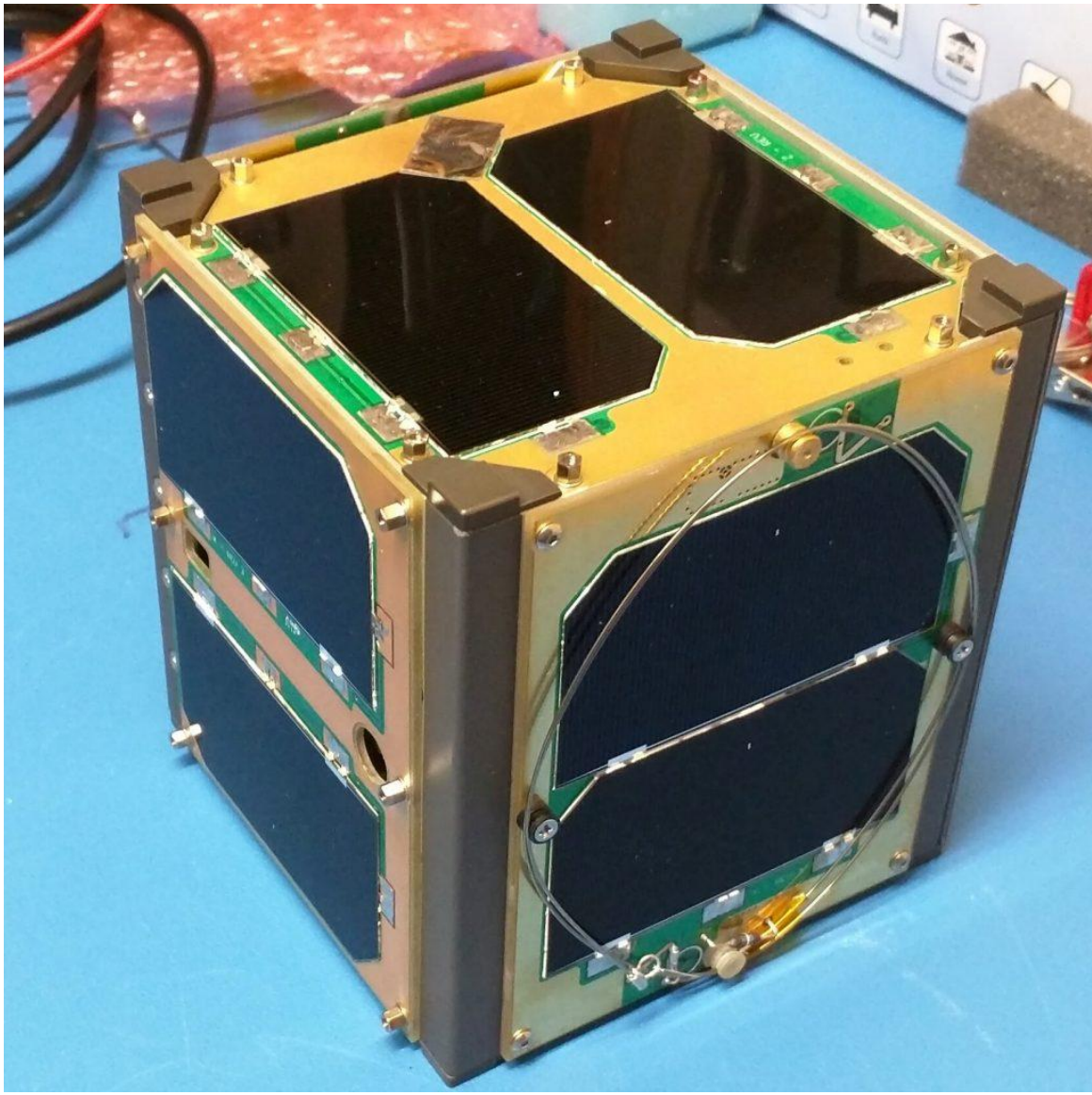
Radioamateur FM Satellites



Chris VE2MW

FM Satellites

as of December 25

SO-50 (SaudiSat-1C) Active

AO-91 (RadFxSat / Fox-1B) Day-time only

AO-92 (RadFxSat / Fox-1D) Back in operation; day-time only

LilacSat-2 (CAS-3H) Transponder activations sporadic

IO-86 (LAPAN-A2) In equatorial orbit, activations by schedule

PO-101 (Diwata-2) Active by schedule

AO-27 Currently on for four minutes on ascending and descending passes over mid-latitudes of the Northern Hemisphere

ISS (ARISS) Active

All are cross-band repeaters.

You already have what is needed…

You can work FM satellites:

- If you have a dual-band radio (2m – 70cm)
- Can operate split VFO (half-duplex)

Take note:

- You will not be able to hear yourself on the downlink
- Therefore, you will not know if you are accessing the satellite.

You already have what is needed…

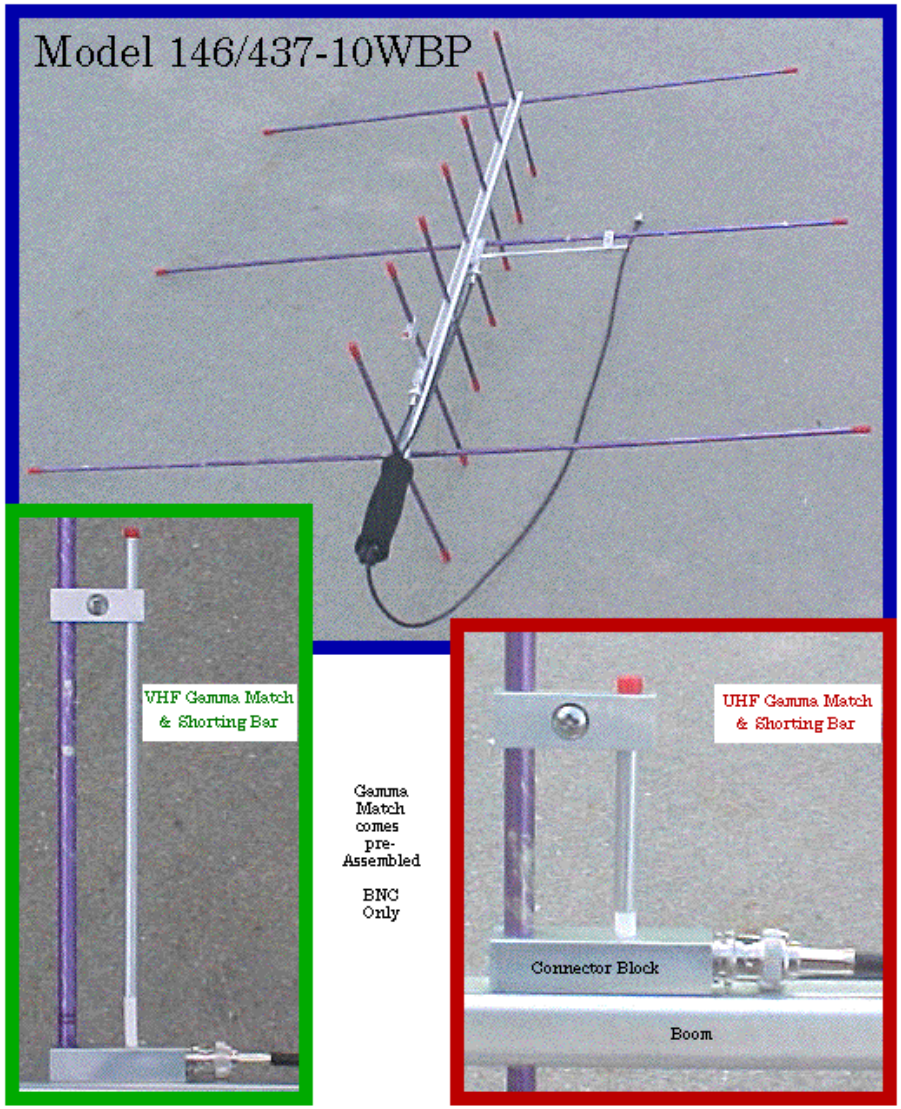
- A mobile dual-band antenna (with gain).
- Not the best.
- Works on relatively low passes.
- A base station 2m-70cm vertical will also work.

Rubber duck with gain?

Good luck!

Upgrade the station…

1 : A better antenna!



It is important to have the best reception possible

A two-band Yagi is ideal.

This one has a diplexer in the handle.

