Directional Antennas & HF Long-Range Propagation (two part series)

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W5IFQ
4 MAR 2025
1 APR 2025

Objectives

- Introduce long-range ionospheric skip sky-wave propagation theory and practice.
- Discuss suitable HF antennas for long-range propagation

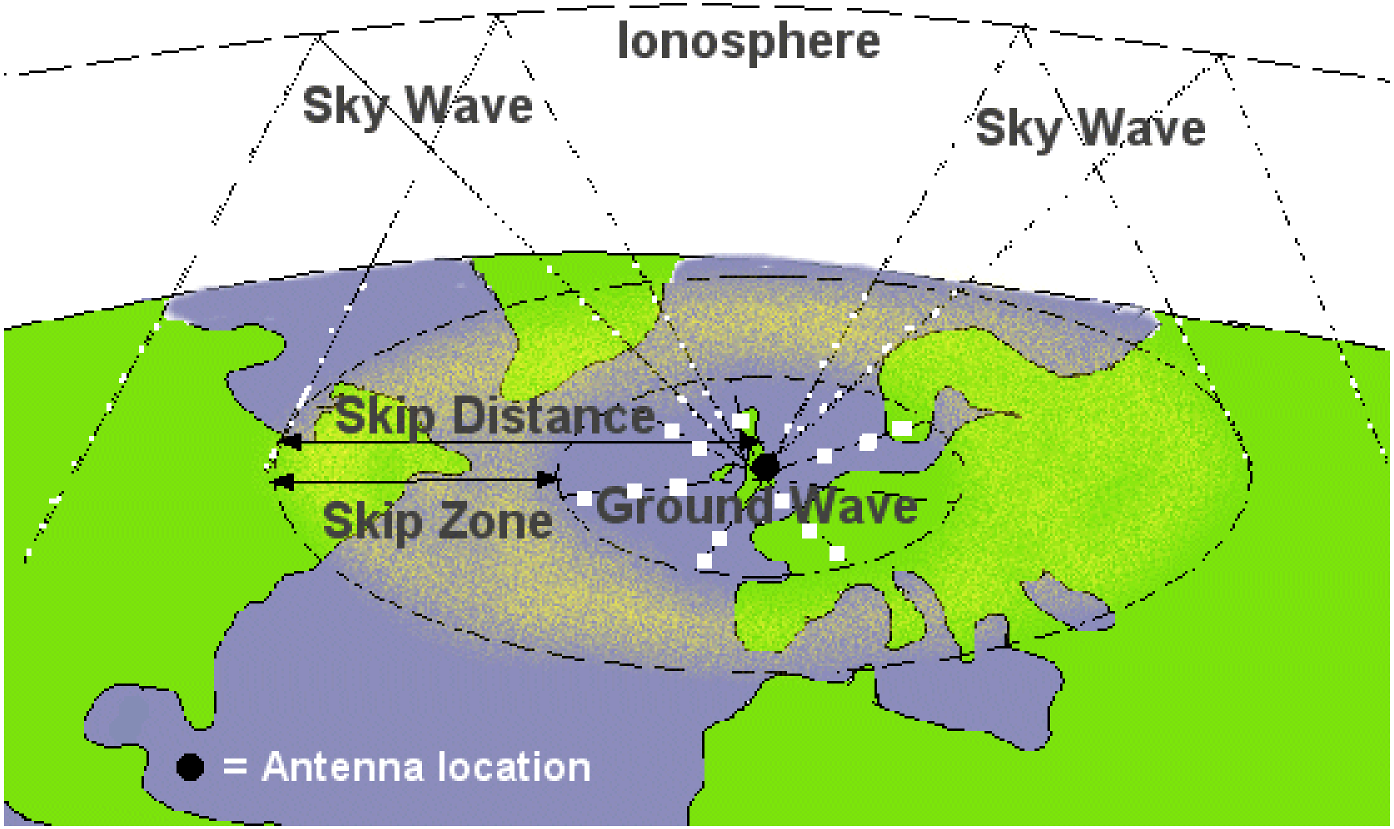
Outline

- Introduction to Long-Range HF Propagation
- Antenna Types
  - Verticals
  - High Dipoles
  - Yagi's
- HF Skywave Propagation theory and Prediction
  - Theory
  - Prediction Program – VOACAP
  - Beacons

HF Propagation Modes
(3 – 30 MHz)

- Free Space – Line of sight
- Ground Wave – Follows Earth's curvature
- Ionospheric Skip
  – Long Distance with a "skip-zone"
  – NVIS (Near Vertical Incidence Sky-Wave)

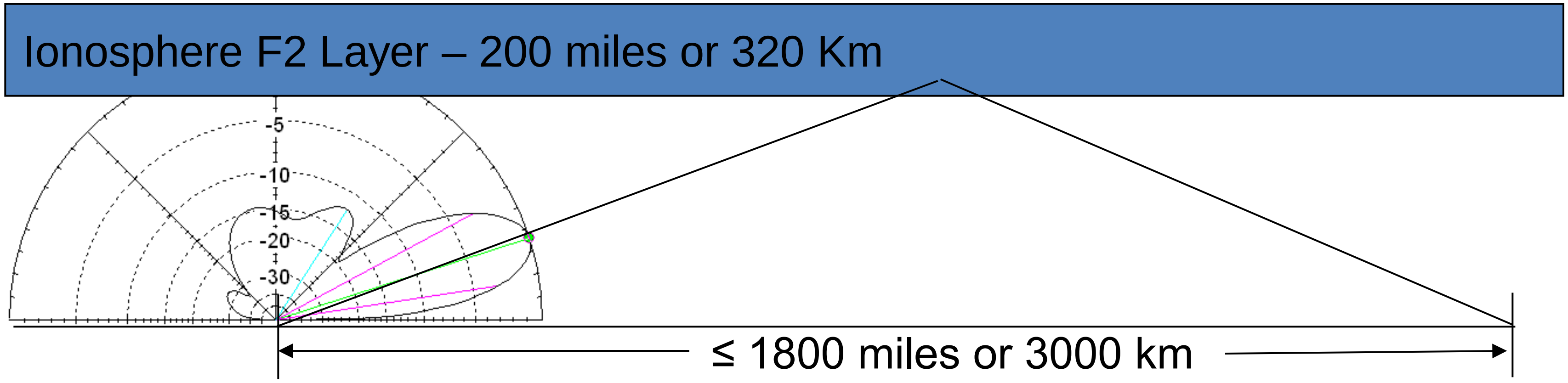
Long Distance Sky Wave



HF Sky-Wave Antennas

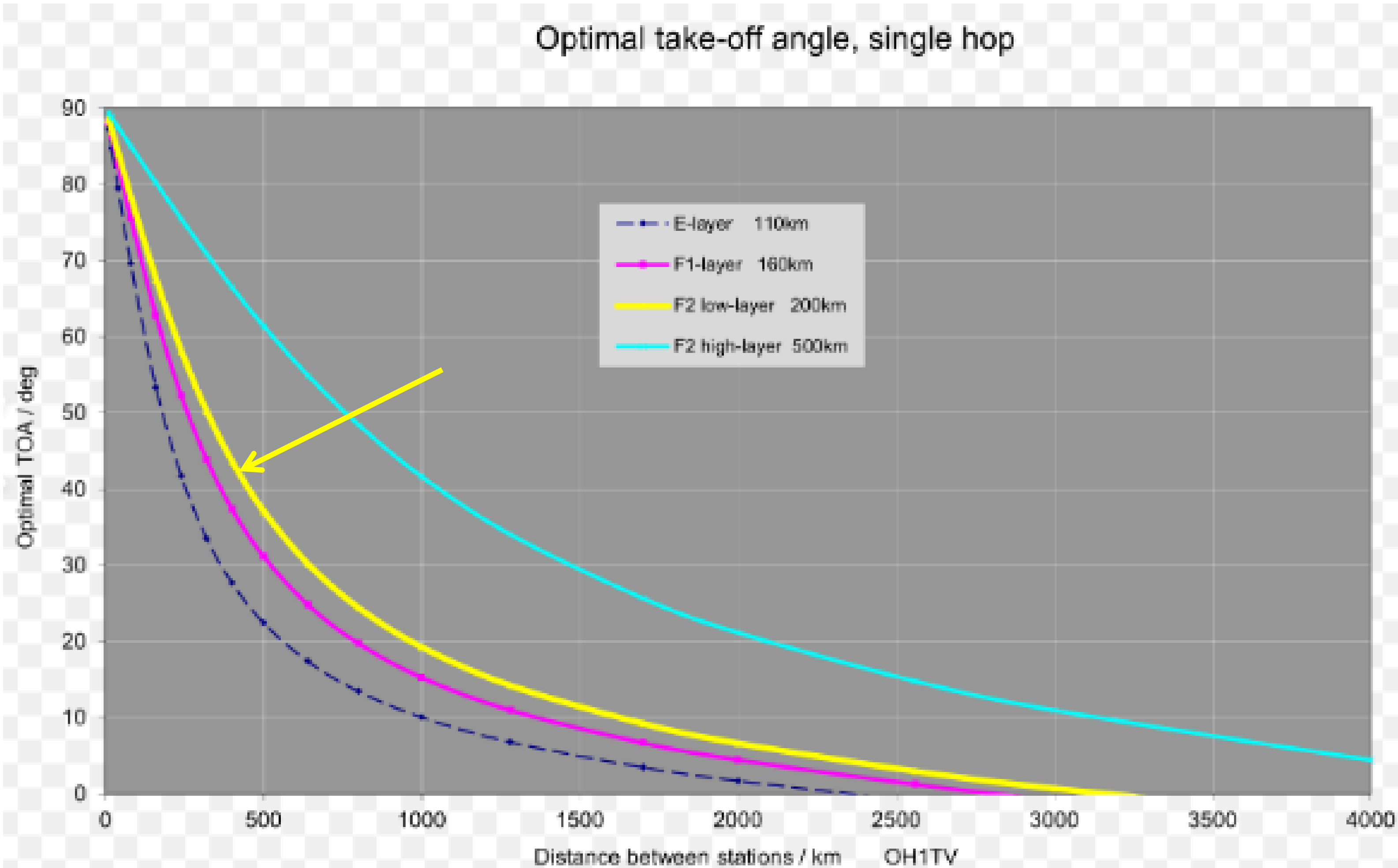
- To conduct successful long-range HF sky-wave communications, all antennas must generate low take-off angle (TOA) RF emission.

TYPICAL LONG-RANGE PROPAGATION



Both F2 & E layers propagation can be involved in multiple reflection circuits.

TOA Versus Range



Dipole Height versus Range

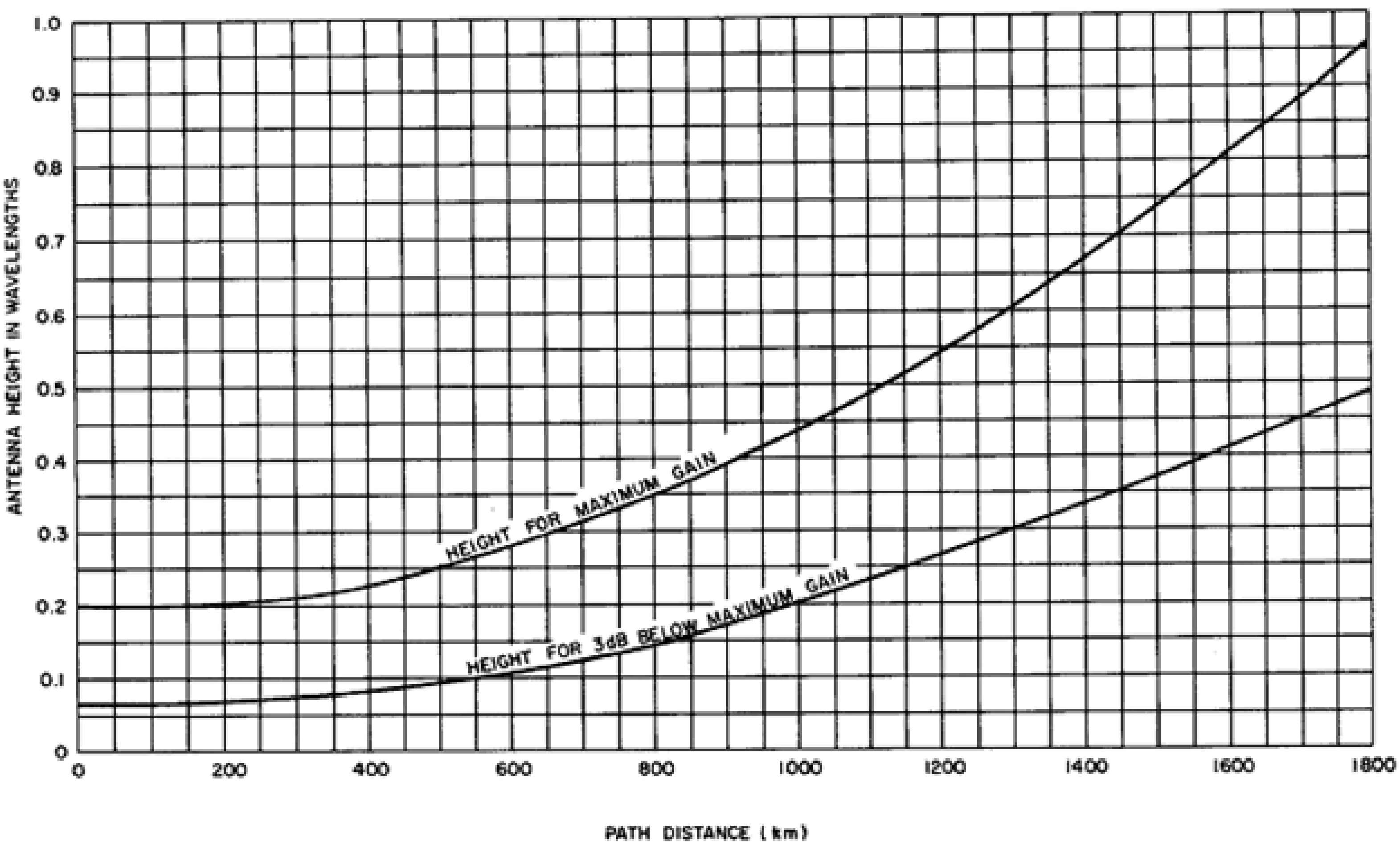


Figure 5–3. Approximate height of half-wave dipole for best F2 layer propagation.

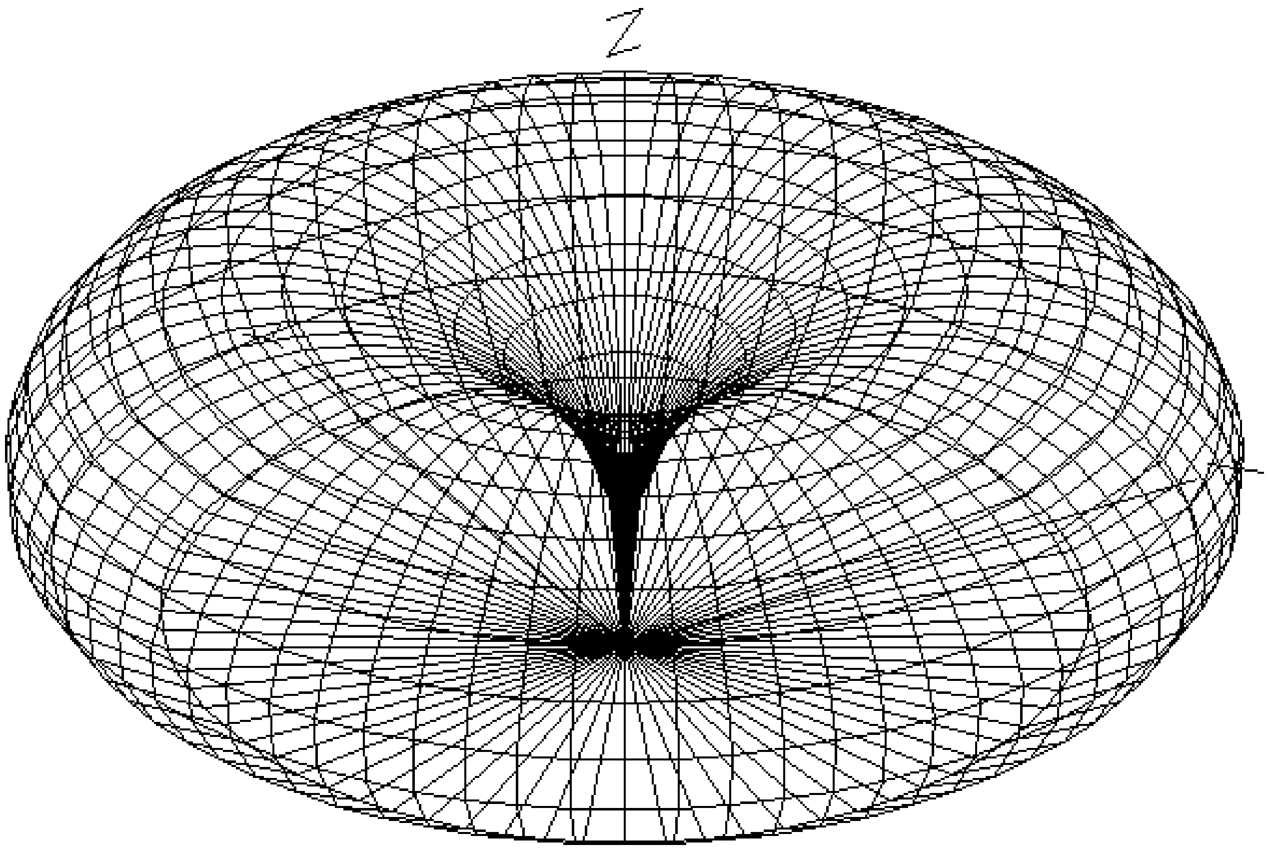
HF Sky-Wave Antennas

- The TOA is a function antenna type and operating frequency and can include:
  - Verticals
  - High Dipoles (one-half wavelength or higher)
  - Yagi's
- In addition, all antennas must present a load impedance of about 50 ohms to the rig's transmitter to radiate efficiently using one of the following techniques:
  - Rig internal auto-tuner (<3:1 SWR)
  - External tuner or auto-tuner
  - Special tuning elements incorporated in the antenna.

HF Vertical Antennas

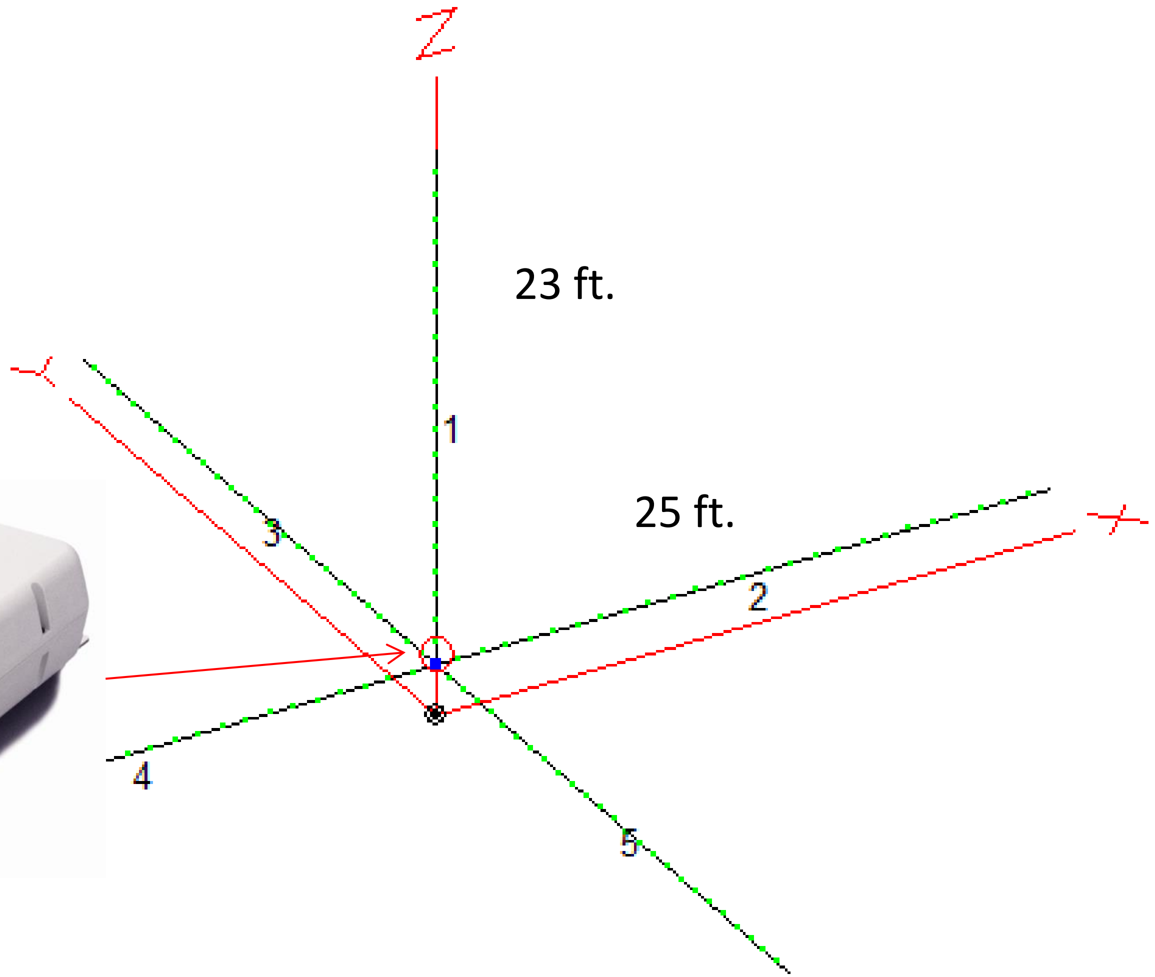
- The HF vertical antenna type, either ground mounted or elevated naturally generates a low TOA signal ideally suited for long-range sky-wave communications.

Vertical Antenna Pattern



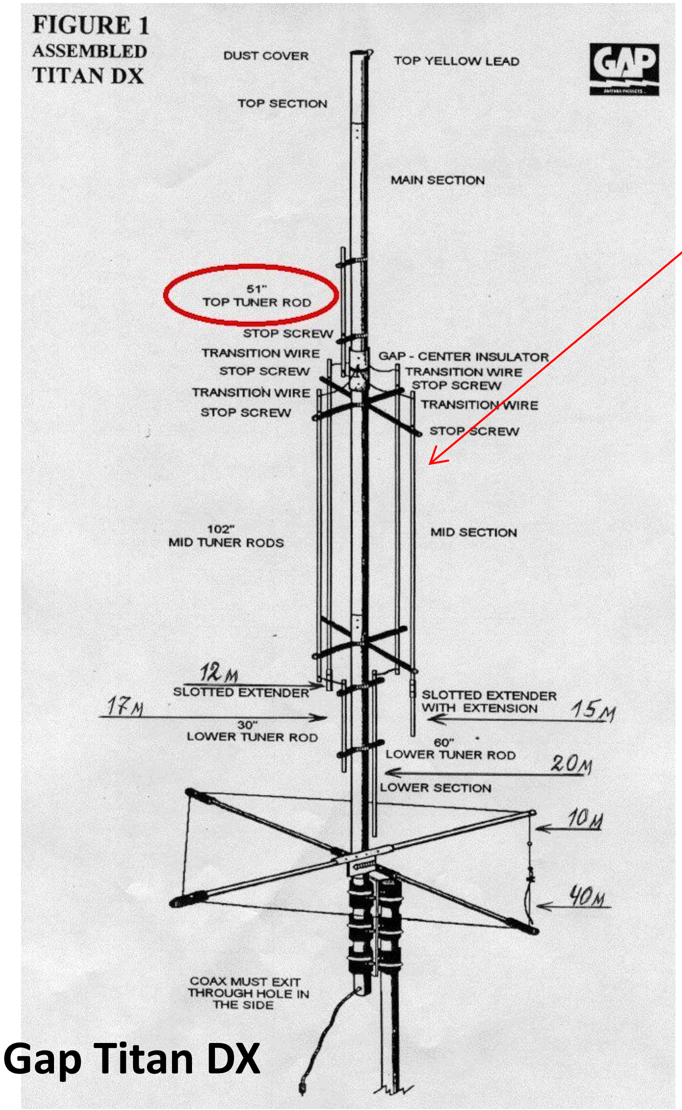
Marine Vertical

(Shakespeare 393 Marine SSB HF)

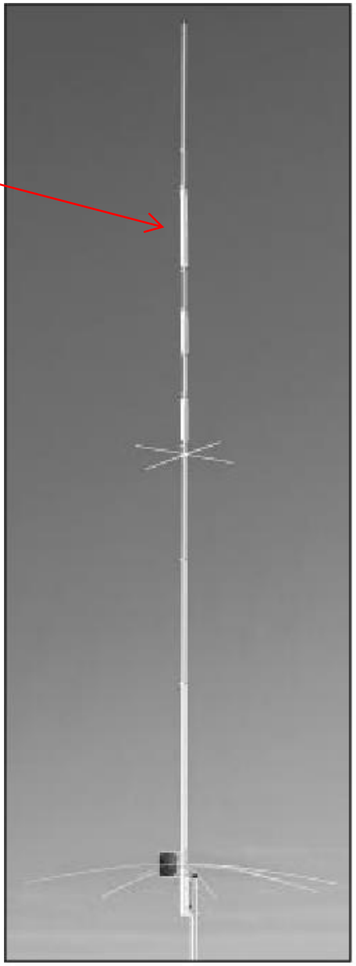


ICOM AH-4
Auto-Tuner

Special Tuning Elements



Gap Titan DX

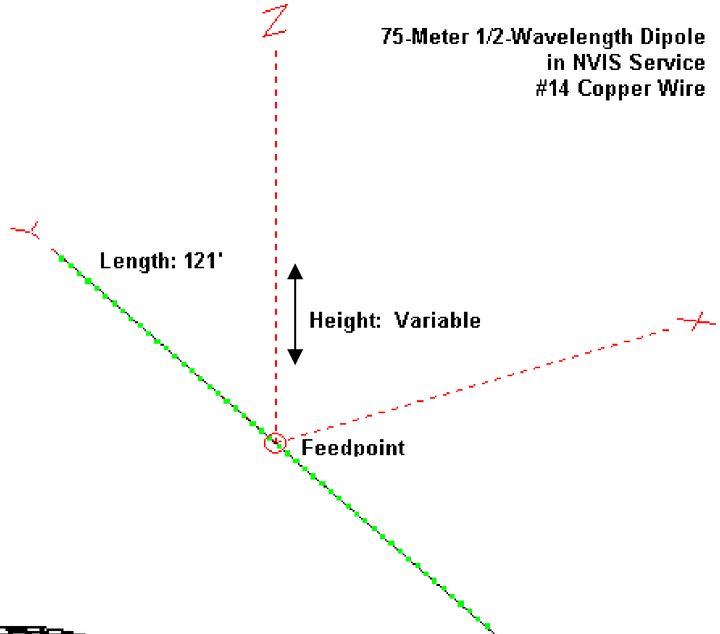


R7000

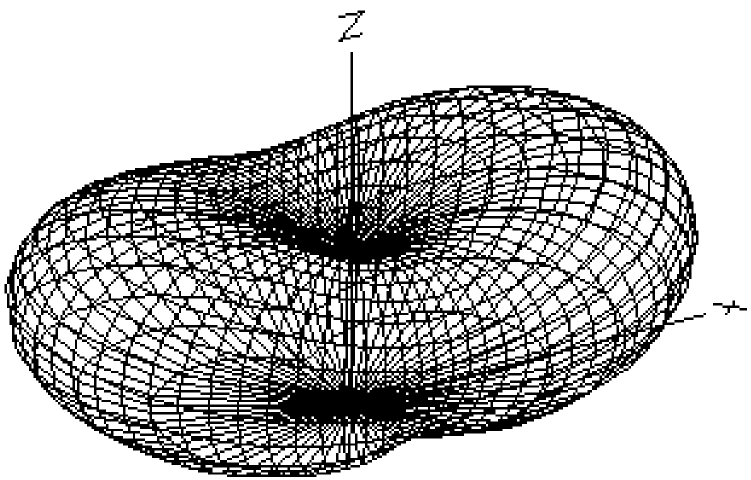
High Dipole Antennas

- A horizontal dipole's directivity pattern changes dramatically with height above earth ground.
- At heights less than ¼ wavelength, the combination of the dipole and earth ground generate a virtual two element Yagi antenna with all the RF energy directed up. Suitable for NVIS.
- When the height exceeds ½ wavelength, the dipole generates long-range directional pattern with a low TOA and maximum gain broadside to the dipole.

