Ham Radio Satellites

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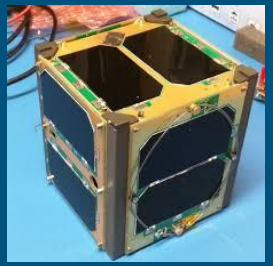
What we are going to cover?

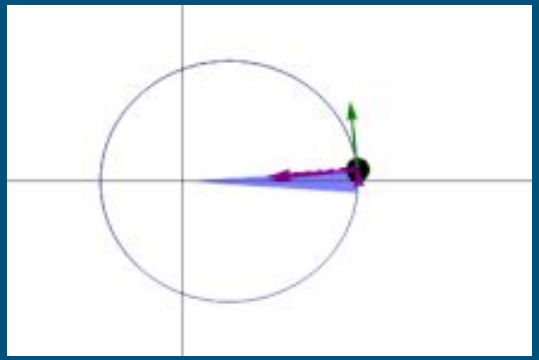
Kepler Laws of planetary motion
Types of Orbits (LEO, MEO, GEO & GSO)
Satellite modes
FM Repeaters vs Linear Transponders
Doppler shift
Terminology
What do we need to work the birds? (Tx/Rx, Antenna, Software)
AMSAT
The QSO
ISS
Tips



Kepler Laws of planetary motion

The 2nd law describes the speed of a planet traveling in an elliptical orbit around the sun. It states that a line between the sun and the planet sweeps equal areas in equal times. Thus, the speed of the planet increases as it nears the sun and decreases as it recedes from the sun.

Johannes Kepler (1571 - 1630)

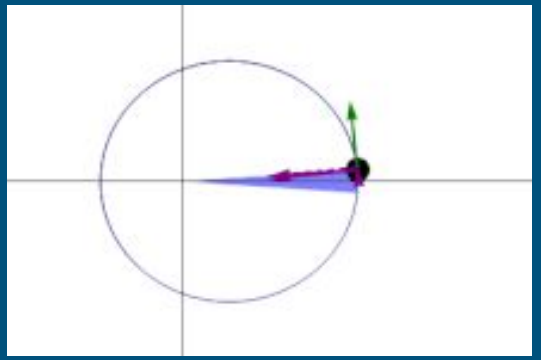


Kepler Laws of planetary motion

In other words:

With the TLEs (two line elements), and your station location, you can compute when the satellite will be in view and where to point your antennas

Johannes Kepler (1571 - 1630)



Types of Orbits

LEO - Low Earth Orbit (160 to 2000 km)

MEO - Medium Earth Orbits (2000 to 35785 km)

GEO - Geostationary orbit (35786 km)

GSO - Geosynchronous Orbit (35786 km)

Polar orbits - Earth observations (200 - 1000 km)

Types of Orbits

LEO - Low Earth Orbit (160 to 2000 km)

Smaller satellite, Orbit is close to the earth.

The rockets that launch them are smaller and cheaper.

We need many to cover a specific area on Earth.

We need more frequencies to avoid interfering with each other

Orbital period of 90 minutes.

Great for mobile communications as it has low latency (constellation)

Types of Orbits

MEO - Medium Earth Orbits (2000 to 35785 km)

We still need many to cover a specific area on Earth.

Common use is for positioning information (GPS)

GPS satellites are at 22000 km - give orbital period of 12 hours.

Satellites are bigger, need to transmit with more power for a stronger signal.

More latency.

Still need constellation

Types of Orbits

GSO - Geosynchronous Orbit (35786 km)

Takes exactly one day to complete an orbit

The satellite will return to the exact same position in the sky after one day

It can go with or against Earth’s direction

Communicating back and forth with spacecraft (like the Hubble Space Telescope and space shuttles)

Types of Orbits

GEO - Geostationary Equatorial Orbit (35786 km)

The satellite ALWAYS appears stationary above the same point on Earth

The satellite's orbit is ALWAYS above the Equator

The ground station antennas don’t have to move to track the satellite position

Less interference from obstacles on Earth

Types of Orbits

Polar orbits - Earth observations (200 - 1000 km)

The satellite passes over the Earth’s polar regions from North to South

Passes < 30 degrees of the poles considered as polar orbit

Demonstration

Orbits

Meet OSCAR

OSCAR = “Orbiting Satellite Carrying Amateur Radio”

The designation is assigned by AMSAT (Amateur Radio Satellite Organization)

Currently 18 are active!

