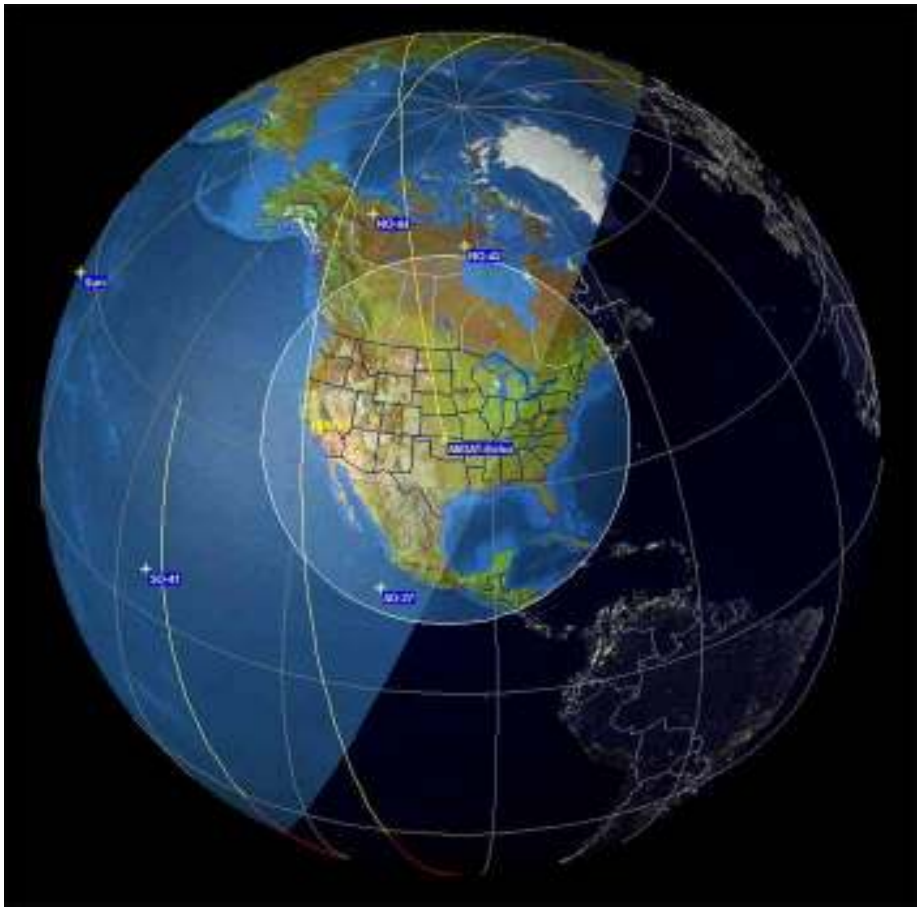
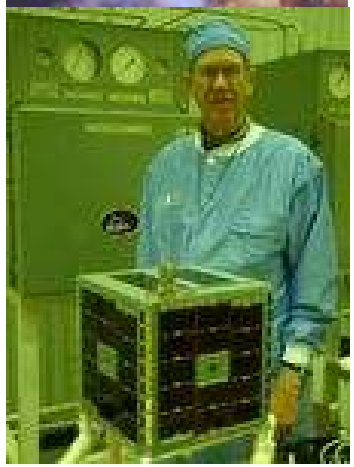
N0NBH - Amateur Satellites



Paul L Herrman
Sierra Vista AZ DM41um
•AMSAT Member # 35541

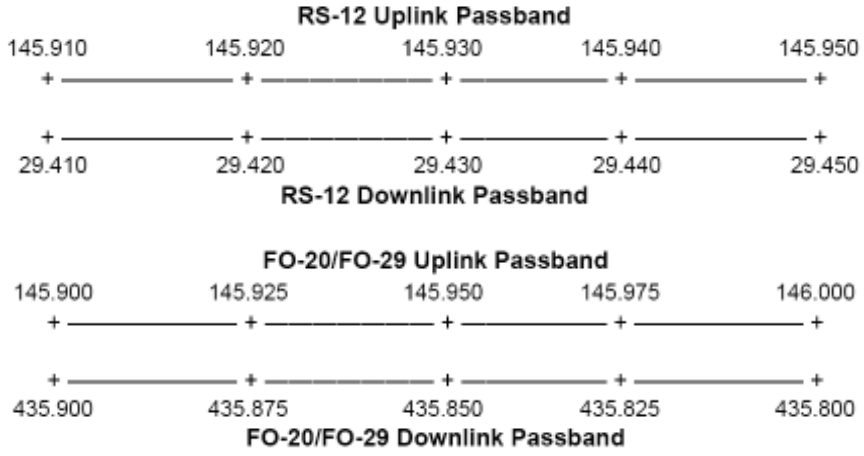
Amateur Satellites

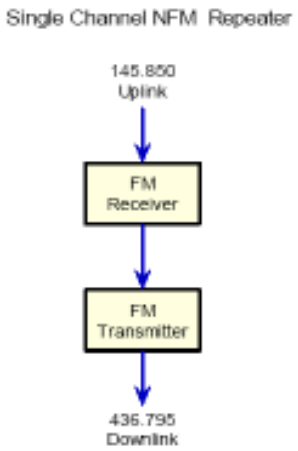
- What are Amateur Satellites
  - Built by Amateur's for non-commercial use
  - Modes depend on satellite design
    - FM Repeater
    - Linear Transponder
    - Inverting Transponder
    - CW
    - Voice (SSB/FM)
    - Digital Packet
    - PSK-31
    - Telemetry
    - Beacon
    - HF, VHF, UHF, L-Band, S-Band, C-Band, X-Band, K-Band, APRS
  - Coverage area (Footprint) depends on orbit

