

# ■ **Beginners Guide to Amateur Satellites**

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In collaboration with

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**AMSAT-UK**



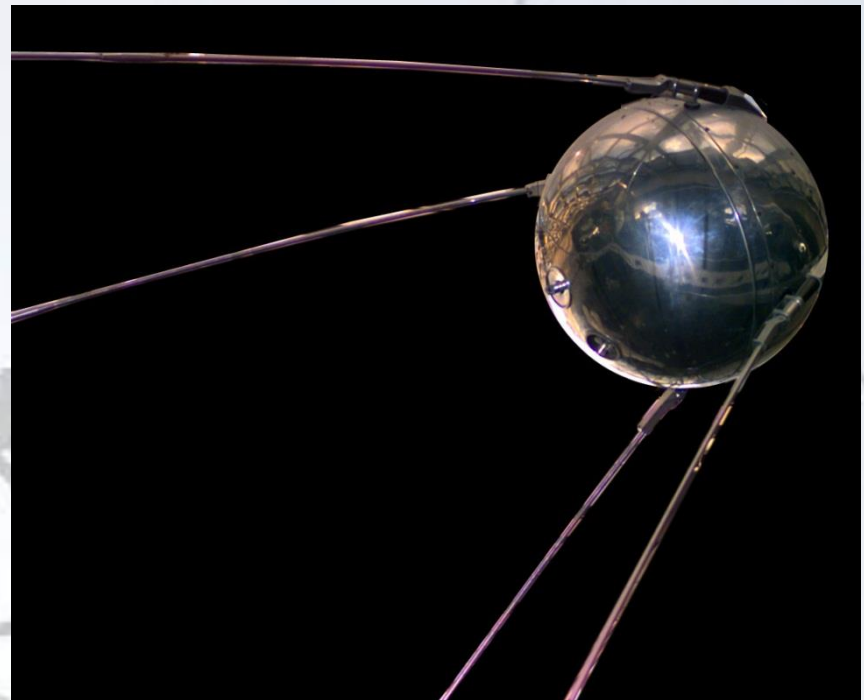
# ***Why Oscar?***

- 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
- AMSAT-OSCAR designations granted after launch



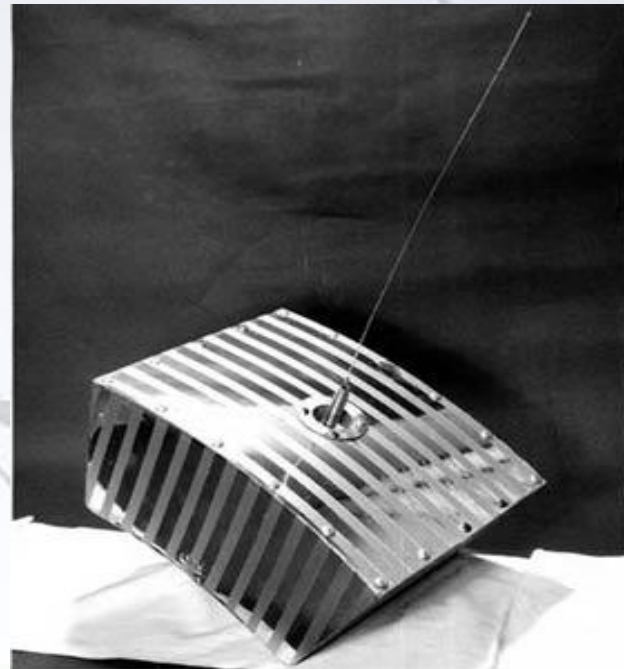
# ***A bit of History***

- Sputnik 1 was the world's first Earth-orbiting artificial satellite. Launched by the Soviet Union on October 4, 1957.



