

# Getting Started on FM Satellites

May 3, 2021

Presented by Paul Stoetzer, N8HM

Executive Vice President, AMSAT

# Agenda

- Getting Started on FM Satellites
  - What Equipment Do I Need?
  - How Do I know Where the Satellites Are?
  - How Do I Know What Frequency to Be On?
  - How Do I Track a Satellite?
  - What Do I Say?
  - Tips & Best Operating Practices



# So, What's the Big Deal about Satellites?

- Great entry point for new hams:
  - Anyone with a Technician Class license is able to use amateur satellites.
  - You can make just as many contacts with a \$30 station as someone who spent \$4,000 on theirs.
  - Opportunities to earn Awards: WAS, VUCC, DXCC, etc.
- Yet, plenty to offer the “seasoned” hams: linears + 1.2 GHz and up.
- Amateur satellites work, no matter the condition of the bands.
- Nothing more thrilling than making a contact through a 4-inch, cubed satellite, hurtling through space at 17,500 mph, with just a 5-watt HT.



# What We Will Cover?



So easy a caveman can do it?

- What Equipment Do I Need?
- How Do I know Where the Satellites Are?
- How Do I Know What Frequency to Be On?
- How Do I Track a Satellite?
  - Manually Tracking
  - Polarization
- What Do I Say?
  - Minimum Exchange
  - Standard QSO
- Tips & Best Operating Practices

# Introduction to Satellites

The first amateur radio satellite (OSCAR 1) was launched in 1961.

Since then, more than 100 amateur radio satellites have made it to space and successfully operated.

Limited battery life (before solar cells), decaying orbit/re-entry, parts failure, and the effects of radiation have reduced the number of currently operable satellites to about 30.

Types of amateur radio satellites include:

- Linear Transponders (SSB/CW)
- FM Repeaters
- Digital (Packet, BPSK, PSK31, etc..)
- Telemetry only



What Equipment  
Do I Need?

# What Equipment Do I Need? Radio

In general:

- A dual-band transceiver that can simultaneously transmit and receive on VHF and UHF (at the same time) – full duplex, or
- Two separate (non-full duplex) transceivers to give you full duplex capability, or
- A dual-band, VHF/UHF (non-full duplex) transceiver and a multi-band receiver
- Note:
  - Not all dual band transceivers are full duplex
  - Not all advertised full duplex transceivers are truly full duplex
  - Not all receivers are created equally



# What Equipment Do I Need? Radio

## Full-Duplex FM Handhelds for U/v and V/u

- Icom IC-W2A, IC-W32 (5-digit SN)
- Kenwood TH-D7, **TH-D72**
- Yaesu FT-470, FT-530, FT-51R

## Full-Duplex FM Handhelds for U/v only

- AnyTone TERMN-8R
- Icom IC-W32 (7-digit SN)
- Wouxun KG-UV8D, Wouxun KG-UV9D



# What Equipment Do I Need? Radio

## Full-Duplex FM Mobile Radios for U/v and V/u

- Icom IC-2710, IC-2720, IC-2728H, and IC-2800
- Kenwood TM-D700A, TM-D710A, **TM-D710GA**, TM-741, TM-742, TM-941, TM-942
- Yaesu FT-5100, FT-5200, FT-8800, **FT-8900**, FTM-350



*Use minimal power to  
complete the QSO –  
Usually 5 watts or less!*



# What Do I Need? Radio

## Full-Duplex FM and SSB/CW Base Station Radios for U/v and V/u

- Icom IC-820, IC-821H, IC-910H, Icom IC-970, IC-9100, **IC-9700**
- Kenwood TS-790, **Kenwood TS-2000** (birdie that interferes with SO-50 receive)
- Yaesu FT-726 (w/ sat & tone modules), FT-736 (w/ tone module), FT-847



# What Equipment Do I Need? Radio

## Dual-Band FM and SSB/CW Half-Duplex Transceivers

- Icom IC-706MKIIG, IC-7000, IC-7100
- Yaesu FT-817, **FT-818**, **FT-857**, FT-897, FT-991, **FT-991A**



# What Equipment Do I Need? Antenna

- Key to reliable satellite communication is to put together the best receive station you can – which starts with your antenna.
  - Don't be fooled by HT and Rubber Duck videos on YouTube.
- The best antenna for satellite work is a small beam that is pointed at the satellite.
  - Arrow Antenna
  - Elk Antennas
  - VE2ZAZ "Arrow Style" homebrew
  - WA5VJB "Cheap Yagi"



# What Equipment Do I Need? Antennas

## Arrow II Satellite Yagi Antenna

- Standard Arrow antenna is a 3-element 2m + 7-element 70cm antennas at 90-degrees, each with a BNC connector
- Alaskan Arrow antenna is a 4-element 2m + 10-element 70cm
- Options include a split boom and diplexer



