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Huntsville Alabama & Gigaparts Microwave Symposium

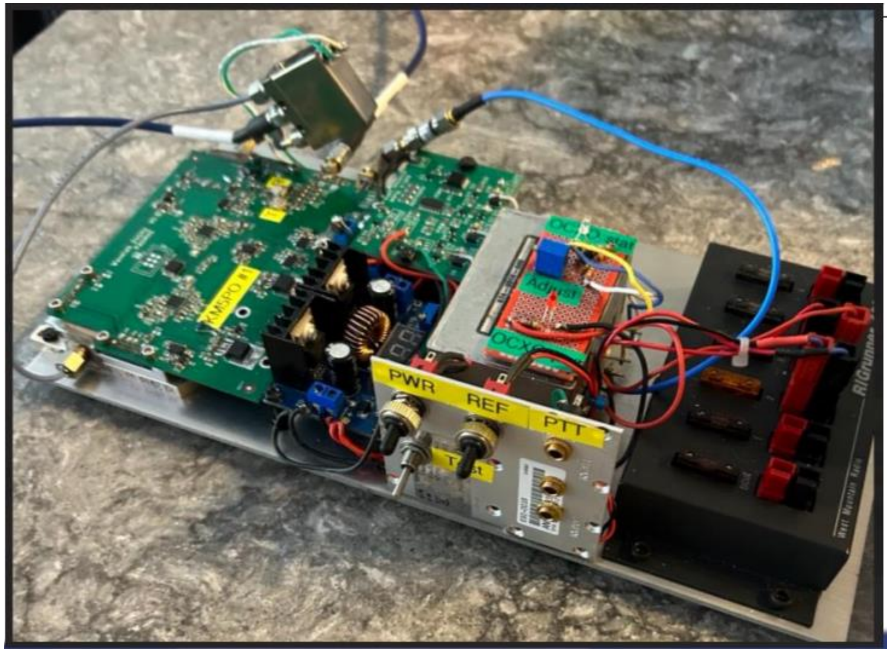
August 27, 2024

Get on 24 & 47 GHz microwave bands!

August 27, 2024

24 GHz equipment

- Wavelab 23 GHz module and PA0MHE control board [1.5-2.0 w out]
- Wavelab units are salvage from ODU. XP model or XN model w/mod
- Add 10 MHz ref
- Add power/SMA relay/Ant



24 GHz equipment

- DB6NT 24 GHz transverter
  - Transverter model
    - EME [24048] or Terrestrial [24192] models
    - 2.5 watts output
    - NF 3.5 dB
  - Requires LO at 12024 MHz
  - LO requires reference [10 MHz]

24 GHz equipment

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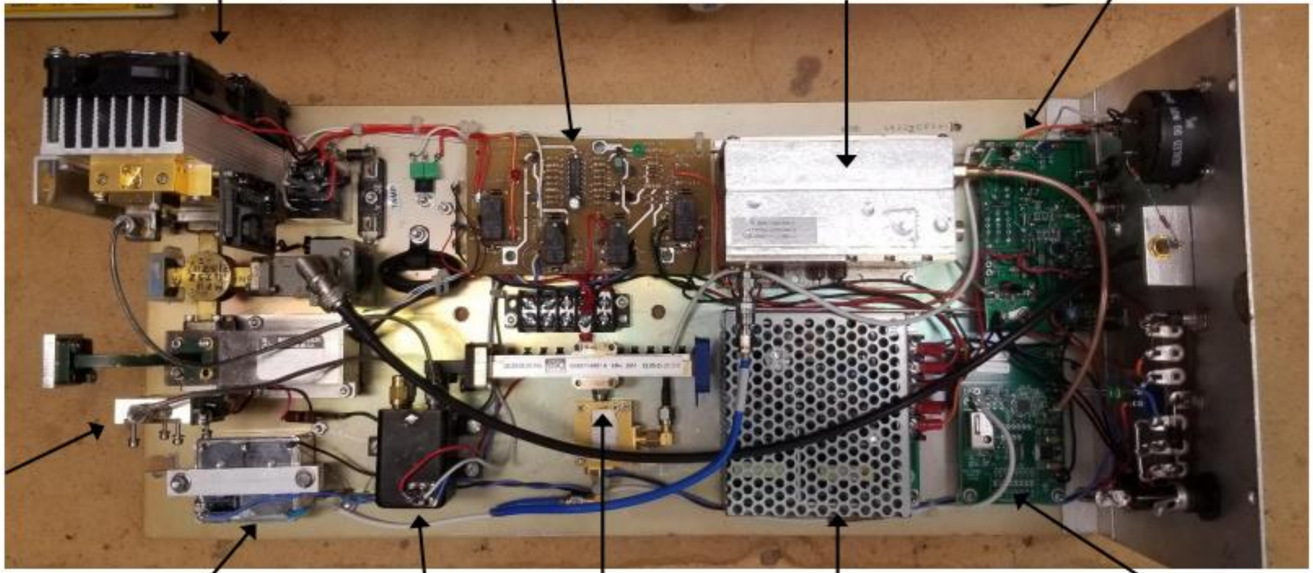
- Component build – ex. W5LUA



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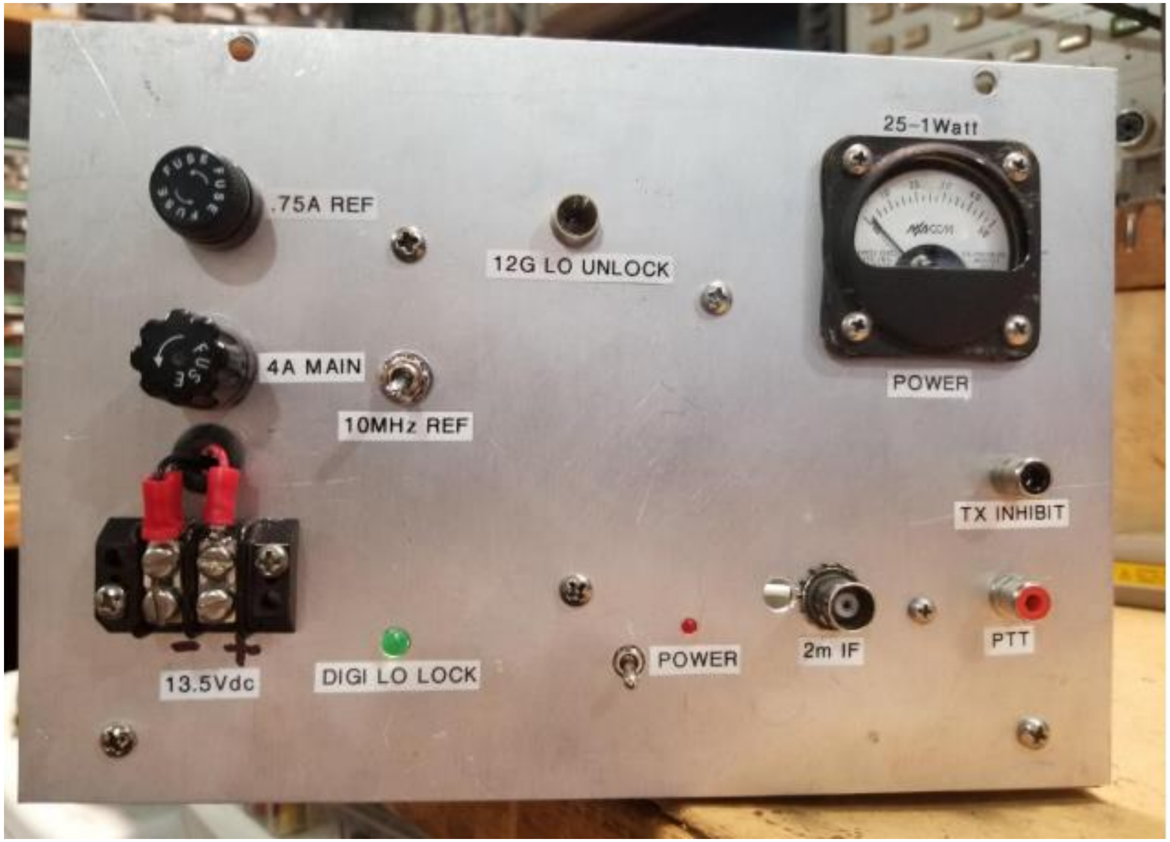
24 GHz equipment

- Component build – ex. W5LUA



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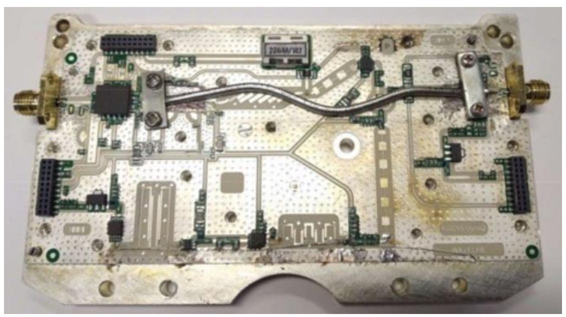
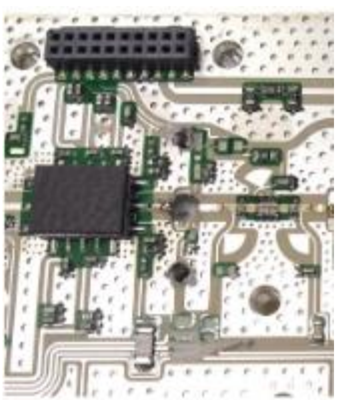
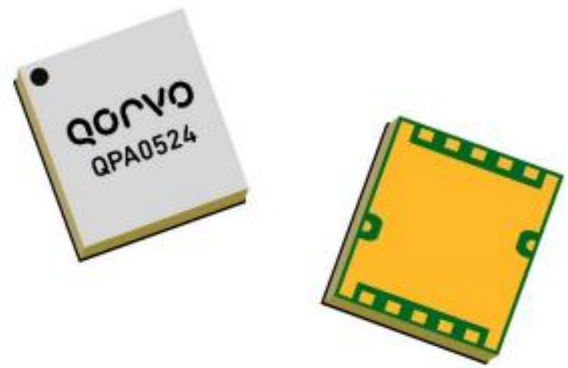
24 GHz equipment

- PA options
  - Modified Wavelab XN model (cheaper than XP model) to utilize PA stage (2 w)
  - Qorvo 5 watt amp







Key Features

- Frequency Range: 24.25 – 26.5 GHz
- Linear P_{OUT}: 26 dBm
- ACPR (P_{OUT} = 26 dBm, 802.11ac): -30 dBc
- P_{OUT} (P_{IN} = 20 dBm): 37 dBm

