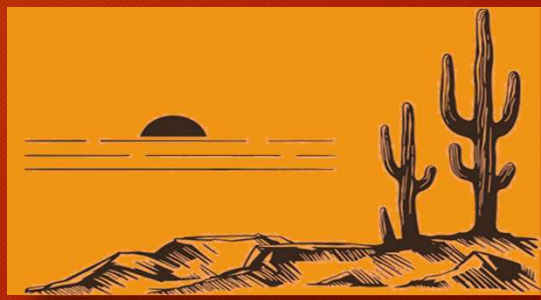
On The Road with 10GHz: Small Dish EME



Charles (Chuck) Claver, NJ6D

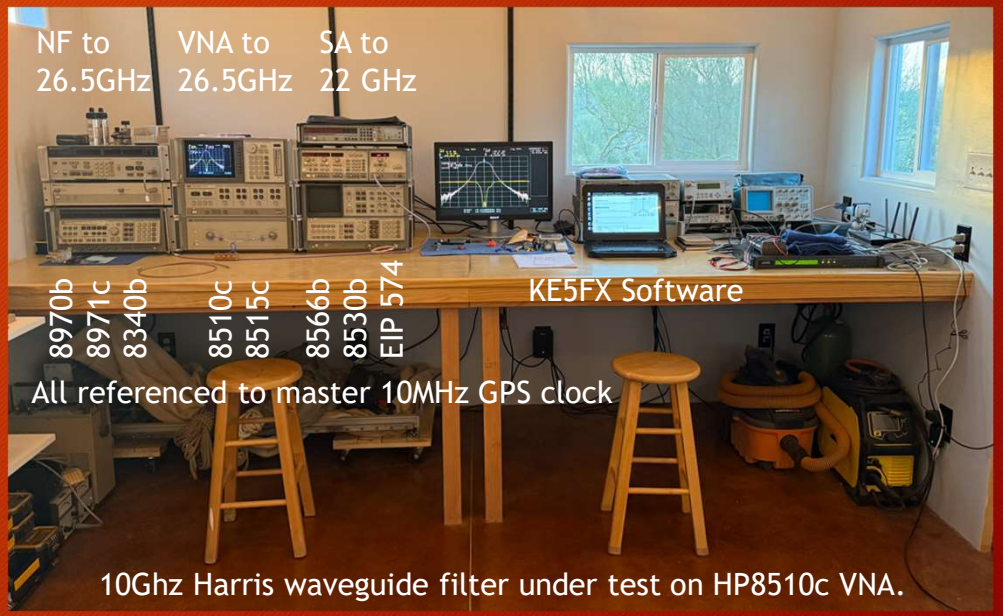
Overview

- Getting started
- Putting my system together with RF Lego Blocks
- Every dB matters but not all dBs are equal
- Evolution of my build
- Out on the Road
  - Mountain Tops
  - New Mexico EME
  - MT, WY and UT EME
- Next Steps
  - System Evolution
  - Trip plans

Getting started

- Licensed in 1977 – I took a liking to HF, CW, DXing, Contesting and Antenna Design
- December 2023: I wanted to do something completely different with radio - Microwaves seemed to be far enough removed to grab my curiosity. I had no idea what I was doing or how to start…
- Solution:
  - Read and then read some more
  - Find people to talk to
  - Tinker and play
  - Scrounge parts and play some more
  - Get serious and design-build a working system
  - Build it again, and again, and…

Fulfilled my dream to build an RF test lab



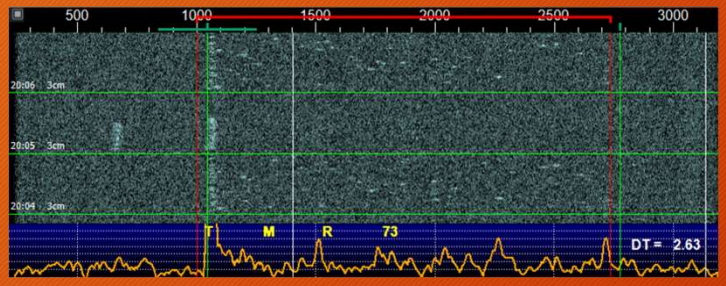
10Ghz Harris waveguide filter under test on HP8510c VNA.

If you can measure it, you can build it

The first build: RF Lego Blocks + 76cm +10W

First moon signals and QSO

```
------ 2025-03-07 - 20:02:00 UTC - 3cm - Q65 ------
2002 -18  2.6 1059 :  CQ DL0SHF JO54       q3 CQ Zone 14 [5536 m
------ 2025-03-07 - 20:04:00 UTC - 3cm - Q65 ------
2004 -16  2.6 1065 :  CQ DL0SHF JO54       q3 CQ Zone 14 [5536 m
------ 2025-03-07 - 20:06:00 UTC - 3cm - Q65 ------
2006 -15  2.6 1064 :  CQ DL0SHF JO54       q3 CQ Zone 14 [5536 m
```



First decodes off the moon on 10GHz

```
UTC   dB   DT Freq    Message
2200 -21  2.5  978 :  N6RMJ ON5TA JO20      q0  [5530 mi / 35°]
------ 2025-03-08 - 22:03:00 UTC - 3cm - Q65 ------
2203 -20  2.5  970 :  N6RMJ ON5TA JO20      q0  [5530 mi / 35°]
------ 2025-03-08 - 22:05:00 UTC - 3cm - Q65 ------
2205 -21  2.3  971 :  N6RMJ ON5TA JO20      q0  [5530 mi / 35°]
------ 2025-03-08 - 22:08:00 UTC - 3cm - Q65 ------
2208 -20  2.3  976 :  N6RMJ ON5TA JO20      q0  [5530 mi / 35°]
2208 -20  2.3  976 :  N6RMJ ON5TA JO20      q0  [5530 mi / 35°]
```

Pat (N6RMJ): “Call him and try!!!”

```
UTC   dB   DT Freq    Message
2302  Tx        973 :  ON5TA NJ6D -21
2304 -23  2.7  973 :  NJ6D ON5TA JO20       q3
2306  Tx        973 :  ON5TA NJ6D -21
2308 -20  2.7  972 :  NJ6D ON5TA R-24       q3
2310  Tx        973 :  ON5TA NJ6D RRR
2312 -21  2.7  976 :  NJ6D ON5TA R-24       q3
2314  Tx        973 :  ON5TA NJ6D RRR
2316 -22  2.7  969 :  NJ6D ON5TA 73         q3 CQ Zone 14
```

First competed QSO on 10GHz EME

Pushing the limits: Friis's formula and the inequity of dBs

- System noise is dominated by the first term(s) before any active gain.
- Passive component loss: -gain = noise
- Pre-LNA losses are critical
  - Essentially additive noise with no gain dilutions
- Mixer conversion loss/gain often overlooked
  - LO Power and conversion loss

Cascade Noise Factor

$$F_{\text{total}} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \frac{F_4 - 1}{G_1 G_2 G_3} + \cdots + \frac{F_n - 1}{G_1 G_2 \cdots G_{n-1}}$$

Noise Figure:
Expressed in dB
where *N_i = F_i*

$$Noise_{total} = 10 \log_{10}\left(n_1 + \sum_{i=2}^{M} \frac{n_i - 1}{\prod_{j=1}^{i-1} g_j}\right)$$

$$n_i = 10^{\frac{N_i}{10}}; \quad g_i = 10^{\frac{G_i}{10}}; \quad Gain_{total} = \sum G_i$$

System noise model

Stage-1: Feed to 1st coax relay
Stage-2: 2.9mm 40GHz coax relay
Stage-3: 1st coax relay to LNA input
Stage-4: DU3T X-band LNA
Stage-5: LNA to 2nd coax relay (FSJ1)
Stage-6: 2nd 26 GHz coax relay
Stage-7: Harris w4-pole waveguide filet
Stage-8: REMEC Magnum 6-12 GHz mixer
Stage-9: Mixer to IF gain stage
Stage-10: PGA103 144Mhz IF gain + filter

Select Number of Stages

Stage 10

	NF(dB)	Gain(dB)
Stage 1	0.16	-0.16
Stage 2	0.06	-0.06
Stage 3	0.23	-0.23
Stage 4	0.6	26
Stage 5	2.2	-2.2
Stage 6	0.12	-0.12
Stage 7	0.19	-0.19
Stage 8	5	-5
Stage 9	.1	-.1
Stage 10	0.5	23

Result

Total NF

1.11

Total Gain

40.94

A word about mixers:

Often overlooked, but because of relatively large conversion loss they can have an impact on system NF even after gain stages.

