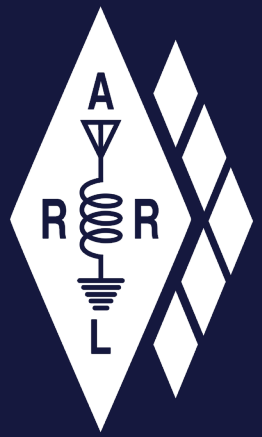
Inexpensive Space Communications



ARRL
The National Association for
Amateur Radio®

Who Am I?

Front of HQ these days

W1AW

The Lab

W1HQ

Some new stuff!

Some things I have done recently

Built and fixed multiple RF Amplifers

Built a few different EME capable antennas

Modelled and designed diplexer used in ARRL 2m 70cm Handheld Antenna

Built Directional Couplers for High Power Microwave

Why Space?

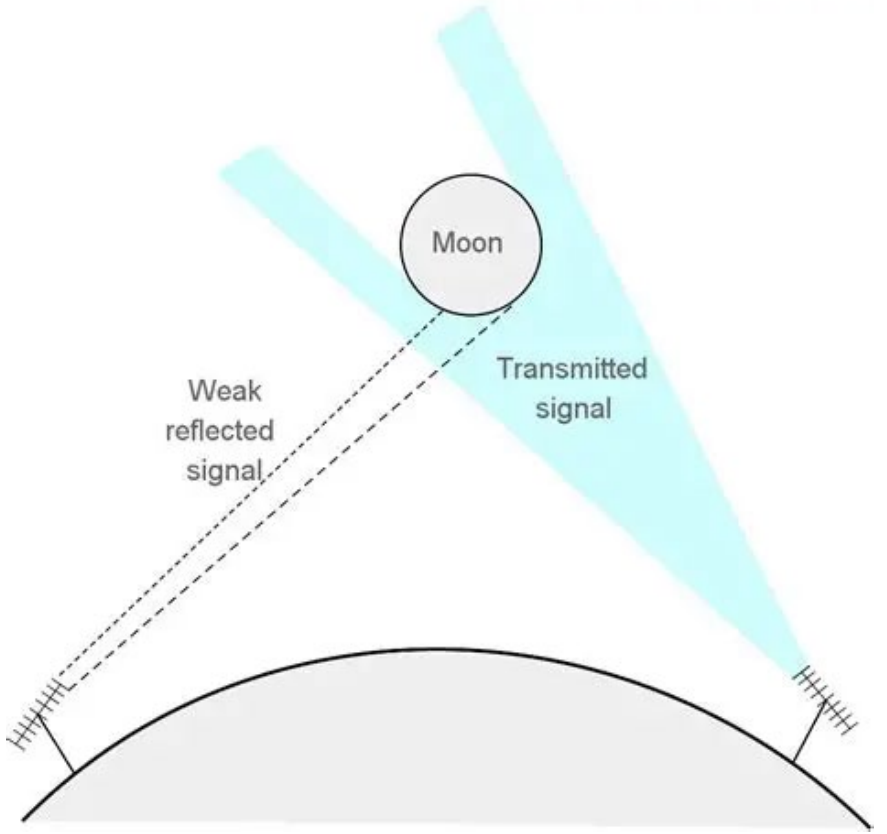
An Overview

- Moonbounce
  - Equipment Needed
  - Different Antennas that are affordable
  - DIY Solutions to Antennas
  - Rotators
- Satellites
  - Radios
  - Antennas
  - Automated Solutions

MoonBounce (EME)

What do you need?

- Highly directional antennas
- Rotator system
- Transceiver
- Preamplifier
- POWER



Tools

- Software:
  - WSJT-X
  - ISS Tracker (Mobile App)
  - EME Observer
  - OE2IGL EME Link budget tool
  - ARRL RF Exposure Calculator
- Hardware:
  - Soldering Equipment
  - Drilling tools
  - Metal cutter (Hacksaw, jigsaw)
- Test Equipment:
  - NanoVNA-F V2 or better
  - TinySA Ultra (Signal generator + spectrum analyzer)
  - Multimeter
  - Wattmeter/VSWR Bridge

What Band to Use?

- Bands that allow smaller antenna systems:
  - 902 MHz+
- Bands with Readily Available Equipment
  - 2m, 70cm, 1296, 2.4GHz, 10 GHz

The Target

- 1296 MHz
- 500 Watts
- 20 dBi of gain or more
- Manual Rotating System

Antennas

W2HRO Folding Dish Design

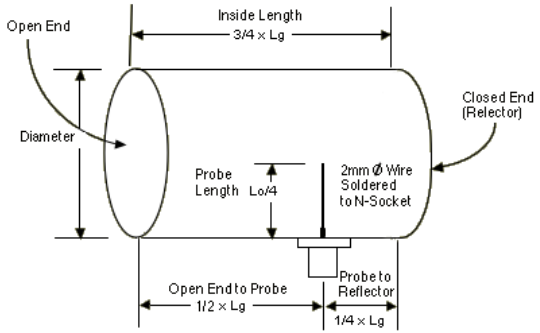
OZIBXM Yagi Uda Array

Antennas –DIY Solutions

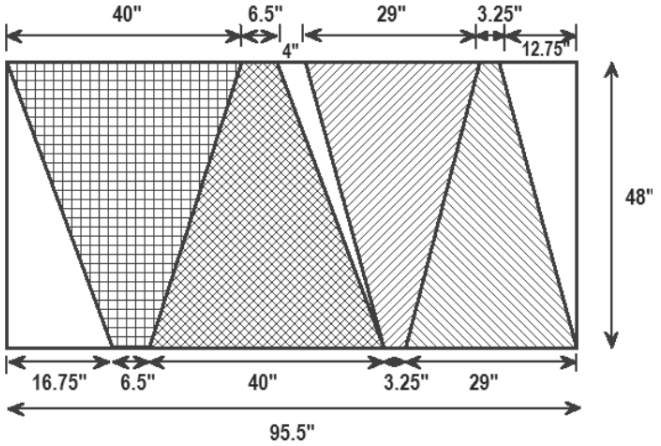
If you don’t care for aesthetics and are on a budget