# What Equipment Do I Need? Antennas

## Elk Antennas 2M/440L5

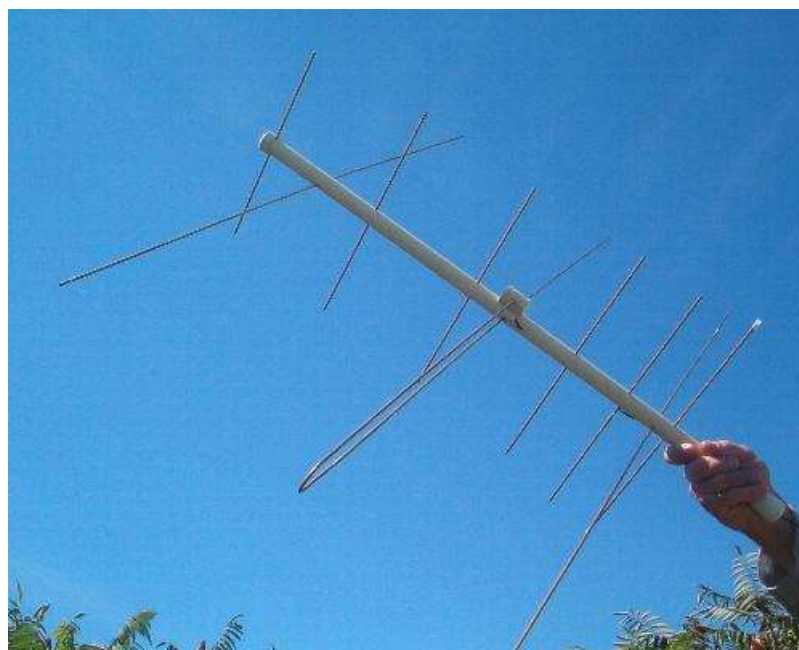
- A dual-band VHF/UHF satellite antenna. It has a single SO-239 connector (optional N connector)
- As a log periodic, no diplexer required when working with a single dual-band radio



# What Equipment Do I Need? Antennas

## **VE2ZAZ Arrow-Style Antenna**

- For a few dollars in parts, you can also build a portable antenna.
- Bertrand, VE2ZAZ has designed and documented an easy to build dual-band LEO antenna
- [http://ve2zaz.net/Arrow\\_Ant/Arrow\\_Style\\_Ant.htm](http://ve2zaz.net/Arrow_Ant/Arrow_Style_Ant.htm)



# What Equipment Do I Need? Antennas

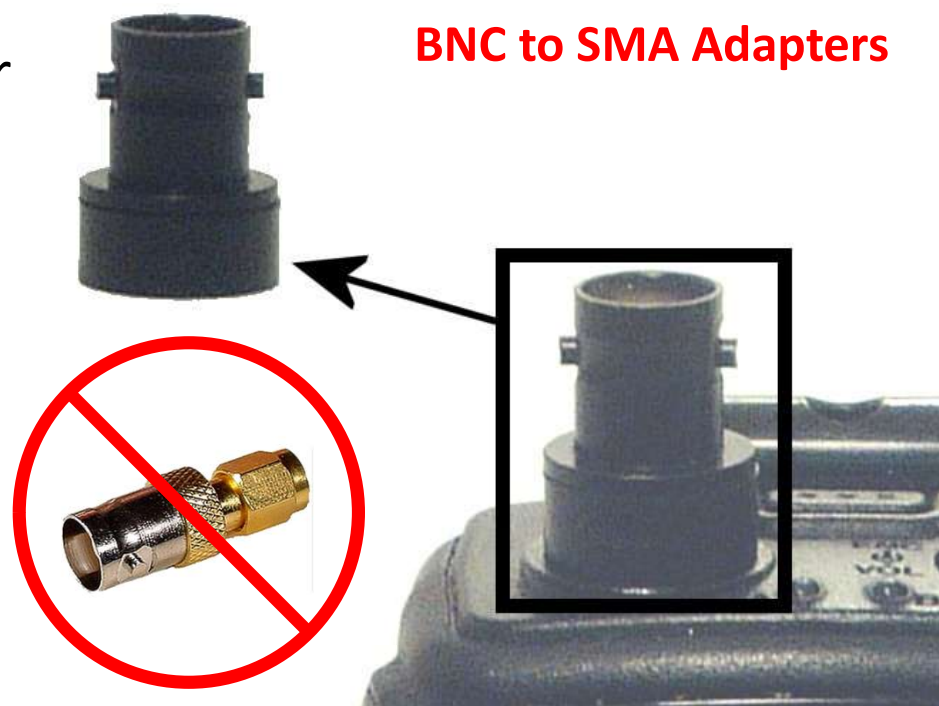
## **WA5VJB Cheap Yagi Antenna**

- For a few dollars in parts, you can also build a portable antenna.
- Kent Britain, WA5VJB has designed and documented an easy to build dual-band LEO antenna
- [www.wa5vjb.com/references/Cheap%20Antennas-LEOs.pdf](http://www.wa5vjb.com/references/Cheap%20Antennas-LEOs.pdf)