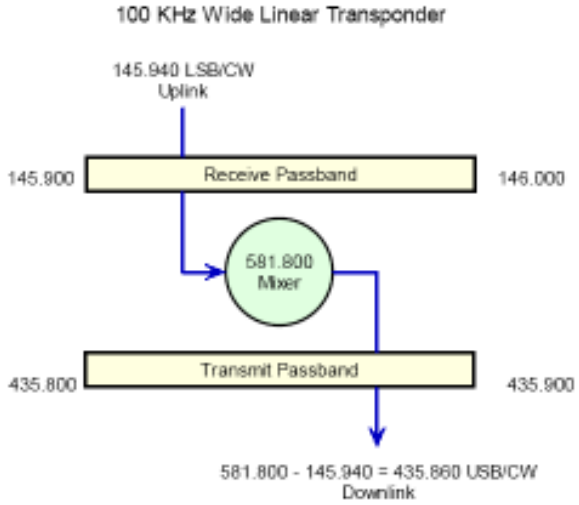


Amateur Satellite Types

- FM Repeater
  - Simple Cross-Band Repeater
  - One Conversation at a time
- Linear Transponder
  - Wideband Receiver/Transmitter
  - Multiple Conversations
  - Inverting/Non-inverting
  - CW/SSB

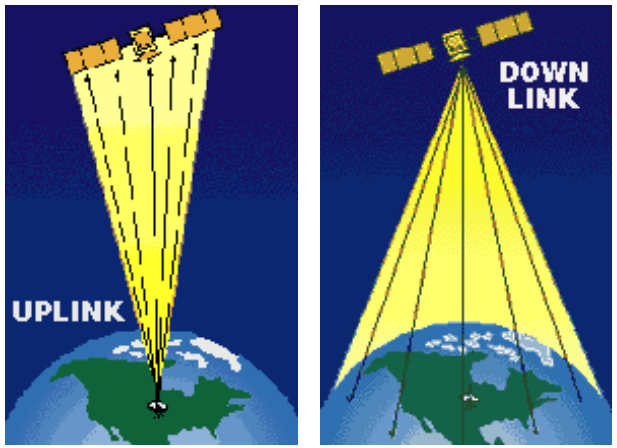


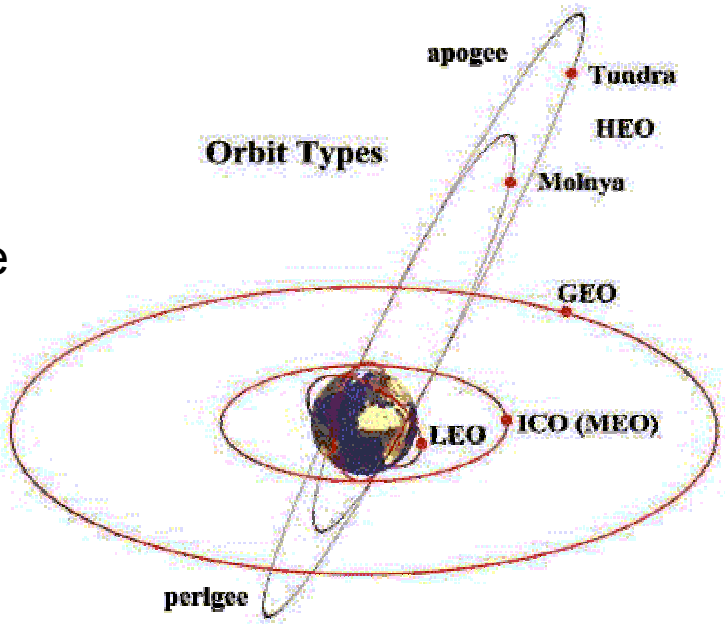




Amateur Satellite Terminology

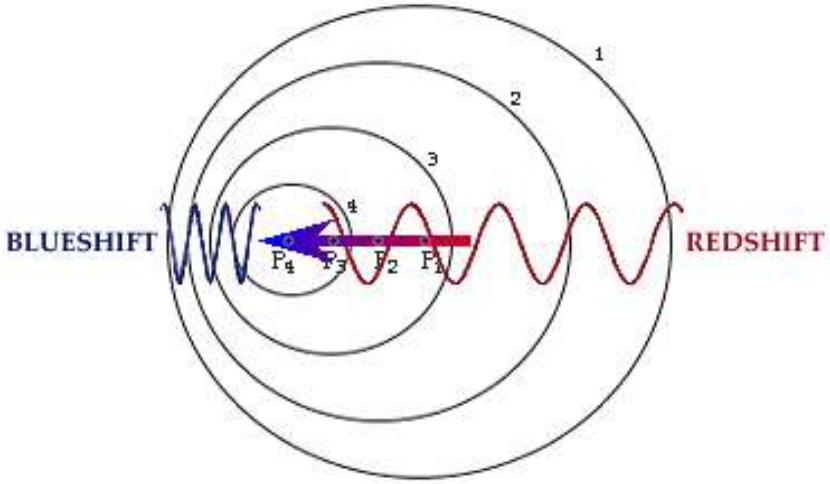
- Acquisition of Signal (AOS) - satellite is in sight
- Loss of Signal (LOS) - satellite is out of sight
- Apogee - Where the satellite is highest (farthest distance) from earth
- Perigee - Where the satellite is lowest (closest distance) to earth
- Uplink – frequency used to transmit to satellite
- Downlink - frequency used to receive from satellite
- Orbit – path around the earth
- Footprint – circular area where satellite is line of site
- Inclination – angle of satellite (equator=zero)
- Doppler – shift in frequency caused by satellite motion
- Low Earth Orbit (LEO) - 400 to 2000km
- Highly Elliptical Orbit (HEO) >20000km





Doppler Shift

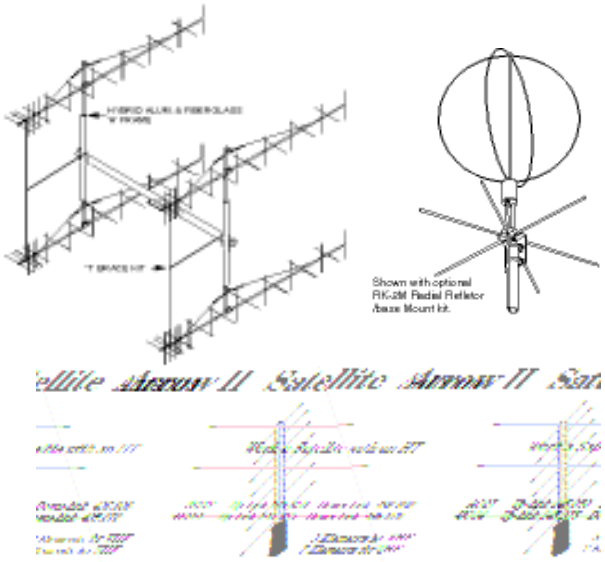
- Remember a train blowing its whistle and how the tone seemed to change as it passes by?
- Doppler shift is the variance in frequency that results from the relationship of an observer to a source that's moving
  - Occurs in RF as well as audio
  - Train = 60 to 70 mph
  - Satellite = 17,000 mph
- Requires constant tuning of your receiver or transmitter to make up the difference
  - Amateur satellites use a de facto standard of changing the higher of the two frequencies
  - Satellite also sees a shift in the signal it is receiving
  - Varies from +/- 2.5 kHz to +/- 10 kHz dependent on frequency



- Hardest part about Doppler Shift is finding your desired signal
  - FM - Tune to transmit frequency and leave – tune receive to downlink frequency and adjust receive until downlink is clear
