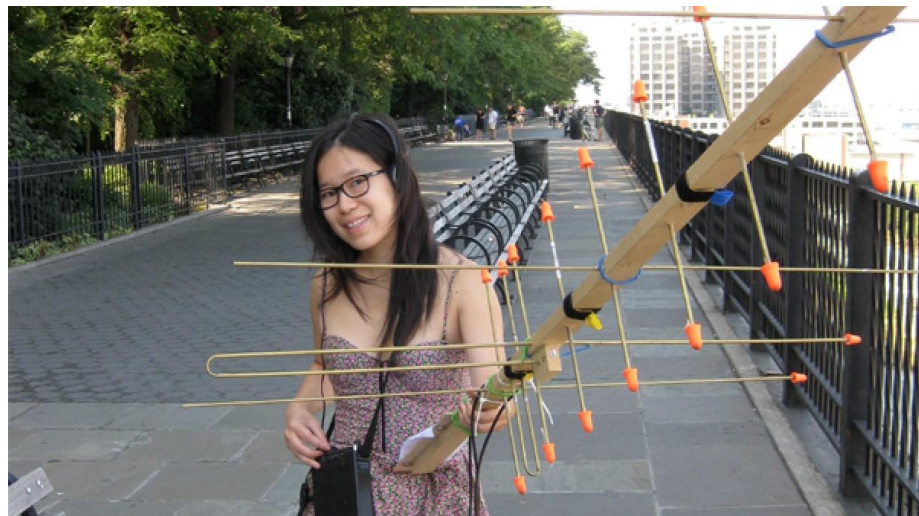
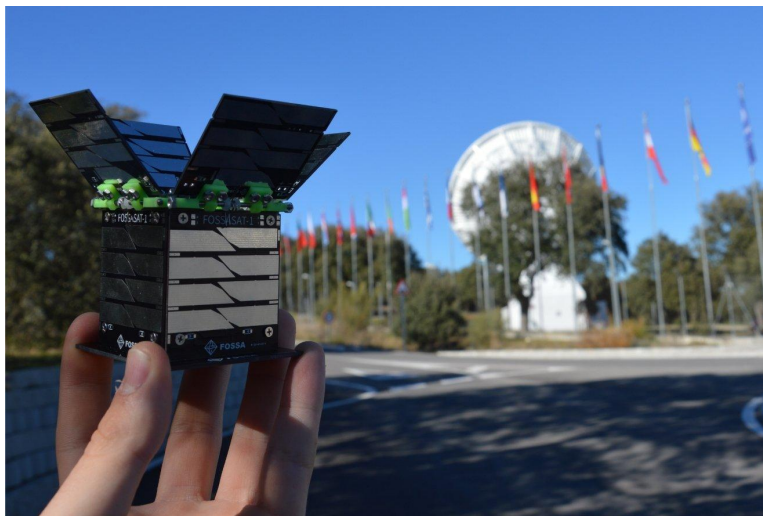


Amateur Radio Satellites for Beginners

David Spoelstra, N9KT



Why get into amateur radio satellites?

Sunspots are at a record low. Since 1854, there have only been two years worse than 2019 (1901 & 1913).

There are more satellites covering more modes than ever before.

Beginning equipment is simple and inexpensive.

It's a great opportunity to get young people into the hobby.

IT'S FUN!

What am I going to show you today?

I'm going to show you how to get started with amateur radio satellites by showing you:

- How to receive an SSTV image from the ISS
- How to talk on an FM bird

Why those two?

- Easy to do
- Use minimal equipment.
- Getting pictures from the ISS is fascinating - especially if it's a visible pass. Kids are especially mesmerized by it.

A little history...

Dec 12, 1961 - The first amateur radio satellite Oscar 1 (Orbiting Satellite Carrying Amateur Radio) was launched only four years after the launch of the very first satellite Sputnik 1.

Telemetry only. Over 570 amateur radio operators in 28 countries heard it.

Since 1965 most amateur radio satellites have had two-way communications.



ARISS - Amateur Radio on the ISS - ariss.org

Amateur Radio was a regular payload on Shuttle missions starting with STS-9 in November 1983, when Owen Garriott, W5LFL, carried a hand-held ham radio aboard Space Shuttle Columbia.

In 1996 ARISS, or Amateur Radio on the International Space Station (ISS), was formed and ratified by the eight nations involved in the ISS to design, build and operate Amateur Radio equipment in space for educational purposes.