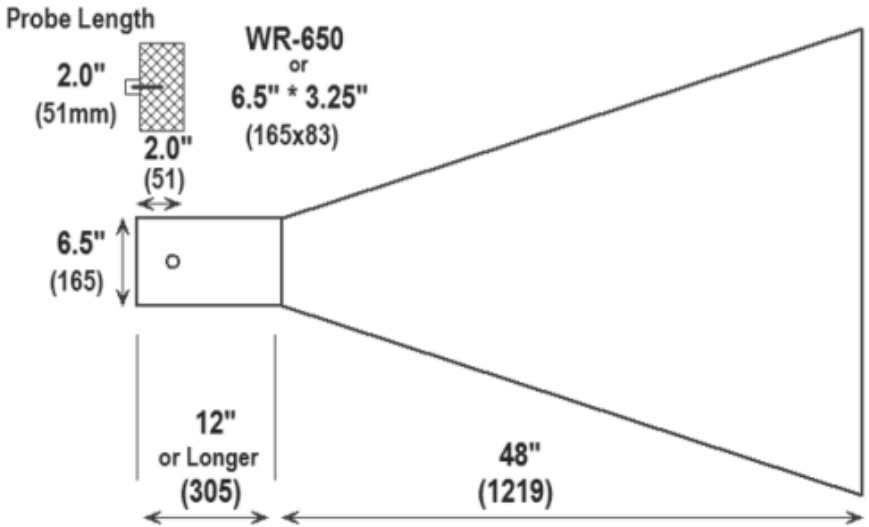
Phased Array Venting Duct

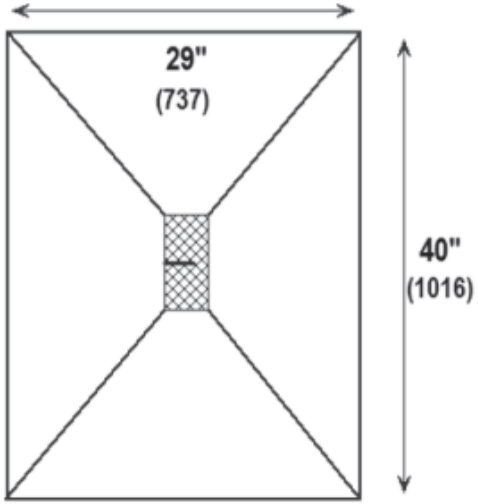
- Use normal Venting duct from Home Depot or Lowes
- 8 of them make for a capable phased array with about 20 dBi of gain
- Material cost likely similar to a manufactured yagi of similar gain



Foamboard Insulation







- https://ok2kkw.com/next/horn_23cm.pdf
- 32 dollars for 1 8’ by 4’ sheet, enough to make a 23cm horn antenna
- FRAGILE, do not use in windy conditions
- Quick to build
- 50 dollars

Folding Dish – W1DRF Style

- Patio Umbrella, Window Screen, Copper Wire, PVC Pipe, and 1” 8 tpi threaded steel rod
- Faraday Cloth potential alternative to window screen
- 2.8m dish for around 200 dollars
- Fiberglass is fragile!

- Armstrong Method
  - Telescope mount
- Az El Rotator System
- Linear Actuators + Azimut

Rotator System

Radios: Two Approaches

- Transverters
  - Less Expensive
  - Adds point of failure and noise
  - Low power output (1-3 watts for most, sometimes 10)
  - DIY!

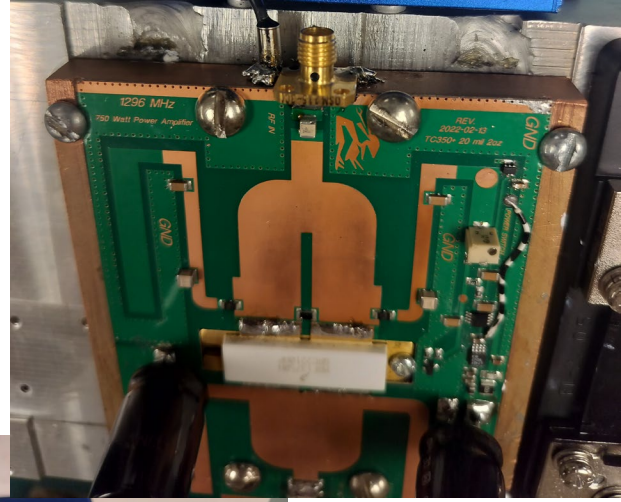
- Baseband Radios
  - More Expensive
  - Reliable
  - More output power and direct keying
  - More Band Capabilities

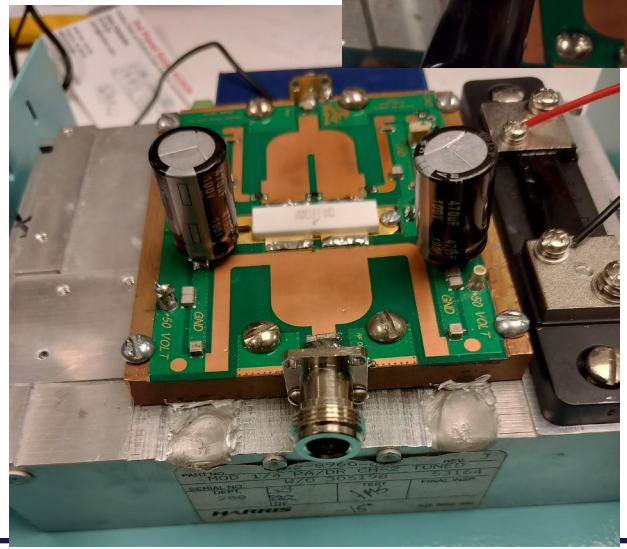
What is a Preamplifier?