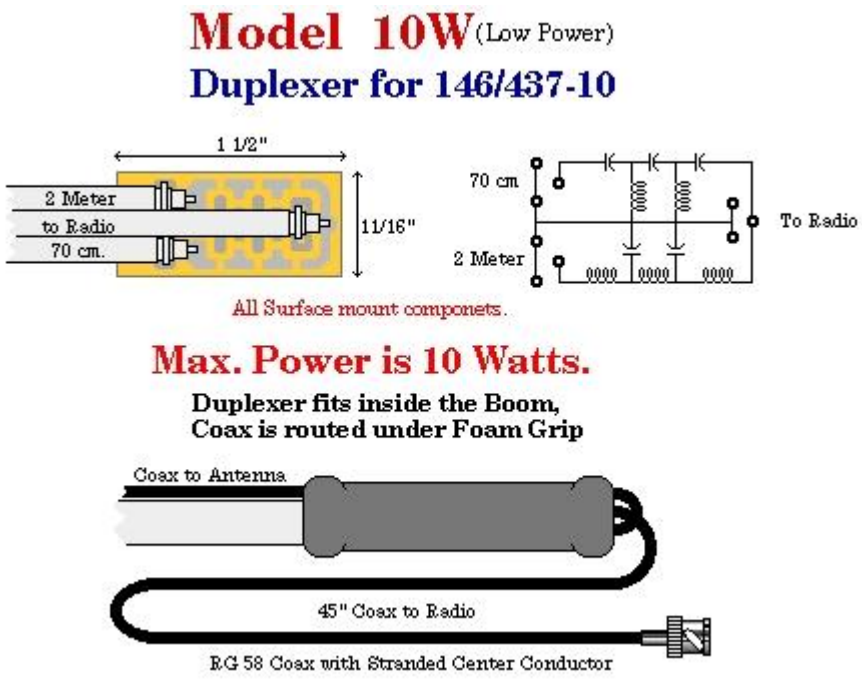
Elk Antennas – Log periodic antenna

This is a good example of the simplest of portable stations.

Diplexer : one radio on two antennas

Diplexer :

- Allows simultaneous operation on two bands.
- Consists of a low-pass filter (VHF) and high-pass filter (UHF).



Duplexer :

- Allows simultaneous operation **on two frequencies** on the **same band.**

Upgrade the station…

One duplex radio: Kenwood TH-D72 or Alinco DJ-G7
Diplexer required with the Arrow antenna
or

Downlink

Uplink

Two radios : Duplex

- We can hear our downlink signal
- We can be sure that we are accessing the satellite
- Diplexer not required.
  - However…

Receive

Transmit

Just a tinny little problem in mode V/u if we use two radios:

We transmit (uplink) on VHF (145.850)

The third harmonic of 145.850 is 437.55 MHz

Can cause a de-sense of the UHF receiver

To remedy this, we can install a low-pass filter on the VHF line.

- Eliminates the harmonics.

Here's where the low-pass side of a diplexer can be useful.

Also help reduce interference on the VHF side when transmitting in UHF.

Some accessories...

To find the AOS, TCA and LOS azimuths.

Prevents feedback into the speaker

Programming the radios

https://www.amsat.org/fm-satellite-frequency-summary/

FM Satellite Frequency Summary

RadFxSat / Fox-1			
	Uplink FM (67 Hz CTCSS)	Downlink FM	Comments
AO-91 (RadFxSat / Fox-1B)	435.250 MHz	145.960 MHz	Operational
SaudiSat-1C			
	Uplink FM (67 Hz CTCSS)	Downlink FM	Comments
SO-50 (SaudiSat-1C)	145.850 MHz	436.795 MHz	Operational
SO-50 also has a 10 minute timer that must be armed before use. Transmit a 2 second carrier with a CTCSS tone of 74.4 Hz to arm the timer.			

Programming the radios

https://www.amsat.org/fm-satellite-frequency-summary/

	Uplink FM We transmit on…	Downlink FM We receive on…
AO-91 **(Mode U/v)**	**435.250 MHz (67 Hz)**	**145.960 MHz**
	Uplink FM	Downlink FM
SO-50 **(Mode V/u)**	**145.850 MHz (67 Hz)**	**436.795 MHz**
SO-50 also has a 10 minute timer that must be armed before use. Transmit a 2 second carrier with a CTCSS tone of 74.4 Hz to arm the timer.		

Exception for PO-101 (Diwata-2) : CTCSS 141.3 Hz

Programming the radios

AO-91 (FOX-1B) Mode U/v

Doppler effect: more pronounce on UHF than on VHF

	Transmit on: (CTCSS 67 Hz)	**Receive on:**
Acquisition of Signal (AOS)	435.240 MHz	145.960 MHz
Approach	435.245 MHz	145.960 MHz
Time of Closest Approach (TCA) Middle of the pass	**435.250 MHz**	**145.960 MHz**
Departure	435.255 MHz	145.960 MHz
Loss Of Signal (LOS)	435.260 MHz	145.960 MHz

Start transmitting10 kHz lower than the repeater's frequency and increase the frequency by 5 kHz increments during the pass.

The receive frequency stays stable.

Programming the radios

SO-50 (SaudiSat-1C) Mode V/u

Doppler effect is reversed; **we** receive on UHF

	Transmit on: (CTCSS 67 Hz)	**Receive on:**
Acquisition Of Signal (AOS)	145.850 MHz	436.805 MHz
Approach	145.850 MHz	436.800 MHz
Time of Closest Approach (TCA) Middle of the pass	**145.850 MHz**	**436.795 MHz**
Departure	145.850 MHz	436.790 MHz
Loss Of Signal (LOS)	145.850 MHz	436.785 MHz

Start **receiving** 10 kHz **higher** that the repeater's frequency and **decrease** the frequency by 5kHz increments during the pass.

The transmit frequency stays stable.

So, we have

The radios (or one radio),

A good antenna,

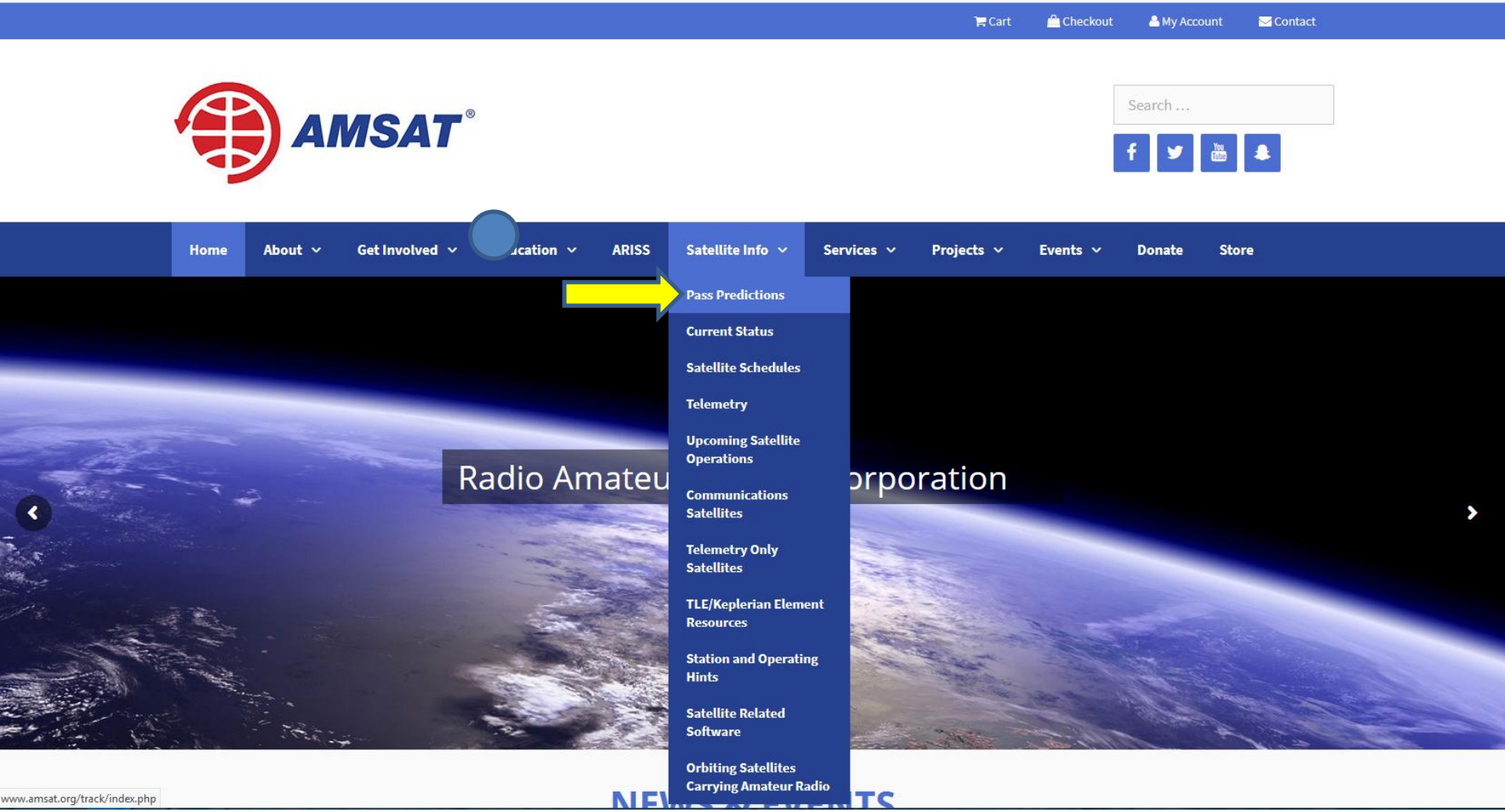
The accessories,

The radio(s) is/are programmed.