ARISS - Amateur Radio on the ISS - ariss.org

Four to six times a year the ISS transmits SSTV images like these:



Receive an image? Get a certificate from ARISS!

IN MEMORY OF
ALEXEI LEONOV, VALERY BYKOVSKY, SIGMUND JÄHN

ARISS SSV Award
№ 150317

David Spoelstra N9KT

Received SSV images commemorating the astronauts Alexei Leonov, Valery Bykovsky, Sigmund Jähn, sent through the amateur radio system installed on the Russian segment of the International Space Station.

Принял SSV изображения посвященные памяти космонавтов Алексея Леонова, Валерия Быковского, Зигмунда Яна, отправленные через радиолобительскую систему установленную на Российском сегменте Международной космической станции.

Руководитель Радиолобительской
Делегации на МКС
Сергей Самбуров RV3DR
ARISS International Chair
Frank Bauer KA3HCO
ARISS Europe Chair
Oliver Altmann DG8BCE
RSOISS Операторы - космонавты
Александр Сиворцов
Oliver Szymanski
Mentor ARISS Europe
Armand Butzanowski SP3QFE
ARISS SSV Award Manager
Sławomir Szymanowski SG3DQCK

RSOISS
28 December 2019 - 1 January 2020

Amateur Radio on the International Space Station
Любительское радио на борту Международной космической станции

What receiving equipment do I need?

A 2m receiver. I have successfully used:

- A police scanner
- A 2m mobile
- Various 2m HTs including the one I use now, a Baofeng UV-5R.
- SDR-RTL dongle



What antenna do I need?

I have successfully used:

- A stock police scanner whip
- The stock Baofeng rubber duck (difficult)
- An aftermarket long HT whip
 - This is what I usually use!
- A 2m/70cm JPole
- A discone
- A yagi

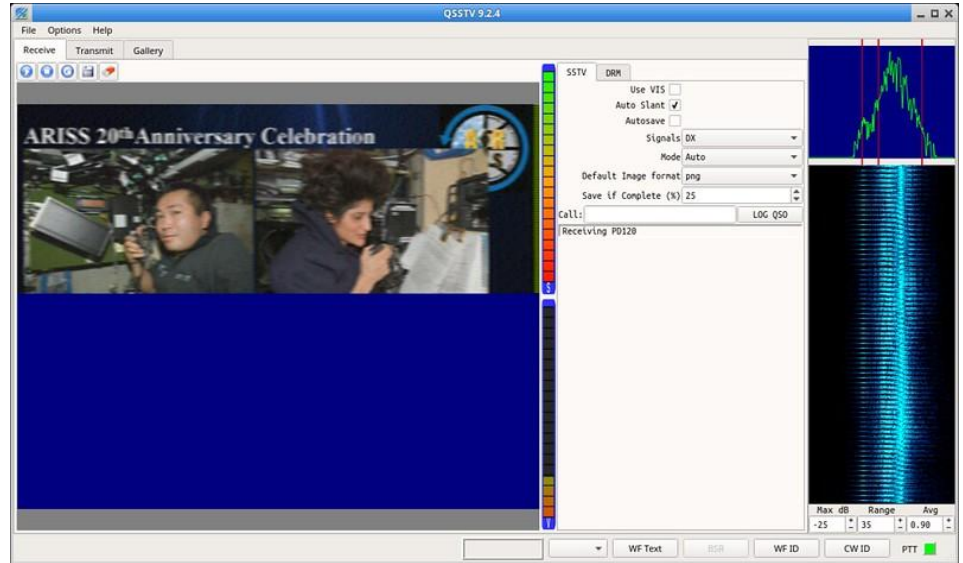
For the best price/performance and success, I suggest an aftermarket long whip on an HT.



What hardware/software do I use to decode the image?

I have used PCs, Macs, and Smartphones.

- Linux: QSSTV
- Mac: Multiscan 3B SSTV
- Windows: MMSSTV
- Android: Robot36
- iPhone: SSTV Slow Scan TV



How do I know when to listen?

Lots of websites out there. I recommend these ones:

- AMSAT - amsat.org/track
- Heavens Above - heavens-above.com
- N2YO - <https://www.n2yo.com/?s=25544>
- SATFLARE - satflare.com

For the Android and iPhone, I highly recommend “ISS Detector”. It’s just simply awesome and will also track all the other amateur radio satellites and show you visible passes.