# *From small beginnings*

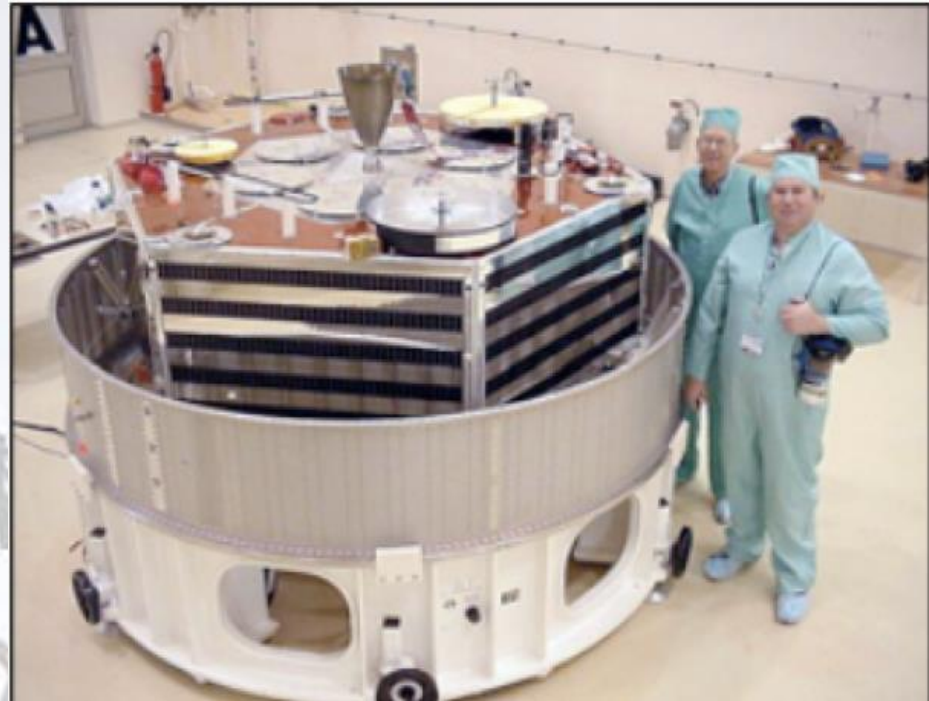
- OSCAR-I , which had a battery powered 140mw transmitter operating in the 2 meter band.
- Transmitted it's message of "HI" for three weeks and re-entered the atmosphere on January 31, 1962 after making 312 orbits.





# *To the very ambitious*

- OSCAR-40, a High Earth Orbit satellite with an apogee of 60,000 KM.
- A set of linear transponders, transmitting and receiving on selected frequencies.
- Data modes still in use today.
- Experiments included GPS for orbit determination.





# How Many Now?

Name	Transponder/Repeater active		Telemetry/Beacon only		No signal		Conflicting reports		ISS Crew (Voice) Active	
	Oct 3	Oct 2	Oct 1	Sep 30	Sep 29	Sep 28	Sep 27	Sep 26	Sep 25	Sep 24
CUTE-1										
UKube-1		1 1	2 11		1112 1	111				11
LilacSat-2			141132 1							
FS-3		1	12 1	1 21	1 11	1 1			1 1	1
[A] AO-7		1 1	1 1							
[B] AO-7	11	121123321	221123313111	3 13513 1	113342211				222143	
[B] UO-11		1 1	1 1	1 1	1 1	1			1	1
RS-15		2				2				
AO-27			1 2 1		1					
FO-29	43 3	42 31 37	122132 1 351	134 112521	143 2 151	441 371				
XW-2A	3 1	121 11 1	1 21 13	1 2 131 1	111 132	1 2 24				
XW-2B	11	141 1	1 133 11111	212 1 11	111 112	1122 1				
XW-2C	11	313 1	1 212 1121	12 12 11	211 11	12 1 1				
XW-2D	11	132 2	2 21 11 1 11	11 1 11	11 1 1	2 3				
XW-2F	21 1	13 12	11 22 11 1 11	111 1111	31 1121	122 1 1				
CAS-2T		1	11		1					1
NO-44			11							
CAS-4A	1	1	1 1	11	11	1				
CAS-4B	11	1 1	12 1	11	11	1				
SO-50	4	11124221 2	12172 12	421241	11 2421 1	22232 1				
AO-73	2 1	111 21 1	1 211242	1 2121 14	111 12 1132 1	12 11 1				1
EO-79			1 1							
AO-85		113	11 21	1 21 1 1 11		132				3
IO-86	1111	1111112	111 11	1 1 111	11121111	11111211				
EO-88	1	1 1 12	1 11 111	1 3111 1	1 11 111	1 11 2 1				
LO-90			1			1				
AO-98										1
Delfi-C3		1	1	1 1	1 1	1 1			1 1	
ISS-FM						1				
NO-84 Digi	1	13	1 311	3 2 1	114	1				1
NO-84 PSK										1
ISS-DATA		1 32	1212	11 241	1 1 11	2 261				



