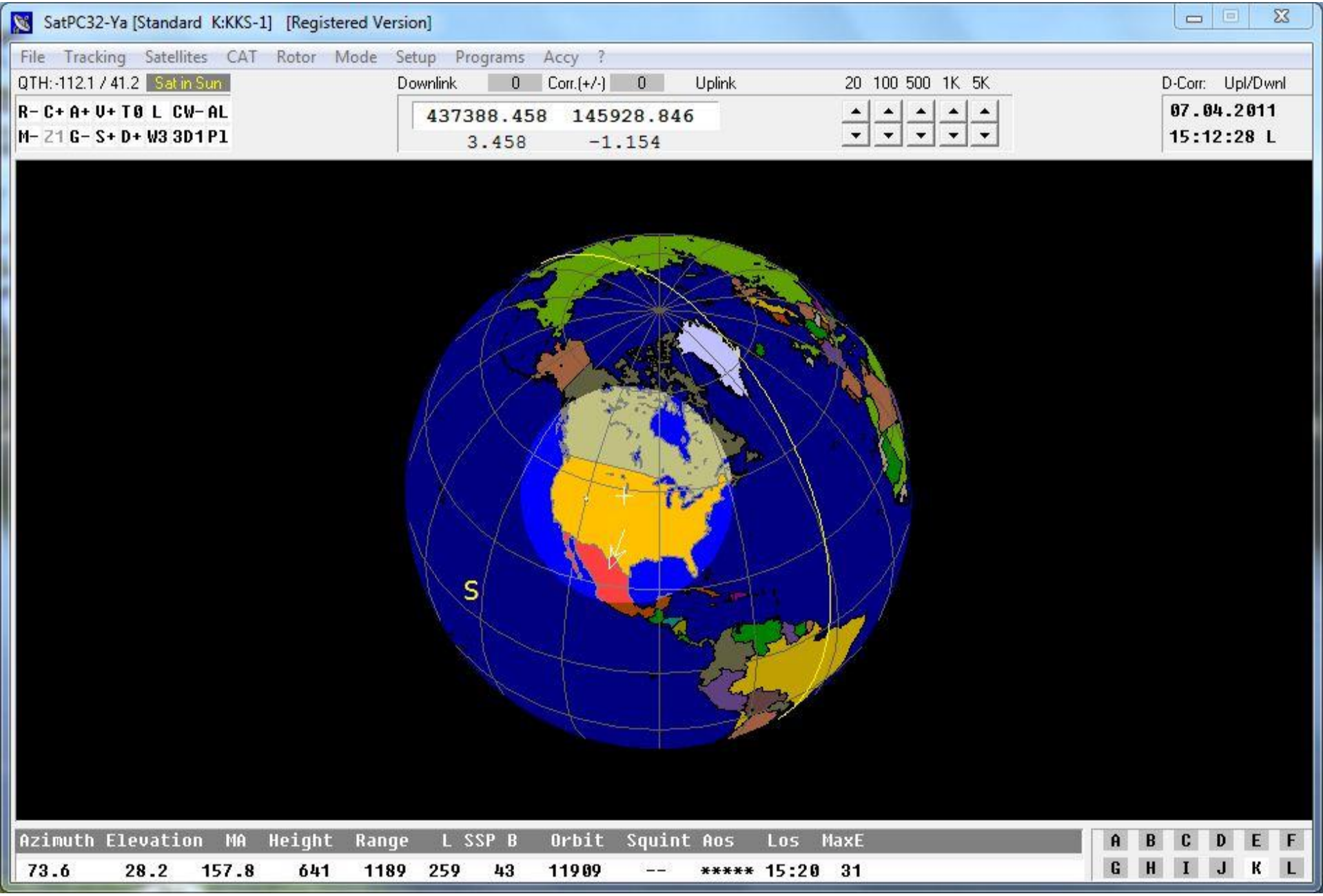
Contact Dog Park Software

PDA

- PetiTrack for Zaurus
- PocketSat for Palm and PalmPC



Nova for Windows


SatPC32-Ya [Standard K:KKS-1] [Registered Version]
File Tracking Satellites CAT Rotor Mode Setup Programs Accy ?
QTH:-112.1 / 41.2 Sat in Sun
R- C+ A+ V+ T0 L CW- AL
M- Z1 G- S+ D+ W3 3D1 P1
Downlink 0 Corr.(+/-) 0 Uplink
437388.458 145928.846
3.458 -1.154
20 100 500 1K 5K
D-Corr: Upl/Dwnl
07.04.2011
15:12:28 L
S
Azimuth Elevation MA Height Range L SSP B Orbit Squint Aos Los MaxE
73.6 28.2 157.8 641 1189 259 43 11909 -- ***** 15:20 31
A B C D E F
G H I J K L