I also like “Look4Sat”, but it’s only available on the Android.

How do I know where the ISS is?

First some terms: AOS means “Acquisition of Signal” - when the ISS rises above the horizon. LOS is “Loss of Signal” - when the ISS goes below the horizon.

The sites on the previous page will also show you the compass direction (azimuth or AZ) of the ISS at AOS and LOS.

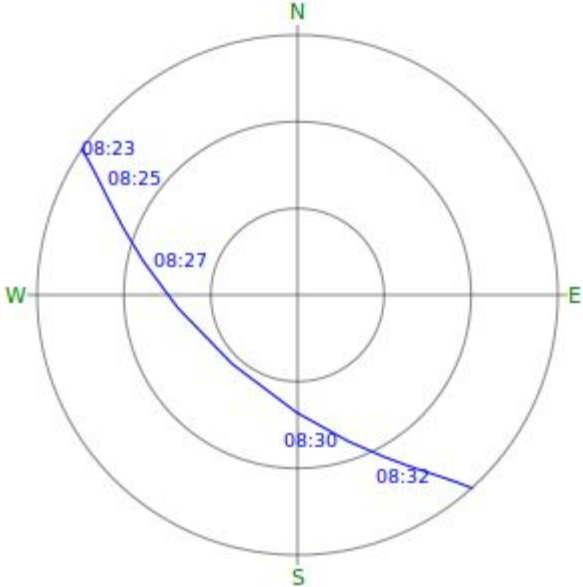
They also show you the maximum Elevation (or EL or Altitude) which is how high in the sky the ISS is. 90 degrees is directly overhead.

The AZ and EL together describe the curve in the sky of the ISS as it passes over.

This is usually shown in a polar coordinates plot.

Examples of tracking information

AMSAT Online Satellite Pass Predictions - ISS							
View the current location of ISS							
Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)
18 Jan 20	00:19:19	00:09:11	187	13	127	71	00:28:30
18 Jan 20	01:54:52	00:10:52	238	65	330	51	02:05:44
18 Jan 20	03:32:43	00:09:44	280	16	339	47	03:42:27
18 Jan 20	05:10:56	00:09:02	307	11	7	60	05:19:58
18 Jan 20	06:48:05	00:10:12	314	22	11	94	06:58:17
18 Jan 20	08:24:47	00:10:45	304	55	212	138	08:35:32
18 Jan 20	10:02:55	00:06:40	274	5	233	197	10:09:35
18 Jan 20	23:32:22	00:07:38	171	7	130	81	23:40:00
19 Jan 20	01:06:55	00:10:47	226	71	137	55	01:17:42
19 Jan 20	02:44:22	00:10:06	270	20	329	46	02:54:28



So how do I actually do it?

Set your radio to 145.800 FM. Open your squelch and turn on your SSTV decoding software. Set it to decode the correct format (PD120 or PD180).

Just before AOS, hold your antenna perpendicular to where the ISS is coming over the horizon. Hold the speaker of your radio near the microphone of the device doing the decoding.

When you hear the signal, your software will start decoding and showing the image. Continue to move your antenna perpendicular to the ISS as it moves across the sky until LOS.

DEMO and Movie Time!

Using an HT and phone and stock antenna! Notice how he moves the antenna orientation around when he gets static:

<https://www.youtube.com/watch?v=xzQktX5r5IY>

Another HT and phone - <https://www.youtube.com/watch?v=jZkPiAGUXvA>

PD120 test recording. Use this to test your decoding software:

<https://soundcloud.com/spacecomms/pd120-sstv-test-recording>

Other things you can receive with this setup

A lot of the satellites send telemetry you can decode with the correct software.

Weather satellites send pictures of the earth which you can decode with the correct software.