- Preamps help overcome line loss when installed near the antenna feed
- Need to add a keying circuit to bypass the preamp on transmit
- Look for Narrow band preamps with low noise figures
- eBay is your friend

Get Extra Juice

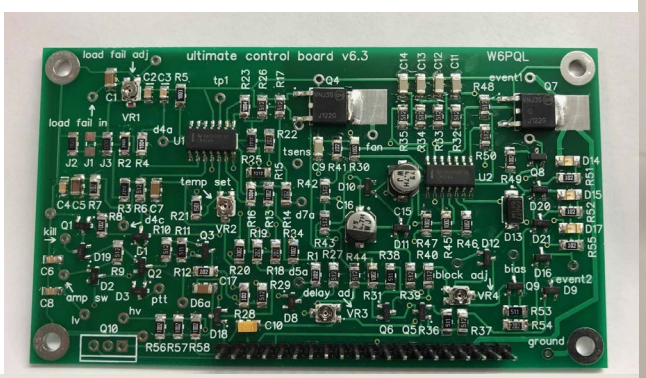
- The key to being able to work anything on EME with a compromise setup is POWER
- No Harmonic suppression requirement under Part 97 (so no need for complex microwave filters)
- DIY a basic amp for less than 500 dollars
- MRF 13750 23 CM AMP Pallet, copper heat spreader, heatsink, PQL MosFET switch, input and output relays

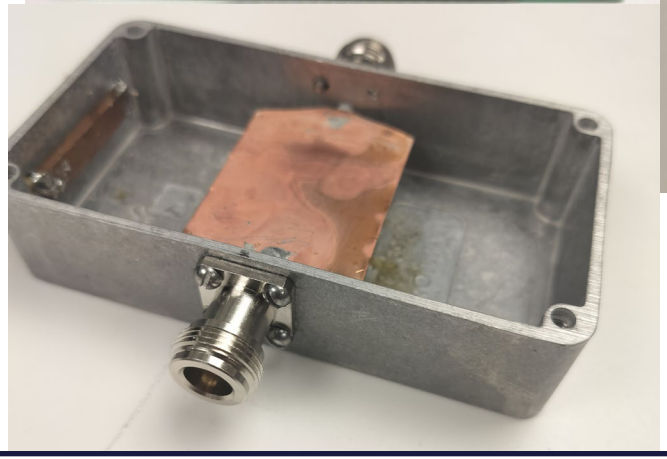




Helpful things to add

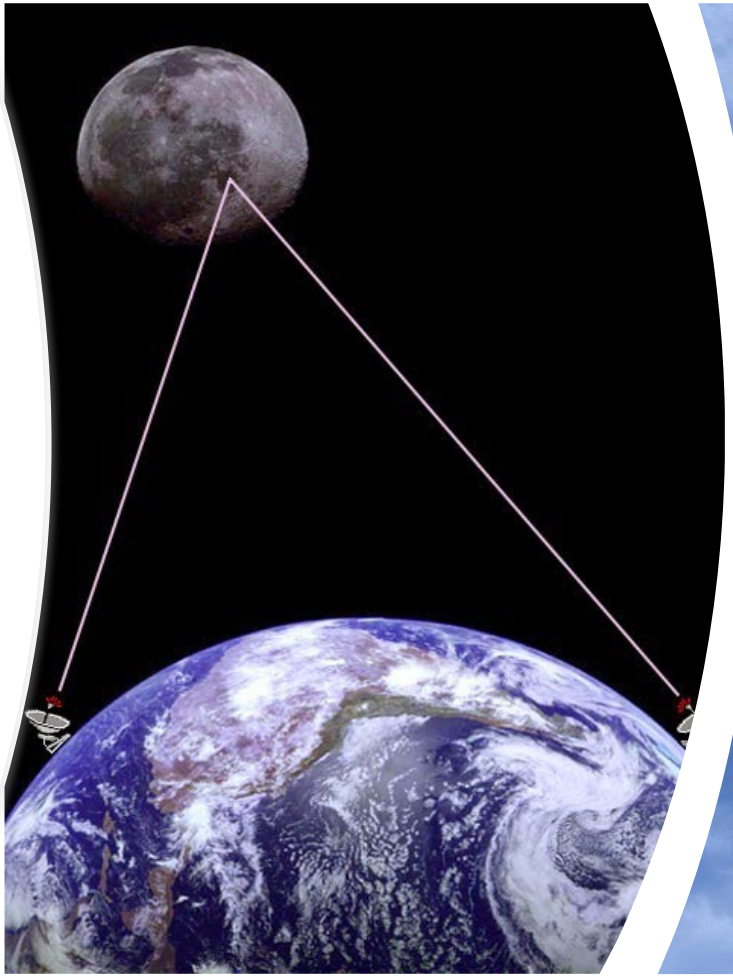
- SWR Protect
- Voltage monitor
- Power monitor
- Temperature monitor
- ALC Feedback