This mixer uses a nominal 10dBm LO drive with approximately 7-8dB of conversion loss. Increasing LO drive to near its 15dB maximum at 14dBm lowers the conversion loss to ~5dB.

Net effect is approximately 0.2dB in integrated cascaded system NF.

Anatomy of two feed arrangements

- Pre-LNA losses are critical - essentially additive noise with no gain dilutions
- Follow the path
  - W1GHZ dual band feed – 0.1dB (est)
  - Male-Male SMA adapter – 0.09dB (mea)
  - Ducommun 26GHz relay – 0.12dB (mea)
  - Semi-rigid coax – 0.22dB (mea)
- DEMI LNA NF=0.85dB, Gain = 23dB
- At LNA output: **NF = 1.38dB, Gain = 22.47**
- **Predicted Sun noise = 7.64**

Where possible, each piece was measured at 10.4 GHz (HP8510 VNA) and selected out of supply to have the lowest loss possible. Even if the measured difference was only a few hundredths of a dB.

Anatomy of two feed arrangements

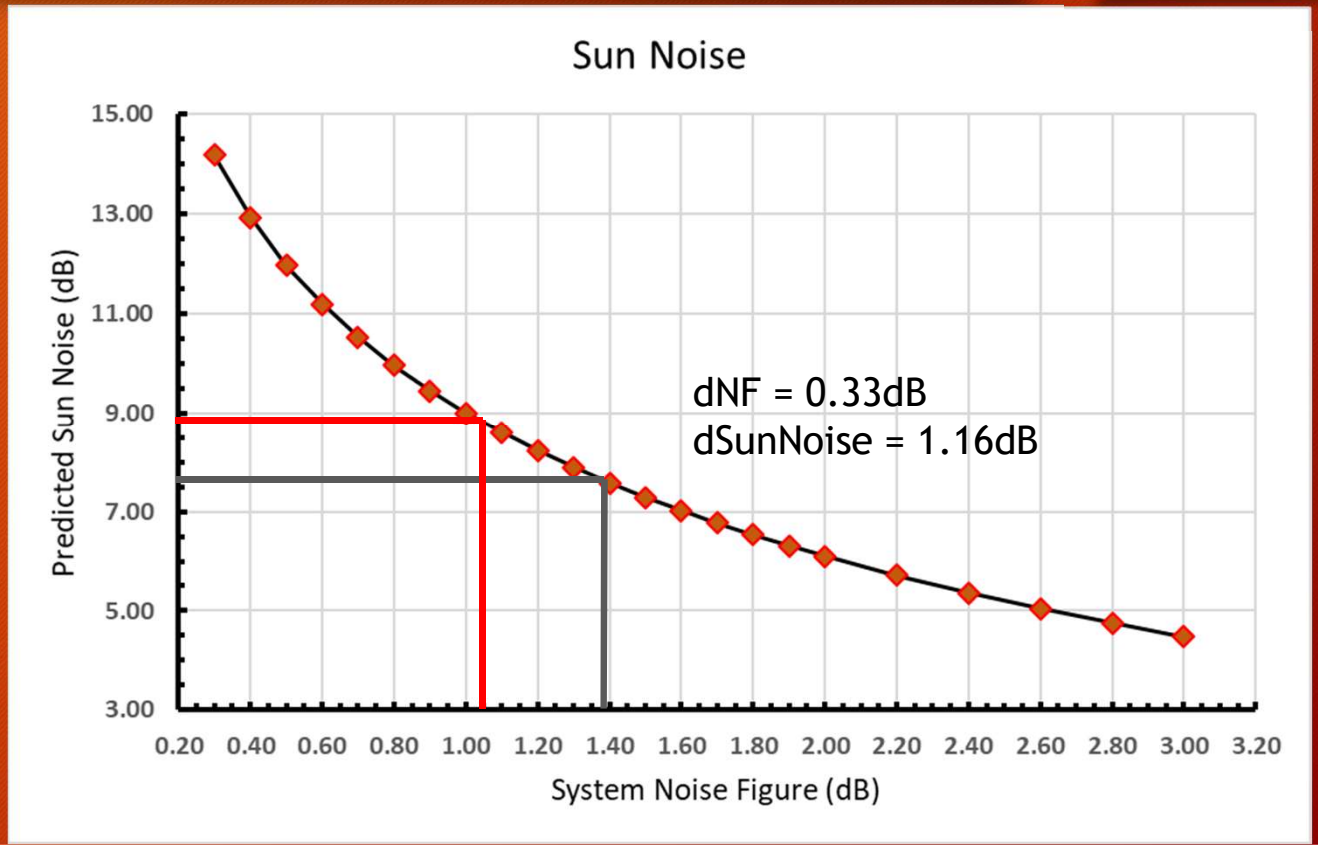
- **Pre-LNA losses are critical** - essentially additive noise with no gain dilutions
- Follow the path
  - W1GHZ dual band feed: probe + low pass filter- 0.1dB (est)
  - High performance Male-Male SMA adapter – 0.06dB (mea)
  - Ducommun 2.92mm 40GHz relay – 0.06dB (mea)
  - High performance rigid coax – 0.12dB (mea)
  - WR90-SMA transition: 0.11 (mea)
- DU3T LNA NF=0.60dB, Gain = 27dB
- At LNA output: **NF = 1.05dB, Gain = 26.55**
- **Predicted Sun noise = 8.80dB**

Where possible, each piece was measured at 10.4 GHz (HP8510 VNA) and selected out of supply to have the lowest loss possible. Even if the measured difference was only a few hundredths of a dB.

Sun Noise versus System Noise

10GHz solar flux = 272 SFU
1m Dish Gain = 39dB

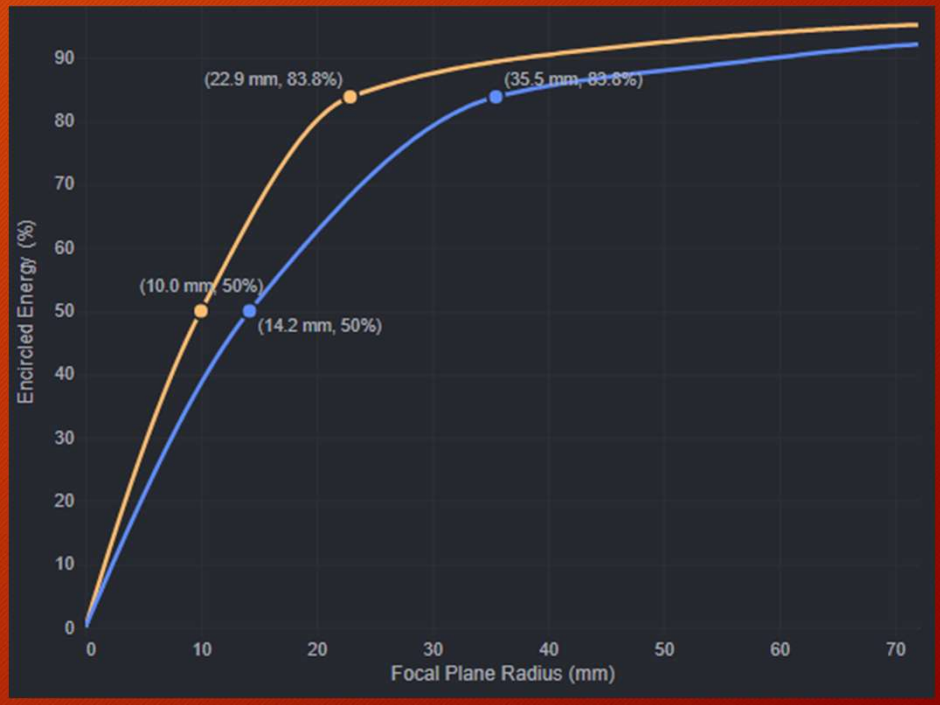
Normalized for 9dB sun noise with 1dB system NF



Details matter – feed alignment for 0.1dB loss
(Fun with AI)

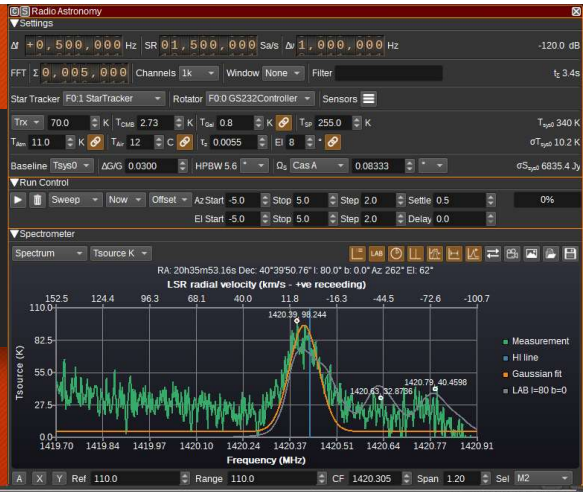
Metric	Raw Circular Catchment (Flat Math)	W2IMU Dual-Mode Horn (Electromagnetic Reality)	Key Physical Driver
Lateral Tolerance	±2.5 mm	**±4.5 mm**	Buffered by the horn's natural Gaussian-like edge taper profile.
Axial (Z) Tolerance	±7.0 mm	**±1.5 mm**	Extremely sensitive to phase curvature disrupting internal TE_{11}/TM_{11} mode balance.