I'm in  with

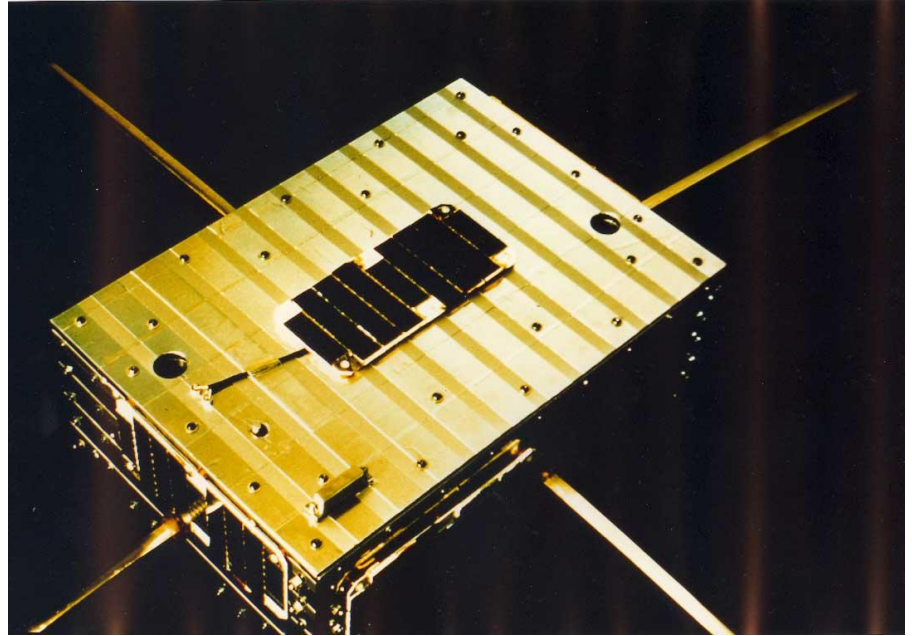
satellites and I want
to TALK on one!

AMSAT - The Radio Amateur Satellite Corporation

501(c)3 formed March 3, 1969 to embrace and expand on the work started by Project OSCAR.

Today AMSAT builds and manages all of the amateur radio satellites in orbit.

AMSAT-OSCAR 6 (AO-6) to the right.
Note the “tape measure” antennas.
That’s really what they are!



Current FM Repeater Satellites

- PO-101 (Diwata-2)
- AO-91 (Sunlight only!)
- SO-50 (SaudiSat-1C)
- AO-27
- ISS
- LilacSat-2 (CAS-3H)
- UVSQ-SAT



SO-50
10 cm x 10 cm x 10 cm

Current Linear Transponder Satellites

- AO-7
- FO-29 (JAS-2)
- AO-73 (FUNcube-1)
- XW-2A (CAS-3A)
- XW-2C (CAS-3C)
- XW-2F (CAS-3F)
- EO-88 (Nayif-1 / FUNcube)
- CAS-4A
- CAS-4B
- JO-97 (JY1Sat)
- FO-99 (NEXUS)
- JAISAT-1
- RS-44
- QO-100 (Es'hail-2 / P4A)

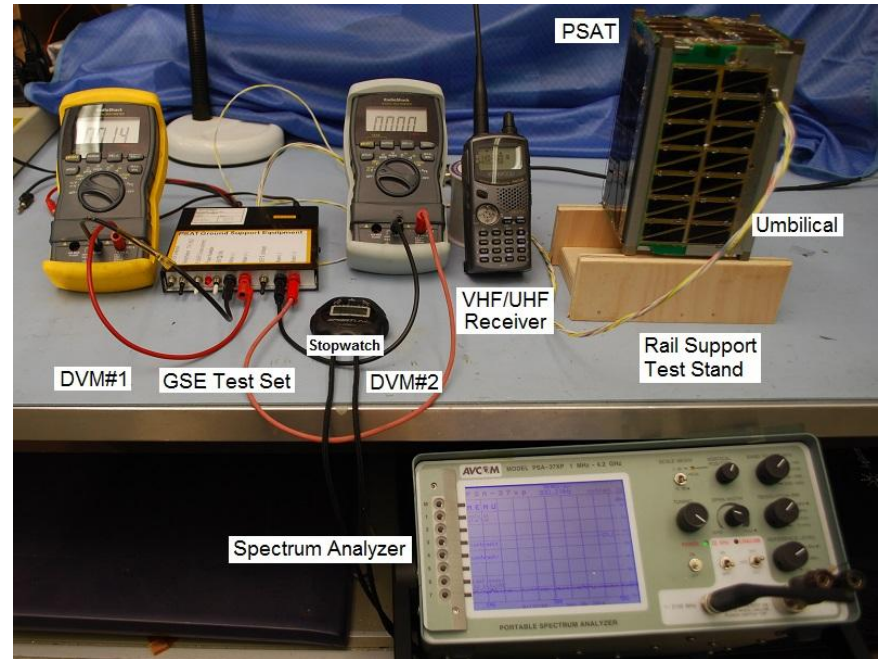


AO-73
10 cm x 10 cm x 10 cm

Current Digital Satellites

Images, PSK31, Digipeaters, Store and Forward, etc!