  - Transponder – Tune to desired receive frequency and corresponding transmit frequency. Transmit (tone or calling CQ) while adjusting transmit frequency until you hear clearly. Now adjust only higher frequency during QSO.

Required Equipment

- Antennas
  - As with ground communications the most important part of station
  - Sizes aren't bad due to frequencies used, and it is possible to obtain a lot of gain in a small size
  - Most of the time satellites are no higher than 35 degrees above the horizon
    - Closer to the horizon - greater the distance, higher the path loss, and greater the transmit and receive gain needed to work the bird
  - Directional antennas are best
    - Requires time, space and inclination
    - With only azimuth control, tilt them about 30 degrees
    - Best is circular polarized with azimuth/elevation rotor
  - Omni vertical antennas will work
    - High gain verticals are optimized for low angles of radiation
    - Signal strength falls off rapidly as your elevation angle increases
    - Natural and man-made noise tends to be vertically polarized
    - Very apparent with SSB and C, not bad with FM
  - Dipoles also work
    - Suffer from loss of gain off the ends
    - Good coverage using two at right angles from each other
  - Need not be expensive - consider making your own antennas (see web)



- Feedline
  - No matter which antenna you decide to use, don't forget the importance of using a high quality, low loss transmission line and good connectors
  - Use the very best you can afford because, if you skimp here, you could loose a significant part of your signal as line loss

Required Equipment

- Transceiver
  - Can use Handheld, Mobile, or Base units
  - Single Radio must operate full duplex
  - Can use multiple radios
  - Requires band and mode of the satellite
- Optional
  - Rotator
    - Azimuth only
    - Azimuth and Elevation
      - With automatic tracking control
      - Integrated or stacking two az rotors
  - Amplifier and Preamps
  - Signal Processing
  - Diplexers, Triplexers