Info from <http://www.amsat.org/status/>

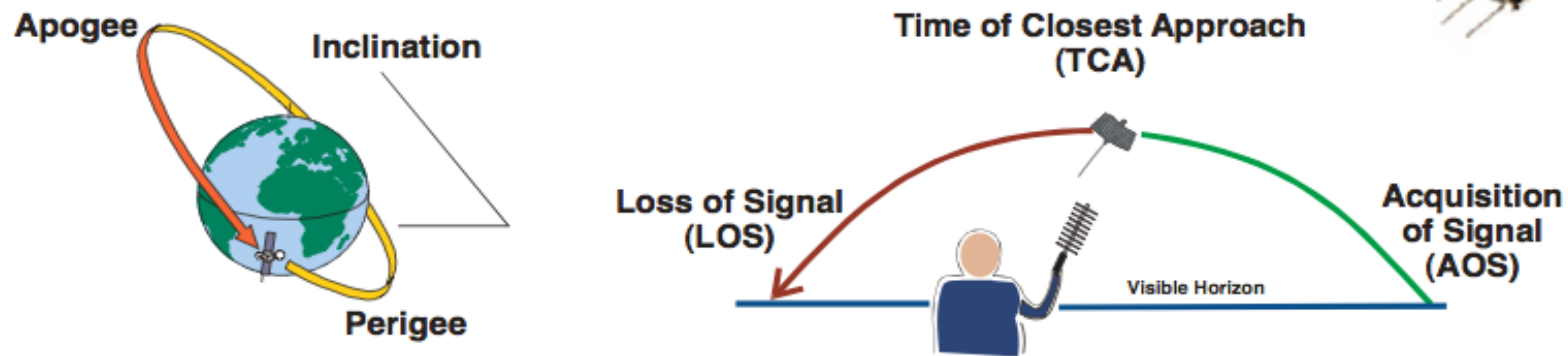
# *Some important terms*



<b>Orbit</b>	⇒	The <b>path</b> a satellite travels around the earth
<b>Doppler</b>	⇒	A <b>shift</b> in frequency caused by satellite motion
<b>LEO</b>	⇒	A satellite in <b>Low Earth Orbit</b> (400-2000km)
<b>HEO</b>	⇒	A satellite in a <b>High Earth Orbit</b> ( > 20,000km)
<b>GEO</b>	⇒	A satellite in a <b>Geosynchronous orbit</b> (35,680km)
<b>Uplink</b>	⇒	The frequency used to <b>transmit</b> to a satellite
<b>Downlink</b>	⇒	The frequency used to <b>receive</b> a satellite
<b>Footprint</b>	⇒	A circular area where the satellite is <b>line of sight</b>
<b>Apogee</b>		When the satellite is at it's <b>highest</b> altitude
<b>Perigee</b>		When the satellite is at it's <b>lowest</b> altitude
<b>Inclination</b>		The <b>angle</b> of the satellite where equator = zero



# Satellite Orbit Tracks



- Artificial satellites travel in an arc determined by height, eccentricity, and inclination.
- **Inclination** can range from  $0^\circ$  (equatorial) to  $90^\circ$  (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



# *Low Earth Orbit (LEO)*

- LEOs are satellites that are orbiting the earth from 400 to 2000 KM altitude
- Pass times range from 12 to 22 minutes
- Linear transponder (SSB/CW) or FM repeater
- Typically operate in the 2m / 70cm bands
- Polar / high inclination orbit



SO - 50

# *Inclined Orbit*



- Circular orbit that is equally inclined in northern and southern hemispheres
- Spends most of the time in sun at some times, and most in eclipse at other times.
- Batteries required when in eclipse
- All parts of planet receive equal access

