Amateur Radio Satellites

AMSAT and an Introduction to Operation

Plano Amateur Radio Klub

May 18, 2020

Tom Schuessler, N5HYP

N5HYP – Driveway portable

Agenda

- Introduction to AMSAT
  - Current AMSAT Satellites
  - Future AMSAT Satellites
- 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
- More to do than just FM

About AMSAT

In the U.S., **The Radio Amateur Satellite Corporation**, or **AMSAT**, is a part of worldwide group of Amateur Radio Operators (Hams). It was formed in the District of Columbia in 1969 as an educational organization.

For over 50 years AMSAT groups in North America and elsewhere have played a key role in significantly advancing the state of the art in space science, space education, and space technology. The work now being done by AMSAT volunteers throughout the world will continue to have far-reaching, positive effects on the future of both Amateur Radio, as well as other governmental, scientific and commercial activities in Space – The Final Frontier.

AMSAT Mission

- AMSAT's goal is to foster Amateur Radio's participation in space research and communication. The Organization was founded to continue the efforts, begun in 1961, by Project OSCAR, a west coast USA-based group which built and launched the very first Amateur Radio satellite, OSCAR, on December 12, 1961, barely four years after the launch of Russia's first Sputnik.
- Today, the "home-brew" flavor of these early Amateur Radio satellites lives on, as most of the hardware and software now flying on even the most advanced AMSAT satellites is still largely the product of volunteer effort and donated resources.
- Though we are fond of traditions our designs and technology continue to push the outside of the envelope.

AMSAT's Current Operating Satellites

AO-7 launched November 15, 1974 by a Delta 2310 launcher

AO-85 (Fox-1A) launched on NASA ELaNa flight on October 8, 2015.

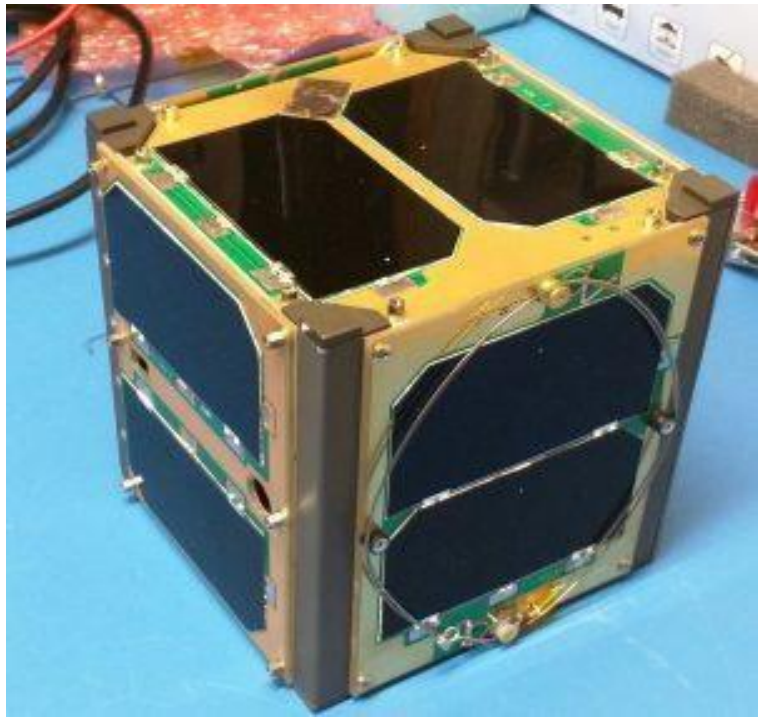
AO-91 (Fox-1B/RadFxSat) launched by a Delta II on November 18, 2017

AO-92 (Fox-1D) launched aboard Indian PSLV-C40 on January 12, 2018

AO-95 (Fox-1Cliff) launched via SpaceX Falcon 9 on December 4, 2018

Fox-1 [A,B,C,D,E] Satellite Overview

- 1u CubeSat 10x10x10cm (4 inch cube)
  - Standardized Space Frame
  - Fixed Solar Panels
  - Deployable Antenna
- Low Earth Orbit (LEO)
  - Nominal 600- 800 km, circular, depending on launcher.
- Single channel FM transponder; Mode U/v
- Fox-1C and D include L-Band “downshifter” Mode L/v
- 500 mW EIRP
- Experiments
  - Radiation/Gyroscope/Camera
- Data Under Voice (DUV) FSK telemetry



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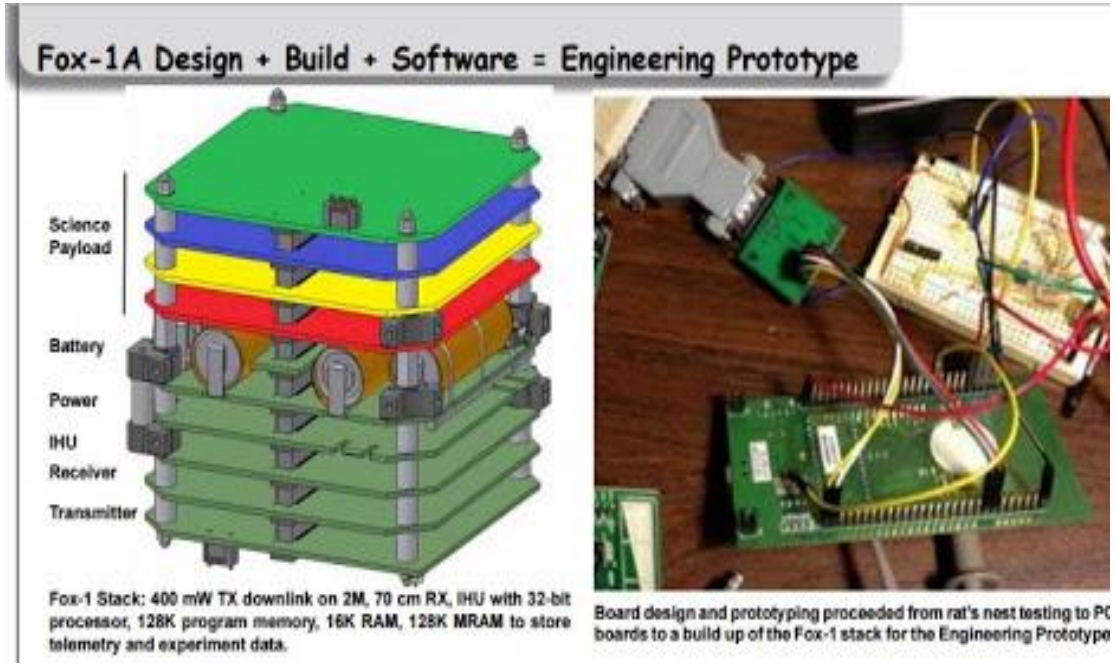

AMSAT's Upcoming Satellites

Fox-1E (RadFxSat-2)

- Final in Fox-1, 1u cubesat series; linear transponder.
- Launch via Virgin Galactic LauncherOne ~ 2020.

GOLF Tee

- Will serve as testbed for future missions and include Fox-1E linear transponder + new "five and dime" 5 GHz uplink / 10 GHz downlink SDR transponder, with a launch as early as the fourth quarter of 2019.

GOLF

- Will aim for higher LEO orbit as the first official "Greater Orbit, Larger Footprint" AMSAT CubeSat. Launch is targeted for 2020-2021.

AMSAT cooperative opportunities

Push to get Amateur Radio on every Cubesat.

AMSAT is offering a free board stack of Transmitter/Receiver/IHU to any university who wants it for their communications payload in return for eventual full time Amateur Radio use.

University of Washington's HuskySat-1 is the first such payload.

Currently on-orbit.
Transponder just released for Amateur radio use..

Join AMSAT

Membership includes the AMSAT® Journal and discounts on purchases made through the AMSAT store. Membership also supports many AMSAT activities including:

- OSCAR satellite operations
- Amateur Radio on the ISS
- Educational support
- Hamfest forums
- Beginner materials
- Technical achievement awards
- Future satellites

https://www.amsat.org/join-amsat/

Getting Started on FM Satellites

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.

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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

Types of amateur radio satellites include:

- FM Repeaters
- Linear Transponders (SSB/CW)
- Digital (Packet, BPSK, PSK31, etc..)
- Specialty modes (Digital Voice, 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!

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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

Arrow II Satellite Yagi Antenna

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- 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

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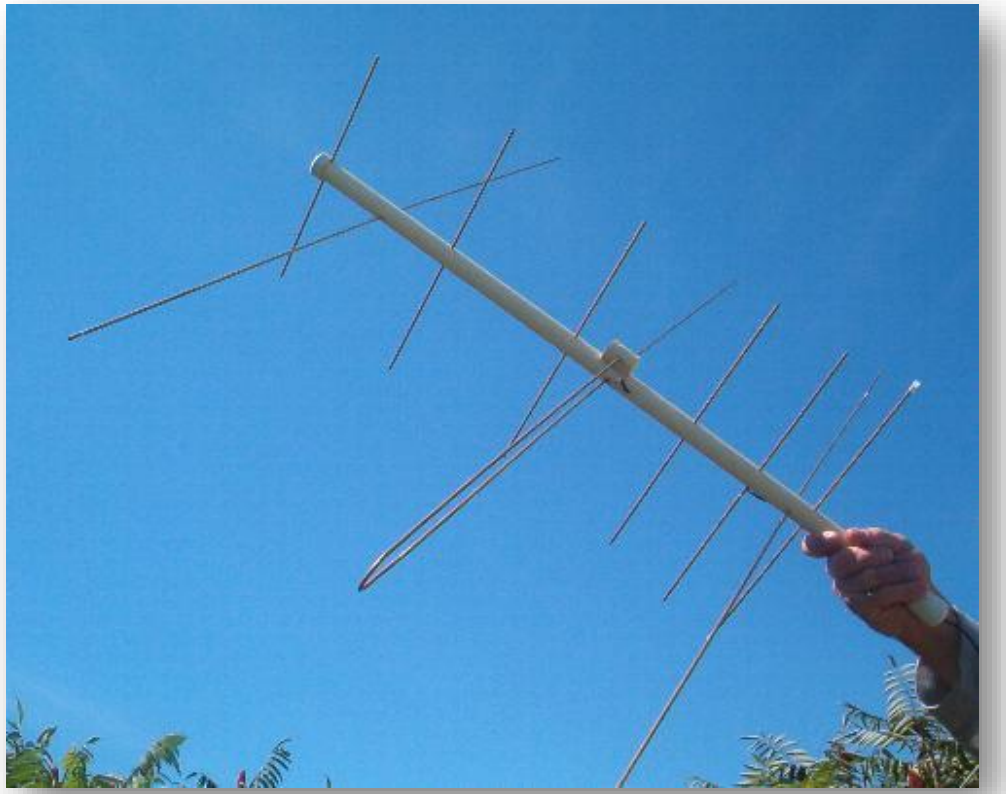
What Equipment Do I Need? Antennas

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



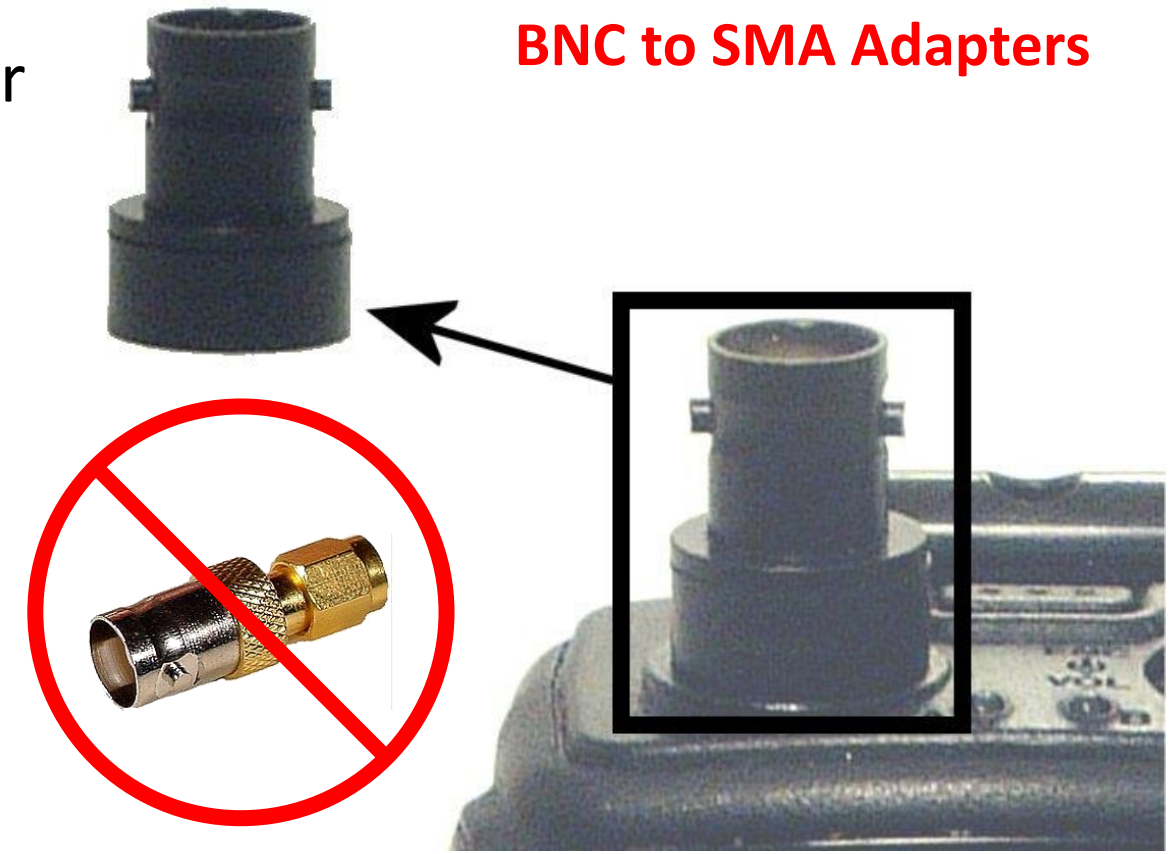
What Equipment Do I Need? Antennas

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

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.



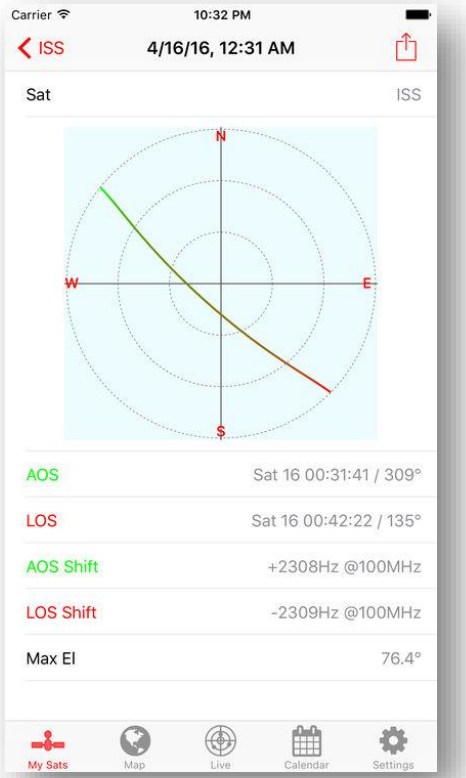
What Other Equipment Do I Need?