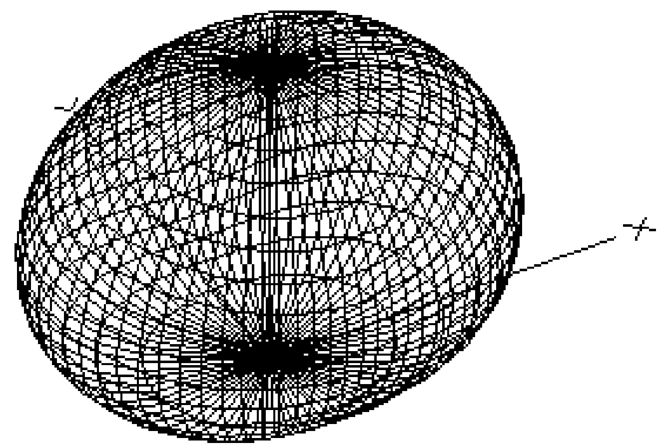
Dipole Height Versus Directivity



Height = ½ λ



Height = 0.12 λ



Yagi (Beam) Antennas

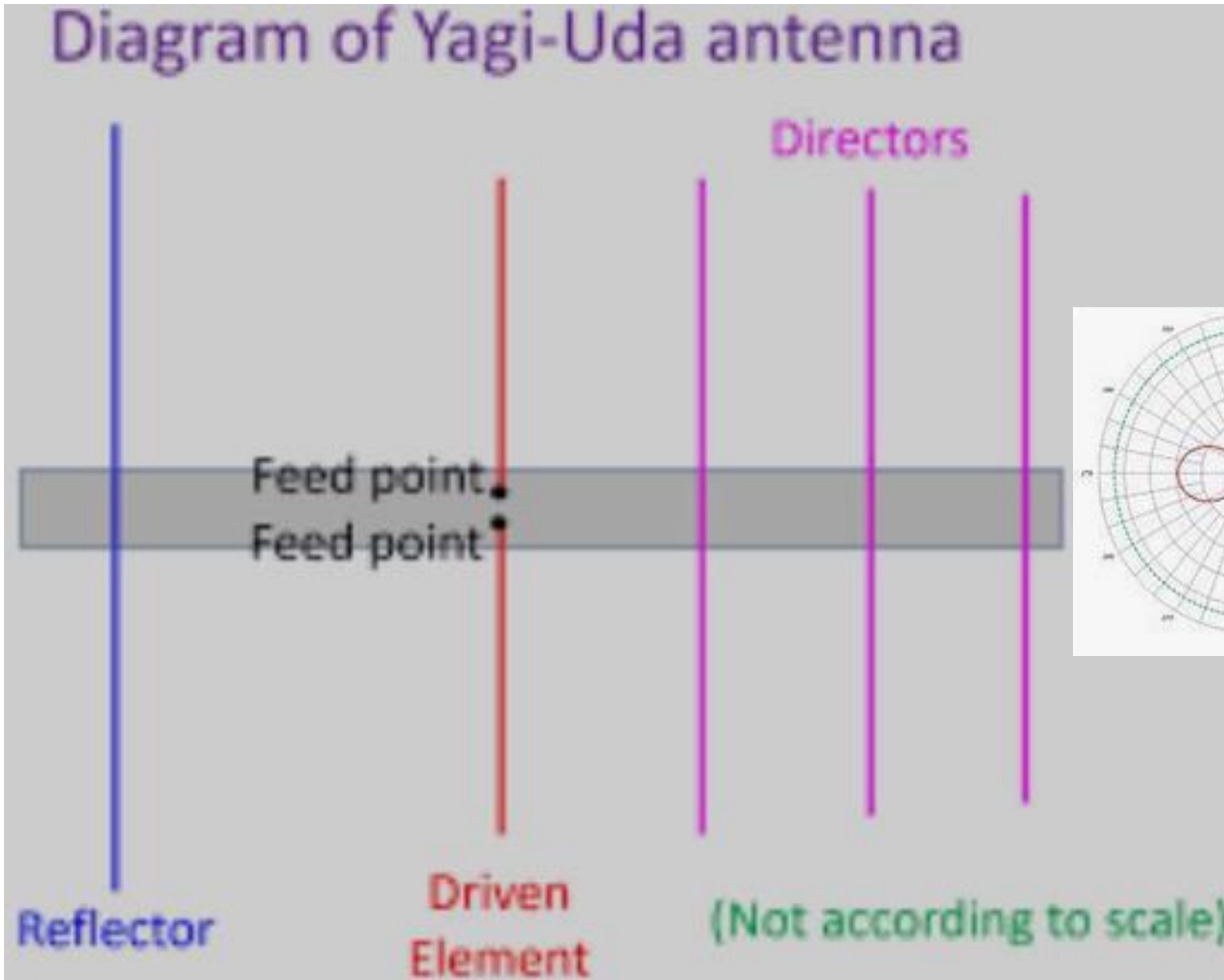
- Yagi’s are multi-element **horizontally** polarized antennas whose parasitic elements enhance the horizontal directivity (azimuth) of the imbedded dipole.
- The Yagi must be at a height of **½ wavelength to achieve a low TOA**, just like the standard dipole.
- A rotor must be employed to rotate the Yagi to the desired azimuth.

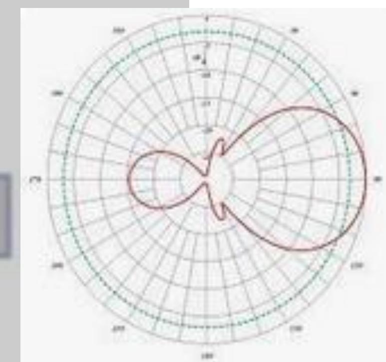
Yagi Antennas

SteppIR DB-36 at 70 ft.

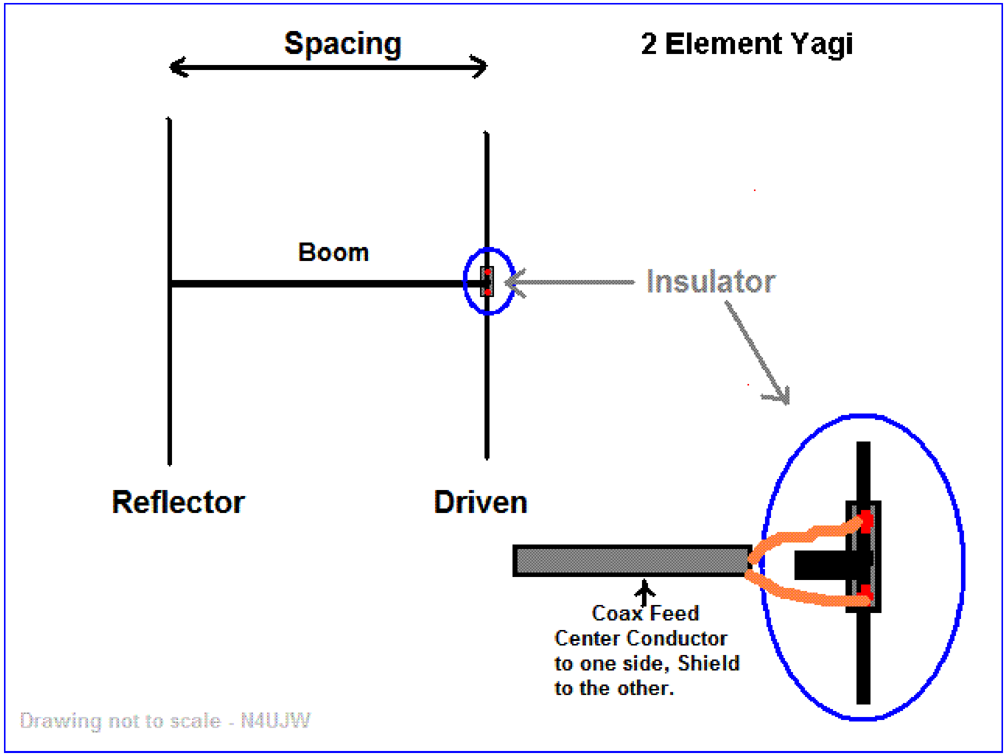
Hex Beam

Typical Yagi-Uda Antenna





Hex Beam Theory

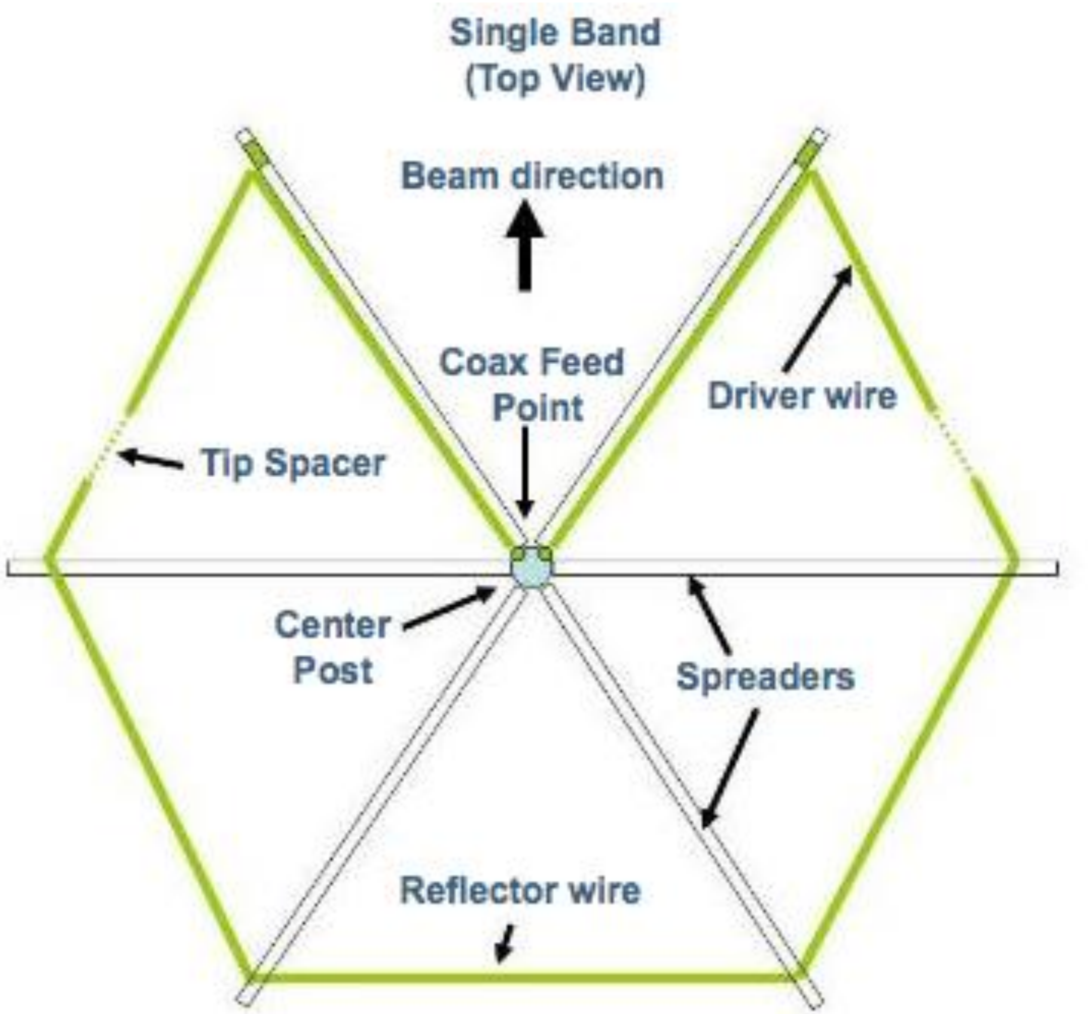


Gain is about 5dBd.

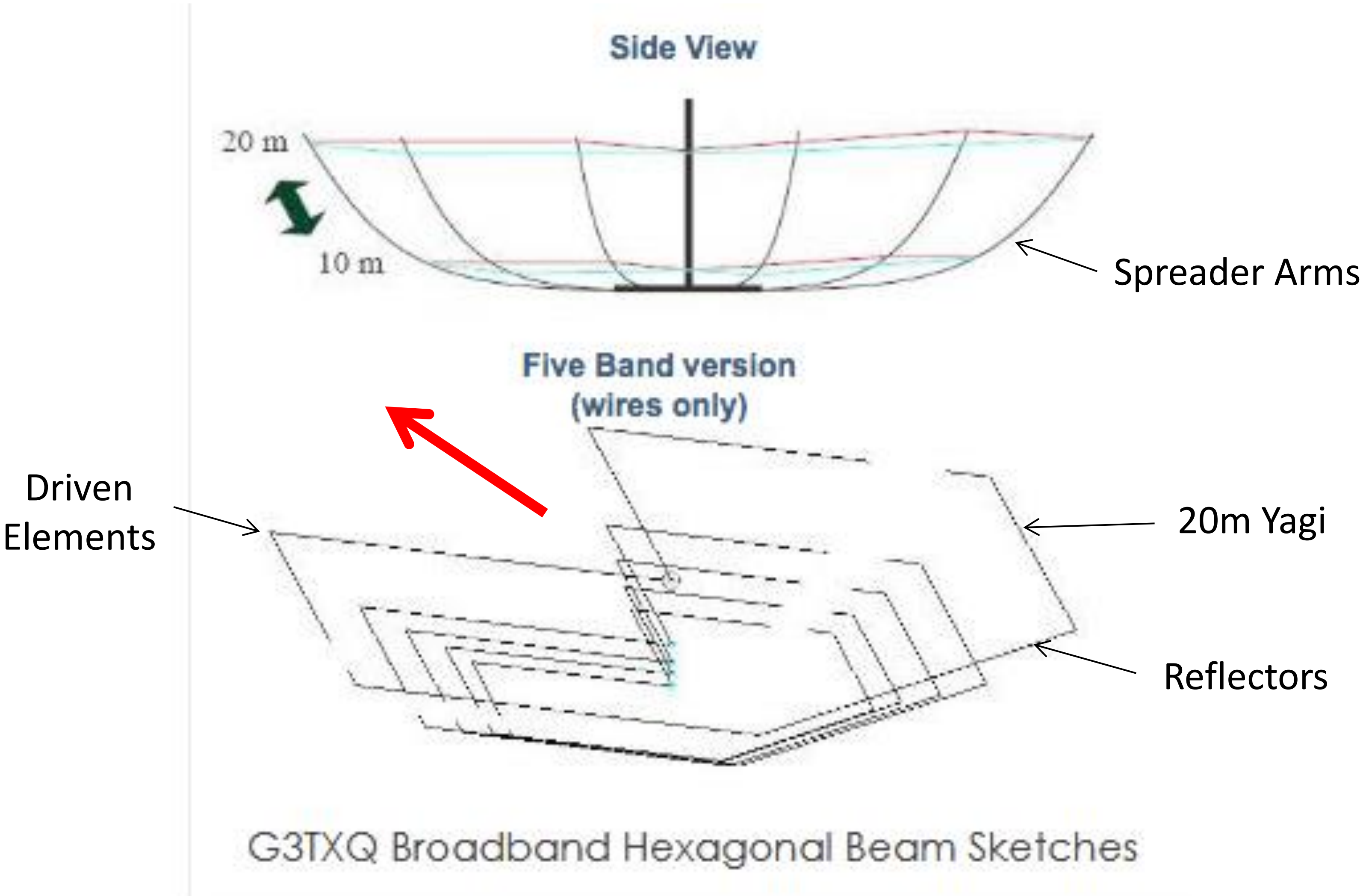
Reflector is 5% longer than the Driven Element.

Spacing can vary from 0.15-Wave to 0.25-Wavelengths, with little change in the array gain.

Hex Beam: Single Yagi Element

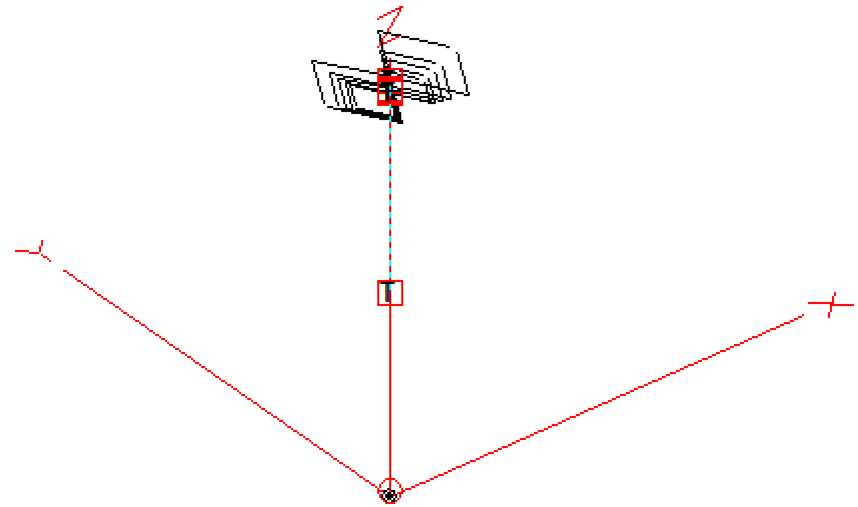


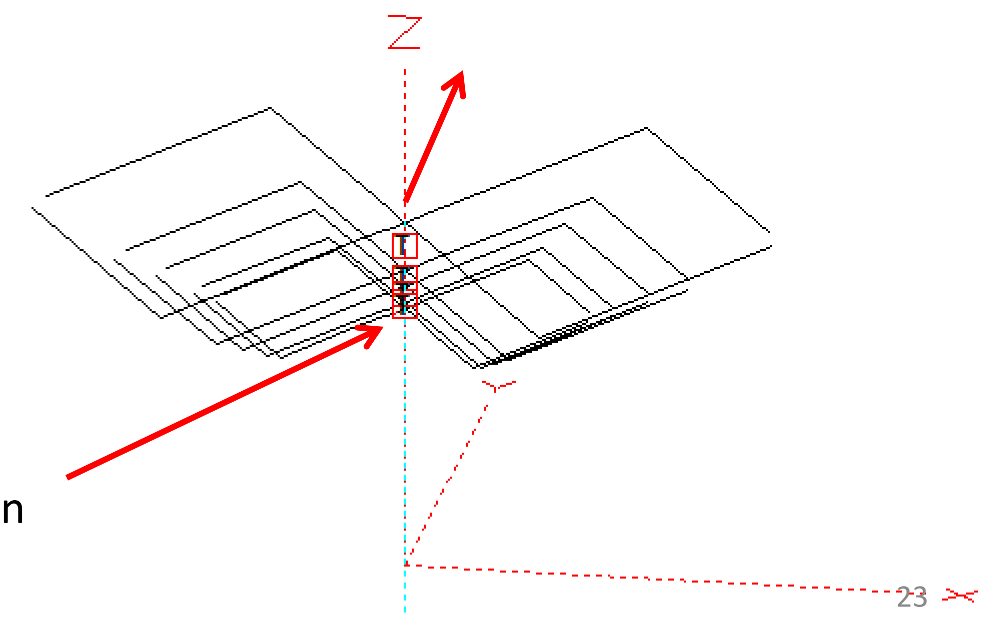
Hex Beam: Multi-Band



EZNEC Geometry

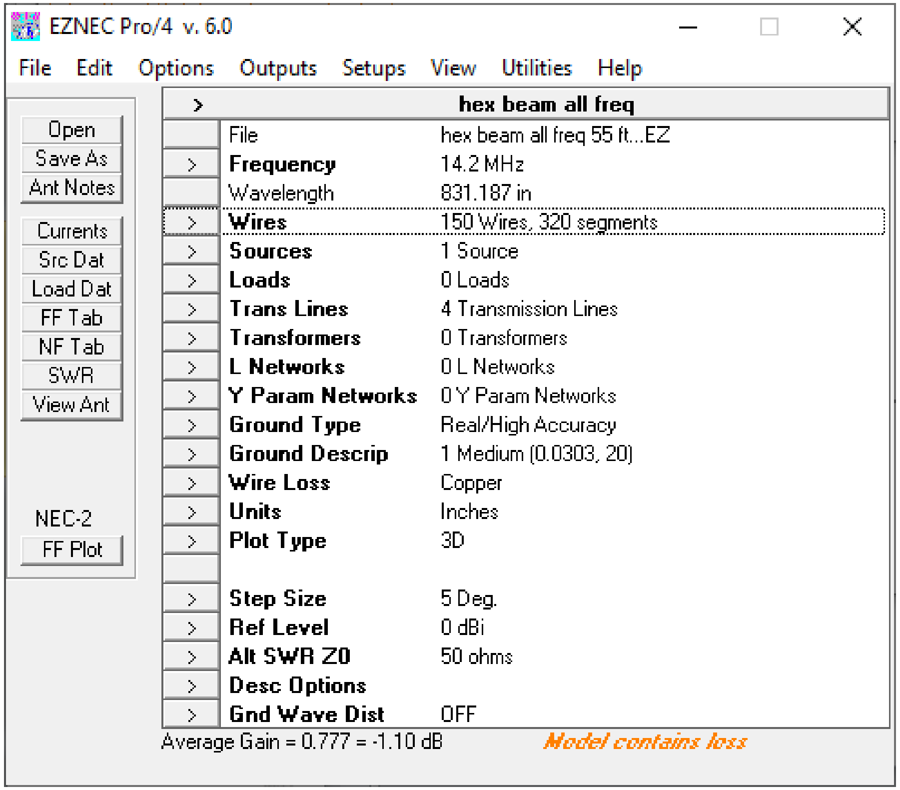
G3TXQ HEX BEAM
Height – 55 ft.
Wire - #16 AWG Cu
Transmission Line – 100 ft. of
LMR-400