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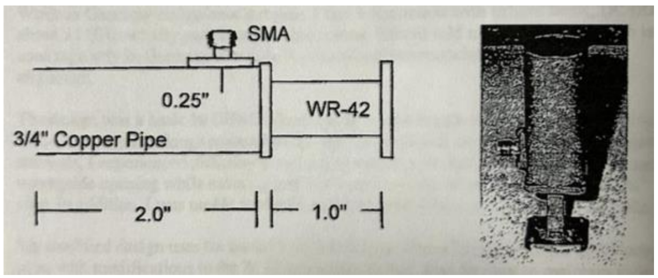
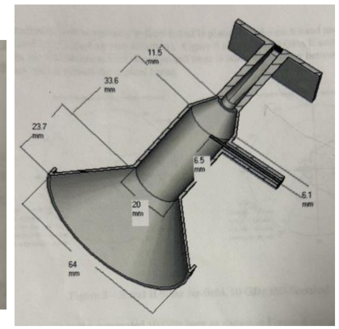
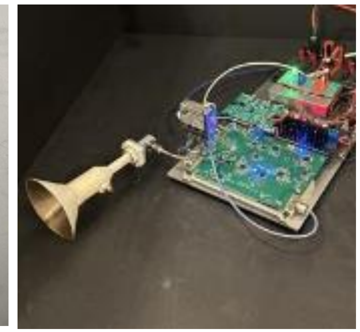
24 GHz antennas

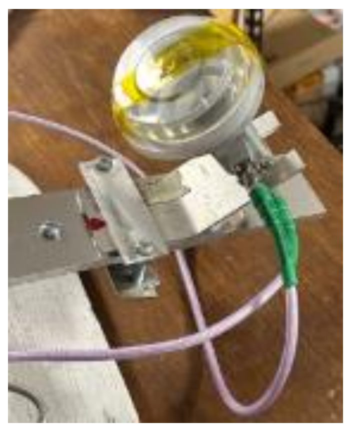
- Dual band feedhorn for offset dishes (10 & 24 GHz)
  - Homebrew







  - K2UA machined W1GHZ horn (rus.healy@gmail.com)



  - Requires a SMA to waveguide transition

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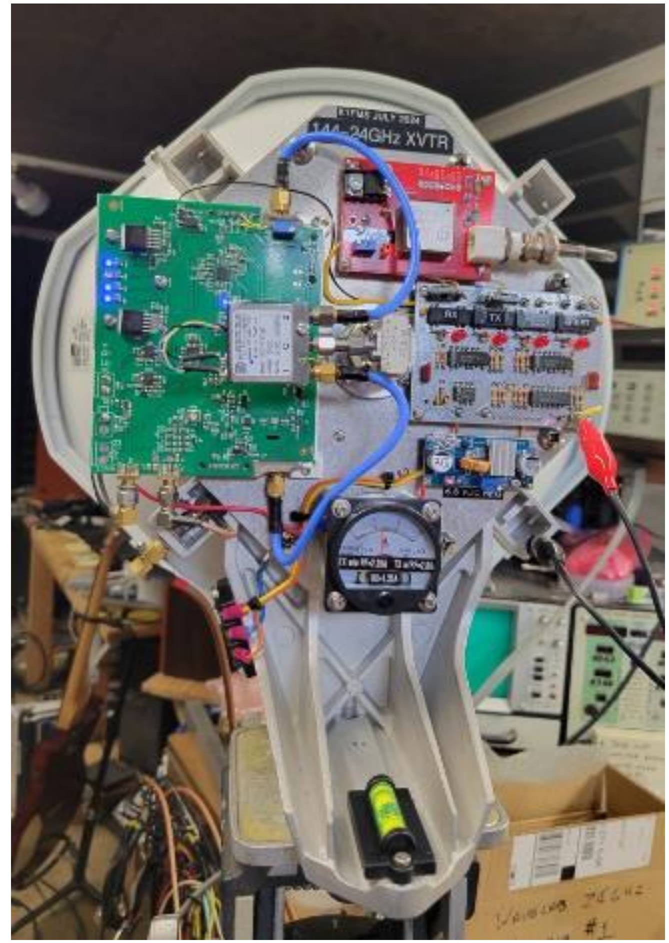
24 GHz antennas

- Prime focus
  - K1FMS Wavelab implementation uses
    RADIOWAVES dish – ebay seller: layahoo



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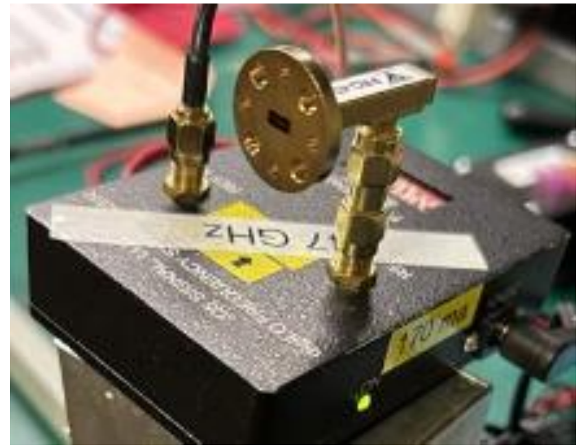
24 GHz testing

- DEMI WSS
  - Provides harmonic output beyond 100 GHz
  - With 10 MHz reference it is stable as a LO (used in all DEMI kits)
  - Supplied chart indicates how to set frequency

INDEX	FREQ	FREQ SELECT JUMPERS								SUGGESTED APPLICATION
		1	2	3	4	5	6	7	8	
32	50.100			X						50.100 MHz WSS
33	70.100			X					X	70.100 MHz WSS
34	144.100			X				X		144.100 MHz WSS
35	222.100			X				X	X	222.100 MHz WSS
36	432.100			X			X			432.100 MHz WSS
37	435.100			X			X		X	435.100 MHz WSS
38	902.100			X			X	X		902.100 MHz WSS
39	903.100			X			X	X	X	903.100 MHz WSS
40	915.100			X		X				915.100 MHz WSS
41	1275.100			X		X			X	1275.100 MHz WSS
42	1296.100			X		X		X		1296.100 MHz WSS
43	2304.100			X		X		X	X	2304.100 MHz WSS
44	3400.100			X		X	X			3400.100 MHz WSS
45	5760.100			X		X	X		X	5760.100 MHz WSS
46	3456.033			X		X	X	X		10368.100 MHz / 3 WSS
47	3456.014			X		X	X	X	X	24192.100 MHz / 7 WSS
48	28.100			X	X					28.100 MHz WSS
49	1420.000			X	X				X	1420.000 MHz WSS
50	2401.000			X	X			X		2401.000 MHz WSS
51	4838.420			X	X			X	X	24192.100 MHz / 5 WSS
52	3139.207			X	X		X			47088.100 MHz / 15 WSS



DEMI WSS set for 47 GHz with waveguide transition

Arduino based DEMI WSS with selectable frequencies using jog button (NTMS website)

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24 GHz testing

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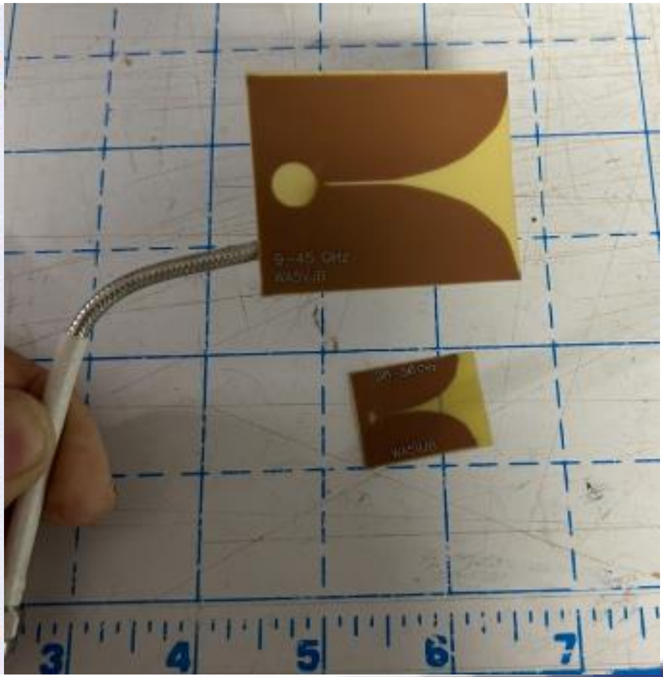
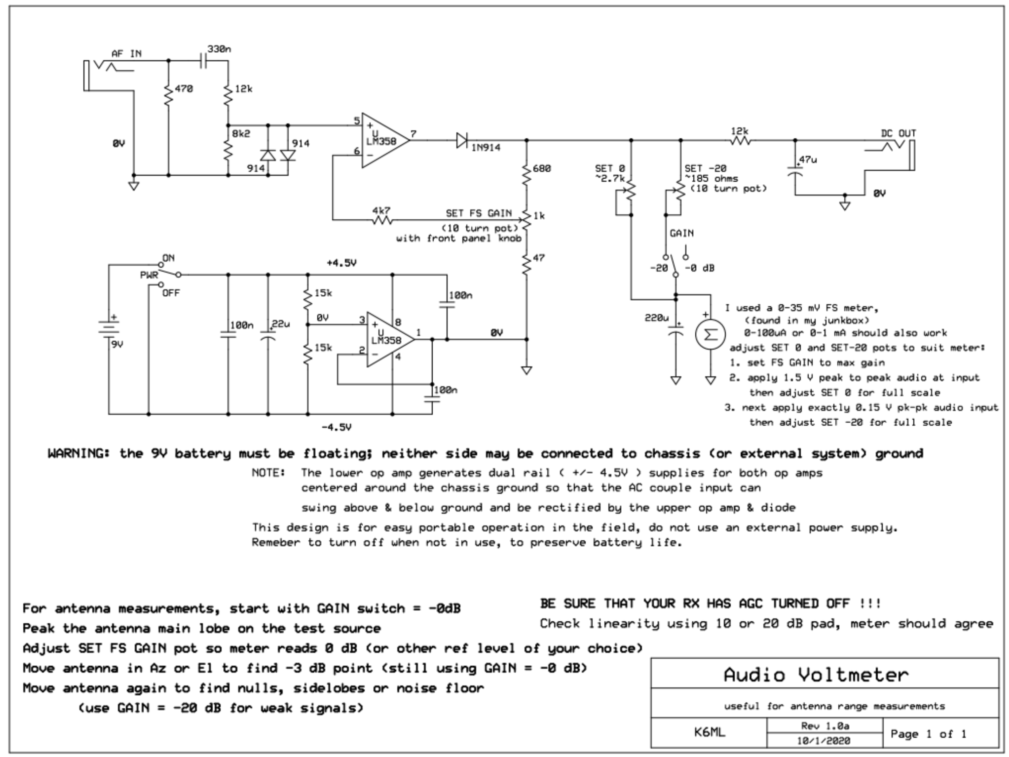
- DEMI WSS
  - Use SMA 3dB attenuator on 24 GHz [1 mile DX using Wavelab and 18” dish]
  - Log periodic, Vivaldi or horn good choices
  - Travel kit with two WSS, two OCXO, Battery & PDU + Weatherbox