# What Equipment Do I Need? Coax

- You will need coax to connect your antenna to your radio. Your antenna may come with coax, like the diplexer on an Arrow antenna, or you may have to supply the cable.
- While any 50-ohm cable will work, you'll get the best performance from Times Microwave LMR-240 Ultraflex coax (or similar) for your antennas and jumpers.



# What Other Equipment Do I Need?



# How Do I Know Where the Satellites Are?

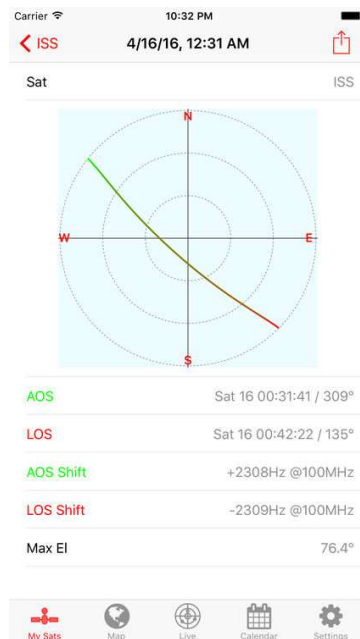
- Satellite tracking apps/software provide critical information
  - AOS Time and Azimuth
  - TCA Time, Azimuth and Elevation
  - LOS Time and Azimuth
  - Graphical representation of satellite pass and satellite footprint
- Satellite tracking software includes both rig and rotor control
- AMSAT provides satellite pass predictions
  - [www.amsat.org/track/index.php](http://www.amsat.org/track/index.php)
- N2YO.com provides real time, online satellite tracking



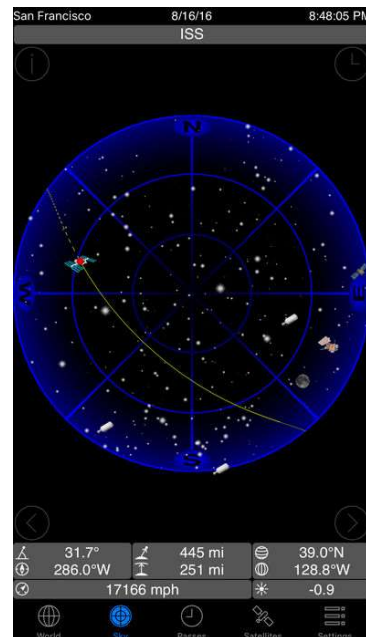
# Satellite Pass Prediction/Tracking Apps