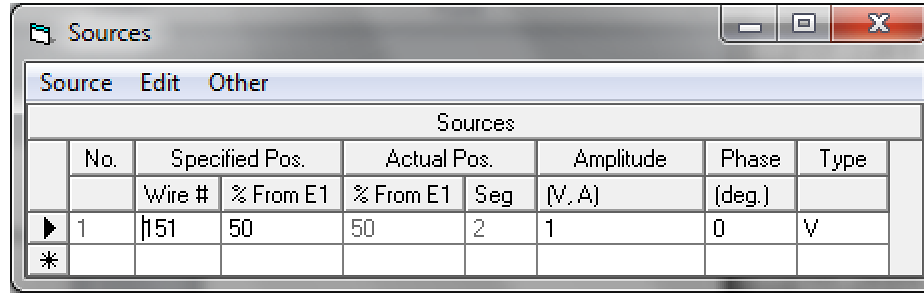


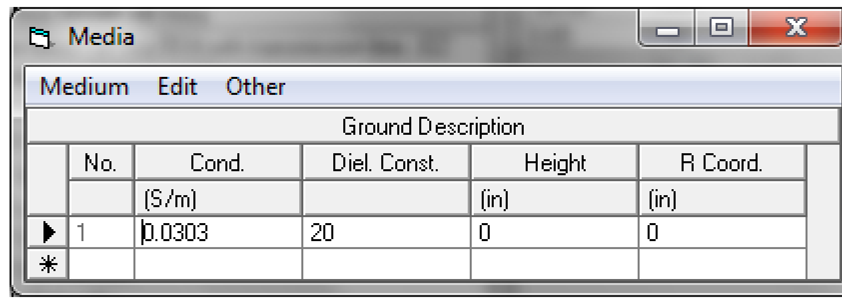


Separate Hex Yagi's are
Connected in Parallel
Using short transmission
Lines

EZNEC Pro Setup

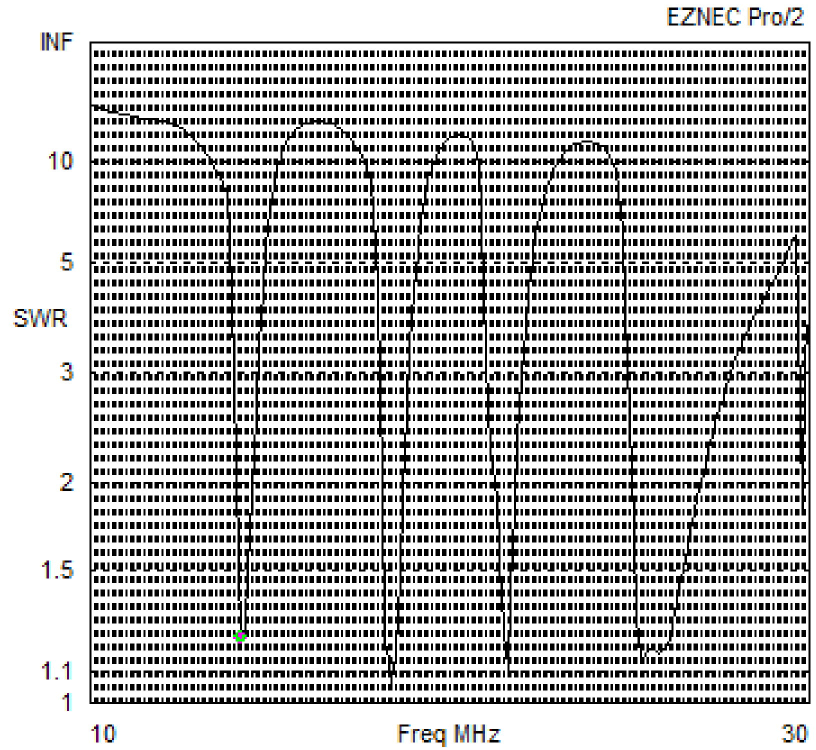






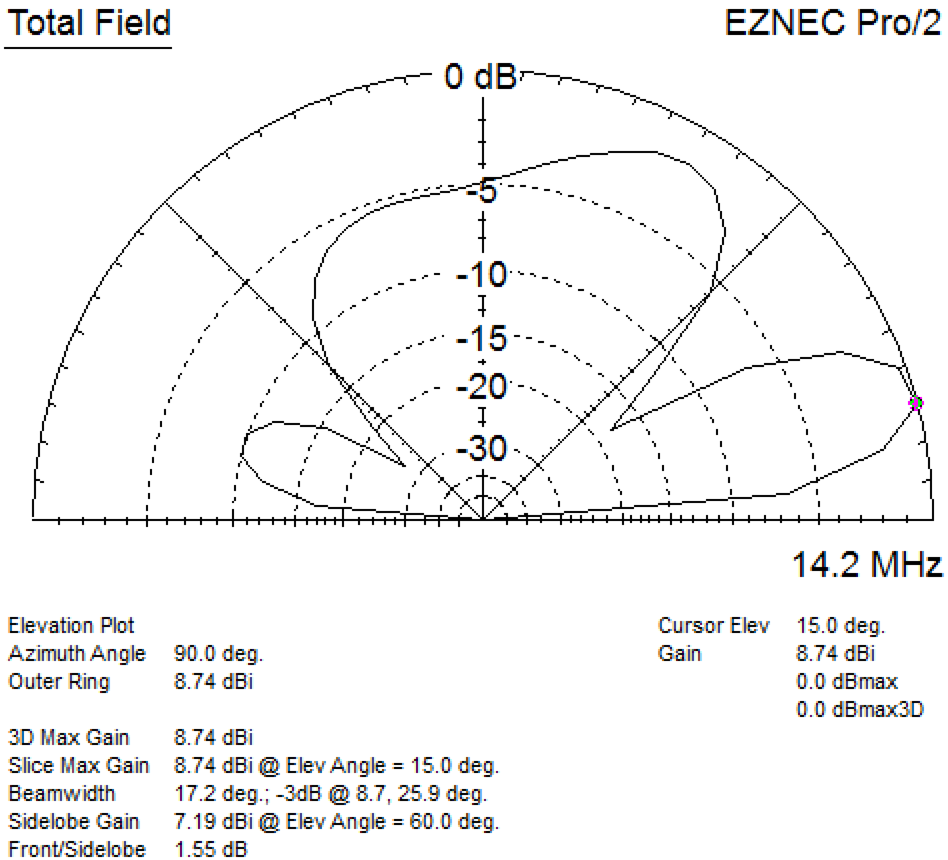
SWR
10 – 30 MHz

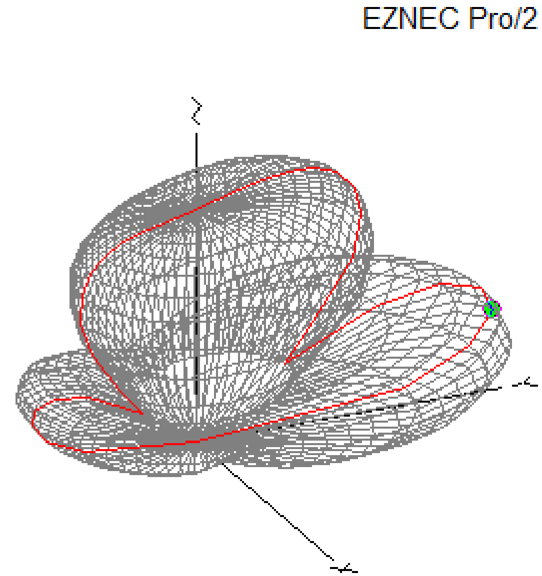
Low SWR Frequencies:
14.2 MHz
18.4 MHz
21.6 MHz
25.4 MHz
29.8 MHz

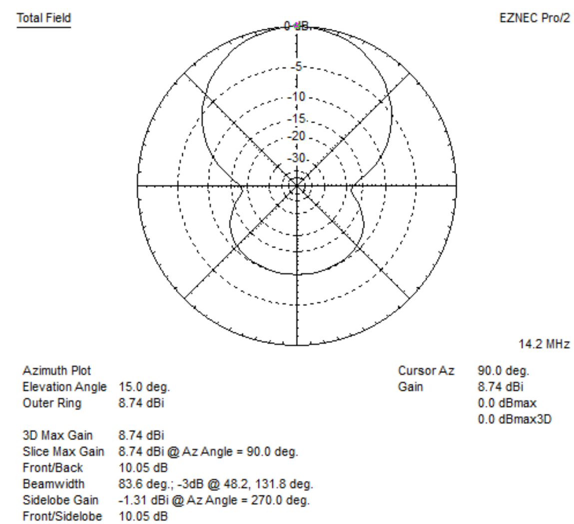


Freq	14.2 MHz	Source #	1
SWR	**1.22**	Z0	50 ohms
Z	60.52 at -2.25 deg.		
	= 60.48 - j 2.376 ohms		
Refl Coeff	0.09721 at -11.55 deg.		
	= 0.09524 - j 0.01946		
Ret Loss	20.2 dB		

Azimuth & Elevation – 14.2 MHz

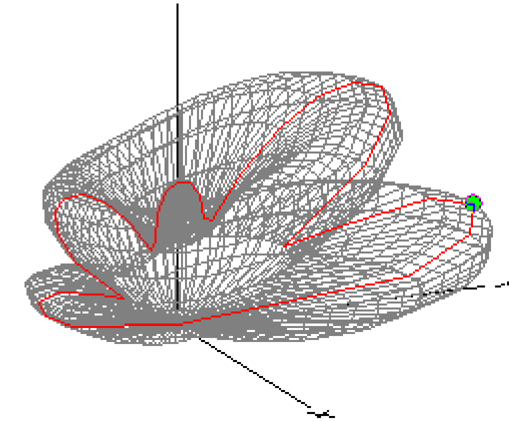


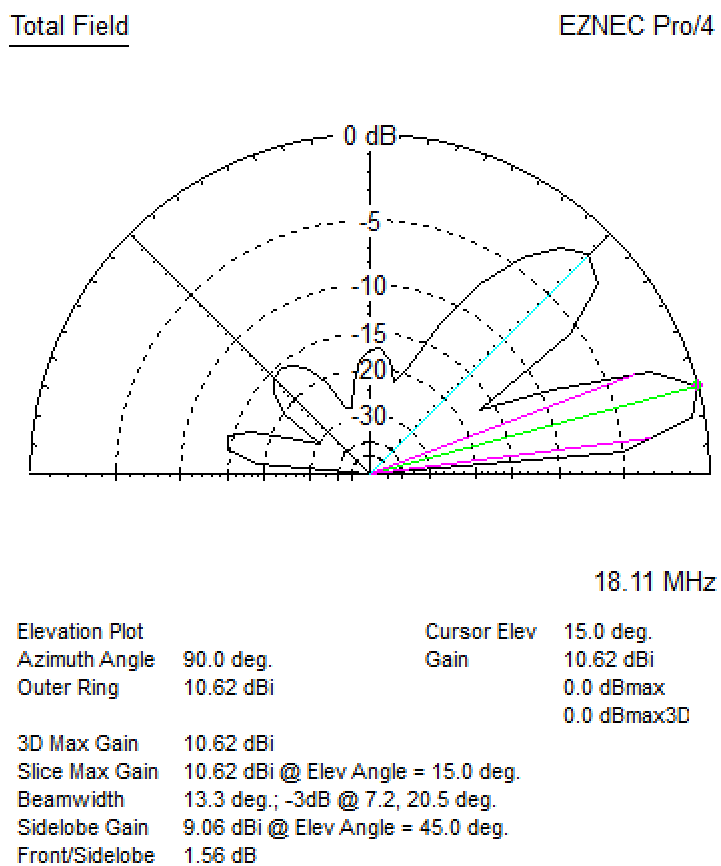


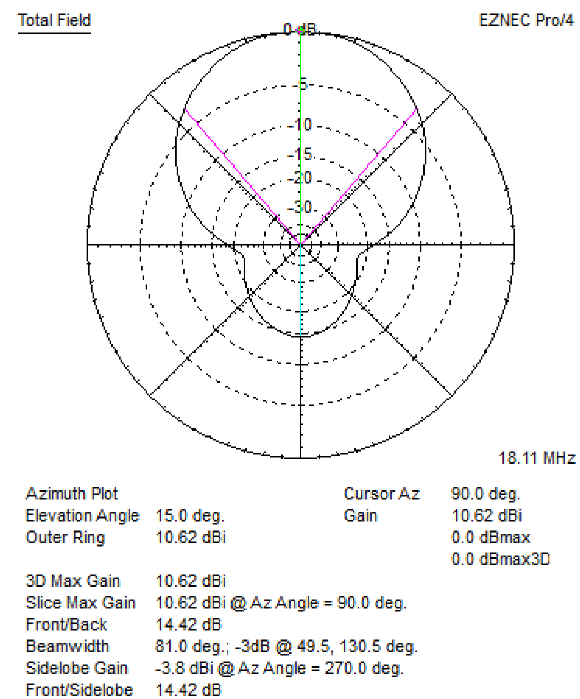


Azimuth & Elevation – 18.110 MHz

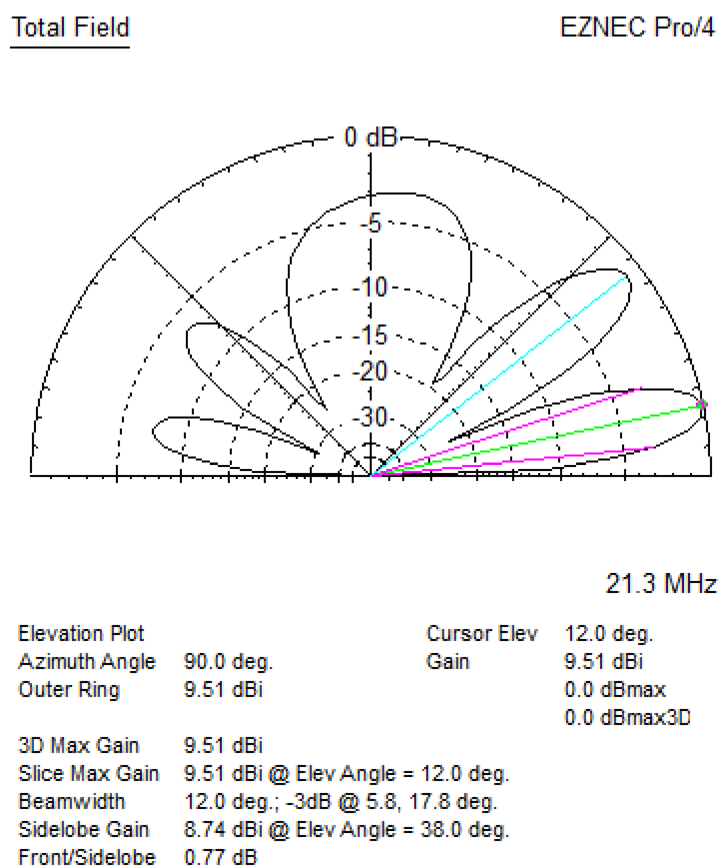
EZNEC Pro/2

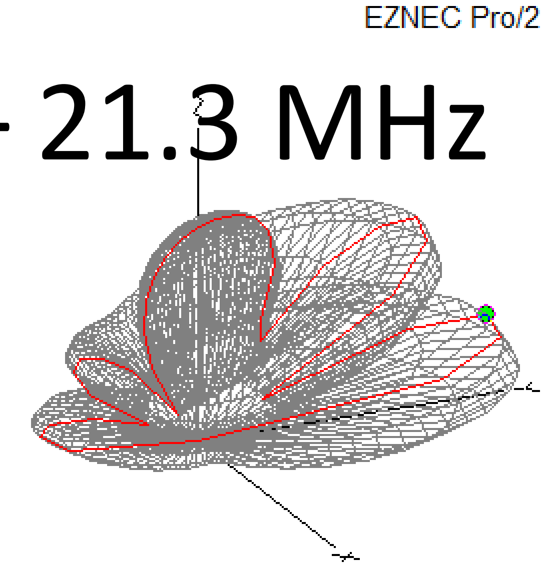


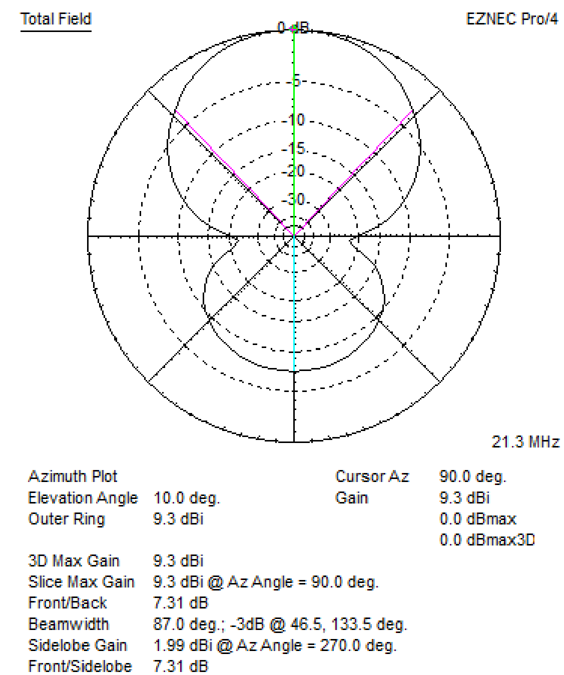




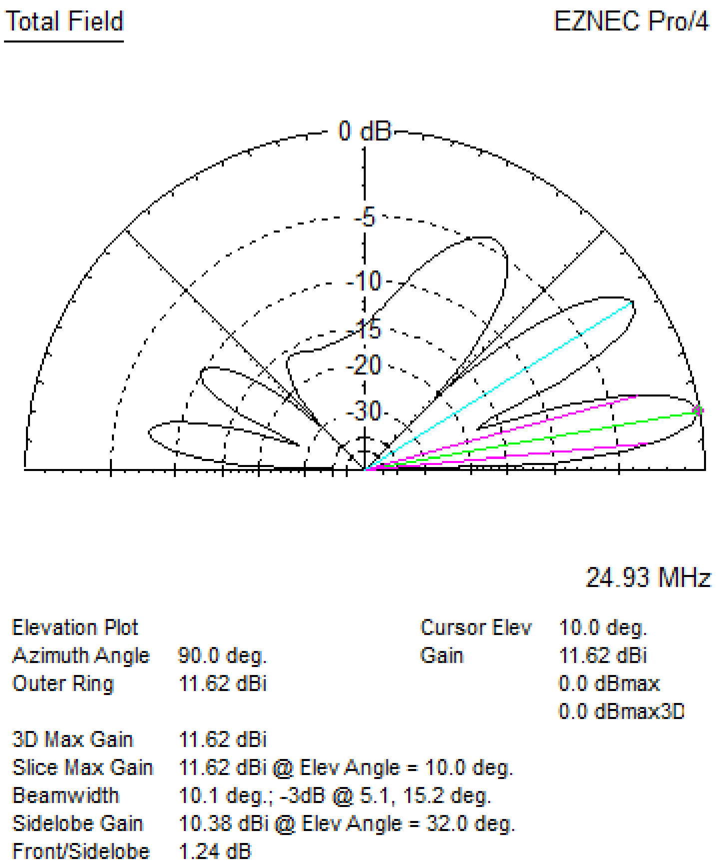
Azimuth & Elevation – 21.3 MHz

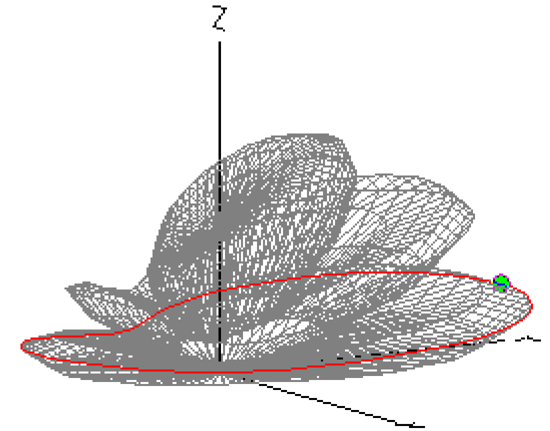


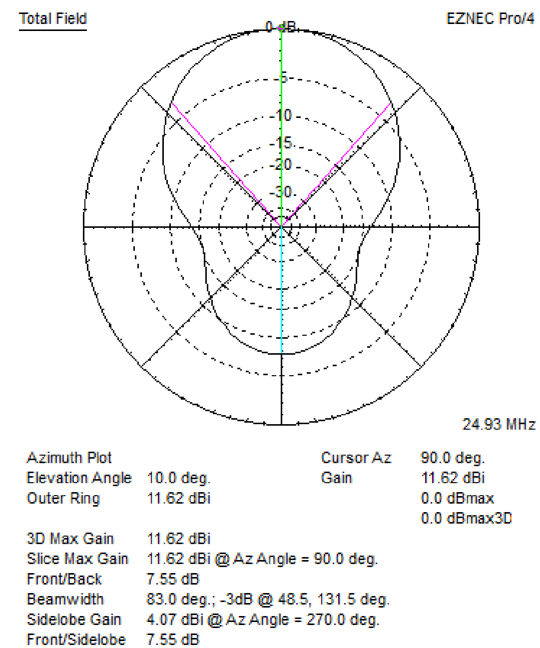




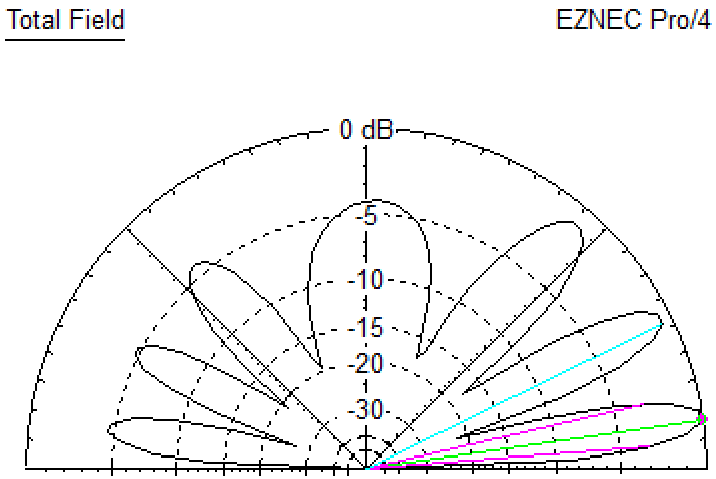
Azimuth & Elevation – 24.93 MHz







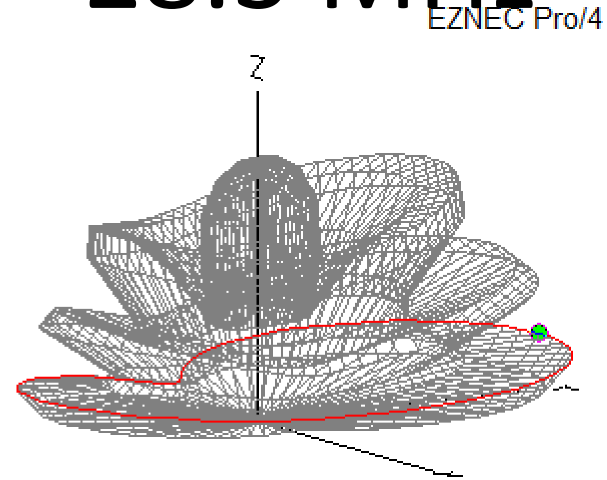
Azimuth & Elevation – 28.3 MHz

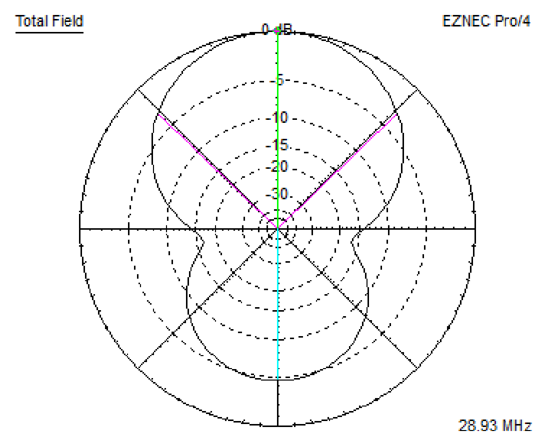


28.93 MHz

Elevation Plot		Cursor Elev	8.0 deg.
Azimuth Angle	90.0 deg.	Gain	9.63 dBi
Outer Ring	9.63 dBi		0.0 dBmax
			0.0 dBmax3D

3D Max Gain 9.63 dBi
Slice Max Gain 9.63 dBi @ Elev Angle = 8.0 deg.
Beamwidth 8.6 deg.; -3dB @ 4.3, 12.9 deg.
Sidelobe Gain 9.15 dBi @ Elev Angle = 26.0 deg.
Front/Sidelobe 0.48 dB



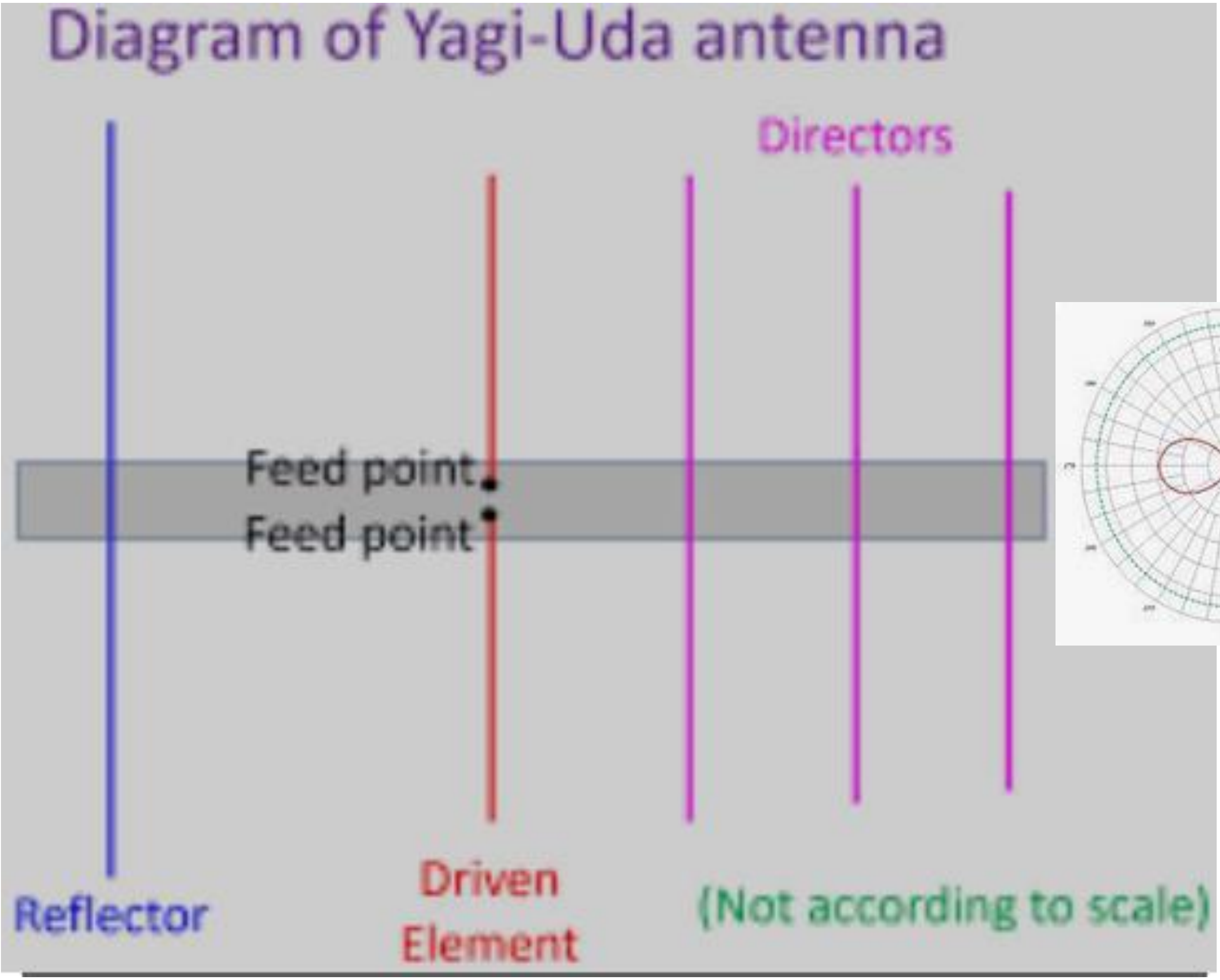


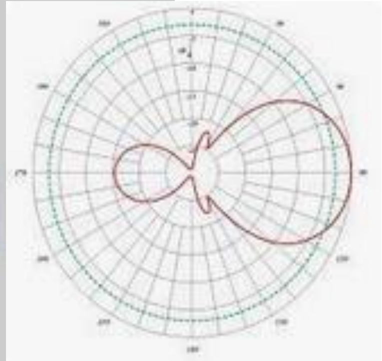
28.93 MHz

Azimuth Plot		Cursor Az	90.0 deg.
Elevation Angle	10.0 deg.	Gain	9.41 dBi
Outer Ring	9.41 dBi		0.0 dBmax
			0.0 dBmax3D

3D Max Gain 9.41 dBi
Slice Max Gain 9.41 dBi @ Az Angle = 90.0 deg.
Front/Back 4.54 dB
Beamwidth 92.4 deg.; -3dB @ 43.8, 136.2 deg.
Sidelobe Gain 4.87 dBi @ Az Angle = 270.0 deg.
Front/Sidelobe 4.54 dB