Required Equipment

- Satellite Tracking
  - Freeware or Shareware
  - Notebooks
  - Palms and PDAs
  - With or without antenna controller

Operating Procedures – FM Satellites

- Procedure is good operating habits and common sense
- Key constraints placed upon the FM transponders
  - Limited QSO throughput due to single channel operation
  - Higher levels of demand
  1. First and foremost is to listen before and while transmitting
     - Ensure your transmissions don't drown out a weaker station
     - Set your station up so you can monitor the downlink while transmitting
       - To hear how well you are accessing the satellite
       - Accidentally clobbered someone else
     - If you can't hear the transponder, don't transmit
     - Keep your SQUELCH OFF
  2. Be brief
     - Contest style (callsign/signal report/next station) operation is the most appropriate
     - Exchange QTH and first names only if time permits
     - If activity is low, you can have a brief chat
  3. Take turns
     - Be polite and hand the transponder over to someone else
     - There may be an opportunity to call back in later during the pass and work some different stations as the satellite passes
  4. When calling, make it a simple announcement
     - This is N0NBH listening AO-51
     - A short CQ call ("CQ AO-51") is OK too.
     - Long CQ calls waste transponder time and frustrate everyone listening.

Operating Procedures – FM Satellites

5. Wait your turn
   - If a QSO is in progress, wait until it finishes before putting in your call
6. Don't tune up!
   - Simply putting out a call at the appropriate time will provide all the signal checks you need (and net you a worthwhile contact!
7. Reward good operation.
   - If all satellite users favor good operators, perhaps everyone will learn that good ops have the highest QSO rates and earn the most satellite awards
8. Use the minimum power necessary
   - While power levels are not critical on FM satellites using the minimum power necessary allows you to easier tell if you're 'doubling' with someone else

– If everyone follows these simple guidelines (which are basically common sense and courtesy), then FM satellite operation can be enjoyable for everyone, regardless of whether you run a sophisticated satellite station or a couple of handhelds from the back yard.

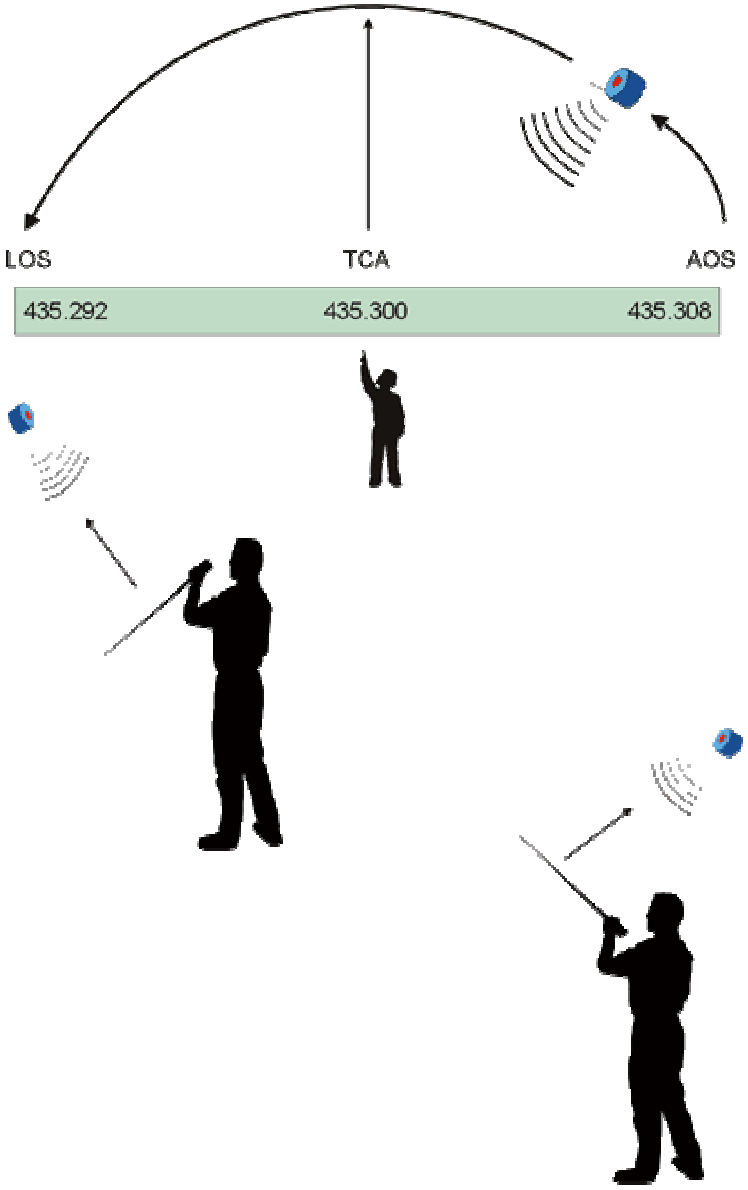
– FM satellite transponders are like FM repeaters, only more extreme. On the positive side, they can enable minimally equipped stations thousands of kilometers apart to communicate with ease. On the other hand, the worst aspects of repeaters can be experienced as well, such as congestion, doubling and even the odd idiot dropping carriers!