SO-41, SO-50, RS-15, ISS



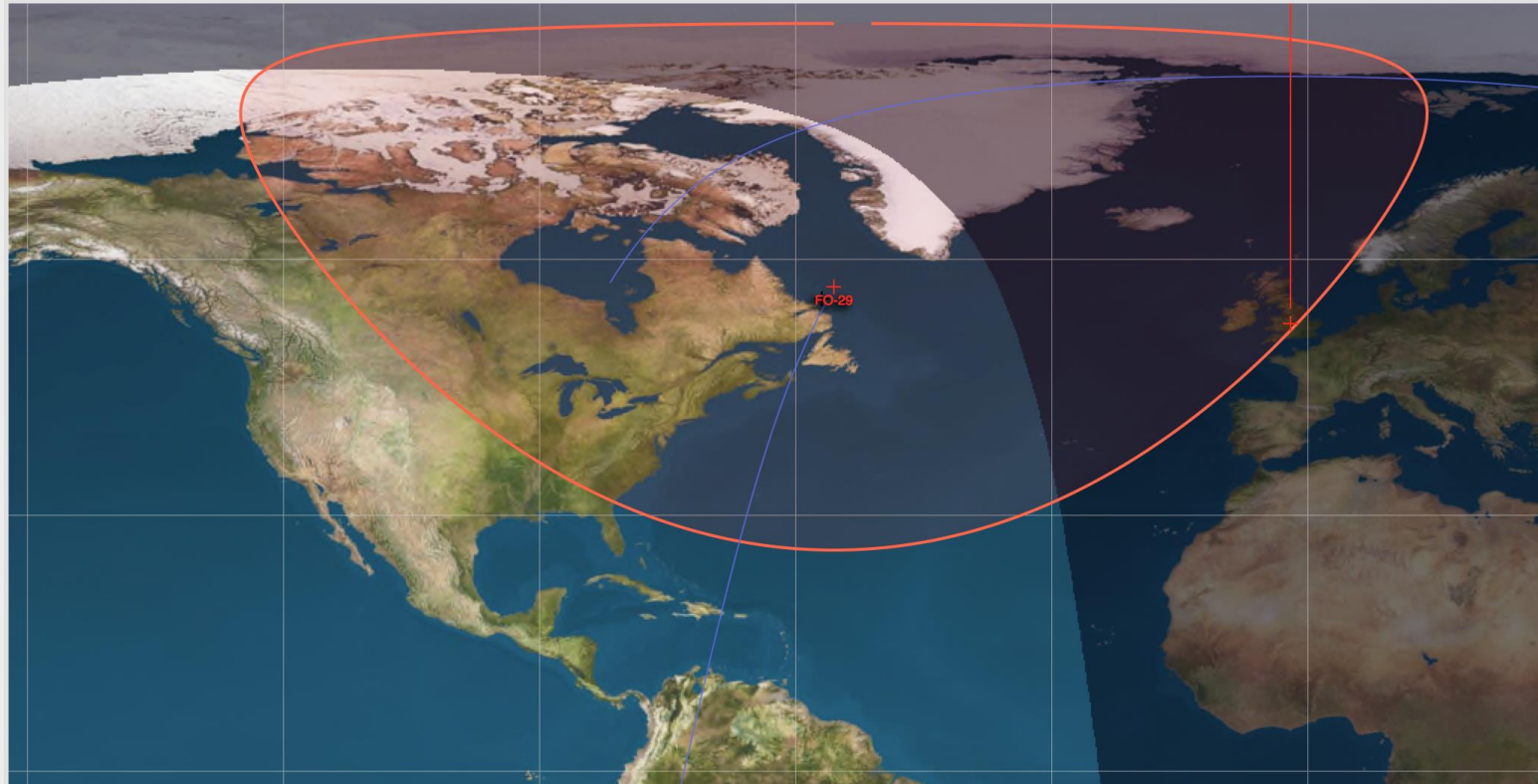
# Satellite Coverage

Next: 00:00:00 Length: 00:00:21 Elev: 0.6

Path Loss: 156.8dB G4DPZ v2.25

2D 3D

Follow Sat  Track List



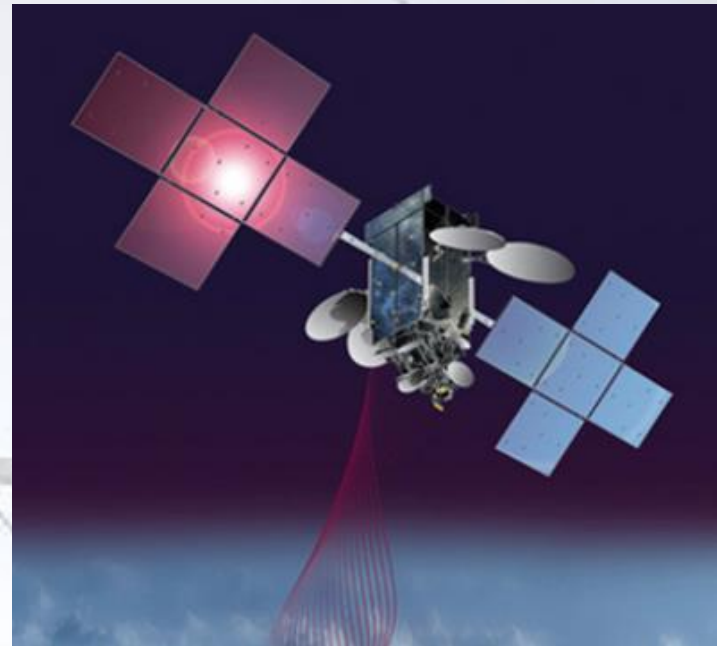
+05:59 2017/10/13 02 21 27 Europe/London





# ***GEO***

In conjunction with AMSAT-DL, Qatar's Es'hail 2 satellite will provide the first amateur radio geostationary communications that could link amateurs from Brazil to Thailand. The satellite is expected to launch in the 3rd quarter of 2017 and will be positioned at 25.5 degrees East.