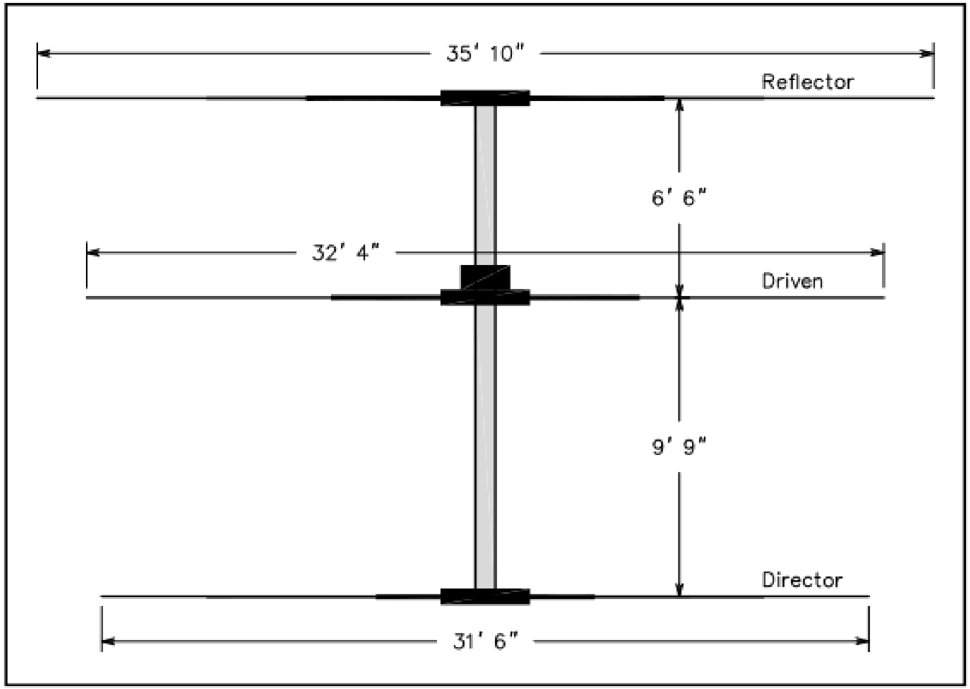
Single Band Yagi-Uda Antenna





Homebrew 3 element 20m Yagi

From July 2001 QST © ARRL



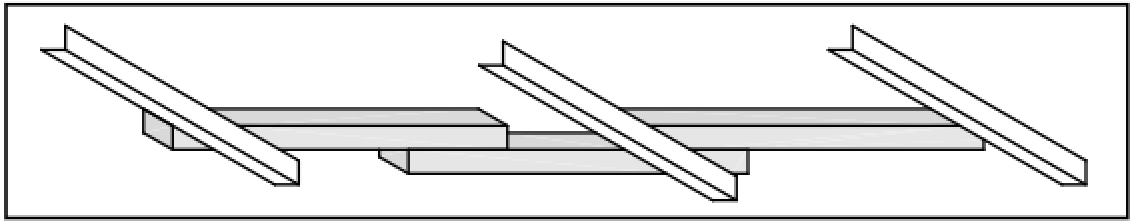
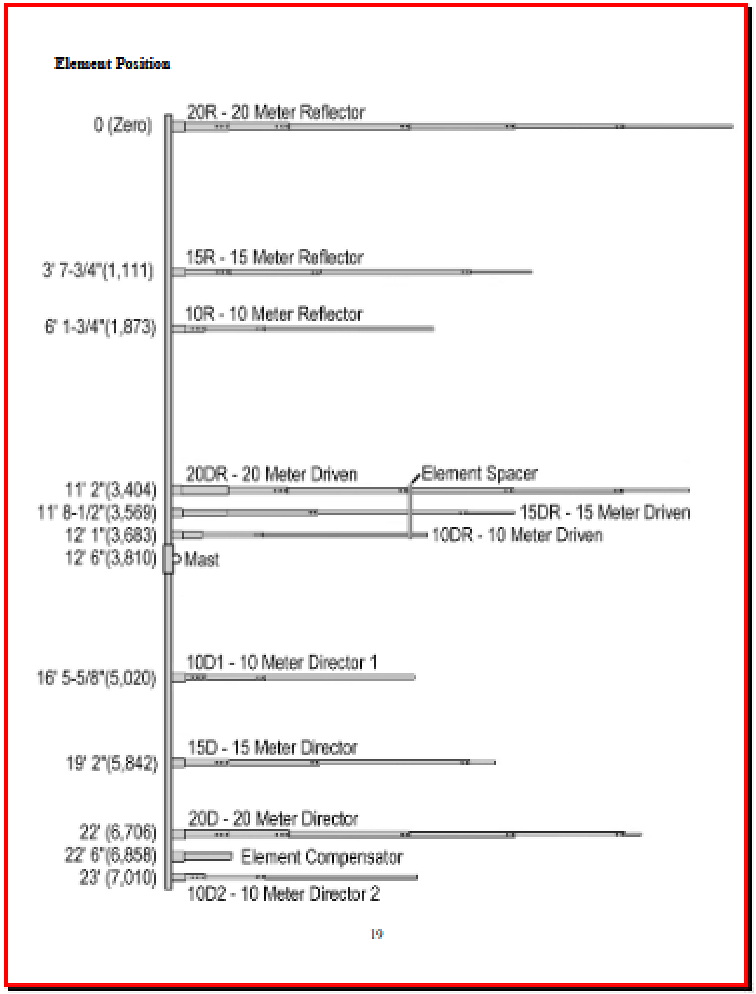


Figure 2—The boom and element brackets.

Commercial Multi-Band Yagi

$2,350.97
[DX Engineering Skyhawk Tri-Band Yagi Antennas]
Antenna, Yagi, Skyhawk, Tri-Band 20, 15, 10 meters, 20m, 15m, 10m, 10 Elements, 2.5 kW, **24 ft. Boom,**



Homebrew Multi-Band Wire Yagi

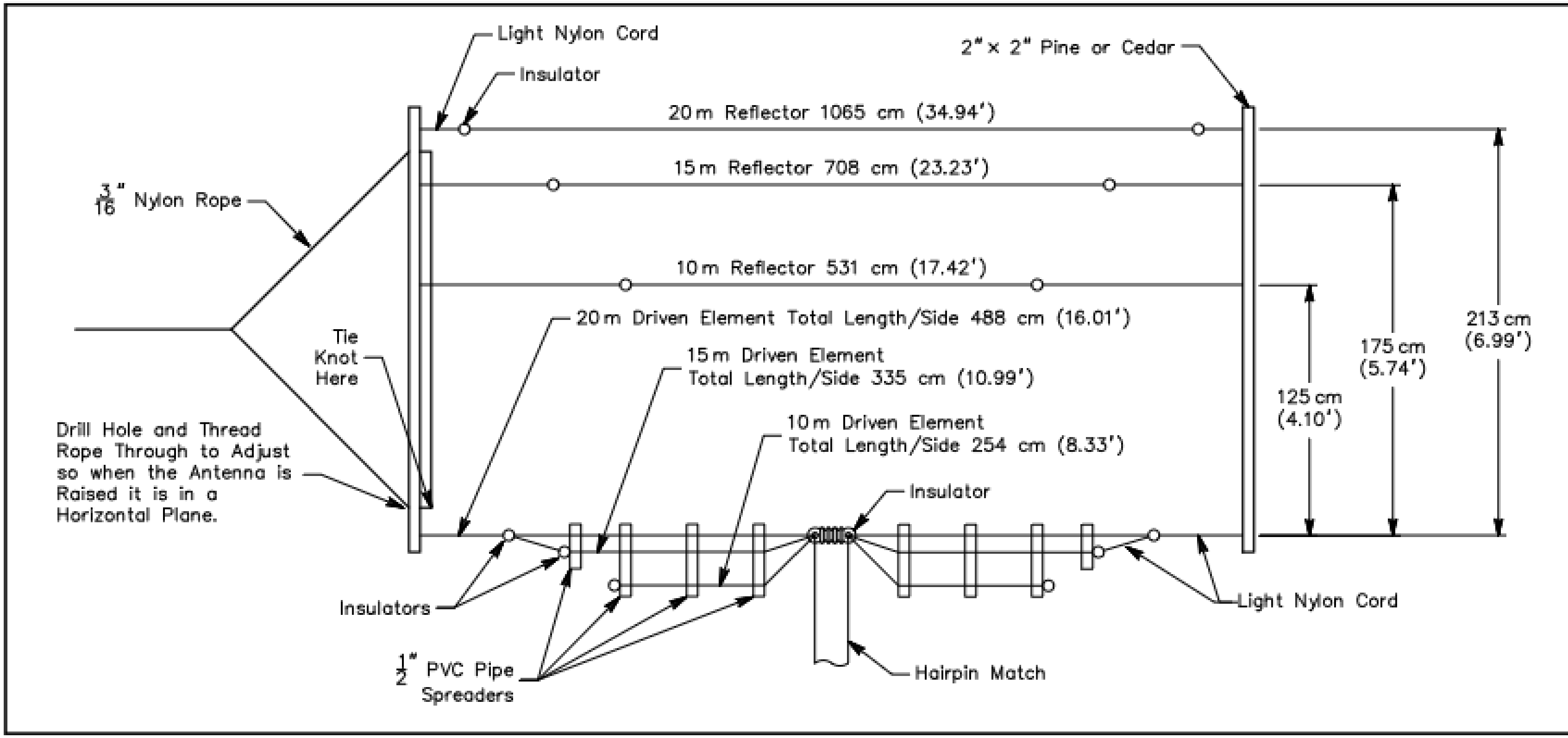


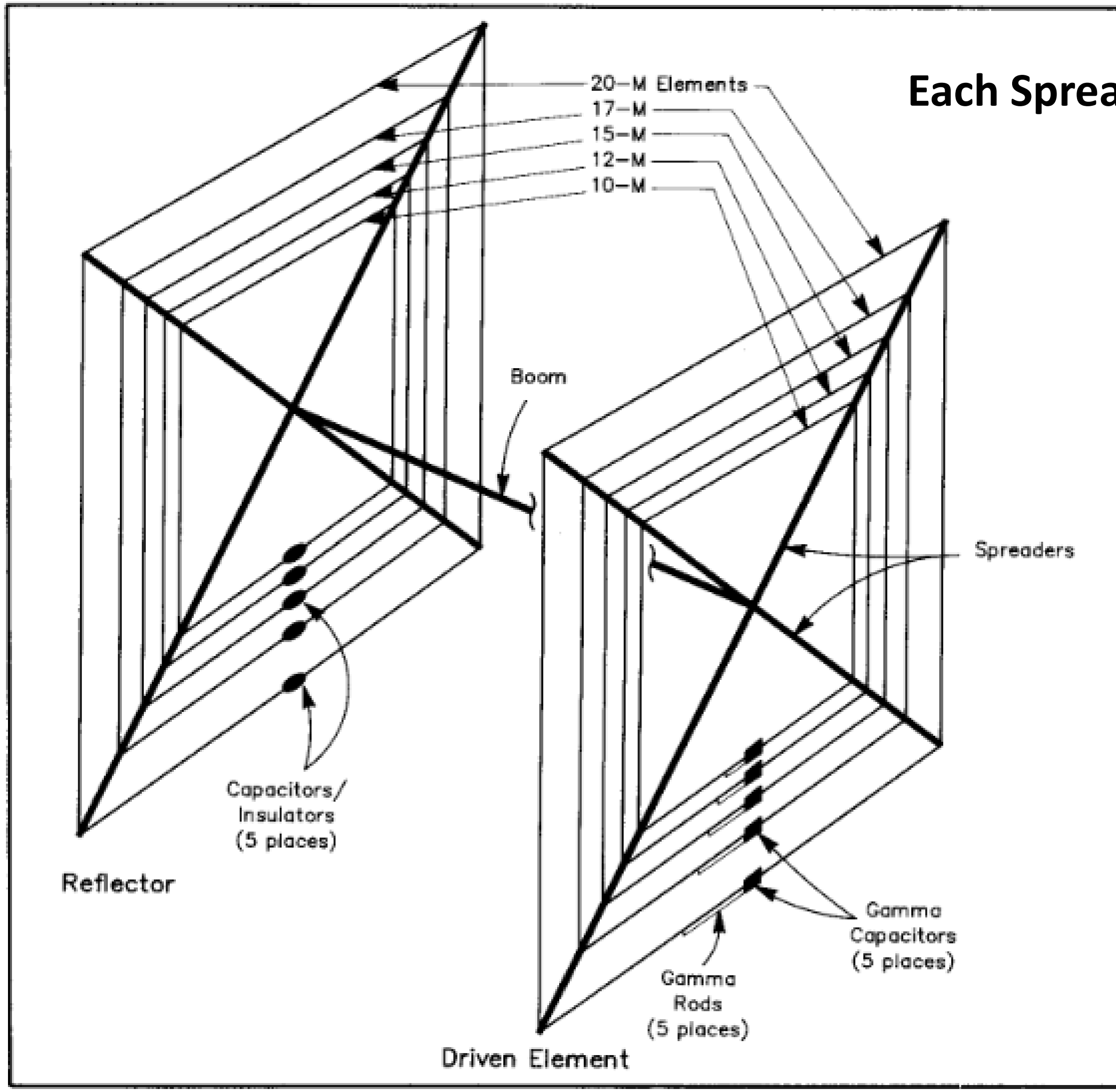
Figure 1—Dimensions for VE7CA's 2-element wire triband Yagi.

QST November 2001 35

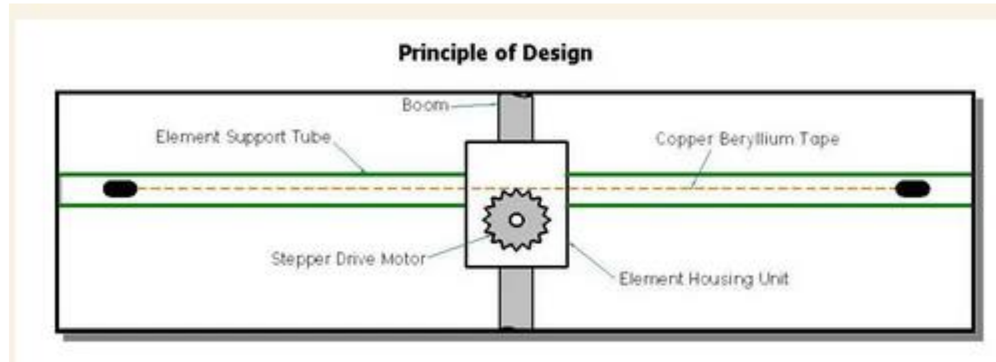
Homebrew Cubical Quad 5-band Yagi

April 1992 QST

Each Spreader-8 ft.

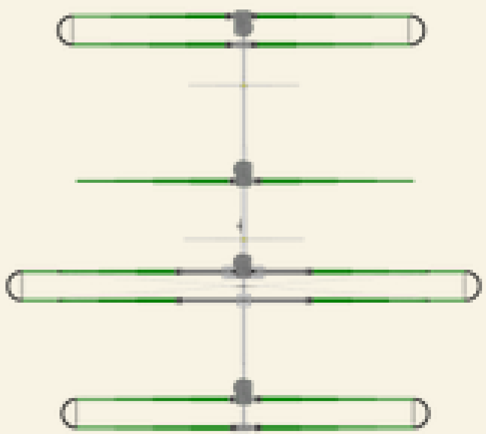


Continuous Frequency Coverage Yagi
STEPPIR



Continuous Frequency Coverage Yagi SteppIR

DB36 Yagi Antenna, 80m-6m Package



- **DB36 Yagi, 80m-6m (w/ SDA 100)**
- **DB36 Yagi, 80m-6m (w/ OptimizIR 2.0)**

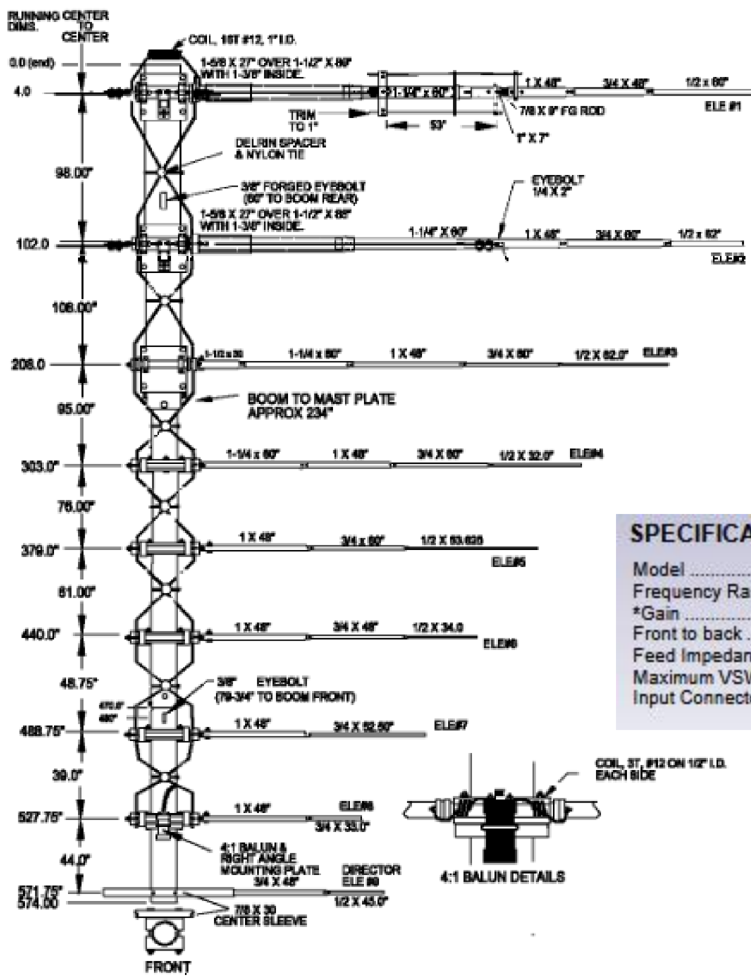
Package includes:

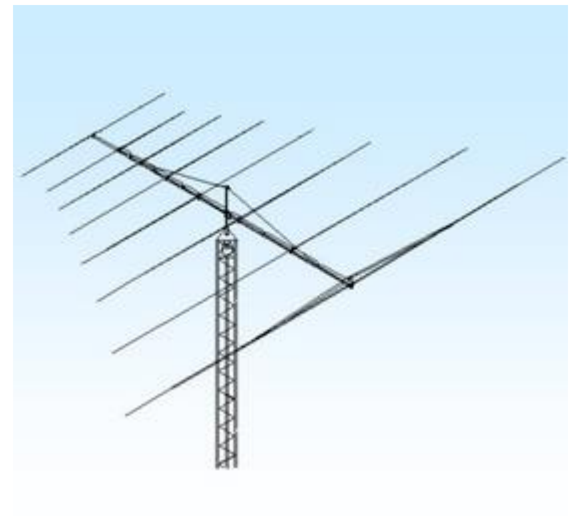
- Connector junction box
- Element truss kit
- Single Boom Truss (Boom Double Truss Upgrade Available)
- 6m Passive element kit
- 80m dipole kit
- DB25 Cable splice
- Pre-Wired Control Cable
- Reinforced DB Mounting Plate
- High Performance Balun
- 36V, 4.14A Power Supply

$9,603.77 – $10,153.77

Log-Periodic Beam Antennas

8-30LP9 DIMENSION SHEET





SPECIFICATIONS:

Model	8-30LP9	Power Handling	3 Kw, Higher avl.
Frequency Range	8 To 30 MHz	Boom Length / Dia	48' X 4&3" X 0.125 wall
*Gain	9.5 dBi @ 70' OG	Maximum Element Length	50'
Front to back	12 dB	Turning Radius:	36'
Feed Impedance.	50 Ohms Unbalanced	Wind area / Survival	18 Sq. Ft. / 100 MPH
Maximum VSWR	1.9:1	Weight / Ship Wt.	170 lbs. / 190 lbs.
Input Connector	SO-239, "N" Female avl.		

Cost - $11800.00

Tennadyne Log Periodic Antennas

Model	Coverage	Gain (dbd/dbi)	Boom Length	Elements	Longest	Turn Radius	Wind Load	Weight	Price
T6	13 – 30 MHz	5.10/7.24	12 FT	6	38 FT	20 FT	6.2	47#	$1,095
T7	18 – 32 MHz	6.2/8.3	18 FT	7	29 FT	16.5 FT	6.8	53#	$1,290
T8	13 – 32 MHz	5.80/8.34	18 FT	8	38 FT	20.9 FT	8	68#	$1,480
T10	13 – 33 MHz	6.10/8.24	24 FT	10	38 FT	22 FT	10.1	78#	$1,825
T11	13 – 55 MHz	5.80/7.94	24 FT	11	38 FT	21.5 FT	8.5	73#	$1,965
T12	13 – 33 MHz	6.50/8.64	30 FT	12	38 FT	24.6 FT	11.7	97#	$2,435

Tower Wind Loading

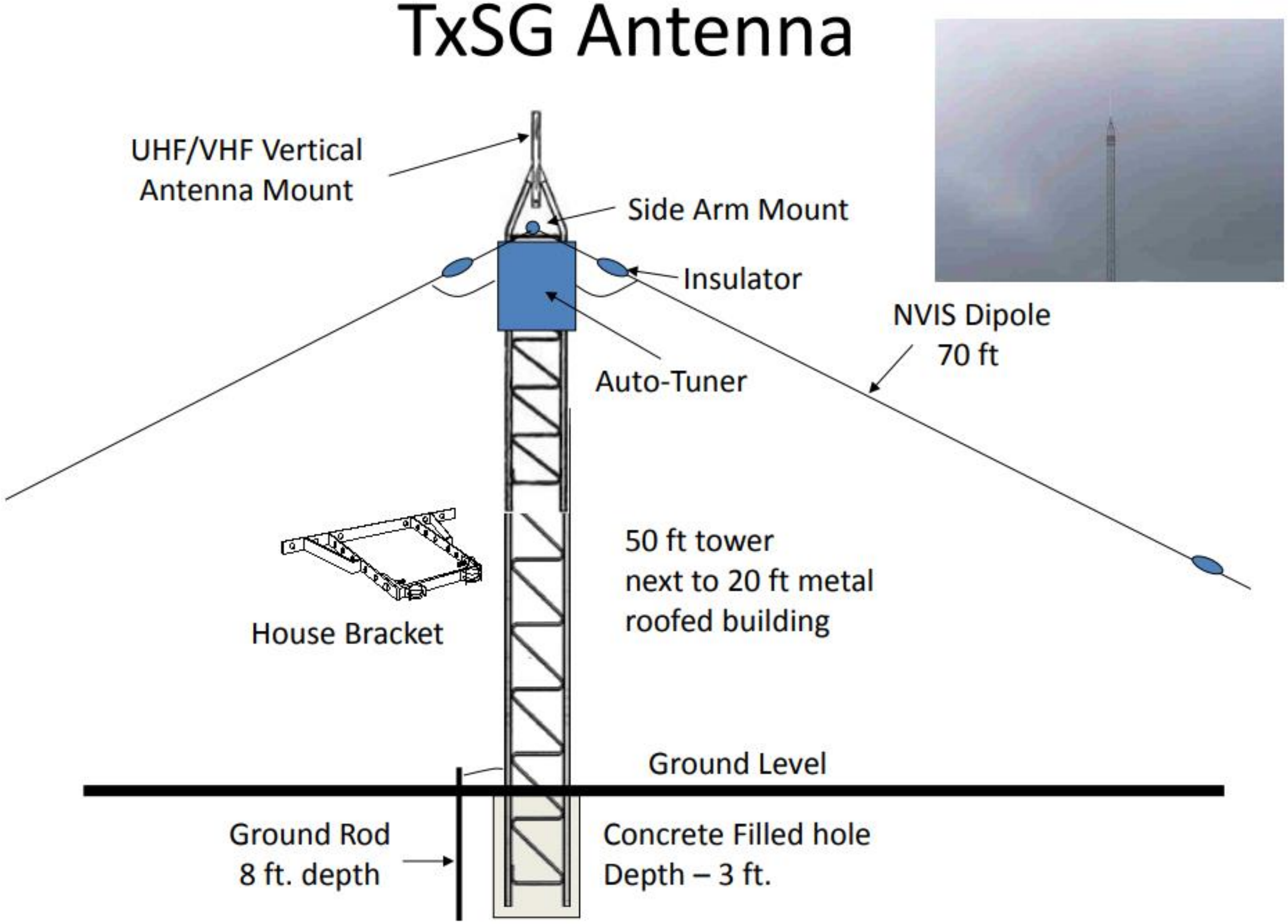
- Towers designed for mounting horizontal antennas will have a maximum stated wind load given in Sq. Ft. of largest recommended antenna at a given wind speed.
- Each Yagi antenna will list its Sq. Ft. area.
- The tower and antenna selections should be matched so that the antenna tower is not overloaded by too large an antenna. Note that the height of the antenna above the top of the tower must be taken into consideration since this additional height increases the rotational moment loading.

Rohn 25G – 80 ft. Guyed

Two Point Anchor of Rohn 25G

- Rohn 25G is man-climbable to 50 ft. when base is set in concrete and a strong house bracket is used at a height of 15-20 ft.

TxSG Antenna

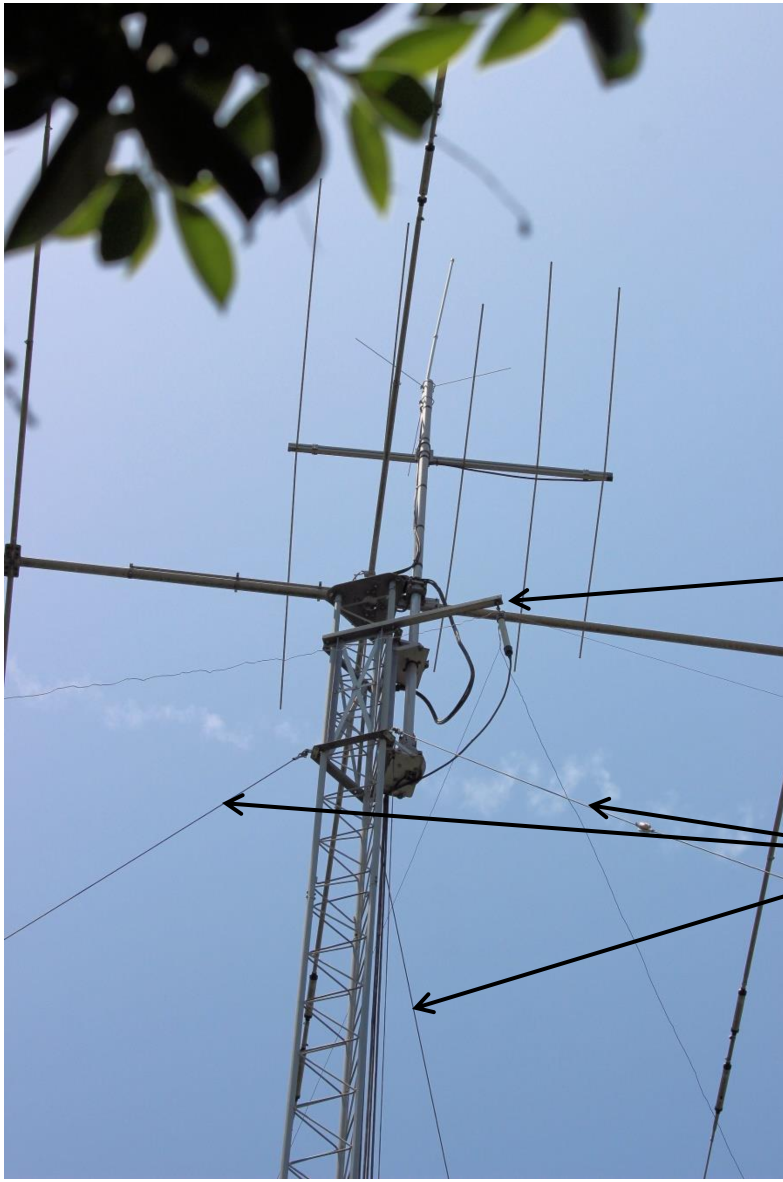


Two Point Anchor with Glen Martin Hazer

Two Point Anchor with Razor
http://www.rtinnovations.net/

Rohn 25 G - $900.