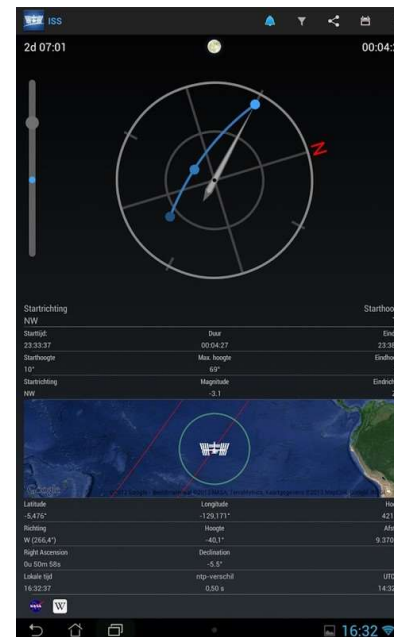
SatSat



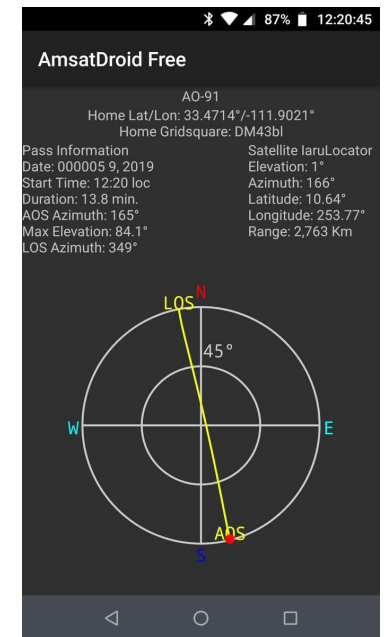
GoSat Watch



ISS Detector

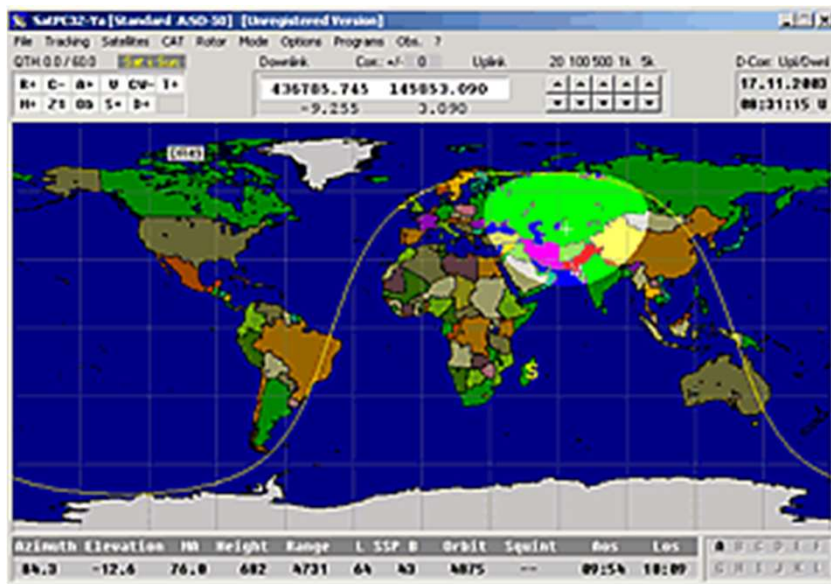


AMSAT Droid Free

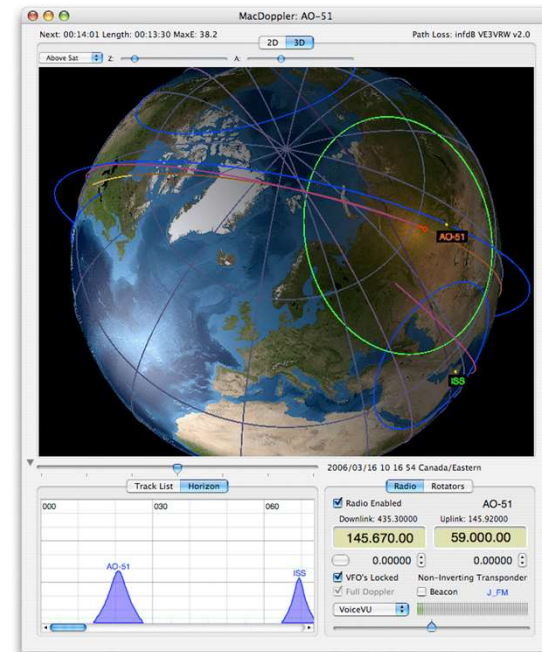


# Satellite Pass Prediction/Tracking Software

## Windows – SatPC32



## MacOS – MacDoppler

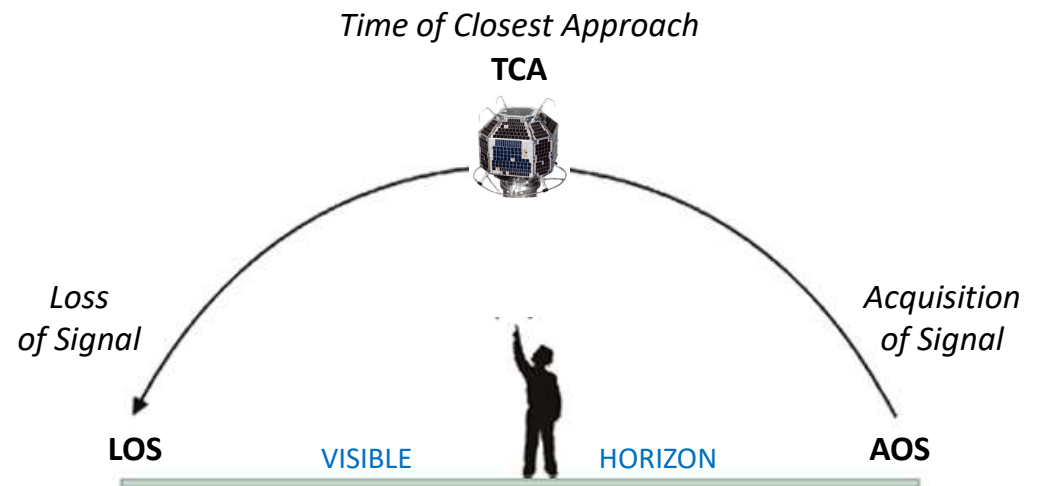


# Terminology



# The Pass

- The time a satellite is visible (in range) to a ground station is called a satellite “**pass**.”
- During a pass, you are in “**footprint**” – line of sight with the satellite.
- The altitude of the satellite above the Earth determines the length of the pass or “**time on station**” (typically 4-12 minutes).