Using Handhelds for Satellite Operation

- THE ONE TRUE RULE for HT success (and even for FM base station users) - keep your SQUELCH OFF
  - Working satellites starts off as a process of finding weak signals, so don't expect the satellite to be anywhere as strong enough to break squelch like your local repeater
  - Noise can also be an aid in locating the satellite because when the frequency starts to exhibit QUIETING, that's a sure sign that you are hearing the satellite, and you should get ready.
  1. LISTEN FIRST! Even though you only have 5 watts, it's still possible to jam other stations. Expect to hear other stations before you transmit. If you can't hear other stations and need to check your uplink, don't call CQ, just transmit your callsign. If others hear you, they will want to work you.
  2. Use a good antenna for your HT. A good gain whip antenna like the AL-800 is very good. Using an Arrow dual-band handheld antenna is better, and if you prefer to homebrew your antenna, Alex Diaz XE1MEX has an excellent Yagi design
  3. When you identify yourself, always say your CALLSIGN followed by "HANDHELD" - I've found most operators will give way to HT users if they identify themselves that way.

Using Handhelds for Satellite Operation

4. Set up your radio so you can to tune for DOPPLER. If your HT only has 5KHz tuning steps, start listening 5 KHz above the center frequency - you will hear the satellite sooner and clearer. When you hear the downlink signals get scratchy or fuzzy, tune down 5KHz and it should be clearer. Follow the signal down in frequency as the pass continues. (See the graphic to the right.)
5. Don't hold your whip antenna upright. Vertical antennas are not good, and a HT held upright isn't either. The satellite isn't on the ground (which is what HT's and vertical antennas were designed for). TILT IT about the same amount as the satellites ELEVATION. This means that if you are FACING the satellite, tilt it down towards the ground from HORIZONTAL an equal amount. If the satellite is to your back, tilt it up an equal amount away from the satellites position off the vertical. You will be surprised at the difference.