Displacement Axis	Original W2IMU (10.. GHz Only)	W1GHZ Feed @ 10 GHz	W1GHZ Feed @ 24 GHz	Critical Operational Rule
Lateral (X or Y)	± 4.5 mm	± 5.5 mm	**± 1.9 mm**	**Must align to 24 GHz criteria.** 10 GHz will naturally be centered.
Axial (Z-Focus)	± 1.5 mm	± 2.2 mm	**± 0.65 mm**	**Extremely critical.** A sub-millimeter shift ruins 24 GHz performance.

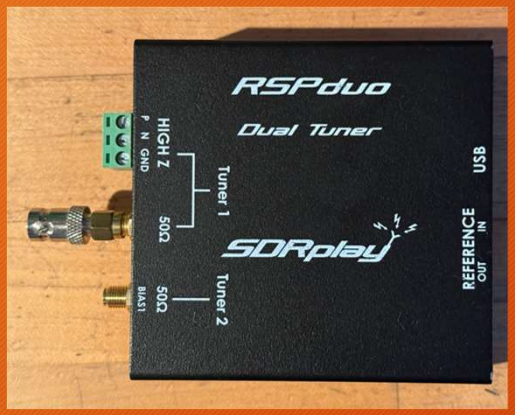


Noise measurements: SDR and Software

If you can measure it, you can build it!



Current SDR hardware / Software software tools allow high precision RF noise measurements that were not within reach of the amateur that long ago.



SDRplay RSPduo ~$250

Software (mostly free):

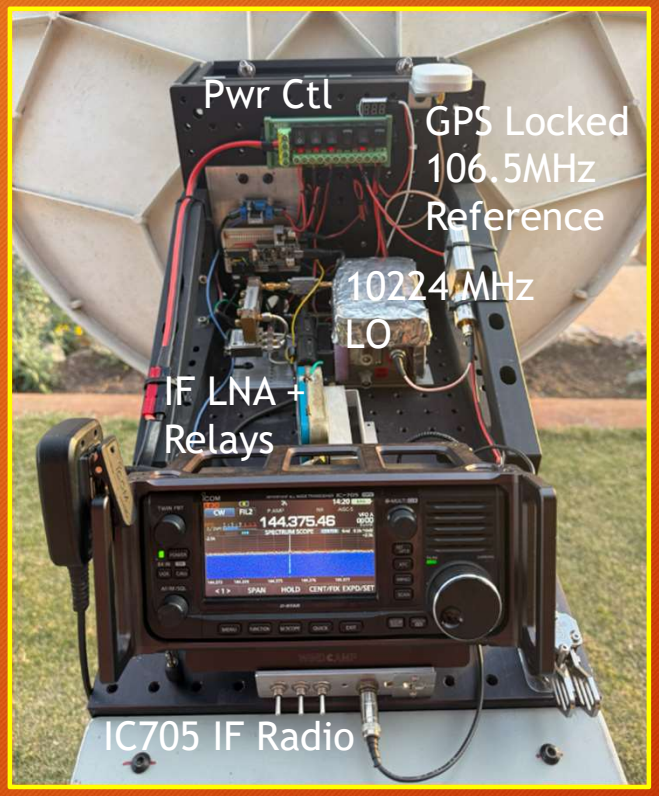
- Total Power – Mario, I0NAA
- SDRAngel - Radio Astronomy Plugin
- SpectraVue

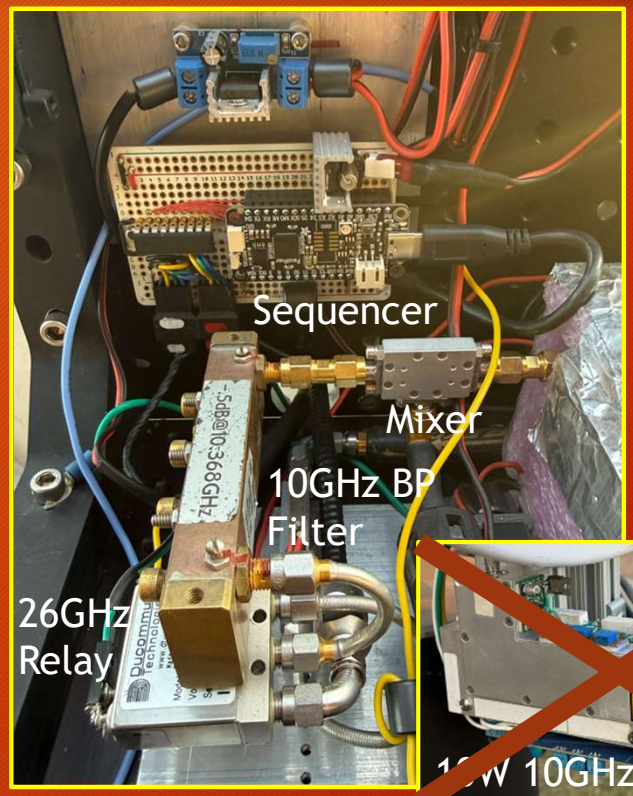
Radio Astr
1.4GHz (21cm) H

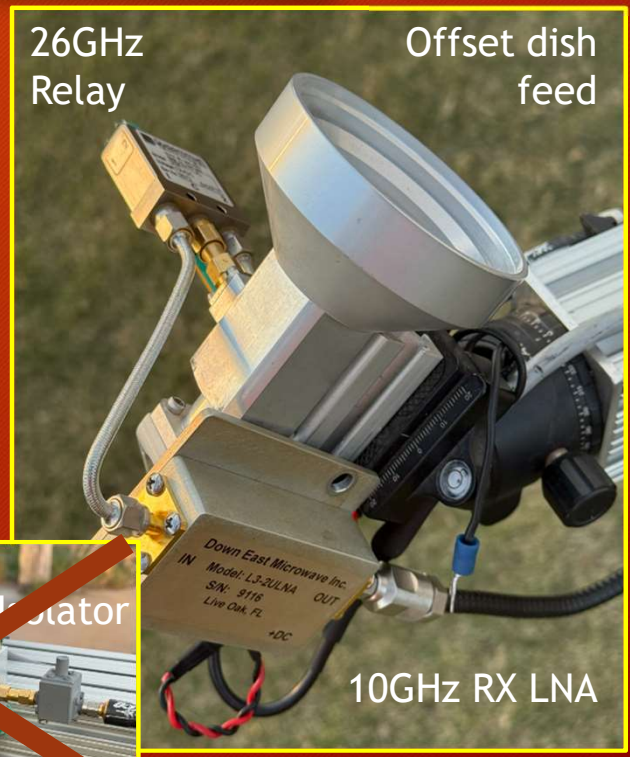
Moon noise with 1M dish (old front end). 0.27dB easily measured.

RTL-SDR <$50

Current Evolution of RF Lego Blocks System







1m + 45W 10GHz Transportable System

- 1m offset dish w/W1GHZ feed & Pelco positioner
- Home brew transverter from “RF Lego Blocks”
- IC705 IF Radio
- Wireless connection to Laptop
- WSJT-X Improved Plus

Now with 45W measured at the feed input!