- FalconSAT-3
- NO-44 (PCsat)
- NO-84 (PSAT) PSK31 / Digipeater
- AISAT-1
- NO-103 (BRICSAT2)
- NO-104 (PSAT2)
- ISS Ham TV



Which satellites are working?

Satellites get launched regularly.

Satellites also re-enter the earth's atmosphere and burn up or sometimes the batteries die or they just malfunction.

You can always find live reports of which satellites are working at this page:

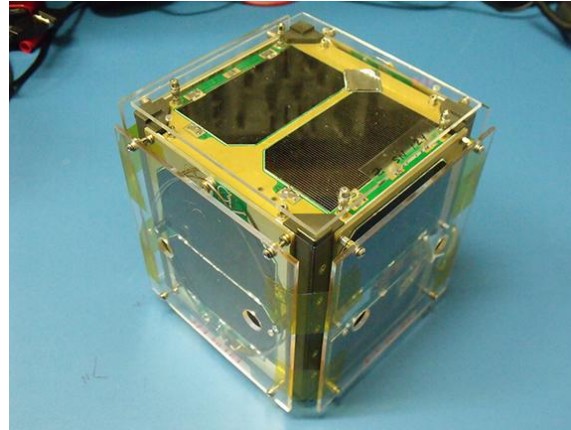
<https://www.amsat.org/status/>

As a beginner, which ones should I talk on?

The easiest ones to talk on with the minimal equipment are the FM birds.

My favorites are:

- PO-101 (Diwata-2)
- AO-91 (Sunlight only!)
- SO-50 (SaudiSat-1C)
- AO-27
- ISS



PO-101

All the above FM birds are dual band and transmit on either 2m or 70cm and receive on the other band. They all use a CTCSS tones.

BTW, sometimes the astronauts make random FM contacts from the ISS!!!

What transceiver do I need?

You will need a dual-band 2m/70cm rig.

The best ones to use are **full-duplex** (SIMULTANEOUSLY transmit on one band while listening on the other).

Some common ones: Kenwood TH-D72, D7, D7(G), Yaesu FT-470 and FT-530, and Wouxun Dual Band. Here's a list:

<http://freefishnj.blogspot.com/2017/01/full-duplex-radios-for-satellites.html>

Some people just use two inexpensive radios like Baofeng UV-5Rs! One for transmit and one for receive. I have used this method and it works pretty well.

You CAN just use a single half-duplex radio like one Baofeng UV-5R. I have done it, but It's not as easy and it's definitely NOT recommended!

What antenna do I need?

You ABSOLUTELY need something better than a stock rubber duck!

I HAVE used a longer whip on an HT, but it is difficult.

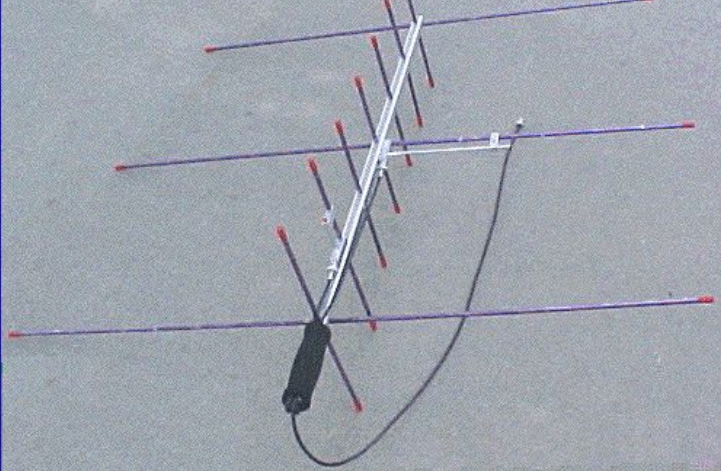
I recommend a 2m/70cm yagi:

- Arrow (\$150 - that's what I use. True crossed beams)
- Elk (\$130)
- New AMSAT South African antenna (\$68, but you have to buy 6 at a time).