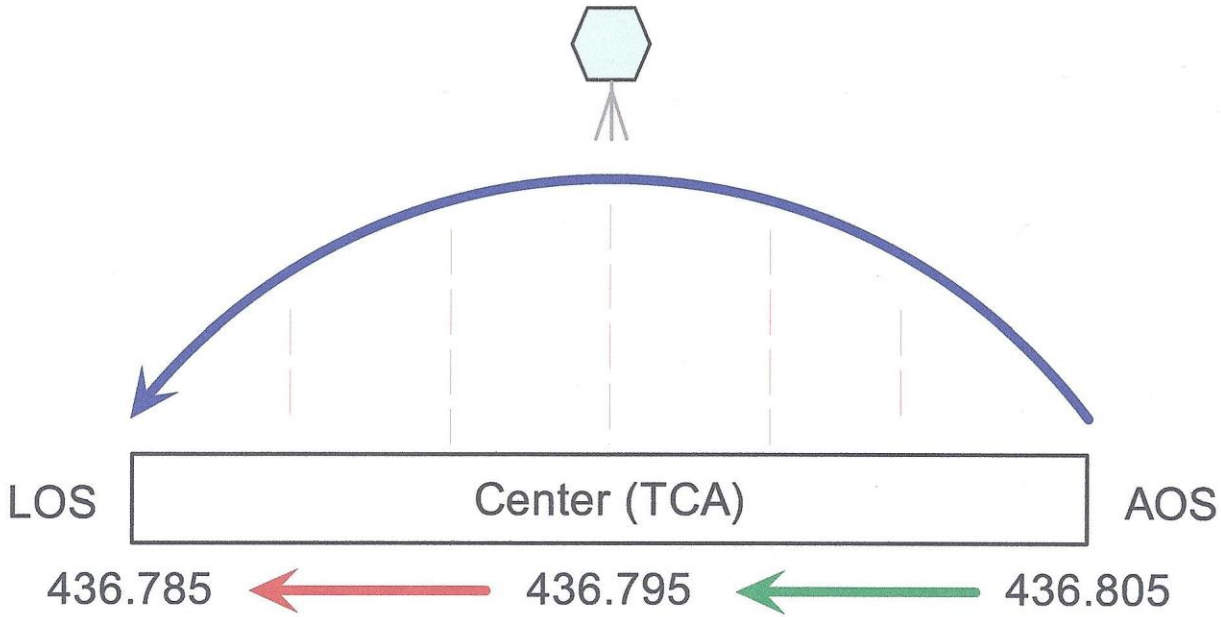
Keplerian Elements

```
AO-7
1 07530U 74089B 04140.70617484 -.00000029 00000-0 10000-3 0 2774 2
07530 101.6834 187.8825 0012044 277.9198 82.0507 12.53568957350341
```

- Keplerian Elements are a mathematical model of a satellites orbit
- Used by tracking programs to predict where the satellite is at a given time
- Need to be updated periodically (esp ISS – it can be maneuvered)
- Most tracking programs do this over the internet
- Two formats –
  - NORAD Two Line Elements (TLE – most common)
  - AMSAT Verbose Format

Doppler for Beginners - Receiving

Satellite transmits at 436.795



The overriding rule of thumb is to tune so you can hear other stations clearly.