Can be used free of charge for Licensed Amateur Radio

Operate for Voice (FM, SSB), Data (Packet, APRS).

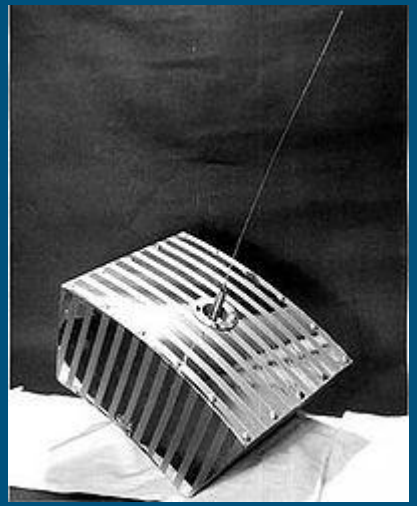
Act as “Repeaters,” “Linear Transponders,” digital “Store and Forward”

Meet OSCAR - trivia...

The first Amateur Satellite named OSCAR 1

Launched on December 12, 1961

Was in orbit only…. 22 days



FM Repeaters

Like a standard repeater that works on a fixed frequency to receive the signal (Uplink) and a fixed frequency to transmit the signal (Downlink).

SO-50, AO-91, AO-92

Linear Transponders

Repeaters that work on a range on frequencies instead of a fixed frequency.

They receive a wide bandwidth and add a set frequency offset to the received signal.

Example:

Assume that our transponder receive range is 145 to 145.5 Mhz.

If a signal is received at 145.2 Mhz, it would translate up to 435.2 Mhz.

If a signal is received at 145.4 Mhz, it would translate up to 435.4 Mhz.

Linear Transponders - continue

Most Linear transponders are used for SSB and CW.

They knows as “Inverting Transponders.”

We transmit LSB (Uplink), it is changed, and we receive USB (Downlink)

We must use as least power as possible as the power is shared between all stations on the bandwidth, and to avoid reducing the downlink power.

AO-73, FO-29, OSCAR-7

Store and Forward digital relay

We can upload a message on one side of the world, and download the message once the satellite travels to the other side of the world.

Expensive & hard to maintain

OSCAR-7 - Used to repeat CW transmissions (18WPM)

FO-29 - Worked like a BBS

Satellites modes

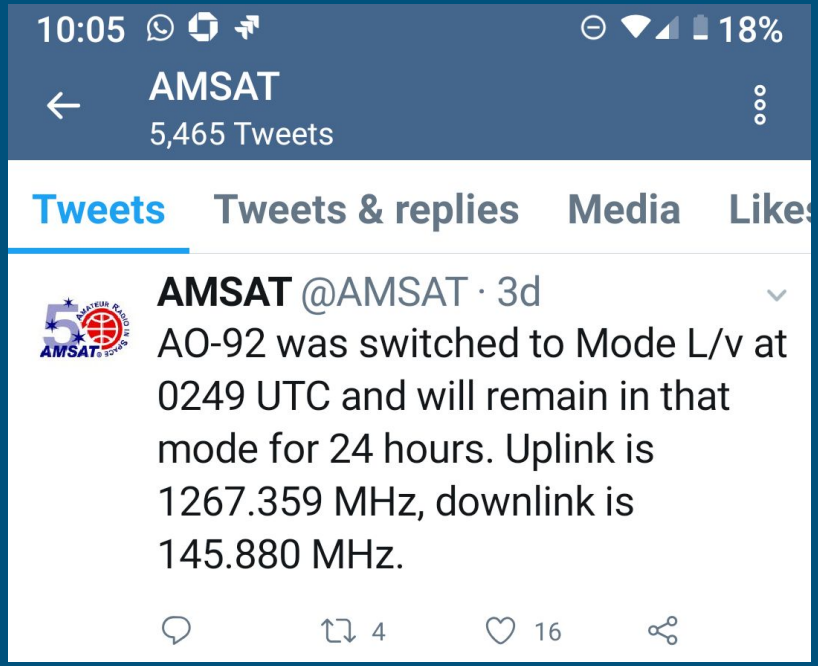
OSCAR uplink (transmit to) and downlink (receive from) frequencies use sets of paired letters following the structure X/Y where X is the uplink band and Y is the downlink band.