Thank you Eric – OE9ERC

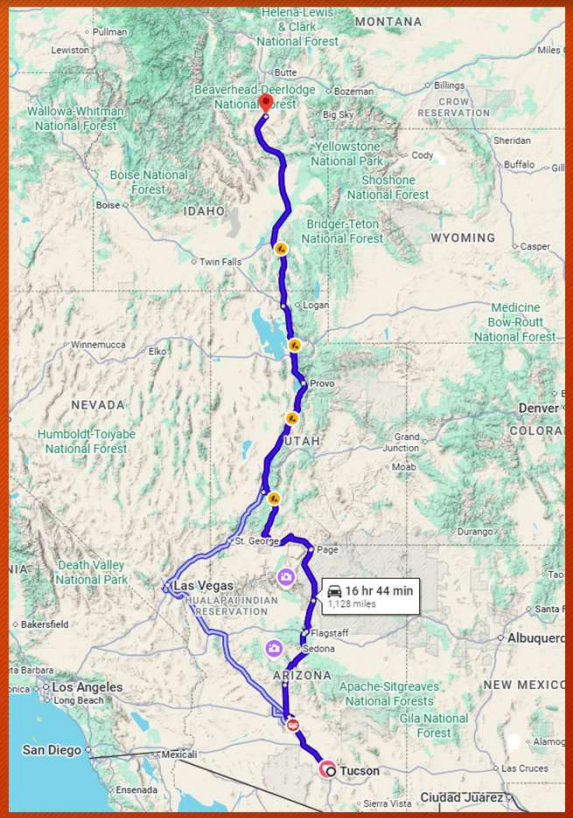
On the road – 1st Stop New Mexico (10W)

NJ6D/P DM65qc

UTC	Call	SENT	RCVD
2339	OZ1LPR	+04	-23
2347	ON5TA	-12	-20
2353	W5LUA	-07	-22
2359	VE4MA	-14	-25
0008	OK1KIR	-10	-20

Success!! Now What?

Family road trip to Dillon, Montana



An opportunity to put several “rare” states on the air via 10GHz EME:

- Montana
- Idaho
- Wyoming
- Utah

The Big Rove:
Montana, Wyoming, Idaho & Utah

President Dwight D. Eisenhower:

"Plans are worthless…
… but planning is everything."

November 1957
National Defense Executive Reserve Conference

Make a plan!

Operating Plans: 5 – 13 June 2026
Setting Expectations

June 2026

- 5-6: Travel from Tucson, AZ to Dillon, MT, overnight near Salt Lake City, UT
- 7-8: Family time with son, Ryan
- 9: QRV ~09:30 UTC MT-ID border from Lemhi Pass (or alt)
- 10: QRV ~10:30 UTC MT-ID border from Chief Joseph Pass
- 11: QRV ~12:30 UTC WY-UT border, 3hrs drive to site
- 12: QRV ~11:00 – 17:00 UTC, Evanston, WY – Drive to Page, AZ (7hrs)
- 13: Travel from Page, AZ to Tucson, AZ (Home)

Operating Plans: 5 – 13 June 2026
Setting Expectations

- This will be a ***Digital Only*** operation
  - Primary mode: Q65-60D CFOM 1st
  - Alternate mode: Q65-120D CFOM 1st
- HB9Q for coordination/status (connectivity permitting)
- Moonrise occurs *very early* local time
- Driving time to operating sites in Montana are 60-90 minutes
- QRV will be targeted for an hour or so after local moonrise
- Will stay QRV as long as possible
- Libration Broadening (see charts)
  - Conditions improve later each day and through the week towards New Moon
  - EU is favored near their moonset
  - NA is favored at local moonrise and moonset

Daily Operating Strategies
Setting Expectations

Montana-Idaho
June 9: 10:00-??? UTC

- Europe has priority through their moonset ~14:00 UTC
- NA has bad Libration broadening mid-day >150Hz
- NA improves as moon sets, <100Hz after 18:00 UTC

Montana-Idaho
10 June: 10:30 - ??? UTC

- Europe has priority though their moonset ~15:30 UTC
- Both NA and EU have similar Libration broadening to start
- NA improves as moon sets, <100Hz after 18:00 UTC

Wyomining-Utah
11 June: 12:30 - ??? UTC

- 3 Hrs drive from Dillon to WY-UT border site, Setup 30 min
- Europe has priority through their moonset ~17:00 UTC
- NA very good after 18:00 UTC <100z and <50hz 19:00 – 21:00
- 22:00 pack up and leave for Evanston, WY

VK, ZL Oceana will try with you anytime
Not sure I can TX on 10.45GHz for JA

HB9Q Digital Q65 Coordination
Setting Expectations

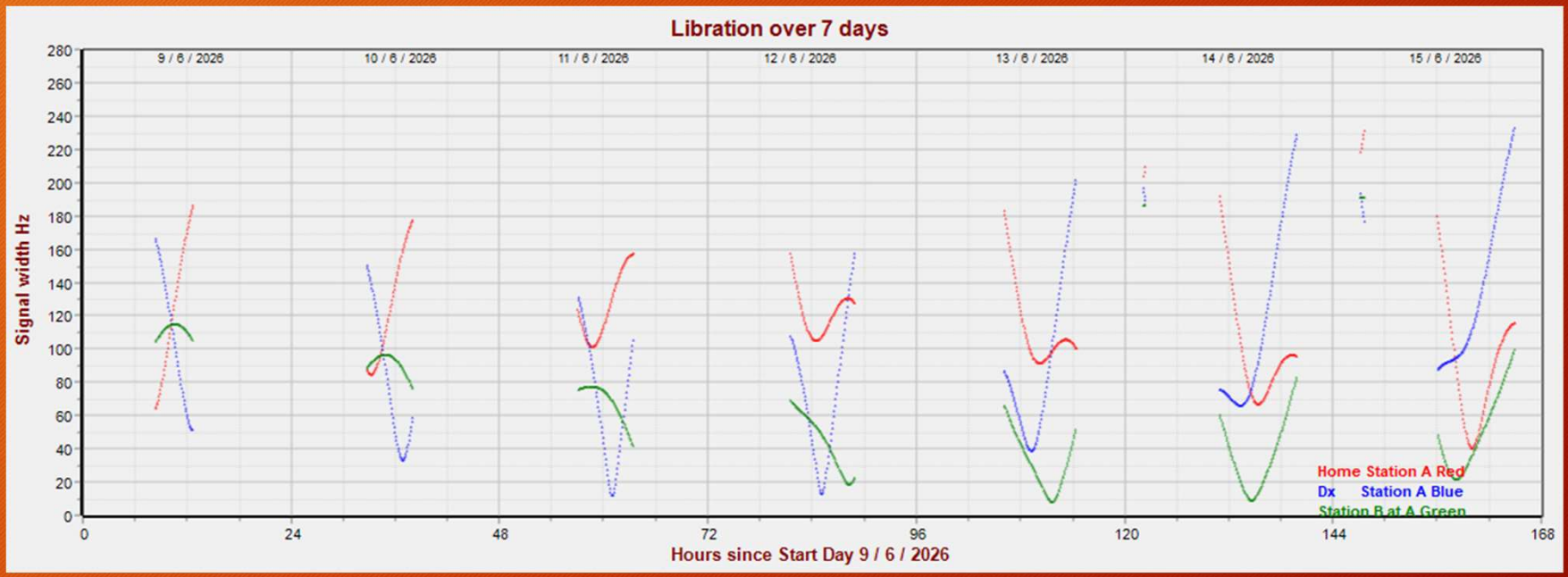
- I will be using my cell phone as a portable hotspot
- Connectivity at operating sites is unknown at the moment
- Assuming connectivity:
  - Having the caller and grid keyed into WSJT-X helps significantly with Q65 decodes – particularly stations at the noise floor
  - I will try to indicate who I am listening for on HB9Q – I will post something like "AB1CDE call now" and "The order as I have it…"
  - To keep my ops as simple as I can will always TX 1st cycle
- If no connectivity:
  - I will call CQ on 10368.200 CFOM 1st Q65-60D. I will answer whoever I decode.

I am open to suggestions to improve the opportunities for others or to follow established protocols – remember I am new to this.