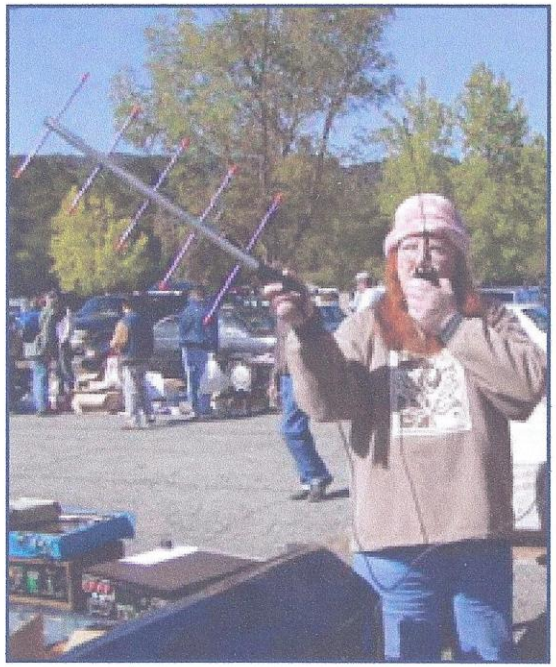
Simple Transmitters/Receivers

- VERY BASIC LIST:
- VHF/UHF FM transceiver/hand held transceiver.
- VHF/UHF ¼ wave antenna.
- 2.5 W for the hand held.

- INTERMEDIATE LIST
- VHF/UHF Multimode.
- VHF/UHF beam antennas.
- Azimuth & Elevation control rotator.
- Higher power for the elliptical orbit satellites.

Minimum Requirements

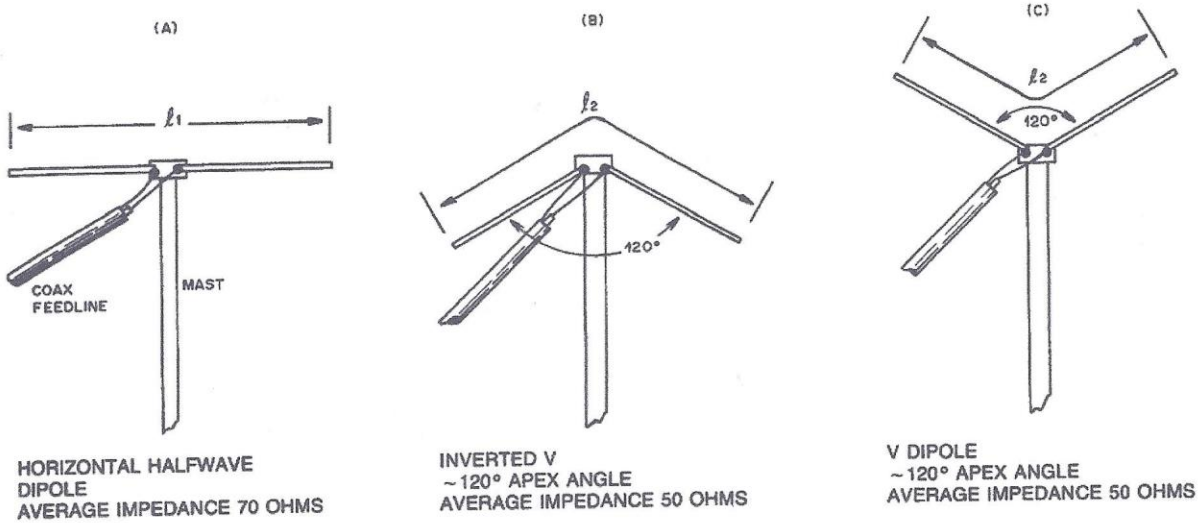
- All mode 2m/70cm radio or Dual VFO HT
- Dual Band Arrow Antenna or high gain whip antenna
- Palm computer with tracking software
- Patience