All we need to know is…

When and where?

AMSAT-NA: https://www.amsat.org/



AMSAT Online Satellite Pass Predictions

Please select a satellite and provide your latitude, longitude and elevation or calculate them from your grid square. If you choose we will save your position information in a cookie on your system for future predictions.

2

Show Predictions for: AO-91 *for Next* 10 *Passes*

1

Calculate Latitude and Longitude from Gridsquare: fn25ck Calculate Position

or

Or

1

*Enter Decimal Latitude:** 45.4375 North

*Enter Decimal Longitude:** 75.7916 West

Elevation in meters AMSL:

4 Predict

3 ☑ *Save my location for later use*

For the best in full featured tracking software visit The AMSAT Store

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Based on the Predict engine, courtesy of John Magliacane, KD2BD
2020 Oct 22 13:18:02 UTC

AMSAT Online Satellite Pass Predictions - AO-91

View the current location of AO-91

Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)	
06 Mar 18	18:52:13	00:13:26	209	19	268	333	19:05:39	
07 Mar 18	05:03:30	00:11:08	31	12	90	139	05:14:38	
07 Mar 18	06:39:06	00:13:57	11	81	261	197	06:53:03	
07 Mar 18	08:16:18	00:10:48	355	12	297	254	08:27:06	
07 Mar 18	16:01:58	00:12:56	117	17	58	2	16:14:54	
07 Mar 18	17:36:35	00:15:20	168	82	274	347	17:51:55	
07 Mar 18	19:15:22	00:12:02	223	12	281	328	19:27:24	
08 Mar 18	05:25:19	00:12:19	26	19	83	154	05:37:38	
08 Mar 18	07:01:23	00:13:39	8	49	286	210	07:15:02	
08 Mar 18	08:38:58	00:09:18	350	7	310	267	08:48:16	

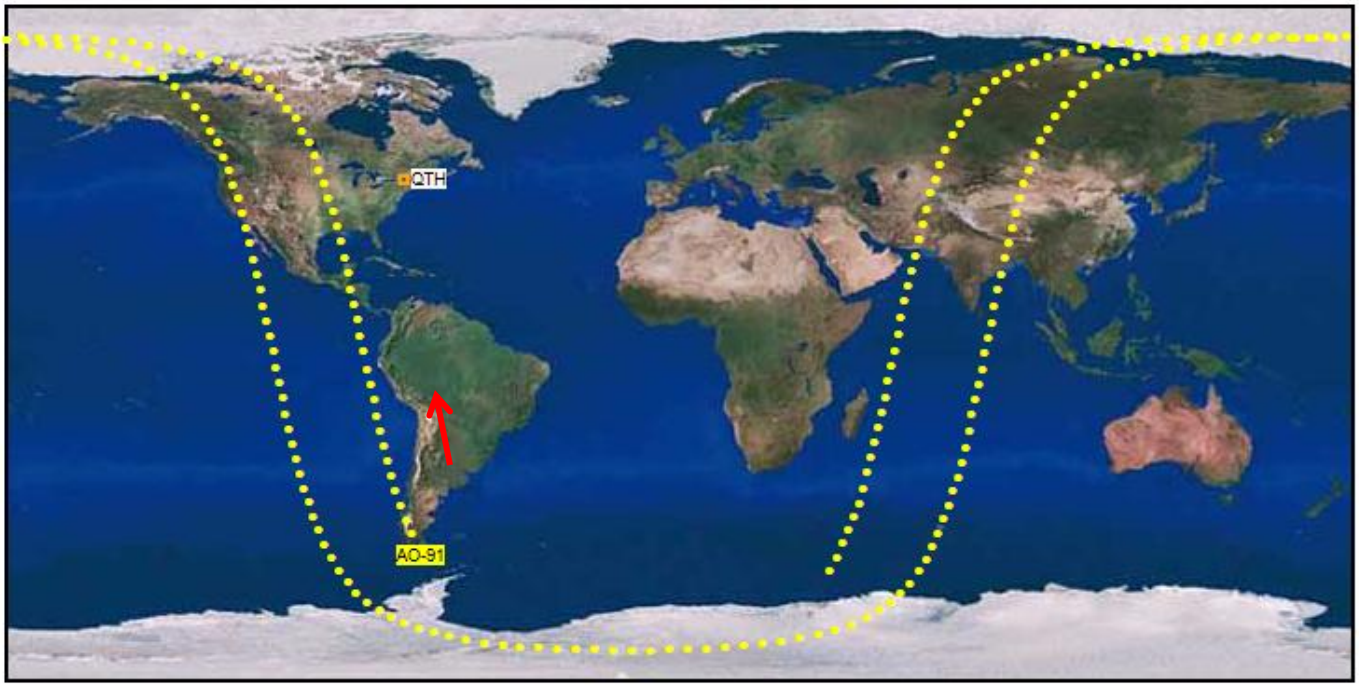
AMSAT™

Satellite Tracking for AO-91

10605 Concord St, #304
Kensington, MD 20895
1-888-322-6728

Current Position of AO-91

Tue, 06 Mar 2018 18:30:48 GMT (13:30:48 local time)
Current Location: 68.5W 57.5S



Select a Different Satellite: AO-91

Note: Position is approximate and depends on your computer's performance.

For the best in full featured tracking software visit The AMSAT Store

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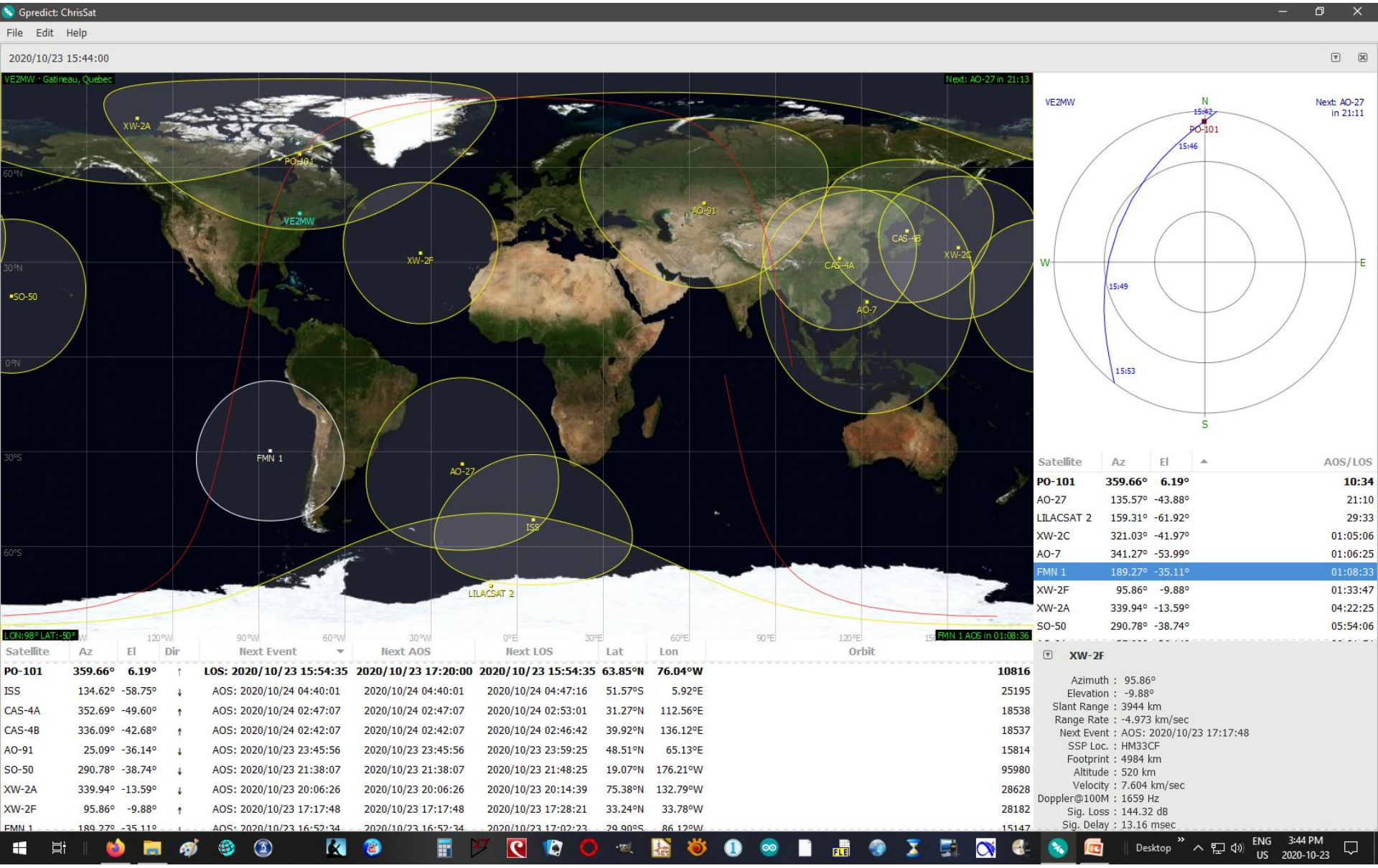
GPredict