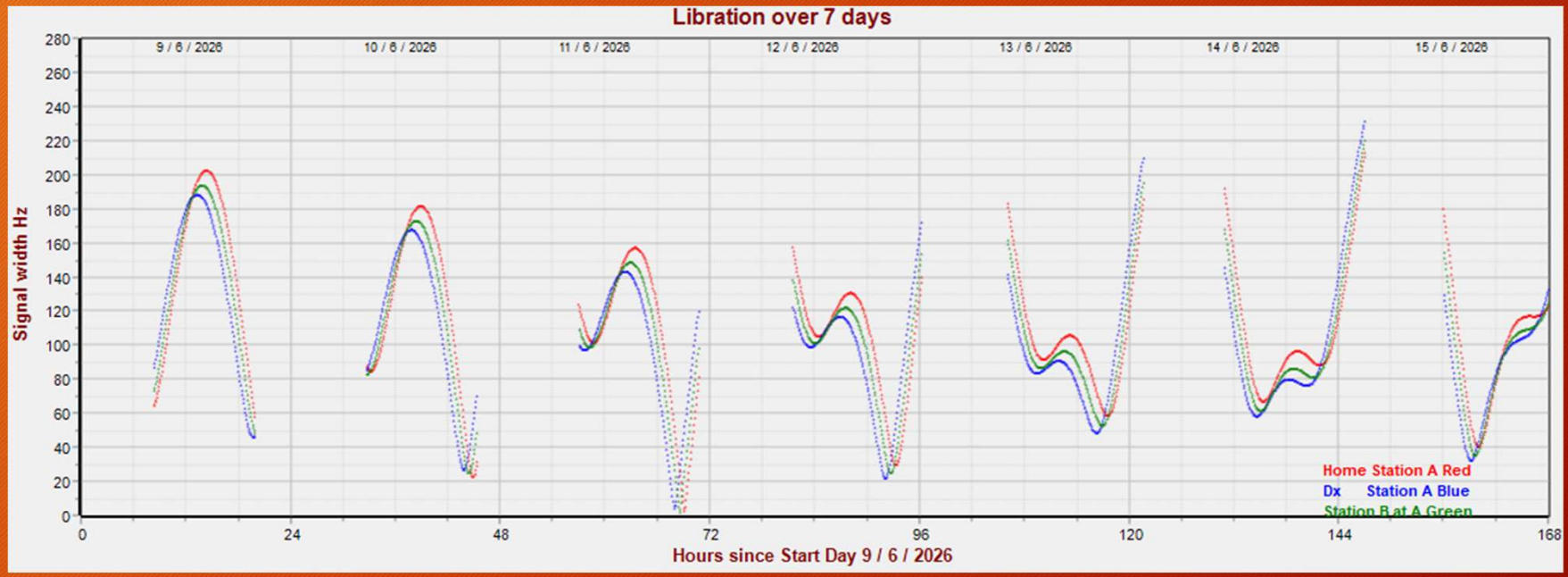
Moon Schedule for MT (MT, UTC-6)

2026	Moonrise/Moonset			Meridian Passing		
Jun	Moonrise	Moonset	Moonrise	Time	Distance (mi)	Illumination
1	-	6:11 am ↙ (228°)	11:05 pm ↘ (132°)	2:13 am (16.1°)	252,499	99.0%
2	-	7:05 am ↙ (229°)	11:47 pm ↘ (129°)	3:04 am (16.3°)	252,193	96.3%
3	-	8:06 am ↙ (232°)	-	3:55 am (17.9°)	251,387	91.8%
4	12:21 am ↘ (125°)	9:12 am ↙ (237°)	-	4:43 am (20.7°)	250,038	85.6%
5	12:49 am ↘ (119°)	10:20 am ↙ (243°)	-	5:30 am (24.7°)	248,120	78.0%
6	1:11 am ↘ (112°)	11:28 am ↙ (251°)	-	6:15 am (29.6°)	245,620	69.1%
7	1:31 am ↘ (105°)	12:37 pm ← (259°)	-	6:59 am (35.2°)	242,582	59.1%
◑ 8	1:49 am → (96°)	1:47 pm ← (268°)	-	7:42 am (41.3°)	239,089	48.5%
9	2:07 am → (87°)	2:59 pm ← (278°)	-	8:26 am (47.8°)	235,314	37.6%
10	2:27 am ↗ (78°)	4:15 pm ↖ (287°)	-	9:13 am (54.4°)	231,481	26.9%
11	2:49 am ↗ (69°)	5:36 pm ↖ (296°)	-	10:04 am (60.6°)	227,906	17.1%
12	3:16 am ↗ (61°)	7:00 pm ↖ (304°)	-	11:00 am (66.1°)	224,907	8.9%
13	3:52 am ↗ (54°)	8:24 pm ↖ (309°)	-	12:02 pm (70.2°)	222,844	3.1%
● 14	4:41 am ↗ (50°)	9:40 pm ↖ (312°)	-	1:08 pm (72.3°)	221,971	0.3%

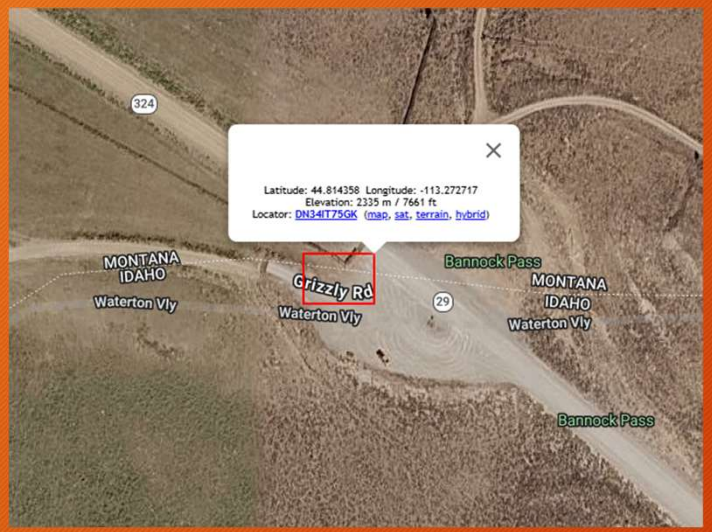
Lunar Libration Broadening: Europe (DL)



Lunar Libration Broadening: North America (VE4)

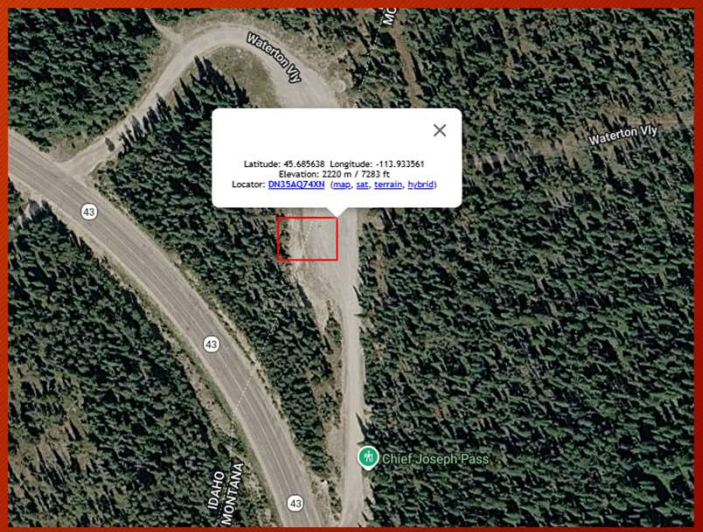


Montana – Idaho Border Sites



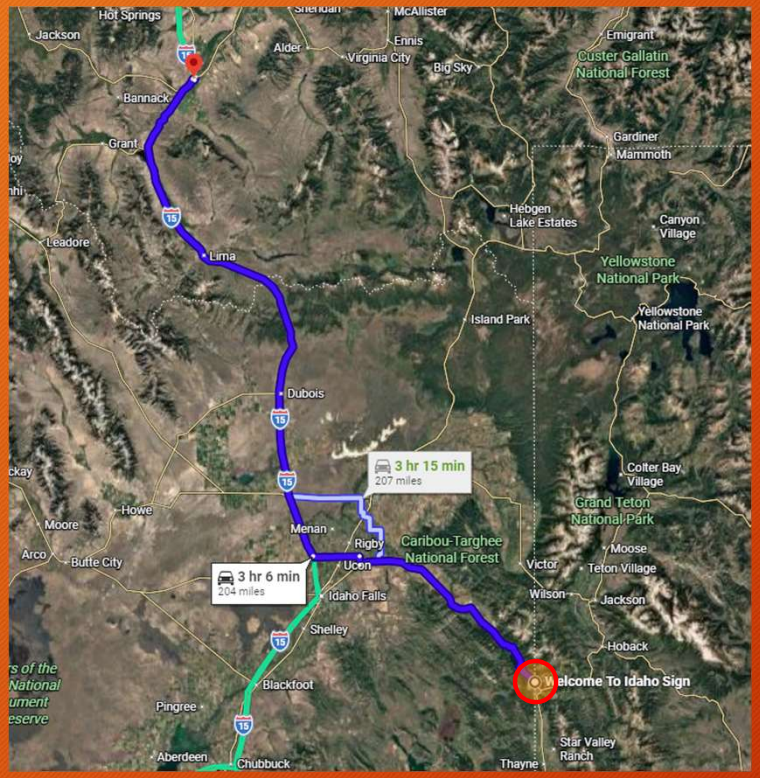
Bannock Pass:
Lat: +44.814358
Lon: -113.272717
Grid: DN34IT75GK

Lemhi Pass
Lat: +44.981753
Lon: -113.44614
Grid: DN34GX65LO



Chief Joseph Pass
Lat: +45.685638
Lon: _113.933561
Grid: DN35AQ74XN

Wyoming – Idaho Border Site



Along HWY-26
Lat: +43.200819
Lon: -111.044008
Grid: DN43LE48RE

Weather!!!