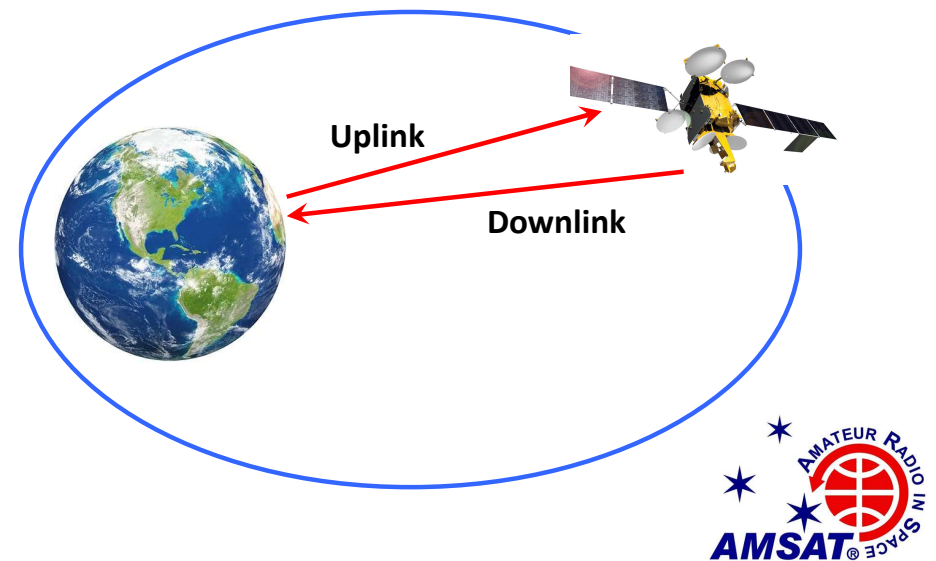


# Uplink & Downlink

The frequency you transmit on is the receive frequency of the satellite, and vice versa.

To eliminate confusion, we use the terms Uplink and Downlink.

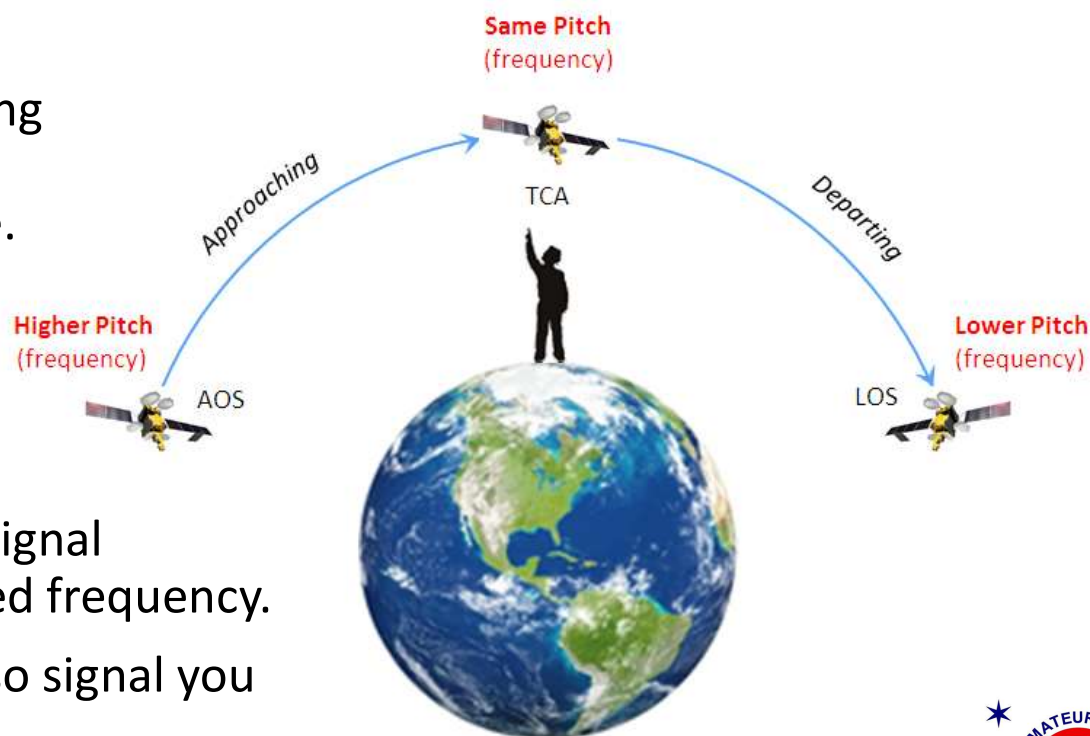
- Uplink
  - Frequency/information going to the Satellite.
- Downlink
  - Frequency/information coming from the Satellite.