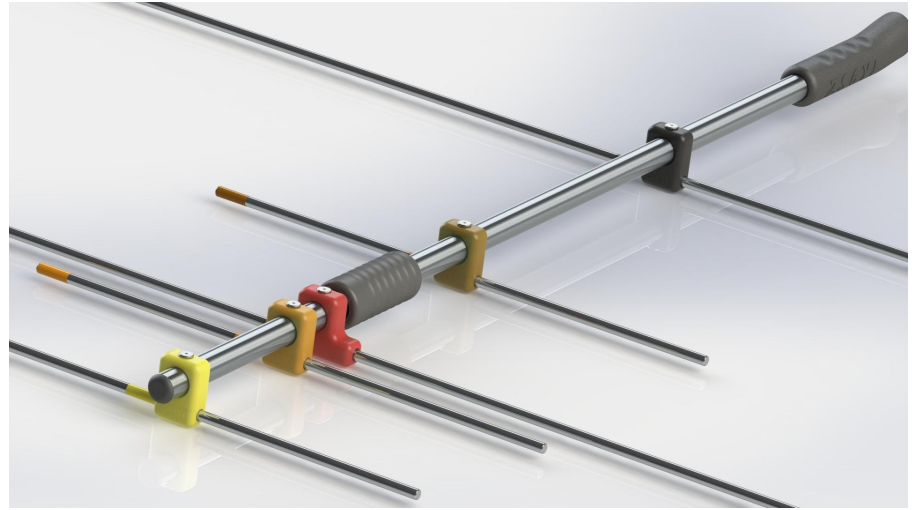
You can also build one yourself - a tape measure antenna.

2m/70cm Yagi

Model 146/437-10WBP



Arrow Dual Band Antenna -
<http://www.arrowantennas.com/arrowii/146-437.html>



AMSAT SA Dual Band Yagi -
<http://www.amsatsa.org.za/DualbandYagi.htm>



Elk Dual Band Yagi -
<https://elkantennas.com/product/dual-band-2m44015-log-periodic-antenna/>

Tape Measure Antenna



<http://km4lgm.com/2015/07/dual-band-tape-measure-yagi-antenna/>

Additional Equipment

Headphones - since you are running full-duplex, you must use headphones so you don't get feedback. You ARE using full-duplex aren't you?

Recorder - since both hands are busy, it's much easier to just record the entire pass and review it later. I just bought a cheap (\$20) digital recorder and use a splitter cable to split the audio output of my HT to the recorder and the headphones.

Can I really make contacts with such simple equipment?

ABSOLUTELY!

I have a 5 watt Yaesu FT-530 dual-band full-duplex HT and an Arrow antenna.

I have been working the FM birds for three months and have 47 states confirmed and 175 grids (as of 1/20/21)!

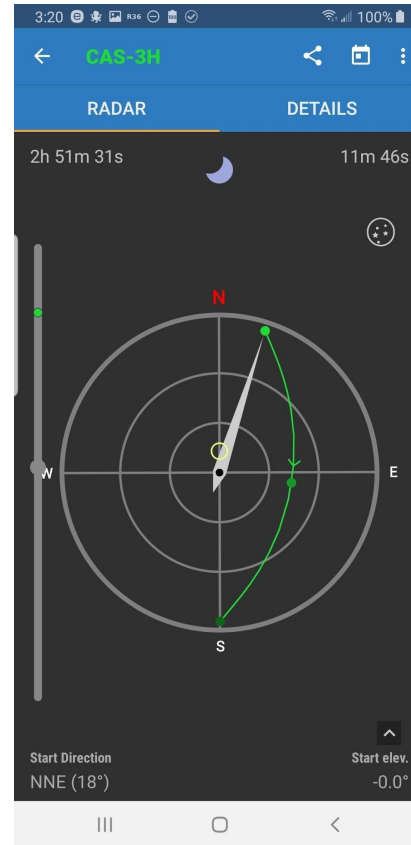
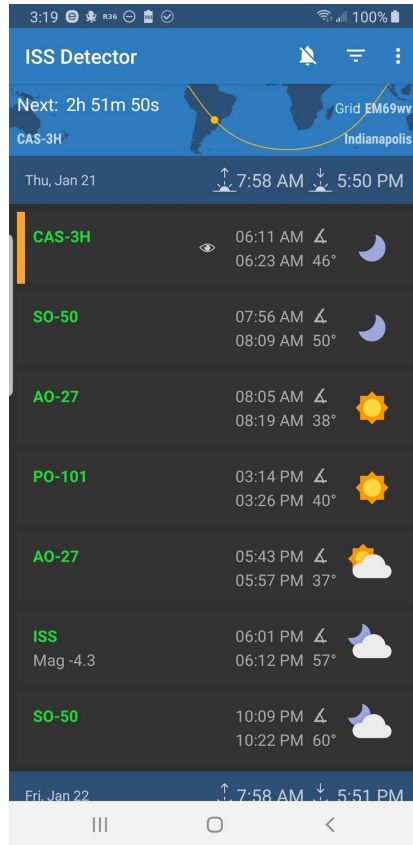
Tracking Software