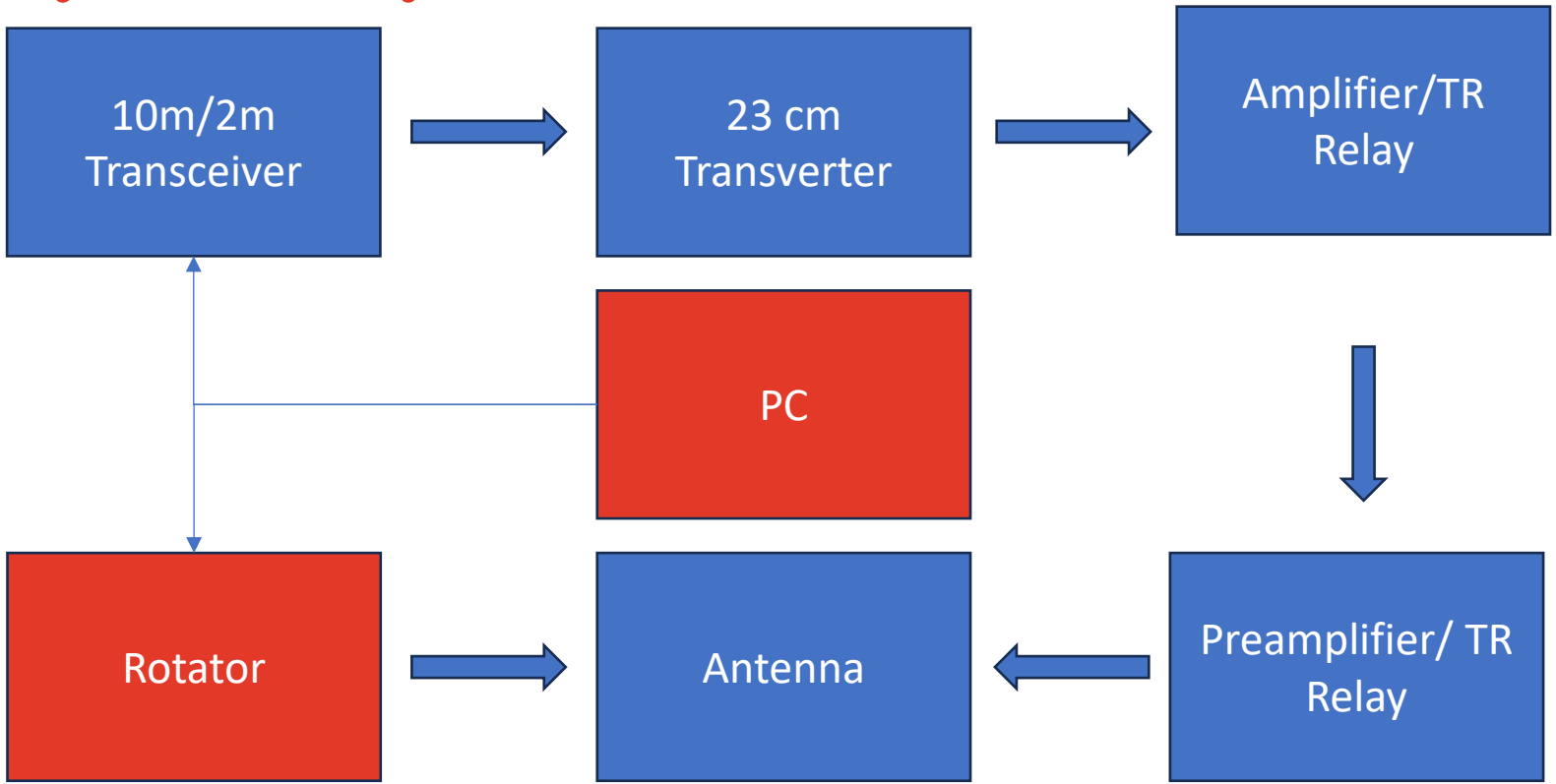


Limits of Moonbounce

EME with Q65 can make contacts 12,000 miles away with just 50-100 watts



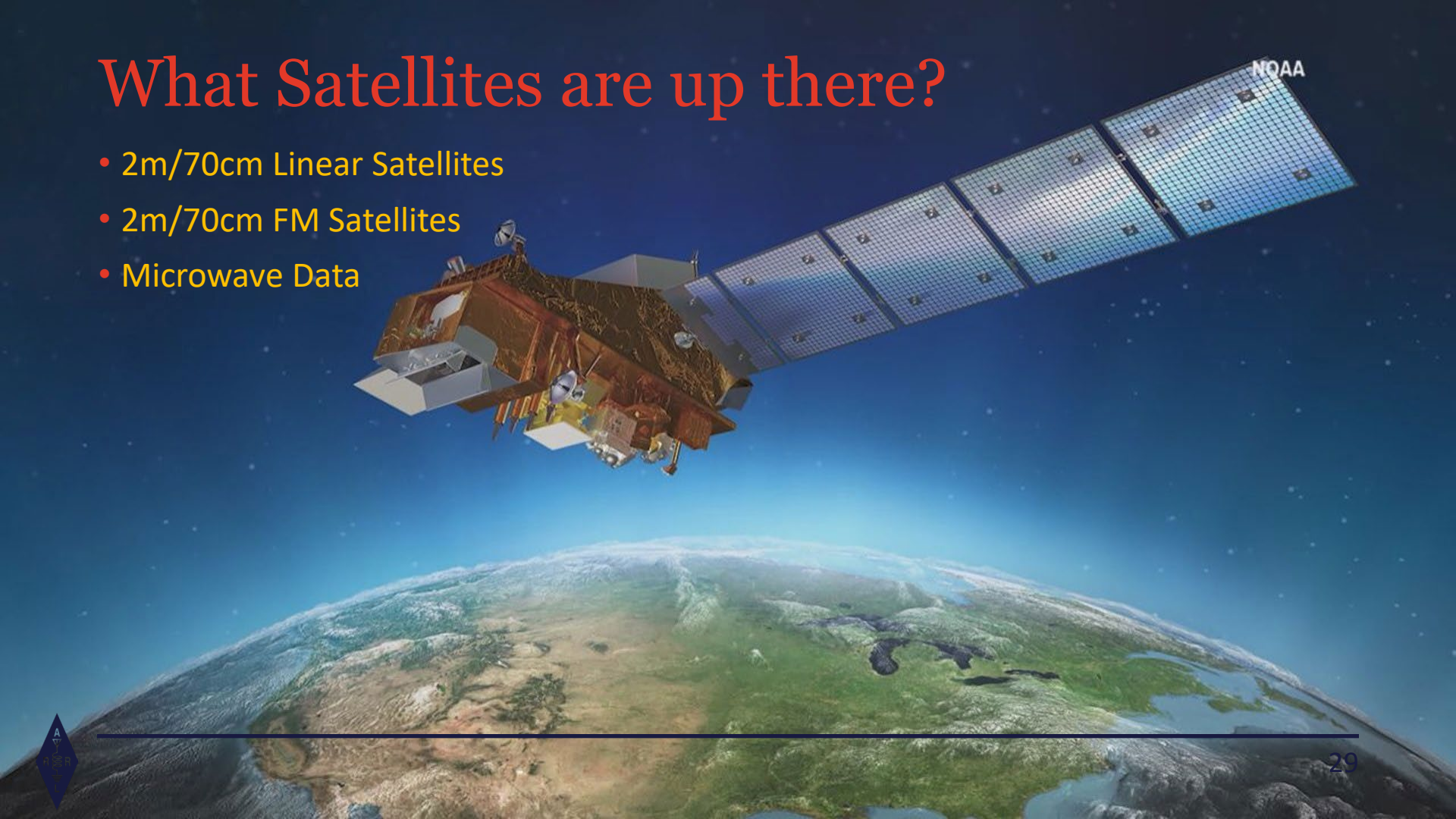
System Layout



Satellites

What Satellites are up there?

- 2m/70cm Linear Satellites
- 2m/70cm FM Satellites
- Microwave Data



Linear Satellites – How they work

- Retransmits signals within a band of frequencies, usually 50 to 100 kHz, using a transponder
- Weak Receive Weak Transmit
- Have to "tune around" to find QSOs
- More modes available than FM Satellites

Challenges of Linear Satellites

- Doppler shift causing frequency to change
- Most VHF/UHF Radios are FM Only
- Power levels needed usually more than for FM Satellites
- Polarization Mismatch

Equipment

- Radios:
  - Sideband Capable
  - Power - at least 5W for reliable links
  - Frequency – 2m 70cm