# Doppler Effect

Apparent change in frequency of the radio signal due to the increasing or decreasing distance between the ground station and the satellite.

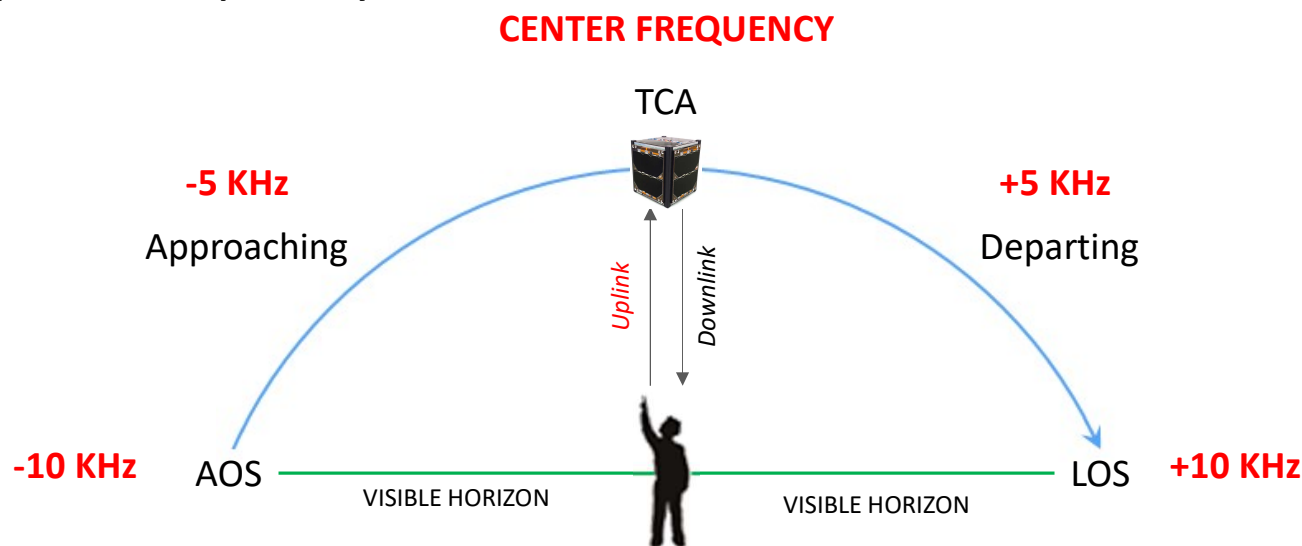
*Just like a train whistle*



- U/v satellites – adjust uplink, so signal received by satellite is on designed frequency.
- V/u satellites – adjust downlink, so signal you receive is on frequency.

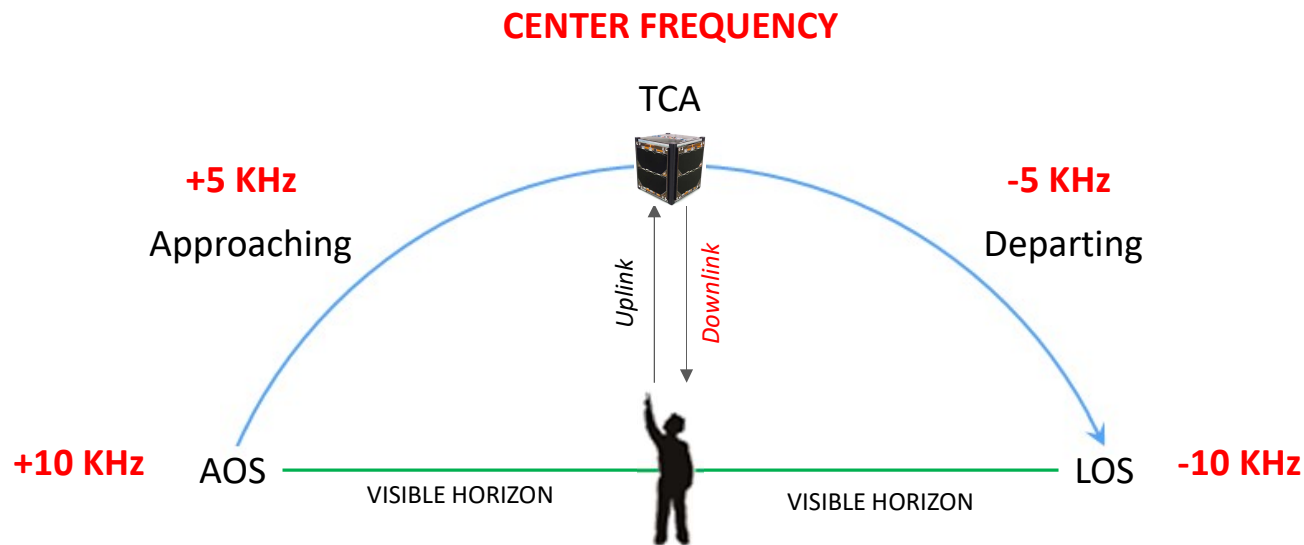
# Doppler Correction – U/v Satellites

On U/v satellites (AO-85, AO-91 and AO-92), you must adjust your **uplink frequency**, so your signal arrives at the satellite on the designed (center) uplink frequency.