24 GHz testing

- Use an audio meter for peaking antenna feed horn – design by K6ML Mike Lavelle



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24 GHz testing

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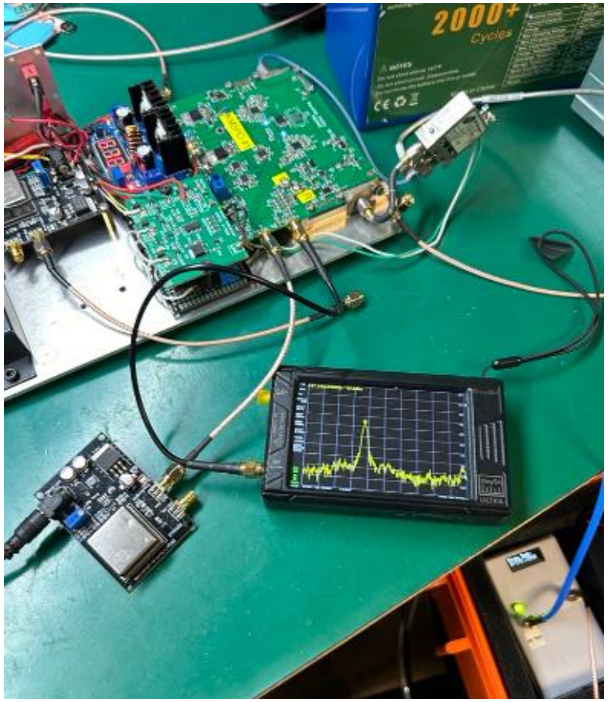
- Ultra SA
  - For Wavelab LO checks &

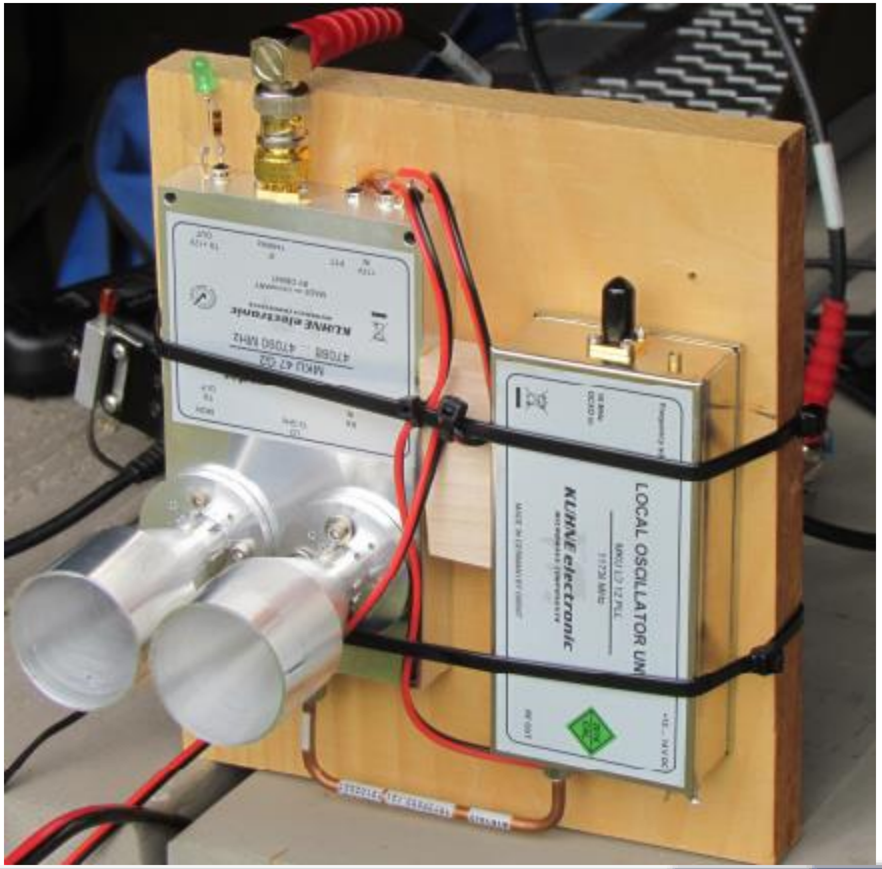


47 GHz equipment

- DB6NT 47 GHz transverter
  - Requires LO at 11736 MHz
  - 30 mw output
  - NF 6.0 dB
- PA options
  - No commercial units at present

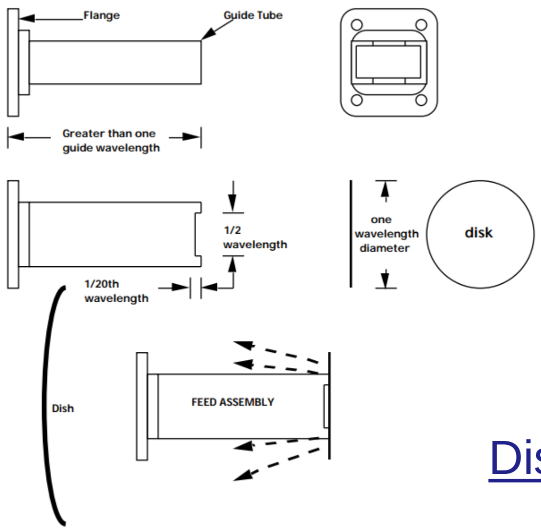
47 GHz antennas

- Two conical horns
  - W1GHZ



47 GHz antennas

- Prime focus
  - 3D printed splash feed



Dish_Not.pdf (packratvhf.com)

47 GHz antennas

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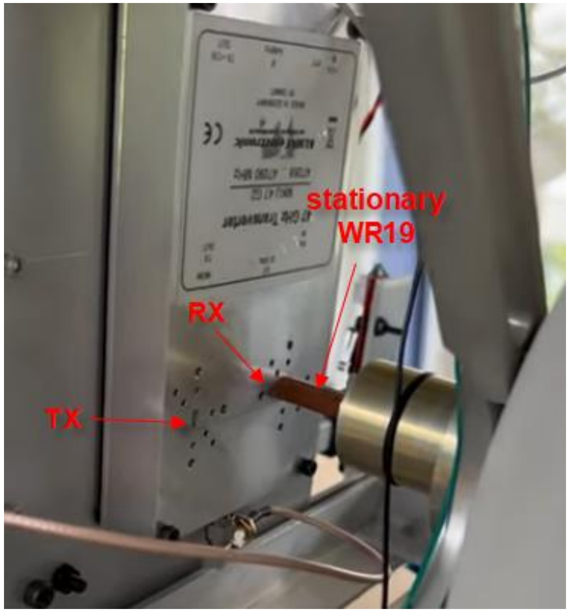
- Prime focus
  - Slide option for prime focus dishes – KM5PO
    - Uses Arduino/linear actuator & limit switches
    - Slides from RX position to TX position on PTT (4 seconds)
    - Ports on transverter line up with WR19 waveguide inserted into Prime Focus splash feed



47 GHz antennas

- Prime focus
  - Slide option for prime focus dishes – KM5PO

47 GHz antennas

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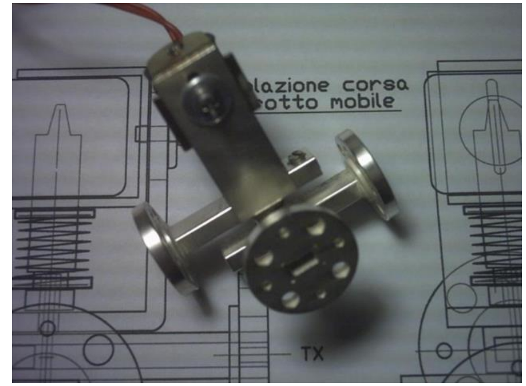
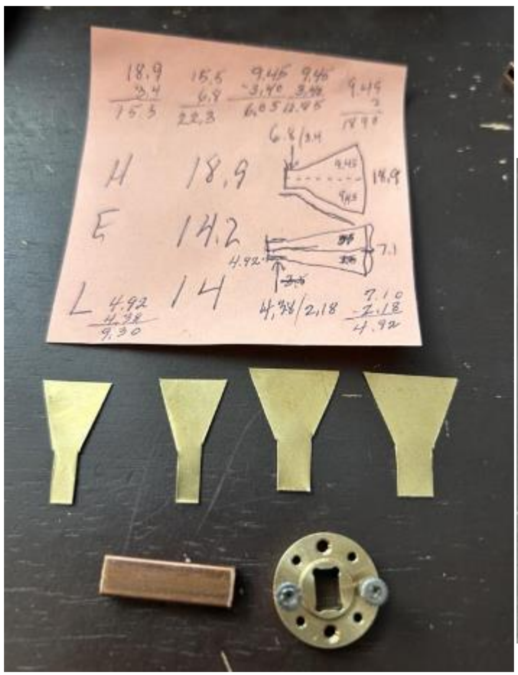
- Prime focus
  - Slide option for prime focus dishes – W1GHZ
    - Uses two conical horns that beam through hole in dish & reflect off splash feed
    - Manually move from RX to TX with transverter mounted on rails system