Designator	H	A	V	U	L	S	S2	C	X	K	R
Band	15 m	10 m	2 m	70 cm	23 cm	13 cm	9 cm	5 cm	3 cm	1.2 cm	6 mm
Frequency (General)	21 MHz	29 MHz	145 MHz	435 MHz	1.2 GHz	2.4 GHz	3.4 GHz	5 GHz	10 GHz	24 GHz	47 GHz

Satellites modes - continued

Mode (old)	Mode (new)	Uplink	Downlink
K		21 MHz	29 MHz
T		21 MHz	145 MHz
A		145 MHz	29 MHz
J	VU	145 MHz	435 MHz
B	UV	435 MHz	145 MHz
S	US	435 MHz	2400 MHz
L	LU	1268 MHz	435 MHz
	LS	1268 MHz	2400 MHz
	LX	1268 MHZ	10450 MHz
	VS	145 MHz	2400 MHz

Satellites modes - continued



Doppler shift

“The change in frequency or wavelength of a wave for an observer who is moving relative to the wave source.”

Doppler Shift is experienced as the satellite (wave source) is moving relative to you, the observer (or receiver) of the transmitted wavelength.

We are getting Upward shift in frequency when the wave source is approaching.

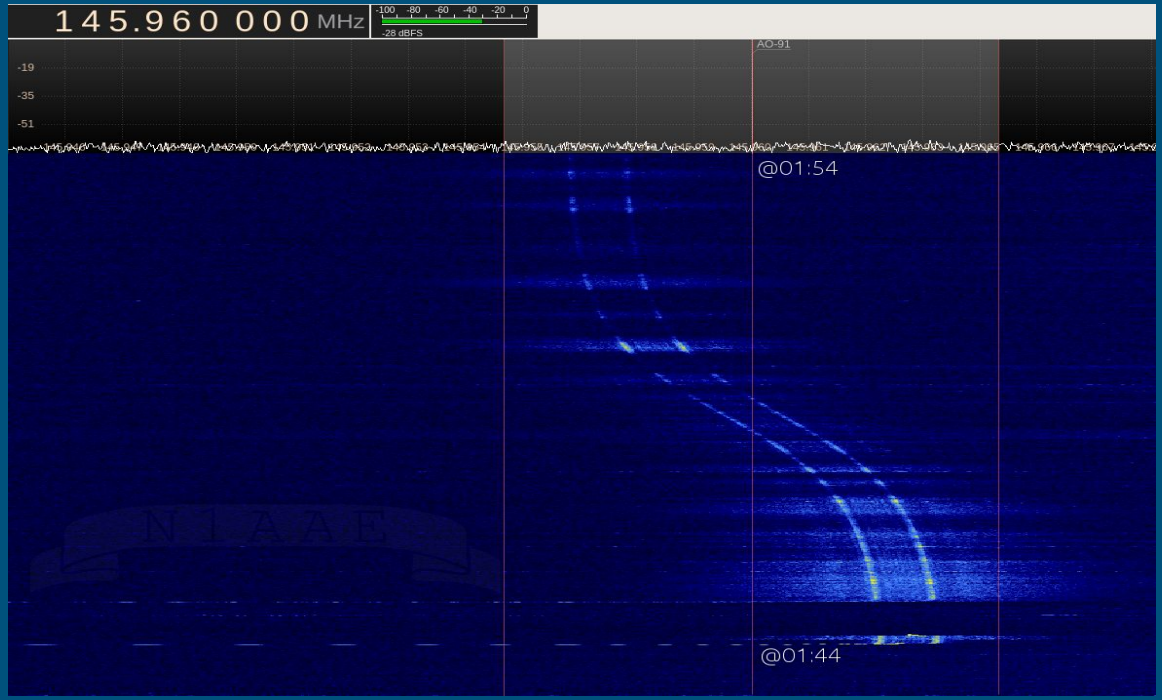
We are getting Downward shift in frequency when the wave source is retreating.