With a yagi, you need to point at the satellite. To do that, you need to know where it is - that's where tracking software comes in. I'm going to assume you are outside holding your antenna, so using your smartphone is easiest.

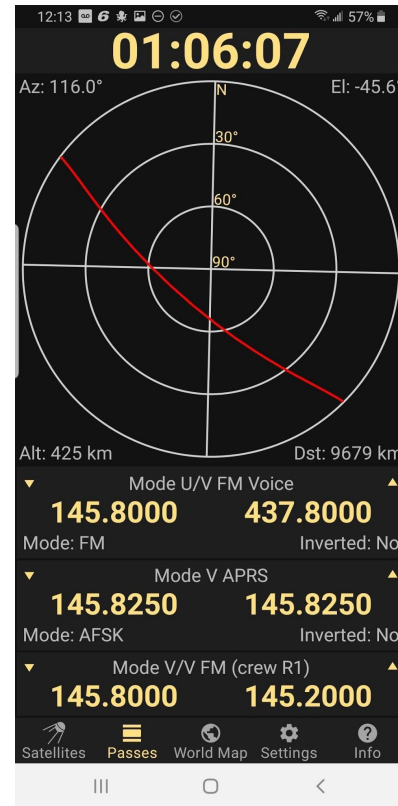
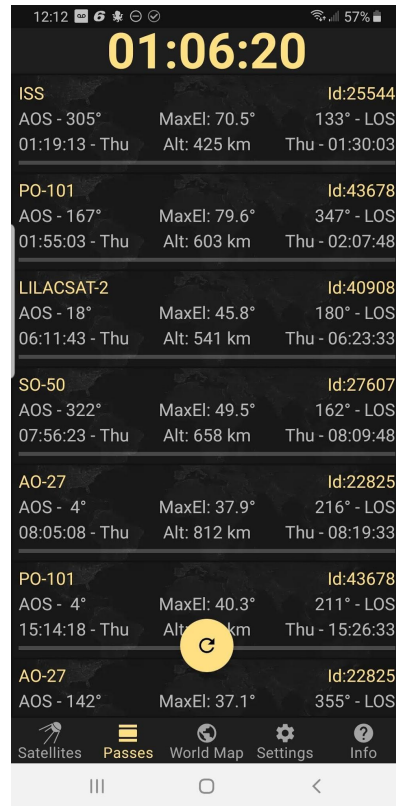
Android and iPhone - "ISS Detector" is simply AWESOME. It has a display that helps you align in the X, Y, and Z axis. Once the dot is in the circle, your phone is pointing right at the satellite. I also like "Look4Sat" on the Android.

Tracking does not have to be super accurate. The yagis have a wide beam, so pointing in the general direction works. After you hear the satellite, move the antenna around for loudest reception.

ISS Detector - Android & iOS Sat Tracking App



Look4Sat - another Android Satellite Tracking App



Doppler

Because the satellite is moving very fast toward you and then away from you, the frequency changes because of the doppler effect.

You need to correct for these frequency shifts in order to have a successful QSO!

The easiest way is to load five frequency pairs into memory and switch as the pass goes by. One each for AOS, 60 degrees toward you, overhead, 60 degrees away from you, and LOS.

CTCSS - the FM satellites use tones. Don't forget to program them in or no QSO!

Example memory frequencies

RX:	145.900		PO-101		Tone: 141.3
TX:	437.490	437.495	437.500	437.505	437.510
	AOS		MID		LOS

Here's an excellent chart with all the FM frequencies here:

https://docs.google.com/spreadsheets/d/1rfluangbvF0qOIL-PyhzXWD09eCs_zZE6ATKZ43j4ujk/edit?usp=sharing

The QSO Exchange

There is only one channel on an FM bird with lots of people wanting to use it, so the exchange is very short. No rag chewing - that's what the linear transponder satellites are for (your next step after you are good with the FM birds).