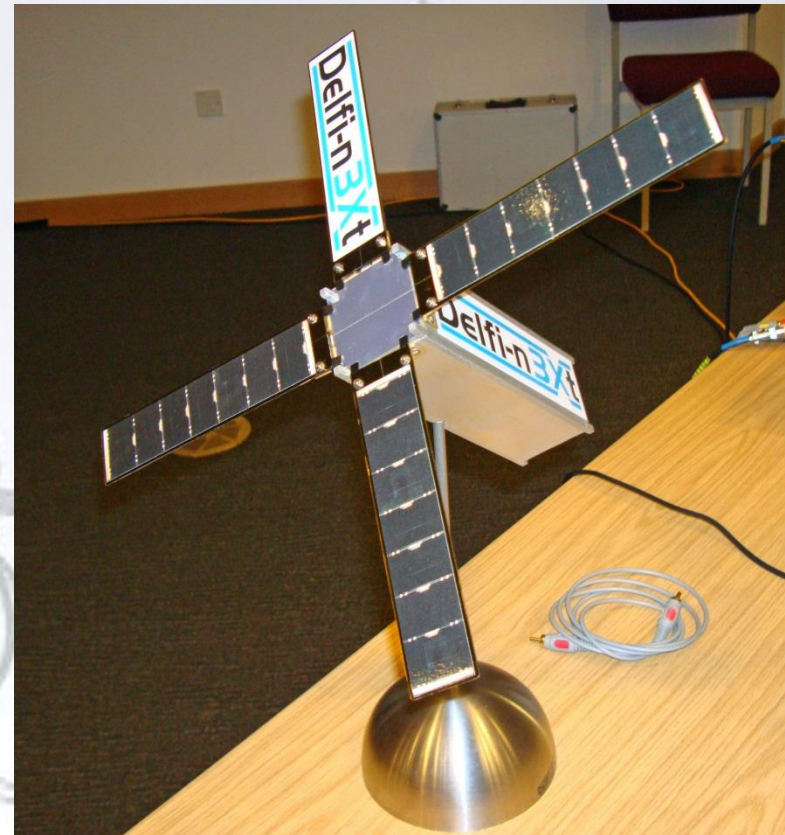


[AMSAT-UK Link](#)



# *CubeSats*

- Based on a 10cm cube but some can be a bit bigger
- Operate in Amateur Satellite allocation
- AX-25 protocol & others
- [Funcube](#) [BBC](#)
- [Launch](#)
- [Celebration](#)





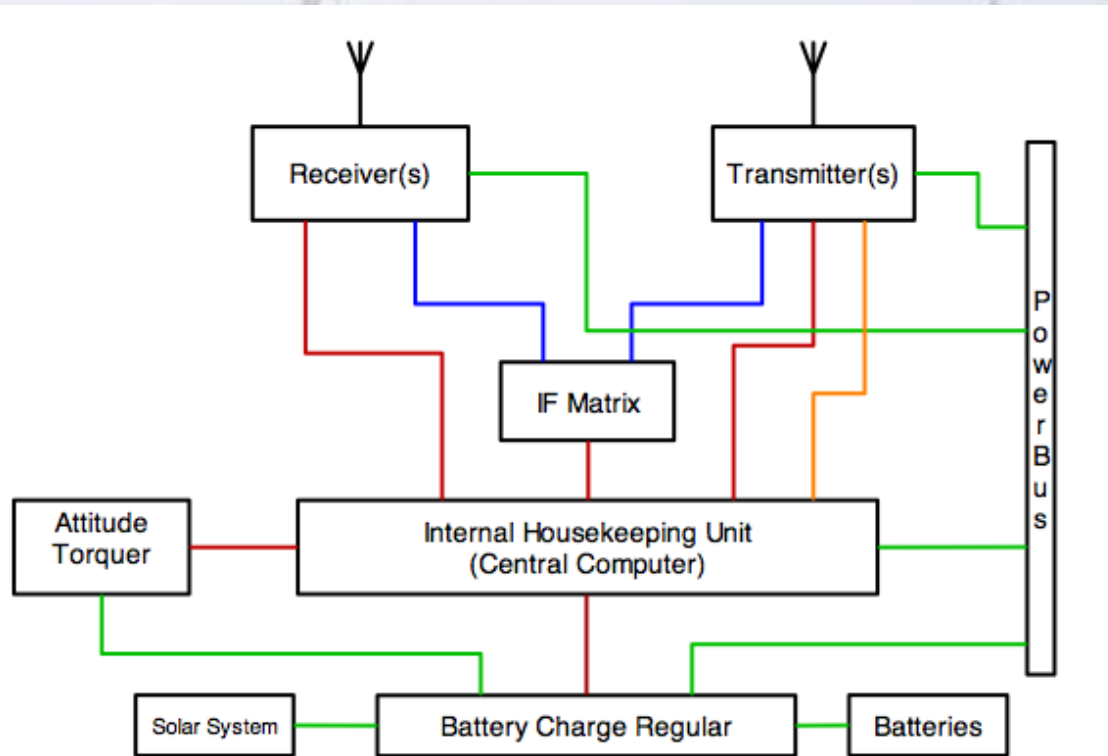
# *Student Satellites*

- PCSAT 1
- US Naval Academy Aerospace student project
- APRS protocol
- note the antennas!