How Do I Know Where the Satellites Are?

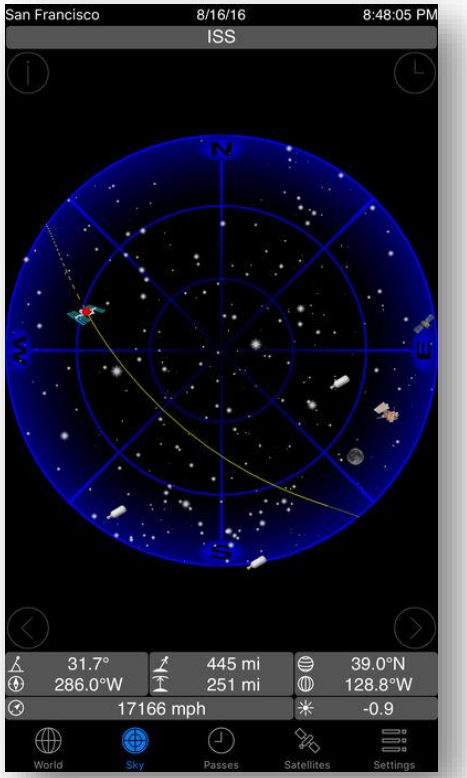
- Satellite tracking apps/software provide critical information
  - AOS Time and Azimuth
  - TCA Time, Azimuth and Elevation
  - LOS Time and Azimuth
  - Graphical representation of satellite pass and satellite footprint
- Satellite tracking software includes both rig and rotor control
- AMSAT provides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