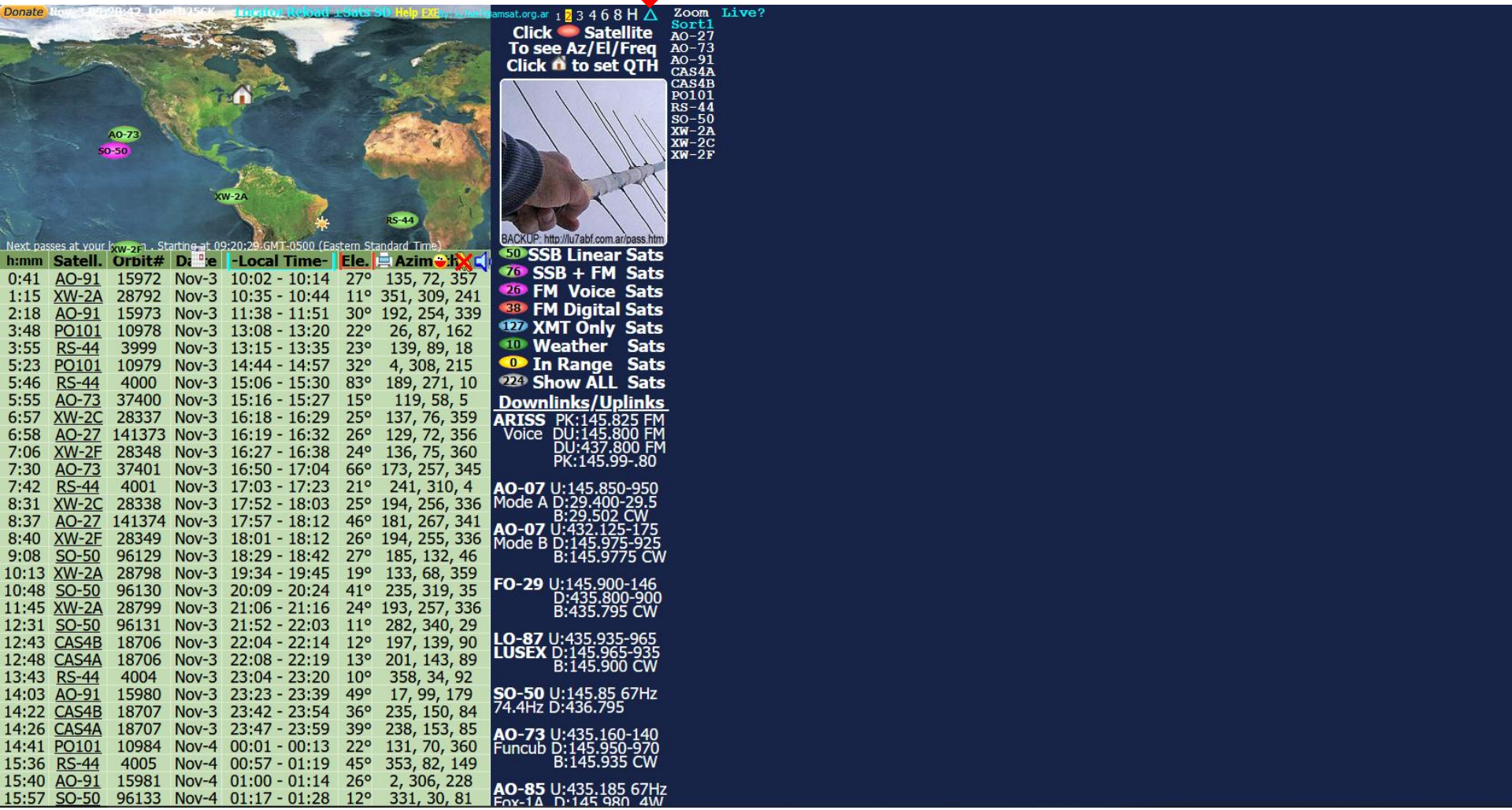
Satellite	Az	El	AOS/LOS
PO-101	**359.66°**	**6.19°**	**10:34**
AO-27	135.57°	-43.88°	21:10
LILACSAT 2	159.31°	-61.92°	29:33
XW-2C	321.03°	-41.97°	01:05:06
AO-7	341.27°	-53.99°	01:06:25
FMN 1	189.27°	-35.11°	01:08:33
XW-2F	95.86°	-9.88°	01:33:47
XW-2A	339.94°	-13.59°	04:22:25
SO-50	290.78°	-38.74°	05:54:06

Satellite	Az	El	Dir	Next Event	Next AOS	Next LOS	Lat	Lon	Orbit
PO-101	**359.66°**	**6.19°**	↑	**LOS: 2020/10/23 15:54:35**	**2020/10/23 17:20:00**	**2020/10/23 15:54:35**	**63.85°N**	**76.04°W**	**10816**
ISS	134.62°	-58.75°	↓	AOS: 2020/10/24 04:40:01	2020/10/24 04:40:01	2020/10/24 04:47:16	51.57°S	5.92°E	25195
CAS-4A	352.69°	-49.60°	↑	AOS: 2020/10/24 02:47:07	2020/10/24 02:47:07	2020/10/24 02:53:01	31.27°N	112.56°E	18538
CAS-4B	336.09°	-42.68°	↑	AOS: 2020/10/24 02:42:07	2020/10/24 02:42:07	2020/10/24 02:46:42	39.92°N	136.12°E	18537
AO-91	25.09°	-36.14°	↓	AOS: 2020/10/23 23:45:56	2020/10/23 23:45:56	2020/10/23 23:59:25	48.51°N	65.13°E	15814
SO-50	290.78°	-38.74°	↓	AOS: 2020/10/23 21:38:07	2020/10/23 21:38:07	2020/10/23 21:48:25	19.07°N	176.21°W	95980
XW-2A	339.94°	-13.59°	↓	AOS: 2020/10/23 20:06:26	2020/10/23 20:06:26	2020/10/23 20:14:39	75.38°N	132.79°W	28628
XW-2F	95.86°	-9.88°	↑	AOS: 2020/10/23 17:17:48	2020/10/23 17:17:48	2020/10/23 17:28:21	33.24°N	33.78°W	28182
FMN 1	189.27°	-35.11°	↓	AOS: 2020/10/23 16:52:34	2020/10/23 16:52:34	2020/10/23 17:02:23	29.90°S	86.12°W	15147

