A presentation by Greg Mitchell, KB1AWM

OSCAR

Orbiting Satellite Carrying Amateur Radio

Introduction

- First OSCAR (*OSCAR-1*) was lunched in 1961, just 4 years after *Sputnik*
- Over 100 OSCARs have been launched since as well as other amateur radio satellites that do not carry the OSCAR name.
- First FM OSCAR was launched in 1990.
- AMSAT was formed in 1969 and is the torch-bearer for amateur radio in space.
    - You can join AMSAT with an annual membership which includes a print copy of their magazine as well as discounts on related products (such as the SatPC32 tracking software).

Satellite Facts

- Power levels are typically 200mW - 1W, occasionally higher.
- The smallest cubesats now are 10x10x10cm plus whip antennas.
- Satellites typically contain a beacon, usually CW but occasionally FSK, the beacon transmits the name of the satellite as well as some telemetry.
- Uplink (earth to satellite) and downlink (satellite to earth) occur on different bands. The four most common satellite bands are 70cm (U), 2m (V), 23cm (L) and 10m (A). Many other bands are used, however.
- Most are in LEO (low-earth orbit), historically some have been in HEO and currently Europse/Africa/West Asia has a geostationary satellite in HEO.

Kinds of “Birds”

- Linear Transponder
- FM
- Digital:
  - Telemetry
  - APRS
  - SSTV
  - D-ATV
  - etc....

Linear Transponder “Birds”

- Have an entire bandpass that is passed through the satellite, typically 25 - 100khz.
- RF on the uplink band is converted to IF, run through and bandpass filter and then converted back to RF on the downlink band.
- Because of the wide band, many QSOs can occur simultaneously.
- Ragchew
- Typically used for CW/SSB
- Power resources are shared and proportional to the input power, so don’t use too much power accessing it!
- More difficult to tune doppler-shift.

FM “Birds”

- Repeater in the sky
- Uses CTCSS tones to access
- 1 QSO at a time, so keep them short, typically exchange callsigns and grid squares
- Less susceptible to doppler shift

Digital “Birds”

- I have no experience with these
- You can receive the *ISS* sstv images using any receiver and antenna.
  - Use SSTV app on your cell phone
  - Hold the phone near the radio speaker during the ISS pass

Awards

- VUCC Satellite
  - Confirm contact with 100 different grid squares via satellite
- WAS Satellite
  - Confirm contact with all 50 states via satellite
- DXCC Satellite (no challenge points though)
  - Confirm contact with 100 DXCC entities via satellite
- AMSAT has some of its own awards

Station

- Radio:
  - Minimal: a dual-band HT, Mobile or base station that supports FM
  - + Full-duplex (can receive at the same time as transmitting). Some HTs, mobiles and base stations support this.
  - + CW/SSB
  - + CAT control (computer controlled radio)
  - + Radio built for satellites that has all the above (ic-910, ic-9100, ic-9700, ft-847, ts-2000)
  - You can always use 2 radios to get full duplex. 2 HTs is a cheap and effective radio setup for FM satellites. SDR dongles can be used as a receiver (and your get the panadapter). Also transverters can be used on an HF radio to get ssb/cw on 2M/70cm.