47 GHz antennas

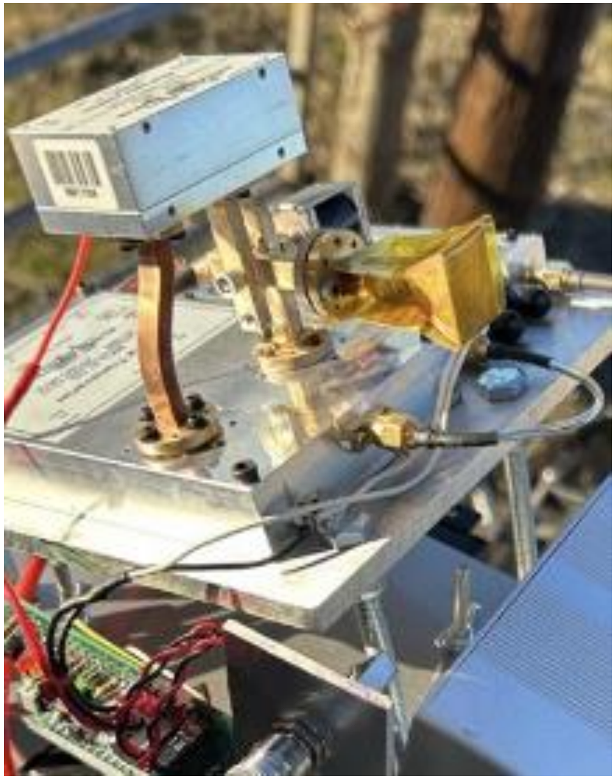
- Offset dish
  - Homebrew feed horn and waveguide relay





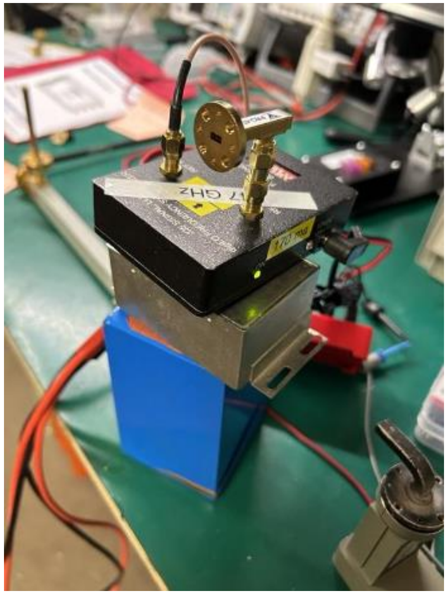
47 GHz antennas

- Offset dish
  - Homebrew feed horn and waveguide relay covered with Kapton tape

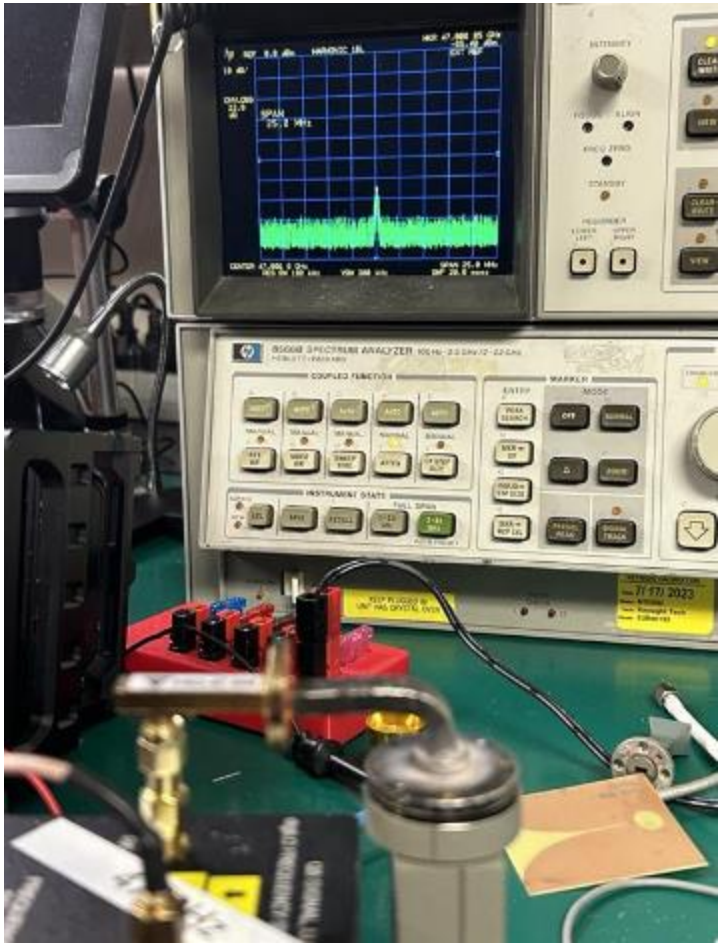


47 GHz Testing

- DEMI WSS



- External harmonic mixer
- Find a friend and work together



24 & 47 GHz propagation

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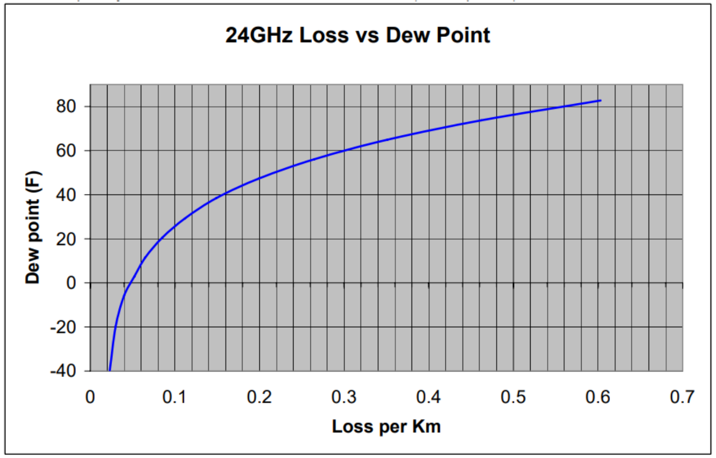
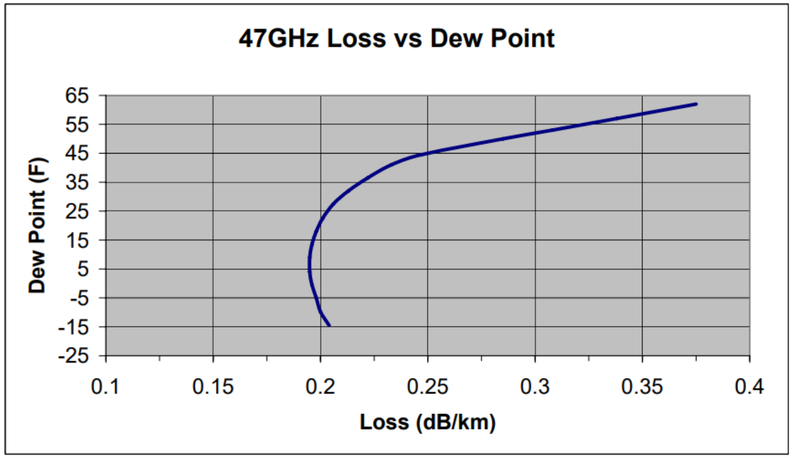
- Lose vs Dew Point higher than 10 GHz or “Low Dew Point is your friend”





Light scatter

Common scattering volume

Scattering in Communications

WA1MBA MUD 2019

https://ntms.org/files/MUD2019/Authors_Speakers/WA1MBA_Tom_Williams/WA1MBA%20MUD%202019%20Scattering%20Presentation.pdf

24 & 47 GHz propagation

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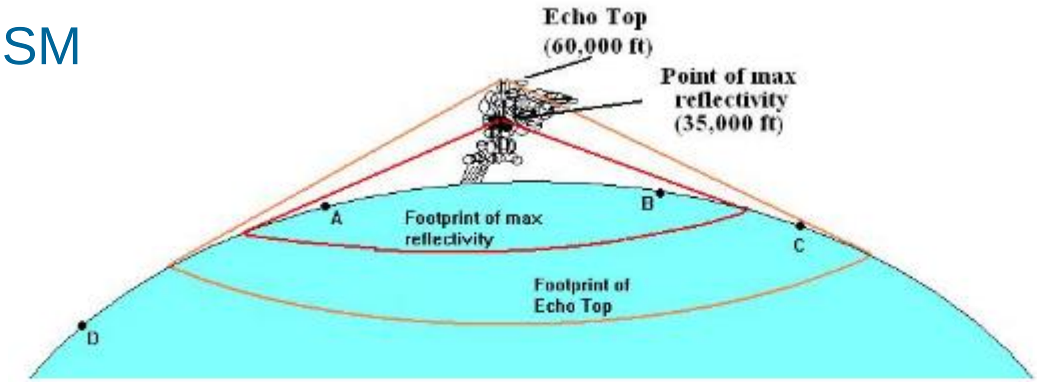
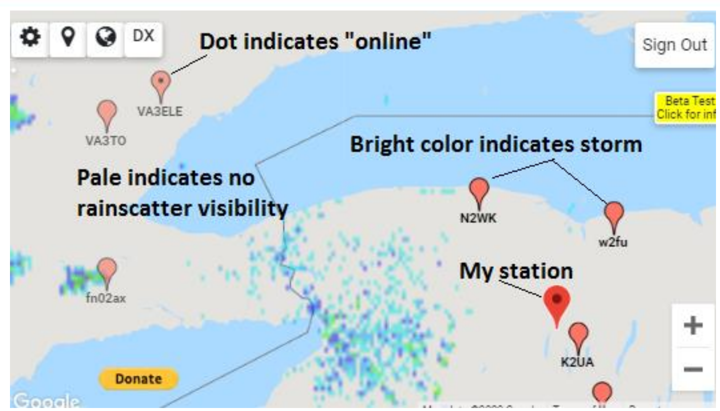
- Rain scatter
- rainscatter.com by K0SM

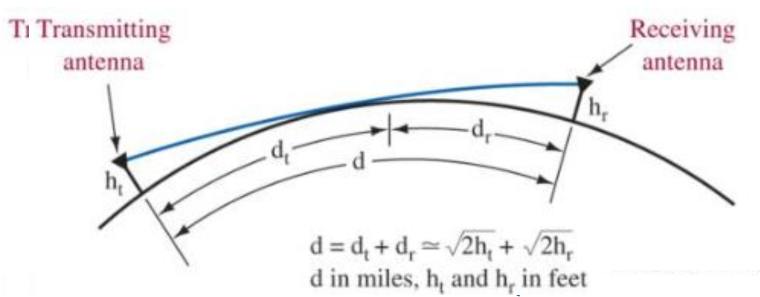




rainscatter.com/help/help.html

24 & 47 GHz propagation

- Terrestrial scatter
  - “Radio horizon” versus common volume scattering.
  - 200 km on 24 GHz achieved
  - 99 km on 47 GHz achieved



  - Ht=100’, SQRT 200 = 14.14 miles
  - Or 22.75 km

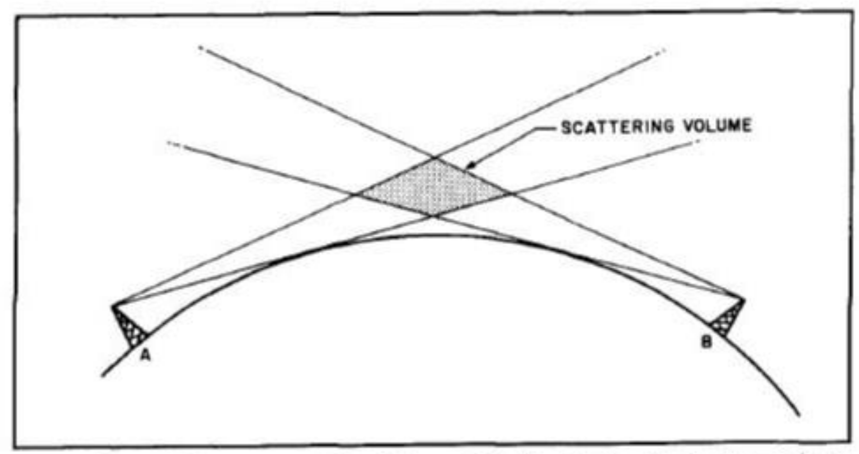


Figure 1. Though the antennas at A and B cannot “see” each other directly, they can both “see” a common region labeled the “scattering volume.”