  - Full Duplex Capability (Separate 2m/70cm ports)
  - OR 2 separate transceivers with a Diplexer
- Antennas:
  - High Gain – at least 10 dBi
  - Cross Polarization or Circular Polarization

Possible Radios

Radio Transceiver	SSB/CW?	Duplex?
Yaesu 817 or 991	Yes	No
Icom 9100/905 (Rare)	Yes	Yes
Yaesu FTX-1 (QRP)	Yes	Duplex
• Icom IC-7100/705	Yes	Duplex

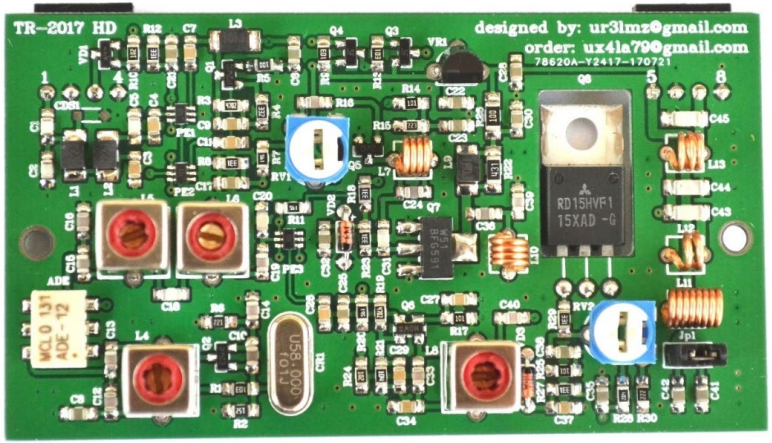
Full Duplex Radios are Rare

VHF Sideband Radios Cost Money!

(Vintage radios are the exception)

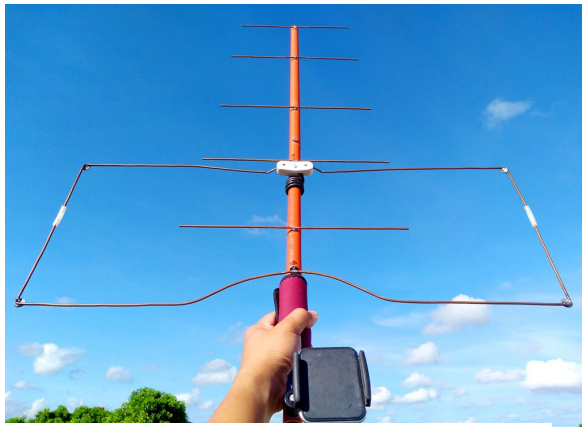
The Best Solution (for now)

- Use a transverter on an Inexpensive QRP Sideband capable radio for Satellite work
- Using an SDR Receiver with a Diplexer to monitor downlinks
- Use SatPC32 with CAT Capable Radio



Antennas

- Tried and true:
  - Yagi antennas on rotating mount
  - Alternative beams such as Moxons will work