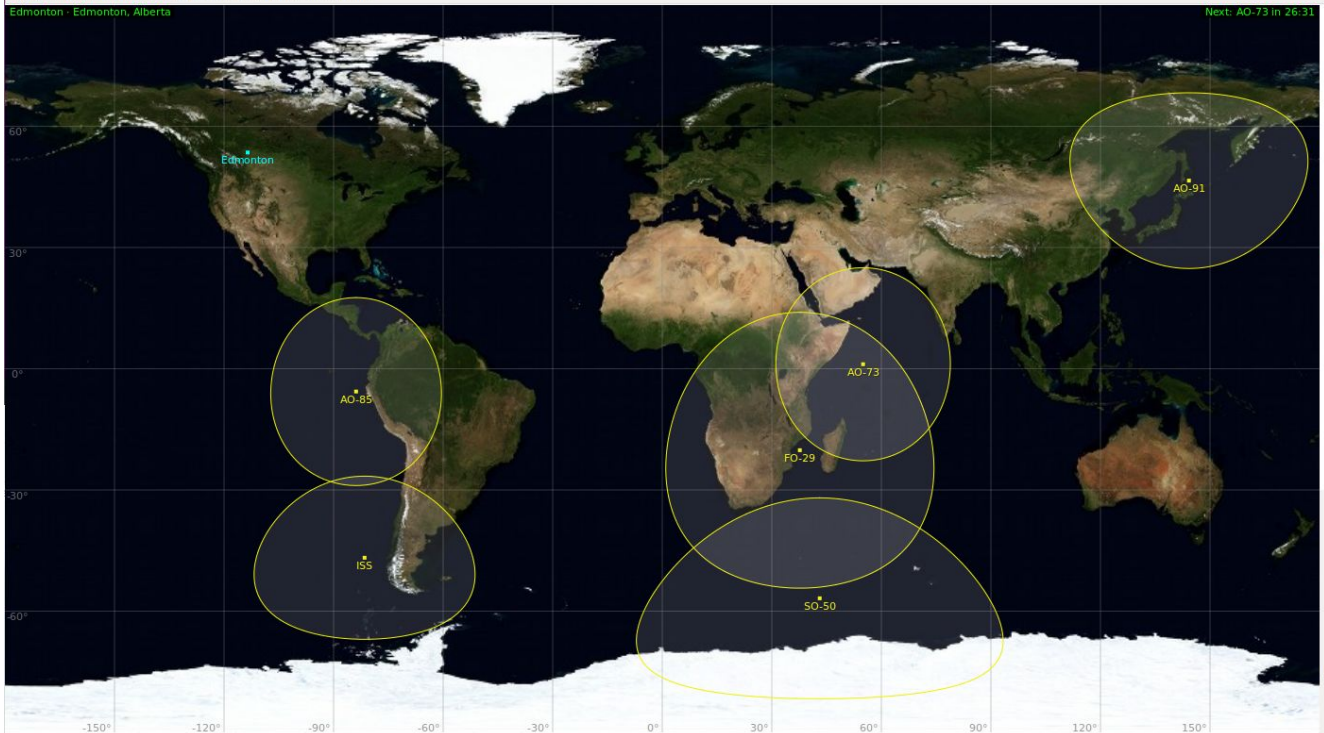
Station (continued)

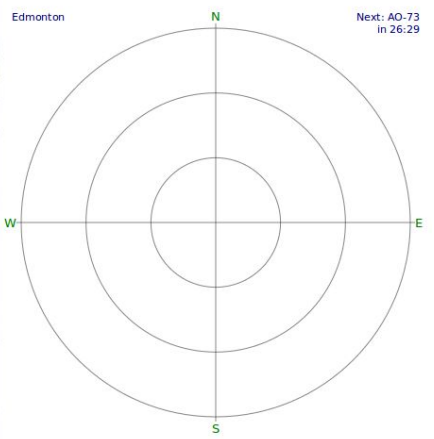
- Antenna(s):
  - Either 1 antenna or 2, directional preferred, but contacts can be made with an omnidirectional antenna. If using 2 antennas, it's more important to have a directional for receiving.
  - I've made contact with a mobile whip (less gain allows for high elevation)
  - Eggbeater antennas are popular and they are also circularly polarized
  - Hand-held yagi or LPDA (Arrow, Elk, homebrew....)
  - M2 LEO SatPack
  - Linear vs Circular polarization?
  - Diplexer/Duplexer?

Station (continued)

- Tracking Software:
  - AMSAT's Pass Predictions on their website: gives static pass data like time, AOS azimuth, LOS azimuth and max elevation
  - SatPC32 (Windows)
  - MacDoppler (Mac)
  - Gpredict (Linux)
  - Several options in the app stores on both Android and iOS
- Misc:
  - Rotator? Azimuth? Azimuth and Elevation?
  - Good feedline - short, lmr 400 or better for long runs
  - Audio recorder (possibly on phone)

2018/07/19 15:47:20 GPS 212398775240.814 seconds old





Satellite	Az	El	Dir	Range	Next Event	Alt	Orbit
AO-73	13.95°	-60.53°	↑	11793	AOS: 2018/07/19 16:13:50	597	24990
AO-85	146.29°	-27.97°	↑	7033	AOS: 2018/07/19 17:36:52	565	5846
AO-91	309.16°	-26.54°	↓	6681	AOS: 2018/07/19 17:02:34	488	3595
FO-29	44.60°	-67.98°	↓	13235	AOS: 2018/07/20 00:10:34	1328	8240
ISS	157.79°	-50.58°	↓	10343	AOS: 2018/07/20 03:16:53	417	12356
SO-50	112.49°	-82.93°	↓	13286	AOS: 2018/07/19 16:34:21	652	83776