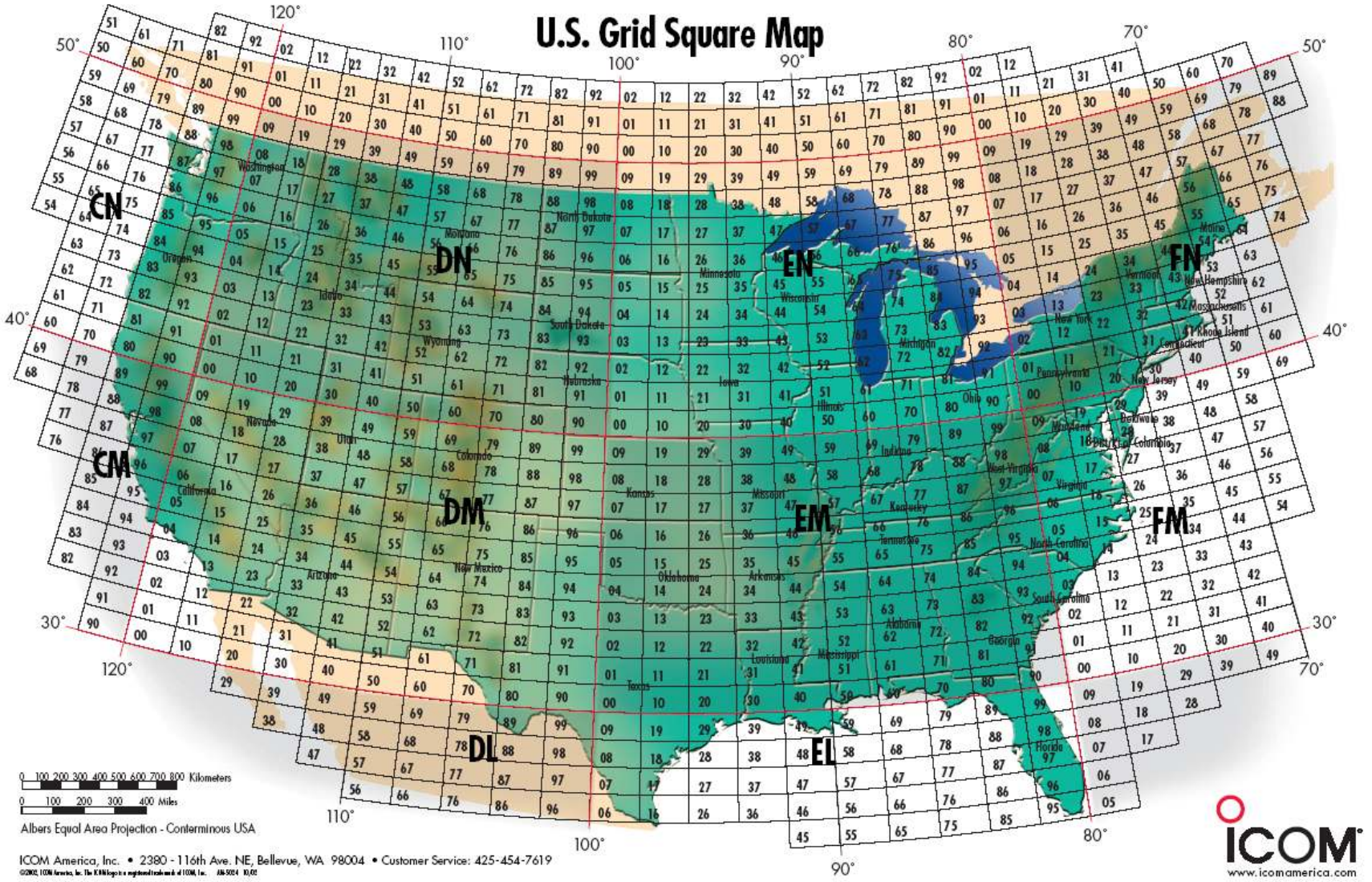
Using Handhelds for Satellite Operation

6. Make sure you know where the satellite is. Even if you don't have a palm sized computer running a tracking program such as PocketSat or PetitTrack you can estimate this. If you know the AOS azimuth and the satellite pass time, you can just estimate how much to move until you find the satellite.
7. HEADPHONES are very important, especially if you are working full duplex. You are much better off listening with two ears than one. If you have a full duplex HT like a Icom IC-W32A you can listen to your own downlink (a good thing).
8. Know your gridsquare as that is a quick way of identifying your location. Saying CM87 is much quicker than saying "San Francisco, California".
9. Map out a strategy for contacts. This isn't rocket science, but close. So preparation and planning is important. Not every pass is workable with an HT, so don't go after the 10 degree passes. Pick your passes, and work the ones you know will give you the best chance.
10. If you don't plan to write down your contacts, try to work out someway to record them. You can hook a MP3 or Cassette recorder into the headphone jack on the receive side to record your contacts so you can review it later.
11. Ask questions! Find an elmer or look up the AMSAT area coordinator for your area. Posting specific questions on the AMSAT bulletin board will also help you find answers.

Operating Procedures – Linear Transponder Satellites (SSB/CW)

- Procedure is good operating habits and common sense
- Linear transponders allow for multiple QSO's on a single satellite
  1. Same basic rules as FM Operation
  2. Listen for the beacon
  3. Longer CQ Calls are necessary to allow a station to find you
  4. Monitoring your uplink is a necessity – not a nice to have
  5. Adjust only the higher frequency during your QSO.
     - If not you end up chasing each other around the dial
  6. Use the minimum power necessary
     - Also adjust channel spacing as not to interfere with an adjacent QSO
     - Also remember you are moving through the usable bandwidth while the QSO is in progress
  7. Stay away from beacons and telemetry portions of the transponder

Grid Squares



Satellite Status

http://www.amsat.org/amsat-new/satellites/status.php

Name	Beacons	HF	VHF	UHF	L-Band	S-Band	C-Band	X-Band	K-Band	APRS	Packet	Comments
AO-51 (Echo)	↑		↑	↑	↑	↑					↑	Check Schedule
VO-52(Hamsat)	↑		↑	↑								Operational
AO-7	→	→	→	→								Sunlit Ops Only
UO-11	↑											
RS-15	→	→	→									Intermittent
AO-16	↑										→	Digipeating
LO-19	↑										↓	CW Beacon Only
AO-27	↑		↓	↓								Recovery Mode
FO-29	↑		↑	↑							↓	
GO-32	↑										↑	
SO-41			→	→								Erratic
NO-44										→	↓	Low Batteries
MO-46	↓										↓	Reported Dead
SO-50			↑	↑								
ARISS			↑	↑						↑	↑	
RS-22			↑	↑								
SSETI Express	↑			↑		↑						May 2005
P3-E Express	↑		↑	↑	↑	↑	↑	↑	↑			
PCSat2		↑	↑							↑		

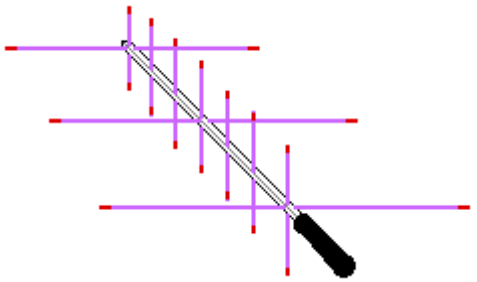
International Microwave Frequency Bands

Band Name	Bandwidth (GHZ)
L-Band	0.39-1.55
S-Band	1.55-5.20
C-Band	3.70-6.20
X-Band	5.20-10.9
K-Band	10.9-36.0

AMSAT-OSCAR 51 (Echo or AO-51)

- Analog Uplink:
  - 145.920 MHz FM (PL - 67Hz)
  - 145.880 MHz FM QRP (no PL)
  - 1268.700 MHz FM (PL - 67Hz)
- Analog Downlink:
  - 435.300 MHz FM
  - 2401.200 MHz FM
- PSK-31 Uplink
  - 28.140 MHz USB
- Digital Uplink:
  - 145.860 MHz 9600 bps, AX.25
  - 1268.700 MHz 9600 bps AX.25
- Digital Downlink:
  - 435.150 MHz 9600 bps, AX.25
  - 2401.200 MHz 38,400 bps, AX.25
- Broadcast Callsign:
  - PECHO-11
- BBS Callsign:
  - PECHO-12

- Launched
  - June 29, 2004
- Status: **Operational**
- AMSAT-OSCAR 51 or Echo as it is more commonly known is a FM satellite carrying 4 VHF receivers, 2 UHF transmitters, a multimode receiver and a 2400MHz transmitter. It can handle voice and FSK data up to 76.8Kbps. Echo was launched into a low, sun-synchronous polar orbit approximately 850 km high. You must transmit a 67Hz PL tone in order to access the Echo voice repeater.