Satellite Pass Prediction/Tracking Apps

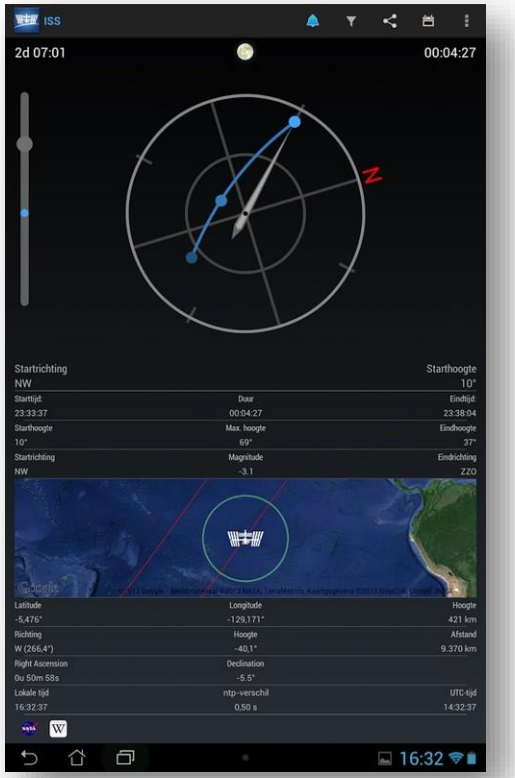
SatSat



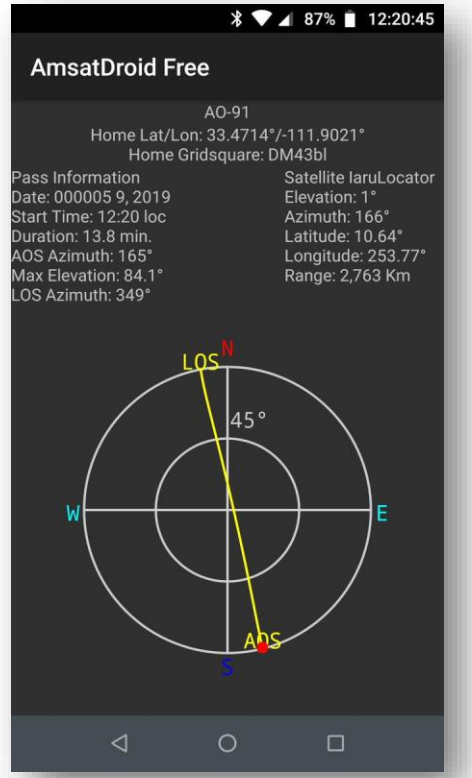
GoSat Watch



ISS Detector

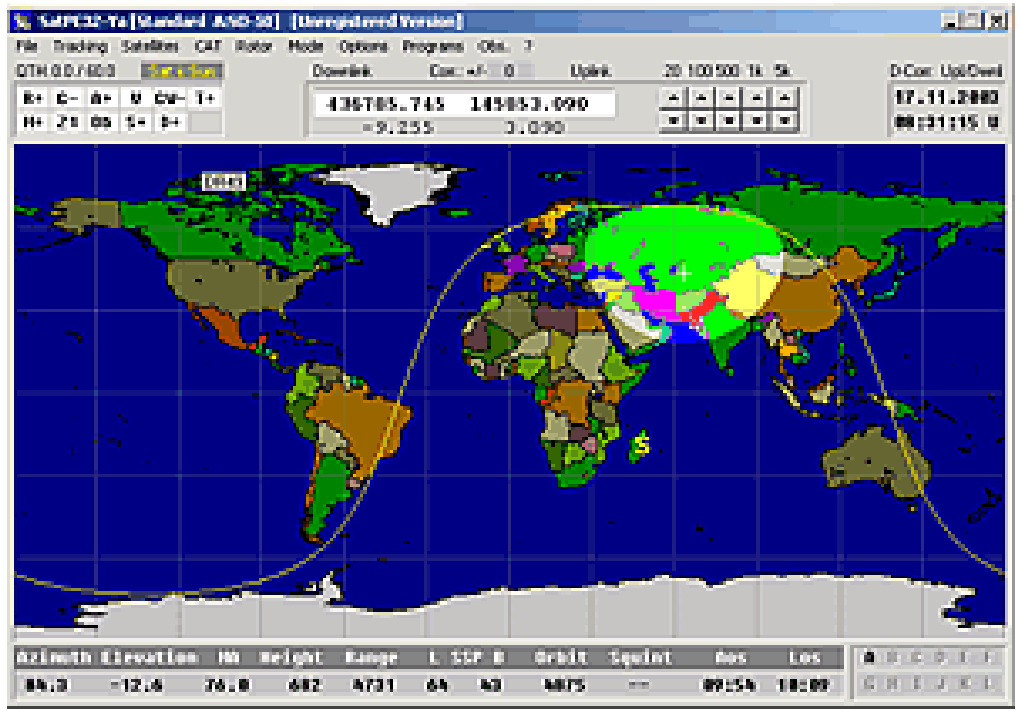


AMSAT Droid Free

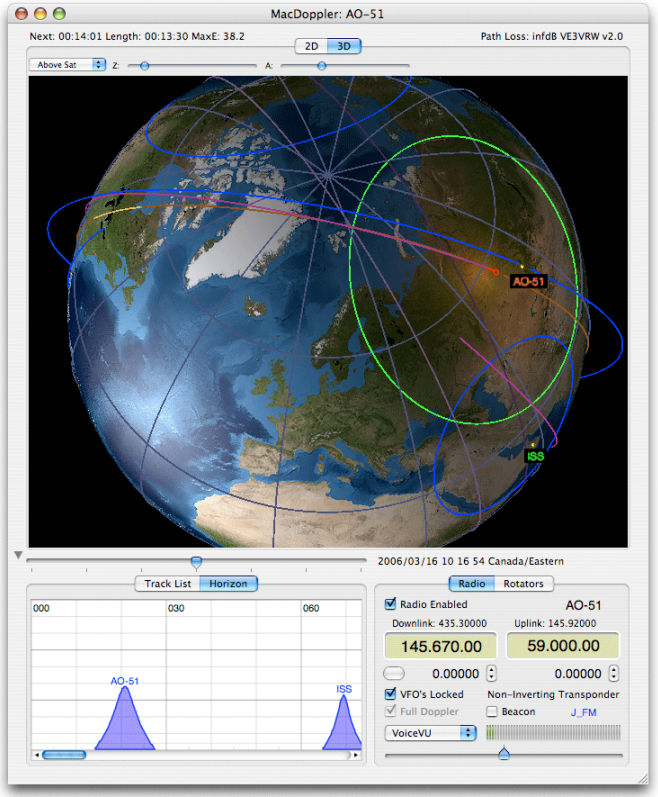


Satellite Pass Prediction/Tracking Software

Windows – SatPC32



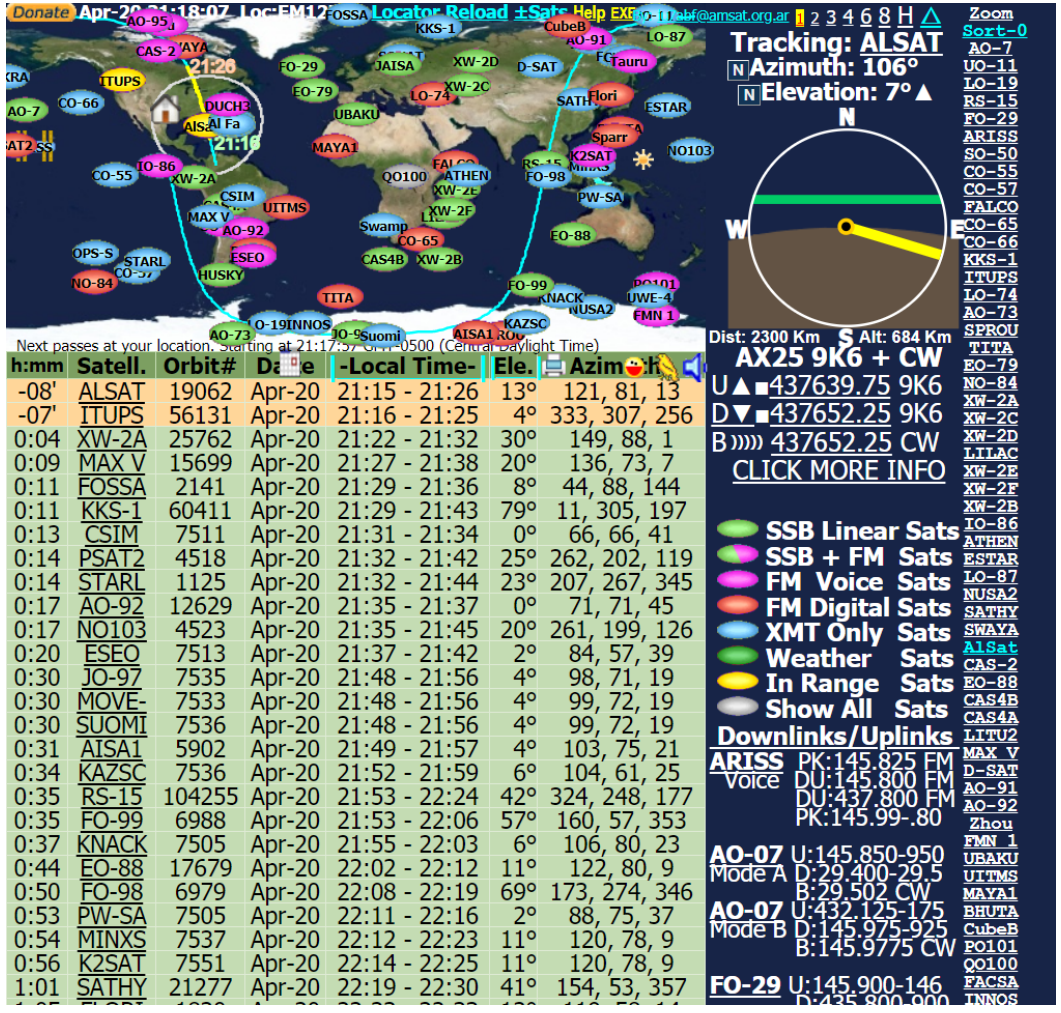
MacOS/OSX – MacDoppler



Satellite Pass Prediction/Tracking Websites

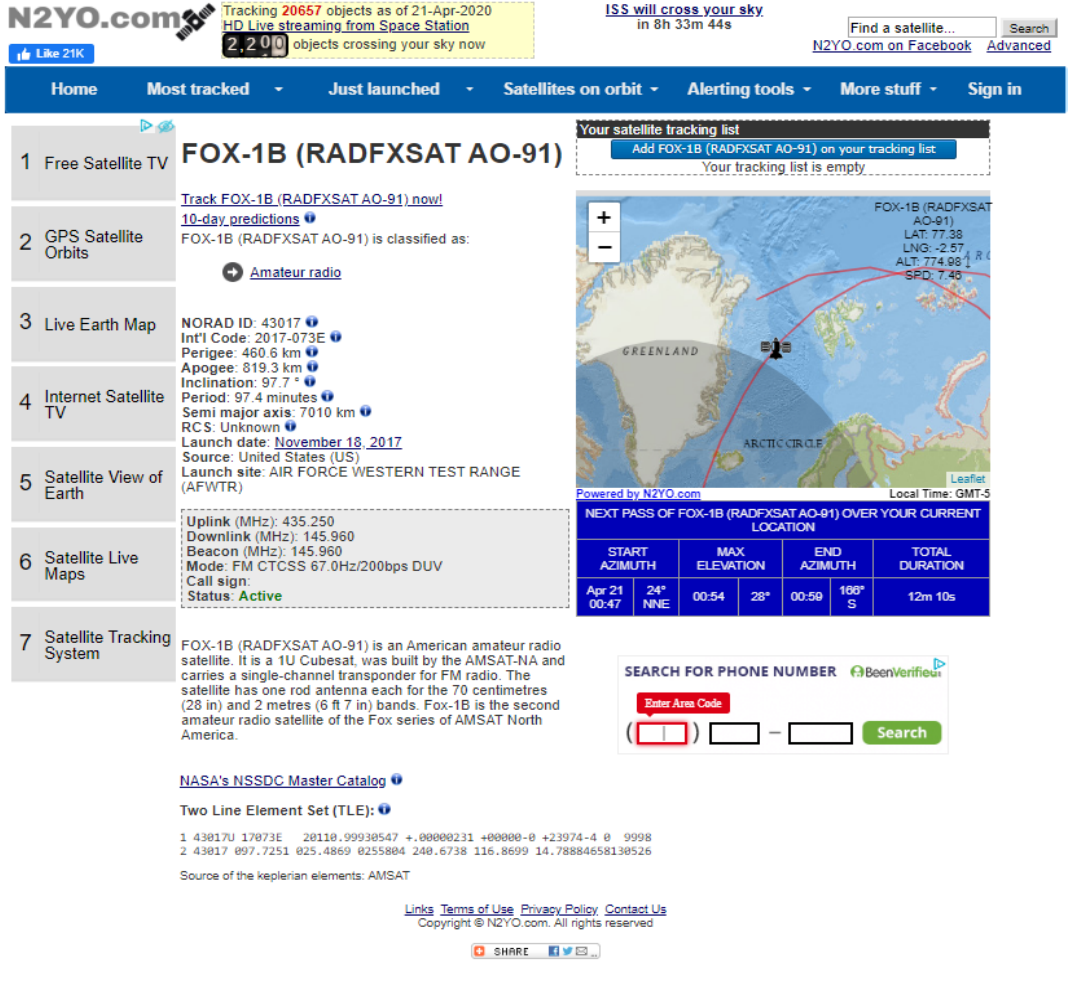
AMSAT Argentina's PASS

http://amsat.org.ar/pass.htm#



h:mm	Satell.	Orbit#	Date	-Local Time-	Ele.	Azimuth
-08'	ALSAT	19062	Apr-20	21:15 - 21:26	13°	121, 81, 13
-07'	ITUPS	56131	Apr-20	21:16 - 21:25	4°	333, 307, 256
0:04	XW-2A	25762	Apr-20	21:22 - 21:32	30°	149, 88, 1
0:09	MAX V	15699	Apr-20	21:27 - 21:38	20°	136, 73, 7
0:11	FOSSA	2141	Apr-20	21:29 - 21:36	8°	44, 88, 144
0:11	KKS-1	60411	Apr-20	21:29 - 21:43	79°	11, 305, 197
0:13	CSIM	7511	Apr-20	21:31 - 21:34	0°	66, 66, 41
0:14	PSAT2	4518	Apr-20	21:32 - 21:42	25°	262, 202, 119
0:14	STARL	1125	Apr-20	21:32 - 21:44	23°	207, 267, 345
0:17	AO-92	12629	Apr-20	21:35 - 21:37	0°	71, 71, 45
0:17	NO103	4523	Apr-20	21:35 - 21:45	20°	261, 199, 126
0:20	ESEO	7513	Apr-20	21:37 - 21:42	2°	84, 57, 39
0:30	JO-97	7535	Apr-20	21:48 - 21:56	4°	98, 71, 19
0:30	MOVE-	7533	Apr-20	21:48 - 21:56	4°	99, 72, 19
0:30	SUOMI	7536	Apr-20	21:48 - 21:56	4°	99, 72, 19
0:31	AISA1	5902	Apr-20	21:49 - 21:57	4°	103, 75, 21
0:34	KAZSC	7536	Apr-20	21:52 - 21:59	6°	104, 61, 25
0:35	RS-15	104255	Apr-20	21:53 - 22:24	42°	324, 248, 177
0:35	FO-99	6988	Apr-20	21:53 - 22:06	57°	160, 57, 353
0:37	KNACK	7505	Apr-20	21:55 - 22:03	6°	106, 80, 23
0:44	EO-88	17679	Apr-20	22:02 - 22:12	11°	122, 80, 9
0:50	FO-98	6979	Apr-20	22:08 - 22:19	69°	173, 274, 346
0:53	PW-SA	7505	Apr-20	22:11 - 22:16	2°	88, 75, 37
0:54	MINXS	7537	Apr-20	22:12 - 22:23	11°	120, 78, 9
0:56	K2SAT	7551	Apr-20	22:14 - 22:25	11°	120, 78, 9
1:01	SATHY	21277	Apr-20	22:19 - 22:30	41°	154, 53, 357

https://www.n2yo.com/



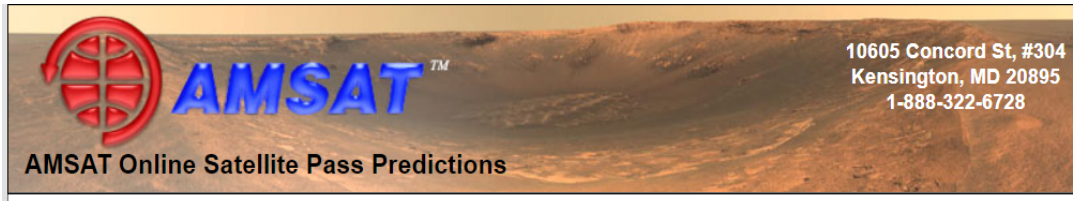
Satellite Pass Prediction/Tracking Websites

AMSAT Pass prediction page, text based

https://www.amsat.org/track/index.php

A simple but very effective way to find out when satellites of interest will be visible over your location.

All you need to know is longitude and latitude or maidenhead grid square.



AMSAT Online Satellite Pass Predictions - AO-92

View the current location of AO-92

Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)
21 Apr 20	04:03:15	00:11:18	157	49	56	355	04:14:33
21 Apr 20	05:38:50	00:07:43	225	7	268	312	05:46:33
21 Apr 20	15:37:20	00:07:16	51	5	77	131	15:44:36
21 Apr 20	17:09:10	00:11:21	7	58	268	200	17:20:31
21 Apr 20	18:45:53	00:03:25	315	1	302	280	18:49:18
22 Apr 20	03:42:05	00:10:43	143	25	81	3	03:52:48
22 Apr 20	05:16:07	00:09:49	206	14	270	325	05:25:56
22 Apr 20	16:47:37	00:11:23	15	63	115	186	16:59:00
22 Apr 20	18:22:41	00:07:20	335	6	291	253	18:30:01
23 Apr 20	03:21:14	00:09:36	127	14	63	12	03:30:50