Hazer System

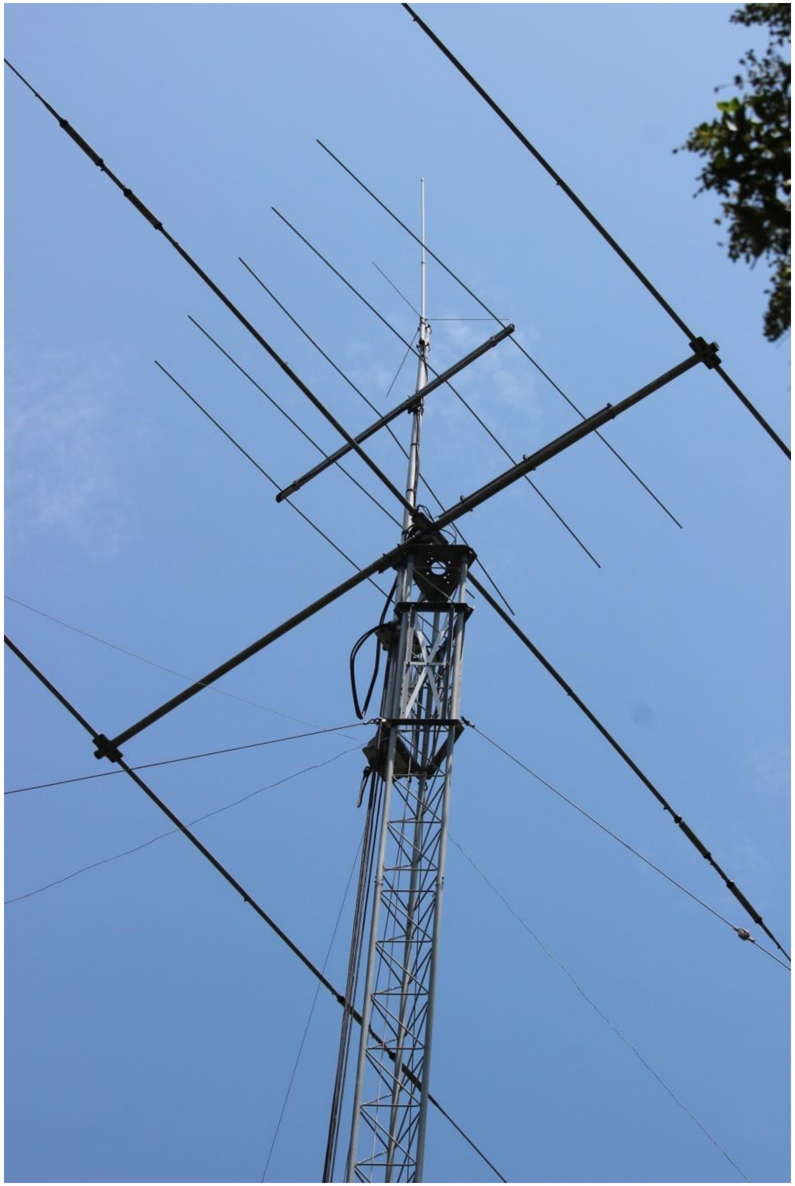


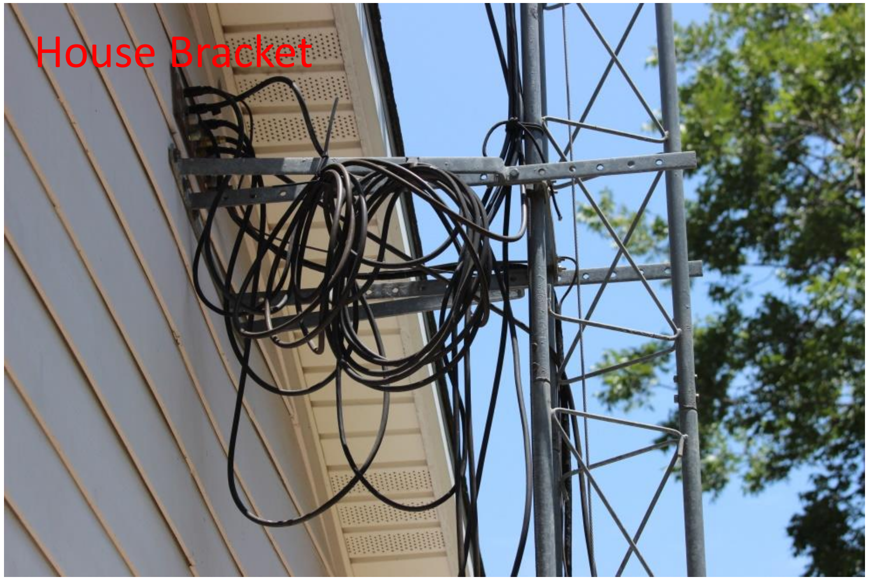
Advantages:
- Can lower Antenna system to roof top for maintenance.
- Only have to climb tower to top once to install pulley.
- Does include fail-safe lock

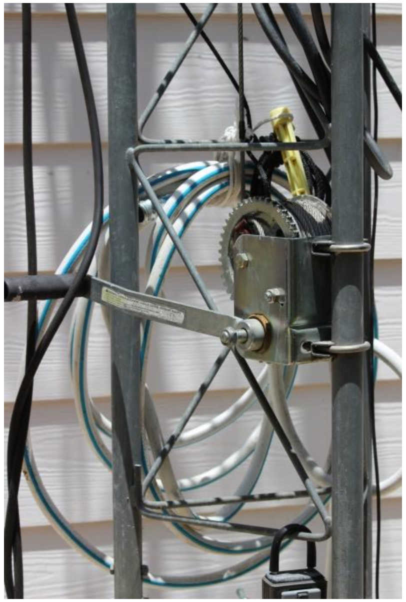
Dipole Hanger
Dipole Balun

Guy Cables

60 ft. Hazer Antenna System







Hazer Winch

HF Long-Range Antenna Conclusions

- Two factors affect your ability to successfully conduct long-range HF contacts:
  - Achieving a low TOA elevation angle.
  - Operating at the MUF for the reflection point.
- Antenna towers must be installed as per manufacturer's recommendations.
- Wind loading must considered with selecting tower height and type of tower and antenna.

Outline

Red is Next Month's Subject

- HF Propagation Modes
- Long Distance, HF Sky-Wave hardware and modes
  - Antenna Requirements
- Antenna Types
  - Verticals
  - High Dipoles
  - Yagi's
- HF Skywave Propagation theory and Prediction
  - Theory
  - Prediction Program – VOACAP
  - Beacons

Questions?

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Home E-mail: w5ifq@att.net

Objectives of Two Part Presentation

- Discuss suitable HF antennas for long-range propagation
- Introduce long-range ionospheric skip sky-wave propagation theory and practice.

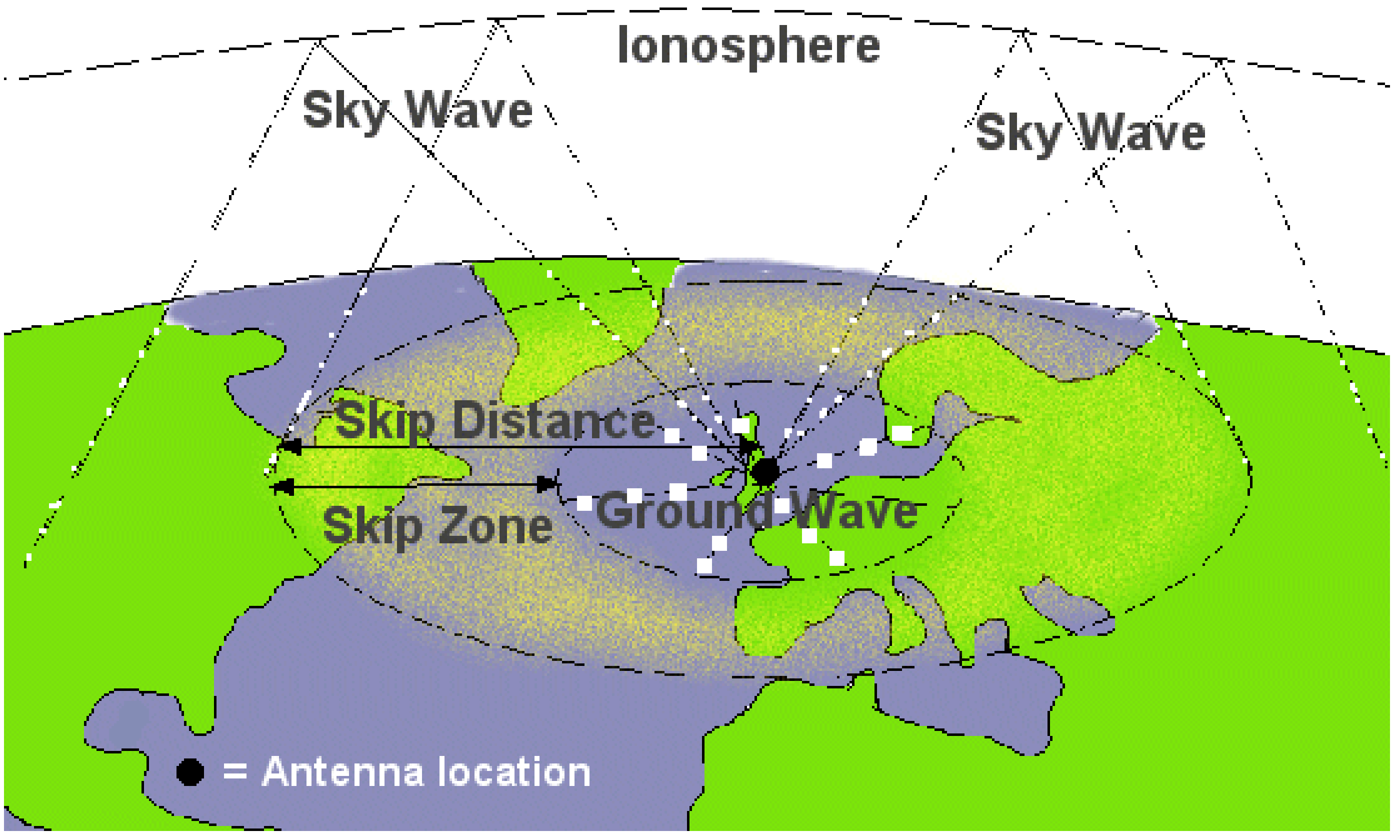
Outline

- Introduction to Long-Range HF Propagation
- Antenna Types
  - Verticals
  - High Dipoles
  - Yagi's
- HF Skywave Propagation theory and Prediction
  - Theory
  - Prediction Program – VOACAP
  - HF Beacons

HF Propagation Modes
(3 – 30 MHz)

- Free Space – Line of sight
- Ground Wave – Follows Earth's curvature
- Ionospheric Skip
  - Long Distance with a "skip-zone"
  - NVIS (Near Vertical Incidence Sky-Wave)

Long Distance Sky Wave

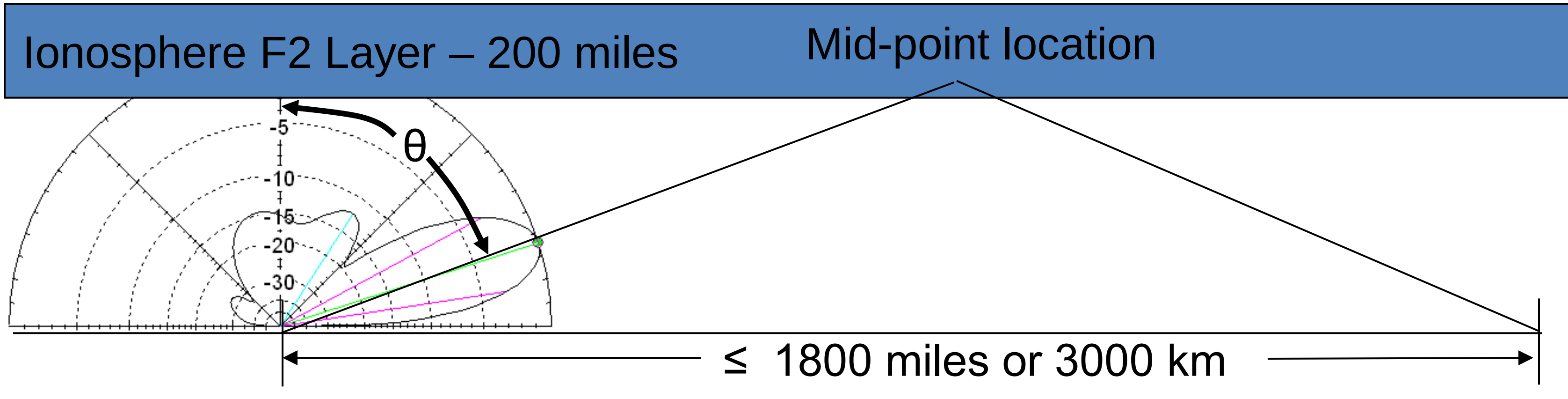


HF Propagation Theory

- A simplified behavior of HF sky-wave propagation using world wide Ionosonde data will show a basic understanding of the phenomena.
- Next, Propagation prediction programs will demonstrate a more realistic behavior that included more complex propagation paths.
- Finally, actual reception of world-wide propagation will be discussed using the NCDXF Beacon system.

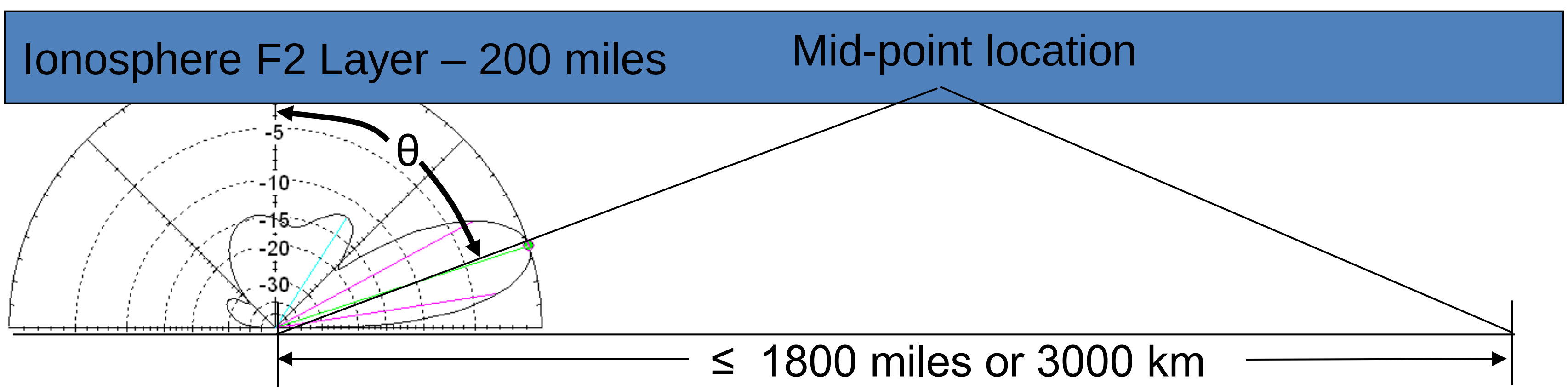
Simplified HF Sky Wave Propagation

- A successful Sky-wave propagation path requires that the Maximum Useable Frequency (MUF) at the **reflection** location be equal to or exceed the operating frequency.
- The required MUF is dependent on Cosine of the TOA.
- For simple F2 layer to earth bounces, this requirement must be met for each succeeding reflection for a multi-hop circuit.



Maximum Useable Frequency (MUF)

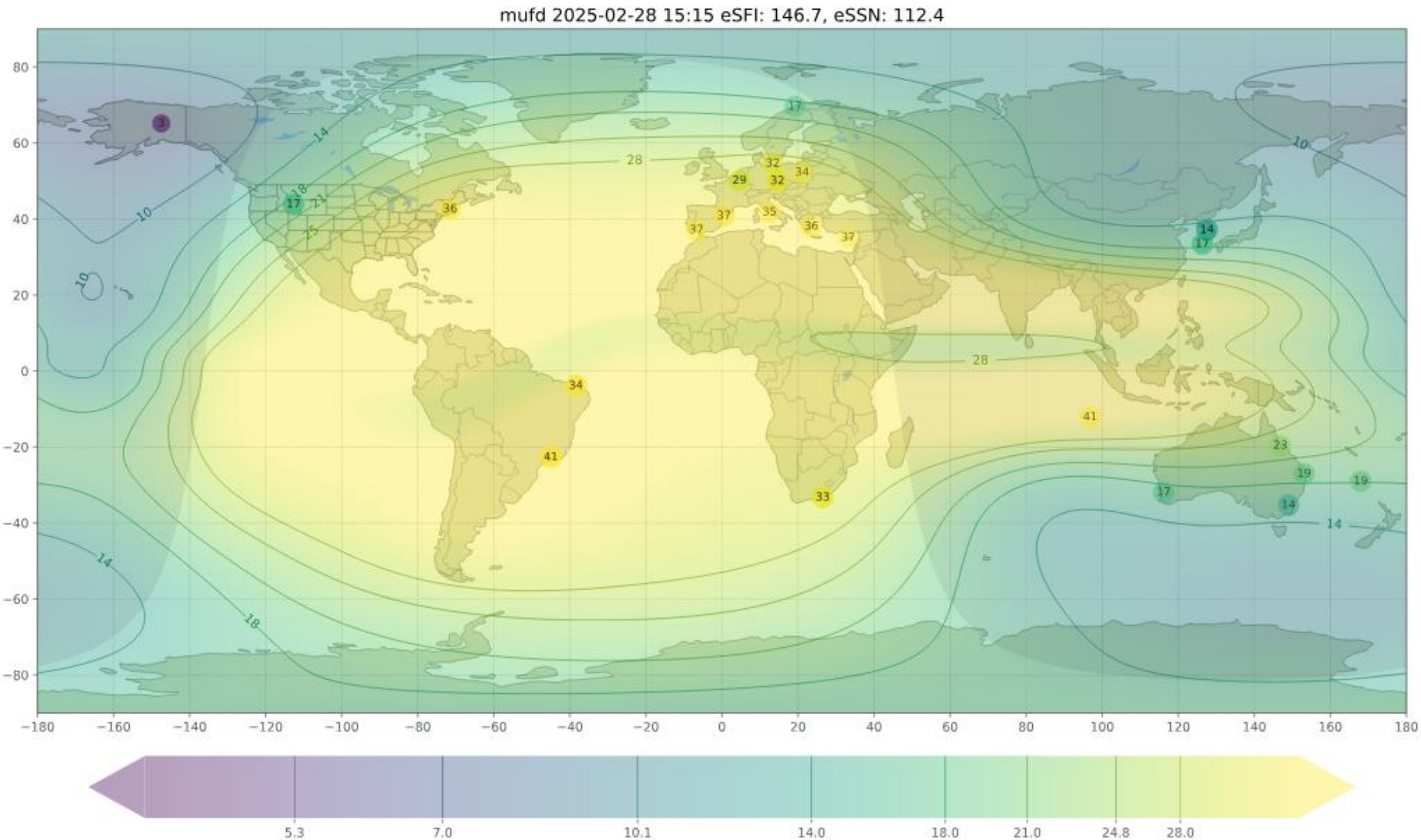
- MUF (Maximum Useable Frequency) is CF/cosθ, where θ is the angle from the take-off beam to vertical.



MUF World Wide Distribution

- The Critical Frequency (CF) and therefore the MUF at the reflection point is dependent on the **local level of UV radiation** from the sun.
- The UV radiation at this location is dependent on the following:
  - Time day
  - Time of the Year
  - Time of the 11 year sun spot cycle
- The CF may also be affected by Solar and Geomagnetic storm events.

MUF Distribution – 28 FEB 2025 (https://prop.kc2g.com/)



MUF World Wide Distribution

- As expected, the MUF and CF are highest in the sun lite portion of the earth.
- I recommend the use of GAMBIT to obtain Critical Frequencies (foF2) at any location in the world. From this data, the MUF for a specific, single bounce can be calculated.

Introduction

- **NOAA is no longer supporting Ionosonde data distribution.**
- The University of Massachusetts Lowell , Global Ionosphere Radio Observatory, GIRO, provides a number of useful products that can assist HF radio operators in selecting the best NVIS (Near Vertical Incident Sky wave) frequency.
- Their GAMBIT product appears to be the most useful product for long range propagation, providing foF2 (Critical Frequency) for any location. GAMBIT uses their IRTAM model to compute **foF2 every 15 minutes using real time data from their world wide Ionosonde data base.**

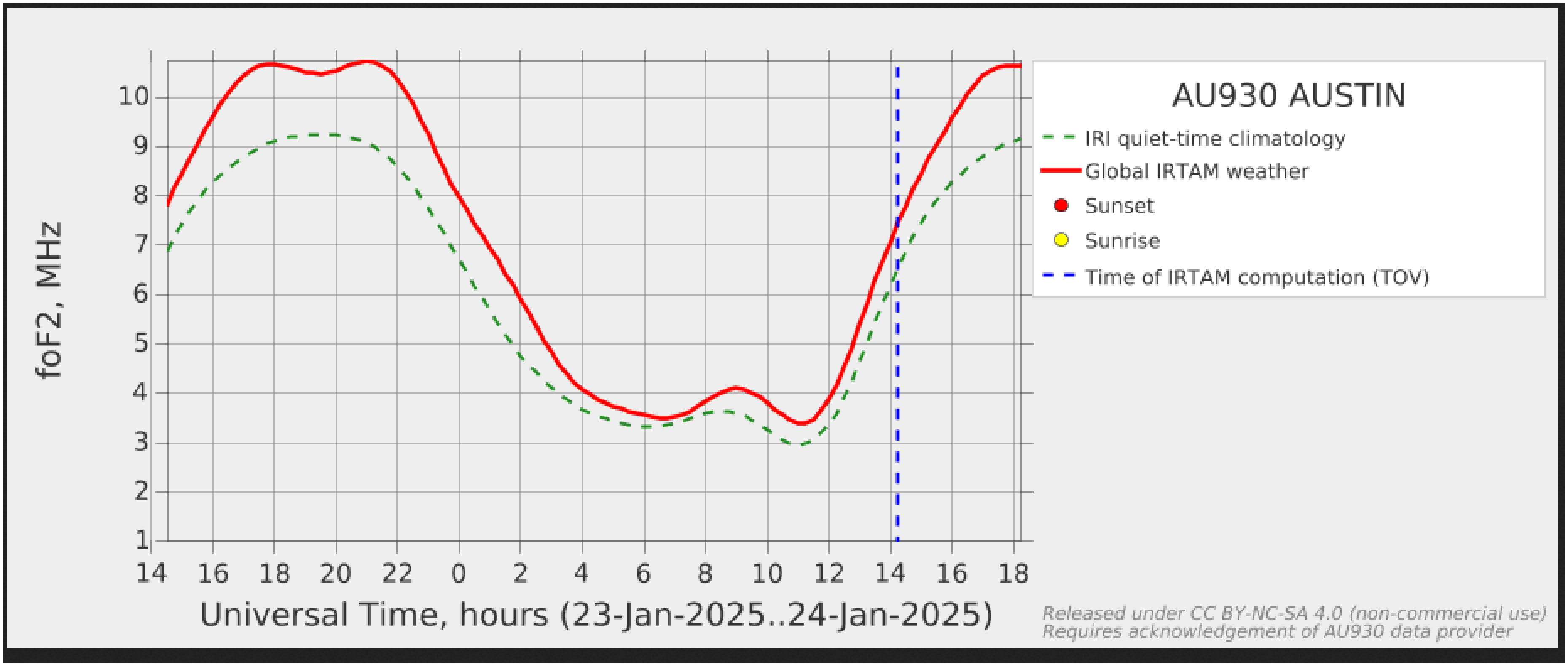
GAMBIT Location on Army MARS Region 6 Solar Weather Page

(https://www.region6armymars.org/resources/solarweather.php)

- GAMBIT - Global Assimilative Model of Bottomside Ionosphere Timeline (World-Wide)
  - Austin
  - Boulder
  - Eglin

- NOAA Solar Weather - Solar Weather plots of Kp and X-Ray and other solar emissions.
- Solen Solar Weather - Good general solar forecast from an individual.
- Solar Ham - SolarHam provides real time solar news, as well as consolidated data from various sources.