WØEEC QSOs with WH6BIE via UO-14 from California to Hawaii – 4000km

Antenna Basics

- Antenna's for Beginners



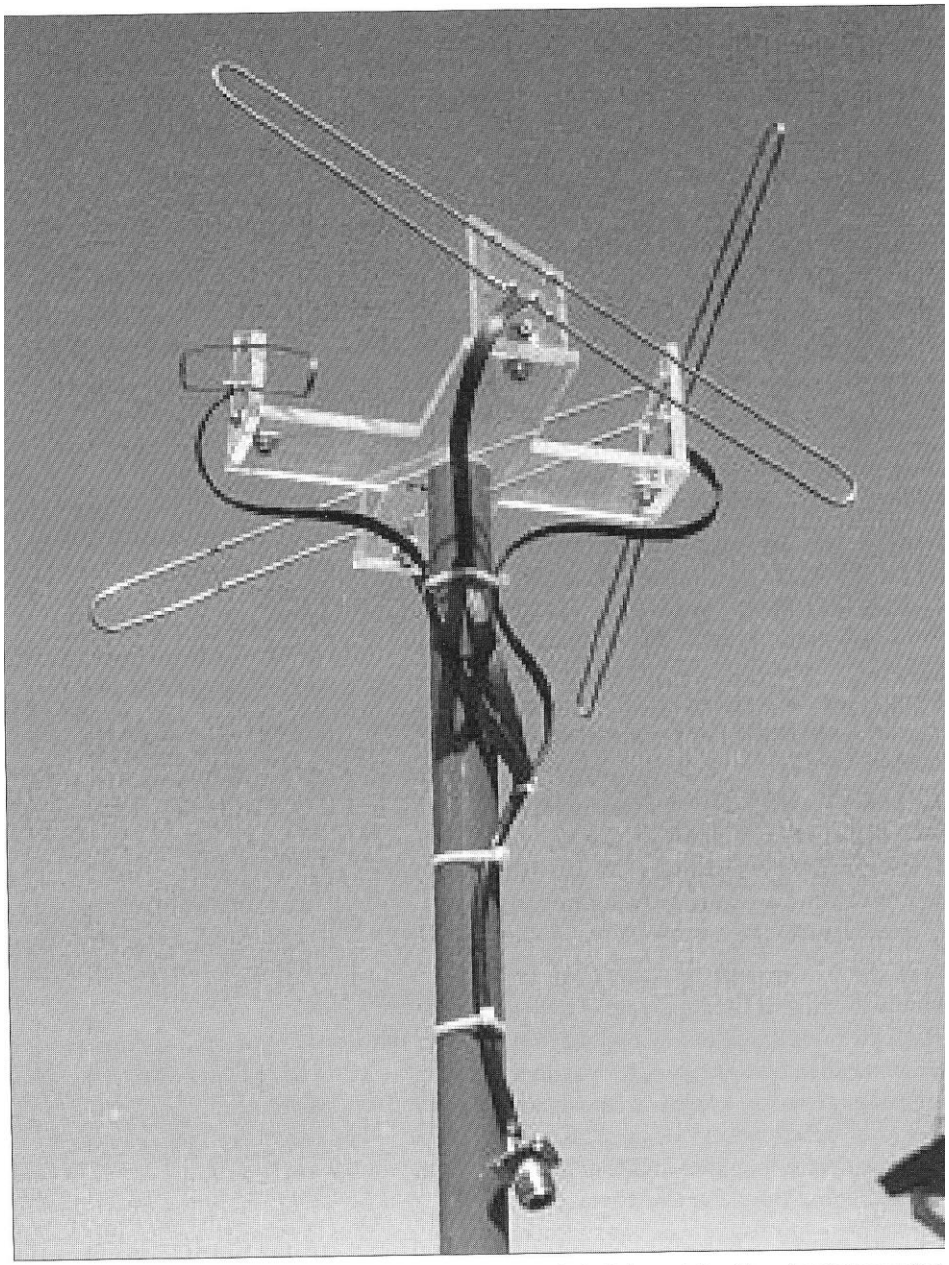
HORIZONTAL HALFWAVE DIPOLE
AVERAGE IMPEDANCE 70 OHMS

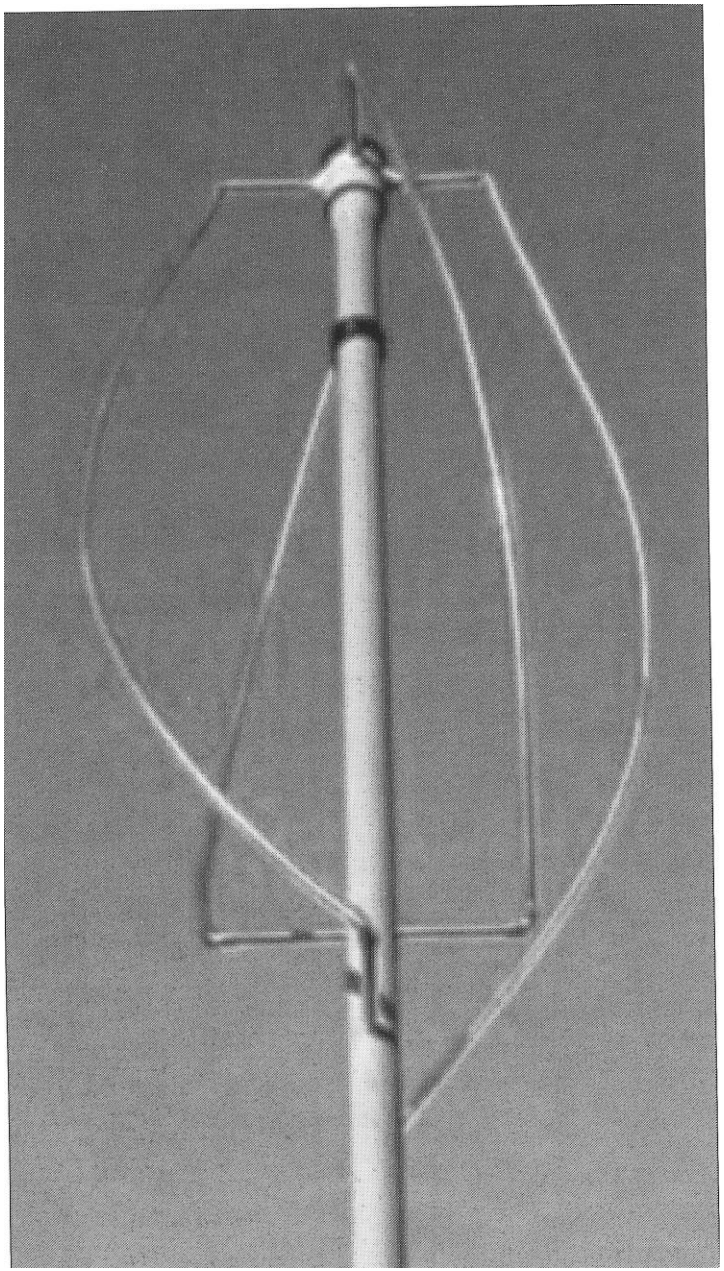
INVERTED V
~120° APEX ANGLE
AVERAGE IMPEDANCE 50 OHMS

V DIPOLE
~120° APEX ANGLE
AVERAGE IMPEDANCE 50 OHMS

FREQUENCY	ℓ_1	ℓ_2
29.5 MHz	15′ 11″	15′ 7″
146 MHz	38.0″	37.0″
435 MHz	12¾″	12½″

NOTE: 1. Lengths are approximate and based on #12 wire.
2. Actual input impedance depends on height and other factors.





Ideal Ground Station for LEOs

- Cross beam or circularly polarized Yagi or helical
- Computer tracking system
- Computer controlled AZ-EL rotators
- Full-duplex dual band radio computer controlled tuning
- TNC and Soundcard Interface for TLM and Packet
- APRS Software