Your results are shown above

Use the form below to request more pass predictions

Show Predictions for: AO-92 for Next 10 Passes

Calculate Latitude and Longitude from Gridsquare: em12ms Calculate Position

Or

Enter Decimal Latitude:* 32.7709 North

Enter Decimal Longitude:* 96.9583 West

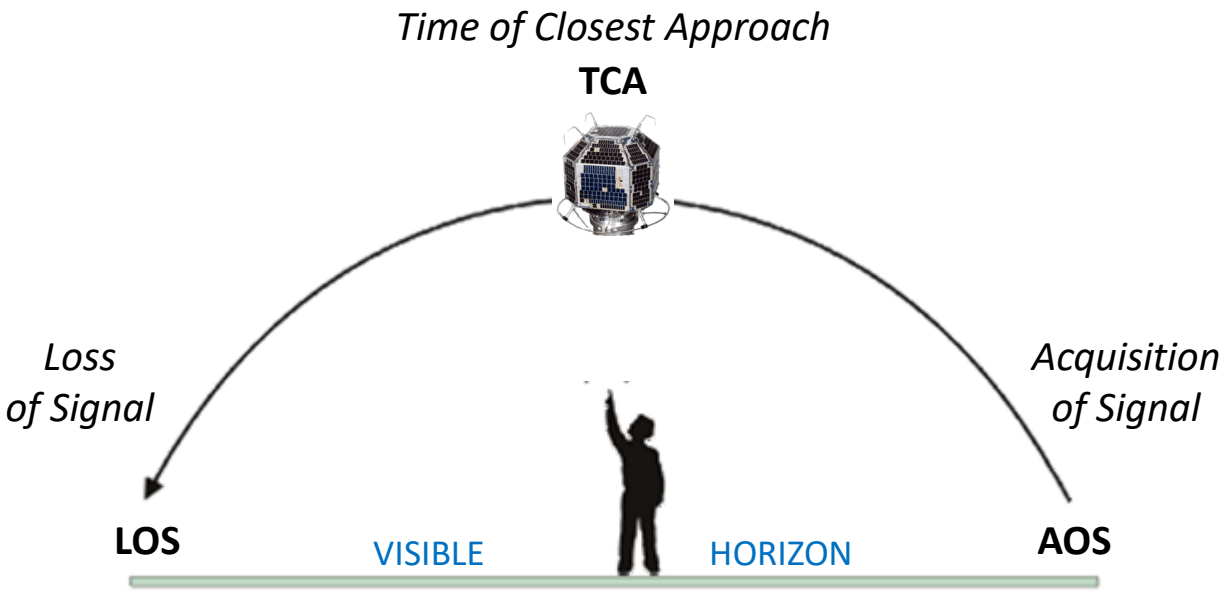
Elevation in meters AMSL: 0

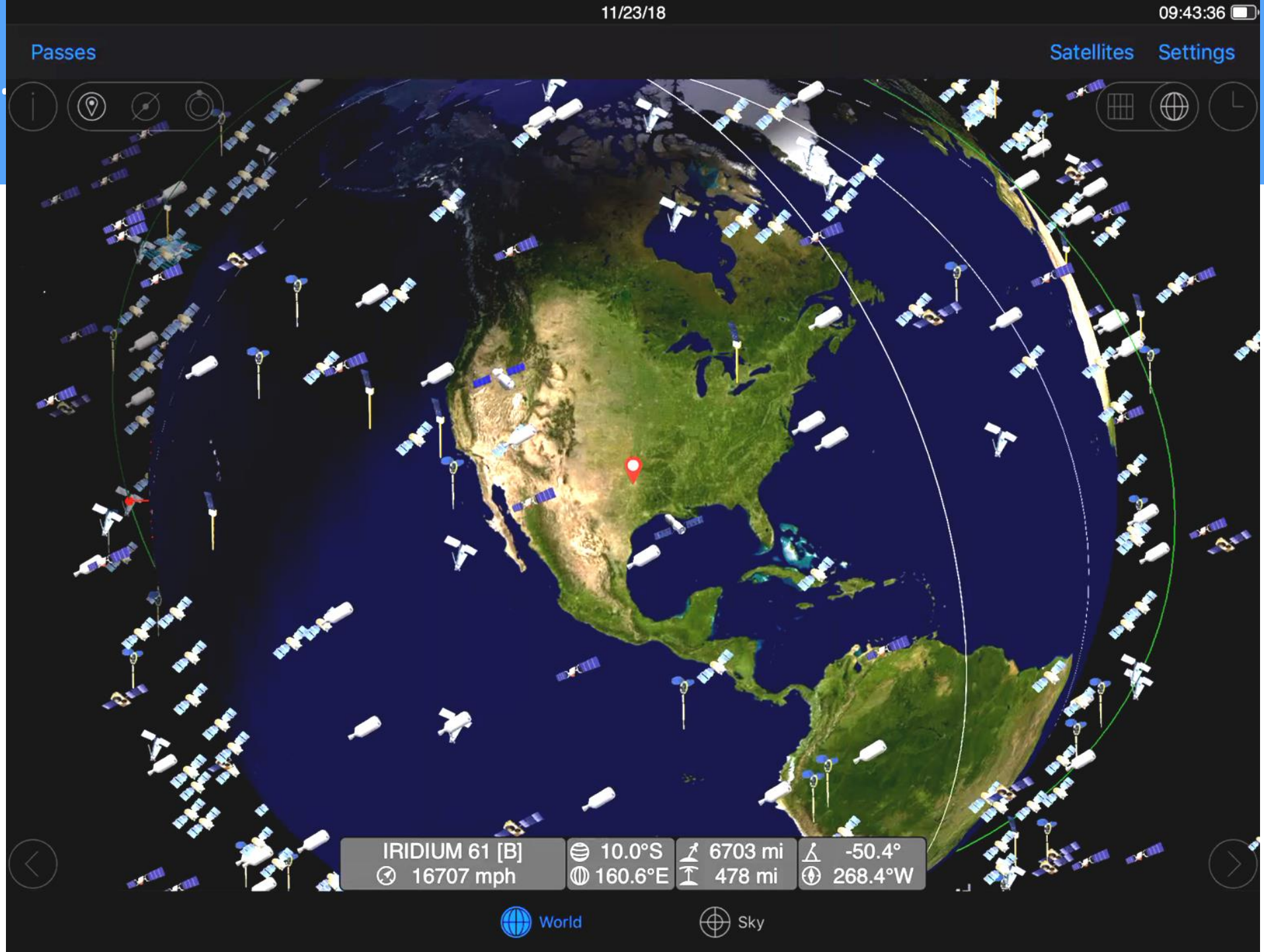
Predict

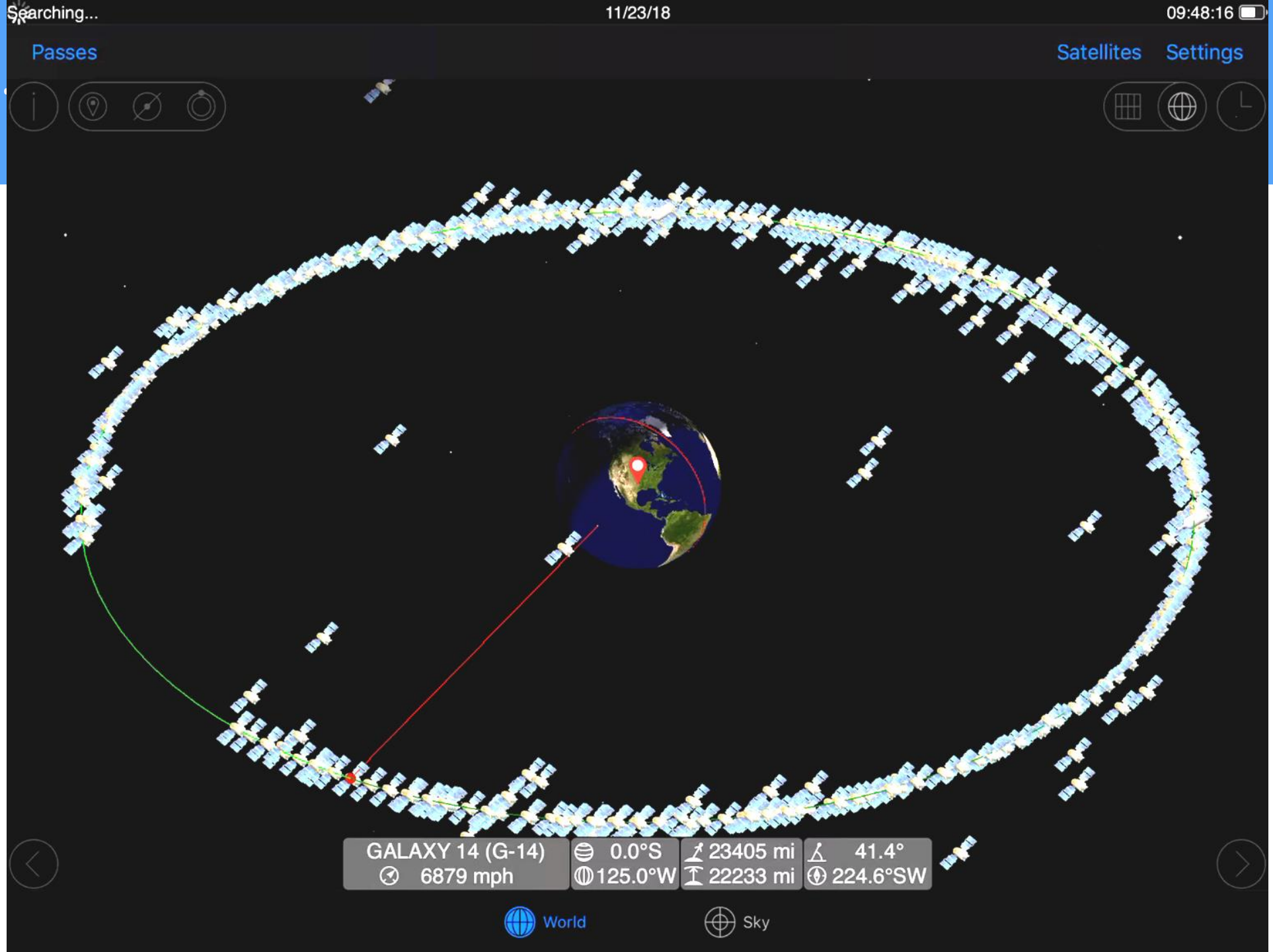
Terminology

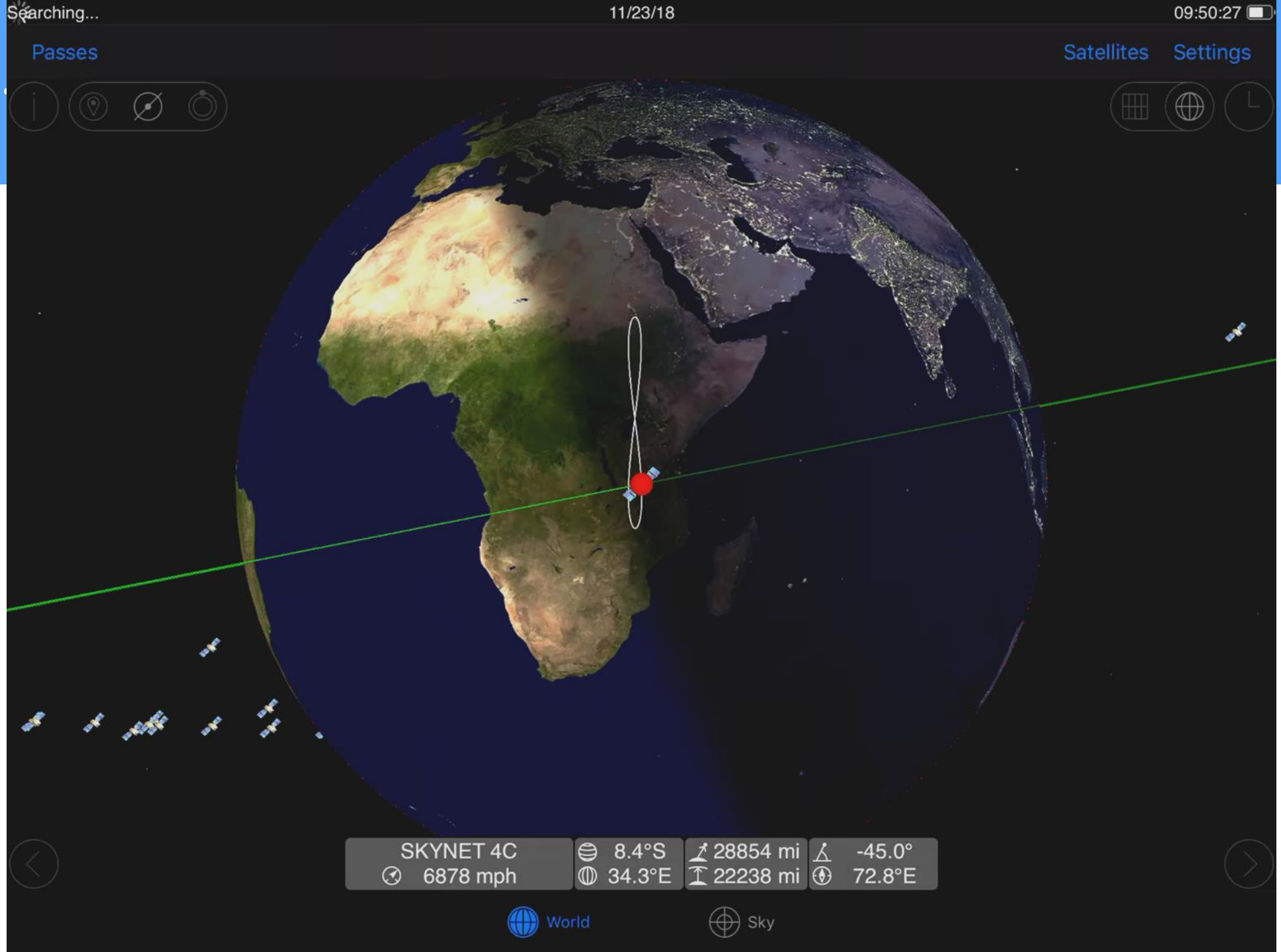
The Pass

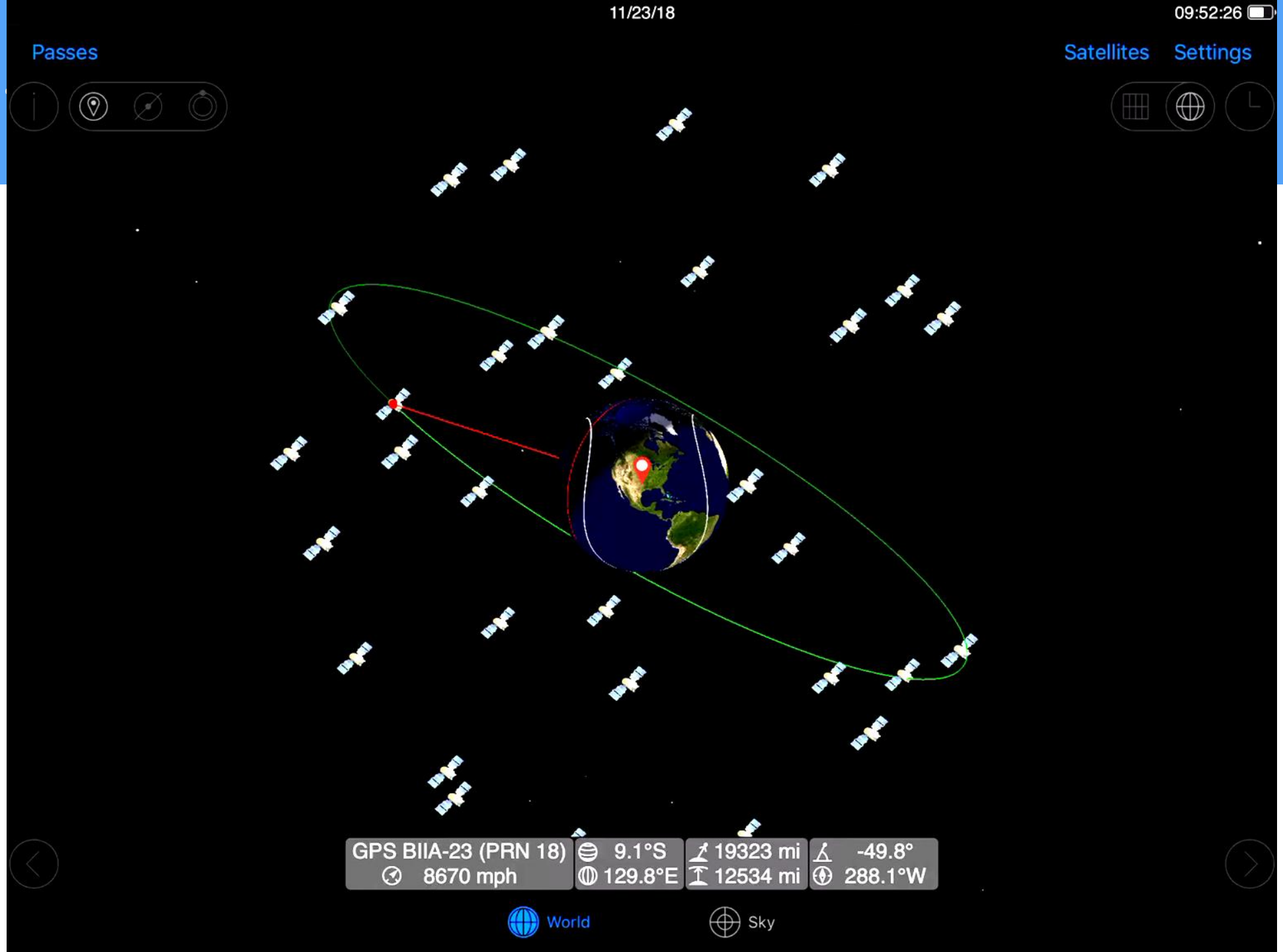
- The time a satellite is visible (in range) to a ground station is called a satellite "**pass**."
- During a pass, you are in "**footprint**" – line of sight with the satellite.
- The altitude of the satellite above the Earth determines the length of the pass or "**time on station**" (typically 4-12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




11/23/18
09:43:36
Passes
Satellites
Settings
IRIDIUM 61 [B]
16707 mph
10.0°S
160.6°E
6703 mi
478 mi
-50.4°
268.4°W
World
Sky


Searching...
11/23/18
09:48:16
Passes
Satellites
Settings
GALAXY 14 (G-14)
6879 mph
0.0°S
125.0°W
23405 mi
22233 mi
41.4°
224.6°SW
World
Sky


Searching...
11/23/18
09:50:27
Passes
Satellites
Settings
SKYNET 4C
6878 mph
8.4°S
34.3°E
28854 mi
22238 mi
-45.0°
72.8°E
World
Sky



AMATEUR RADIO IN SPACE
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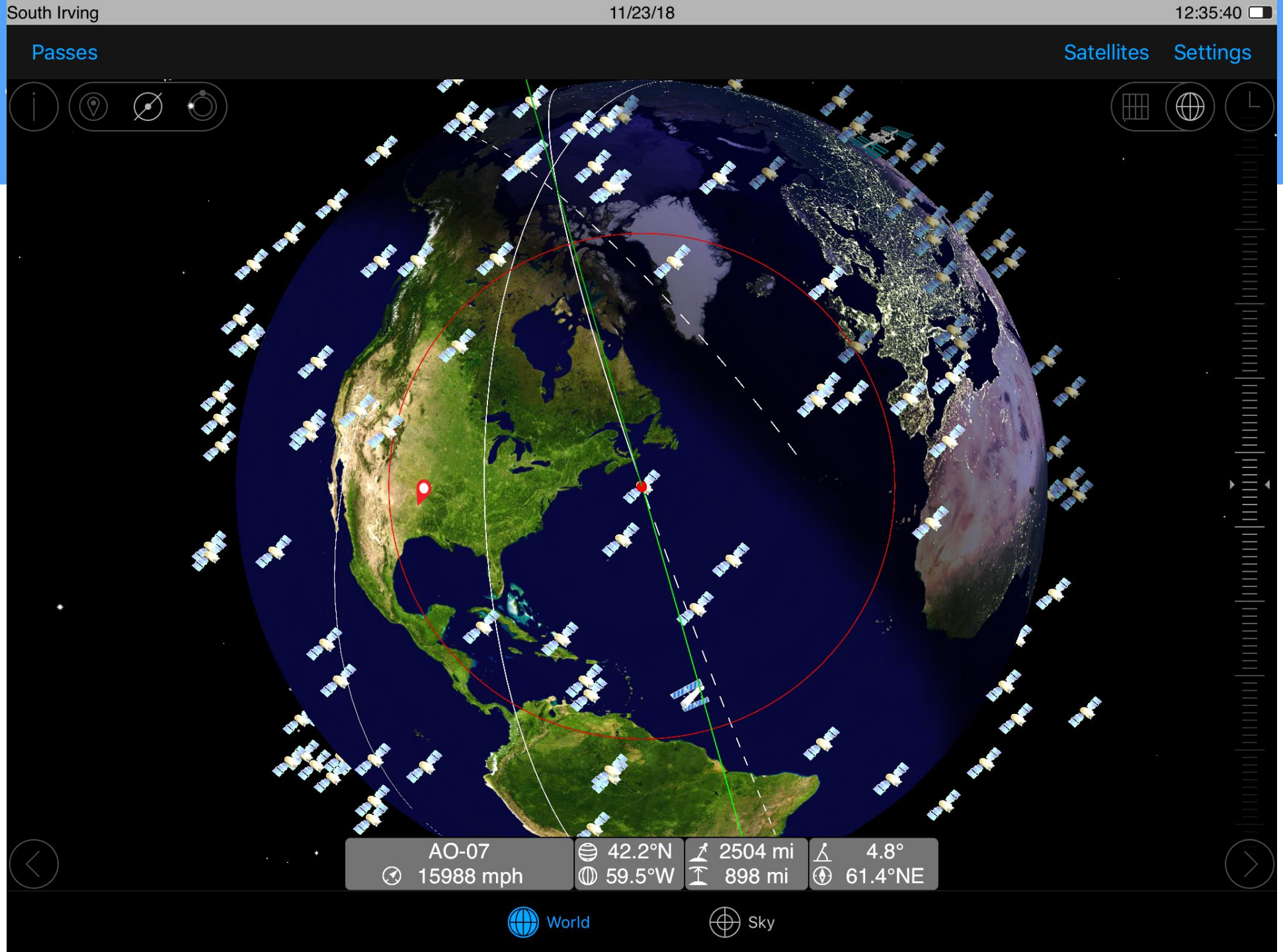

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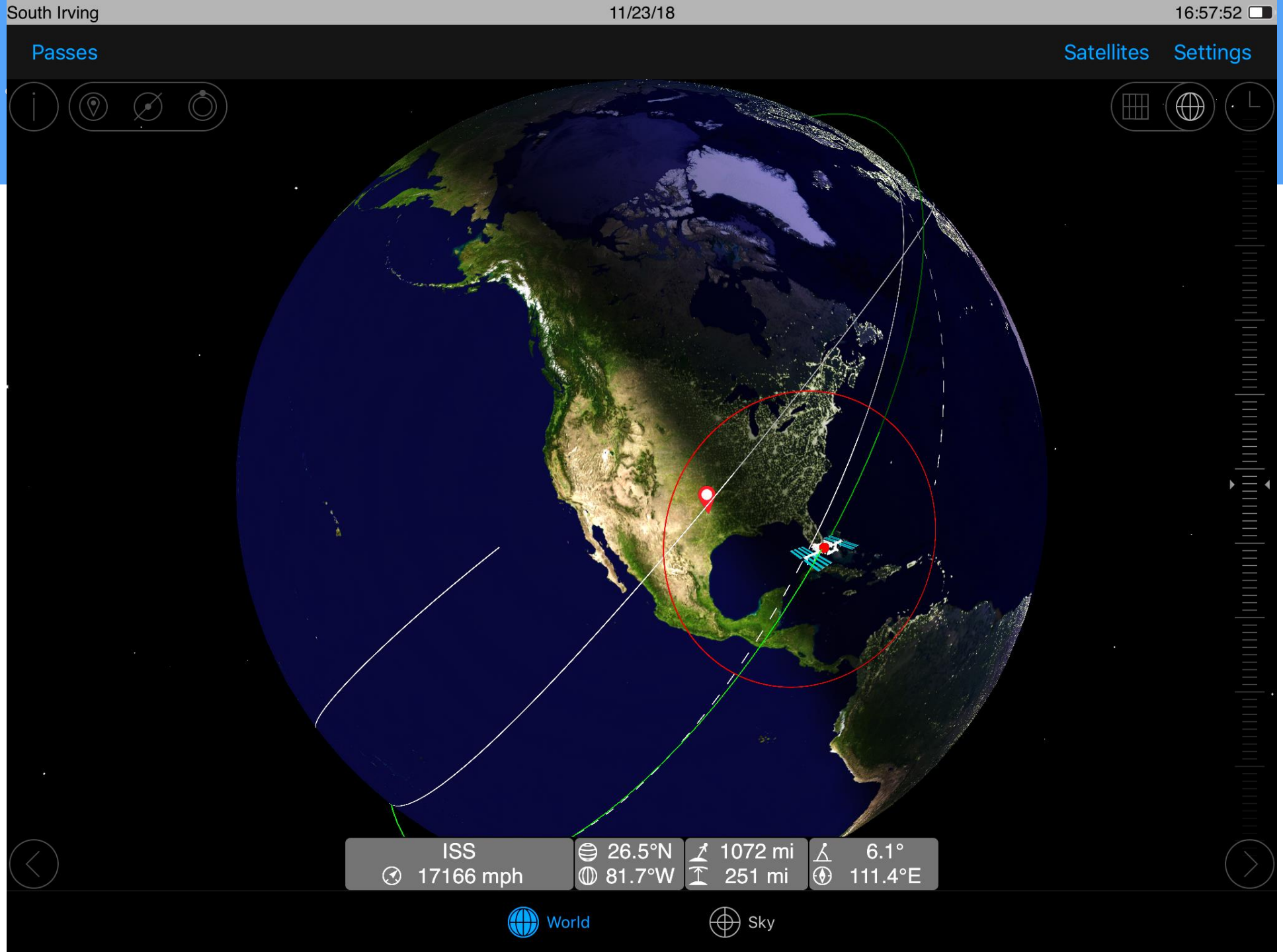