VUSat-OSCAR 52 (HamSat or VUSat)

- Uplink
  - 435.220-435.280 MHz LSB/CW
- Downlink
  - 145.870-145.930 USB/CW (Inverting)
- Beacon
  - 145.936 Unmodulated Carrier
  - 145.860 Telemetry
- Launch
  - Q2 2005
- BBS Callsign:
  - PECHO-12
- Launched
  - June 29, 2004
- Status: **Operational**

- HamSat was constructed by AMSAT India and ISRO. It carries two 1watt linear transponders, and an FM beacon. HamSat was launched aboard the PSLV-C6 launched at 4:45z on May 5 2005. After launch, the primary payload (CartoSat) was deployed, followed 40 seconds later by HamSat. Both the satellites have been placed in polar Sun Synchronous Orbit (SSO) at an altitude of 632 x 621 km with an inclination of 97.8 deg with respect to the equator. HAMSAT has been assigned the OSCAR designation VO-52.

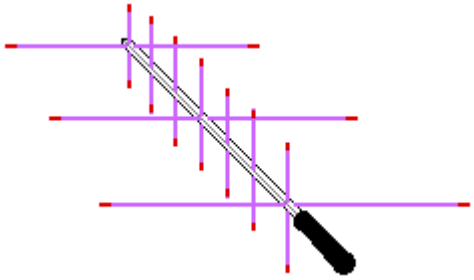
AMSAT OSCAR 7 (AO-7)

- Mode B and C Uplink
  - 432.125 to 432.175 MHz CW/LSB
- Mode B and C Downlink
  - 145.975 to 145.925 MHz CW/USB (inverting)
- Mode B Beacon
  - 145.9775 MHz (CW telemetry)
- Mode C Beacon
  - 435.100 MHz (intermittent)
- Mode A Uplink
  - 145.850 to 145.950 MHz CW/USB
- Mode A Downlink
  - 29.40 - 29.50 MHz CW/USB (non-inverting)
- Mode A Beacon
  - 29.502 MHz (CW telemetry)
- Launched
  - 15 November 1974

- Status: **Semi-operational**
- AO-7 became non-operational in mid 1981 due to battery failure . In 2002 one of the shorted batteries became an open and now the spacecraft is able to run off solar panels. For this reason it is not useable in eclipse and may not be able to supply enough power to the transmitter to keep from frequency modulating the signal. Lately AO-7 has favored Mode B almost exclusively. Mode B (8 Watts PEP) is equivalent to Mode U/V. Mode C is the same as Mode B however the power is 2.5 Watts PEP

AMRAD OSCAR 27 (AO-27)

- Uplink
  - 145.850 MHz FM
- Downlink
  - 436.795 MHz FM
- Launched
  - 26 September 1993
- Status: **Semi-operational**
- On March 24th AO-27's scheduler went into recovery mode and terminated operations until the batteries were recharged. On April 6th, AO-27 control-operators were able to issue commands to the satellite. AO-27 is now running off the boot loader that is programmed in to the ROM and is sending out telemetry, however analogue operations are not possible.
- The first attempts by the control team to upload flight software ran into problems. They are evaluating logs from the attempts and are trying to work out a plan. The control team indicates it will take a lot of work to get it back to operation status and the control team cannot answer questions as to when it will be back in operation at this time.



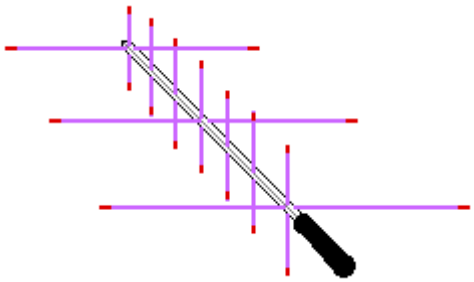
Fuji OSCAR 29 (FO-29)

- Analog Uplink
  - 146.000 to 145.900 MHz CW/LSB
- Analog downlink
  - 435.800 to 435.900 MHz CW/USB
- Beacon
  - 435.795 MHz (normally CW telemetry)
- Digital Uplink
  - 145.850, 145.870, 145.910 MHz FM
- Digital Downlink
  - 435.910 MHz 1200 baud BPSK or 9600 baud FSK
- Digitalker
  - 435.910 MHz FM
- Launched
  - 17 August 1996