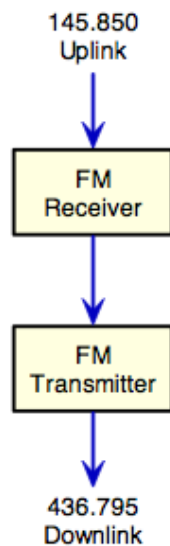


# *How is a Satellite Designed*

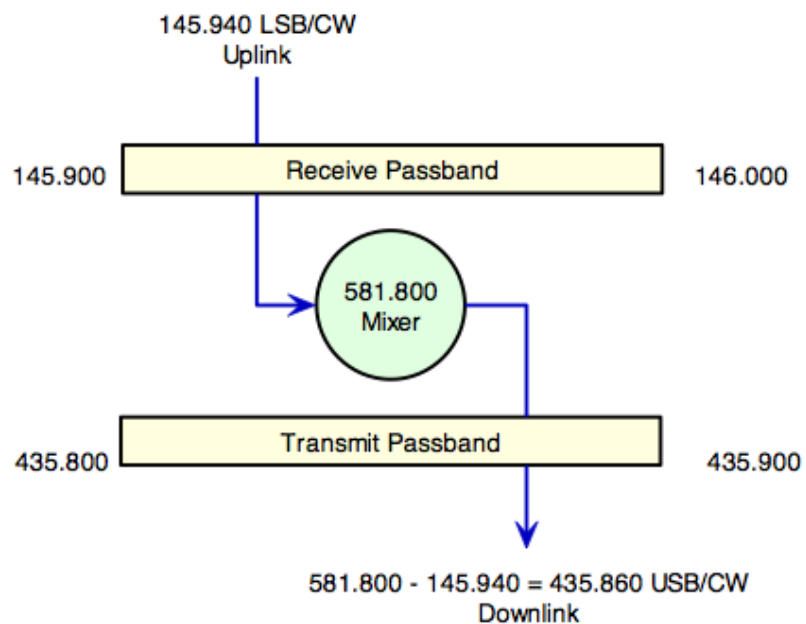


# FM v Linear Transponder

Single Channel NFM Repeater

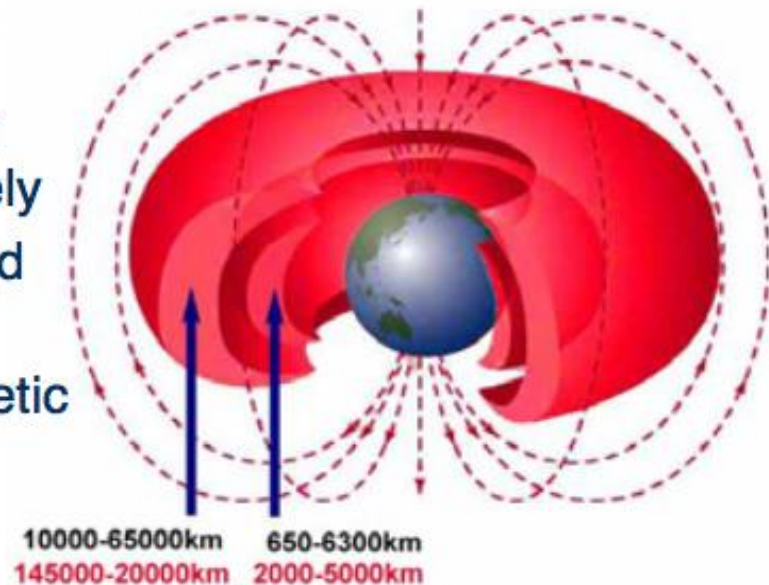


100 KHz Wide Linear Transponder



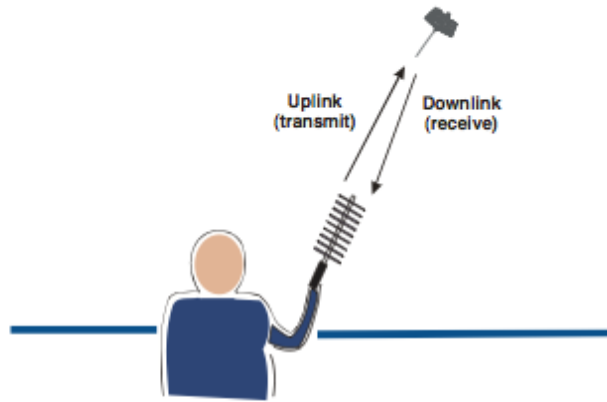
# *Threats to Satellites*

- The Van Allen belts are regions of protons and electrons, held captive by the magnetic influence of the Earth
- Radiation is concentrated and closest to the earth at the poles (aurora)
- Satellite orbits are designed to spend as little time as possible in the belts or avoid them completely
- Satellites that travel in and around the belts may be damaged
- Levels change because of magnetic storms, nuclear explosions





# Operating a Satellite



## Traditional LEO Modes:

Mode A = 10m/2m

Mode B = 2m/70cm

Mode J = 70cm/2m

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

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

V=2m

U=70cm

L=23cm

S=13cm

C=7.5cm

X=3cm

K=1.5cm

Q=5mm

# ***Ground Station Equipment***

- Antennas (rotators)
- Preamps (and phase switches)
- Radios
- Tracking Software

# *Antennas*

- Handheld antennas:
- Good for portable ops (and SOTA)
- Commercial Arrow Antennas



Delfi-C3 transponder enabled



# *Antennas*

- Handheld antennas:  
Elk/Arrow
- DIY out of available materials
- You will generally need a Mux