AMATEUR RADIO IN SPACE
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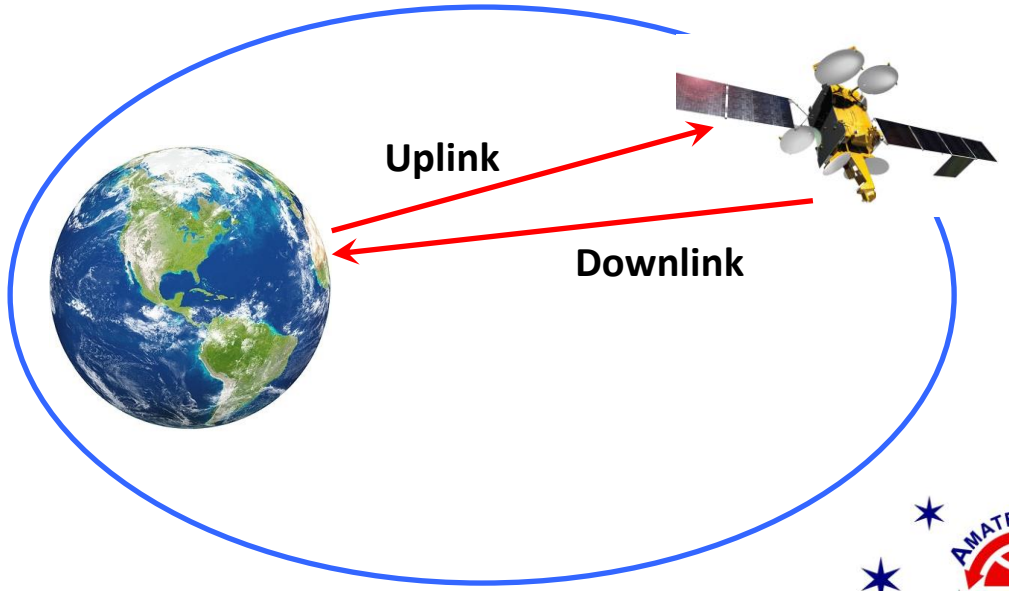
Uplink & Downlink

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.

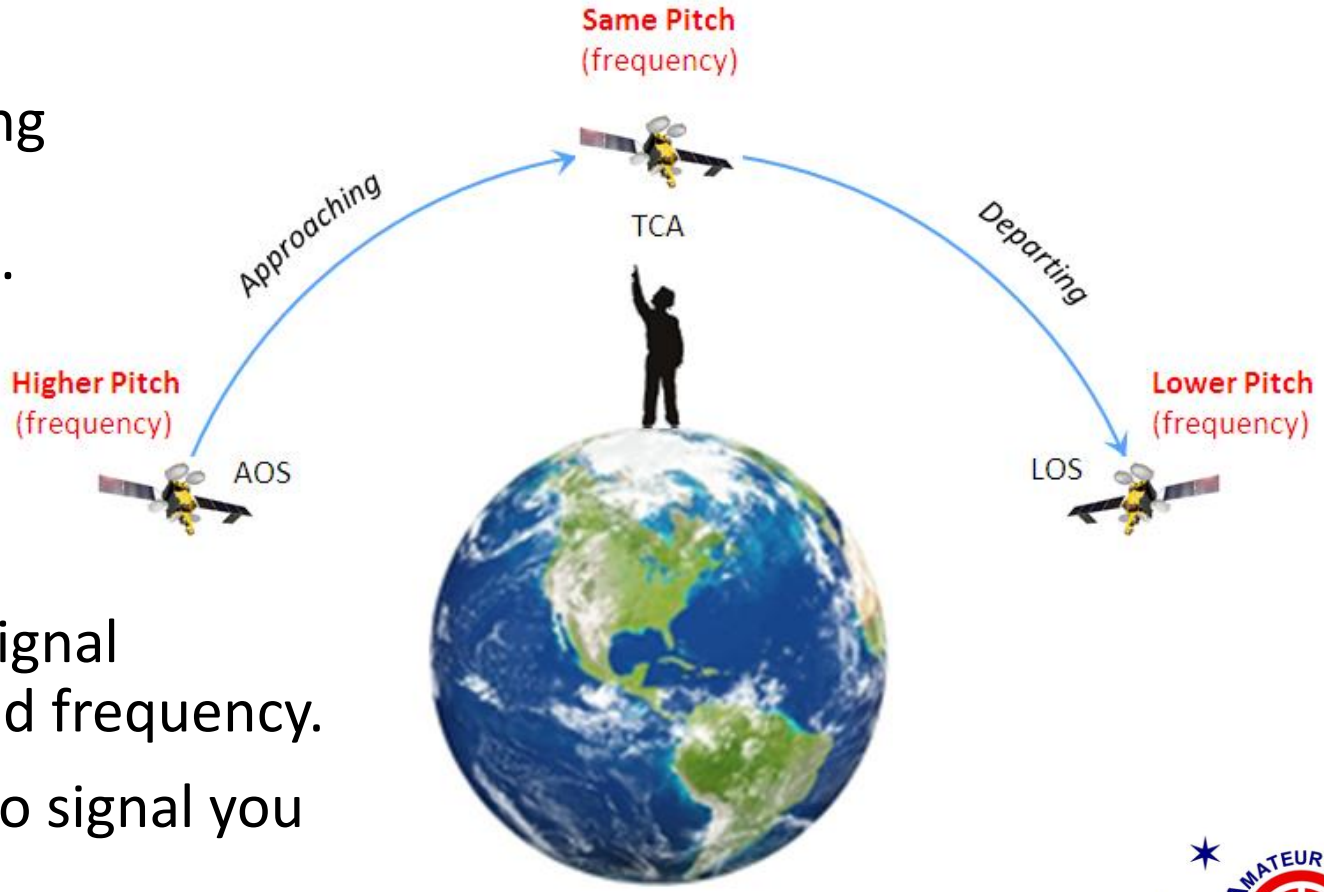
- Uplink
  - Frequency/information going to the Satellite.
- Downlink
  - Frequency/information coming from the Satellite.



Doppler Effect

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

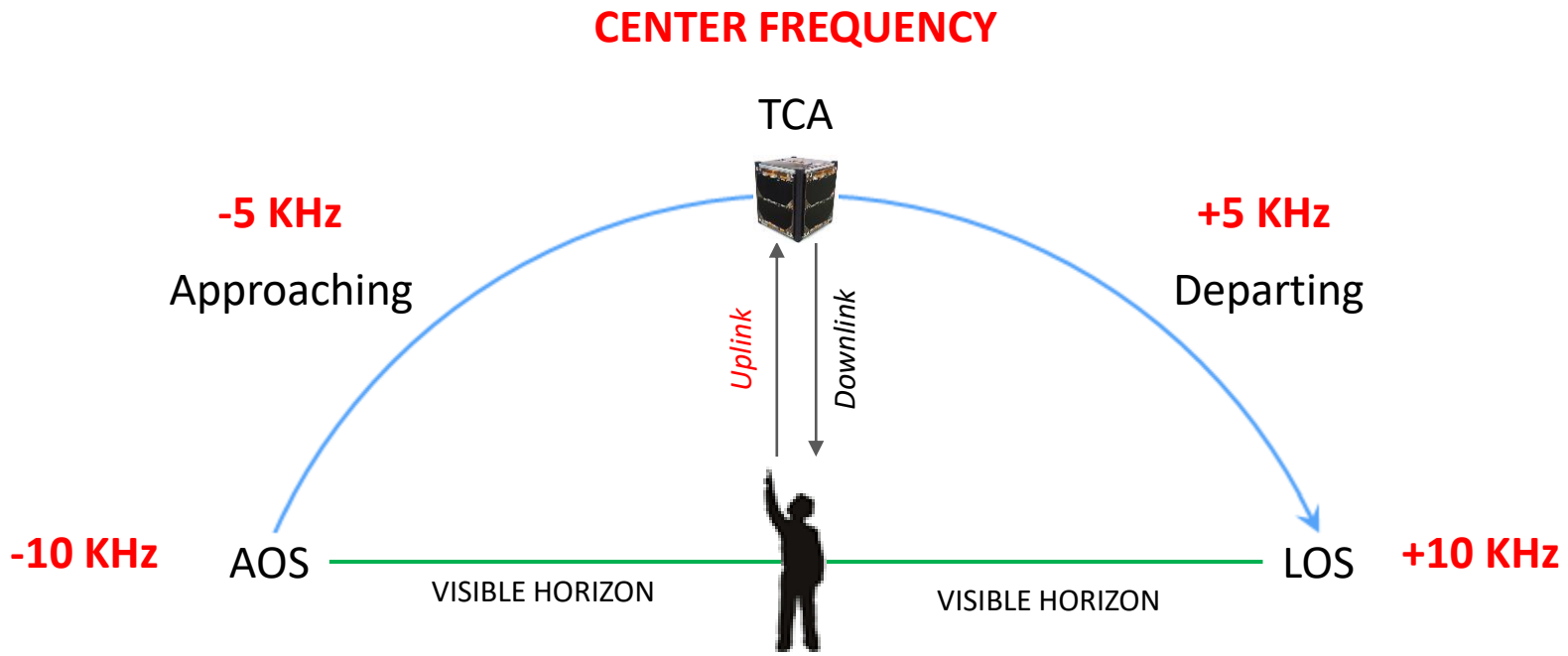
Just like a train whistle



- 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.

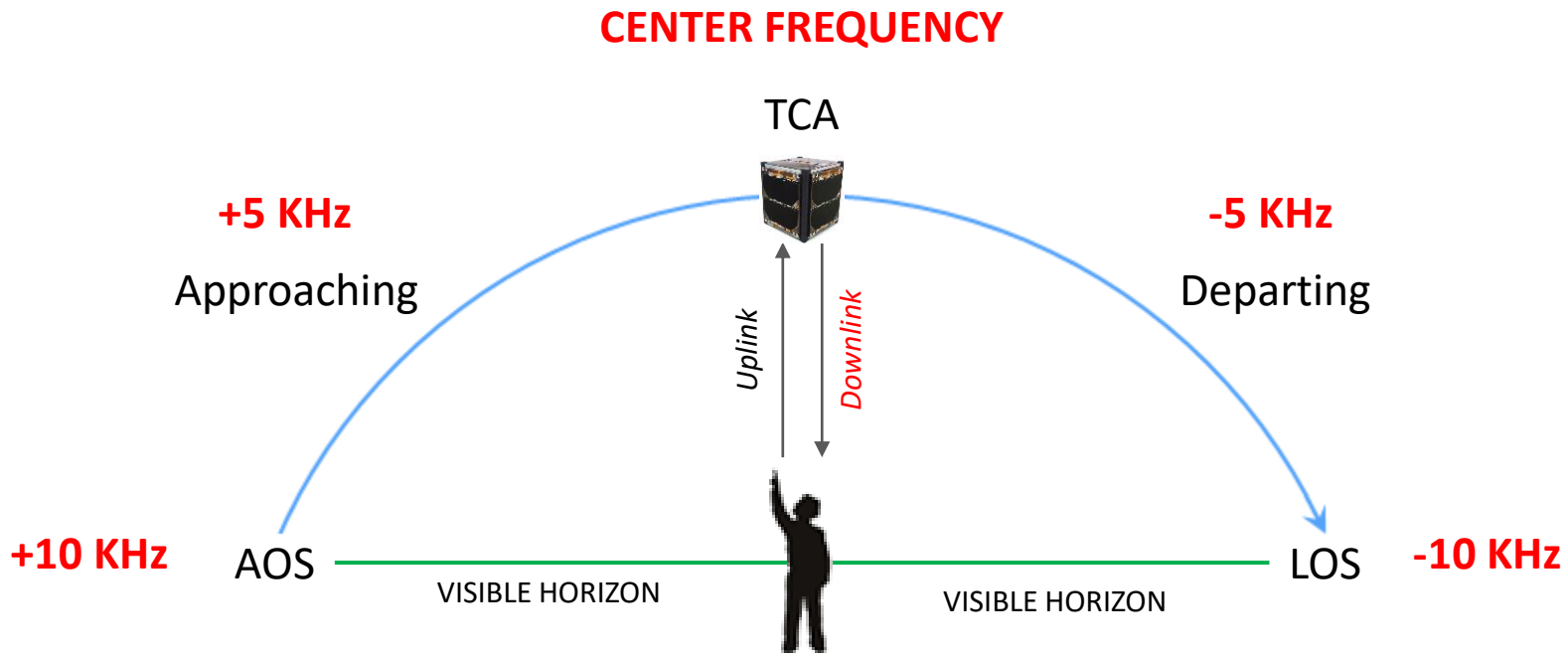
Doppler Correction – U/v Satellites

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

Fox-1D
AO-92

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

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

Downwlink	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: AO-92

- AMSAT with Penn State, VA Tech, Univ IA
- Launched January 12, 2018
- 98 Degree Inclination
- Elliptical Orbit: 490 km X 504 km
- Mode U/v & L/v FM Repeater
- 435.350 MHz Uplink
- 1267.350 MHz Uplink
- 145.880 MHz Downlink
- 67.0 Hz CTCSS on UL (Continuous)
- Digital Under Voice (DUV) Telemetry
- Use FoxTelem to Decode

Downlink	145.880 – 145.885	
AOS (Mem 1)	435.340	-10
Approaching (Mem 2)	435.345	-5
TCA (Mem 3)	435.350	—
Departing (Mem 4)	435.355	+5
LOS (Mem 5)	435.360	+10