- Mast mounted receiver preamps
  (Rule of thumb - it's better to have big ears than a big mouth.)

Photo courtesy of K6IA

ACTIVE SATELLITES - AS OF 1/16/2016

SATEL.	BEACON/TEL. FREQUENCY	MODE	UPLINK	DOWNLINK	MODE	REMARKS		
SO-50		FM	145.85 PL67	436.795	FM Rptr	PL 74.4 to open		
EO-80		FM	435.080 PL210.7	145.84	FM Rptr			
AO-85		FM	435.172 PL67	145.98	FM Rptr			
Lilacsat-2		FM	144.35	437.225	FM Rptr			
AO-7	145.7	CW	432.120-432.180	145.920-145.980	CW/SSB	INV		
FO-29	435.795	CW	145.900-146.00	435.800-435.900	CW/SSB	INV		
AO-73	145.935	BPSK	435.130-435.150	145.950-145.970	CW/SSB	INV		
EO-79			435.047-435.077	145.935-145.965	CW/SSB	INV		
Ukube-1			435.060-435.080	145.930-145.950	CW/SSB	INV		
XW-2A			435.030-435.050	145.665-145.685	CW/SSB	INV		
XW-2F			435.330-435.350	145.980-146.00	CW/SSB	INV		
ISS			144.49	145.8	FM			
			437.8	145.8	FM Rptr			