Mountain sites on MT-ID border were out of the plan.

Winds in Dillion proper were not much better.

Now what? Plan-B…

Extended Forecast for
3 Miles NW Dillon MT

Today	Tonight	Sunday	Sunday Night	Monday	Monday Night	Tuesday	Tuesday Night	Wednesday
20 %	20 %	40%				20 % → 80 %		
High: 79 °F	Low: 44 °F	High: 60 °F	Low: 34 °F	High: 68 °F	Low: 44 °F	High: 65 °F	Low: 38 °F	High: 59 °F
Partly Sunny then Slight Chance T-storms and Breezy	Mostly Cloudy then Slight Chance Showers	Chance Showers and Breezy	Partly Cloudy	Partly Sunny	Mostly Cloudy	Slight Chance Showers then Showers	Showers Likely	Showers Likely

Extended Forecast for
2 Miles W Dillon MT

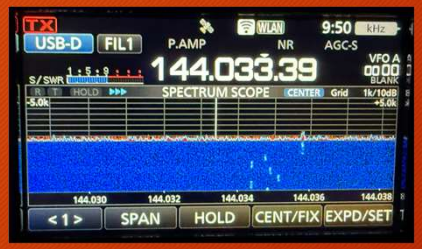
Tonight	Monday	Monday Night	Tuesday	Tuesday Night	Wednesday	Wednesday Night	Thursday	Thursday Night
		20 %	30 % → 80 %	50 %	30 %			
Low: 31 °F	High: 70 °F	Low: 45 °F	High: 65 °F	Low: 36 °F	High: 60 °F	Low: 32 °F	High: 71 °F	Low: 39 °F
Increasing Clouds	Sunny	Cloudy then Slight Chance Rain	Chance Rain then Showers	Chance Showers then Partly Cloudy	Chance Rain then Mostly Sunny	Mostly Clear	Sunny	Mostly Clear

Sunday A 40 percent chance of showers and thunderstorms, mainly between 1pm and 2pm. Partly sunny, with a high near 60. Breezy, with a west wind 6 to 11 mph increasing to 18 to 23 mph in the afternoon. Winds could gust as high as 40 mph.

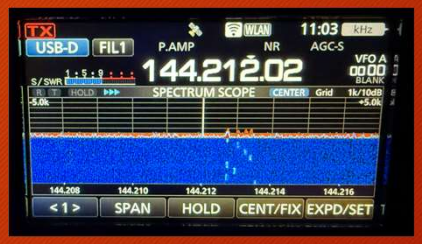
Operating from Dillon, MT

At my son's QTH. Storage shed conveniently served as a wind break for the morning EU run.

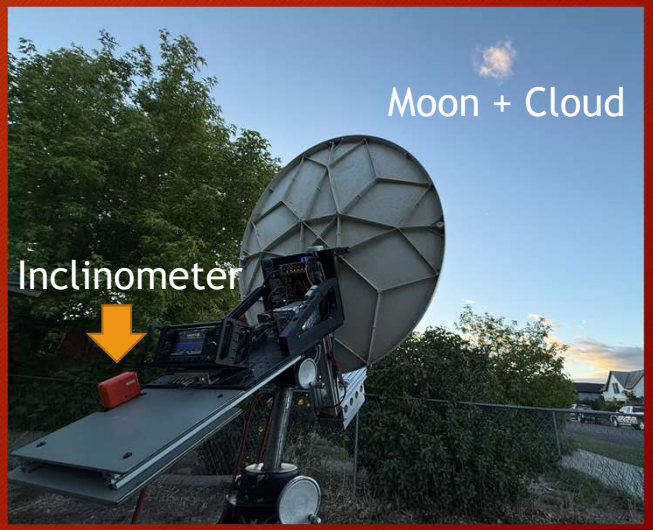
DL0SHF (at high power) and OZ1LPR served as strong beacons for initial alignment through the morning clouds. Both were SSB quality!