Christian Doppler (1803 - 1853)

Doppler shift - continued

AO-91 Doppler Shift Correction		
Memory	**TX Frequency (w/ 67 Hz Tone)**	**RX 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

Doppler shift - continued

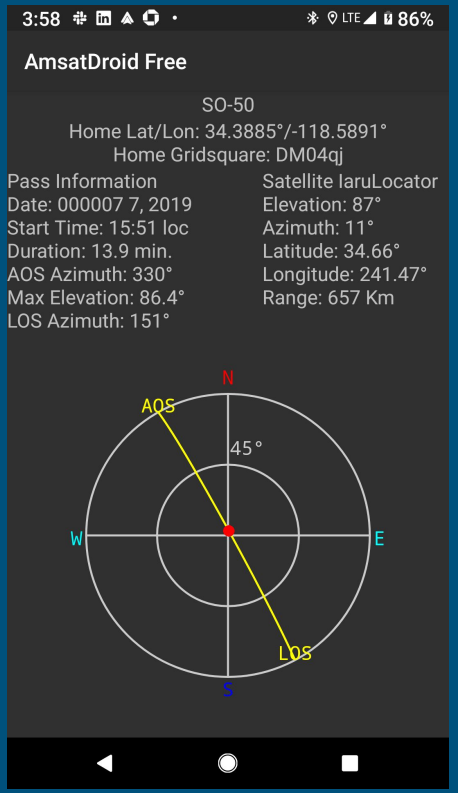


Terminology

AOS (Acquisition of Signal) - The time that a satellite rises above the horizon of an observer

TCA (Time of Closest Approach) - The time when the satellite is closest to the observer and when Doppler shift is zero. This usually corresponds to the time that the satellite reaches maximum elevation above the horizon.

LOS (Loss of Signal) - The time that a satellite passes below the observer's horizon.



Demonstration

Terminology

What do I need to work the birds?

Transceivers

FM - Dual band transceiver with crossband transmit/receive capabilities or separate 2m and 70cm FM transceivers are suitable.

Linear Transponders -

SSB and CW transceivers on the bands of interest are required.

The suggested bands to try for a first attempt are 2m uplink/10m downlink. If you have 2 HF transceivers, it might be worth trying the 10m/15m satellites as well.

Transceivers - continued

BaoFeng UV-5R Dual Band Two Way Radio (Black)