- Status: **Operational**
- Please send the reception reports to lab2@jarl.or.jp . Please use the subject line: 'FO-29reception report'. Mineo, JE9PEL, has an FO-29 satellite telemetry analysis program that will automatically analyze all digital telemetry from the satellite (such as current, voltage and temperature). FO29CWTE is available at: http://www.ne.jp/asahi/hamradio/je9pel/

Saudi-OSCAR 50/SaudiSat 1C (SO-50)

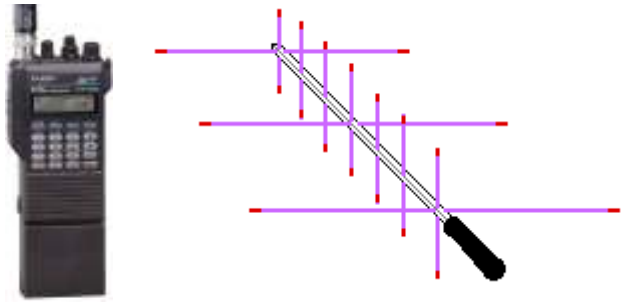
- Uplink
  - 145.850 MHz FM
- Downlink
  - 436.795 MHz FM
- Launched
  - 20 December 2002
- Status: **Operational**
- SO-50 carries several experiments, including a mode J FM amateur repeater experiment operating on 145.850 MHz uplink and 436.800 MHz downlink.
- SO-50 is operational for 10 minutes when turned on by the following procedure: 1) Transmit for 1-2 seconds on 145.850 MHz with a tone of 74.4 Hz to arm the 10 minute timer on board the spacecraft.
- 2) Next transmit on 145.850 MHz (FM Voice) using 67.0 Hz to key the repeater on and off within the 10 Minute window.
- *Note: Sending the 74.4 tone again within the 10 minute window will reset the 10 minute timer.*



Amateur Radio on the International Space Station (ARISS)

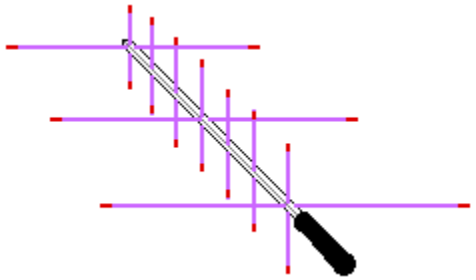
- Region 2 2m uplink
  - 144.490 MHz FM
- Cross Band Repeat Uplink
  - 437.800 MHz FM
- Worldwide downlink (All modes)
  - 145.800 MHz FM
- Worldwide Packet uplink
  - 145.990 MHz FM
- US Voice Callsign
  - NA1SS
- Russian Voice Callsigns
  - RS0ISS, RZ3DZR
- UI Digipeater Callsign
  - ARISS
- Bulletin Board Callsign
  - RS0ISS-11
- Status: **Operational**

- The ISS system has sometimes been turned on to Cross Band Repeat mode. In this mode it functions as a Mode B-FM repeater. Amateurs in the US and elsewhere have reported using the repeater with home stations and handheld radios with great success. The crew is also able to use the radio to transmit even when the system is in this mode.
- While the system is in cross band repeat mode the packet system is turned off and vice-versa.



SSETI Express – Future Launch

- Voice Uplink
  - 437.250 FM 67Hz CTCSS
- Voice Downlink
  - 2401.840 FM
- Packet Up/Downlink
  - 437.250 9k6 packet
- Packet Downlink
  - 2401.840 38k4 packet
- Launch
  - Q3 2005
- Status: **Future Launch**
- SSETI Express is nearing completion at the ESA technical centre in the Netherlands. Data modes will be primarily used for downlinking telemetry and data from the satellites experiments.
- ESA will be providing telemetry capture software for amateurs to use and will be offering a prize to the amateur station who provides them with the most telemtry after launch. The mode U/S FM voice transponder will require 67Hz tone access in a similar way to AO51 and will provide three channels of 256 bit telemetry encoded as DTMF tone bursts. S Band output is 3 Watts to 3 x 8dBic RHCP patch antennas. Launch is currently scheduled for sometime in July 2005.



AMSAT-Phase 3E Future Launch

- AMSAT-Phase 3E is a project of AMSAT-DL and will operate with similar goals as AO-40. Launch is scheduled in 2005-2006.

Band	Analog Uplinks	Analog Downlinks	RUDAK Uplinks	RUDAK Downlinks
10 M			29.500 +/- 5 kHz	
2 M		145.845 - 145.945		145.837 - 145.837
70 cm	436.050 - 436.150		436.200 - 436.350	
23 cm (1)	1268.600 - 1268.750		1268.775 - 1268.925	
23 cm (2)	1260.100 - 1260.250		1260.275-1260.425	
13 cm (1)		2400.275 - 2400.425		2400.600 - 2401.000
13 cm (2)				
6 cm	5668.600 +/- 25 kHz			
X-Band				
K-Band		24048.300 +/- 25 kHz		
R-Band		47088.300 +/- 25 kHz		

Enjoy the Satellites

- Contact me at N0NBH@cox.net with any questions or comments
- My website at http://members.cox.net/n0nbh provides the links you need