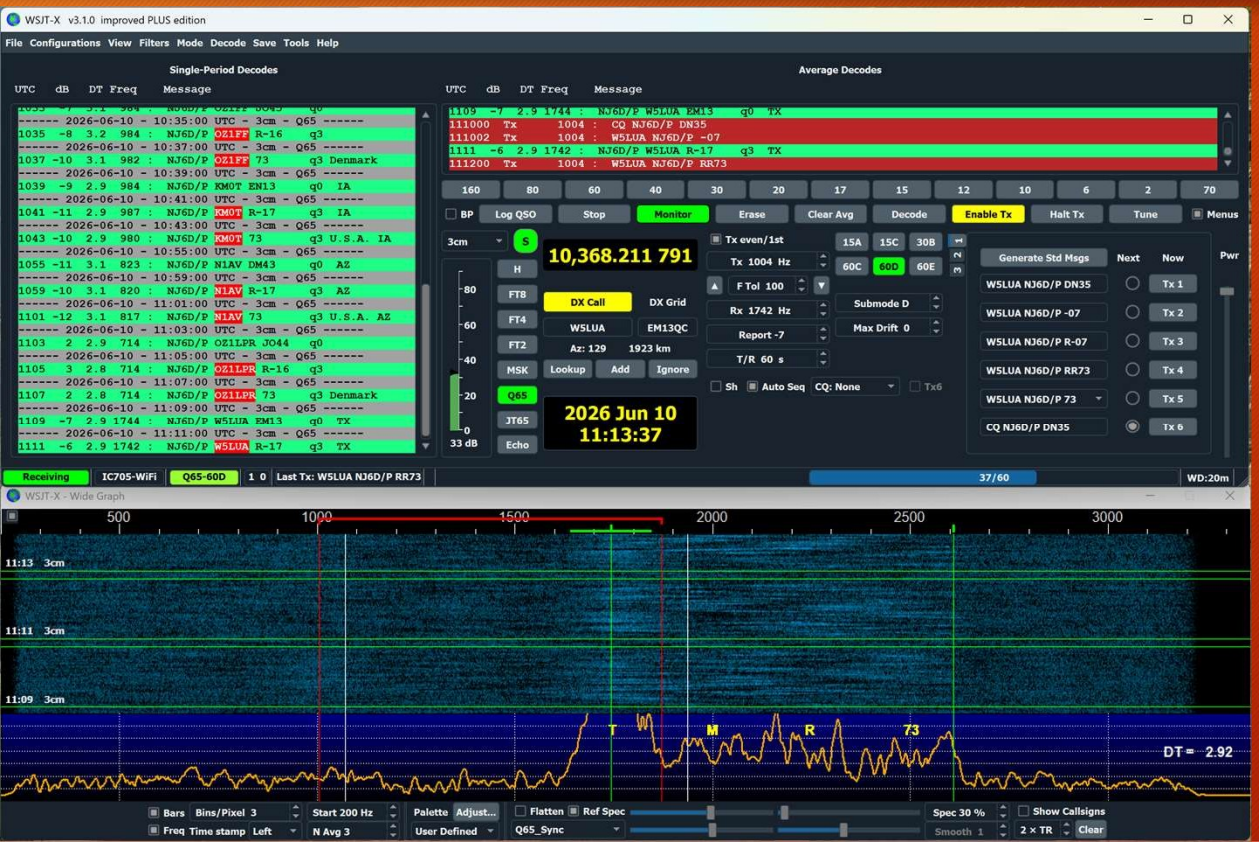
DL0SHF



OZ1LPR



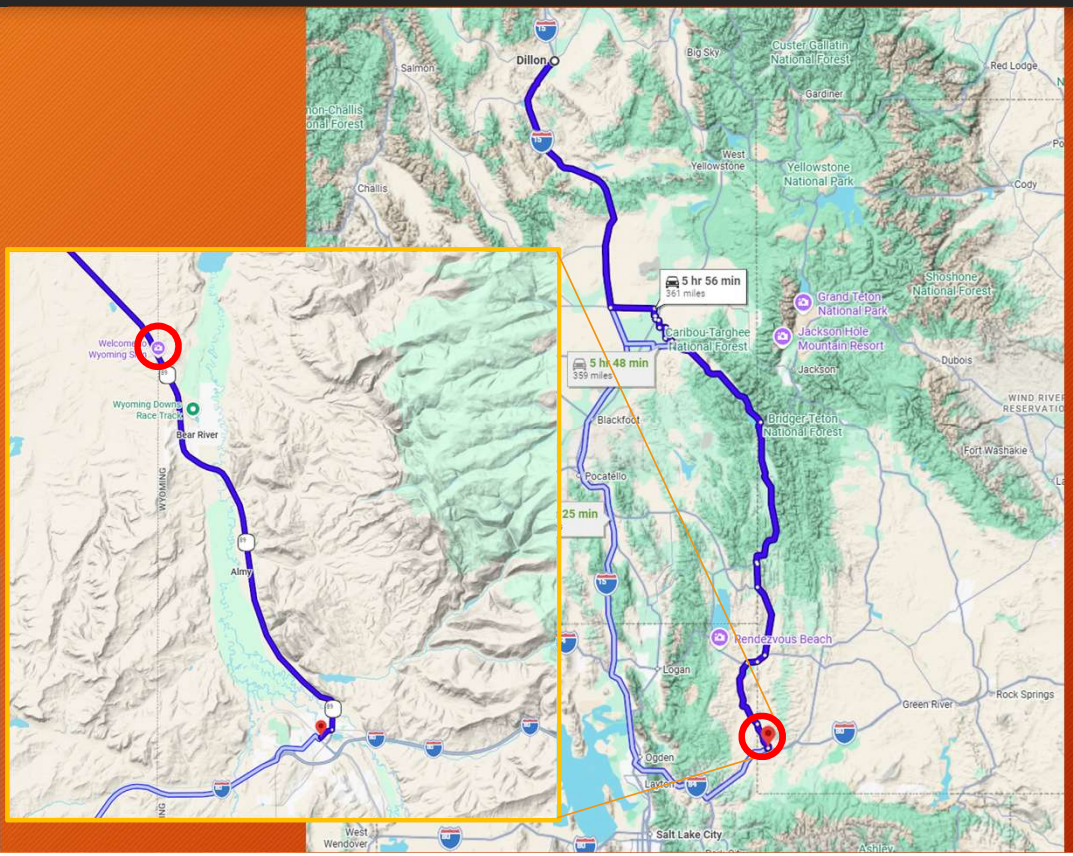
Dillon, MT Summary -2 days of operating

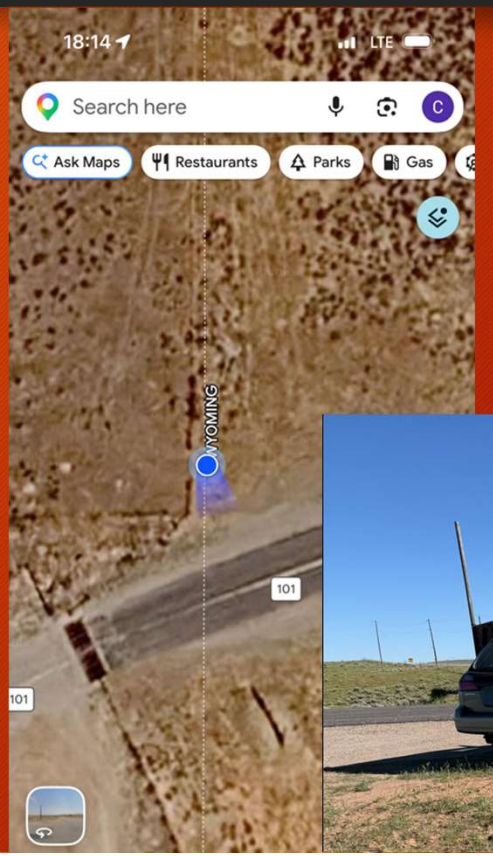


NJ6D/P DN35qf

	QSOs	Unique	Rpt
10 June	11	11	0
11 June	7	4	3
Total	18	15	3

Heading home by way of Evanston, WY





Recon on the way to hotel revealed an ideal location!

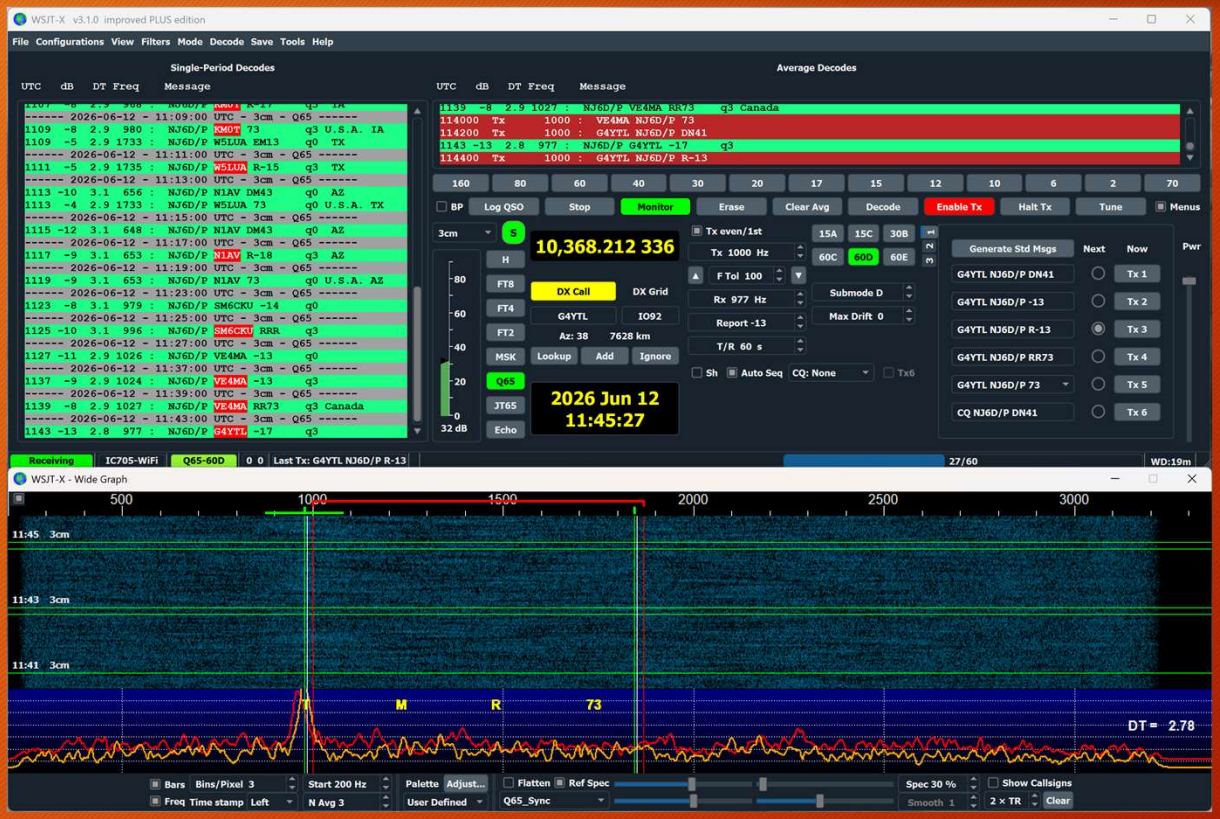
Long horizons, quiet, and exactly straddling the WY-UT border.

Weather forecast called for a cool morning and calm winds.

Wyoming-Utah Operations


```
------ 2026-06-12 - 14:22:00 UTC - 3cm - Q65 ------
1422   3  2.8   983 :  CQ DL0SHF JO54       q3 Germany
------ 2026-06-12 - 14:24:00 UTC - 3cm - Q65 ------
1424   3  2.8   988 :  CQ DL0SHF JO54       q3 Germany
------ 2026-06-12 - 14:26:00 UTC - 3cm - Q65 ------
1426   2  2.8   990 :  CQ DL0SHF JO54       q3 Germany
```