GAMBIT for Austin Ionosonde



Use of GAMBIT For World-Wide foF2 Plots

- GAMBIT URL is now listed on our solar weather web page in place of DIDBase URL. You can select one of the three Ionosondes in Region 6 for foF2 Critical Frequency or use GAMBIT URL for world-wide foF2 and hmF2 calculations by either selecting another Ionosonde or by using the coordination method discussed on page 64.
- Operation is as follows:
  – ***Location*** – A pull down screen allows the user to select a specific Ionosonde by name ***Characteristic*** *fields available:*
    - ***foF2 -*** **Critical Frequency, MHz**
    - *NmF2* – Electron density in the F2 layer (not important)
    - ***hmF2*** **– Height of the F2 layer, Km**
    - *B0*, B1 – IRI vertical profiles (not important)

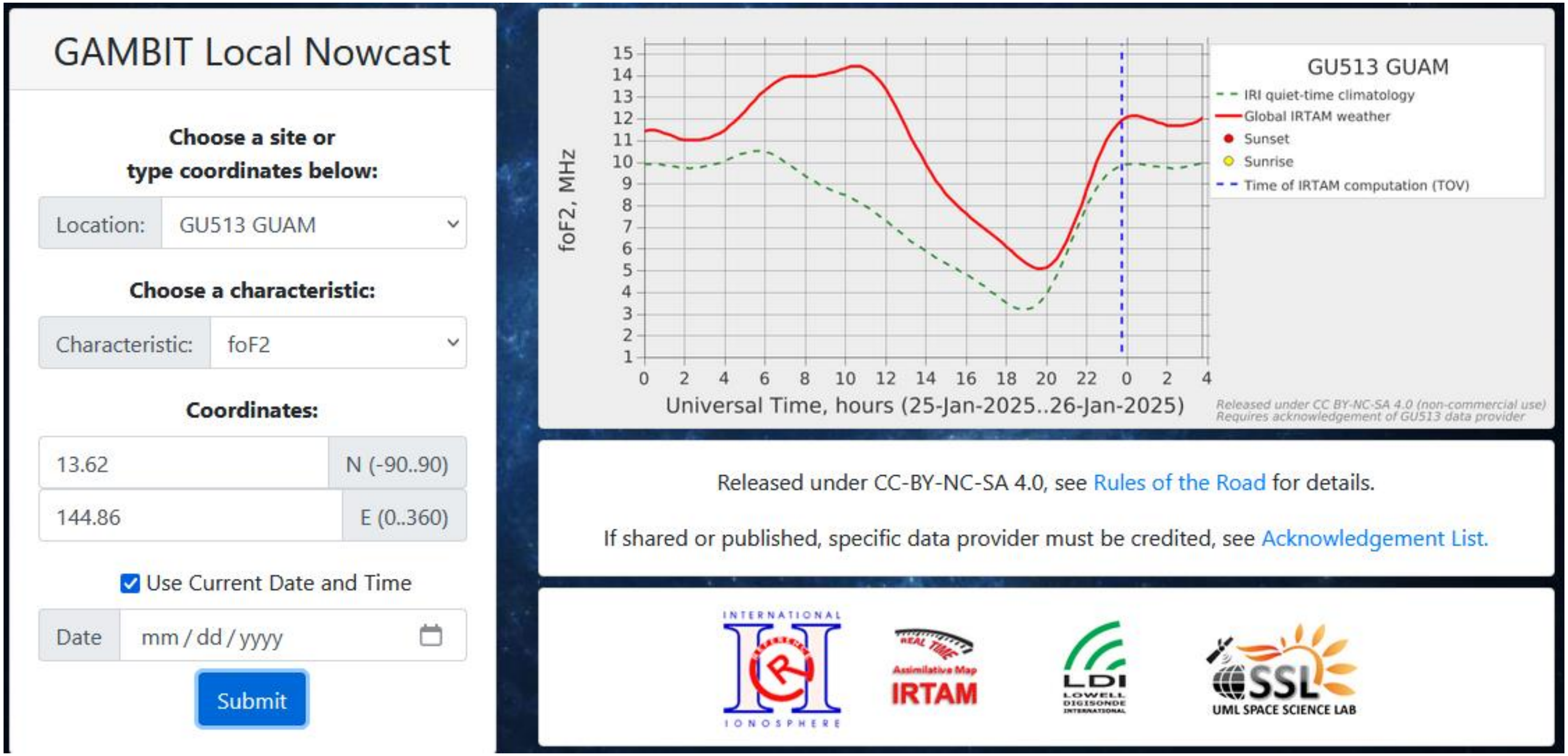
check box *- current date and time (you do not need to enter date and time)*

Submit

If the GIRO server is available, the plot on the right will be generated. If no result wait and try again later. I would recommend copying this plot for use for the next 24 hours if no severe Ionospheric storms are forecasted. Note that date/time on the horizontal axis is in UTC and can include a change in date.

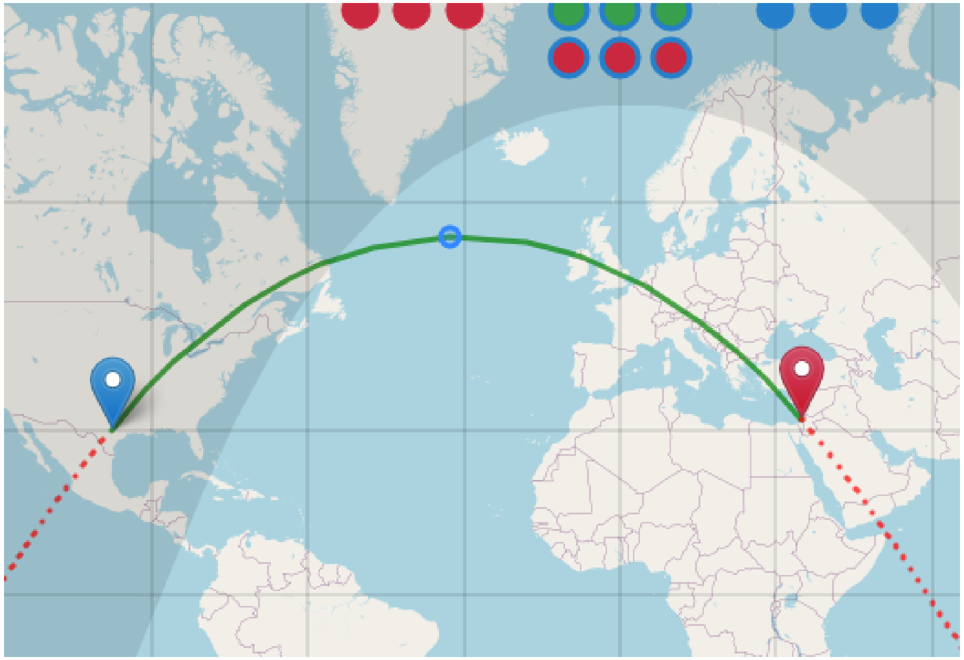
This plot can be easily copied and printed using *Snipping Tool* or similar graphical capture programs. If you distribute this data please include the source (see rules of the road).

GAMBIT Use For Any Ionosonde



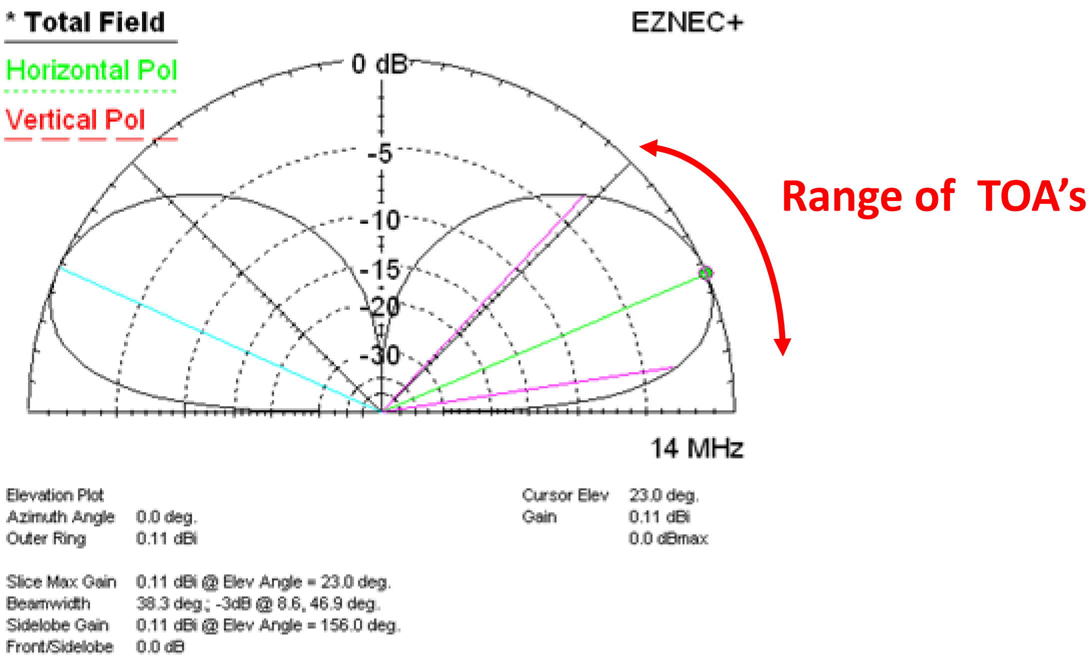
Simple Propagation Behavior: Day/Night

- Since CF is dependent on UV radiation level, maximum propagation frequencies **follow the sun across the earth**. The fact that F2 layer recombination of electrons and ions is slow, allows night-time propagation to occur at reduced frequencies. DX openings occur to Europe in the CONUS morning hours and to Asia in the CONUS evening hours. Similar day/night behavior is seen across CONUS..



Antenna Requirements

- The TOA's generated by antennas, discussed last month, must generate a range of vertical elevation angles that will allow varying range circuits to be excited as long as the MUF requirement is meet.



Propagation Behavior - Example

- For example, a 14 MHz signal, generated by a vertical antenna in central Texas, can be heard in Florida and beyond, but not in Houston or San Antonio unless the MUF at the mid-point location exceeds 14 MHz (unlikely). For the present cycle 25 conditions, dropping down to 40m frequencies would allow good communications at these shorter ranges.

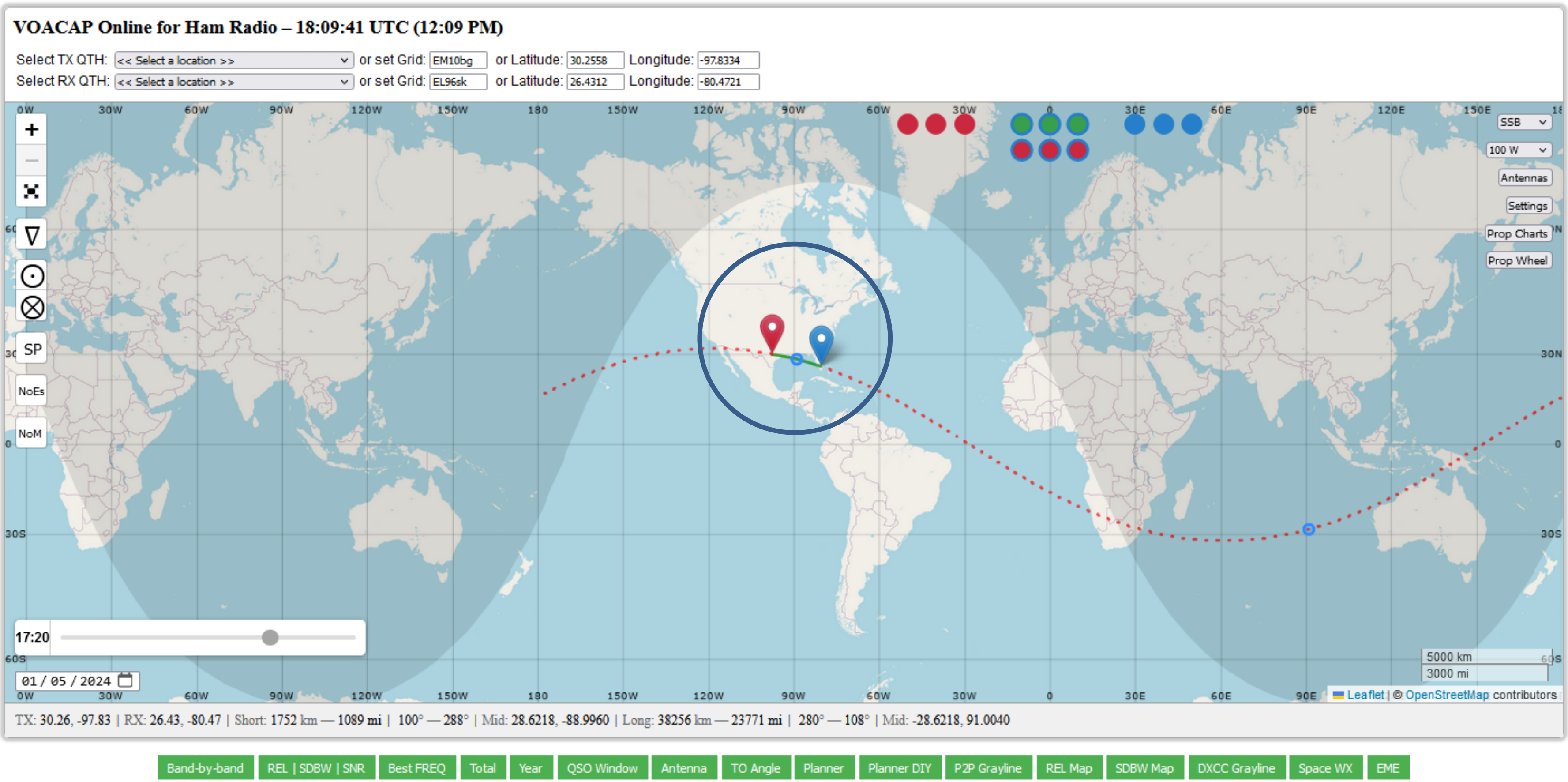
VOACAP Modeling Program

- The most accurate HF sky-wave propagation programs <u>all</u> use forms of VOACAP (Voice of America Coverage Analysis Program). This program was developed by the US Government at considerable expense but is available free.
- Attempts to include Ionosonde data into VOACAP have so far been unsuccessful.
- VOACAP does not work well for NVIS propagation.
- VOACAP is available at: https://www.voacap.com/hf/
  - Select: VOACAP Online For Ham Radio

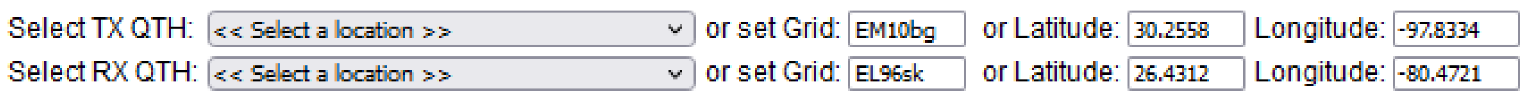
VOACAP For Ham Radio

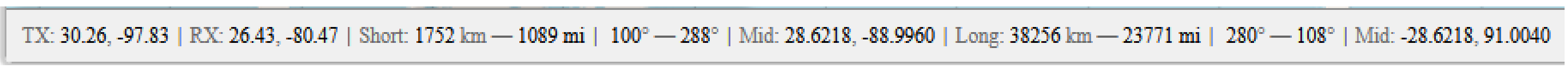
(https://www.voacap.com/hf/)

(Austin to Florida example)



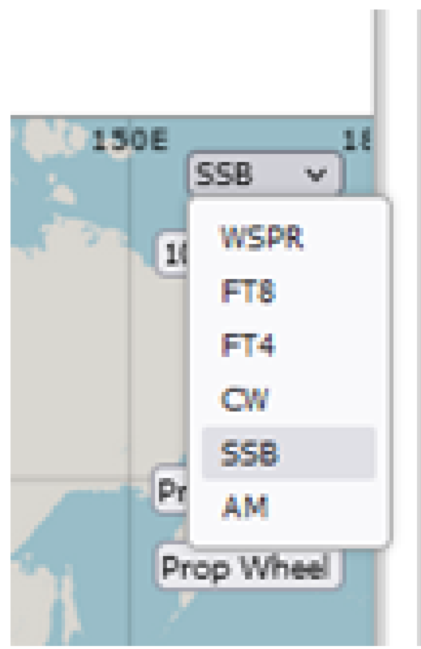
VOACAP Input Variables – Location & Mode





Note: Use negative sign for South Latitudes and West Longitudes.
Use pull-down location menu or Grid locations for easiest entry or drag red and blue markers to approximate locations.

Mode Input



VOACAP Input Variables – Antennas

TX antennas:

10M:	1/4 wl GP Gd Gnd
12M:	1/4 wl GP Gd Gnd
15M:	1/4 wl GP Gd Gnd
17M:	1/4 wl GP Gd Gnd
20M:	1/4 wl GP Gd Gnd
30M:	1/4 wl GP Gd Gnd
40M:	1/4 wl GP Gd Gnd
60M:	1/4 wl GP Gd Gnd
80M:	1/4 wl GP Gd Gnd

Receiver Site

RX antennas:

10M:	1/4 wl GP Gd Gnd
12M:	1/4 wl GP Gd Gnd
15M:	1/4 wl GP Gd Gnd
17M:	1/4 wl GP Gd Gnd
20M:	1/4 wl GP Gd Gnd
30M:	1/4 wl GP Gd Gnd
40M:	1/4 wl GP Gd Gnd
60M:	1/4 wl GP Gd Gnd
80M:	1/4 wl GP Gd Gnd

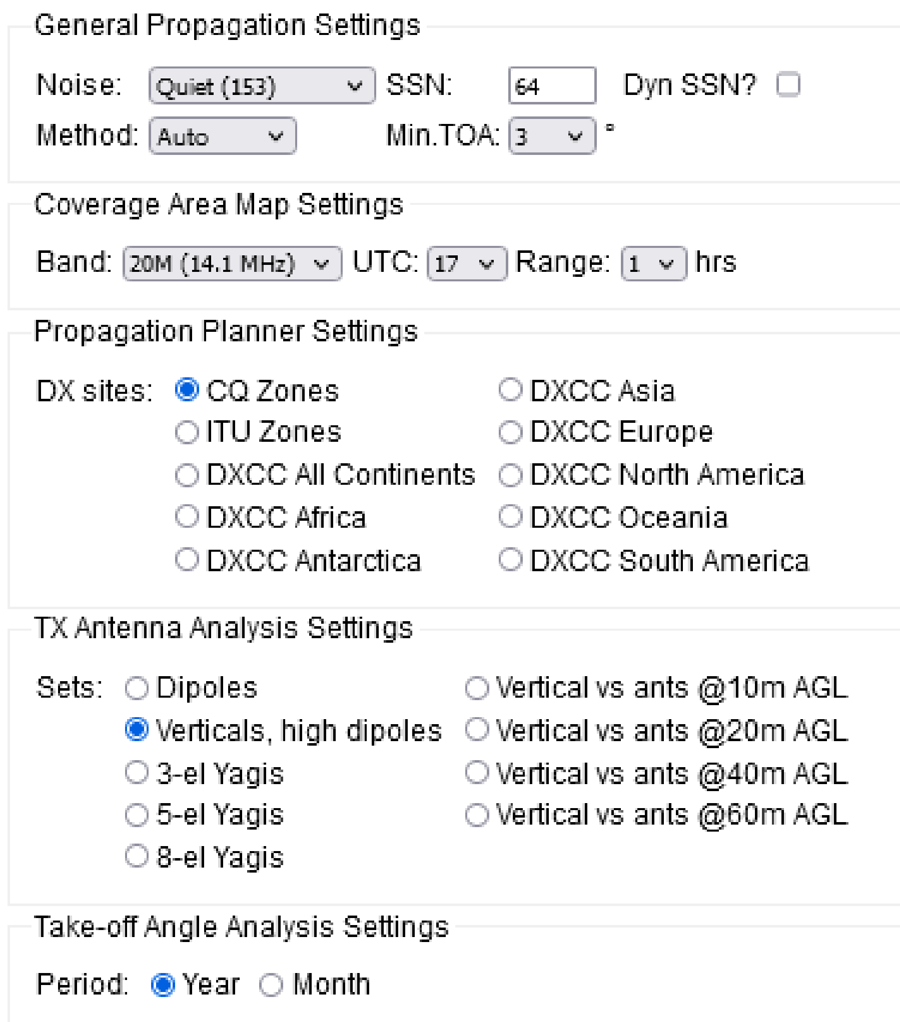
Swap TX/RX antennas

TX Antenna Abbreviations

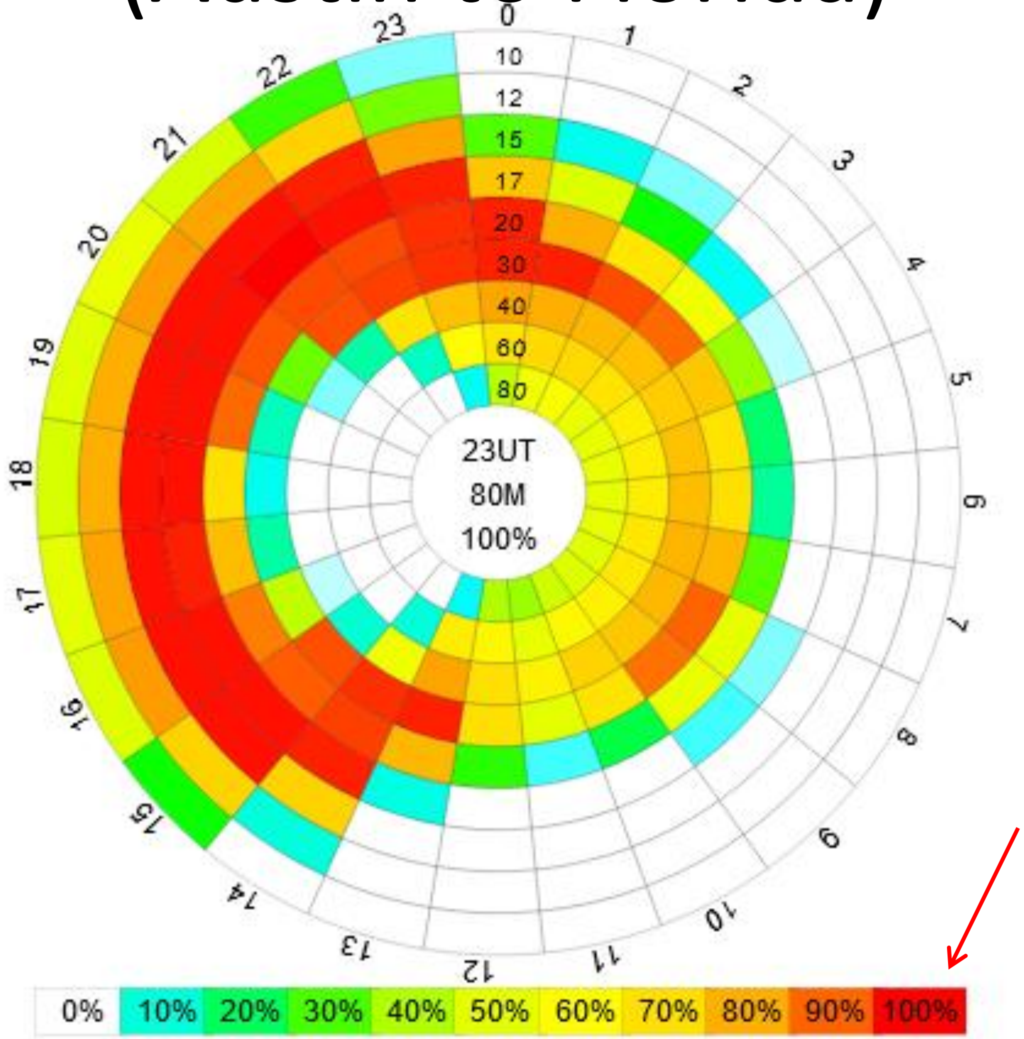
- ISOTROPE = Isotrope, 0 dBi gain
- HVD025 = Half-Wave Vertical Dipole, feed at 0.25wl AGL
- V14 = 1/4 wl Vertical, with Average Ground
- V14GD = 1/4 wl Vertical, with Good Ground
- V32 = 3/2 wl Vertical, with Average Ground
- V58 = 5/8 wl Vertical, with Average Ground
- DxxM = Horizontal Half-Wave Dipole at xx meters AGL
- 3ELxxM = Horizontal 3-element Yagi at xx meters AGL
- 5ELxxM = Horizontal 5-element Yagi at xx meters AGL
- 8ELxxM = Horizontal 8-element Yagi at xx meters AGL

VOACAP Input Variables – Settings

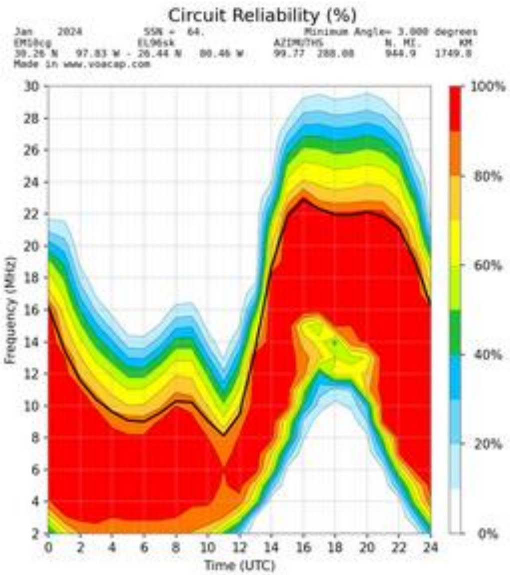
Get SSN from SolarHam.com

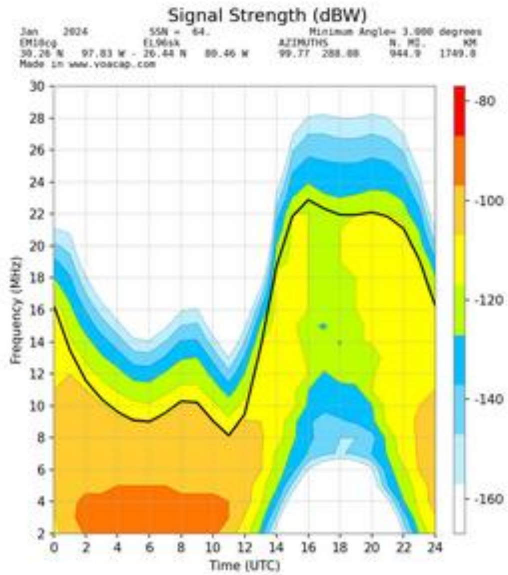


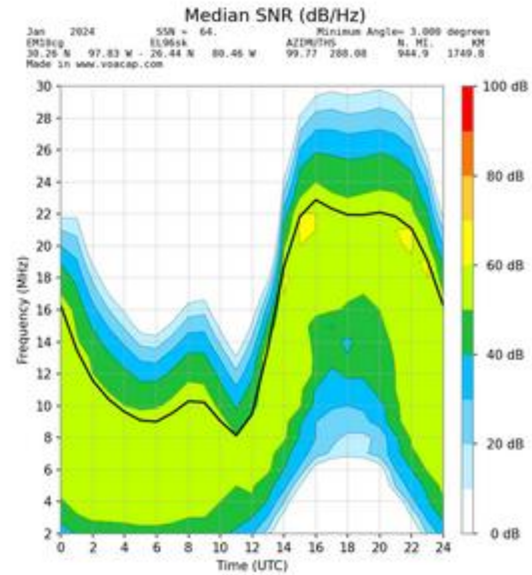
VOACAP Output – Prop Wheel (Austin to Florida)