XW-2F

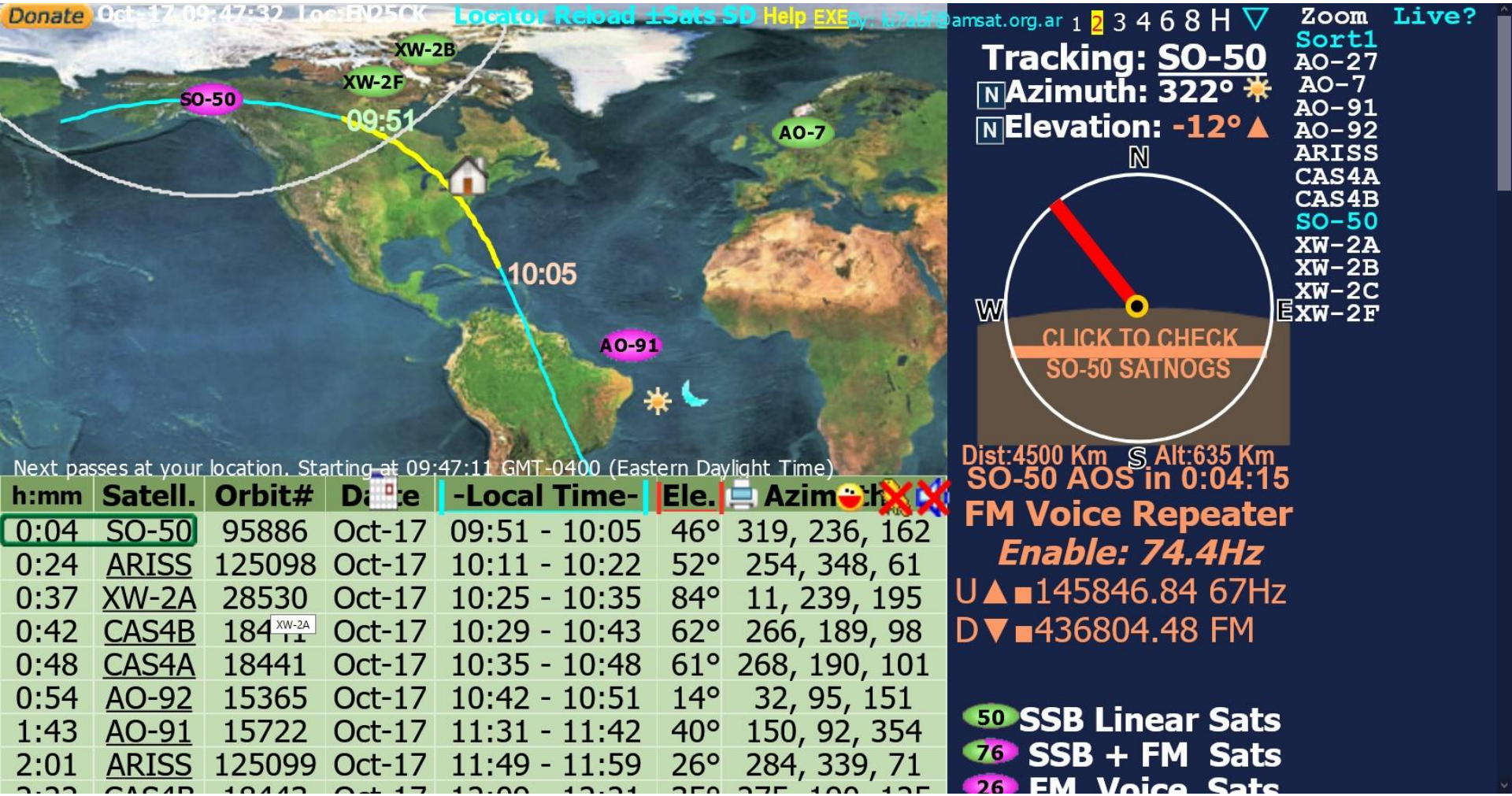
Azimuth	95.86°
Elevation	-9.88°
Slant Range	3944 km
Range Rate	-4.973 km/sec
Next Event	AOS: 2020/10/23 17:17:48
SSP Loc.	HM33CF
Footprint	4984 km
Altitude	520 km
Velocity	7.604 km/sec
Doppler@100M	1659 Hz
Sig. Loss	144.32 dB
Sig. Delay	13.16 msec

Sat Passes : http://amsat.org.ar/pass#



h:mm	Satell.	Orbit#	Date	-Local Time-	Ele.	Azim
0:41	AO-91	15972	Nov-3	10:02 - 10:14	27°	135, 72, 357
1:15	XW-2A	28792	Nov-3	10:35 - 10:44	11°	351, 309, 241
2:18	AO-91	15973	Nov-3	11:38 - 11:51	30°	192, 254, 339
3:48	PO101	10978	Nov-3	13:08 - 13:20	22°	26, 87, 162
3:55	RS-44	3999	Nov-3	13:15 - 13:35	23°	139, 89, 18
5:23	PO101	10979	Nov-3	14:44 - 14:57	32°	4, 308, 215
5:46	RS-44	4000	Nov-3	15:06 - 15:30	83°	189, 271, 10
5:55	AO-73	37400	Nov-3	15:16 - 15:27	15°	119, 58, 5
6:57	XW-2C	28337	Nov-3	16:18 - 16:29	25°	137, 76, 359
6:58	AO-27	141373	Nov-3	16:19 - 16:32	26°	129, 72, 356
7:06	XW-2F	28348	Nov-3	16:27 - 16:38	24°	136, 75, 360
7:30	AO-73	37401	Nov-3	16:50 - 17:04	66°	173, 257, 345
7:42	RS-44	4001	Nov-3	17:03 - 17:23	21°	241, 310, 4
8:31	XW-2C	28338	Nov-3	17:52 - 18:03	25°	194, 256, 336
8:37	AO-27	141374	Nov-3	17:57 - 18:12	46°	181, 267, 341
8:40	XW-2F	28349	Nov-3	18:01 - 18:12	26°	194, 255, 336
9:08	SO-50	96129	Nov-3	18:29 - 18:42	27°	185, 132, 46
10:13	XW-2A	28798	Nov-3	19:34 - 19:45	19°	133, 68, 359
10:48	SO-50	96130	Nov-3	20:09 - 20:24	41°	235, 319, 35
11:45	XW-2A	28799	Nov-3	21:06 - 21:16	24°	193, 257, 336
12:31	SO-50	96131	Nov-3	21:52 - 22:03	11°	282, 340, 29
12:43	CAS4B	18706	Nov-3	22:04 - 22:14	12°	197, 139, 90
12:48	CAS4A	18706	Nov-3	22:08 - 22:19	13°	201, 143, 89
13:43	RS-44	4004	Nov-3	23:04 - 23:20	10°	358, 34, 92
14:03	AO-91	15980	Nov-3	23:23 - 23:39	49°	17, 99, 179
14:22	CAS4B	18707	Nov-3	23:42 - 23:54	36°	235, 150, 84
14:26	CAS4A	18707	Nov-3	23:47 - 23:59	39°	238, 153, 85
14:41	PO101	10984	Nov-4	00:01 - 00:13	22°	131, 70, 360
15:36	RS-44	4005	Nov-4	00:57 - 01:19	45°	353, 82, 149
15:40	AO-91	15981	Nov-4	01:00 - 01:14	26°	2, 306, 228
15:57	SO-50	96133	Nov-4	01:17 - 01:28	12°	331, 30, 81

Sat Passes : http://amsat.org.ar/pass#



h:mm	Satell.	Orbit#	Date	-Local Time-	Ele.	Azimuth
0:04	SO-50	95886	Oct-17	09:51 - 10:05	46°	319, 236, 162
0:24	ARISS	125098	Oct-17	10:11 - 10:22	52°	254, 348, 61
0:37	XW-2A	28530	Oct-17	10:25 - 10:35	84°	11, 239, 195
0:42	CAS4B	18441	Oct-17	10:29 - 10:43	62°	266, 189, 98
0:48	CAS4A	18441	Oct-17	10:35 - 10:48	61°	268, 190, 101
0:54	AO-92	15365	Oct-17	10:42 - 10:51	14°	32, 95, 151
1:43	AO-91	15722	Oct-17	11:31 - 11:42	40°	150, 92, 354
2:01	ARISS	125099	Oct-17	11:49 - 11:59	26°	284, 339, 71

11:06	XW-2A	28537	Oct-17	20:56 - 21:07	34°	148, 91, 354
12:39	XW-2A	28538	Oct-17	22:29 - 22:38	13°	209, 274, 328
13:04	AO-92	15373	Oct-17	22:53 - 23:05	77°	169, 271, 347
13:27	AO-91	15729	Oct-17	23:16 - 23:29	10°	37, 79, 145
14:17	SO-50	95895	Oct-18	00:07 - 00:20	31°	188, 104, 44
15:02	AO-91	15730	Oct-18	00:52 - 01:06	79°	13, 74, 192
15:58	SO-50	95896	Oct-18	01:47 - 02:01	37°	238, 322, 32
16:39	AO-91	15731	Oct-18	02:29 - 02:41	15°	354, 293, 243
17:27	AO-7	210137	Oct-18	03:17 - 03:36	18°	30, 83, 147
17:41	SO-50	95897	Oct-18	03:30 - 03:41	10°	285, 324, 29
19:19	AO-7	210138	Oct-18	05:09 - 05:31	83°	18, 111, 198