Wyoming-Utah Operations



Wyoming-Utah Summary

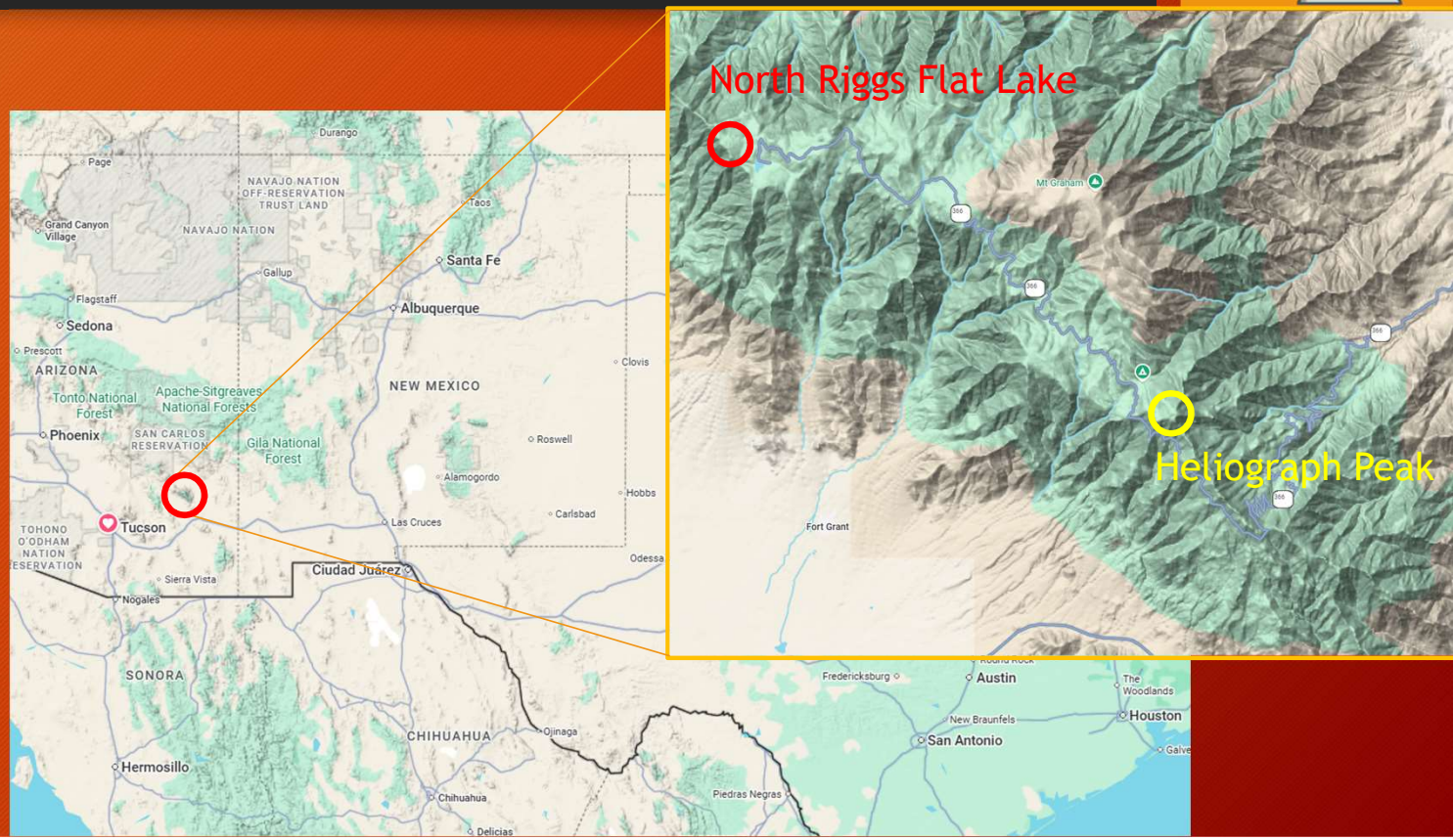
NJ6D/P DN41ln

	QSOs	Unique	Rpt
12 June	25	16	9

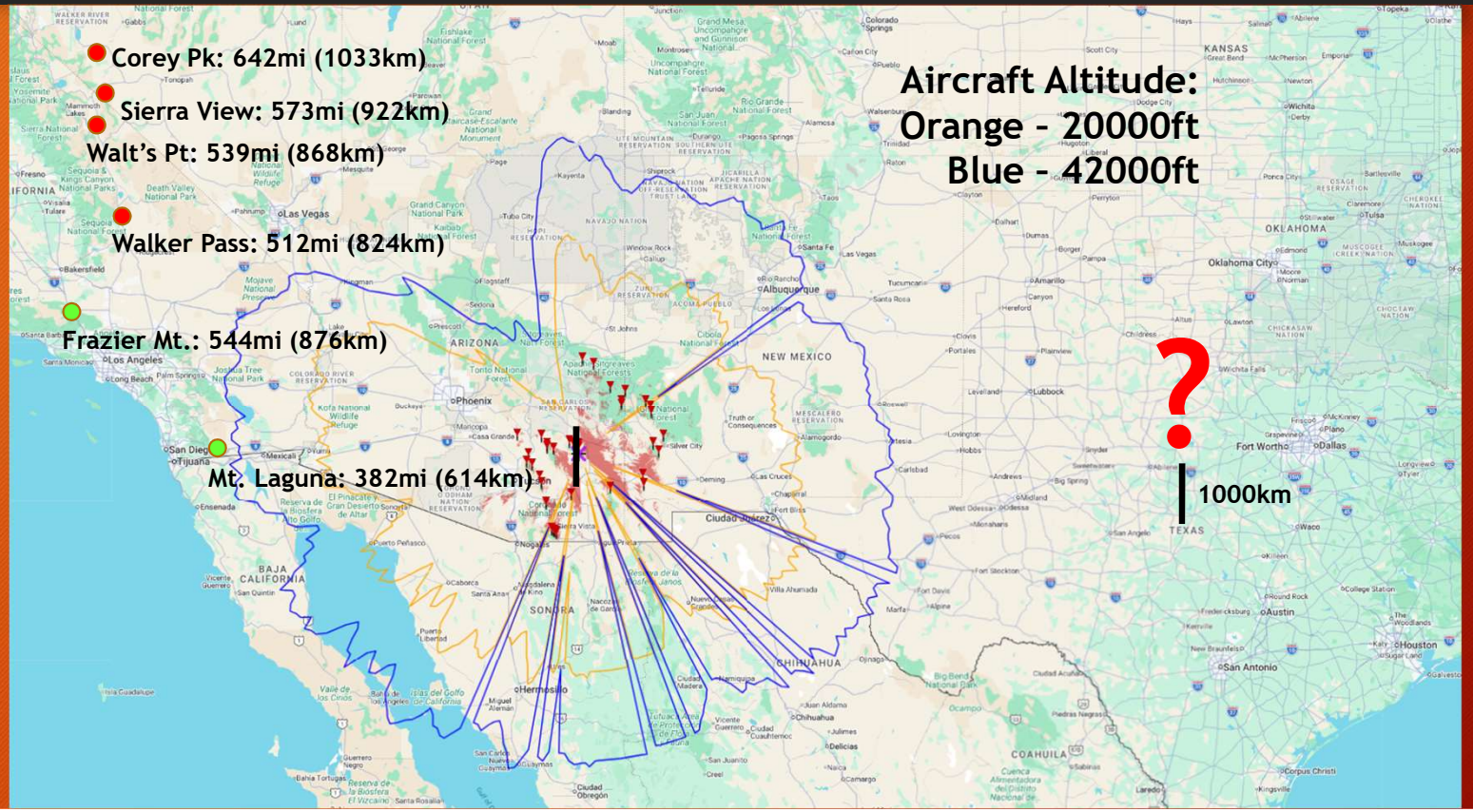
Upcoming activity
Sep 19-20: Heliograph Peak

Penelño Mountains

- Elevations >10000ft
- 2 operating sites
  - Heliograph Pk
  - North Riggs Flat Lake
- Heliograph Pk as an excellent horizon to the east towards Texas
- Texas – AZ on 10GHz: **Would this be a first?**



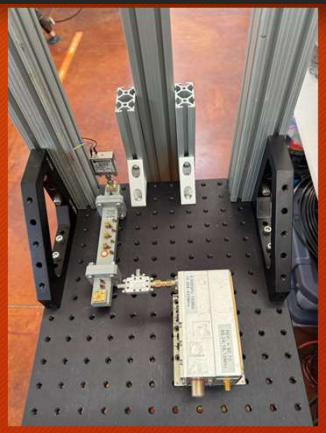
Excellent aircraft horizons



Transportable 10GHz EME v2.0
A bigger dish and waveguide

Design requirements:
- High performance following principles from Ver1 – system NF <1.0dB
- Highly modular – fit in Subaru Outback
- <20lbs per module for easy handling
- Minimum tools for assembly
- Assembly time <20min
- Automated tracking

Note reflection in dish.

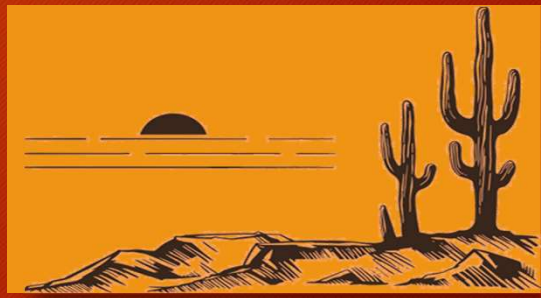


Modular folding dish and feed support using 8020 T-slot.

WR90 switch

1.2 m resurfaced dish
- <<λ/20 p-v at 3cm
- Surface good to >24GHz
- #200 copper mesh (>40GHz)

Thank you for your attention!



More questions…