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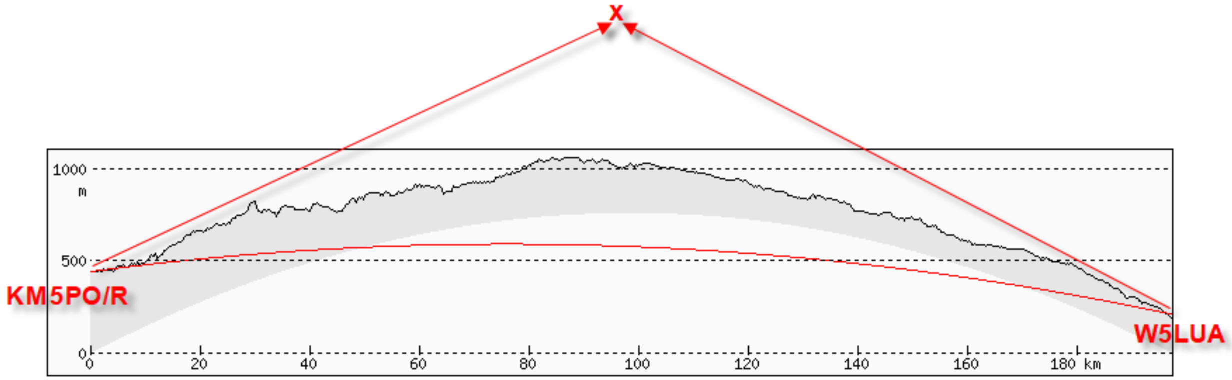
24 GHz – 200 km



47 GHz – 99 km

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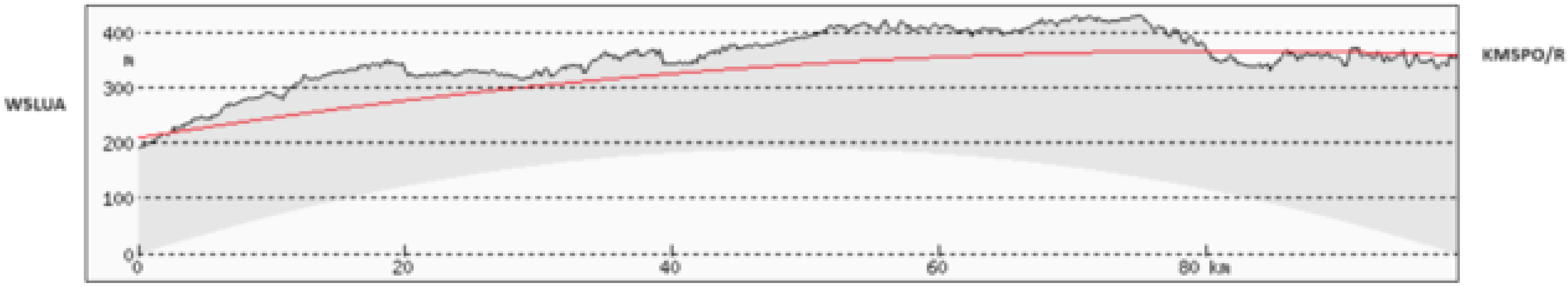

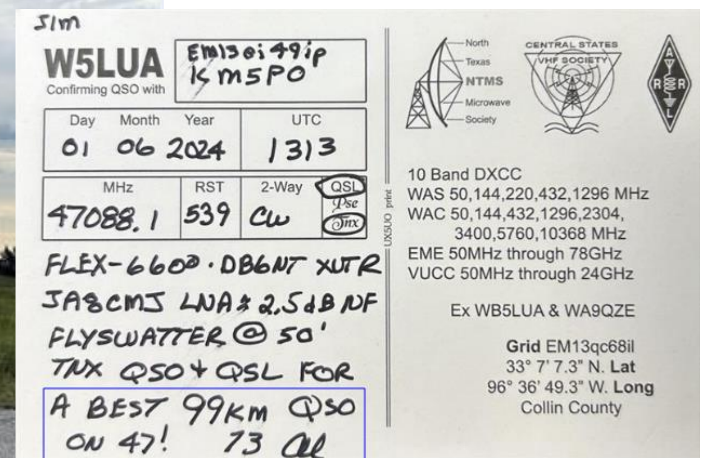

24 & 47 GHz propagation

- Water tower bounce – tune to beacon, scan horizon for peaks

24 & 47 GHz propagation

- Building bounce

KM5PO <> K9PW CSVHFS July 2023 North Little Rock.
10/24/47 GHz Qs via building bounce

KM5PO<>W5LUA F.D. June 2024
10/24 GHz Qs via building bounce

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The power of the tower – K4QF Ben

- Tower bounce – CSVHFS July 26, 2024

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24 & 47 GHz propagation

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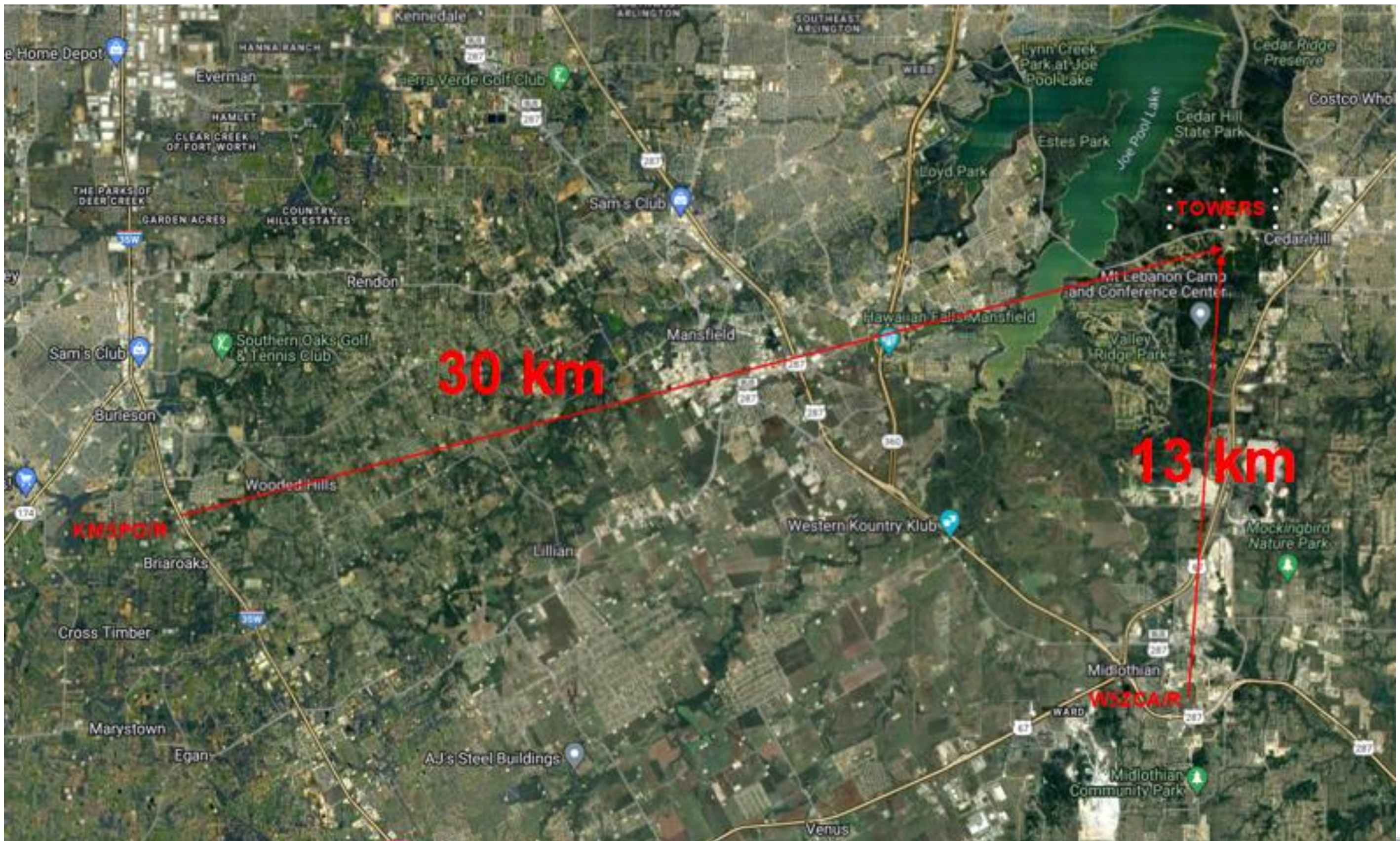
- Tower bounce – August 3, 2024
  - <u>No direct route existed </u>but tower bounce was strong off Cedar Hill tower farm



24 & 47 GHz propagation

- Tower bounce
  - Cedar Hill tower farm consists of 12 towers tallest is 1732 feet

$$d = d_t + d_r \simeq \sqrt{2h_t} + \sqrt{2h_r}$$

d in miles, h_t and h_r in feet

  - Radio horizon = SQRT 3464 = 59 miles

Owner	Height
Richland Towers Tower	1732’
American Towers Tower	1660’
Richland Towers Tower #2	1633’
KTVT Tower	1588’
GBC LP DBA Tower	1581’
WFAA Tower	1580’
KPLX Tower	1558’
American Towers Tower #2	1551'
KXAS TV Tower	1535'
KXTX TV Tower	1535'
QQK Tower Hitchcock	1375'
Hill Tower Cedar Hill	1240'

24 & 47 GHz propagation

- Tower bounce
  - Cedar Hill tower farm consists of many towers – all it takes is one!