1

2

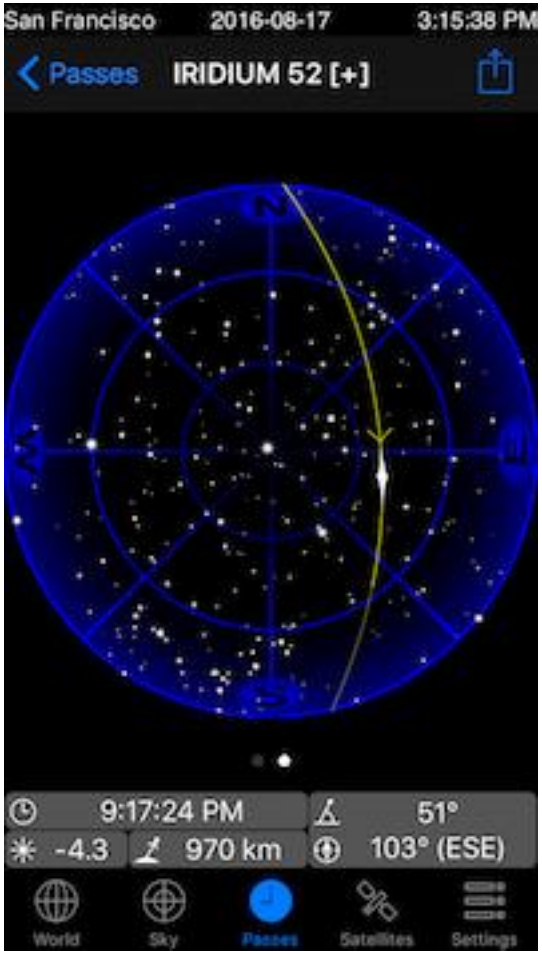
Check or change your Station Grid Locator or Latitude/Longitude Grid?

Google Map	Locator:	FN25CK	Reset	Resolve and Set New						
+North -South =>	Latitude:	45.4375	°	Deg.	45	°	Min.	26	'	Sec.	15	"
+East -West =>	Longitude:	-75.7917	°	Deg.	-75	°	Min.	47	'	Sec.	30	"

Sat Passes : http://amsat.org.ar/pass#

h:mm	Satell.	Orbit#	Date	-Local Time-	Ele.	Azimuth
0:04	SO-50	95886	Oct-17	09:51 - 10:05	46°	319, 236, 162
0:24	ARISS	125098	Oct-17	10:11 - 10:22	52°	254, 348, 61
0:37	XW-2A	28530	Oct-17	10:25 - 10:35	84°	11, 239, 195
0:42	CAS4B	18441	Oct-17	10:29 - 10:43	62°	266, 189, 98
0:48	CAS4A	18441	Oct-17	10:35 - 10:48	61°	268, 190, 101
0:54	AO-92	15365	Oct-17	10:42 - 10:51	14°	32, 95, 151
1:43	AO-91	15722	Oct-17	11:31 - 11:42	40°	150, 92, 354
2:01	ARISS	125099	Oct-17	11:49 - 11:59	26°	284, 339, 71

GoSatWatch from **GoSoftWorks** – an application for iPhone

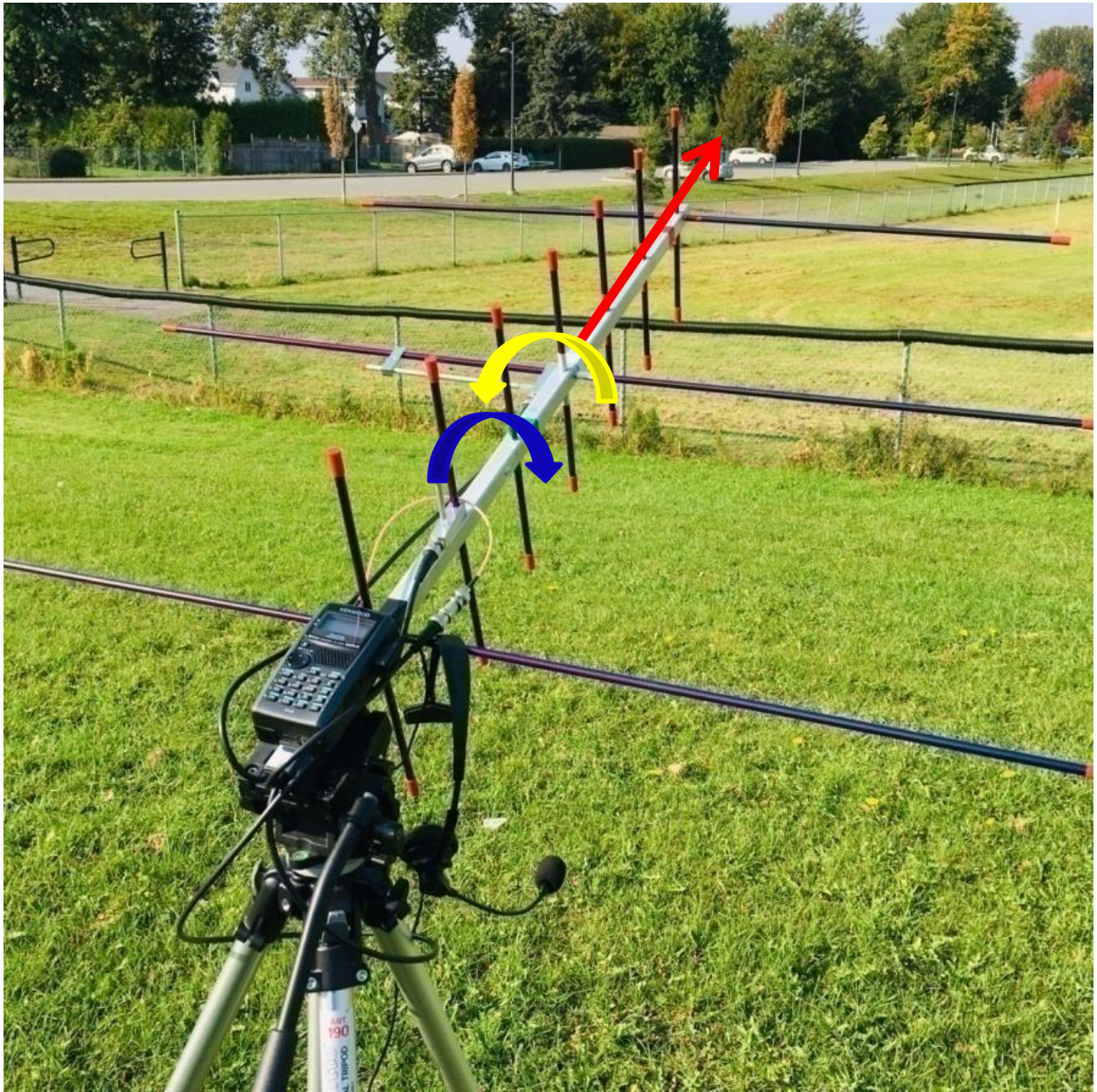


Satellite motions

- A satellite spins on its axis
- It also tumbles.
  - The effect is that the signal polarity changes.
    - There is fading of the signal.

To compensate for the polarity shift, you need to turn the antenna on its axis..

Satellite motions



Certain conventions...

When you have access to the satellite:

1. Transmit your call sign and grid square.
2. Wait for another station to reply.
3. If you want to call another station:
    - Send his call sign, your call sign, your grid.
4. Keep the transmissions short!!
5. Do not call CQ ; this is not done on FM satellites.
6. Let the other stations complete their exchange before transmitting.
7. A station calls another and you call the first one: just plain rude!
8. If you have contacted the stations multiple time, pass your turn. Give others a chance
9. **No more than 10W !!!** (from the radio)

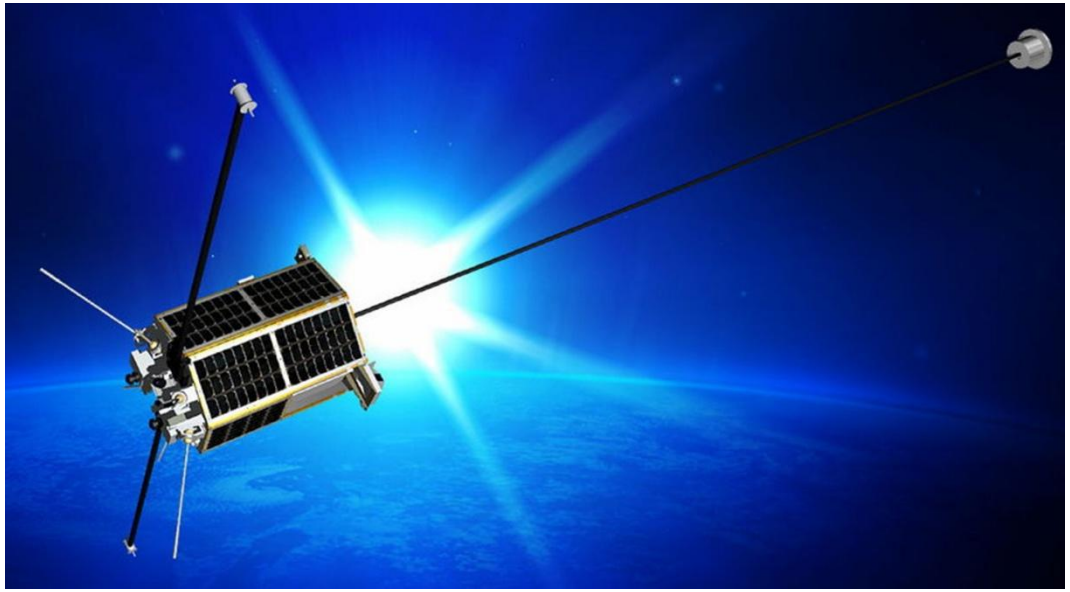
According to moi:

- Operating duplex **is** a necessity.
  - It allows us to hear our signal on the downlink.
  - It helps us know if we are making it into the satellite or not.
  - If we are, the other stations should hear us as well.