The exchange is your grid square.

A typical QSO goes like this (USE PHONETICS!):

- **Me:** N9KT EM69
- **Them:** N9KT NA1SA FN10
- **Me:** NA1SA QSL



Your first satellite QSO

Open the squelch all the way. You should be hearing static.

Set transceiver memory to the AOS pair. Make sure the CTCSS (tone) is on.

Point the yagi to where the satellite should be rising and listen.

When you hear someone, give your call and grid square and follow the QSO script.

Track the satellite with the yagi and switch through the radio memories as the satellite moves overhead.

GOOD LUCK! You can do it! It's easy!

Golden Rules!

Share the bird - there are few satellites and many users.

Let other QSOs finish - that way more contacts are made.

Use full-duplex - that way you don't walk on others and more contacts are made.

Minimize repeat QSOs - don't work 'em again if you already have them.

Do NOT call CQ satellite - just don't do it. Follow my script - short and sweet.

Always use phonetics - it cuts down on repeats so more contacts can be made

Rare/Portable stations take priority - work 'em and get out of the way for others

Use only the minimum power required - 5 watts and a directional antenna are enough

Work the new stations - you might need their grid square anyway

Tips so you don't get a bad reputation on the birds

LISTEN! If you don't hear anyone else on the FM birds, then your receiver is not working or on the wrong channel! Even at 2 am or 3 am local there are people on the FM birds.

DO NOT, DO NOT, DO NOT CALL "CQ Satellite"! You are probably calling that because you don't hear anyone on the satellite which really means your radio is on the wrong receive frequency. There are always people on the FM birds. If you are calling "CQ Satellite" because you can't hear them, you are really talking on top of them!

USE FULL DUPLEX! That way you are not talking on top of other people! You can also hear yourself so you know you are getting into the bird.

One Field Day tip

DO NOT try and work your very first satellite on Field Day with an HT and a handheld yagi! You will NOT be successful.

You CAN work the FM birds with this setup on Field Day (I have), but it's hard because there are many people trying to work the birds for Field Day points with big tracking antennas and 100 watt satellite rigs.

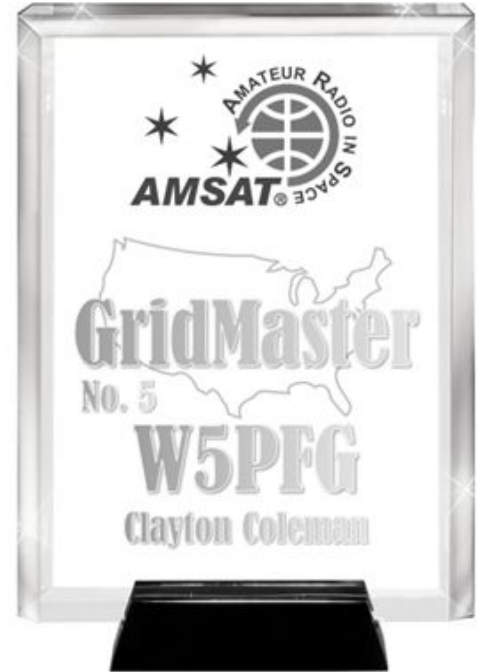
You need to practice with your setup before Field Day to successfully make a QSO on Field Day.

Other fun things - Roving and Awards!

Now you have a portable satellite setup! You can easily take it with you on vacations and activate rare grids. There are awards from AMSAT for activating grids.

The holy grail of satellite awards is the AMSAT GridMaster Award for working all 488 grids in the continental US. Only 26 people have done it. If you want to start collecting grids, get on Twitter and follow:

- @GridMasterHeat
- @The_Grid_life



References

The best place to start for a beginner: work-sat.com This site has everything for the beginner. Subscribe to the email list and you'll get emails when the ISS is going to be transmitting pictures.

ariss.org - Amateur Radio on the International Space Station has all the information on the ISS passes transmitting pictures and where to submit them to get a certificate.

amsat.org - AMSAT is the people that build and launch our satellites. This site has extensive information on everything to do with amateur radio satellites. If you are going to buy an antenna, please buy it through AMSAT. Also, please join and support AMSAT if you use the satellites so that we can get more launched!

Thank you!

Any questions?