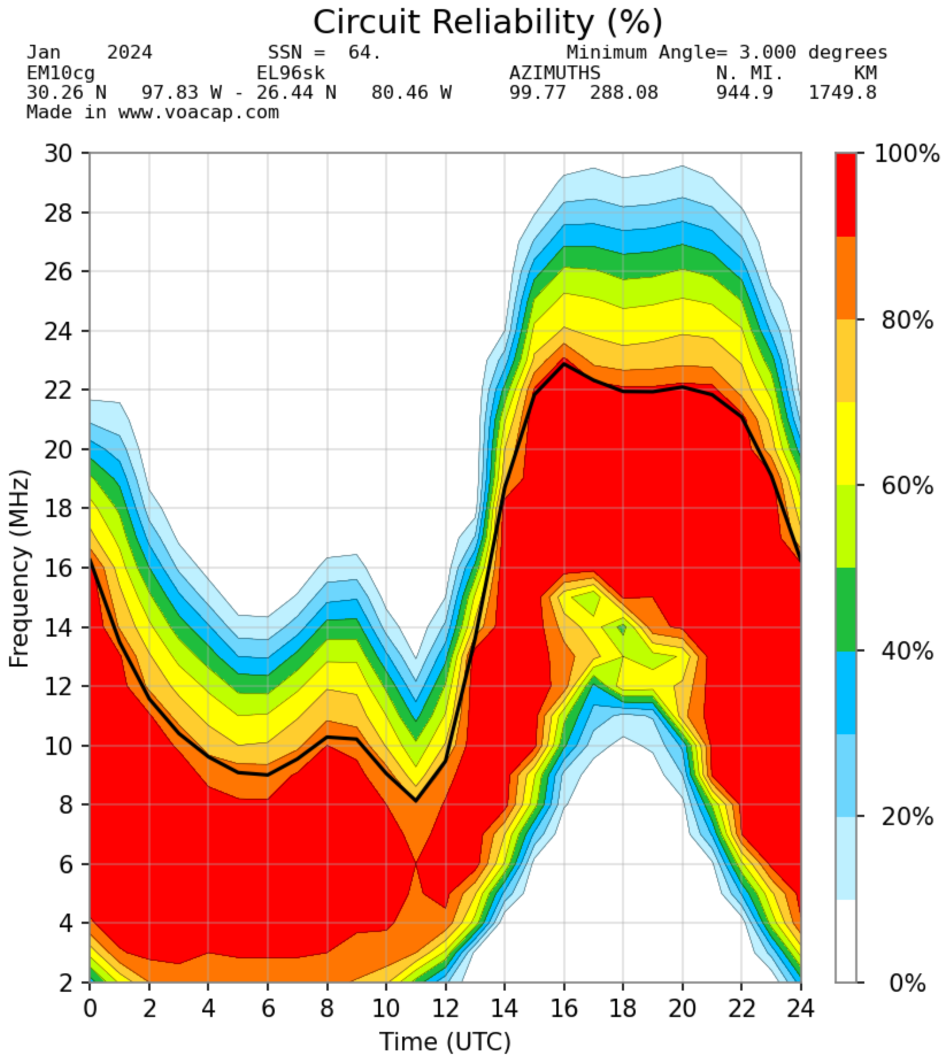
Bottom Button - REL|SDBW|SNR



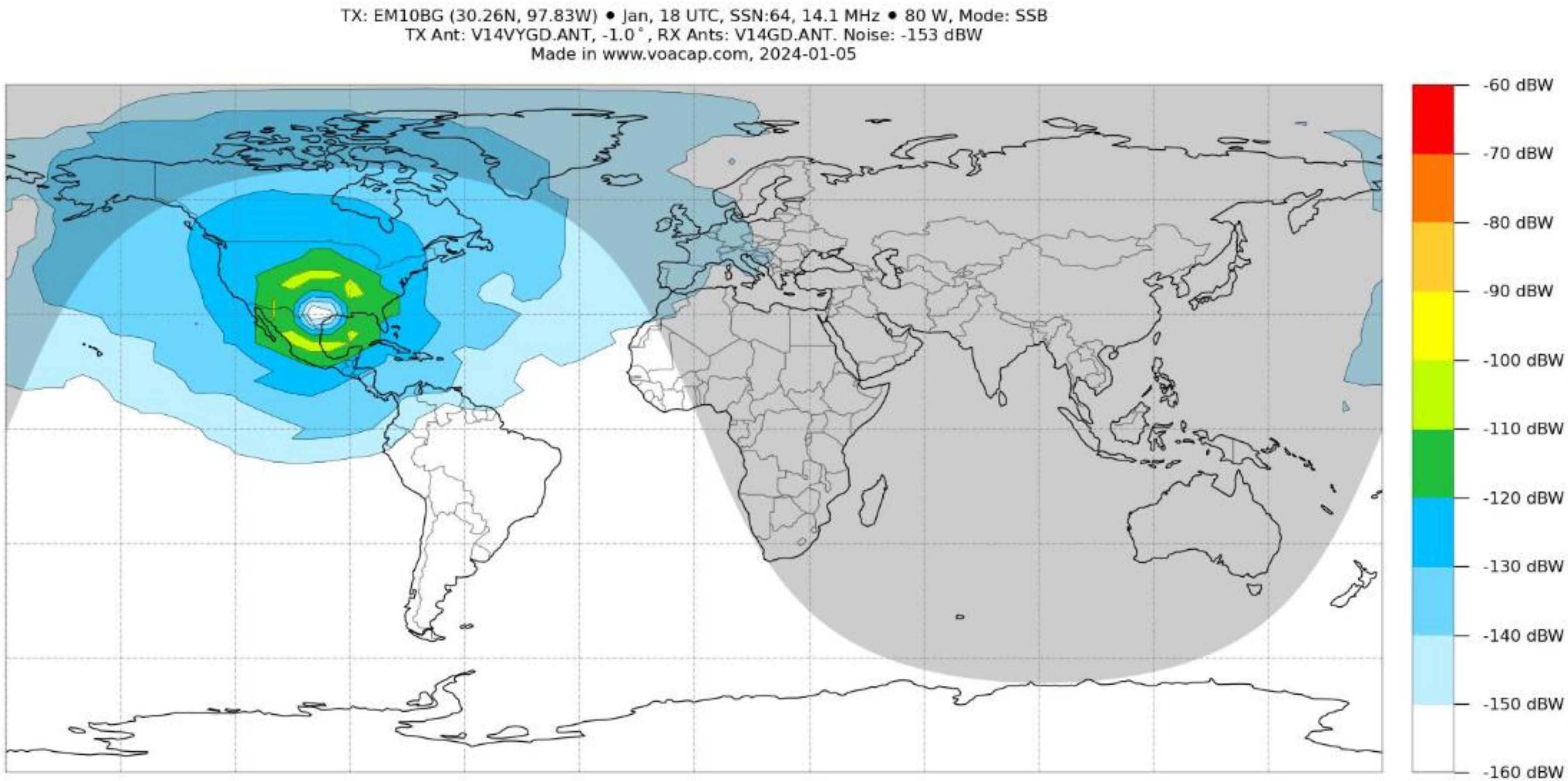




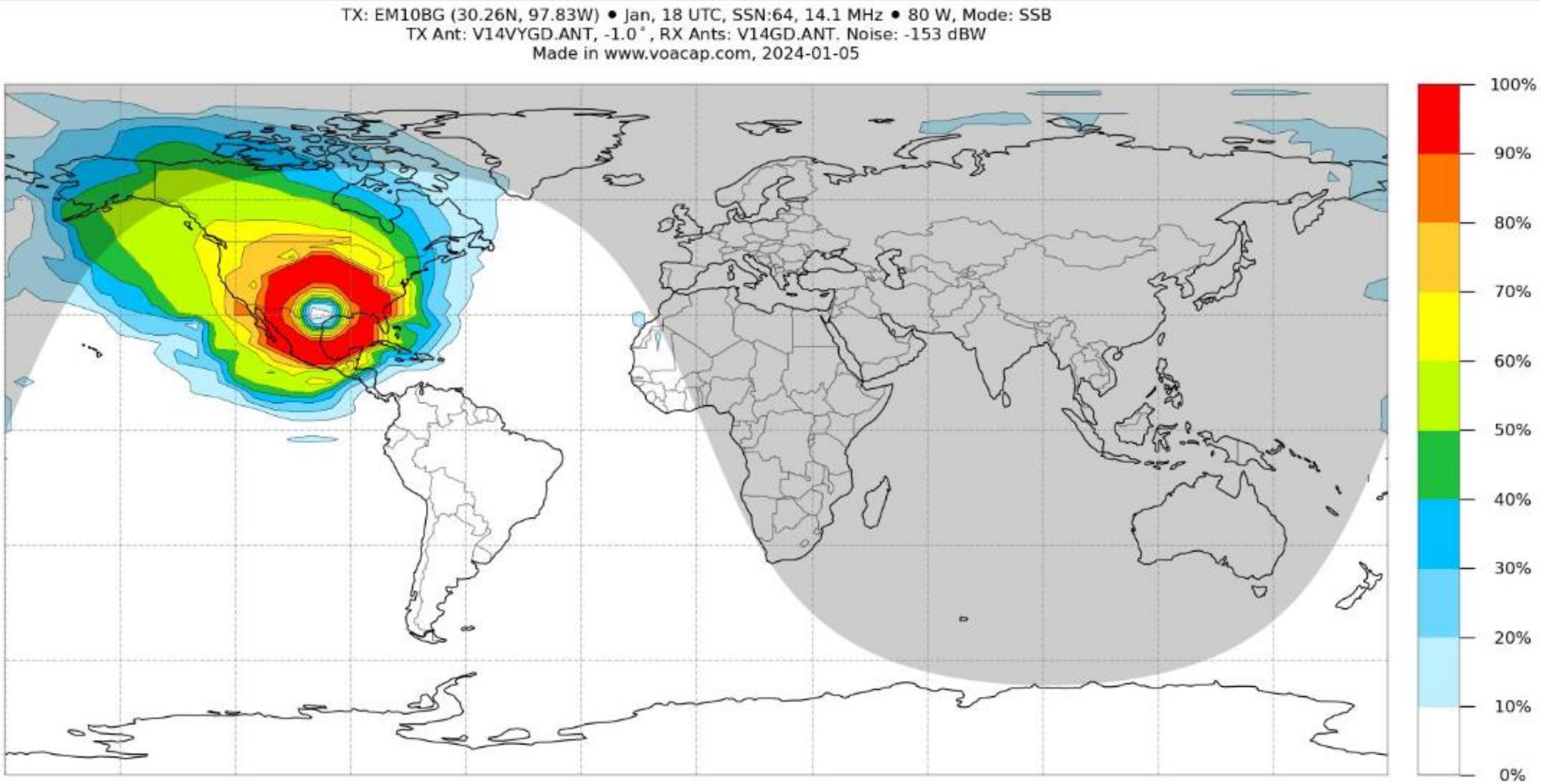
Circuit Reliability



Receive Coverage Map



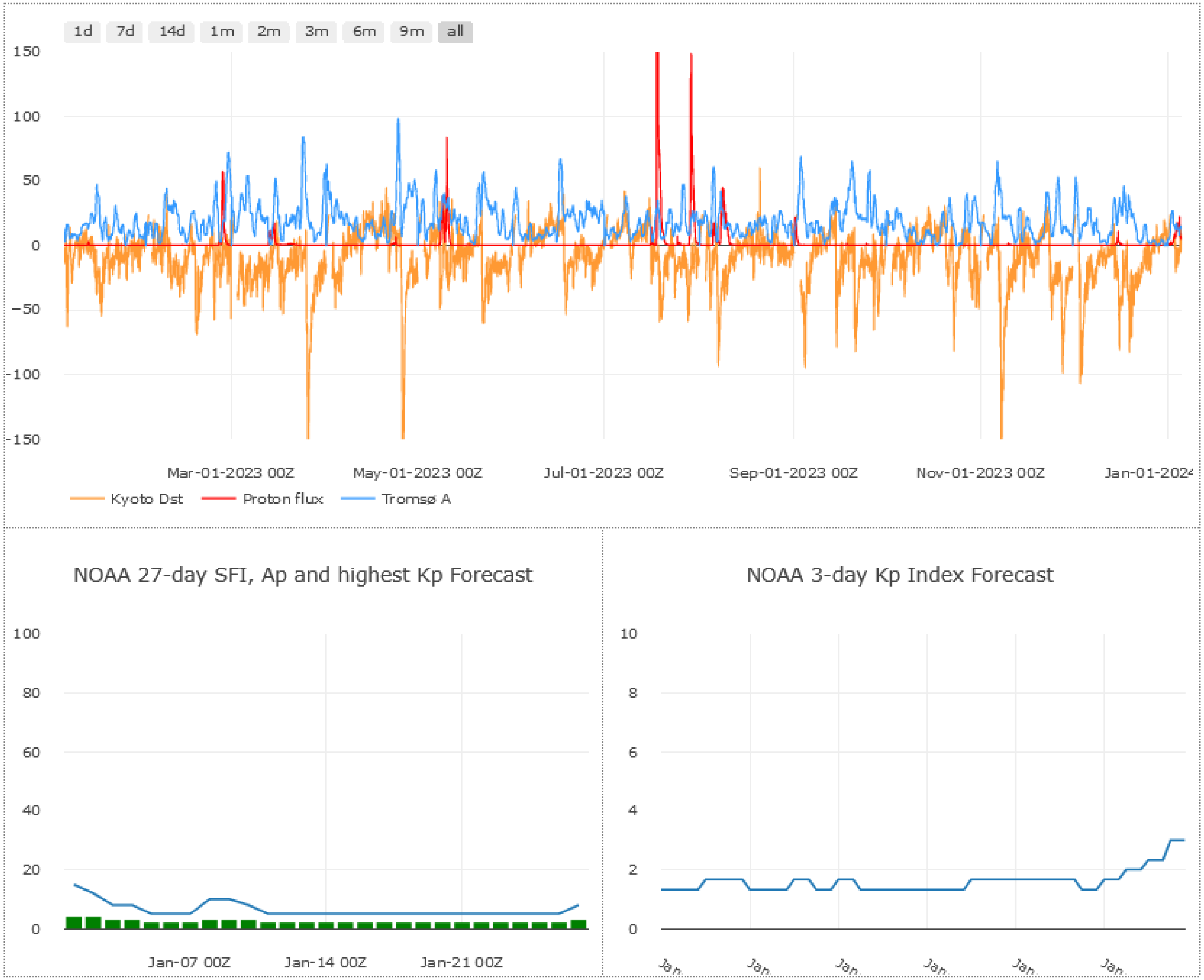
Transmit Coverage Map



Comments on Example

- For this prediction run:
  - Path (Austin to southern Florida) is open with 90% 100% reliability from 1300Z through 2300Z on frequencies from 30 m to 15 m for SSB, 100 watts with vertical antennas.
  - Note the solar terminators.
  - VOACAP assumed solar weather is shown on the next page.

VOACAP - Space Weather



Sources: NOAA 27-day Space Weather Outlook, NOAA 3-day Forecast, GOES-13 Solar Particle and Electron Flux, WDC for Geomagnetism (Kyoto), Tromsø Geophysical Observatory

Accuracy Of VOACAP

- The accuracy of VOACAP was evaluated by me in 2022 using the NCDXF international beacon system.
- I found good agreement between NCDXF beacon reception at my QTH and VOACAP.

Propagation Beacons

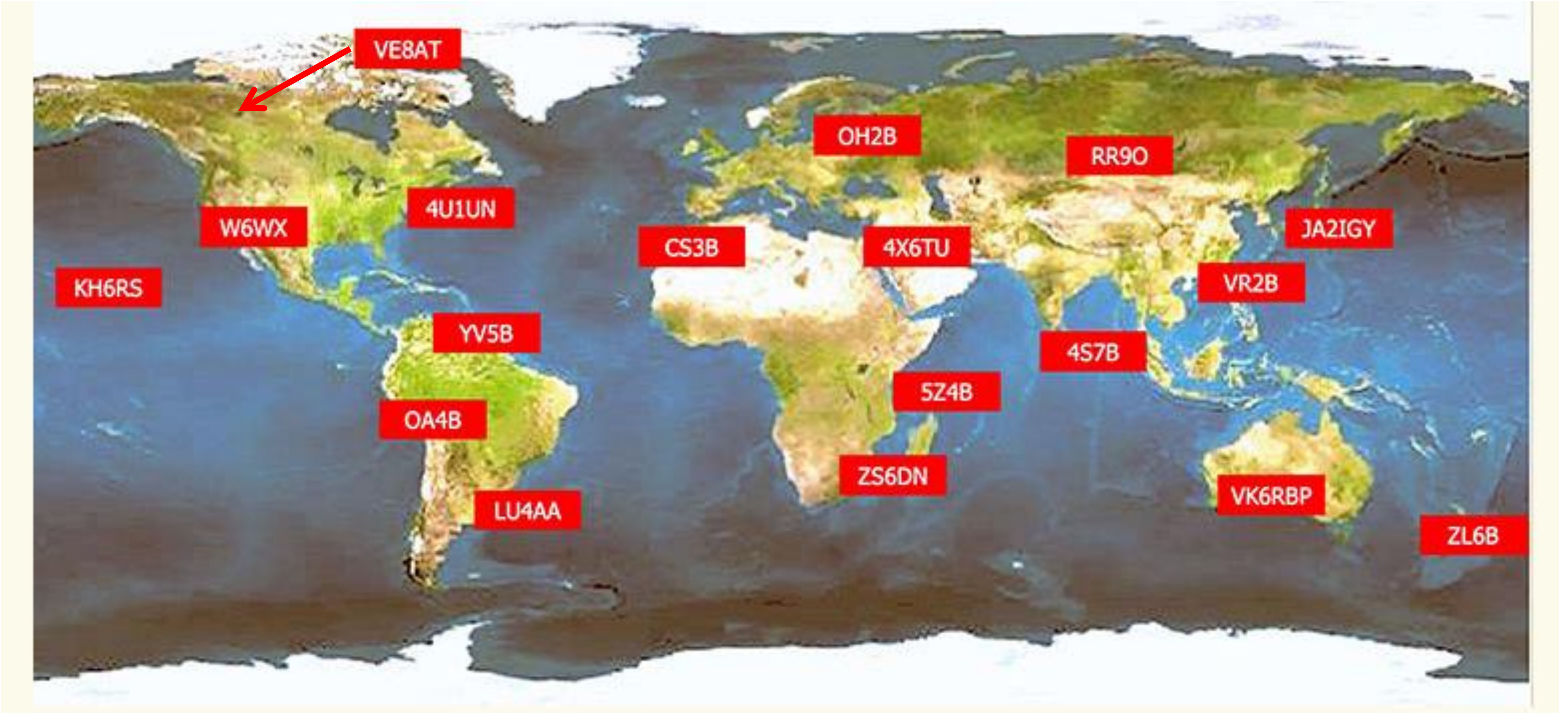
- I found that reverse propagations networks like Reverse Beacon, PSK Reporter or WSPR difficult to use scientifically since the locations of the receiving stations was not well documented and varied in time.
- Therefore, the NCDXF/IARU Beacon Network was used to evaluate the accuracy of VOACAP.

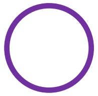
NCDXF/IARU Beacon Network

- Worldwide network of high-frequency radio beacons that transmit on 14.100, 18.110, 21.150, 24.930, and 28.200 MHz.
- The NCDXF (Northern California DX Foundation), in cooperation with the IARU (International Amateur Radio Union), constructed and operates the network.
- The entire system is designed, built and operated by volunteers at no cost to users.

NCDXF Beacons

https://www.ncdxf.org/pages/beacons.html




Off due to hardware failure. The operators are working on the problem. Please be patient.

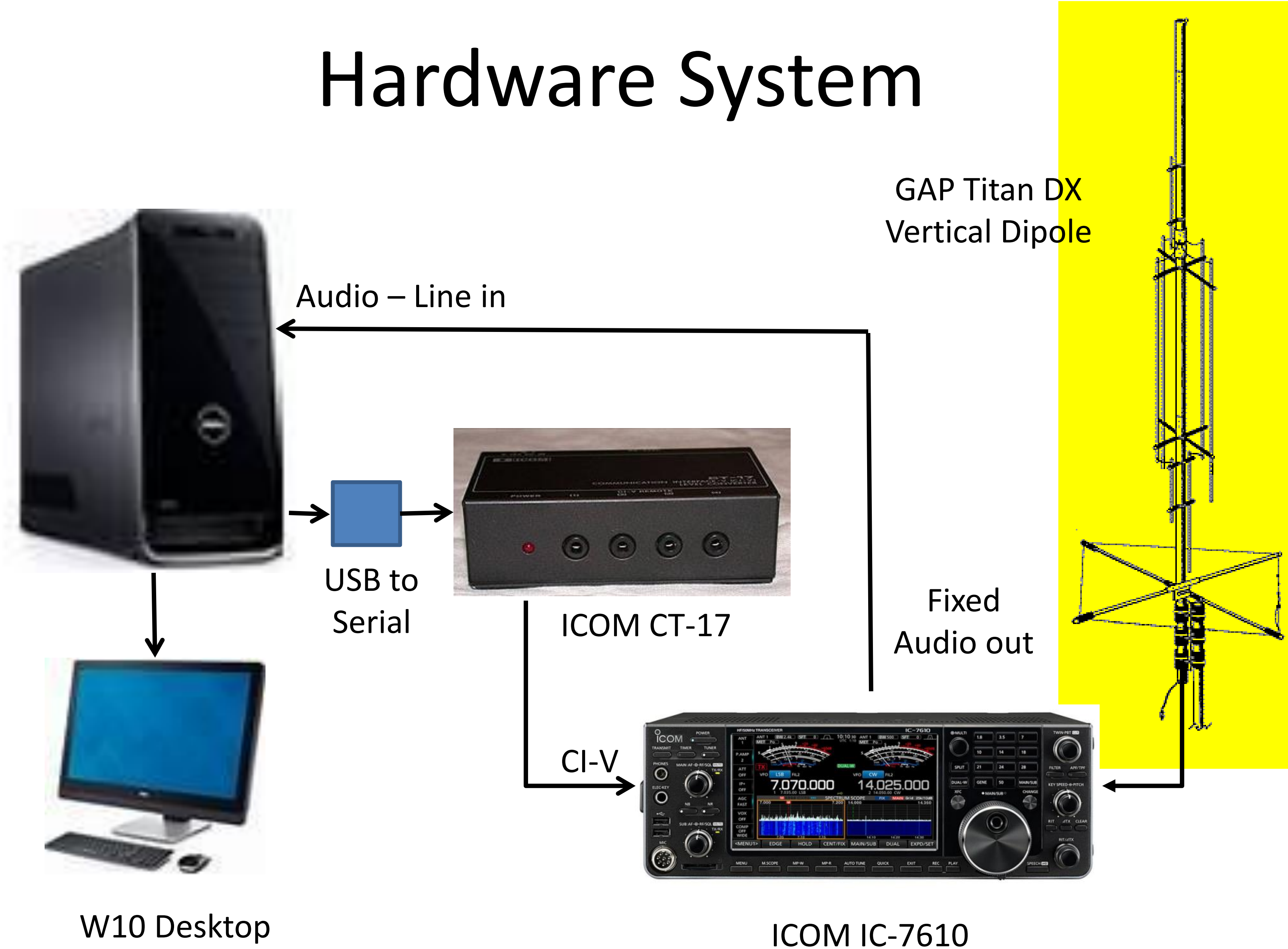
Transmission Pattern

- Each of the 18 beacons transmits once on each band once every three minutes, 24 hours a day.
- A transmission consists of the callsign of the beacon sent at 22 words per minute followed by four one-second dashes.
- The callsign and the first dash are sent at 100 watts. The remaining dashes are sent at 10 watts, 1 watt and 100 milliwatts.
- At the end of each 10 second transmission, the beacon steps to the next higher band and the next beacon in the sequence begins transmitting.
- See: http://www.ncdxf.org/beacon/index.html for real-time display of frequency, station location UTC time.

HF Beacon Monitor Program - Faros

- See: http://www.dxatlas.com/Faros/
- Cost - $25.00
- Scans and records signals from all received NCDXF Beacons.
- Evaluates quality and accuracy of reception using computed time delays for each station.
- Writes all beacon information to a permanent file.
- Should download and install the latest Beacon List as locations do change.

Hardware System



Log File Structure

Sample Log File

```
;DATE=2006-04-01        LAT=7911        LON=-14304
;UTC--MHz--Call--SNR,dB--QSB,%--Evidence--Delay,ms
00:00:00        14      4U1UN    0.0     65       2.47     26
00:00:10        14      VE8AT   -8.2    100       0.14     32
00:00:20        14      W6WX     1.8     62       2.34     25
```

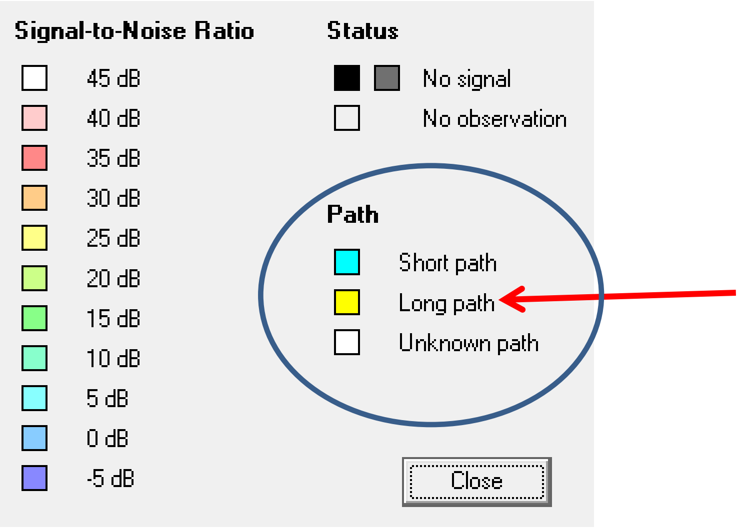
Record Structure

Each record in the log file represents a single observation of the beacon transmission in a 10-second slot. The record consists of 7 tab-separated fields, followed by a CR/LF code. Tab-separated data can be easily imported into MS Excel, MS Access and many other data management programs. The following fields are included in a record:

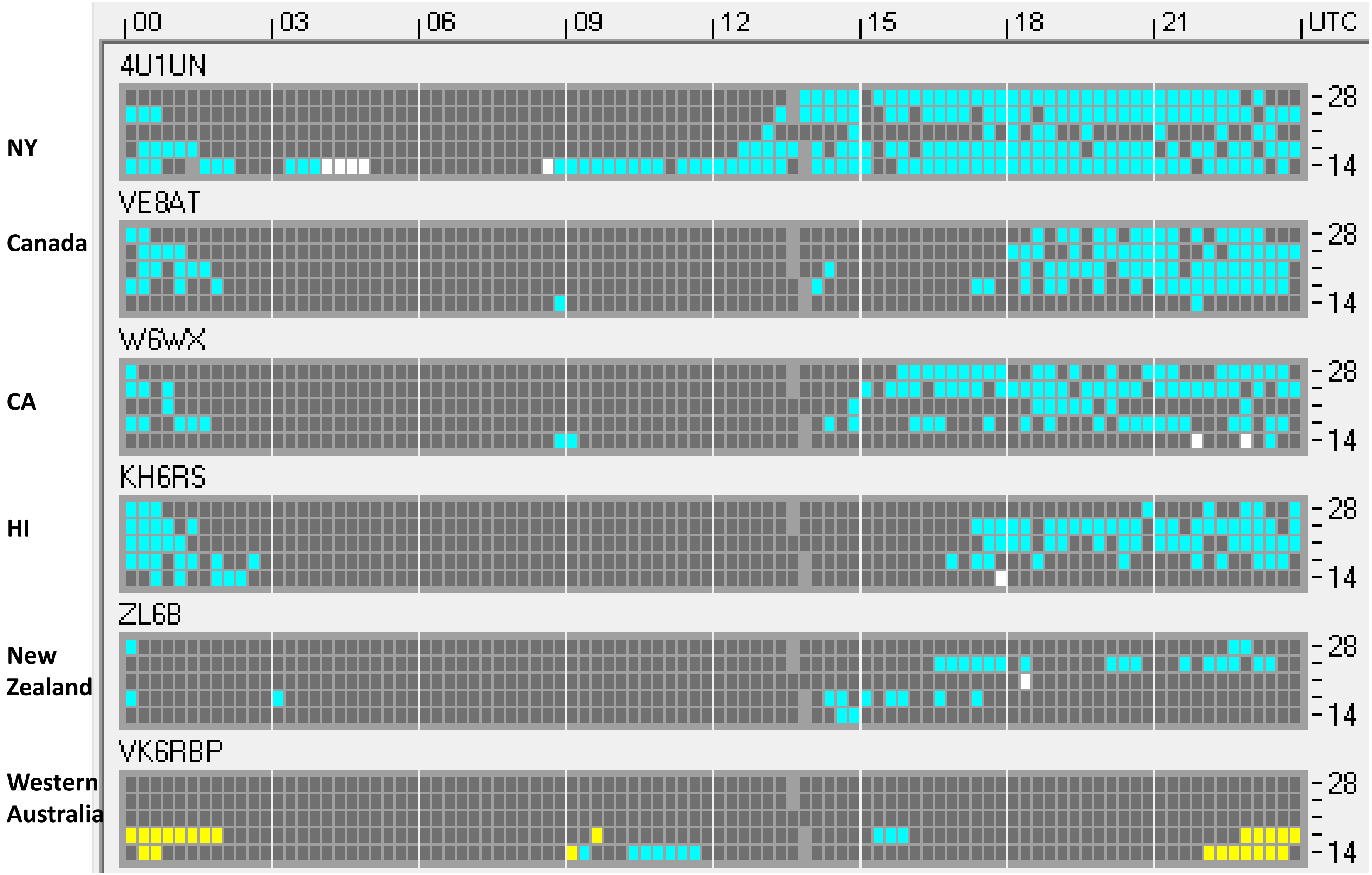
- **UTC** - the time of observation, UTC;
- **MHZ** - the band, in MHz;
- **Call** - the callsign of the beacon;
- **SNR** - the SNR, in Db, of the signal. The SNR is defined here as the ratio of key-down signal to average noise level, in the absence of signal, in an effective noise bandwidth of 100 Hz. See the following paper for a discussion of the SNR definition: *The Weak-Signal Capability of the Human Ear*. Ray Soifer, W2RS. Proceedings of the 36th Conference of the Central States VHF Society.
- **QSB** - the QSB index, defined as the fraction of time on a scale from 0% to 100% during which the signal was below the noise;
- **Evidence** - a measure of probability that the received signal was transmitted by the beacon, on a logarithmic scale. The detection threshold is Evidence = 1.
- **Delay** - the interval, in milliseconds, between the start of the 10-second time slot and the moment when the signal appeared in the audio data. This interval includes the hardware latency of the transmitter and receiver, and the ionospheric propagation delay.