24 & 47 GHz propagation

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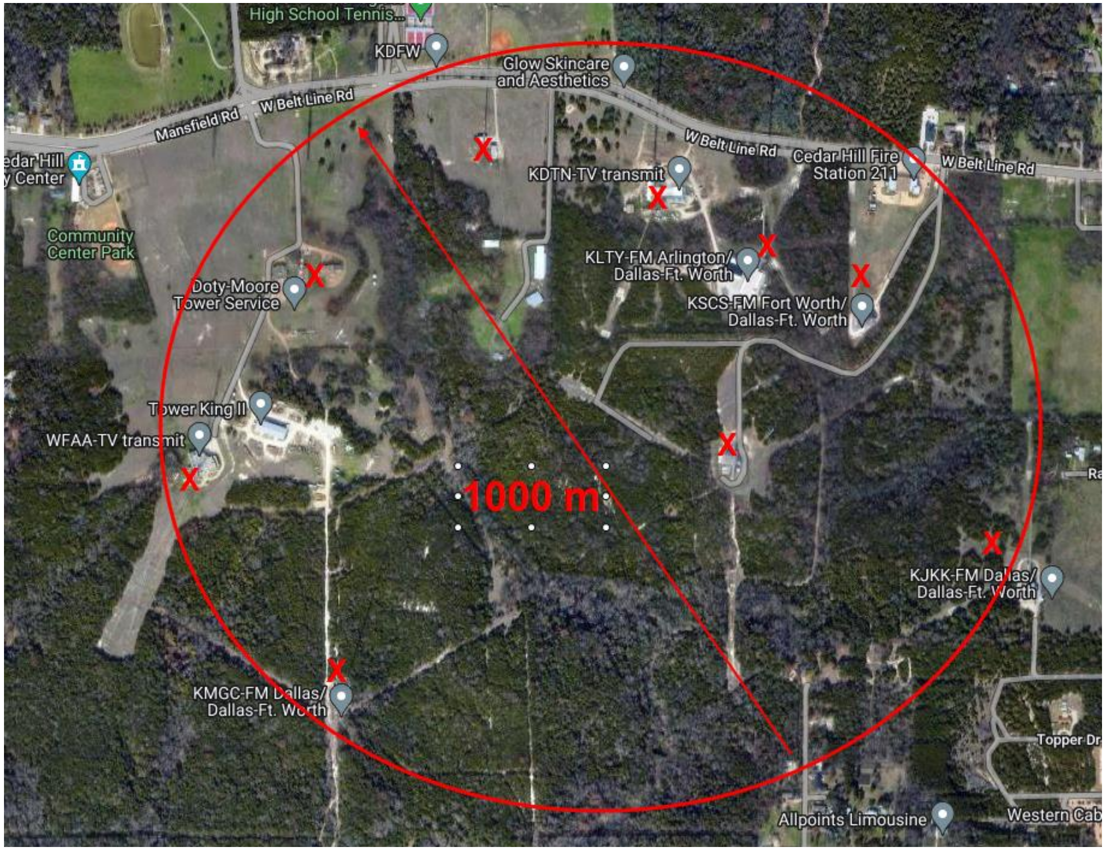
- Tower bounce
  - Cedar Hill towers are clumped within 1000 meter area



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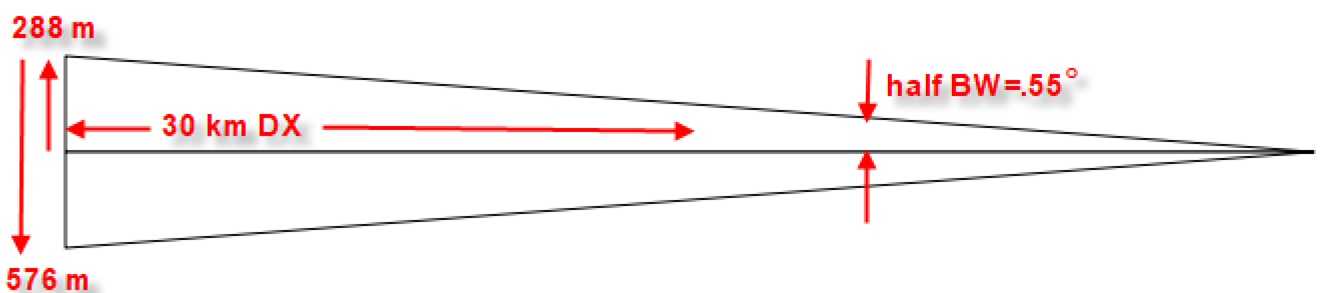
Coverage calcs

- Dish 3 dB beamwidth:
  - θ ≈ 70 * (λ / D)
  - 24 GHz dish = 76 cm so θ ≈ 70 * (1.2 cm / 76 cm) so θ ≈ 1.1 °
  - 47 GHz dish = 45 cm so θ ≈ 70 * (.6 cm / 45 cm) so θ ≈ .9 °
  - SohCahToa – solve for Opp – call it HWD half beam width distance
  - At 30 km the 3 dB beamwidth is:

    tan(0.55 °) = HWD/30 km

    rearrange: HWD = tan(0.55 °) x 30 km

    HWD = .0096 x 30 km = .288 km



More to scale:

24 & 47 GHz propagation

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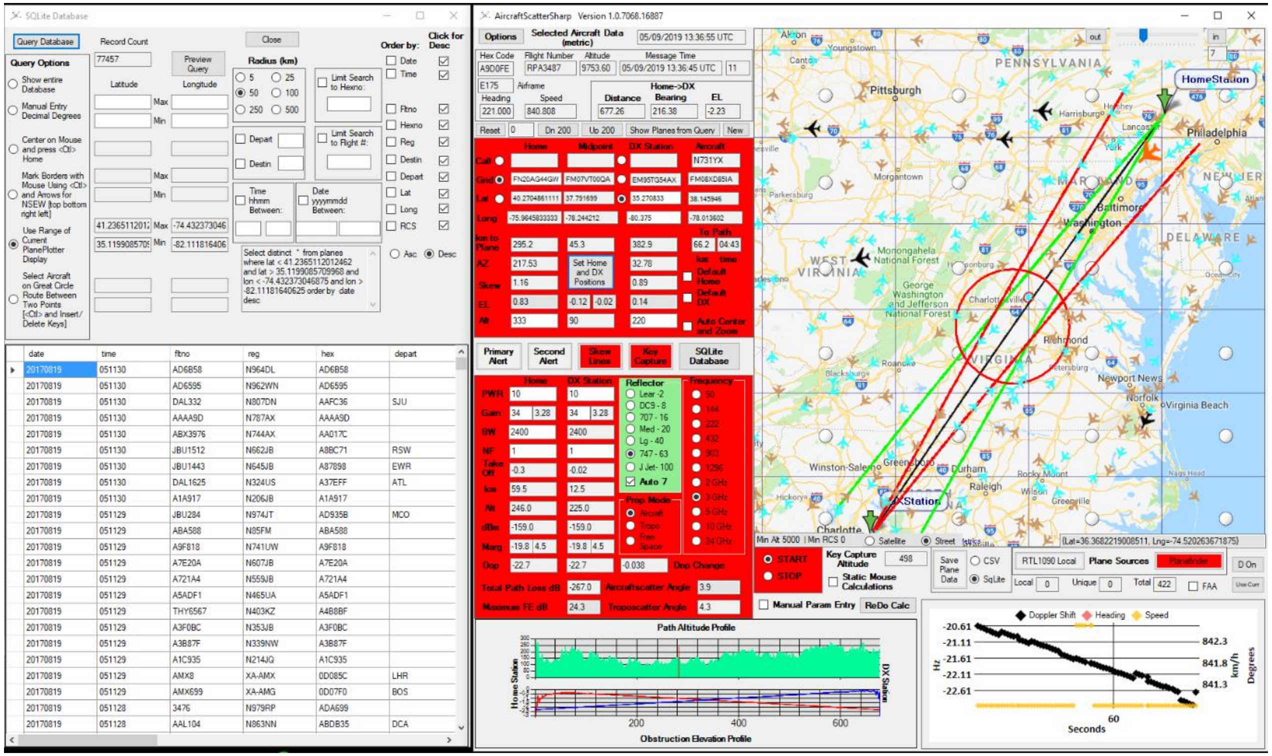
- Aircraft scatter



[W3SZ Aircraft Scatter Page]()

24 & 47 GHz propagation

- Other
  - In searching for your peak:
  - Off direct path peaks – beware of unusual paths that may appear
  - Random A/C scatter can appear suddenly and often does not last long
  - A water tower or building may be producing a reflection
  - Work the contact (do not ***"romance the signal")!***
  - Write down odd observations for further study.
  - If you brought binoculars look in the distance for a tower or building.

24 & 47 Rover operation

- 10/24 dual band feeds
  - Peak on 10, switch to 24
  - Peaking by finding the first null on both sides then split the angle
- Separate 10 & 24 dishes – parallel edges!
- 24/47 feeds on same offset dish
  - Best if 24 GHz signal is weak!
  - Use a closely mounted (24 GHz) Vivaldi in horizontal polarization next to 47 GHz feed. Integrate Wavelab XN low cost module for 24 GHz receive only.
- Heat issues
  - DB6NT LO & other equipment can overheat (get specs vs ambient temps)
  - Peltier cooling

Pointing accurately - Homework

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- Location, location, location
- High ground, falling away terrain in the path of the signal
- Little to no foliage in first 1000 meters
- Verify access to the location
  - Is it located on a right-of-way?
  - Is there automobile traffic?
    - Light versus heavy (be aware of 24 GHz QRM)
  - Do not use school property