67 Hz CTCSS

The FM Birds: SO-50

- Built 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
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	

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The FM Birds: PO-101 (Diwata-2)

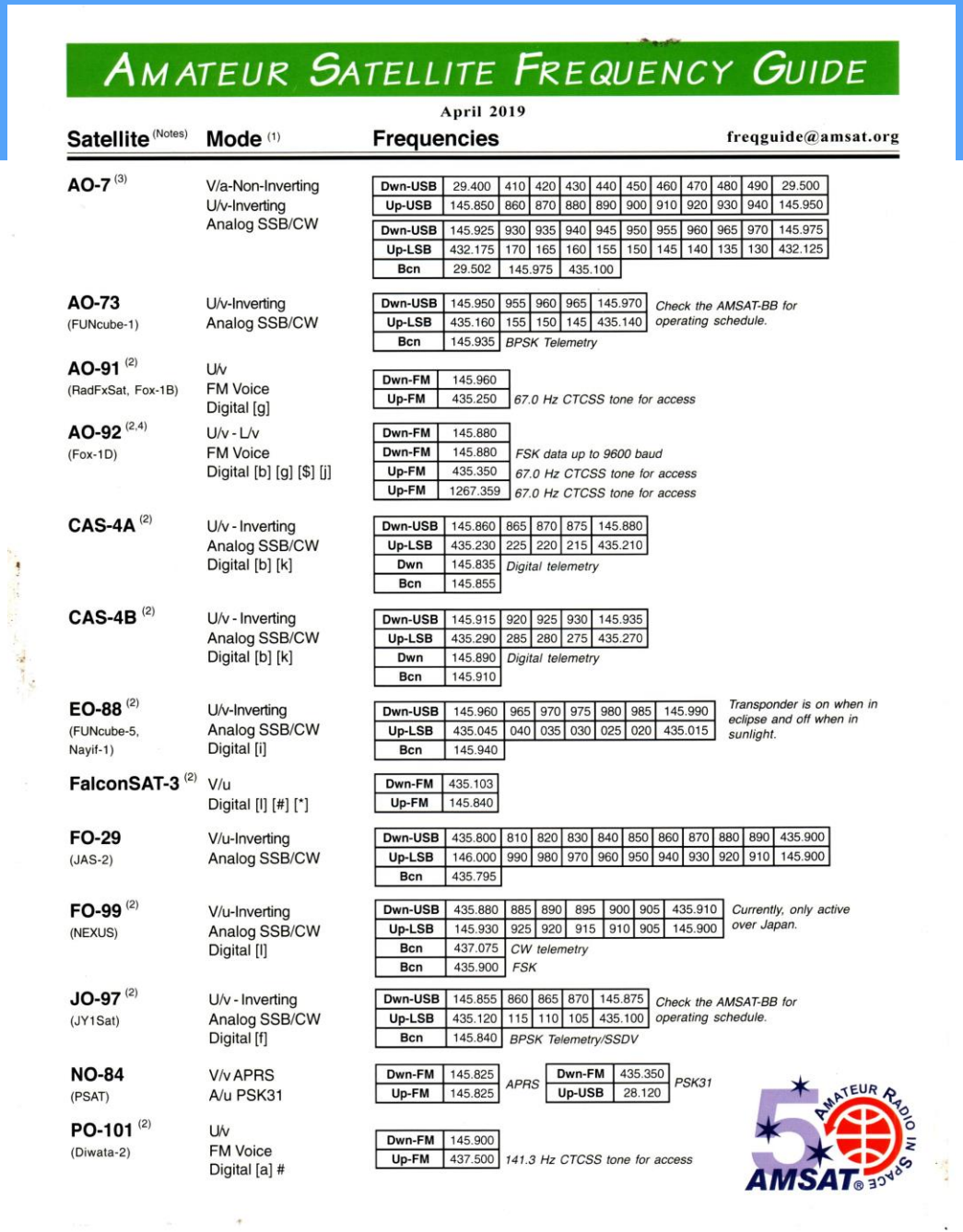
- Joint project between Philippine universities and private industry
- Launched October 29, 2018
- 98 Degree Inclination
- Elliptical Orbit: 529 km X 607 km
- Mode U/v FM & APRS
- 437.500 MHz Uplink
- 145.900 MHz Downlink
- 141.3 Hz CTCSS on UL (Continuous)
- Operations are on a schedule

PO-101 (Diwata-2)			
	Uplink FM (141.3 Hz CTCSS)	Downlink FM	Comments
PO-101 (Diwata-2)	437.500 MHz	145.900 MHz	Operational
FM transponder activated by schedule. The Amateur Radio Unit can operate either as an FM transponder or APRS digipeater. See https://twitter.com/Diwata2PH for schedule. For more details, see http://phl-microsat.upd.edu.ph/diwata2			

For a listing of active and future FM satellites with their frequencies and notes, go to; https://www.amsat.org/fm-satellite-frequency-summary/

Your handy guide.

- AMSAT updates annually, a laminated frequency chart which shows all active and some proposed satellites.
- Available at the AMSAT web store or at a nearby Hamfest.



AMATEUR SATELLITE FREQUENCY GUIDE

April 2019

freqguide@amsat.org

Satellite (Notes)	Mode (1)	Frequencies
AO-7 (3)	V/a-Non-Inverting U/v-Inverting Analog SSB/CW	Dwn-USB 29.400 410 420 430 440 450 460 470 480 490 29.500 Up-USB 145.850 860 870 880 890 900 910 920 930 940 145.950 Dwn-USB 145.925 930 935 940 945 950 955 960 965 970 145.975 Up-LSB 432.175 170 165 160 155 150 145 140 135 130 432.125 Bcn 29.502 145.975 435.100
AO-73 (FUNcube-1)	U/v-Inverting Analog SSB/CW	Dwn-USB 145.950 955 960 965 145.970 Up-LSB 435.160 155 150 145 435.140 Bcn 145.935 *BPSK Telemetry* *Check the AMSAT-BB for operating schedule.*
AO-91 (2) (RadFxSat, Fox-1B)	U/v FM Voice Digital [g]	Dwn-FM 145.960 Up-FM 435.250 *67.0 Hz CTCSS tone for access*
AO-92 (2,4) (Fox-1D)	U/v - L/v FM Voice Digital [b] [g] [$] [j]	Dwn-FM 145.880 Dwn-FM 145.880 *FSK data up to 9600 baud* Up-FM 435.350 *67.0 Hz CTCSS tone for access* Up-FM 1267.359 *67.0 Hz CTCSS tone for access*
CAS-4A (2)	U/v - Inverting Analog SSB/CW Digital [b] [k]	Dwn-USB 145.860 865 870 875 145.880 Up-LSB 435.230 225 220 215 435.210 Dwn 145.835 *Digital telemetry* Bcn 145.855
CAS-4B (2)	U/v - Inverting Analog SSB/CW Digital [b] [k]	Dwn-USB 145.915 920 925 930 145.935 Up-LSB 435.290 285 280 275 435.270 Dwn 145.890 *Digital telemetry* Bcn 145.910
EO-88 (2) (FUNcube-5, Nayif-1)	U/v-Inverting Analog SSB/CW Digital [i]	Dwn-USB 145.960 965 970 975 980 985 145.990 Up-LSB 435.045 040 035 030 025 020 435.015 Bcn 145.940 *Transponder is on when in eclipse and off when in sunlight.*
FalconSAT-3 (2)	V/u Digital [l] [#] [*]	Dwn-FM 435.103 Up-FM 145.840
FO-29 (JAS-2)	V/u-Inverting Analog SSB/CW	Dwn-USB 435.800 810 820 830 840 850 860 870 880 890 435.900 Up-LSB 146.000 990 980 970 960 950 940 930 920 910 145.900 Bcn 435.795
FO-99 (2) (NEXUS)	V/u-Inverting Analog SSB/CW Digital [l]	Dwn-USB 435.880 885 890 895 900 905 435.910 Up-LSB 145.930 925 920 915 910 905 145.900 Bcn 437.075 *CW telemetry* Bcn 435.900 *FSK* *Currently, only active over Japan.*
JO-97 (2) (JY1Sat)	U/v - Inverting Analog SSB/CW Digital [f]	Dwn-USB 145.855 860 865 870 145.875 Up-LSB 435.120 115 110 105 435.100 Bcn 145.840 *BPSK Telemetry/SSDV* *Check the AMSAT-BB for operating schedule.*
NO-84 (PSAT)	V/v APRS A/u PSK31	Dwn-FM 145.825 Up-FM 145.825 *APRS* Dwn-FM 435.350 Up-USB 28.120 *PSK31*
PO-101 (2) (Diwata-2)	U/v FM Voice Digital [a] #	Dwn-FM 145.900 Up-FM 437.500 *141.3 Hz CTCSS tone for access*

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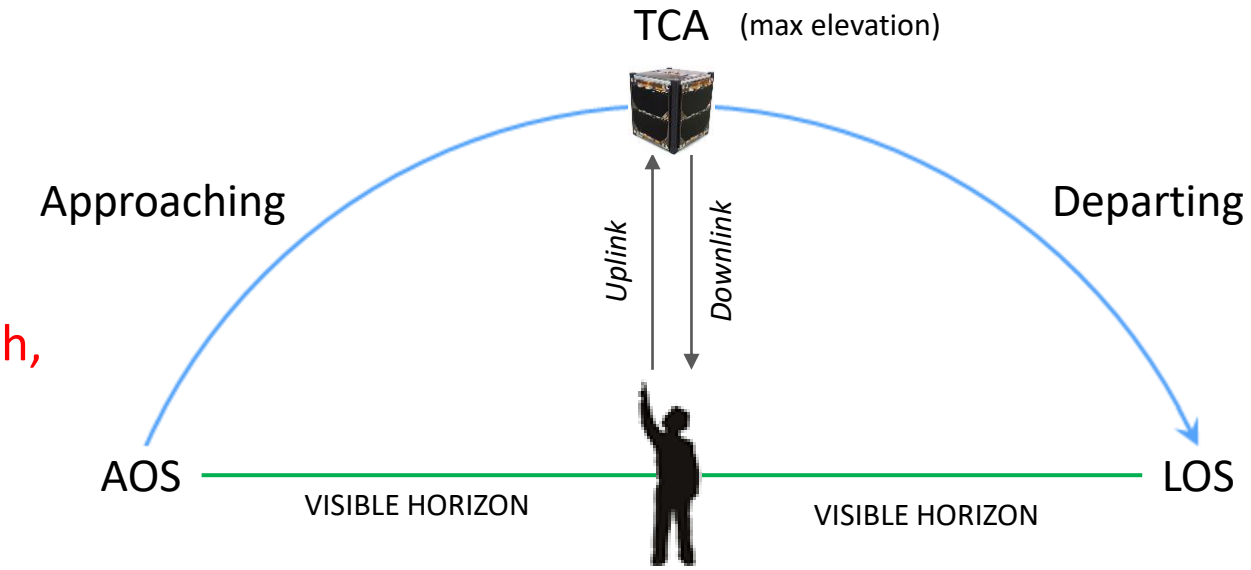
How Do I Track a Satellite? Manually Tracking

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

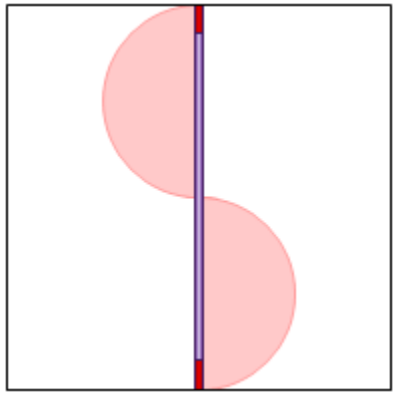
- ID AOS azimuth.
- ID TCA azimuth and max elevation.
- ID LOS azimuth.
  - Note, Azimuth information provided in relation to True North, not Magnetic North.
- Sweep to find and vary your antenna polarization.
- Listen for strongest signal to track.



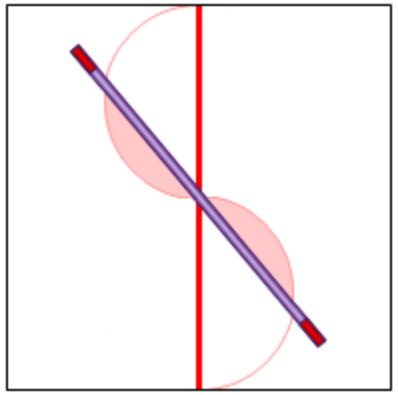
How Do I Track a Satellite? Antenna Polarization

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

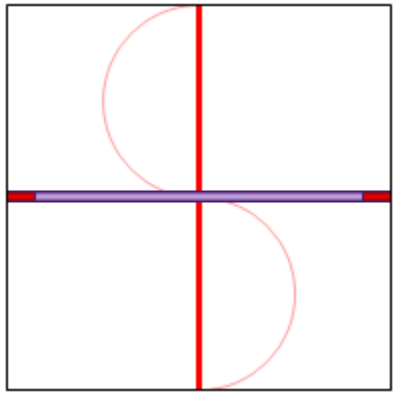
A linear mismatch will result in a loss from 0db (perfect match) to -20db (90 degrees out of phase).



Perfectly Aligned
(0 dB loss)



Inefficient
(6 dB loss)



Complete Signal Loss
(-20 dB loss)

Satellites tumble in in orbit.

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

What Do I Say? The QSO

Be Clear & Concise, Use Standard Phonetics

- You hear N9IP…
- You: N9IP, N5HYP EM12
- Them N5HYP, N9IP EN60, QSL?
- You QSL, N5HYP

- Do NOT call CQ on FM satellites
- If FM pass is quiet, okay to self announce – N5HYP EM12

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 5 Hotel Yankee Papa, EM12

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.

Beyond FM – What else can I do? Suitable gear

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

Yes you can use any of these radios without computer control of Doppler, but it is a challenge. You will end up drifting across the passband.