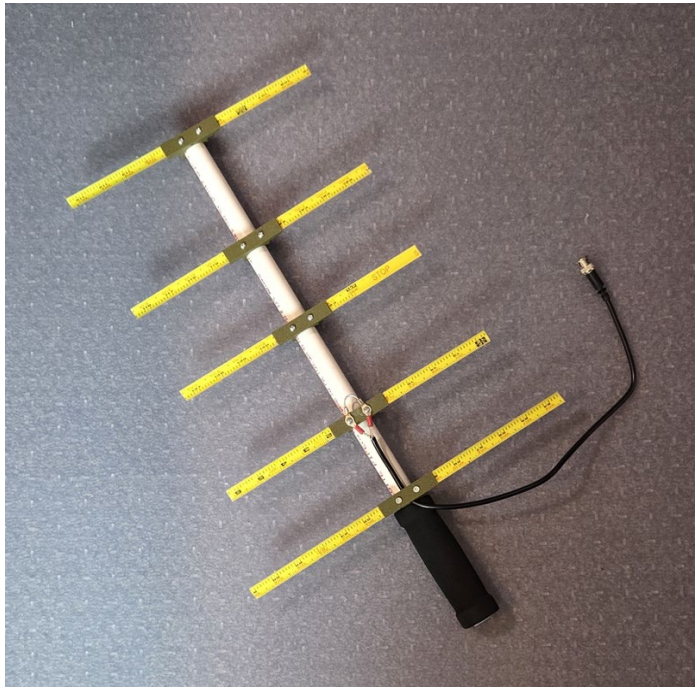


DU1AU Homemade Sat Antenna

- Avoid solutions that rely on unidirectional receive – You won't hear as well as you want and will need much more power on transmit to be heard

Antenna Projects

- Tape Measure Yagi
  - Well Tested and Guaranteed to work

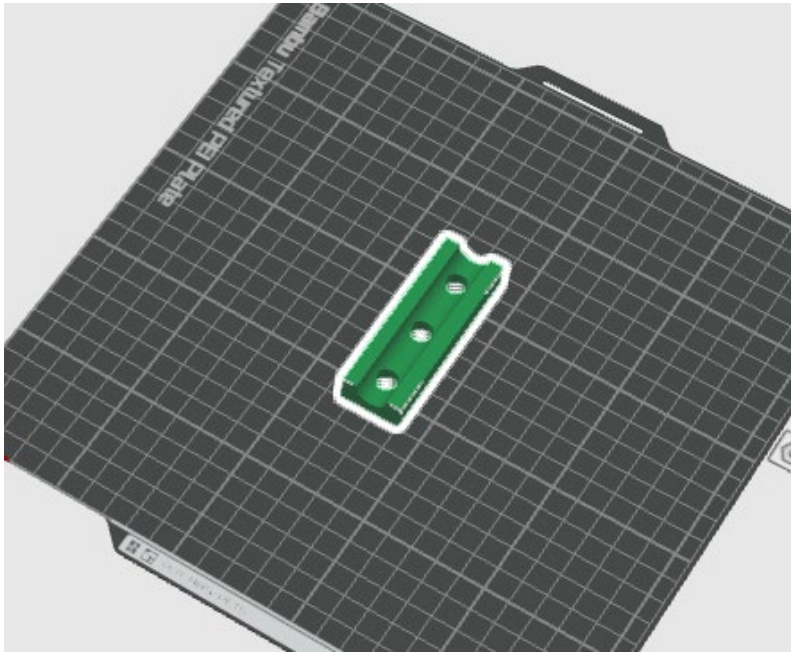


Another Possible antenna

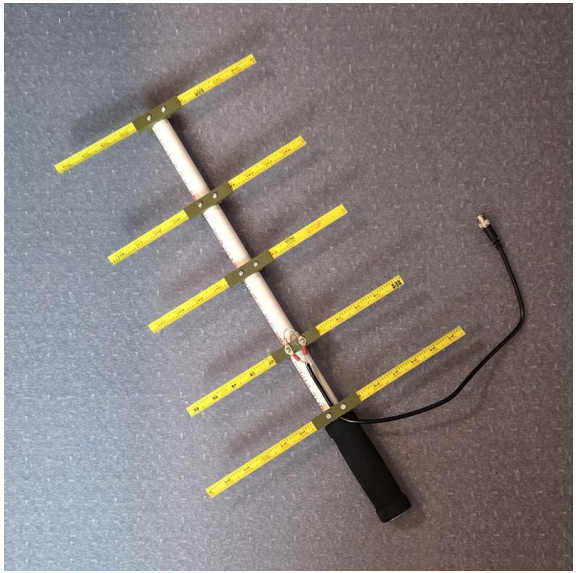
AC9EZ – January 2026 QST

Just Remove the 6m Element and you have a dual band single feed Yagi

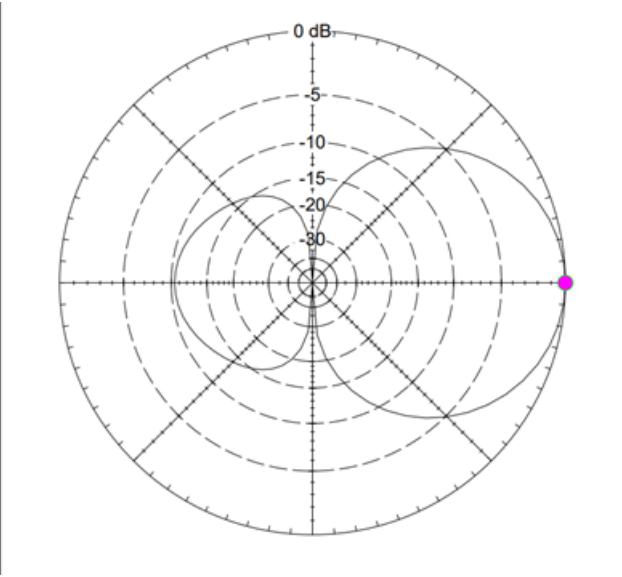
IT CAN BE 3D PRINTED!