Pointing accurately - K7FRY

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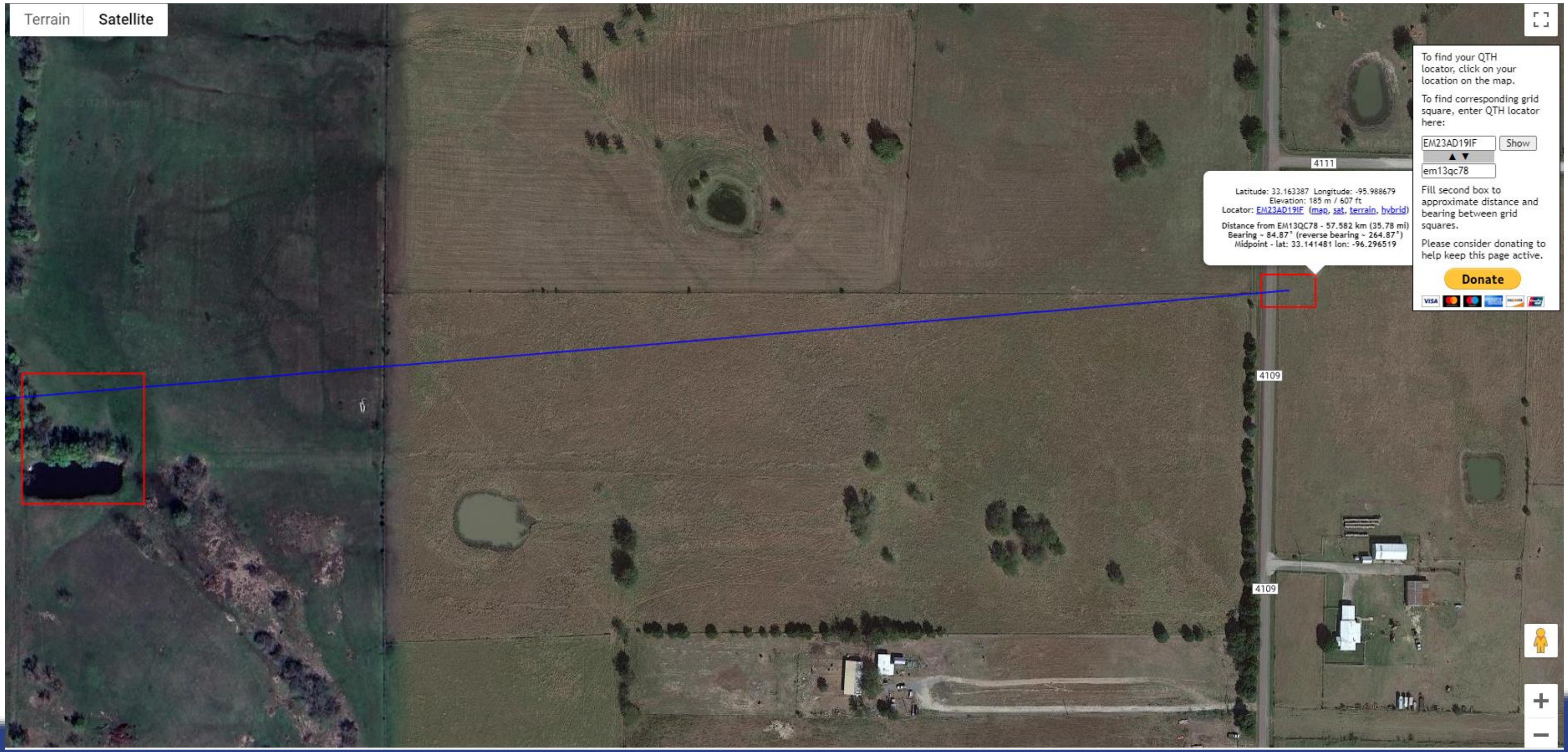
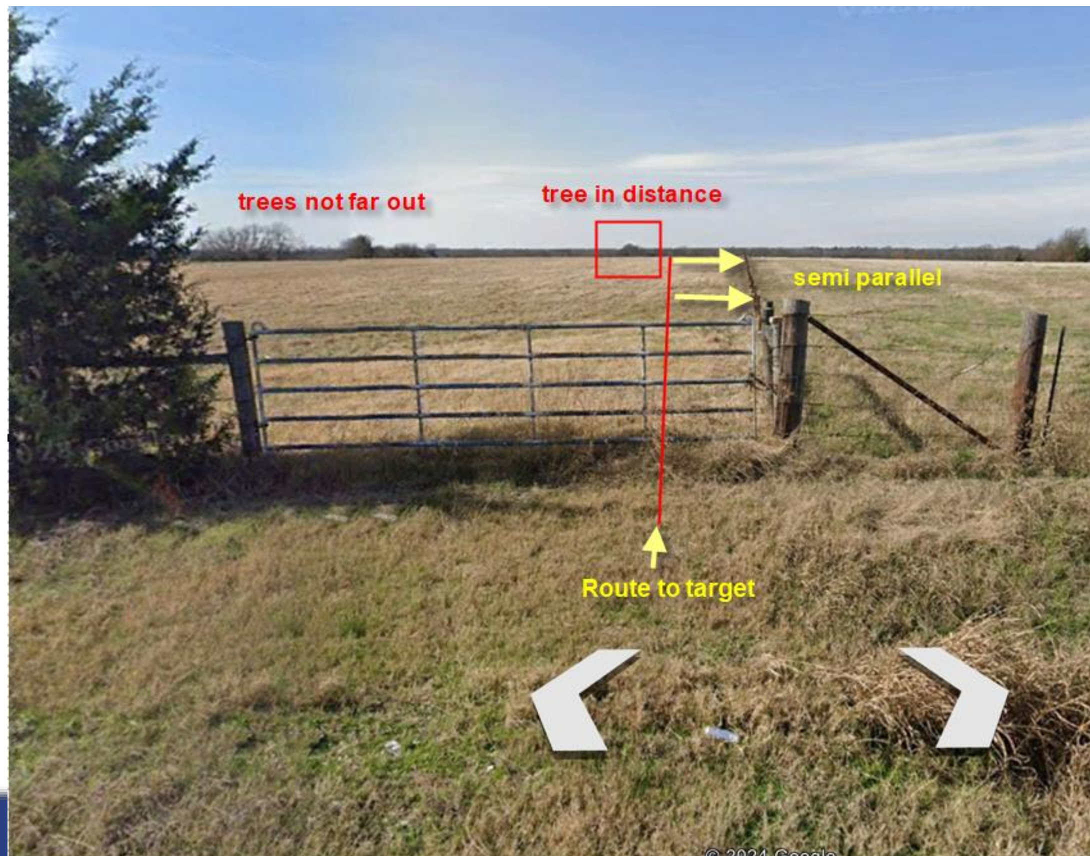
- K7FRY.com accepts a single or double set of grids (up to 10 characters)
  - This is your ***primary trusted data***. From this you will extract landmark(s).
  - Bearing is displayed by this tool as 264.87 degrees, say 265 ***TRUE***



Pointing accurately - Landmark

- Set a very accurate line in Google from your location to target
- Correlate street view to K7FRY to locate suitable landmark

Google's street view after setting route line from your location to the target



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Pointing accurately - Landmark

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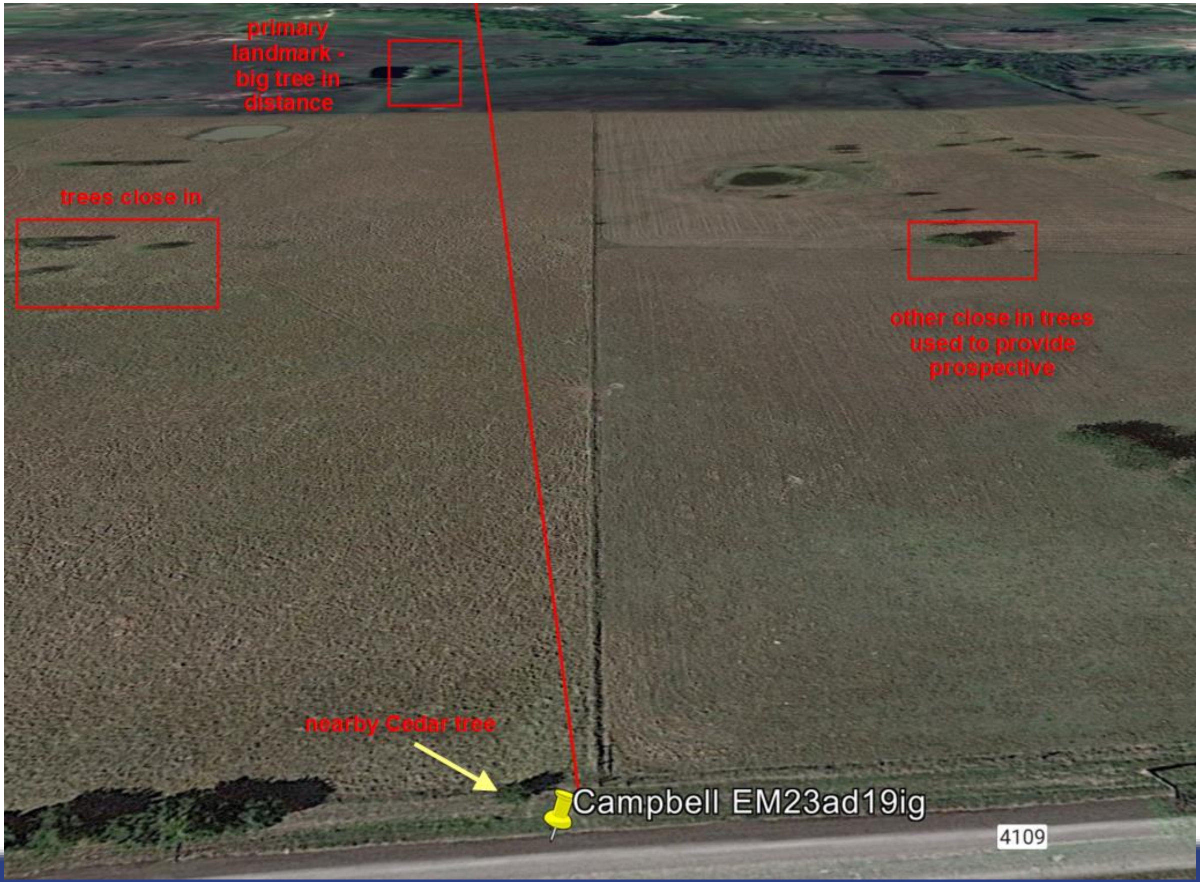
- Use Google maps to tilt view to verify landmark(s)