# *Antennas*

- Extreme portable!:
- Howard Long,  
G6LVB
- Used on AO-40 very  
successfully





# *Antennas*

## Fixed Station:

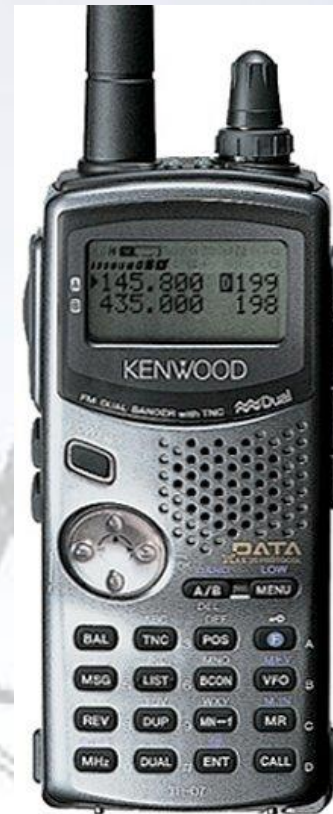
- Wimo X antennas
- Yaesu G5500 rotator
- Homebrew dish with modified LNB





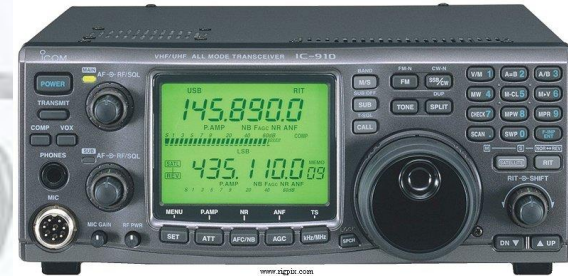
# *Handheld Transceiver*

- The minimum you need to operate.
- Dual Band
- Full Duplex
- CTCSS



# Base Station

- FT-847
- TS2000
- IC-910
- IC-9100
- *FT-736r*
- *IC-9700 (SDR)*





# *Paired Devices*

- FT-817
- SSB VHF/UHF
- Manual tuning for doppler but it works really well...