# Doppler Correction – V/u Satellites

On V/u satellites (SO-50), you must adjust your **downlink frequency**, so the signal you receive is on frequency.



# Pardon the Interruption



# What Frequency Do I Need to be on?

It depends on what satellite you want to work.

- Satellite typically operate crossband, meaning uplink to the satellite is made on a different band than the downlink from the satellite:
  - Mode U/v (B): 70cm uplink, 2m downlink
  - Mode V/u (J): 2m uplink, 70cm downlink
  - Mode L/v: 23cm uplink, 2m downlink
- Satellite amateur radio frequency allocation:
  - 2m 145.800-146.000 MHz
  - 70cm 435.000-438.000 MHz
  - Additional allocations in L, S, C, X, K, Q, and W bands



# Let's Meet the FM Birds



**Fox-1B  
AO-91**



**SaudiSat  
SO-50**

FM Satellites are repeaters, and considered “easy” to use

- Easy to hear
- Easy to work
- Easy to aim your antenna
- Easy on the Credit Card
- AO-27, LilacSat-2, and PO-101 also available, but scheduled



# The FM Birds: AO-91

- AMSAT + Vanderbilt University
- Launched November 19, 2017
- 98 Degree Inclination
- Elliptical Orbit: 453 km X 817 km
- Mode U/v FM Repeater @ 800mw
- 435.250 MHz Uplink
- 145.960 MHz Downlink
- 67.0 Hz CTCSS on UL (Continuous)
- Digital Under Voice (DUV) Telemetry
- High Speed 9600 bps data downlink

Downlink	145.960	
AOS (Mem 1)	435.240	-10
Approaching (Mem 2)	435.245	-5
TCA (Mem 3)	435.250	—
Departing (Mem 4)	435.255	+5
LOS (Mem 5)	435.260	+10

67 Hz CTCSS



# The FM Birds: SO-50

- Built in Saudi Arabia and Launched by Russia
- Launched December 2, 2002
- 65 Degree Inclination
- Slightly Elliptical at 592 km X 695 km
- Mode V/u FM Repeater
- 145.85 MHz Uplink
- 436.795 MHz Downlink @ 250 mW
- 67.0 Hz CTCSS on UL (Continuous)
- 74.4 Hz for 2 Sec every 10 Minutes

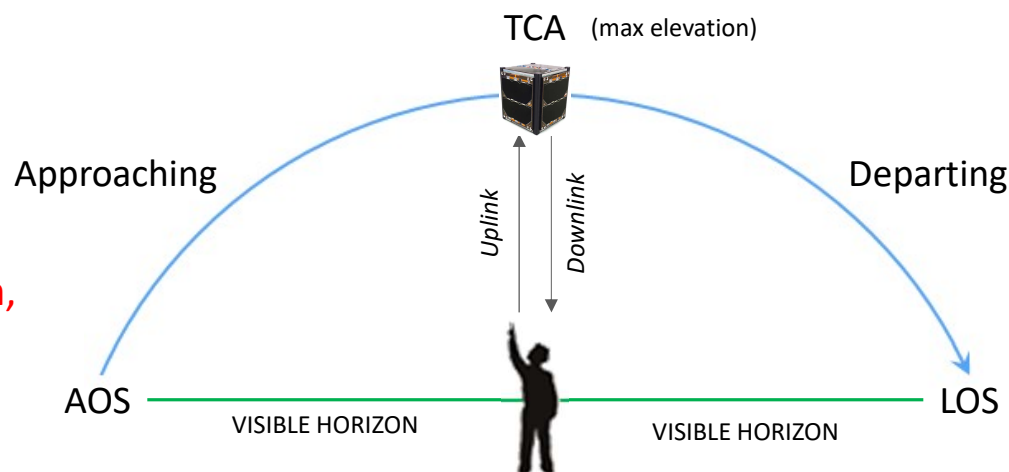
Uplink On	145.850	74 Hz
Uplink	145.850	67 Hz
<hr/>		
AOS	436.810	
Approaching 1	436.805	
Approaching 2	436.800	
TCA	436.795	
Departing 1	436.790	
Departing 2	436.785	
LOS	436.780	



# How Do I Track a Satellite? Manually Tracking

LEO satellites will travel in an arc in relationship to your location.