Pointing accurately - Landmark

- Find landmark when you go to location

This resulted in a successful 47 GHz qso at 60 km.
Signals were 569

Pointing accurately - Terrain

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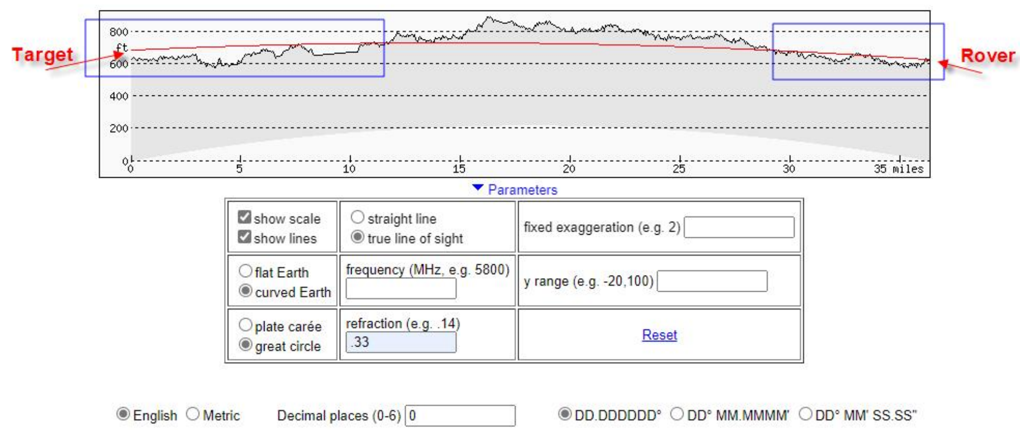
- Note that there is good “takeoff” on both ends
- Terrain is falling away fast on the rover side making the landmark appear more distant or slightly below the near horizon

HeyWhatsThat Path Profiler



Pointing accurately - Bearings

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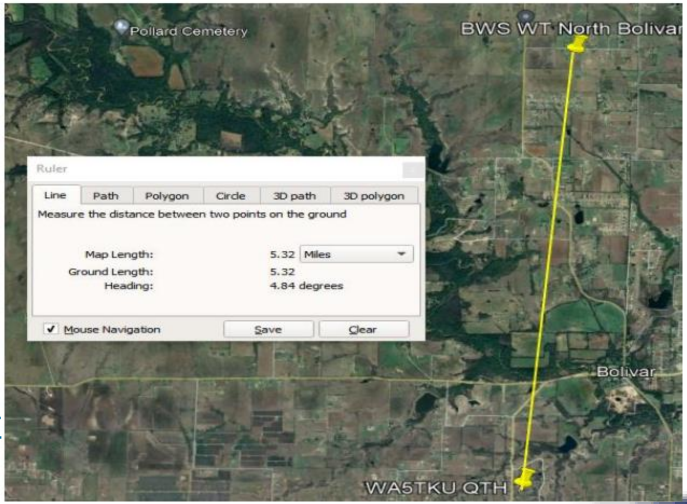
- True versus Magnetic bearing
  - True North is directly over the earth's axis.
  - Magnetic North is somewhere over Canada, moving towards Russia.
  - A Magnetic bearing is in relation to Magnetic North.
  - A True bearing is in relation to True North.



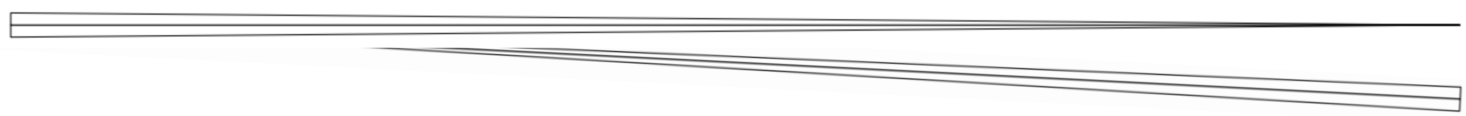
- Be aware of software/mapping bearing values
  - Google values are TRUE degrees
  - K7FRY values are TRUE degrees
  - Theodite app provides both MAGNETIC and TRUE and **the red dot!**

Accuracy counts

Both stations need to be pointed accurately

the impact of being off 2 degrees

At 30 km the miss is > 3000 meters



Pointing accurately - Bearings

- Theodite iphone app – game changer

Theodolite

Catalog #:	1952-67
Object Name:	Theodolite
Date Made:	ca. 1770
Artist-Maker:	Ramsden, Jesse; Made by
Place Made:	England; London
Materials:	brass; copper; wood; mahogany; brass
Dimensions:	H: 13 1/2" x W: 8" x D: 7"
Place Used:	Monticello; Poplar Forest
Class:	Surveying & Navigational T&E
Credit Line:	Gift of Lucy Cocke Elliott, 1952

Description

Narrative

In 1778, Jefferson purchased a sophisticated surveying instrument called a theodolite, which measured both horizontal and vertical angles with telescopes to insure accurate measurements. In addition to land surveying, Jefferson used his theodolite to fix the true meridian of Monticello, perhaps in his observation of a 1778 solar eclipse, and in a complex trigonometric equation, used measurements by the theodolite to determine the elevation of the Peaks of Otter, a landmark in the Blue Ridge Mountains.

Ramsden, Jesse | Surveying & Navigational T&E | Monticello | Poplar Forest | Theodolite

Copy Link https://collections.monticello.org/mDetail.aspx?rID=1952-67&db=objects&d

Pointing accurately - Bearings

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- Theodite iphone app – game changer
- Combines augmented reality for measurement, bearings (True and Magnetic) plus GPS/Grid, maps, 2 axis inclinometer.
- The “RED DOT” is your friend (and target for aiming).
- View through camera can be zoomed to 4 x.

All data should correlate - Review

- K7FRY obtain landmark should match
- Google street view landmark which should match
- Elevated google route view of landmark.

- Theodite (if you use it) "target" red dot should line up with expected (K7FRY & Google) route to target

W5HN

New Example

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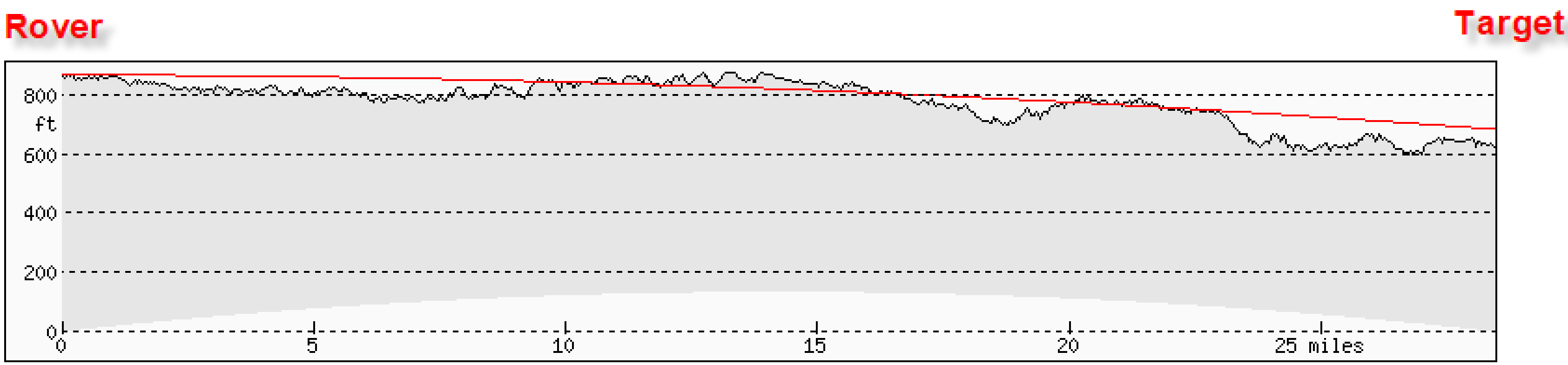
- A location was found on Google with “high” altitude. We decided it was worth the effort to do the homework.
- Initial info showed an elevation of 846 feet with terrain falling away for the first 9 miles. The target also had a good takeoff to the rover.



Pointing accurately - K7FRY

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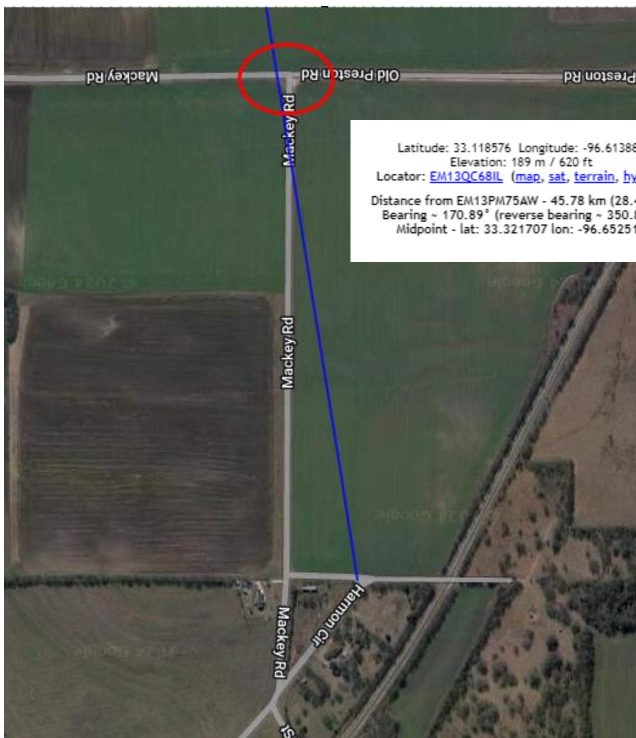
- K7FRY.com accepts a single or double set of grids (up to 10 characters)
  - This is your *primary trusted data*. From this you will extract landmark(s).
  - Bearing is displayed by this tool as 170.71 degrees, say 171 ***TRUE***



Pointing accurately - Landmark

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- Use Google maps to tilt view to verify landmark(s)

Pointing accurately - Landmark

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- Crossroads hard to see in image but note the 171 degrees TRUE and 168 degrees Magnetic. This is dead nuts on!

References & Credits

Wavelab 24 GHz groups.io - https://groups.io/g/Wavelab24GHz

The Audio Meter and schematic shown is a design from K6ML, Mike Lavelle, of 122 GHz DX record fame.

The portable WSS driven by arduino is found here: https://www.ntms.org/files/Feb2023/NTMS%20WSS%20Presentation_20221210.pdf

Brian Justin WA1ZMS Path loss vs Dew Point charts: http://wa1mba.org/mmwloss.pdf

Tom Williams WA1MBA Scatter paper: http://www.wa1mba.org/papers/WA1MBA%20Scattering%20Super%202019%20Paper.pdf

Ben K4QF presentation on tower scatter: https://www.ntms.org/files/August2024/MUD%20TV%20Transmit%20Tower%20Reflections%20II.pdf

ERRATUM: I got Fred Stefanik's call wrong on the slide showing his 12" dish. It should be K1FMS. Fred comments that the unit shown on the slide is now in the hands of Dave and Linda Sumner, K1ZZ/KA1ZD who made a number of 24 GHz contacts with the setup on first leg of the contest.

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Questions?