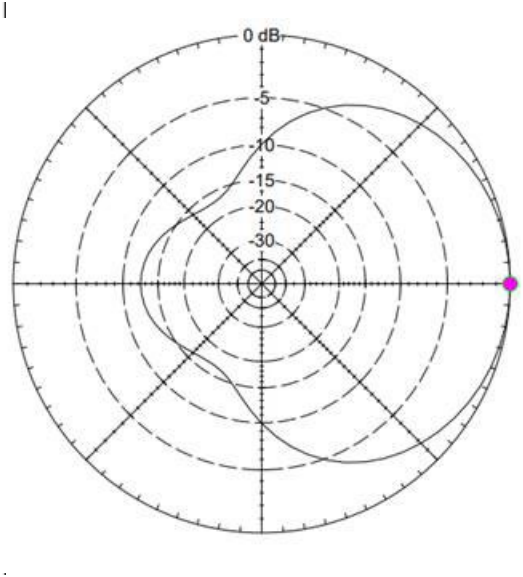


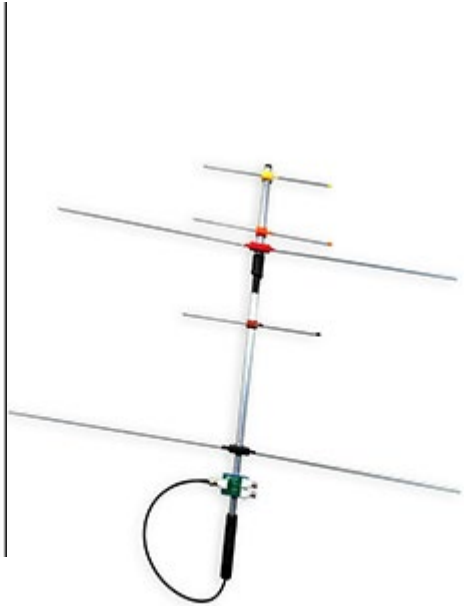
- See Steve K2GOG for more info on 3D printing



ARRL 2m 70cm Handheld Beam Antenna





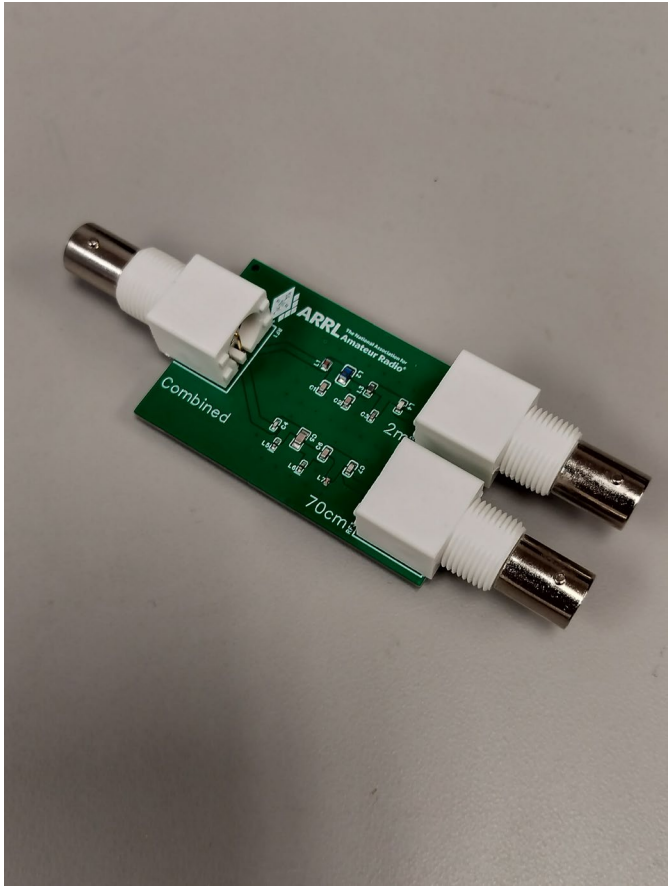


2m Azimuth Plot, 5.7 dBi of Gain

70 cm Azimuth Plot, 8.16 dBi of Gain

Comes With Diplexer!

Order Here

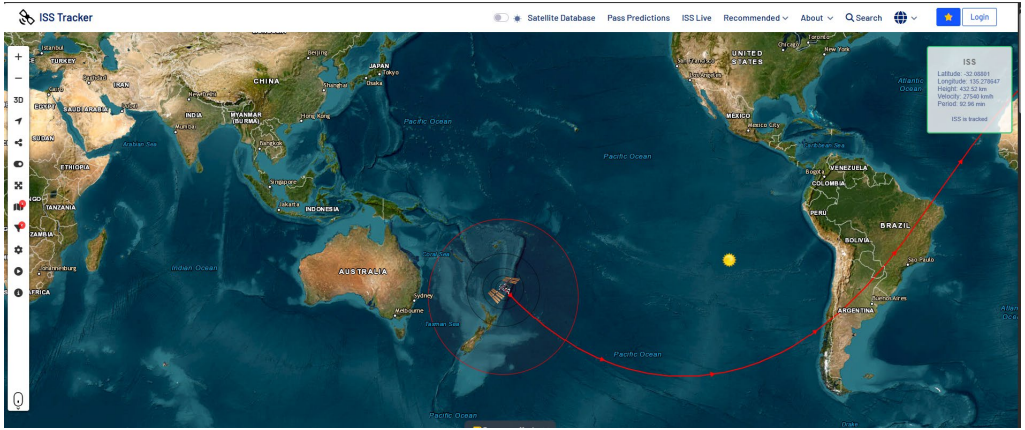


Inexpensive Automatic Tracker Project

- Designed by KN2K
- November 2023 QST
- 300 Dollars worth of Parts
- Surprising amount of Torque