- ID AOS azimuth.
- ID TCA azimuth and max elevation.
- ID LOS azimuth.
  - Note, Azimuth information provided in relation to True North, not Magnetic North.
- Sweep to find and vary your antenna polarization.
- Listen for strongest signal to track.



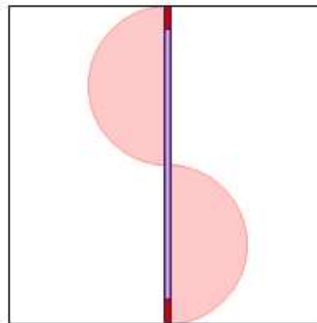
# How Do I Track a Satellite? Antenna Polarization

You must match the polarity of your antenna with that of the satellite – the better the match, the stronger the signal.

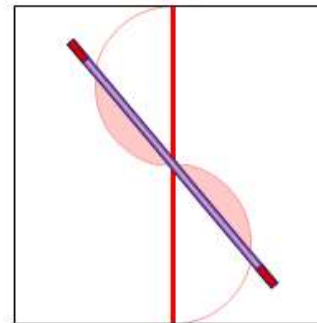
A linear mismatch will result in a loss from 0db (perfect match) to -20db (90 degrees out of phase).

Satellites tumble in orbit.

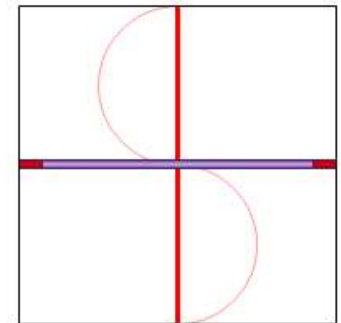
- Constantly check polarity.
- Tune in like “zero beating” a drifting signal.



Perfectly Aligned  
(0 dB loss)



Inefficient  
(6 dB loss)



Complete Signal Loss  
(-20 dB loss)

# What Do I Say? The QSO

Be Clear & Concise, Use Standard Phonetics

- You hear N9IP...
  - You:           N9IP, KE4AL EM71
  - Them           KE4AL, N9IP EN60, QSL?
  - You            QSL, KE4AL
- 
- Do NOT call CQ on FM satellites
  - If FM pass is quiet, okay to self announce – KE4AL EM71



# Working a Pass

## Preparation:

- Program your radio with the correct satellite frequencies, CTCSS.
- Use headphones to minimize feedback and enhance ability to hear.
- Have ability to record satellite pass audio for logging and review.
- Pick a satellite to work.
  - Know its Uplink and Downlink frequencies.
  - Recall the strategy for dealing with the Doppler Effect – The lower frequency is fixed. The higher frequency is adjusted.
- Pick a location where you have clear/best view of the horizon.



# Working a Pass

- Verify AOS, TCA and LOS azimuths and times.
- Open your radio's squelch.
- Tune your RX or TX to the AOS frequency.
- Start your recorder.
- Listen for the Satellite.
  - Do not transmit until you have acquired the satellite.
- When you hear others,
  - Listen for a call sign
  - When the break occurs, make your call:

November 9 India Papa,  
November Eight Hotel  
Mike, Fox Mike 1-8



# So, How Many Hands Does it Take?

- There's a lot of stuff that has to happen all at the same time:
  - Tracking the satellite with your antenna
  - Twisting antenna for strongest signal (polarization)
  - Frequency changes for doppler
  - Listening for call signs/locations
  - Pushing the PTT button
  - Talk,...Listen,...Talk,...Listen
  - Remembering who you talked to

**Don't Panic! Breathe!**

**You got this!**



# Operating Tips & Best Practices

## **LISTEN, LISTEN, LISTEN!**

- A great way to get started is just to listen to passes.
  - Practice acquiring and tracking satellite passes.
  - Get a feel for polarization changes (AO-91, AO-92, and SO-50).
  - Gain better understanding of doppler effect (SO-50).
  - Get a sense of QSO rhythm and techniques.
  - Challenge: Spot the bad operators. Learn from their mistakes.



# Operating Tips & Best Practices

- Use a small, directional beam, clear of obstructions.
- Use the least power necessary to complete the contact.
- Set your transmit and receive frequencies in memories to make tuning easier
- Select the 67.0 Hz CTCSS for transmit on FM birds.
- For receive, open your squelch all the way.
- Use headphones/earbuds to reduce feedback/echo
- Use a printout, smartphone, tablet, or laptop to track the satellite path
- Use an audio recorder to log the QSO
- Twist your antenna as the pass progresses for best received signal. When using crossed-yagis like an Arrow, twist the antenna 90-degrees when you switch from receive to transmit.



Q & A

Questions?