3,532

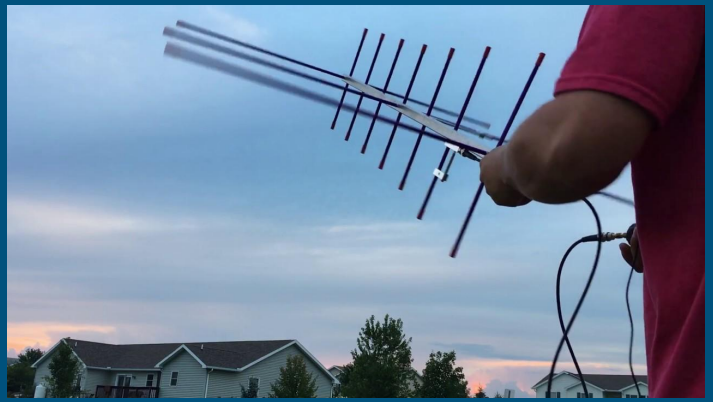
$23.51

$21.49 with quantity discounts

prime FREE Delivery Fri, Jul 19

IC-9700

Antenna types



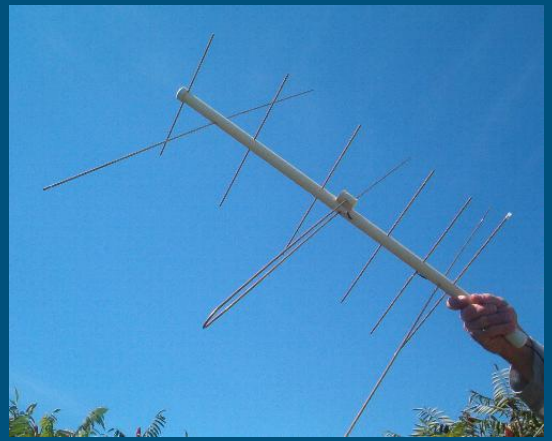
Arrow

Antenna types

Antenna types

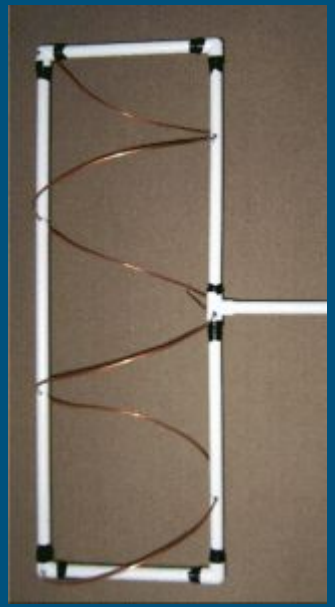
2 or 3 axis rotor

Antenna types - continued



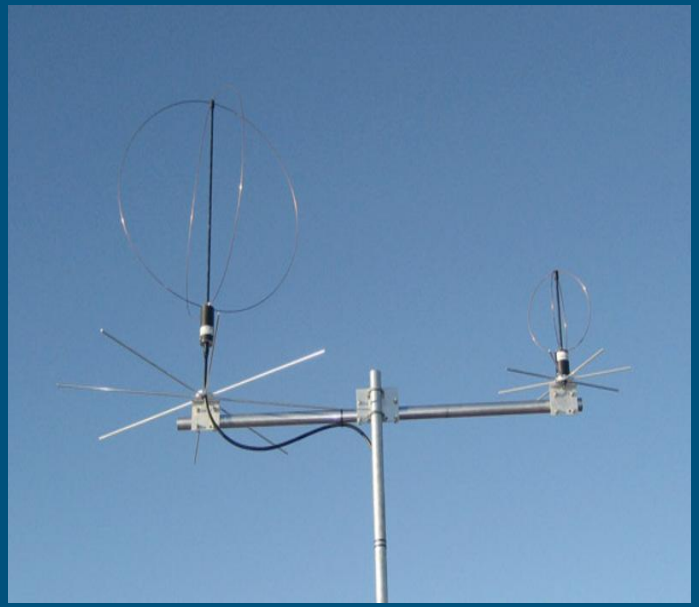
Homemade

Antenna types - continued



Helical/Helix - circularly polarized

Antenna types - continued



Eggbeater

Software

Linux - GPredict, SatTrack

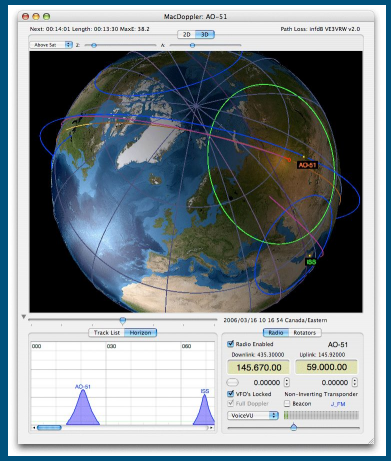
Windows - Nova, HRD, Orbitron, SatPC32

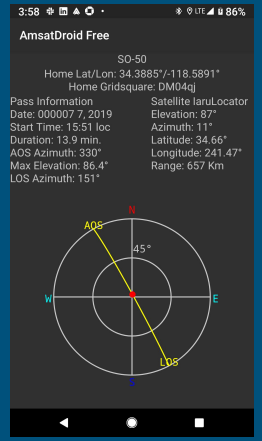
Mac - MacDoppler

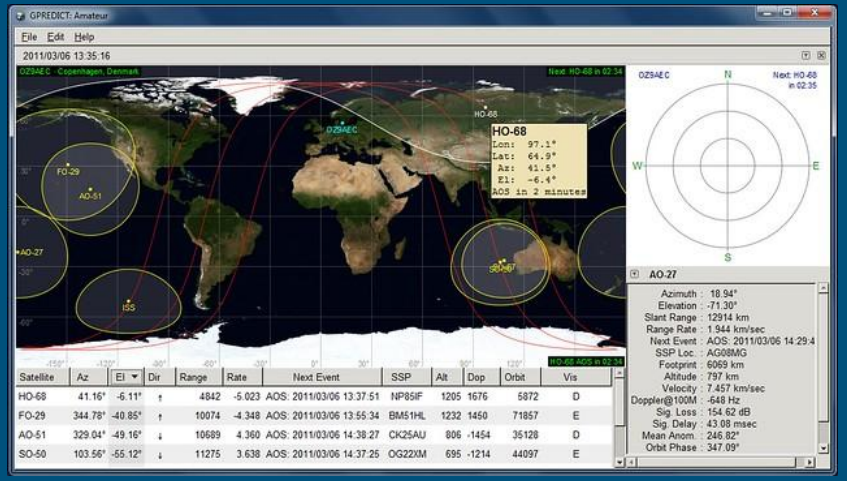
Android - AmsatDroid, Heavens Above

iPhone - SatSat, HamSat

Java - JSatTrak



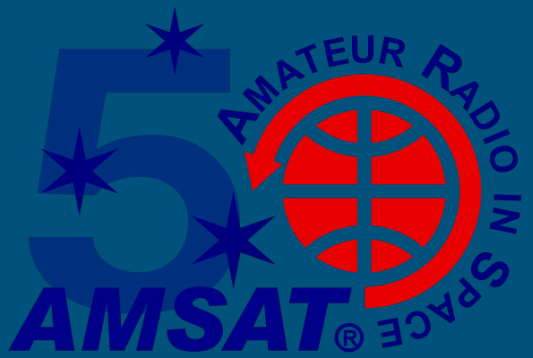


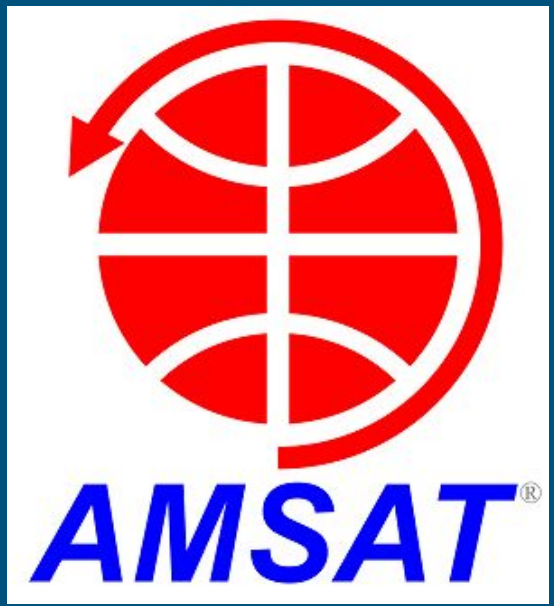


AMSAT

Radio Amateur Satellite Corporation

www.amsat.org





The QSO

How to?

The QSO

Preparations:

Check the time of the pass, AOS, LOS, Elevation

Find a place where you have an unobstructed view of the horizon.

Know how to adjust the 70cm(and above) frequency for the Doppler shift.

During the pass:

Open the Squelch