AO-73

Azimuth :	13.95°
Elevation :	-60.53°
Slant Range :	11793 km
Range Rate :	-3.449 km/sec
Next Event :	AOS: 2018/07/19 16:13:50
SSP Loc. :	LJ71KP
Footprint :	5318 km
Altitude :	597 km
Velocity :	7.577 km/sec
Doppler@100M :	1150 Hz
Sig. Loss :	153.83 dB
Sig. Delay :	39.34 msec
Mean Anom. :	225.79°
Orbit Phase :	317.51°
Orbit Num. :	24990
Visibility :	Daylight

Manual Tracking

- Use orange cones to mark AOS and LOS
- Estimate the max elevation and practice sweeping the antenna through that arc
- Once you start receiving the satellite, you track primarily by ear only moving to improve signal.
- Don’t forget to rotate the antenna for polarization!

Doppler Shift

- Sound, light and radio waves are affected by doppler shift
- When object 1 is moving towards object 2, waves created by either of these objects will be compressed, giving them a shorter wavelength. When the two objects are moving apart, the waves are stretched, giving them a longer wavelength.
    - With radio, this translates to a higher apparent frequency when a satellite is moving toward a ham, and a lower apparent frequency when the satellite is moving away.
    - Doppler effects higher frequencies more than lower frequencies.
    - Typical 2M doppler shift for LEO satellite: +- 3khz
    - Typical 70cm doppler shift for LEO satellite: +- 10khz
- How do you correct for doppler shift?
    - Manually
    - With CAT control of the radio, a satellite tracking program can adjust the frequency

Working an FM Satellite QSO

- Pick a satellite and lookup the information about the pass. You will need to know AOS (Acquisition of Signal) time and azimuth, LOS (Loss of signal) time and azimuth and the TCA (time of closest approach) elevation
- When using manual doppler correction, we always adjust the higher frequency only and leave the other one alone.
- AO-92 (U/v) satellite frequencies: 435.35 Mhz / 145.88 Mhz 67 Hz CTCSS Tone
    - Program memories in your radio from -10khz to +10khz on 70cm
    - If your radio minimum step size in 2.5khz, then 9 memories for the uplink
    - If your radio minimum step size is 5khz, then 5 memories for the uplink

Working an FM Satellite QSO

- When the uplink is on VHF with a UHF downlink, you will tune the downlink. The order is reversed (high to low).
- Set the radio for the first memories (highest frequency on each band)
- Open the squelch
- Start an audio recorder to capture QSOs! You can’t write anything down while doing this!
- Aim the antenna toward the AOS point. Wave it back and forth and adjust polarity to acquire the signal (FM satellite are almost always busy over land).
- Once you are receiving the signal, track the satellite by ear.

Working an FM Satellite QSO

- Do not call CQ on an FM satellite, just put out your callsign/gridsquare: KB1AWM EM93
- If you hear “K1JB FN54”, then you call him: “K1JB KB1AWM EM93”
- Once the contact is established with grid squares, confirm the receipt: “KB1AWM QSL”
- If the satellite is busy, please only make 1 or 2 contacts per pass. By convention, rare grid squares are sometimes worked many more times, but if you are in one of these, let other stations call you.
- Log to LoTW
- Use minimum power necessary, 5W typical. Some mobile rigs will only do 10 or 15W on low power, that’s fine for FM satellites.

Tips

- When you start your audio recorder, announce the time and the satellite you are going to work.
- Headphones/Headsets are helpful. This is weak signal work! You can hook up your audio recorder using a y-splitter cable on the headphone jack to the mic port on the recorder/phone.
- Focus on your receive setup. Your station will have no problem getting into the satellite, hearing it is the hard part
- Use your cell phone: compass app, grid square app, audio recorder
- Keep your Keps updated in tracking software
- ISS FM Voice: 2M both up and down, apply doppler ! They do QSL!