Software

- Field Use:
  - ISS Tracker
  - ISSDetector
- Home Use:
  - MacDoppler
  - SatPC32
  - Orbitron

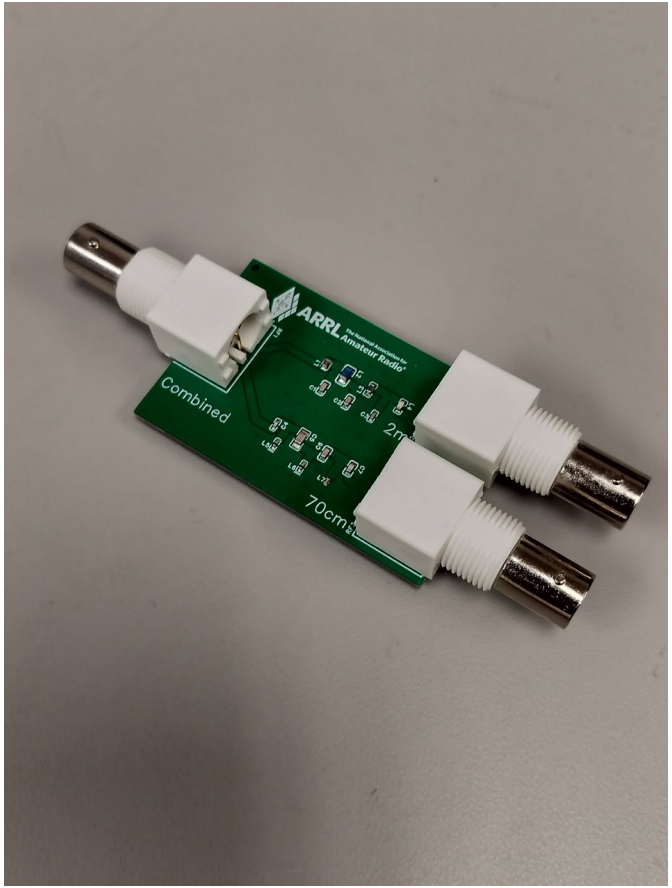


FM Satellites

- Radios:
  - Any 5W HT
  - Look for Radios compatible with OpenGD77

- Antennas:
  - Anything with appreciable gain pointed vaugely at the Satellite

The Diplexer Fixes those

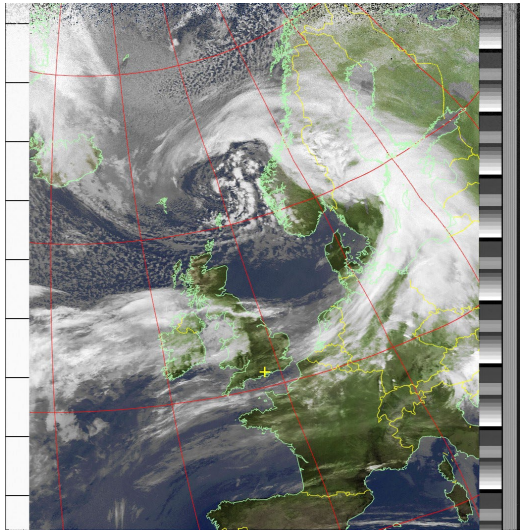


Microwave Data Satellites

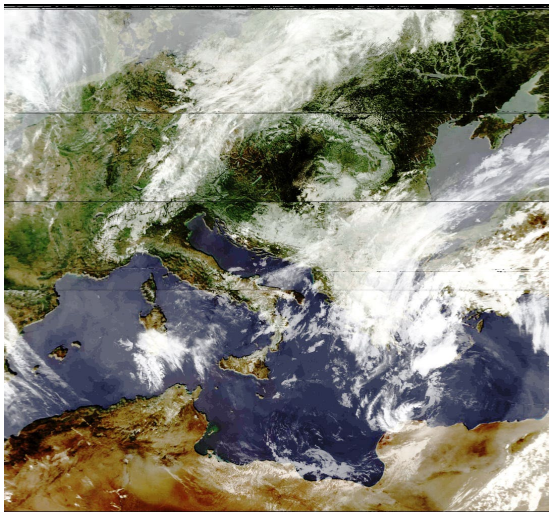
- 5 GHz/ 10GHz Planned by AMSAT
- No permanent data satellites for higher frequencies accessible from Continental US
- Occasional 23 cm experimental Cubesats on the air
- New 33 cm Meshtastic Satelite recently was OTA

NOAA Weather Satellites

- 2.25m satellite going off air soon (137 MHz)
- Can be received with SDR receiver and ARRL 2m 70cm Handheld Antenna



- 1696 MHz Satellite Live
- Need a preamp for good reception
- Can be heard with Cantenna!

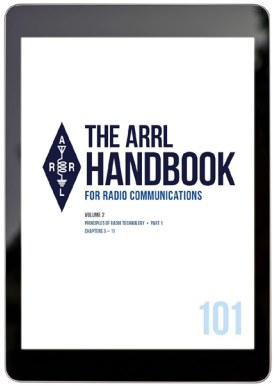


More Resources

- ARRL Membership:
  - Many of the Projects covered here
  - Access to me in the lab
  - Video content and tutorials

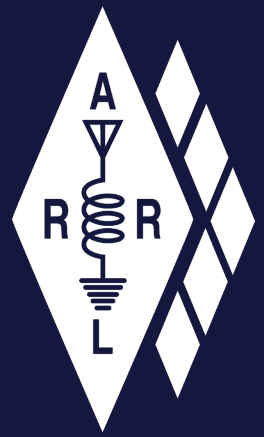
Join Here:

- Publications:
  - Microwave Projects Manual
  - ARRL Handbook Chapter on Satellite Communications and EME
  - International Microwave Handbook



Thank You!

Join ARRL Today!
www.arrl.org/join



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