Adjust the position of the antenna for the best reception (polarity!!)

Short QSO - Remember that many hams are waiting!

Do not transmit if you can’t hear the satellite!

The QSO - example

W6JW: “W6JW, DM04”

W1AW: “W6JW, this is W1AW, FN31, Connecticut, QSL?”

W6JW: “W1AW FN31, Thanks. Echo DM04, California, QSL?”

W1AW: “QSL DM04. Thank you, 73”

W6JW: “QSL, Thank you, 73”

Demonstration

Click to watch the QSO

https://youtu.be/HBiF8S5cLqE

ISS - International Space Station

- USA: NA1SS
- Russian: RS0ISS
- European: DP0ISS, OR4ISS, IR0ISS

Kenwood D700

Astronaut Reid Wiseman, KF5LKT makes personal contacts with hams during the US Field Day exercise in June 2014

Tips

Tips

Software - First step, Set you home location/Grid!!!

Your first QSO? Try high angles, late night, early morning

Pro? Try lower angles for long distance QSOs

Remember only a single QSO can be made at a time

Doppler - set channels/memories in HT

Record your QSOs - if one hand is holding the HT and the other the antenna

Do we actually need a 2 or 3 axis rotor?

LoTW - Hams are waiting for the confirmation…

Twitter - follow AMSAT, ISS...

See you on the Birds...

Thank you & 73!