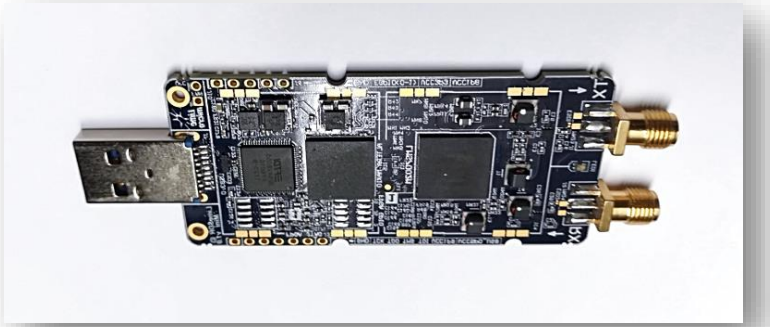
Beyond FM – What else can I do? Suitable gear

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

Beyond FM – What else can I do? Suitable gear

- Software Defined Radio receivers/transceivers
  - RTL-SDR V3
  - SDRPlay
  - Funcube Dongle Pro+
  - HackRF
  - Yardstick One
  - LimeSDR



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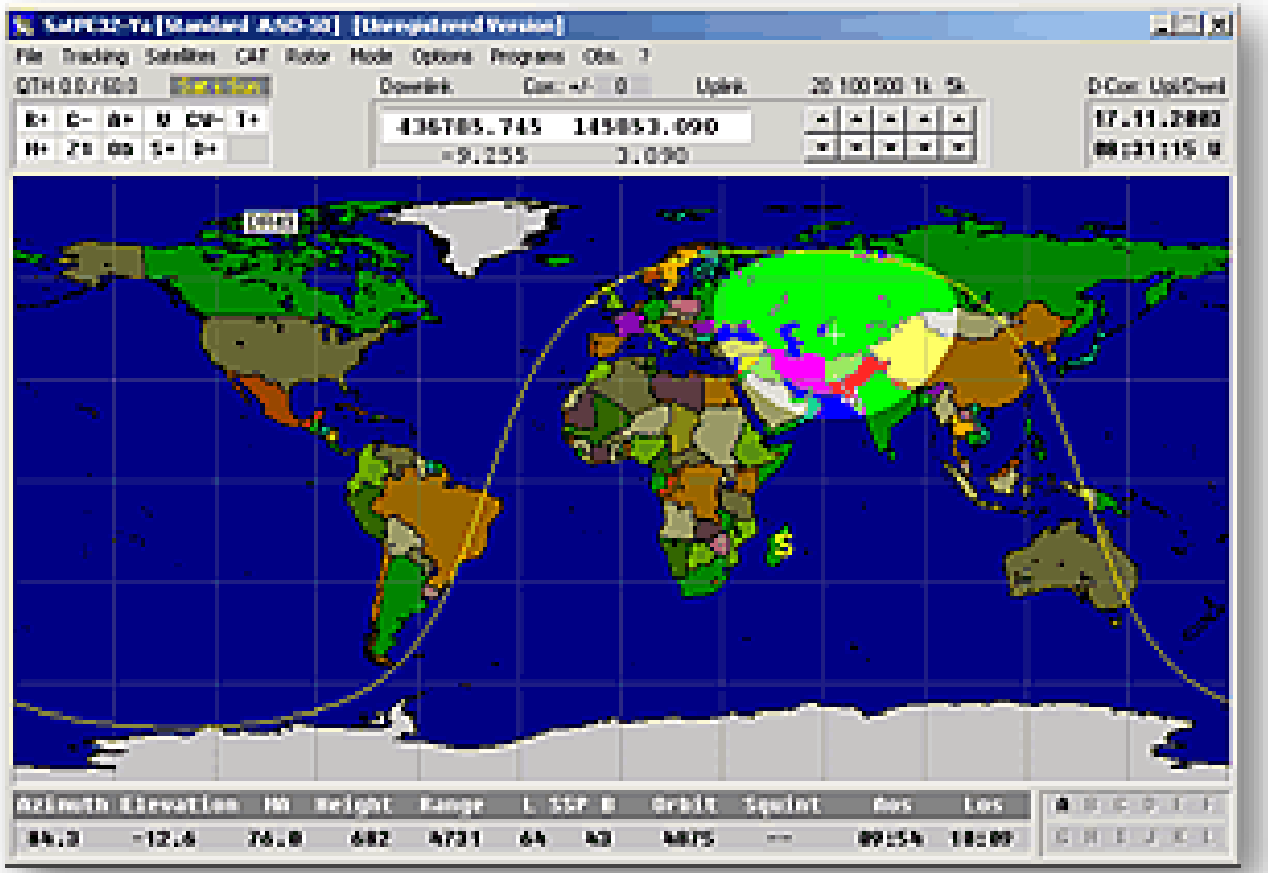
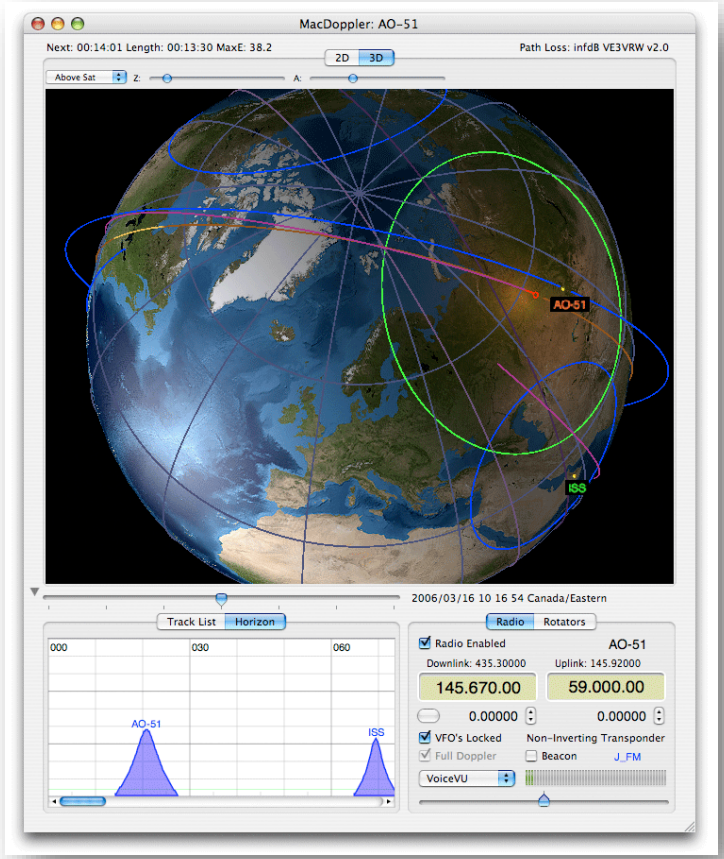
Satellite Pass Prediction/Tracking Software

Windows – SatPC32



MacOS/OSX – MacDoppler



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Satellite Pass Prediction/Tracking Software

- Other options for accurate tracking of satellite position and frequency
  - Ham Radio Deluxe - Has a satellite mode but has had it's share of problems and delays in development and redesign by the developers make it an iffy choice.
  - SDR-Radio Console – Has a satellite mode that does work well fro tracking frequency on SDR based receivers like RTL-SDR, and Funcube Dongle Pro+. Also works with SDR trancievers like Edius and Pluto. Can control a second radio. Good documentation, but can be difficult to get working.

Beyond FM – What else can I do? APRS

Dual-Band FM radios capable of APRS operations via NO-84 (While it lasts), NO-104 (Has a bug) Falconsat-3, ISS.

- Kenwood D72A, D74, TM-D700A, TM-D710A, TM-D710GA
- Other APRS capable radios

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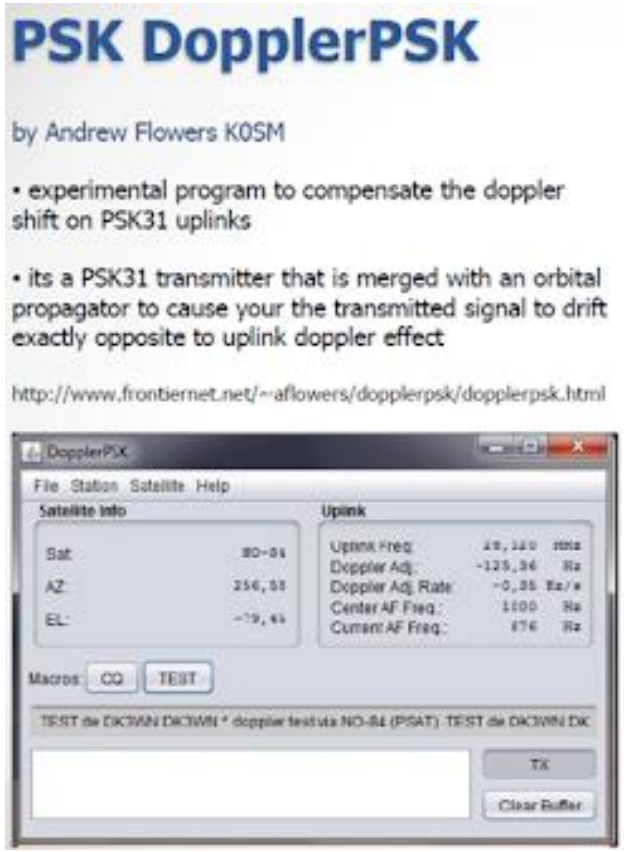
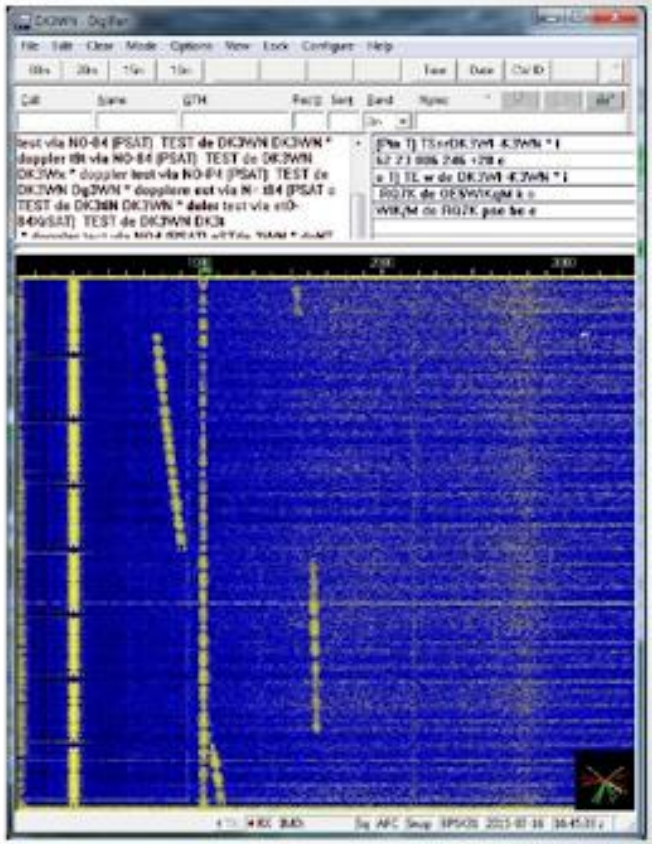
Beyond FM – What else can I do? PSK31 to satellite

Satellites PSAT-2 (NO-104) and PSAT-1 (NO-84) have a unique 10 Meter PSK31 uplink USB to 10 meter FM PSK downlink. Transponder turns on when it hears PSK in passband. Doppler PSK software changes audio frequency output to compensate for doppler shift.

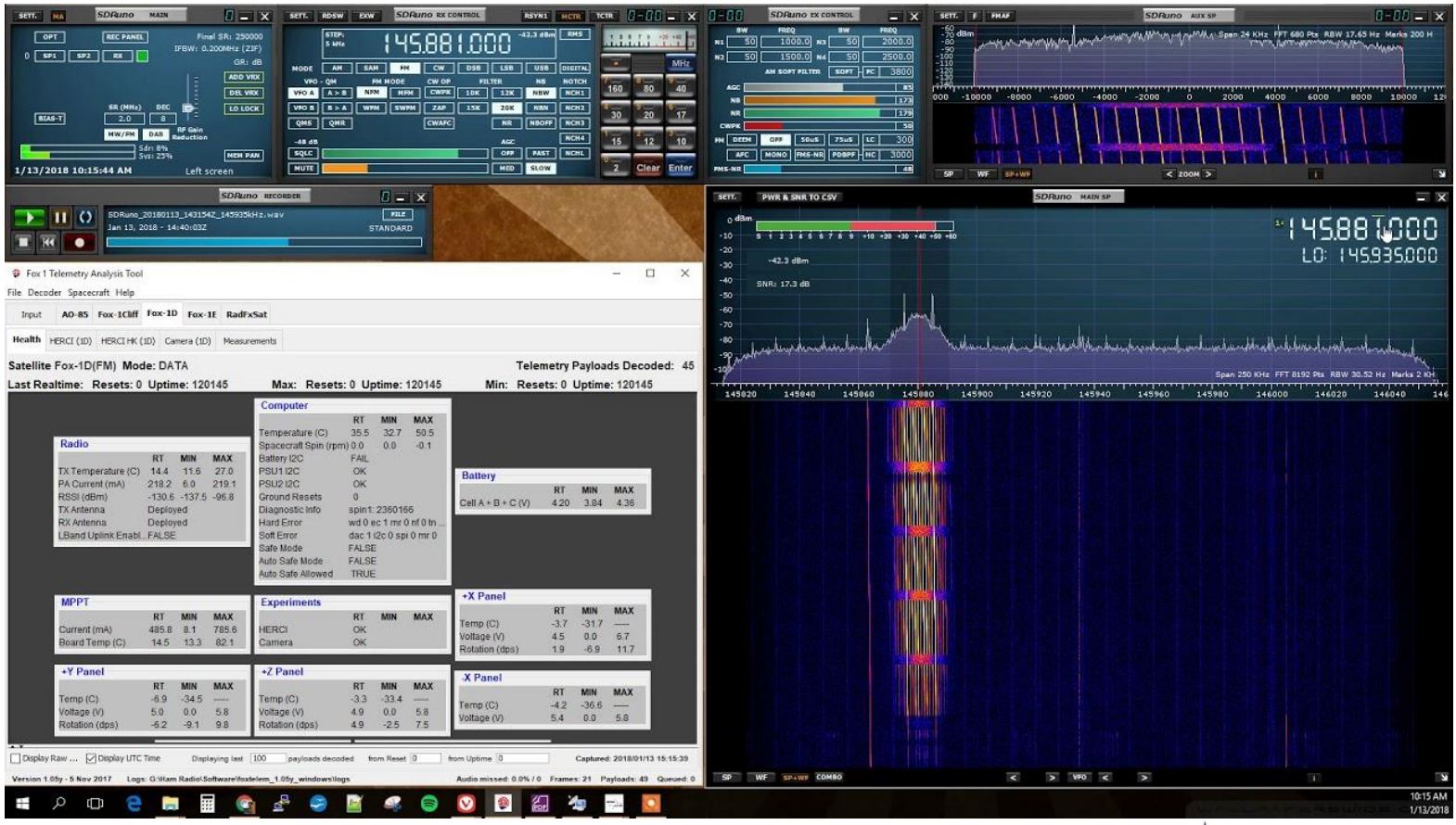




Beyond FM – What else can I do? Automated data

Download data for telemetry and scientific experiments on Amateur Radio satellites.

There may be unique data coding schemes for different satellites. Satellite builder will release special decoder software.