Beacon Reception
11 Jan 2024

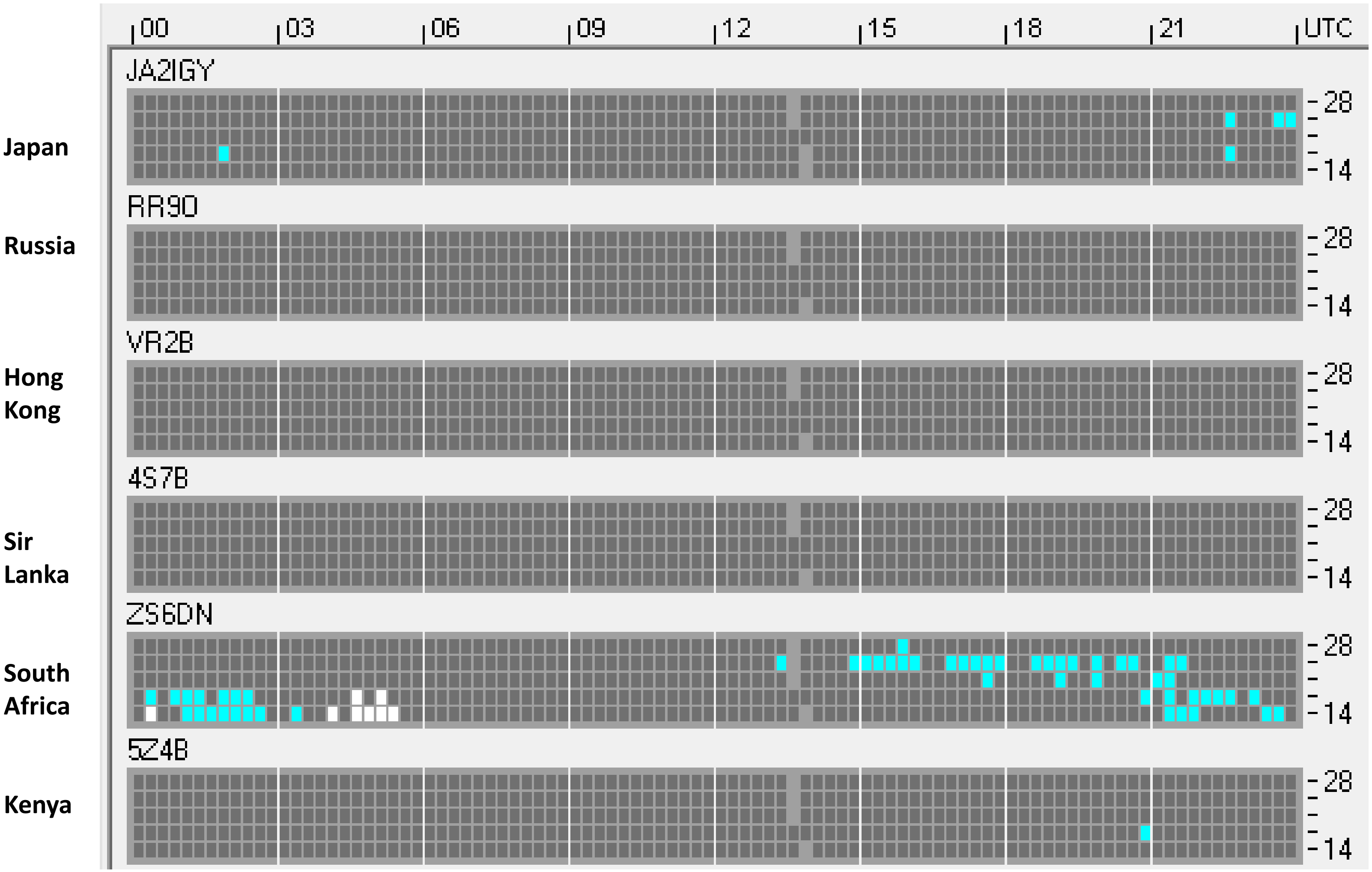
- SSN = 151
- SFI = 193
- Kp = 2, 3 (quiet geomagnetic field)
- Note: Legion



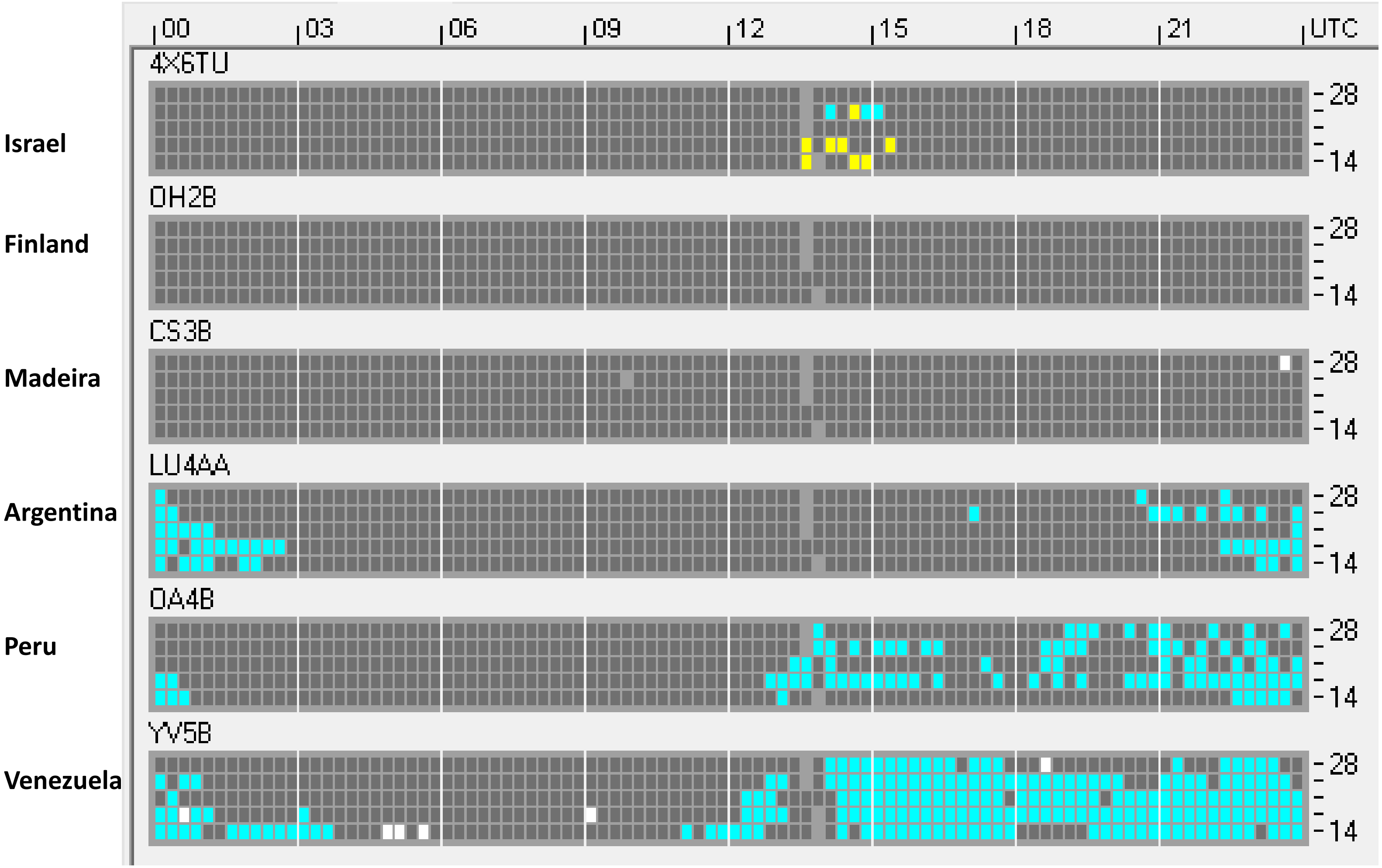
Beacon Received – 11 Jan. 2023



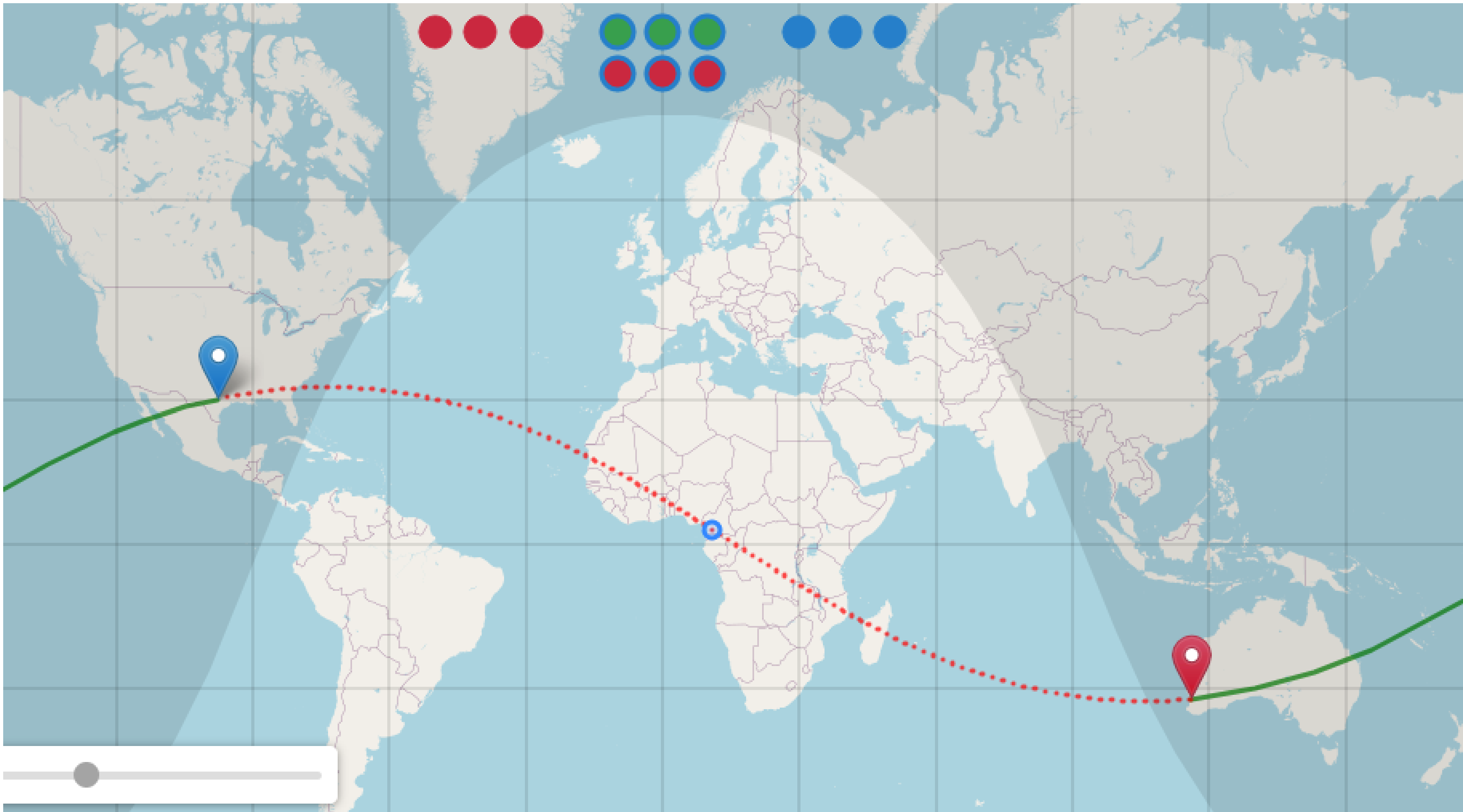
Beacon Received – 11 Jan. 2023



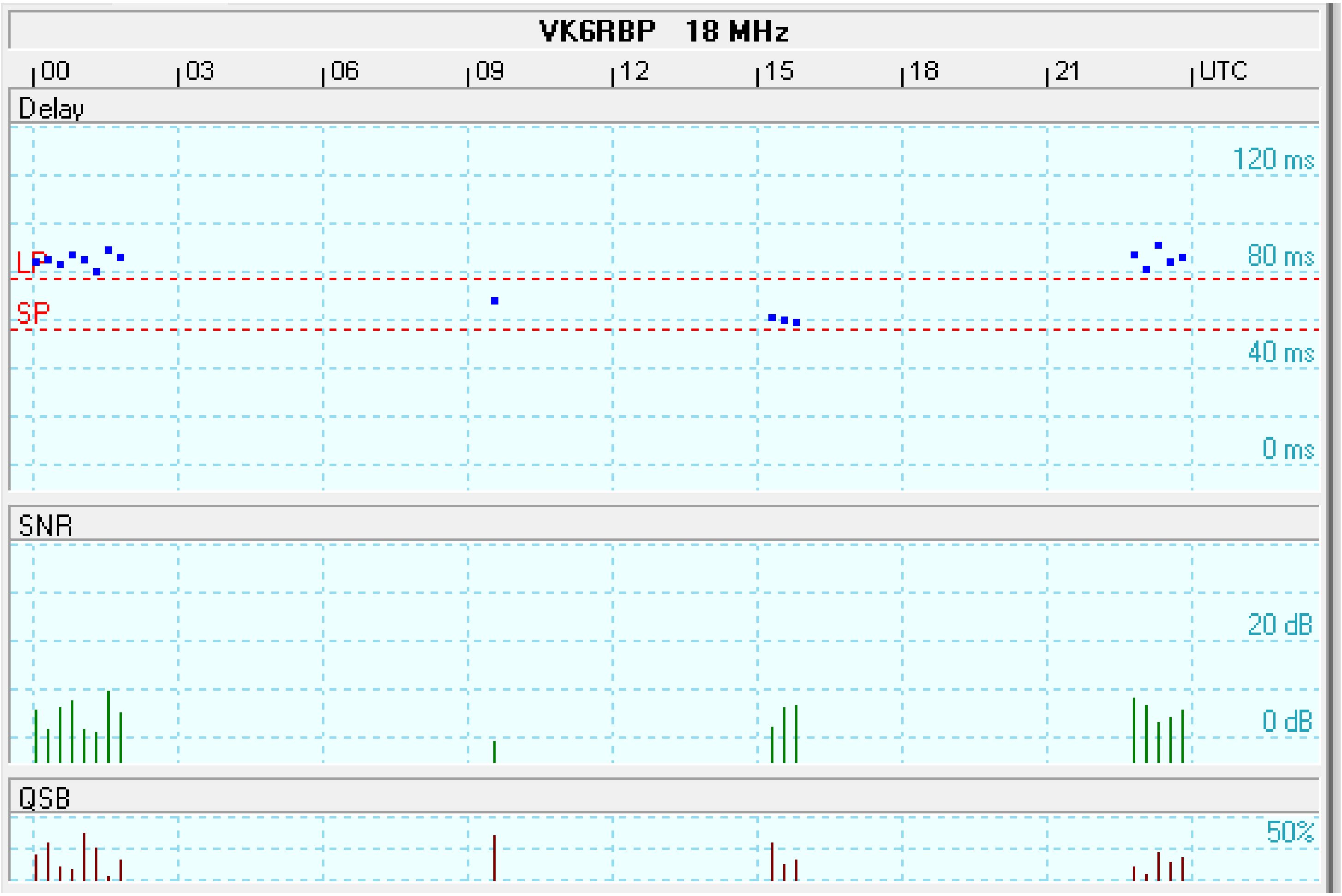
Beacon Received – 11 Jan. 2023



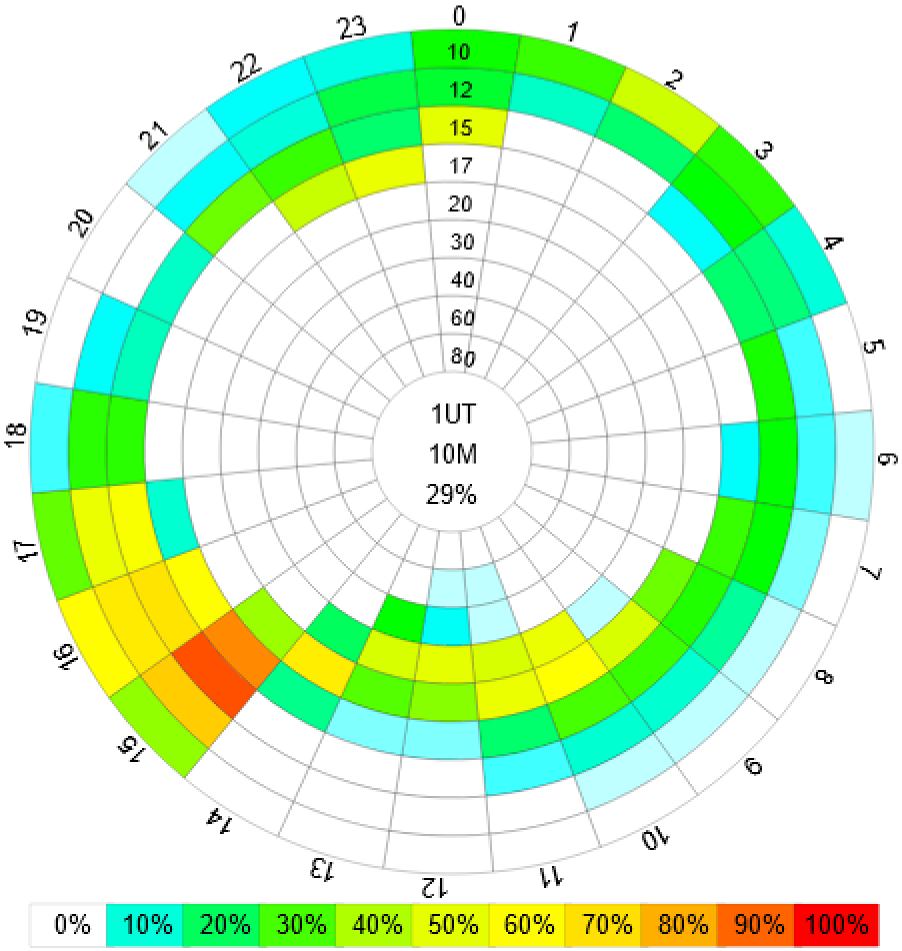
Western Australia Long Path



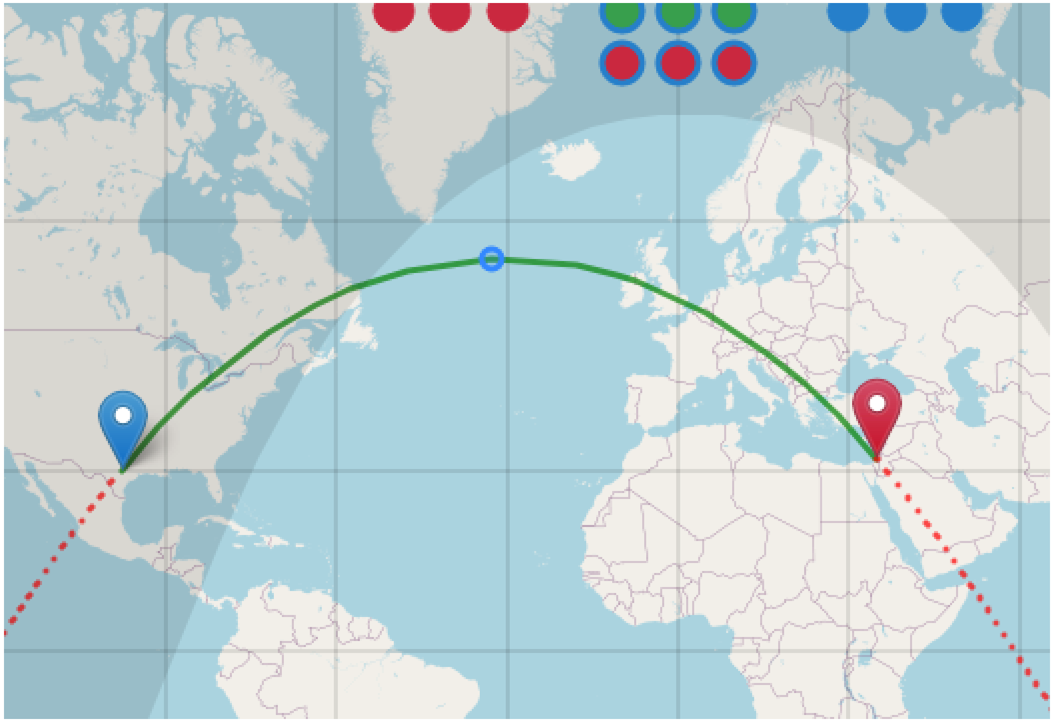
FAROS VK6RBP Long Path



Western Australia – Prop wheel

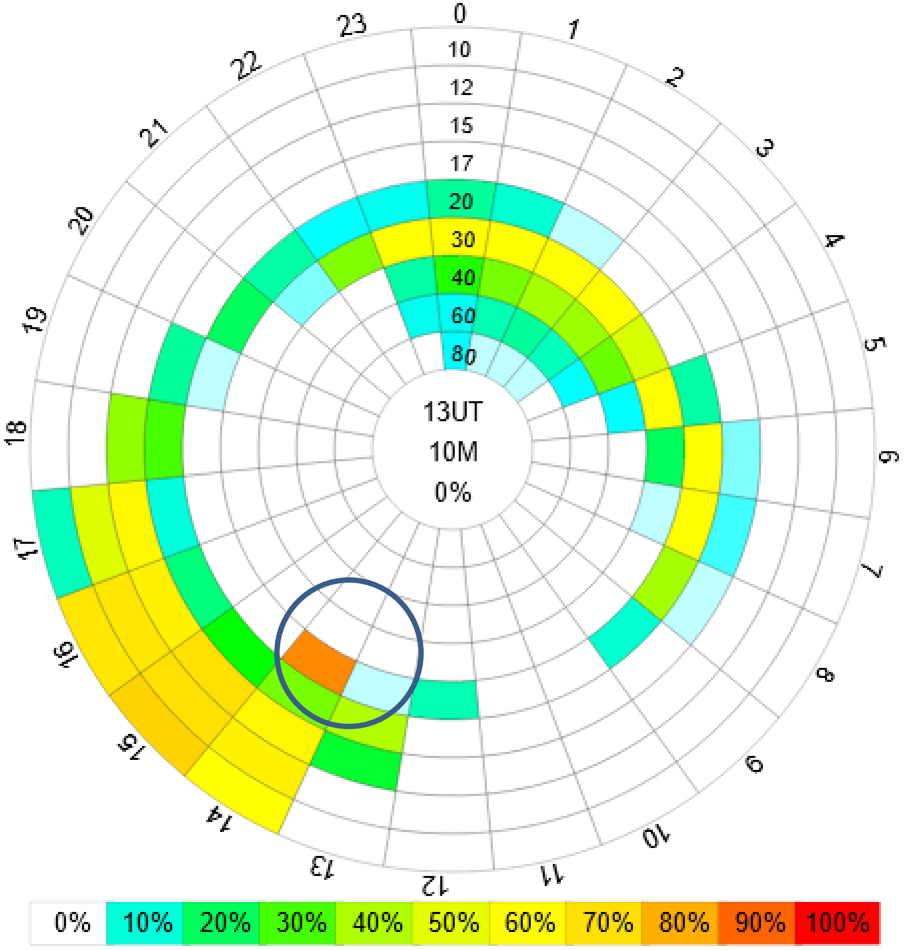


Propagation Path – VOACAP Israel



FAROS 4X6TU (Israel)

Prop Wheel for Israel



Conclusions from 2024 Study

- Note <u>FAROS and VOACAP path discrepancies</u> for Western Australia and Israel.
- VOACAP did not report the Long Path propagation correctly as detected by FAROS.
- I suspect these propagation paths included multilayer hops may not be properly modeled in VOACAP.
- You can see the advantage of using the NCDXF Beacons!

SUMMARY

- HF propagation is complicated and best determined by reception of beacons (actual signals).
- Propagation programs, using VOACAP, do a good job during quiet geomagnetic conditions.
- Operate near the MUF for each circuit to minimize D-layer absorption and maximize signal strengths.
- Best propagation follows the sun, but do try long-paths if using a Yagi by turning 180˚.

Questions?

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University of Texas at Austin

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