Three things to keep in mind:

1. Open your squelch.
2. Antenna, antenna, antenna.
3. Compensate for the Doppler effect on UHF.

Radioamateur Linear (SSB/CW) Satellites



RS-44

Amateur Radio Linear Satellites

AO-7 Oldest linear satellite still active. Launched November 15, 1974.

FO-29 (JAS-2) Due to low battery, transponder is activated by schedule in Japan and remains active until voltage drops

AO-73 (FUNcube-1) Currently in full time transponder mode. See AMSAT-BB for transponder schedule updates

XW-2A (CAS-3A) Operational

XW-2C (CAS-3C) Operational

XW-2F (CAS-3F) Operational

CAS-4A Operational

CAS-4B Operational

RS-44 Operational

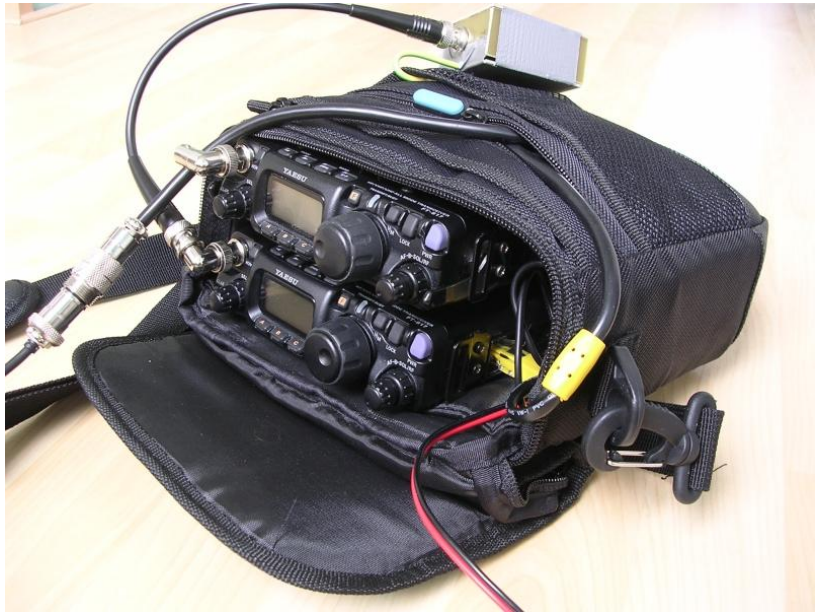
All mode U/v except for FO-29 and RS-44 (mode V/u)

Equipment

Full duplex operation is a must!

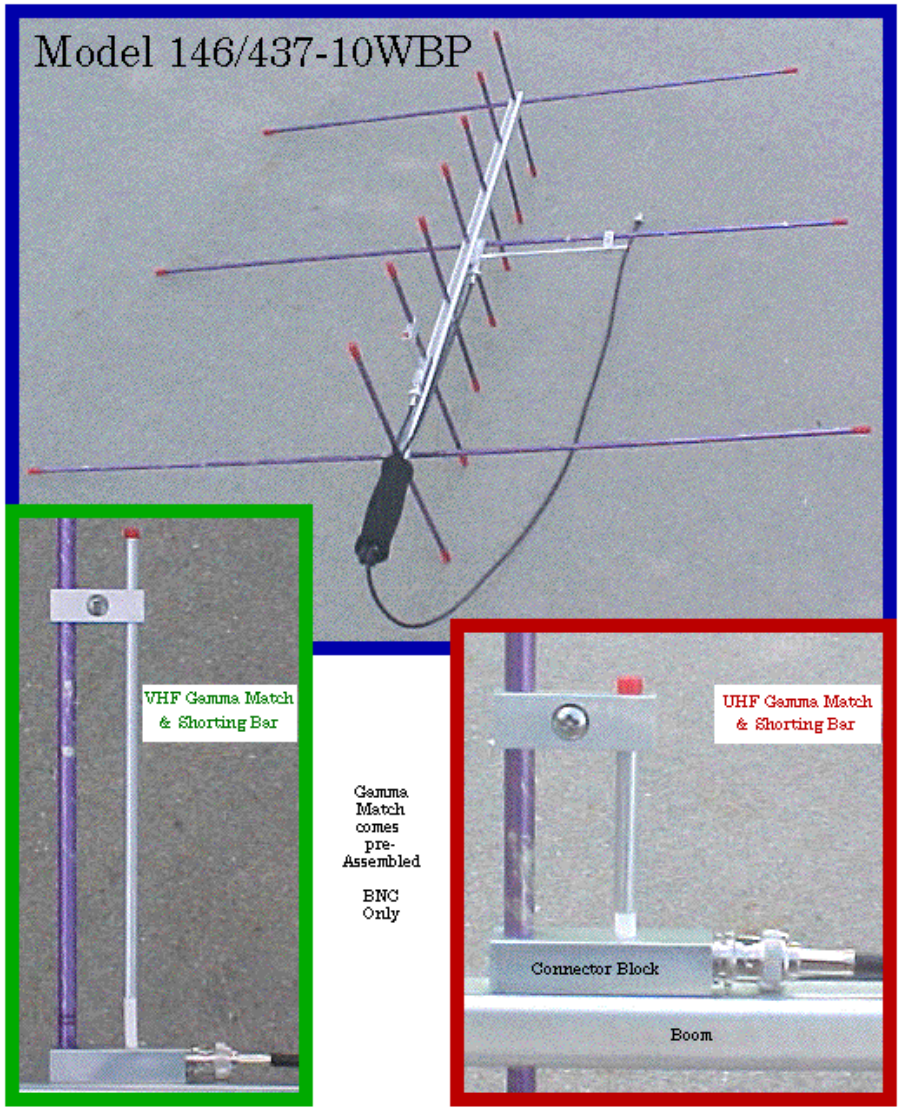
Two radios, multi-mode, VHF/UHF

Yaesu FT-817 are very popular for portable operation – a.k.a. FT-1634



One radio with two VFOs. Does not need to have the satellite function.

Equipment



Typically, satellites have low transmit powers.

You must have a good antenna on receive!

A low-pass filter on the VHF side is also a must.