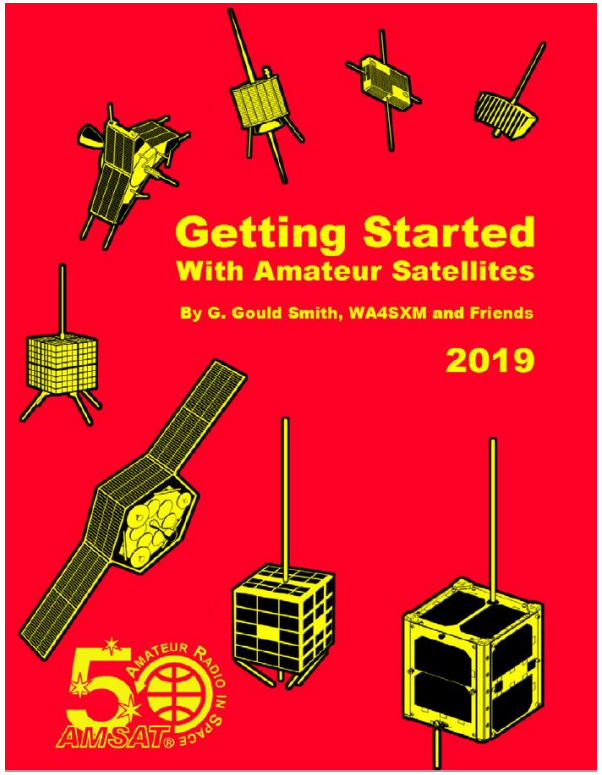
AMSAT® AMATEUR RADIO IN SPACE

Recommended Reading

Getting Started with Amateur Satellites, 2019

This definitive reference is written for the new satellite operator by Gould Smith, WA4SXM, but includes discussions for the experienced operator who wishes to review the features of amateur satellite communications. The new operator will be introduced to the basic concepts and terminology unique to this mode. Additionally, there are many practical tips and tricks to ensure making contacts, and to sound like an experienced satellite operator in the process.

https://www.amsat.org/product/2019-edition-of-getting-started-with-amateur-satellites/



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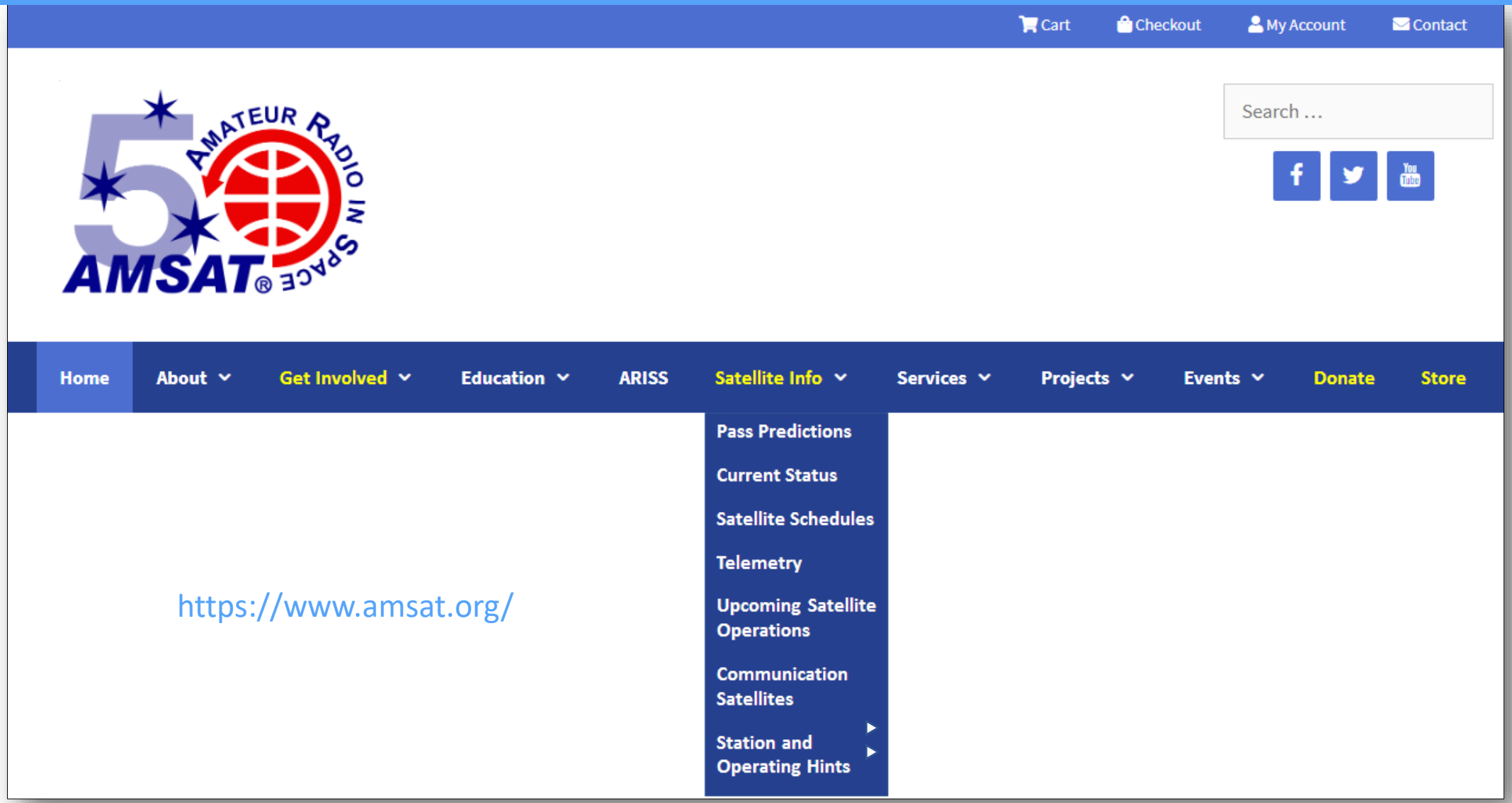
Additional Info Available on AMSAT.org

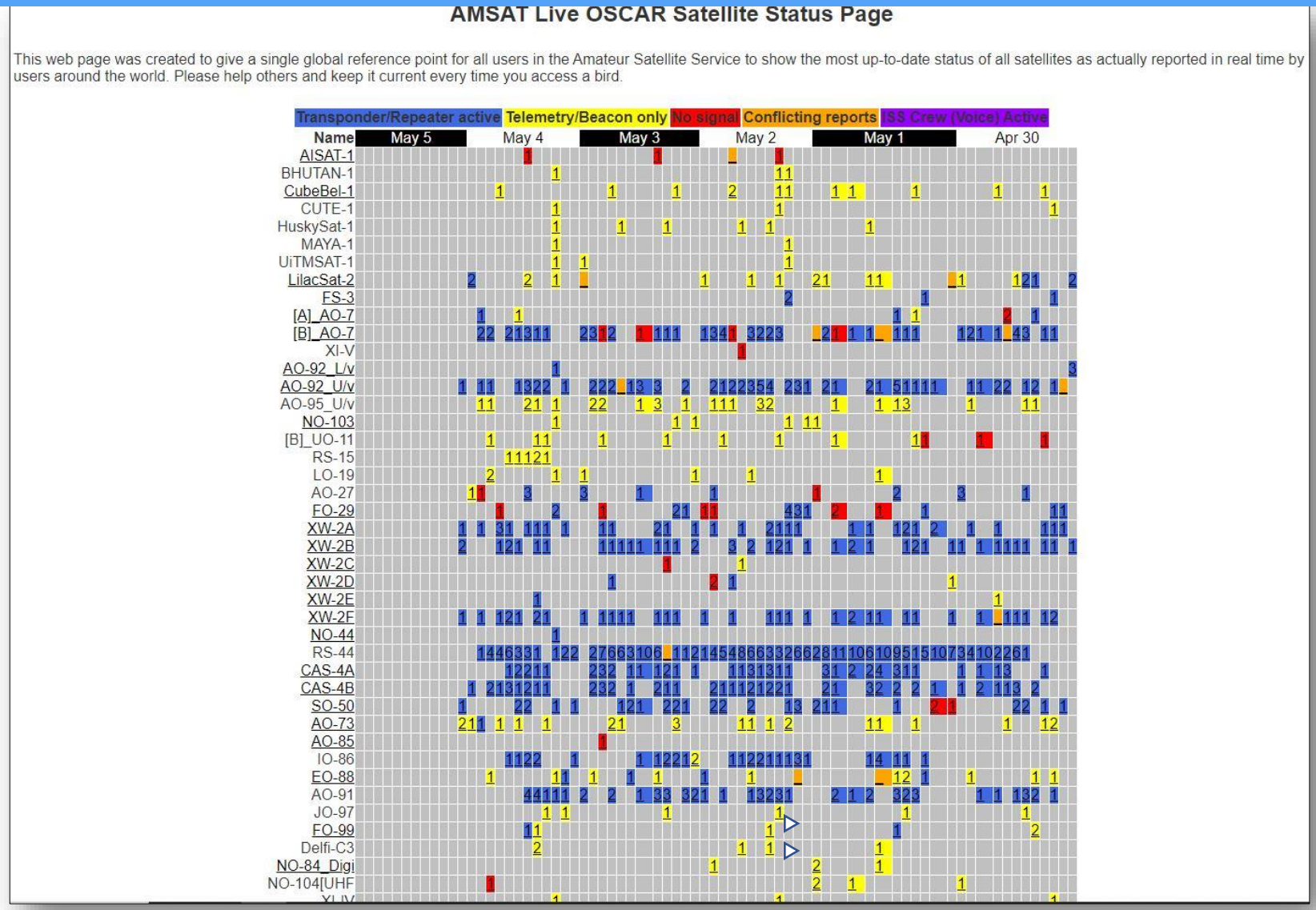


Additional Info Available on AMSAT.org

Linear Satellite Frequency Summary

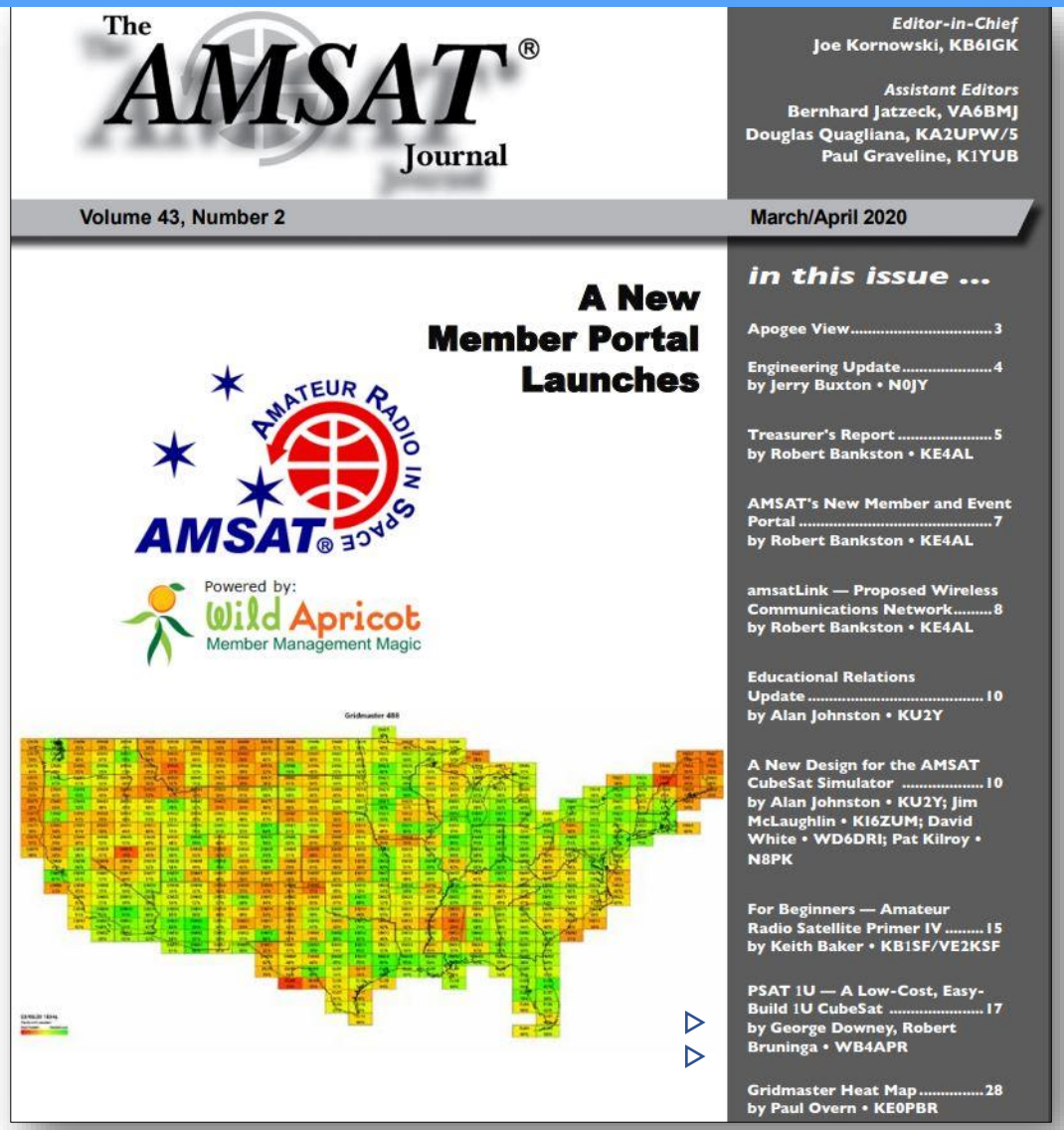
AO-7 Mode A – V/a Non-Inverting Analog SSB/CW			
Uplink USB	145.850 MHz	through	145.950 MHz
Downlink USB	29.400 MHz	through	29.500 MHz
Active only in sunlight. Generally only active when periods of constant sunlight permit the 24 hour timer to switch between Modes A and B or when the satellite switches from Mode B. Beacon 29.502 MHz			
AO-7 Mode B – U/v Inverting Analog SSB/CW			
Uplink LSB	432.125 MHz	through	432.175 MHz
Downlink USB	145.925 MHz	through	145.975 MHz
Active only in sunlight. Beacon 145.975 MHz			
AO-73 (FUNcube-1) – U/v Inverting Analog SSB/CW			
Uplink LSB	435.130 MHz	through	435.150 MHz
Downlink USB	145.950 MHz	through	145.970 MHz
1k2 BPSK 145.935 MHz telemetry. See AMSAT-BB for schedule updates. See FUNcube Data Warehouse for current status. Download FUNcube Telemetry Dashboard software			
FO-29 (JAS-2) – V/u Inverting Analog SSB/CW			
Uplink LSB	145.900 MHz	through	146.000 MHz
Downlink USB	435.800 MHz	through	435.900 MHz
Transponder activated by schedule over Japan and remains active until voltage drops below safe threshold. CW Beacon 435.795 MHz			
XW-2A (CAS-3A) – U/v Inverting Analog SSB/CW			
Uplink LSB	435.030 MHz	through	435.050 MHz
Downlink USB	145.665 MHz	through	145.685 MHz
CW Beacon 145.660 MHz. Digital Telemetry 145.640 MHz 9.6/19.2kbps, GMSK			

Additional Info Available on AMSAT.org



Additional Info Available on AMSAT.org

Current edition of the AMSAT Journal is currently free to anyone for download on the AMSAT.org website home page. COVID-19 special.



https://launch.amsat.org/
New AMSAT membership portal. Joun/renew membership. Access back issues of AMSAT Journal and other future features.

Q & A

Questions?

Contact N5HYP@ARRL.net