Image c/o Ivo, PA1IVO



Drew, KO4MA at AMSAT  
Colloquium 2016



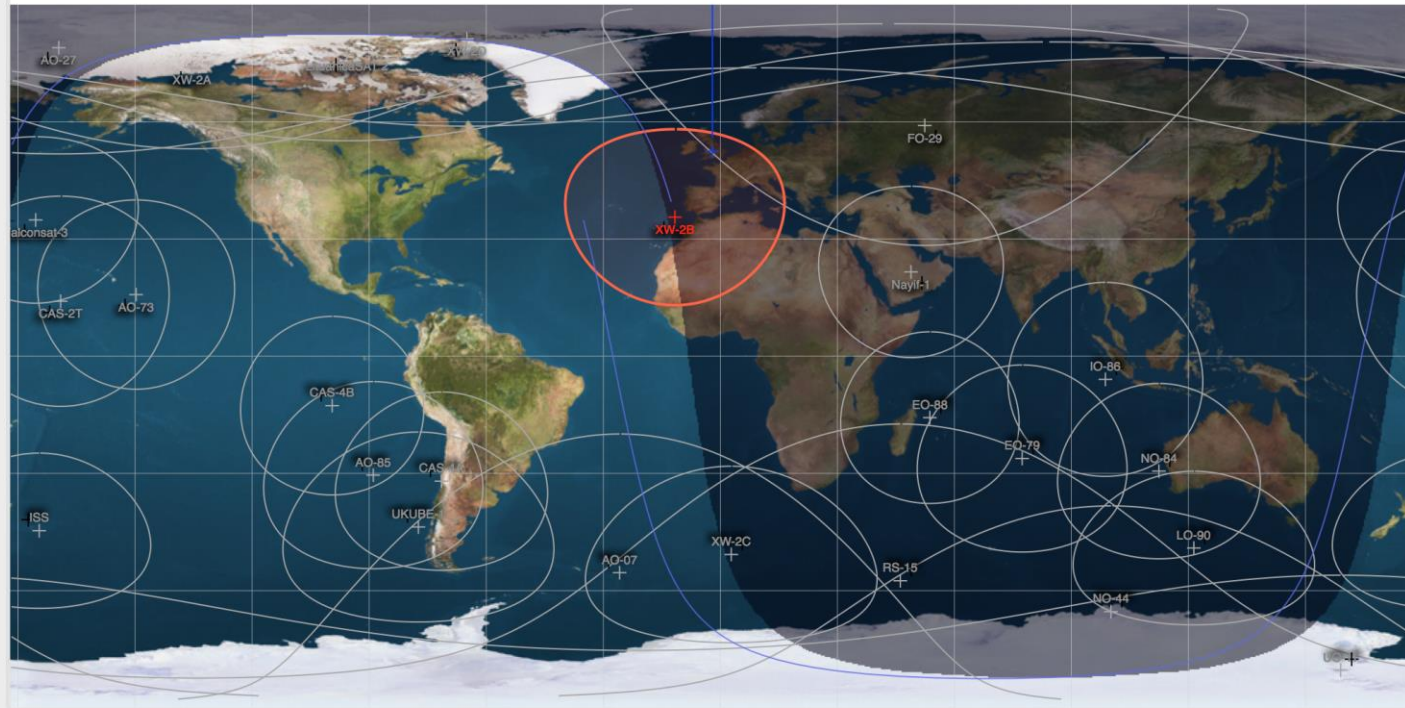
# Tracking Software

Next: 00:00:00 Length: 00:09:42 Elev: 5.2

Path Loss: 57.9dB G4DPZ v2.25

2D 3D

Follow Sat  Track List



2017/10/12 19:14:52 Europe/London

Track List Horizon

Add Satellite   Track List

Satellite	P	Next Pass	Rise	Length	Azimuth	Elevation	...	Ma...	Latitude	Longitu...	A
<input checked="" type="checkbox"/> XW-2B	5	00:00:00	19:14:52	00:09:43	205.94	5.15	+	22.4	35.54	-11.63	
<input checked="" type="checkbox"/> FO-29	7	00:00:00	19:14:50	00:04:29	55.46	0.47	+	1.1	59.05	52.40	
<input checked="" type="checkbox"/> Nayif-1	1	00:10:19	19:25:05	00:02:56	108.49	-20.22	+	0.7	21.19	48.96	
<input checked="" type="checkbox"/> EO-88	5	00:18:57	19:33:47	00:04:35	126.65	-39.25	+	1.9	-15.72	53.71	
<input checked="" type="checkbox"/> XW-2C	5	00:22:14	19:37:02	00:10:05	176.85	-49.88	+	13.6	-50.75	2.81	
<input checked="" type="checkbox"/> AO-85	4	00:25:21	19:40:10	00:11:21	248.31	-54.22	+	16.7	-30.45	-88.95	
<input checked="" type="checkbox"/> UO-11	5	00:34:47	19:49:34	00:12:25	173.43	-75.11	+	31.0	-80.37	159.01	
<input checked="" type="checkbox"/> ISS	4	00:40:53	19:55:44	00:09:53	325.43	-85.17	+	20.5	-44.67	-174.56	

Radio Rotators

Radio Enabled XW-2B

Downlink: 435.852.00 Uplink: 145.950.00

**435.860.74** **145.947.07**

0.000.00  0.000.00

VFO's Locked  Non-Inverting Transponder

Full Doppler  Beacon MODE\_JA

New



# Tracking Software

## Proprietary Tracking Software For Purchase

MacDoppler	Mac OS 10.4 10.5	Dog Park Software
SatPC32	Windows	DK1TB
SCRAP	Windows	Bytheway SDL
InstantTrack	DOS	Paul Williamson, KB5MU

## Shareware or Open Source

Nova for Windows	Windows	Northern Lights Software Assoc.
Orbitron	Windows	Sebastian Stoff
Predict	OS X, Linux & Windows	John A. Magliacane, KD2BD
PortablePredict+	OS X, Linux & Windows	John A. Magliacane, KD2BD
PetitTrack	Embedded Linux	Edson Pereira, N1VTN
PocketSat+	PalmOS, WindowsCE 3.0	Big Fat Tail Productions
SatExplorer	Windows	Gabriel Rivat F6DQM
Gpredict	OS X, Linux & Windows	Alexandru Csete, OZ9AEC
Pass	Linux, Mac, Windows, PalmOS, WindowsCE, Android, Iphone, IPad	Pedro Converso, LU7ABF & AMSAT-Argentina



<http://www.amsat.org/amsat-new/tools/software.php>



# *Other Resources*

## Web Sites (not a complete list, Google is your friend)

AMSAT-DL	<a href="https://www.amsat-dl.org/">https://www.amsat-dl.org/</a>
AMSAT-NA	<a href="https://www.amsat.org/">https://www.amsat.org/</a>
AMSAT-UK	<a href="https://amsat-uk.org/">https://amsat-uk.org/</a>
DK3WN	<a href="http://www.dk3wn.info/satellites.shtml">http://www.dk3wn.info/satellites.shtml</a>
Heavens-Above	<a href="http://www.heavens-above.com/">http://www.heavens-above.com/</a>
N2YO	<a href="http://www.n2yo.com/">http://www.n2yo.com/</a>

## Mobile Applications (these target Amateur, CubeSat, ISS & Weather)

AMSATDroid Free	G4DPZ	Android	<a href="https://play.google.com">https://play.google.com</a>
GoSatWatch	gosoftworks	iOS	<a href="https://itunes.apple.com">https://itunes.apple.com</a>





# ■ Find out more...

**AMSAT-UK: [www.amsat-uk.org](http://www.amsat-uk.org)**

**RSGB: [www.rsgb.org](http://www.rsgb.org)**

**Email: [dave@g4dpz.me.uk](mailto:dave@g4dpz.me.uk)**

**Twitter: [@g4dpz](https://twitter.com/g4dpz)**