Frequencies

https://www.amsat.org/linear-satellite-frequency-summary/

Linear Satellite Frequency Summary

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

XW-2C (CAS-3C) – U/v Inverting Analog SSB/CW

Uplink LSB	435.150 MHz	through	435.170 MHz
Downlink USB	145.795 MHz	through	145.815 MHz

XW-2F (CAS-3F) – U/v Inverting Analog SSB/CW

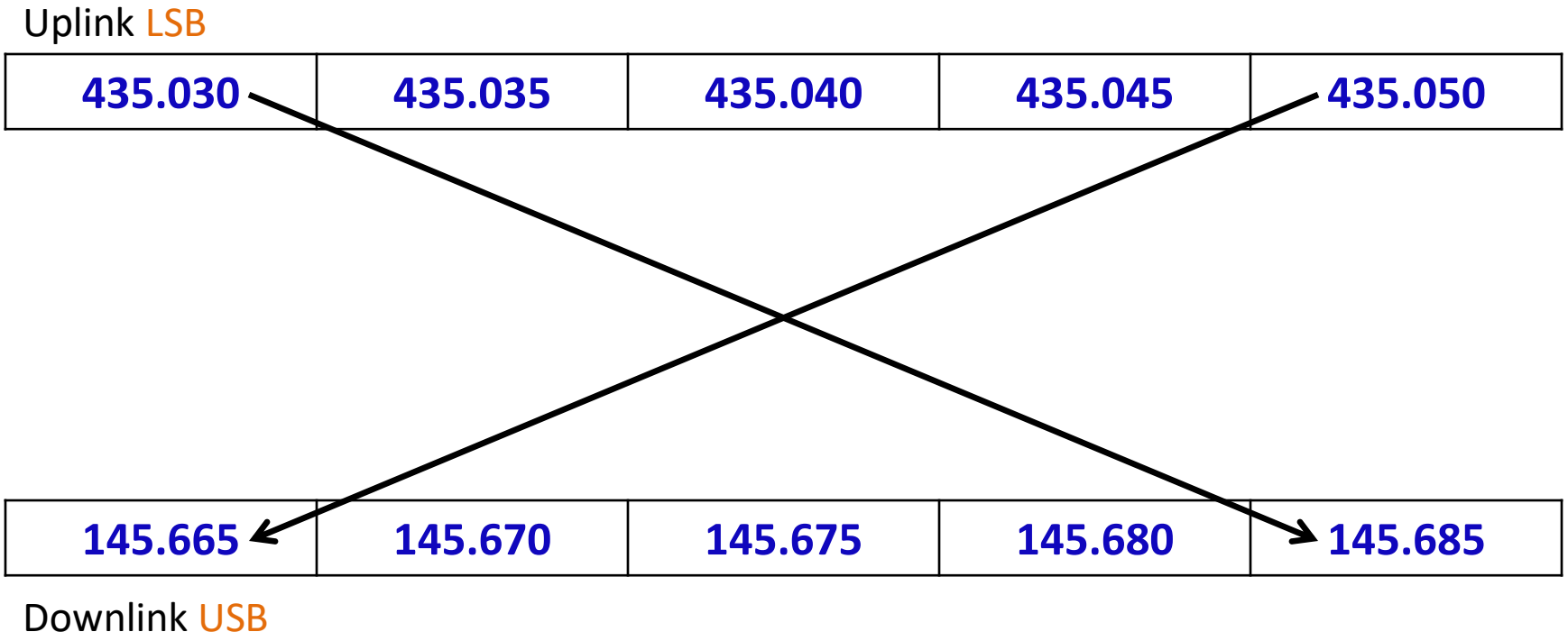
Uplink LSB	435.330 MHz	through	435.350 MHz
Downlink USB	145.980 MHz	through	146.000 MHz

RS-44 – V/u Inverting Analog SSB/CW

Uplink LSB	145.935 MHz	through	145.995 MHz
Downlink USB	435.610 MHz	through	435.670 MHz

Frequencies

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



Frequencies

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

Uplink LSB

435.030	435.035	435.040	435.045	435.050

145.665	145.670	145.675	145.680	145.685

Downlink USB

Doppler effect

... so-called “One True Rule” of thumb for linear satellite operation is that if the uplink band is *higher in frequency* than the downlink, you should slowly shift your ***transmit frequency on the uplink as*** the Doppler effect changes the frequency of your downlink signal. Conversely, you should shift your ***receive frequency if the*** uplink band is *lower in frequency than the* downlink.

TRANSLATION:

Shift the UHF!

https://www.amsat.org/wordpress/xtra/Getting%20Started%205.pdf

In practice…

From Keith Baker, VA3KSF / KB1SF

In an e-mail to me earlier in the fall: **(For mode U/v satellites)**

…pass along the following little operating hint:

One of the "rules of thumb" for operating on our linear satellites is to:

1. try to hold your **DOWNLINK frequency [VHF - USB] as steady as you can**, and
2. just **shift your UPLINK frequency [UHF - LSB]** to first find yourself...
3. and then **move it ALONE [the UPLINK - UHF]** to compensate for Doppler.

In practice…

Keith Baker, VA3KSF / KB1SF

XW-2A mode U/v

UP	435.030	435.035	435.040	435.045	435.050
DN	145.665	145.670	145.675	145.680	145.685

Once you hear activity on the satellite:

- Pick a frequency on the downlink (145.675 MHz USB)
- Start transmitting on 435.026 MHz LSB (435.040 - 14kHz Doppler)
  - while constantly and slowly increasing your **uplink** (UHF) frequency until you hear yourself.
- Leave your downlink constant as much as possible.
- As you transmit, continue to slowly increase your uplink to stay stable on the downlink.

Mode V/u (FO-29 and RS-44)

For mode V/u transponders, the one true rule still applies:

- In this case, keep your uplink (VHF) constant and,
- Shift your downlink (UHF) to receive the other station.

FO-29 (now in sporadic operation) and RS-44 are the only linear satellites that can be worked with one dual-band radio in split mode, as you do not need to shift the uplink frequency (VHF).

See these YouTube videos:

How to operate FO-29 using a single Yaesu FT-817 [Applies to RS-44]
https://www.youtube.com/watch?v=vke3pWkKULU

WD9EWK Demonstrating Satellite Operation - FO-29
https://www.youtube.com/watch?v=Tqx7Beibi7M&list=LL&index=27

But wait, there is more…

Mode V/u (FO-29 and RS-44)

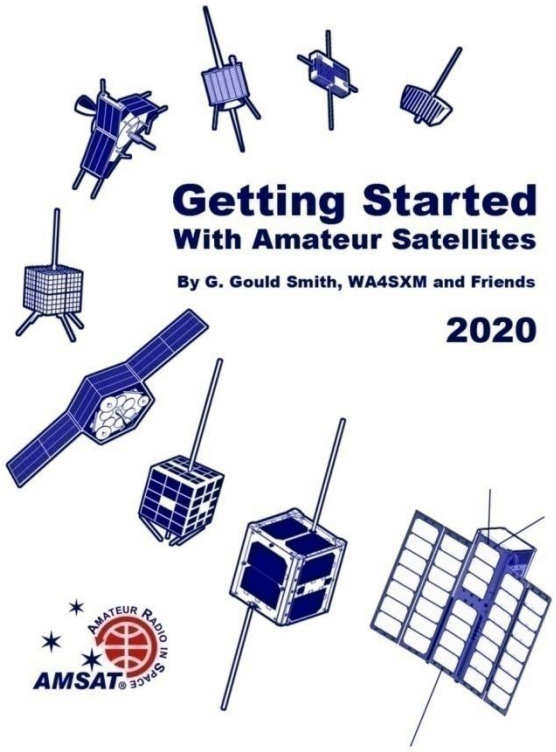
From Keith Baker, VA3KSF / KB1SF

And, yes, the "one true rule" DOES say to shift the higher frequency uplink/downlink [UHF].

However, **as a practical matter**,

- most operators operating in Mode V/U **tend to ignore that rule** [the one true rule]
- … continue to **shift their uplinks** (in the case of RS-44 the 145 MHz uplink)
- … **keep their downlink frequencies constant in the passband**.
- … it is still FAR easier for others to find and work you if your downlink frequency stays relatively fixed in the passband.

So, we have two ways of doing this: the one true rule or what is above. Whatever floats your boat ;-)



Some full-duplex transceivers have a "satellite mode" that couples the transmit and receive VFOs so that you can tune the receive frequency and the transmit frequency automatically tracks the changes.

This worked well with satellites AO-10, AO-13, and AO-40, where for significant parts of the orbit, the Doppler shift, while possibly large, was relatively constant.

For LEO satellites, the Doppler shift is always changing, making this feature nearly useless.

About RS 44 (mode V/u)

RS-44 is in high LEO (~1500km).

The footprint is quite large.

On low eastern passes (20° or so), we can work western Europe

Stations heard from Spain and UK.

The mayhem on the satellite is the same as on HF where everyone is trying to get the Dx.

We can do DX on the satellites!

Distance records

FM

AO-91 – 6,183 km. N5LEX PA < > F4DXV France, 13-Aug-2020

SO-50 – 5,523 km. F4DXV France < > N1AIA Maine. 24-Oct-2018

Linear (SSB)

RS-44 – 8,402 km. KI7UNJ Oregon < >F4DXV France, 19-October-2020

AO-7 – 8,204.592 km. F4DXV in JN14ch < > KE9AJ in DM79iq, 10-Aug-2020

Resources

AMSAT articles for beginners

https://www.amsat.org/introduction-to-working-amateur-satellites/

Dx Enginering has six videos on YouTube done by Sean Kutzko, KX9X

Sean covers both FM and linear satellites

https://www.youtube.com/user/DXEngineering/videos

Sean talks about a frequency chart with Doppler calculated for most satellites.

https://ke0pbr.wordpress.com/2018/12/31/my-frequency-cheat-sheet/

Thank you

VE2MW