

# Near Vertical Incidence Skywave (NVIS)

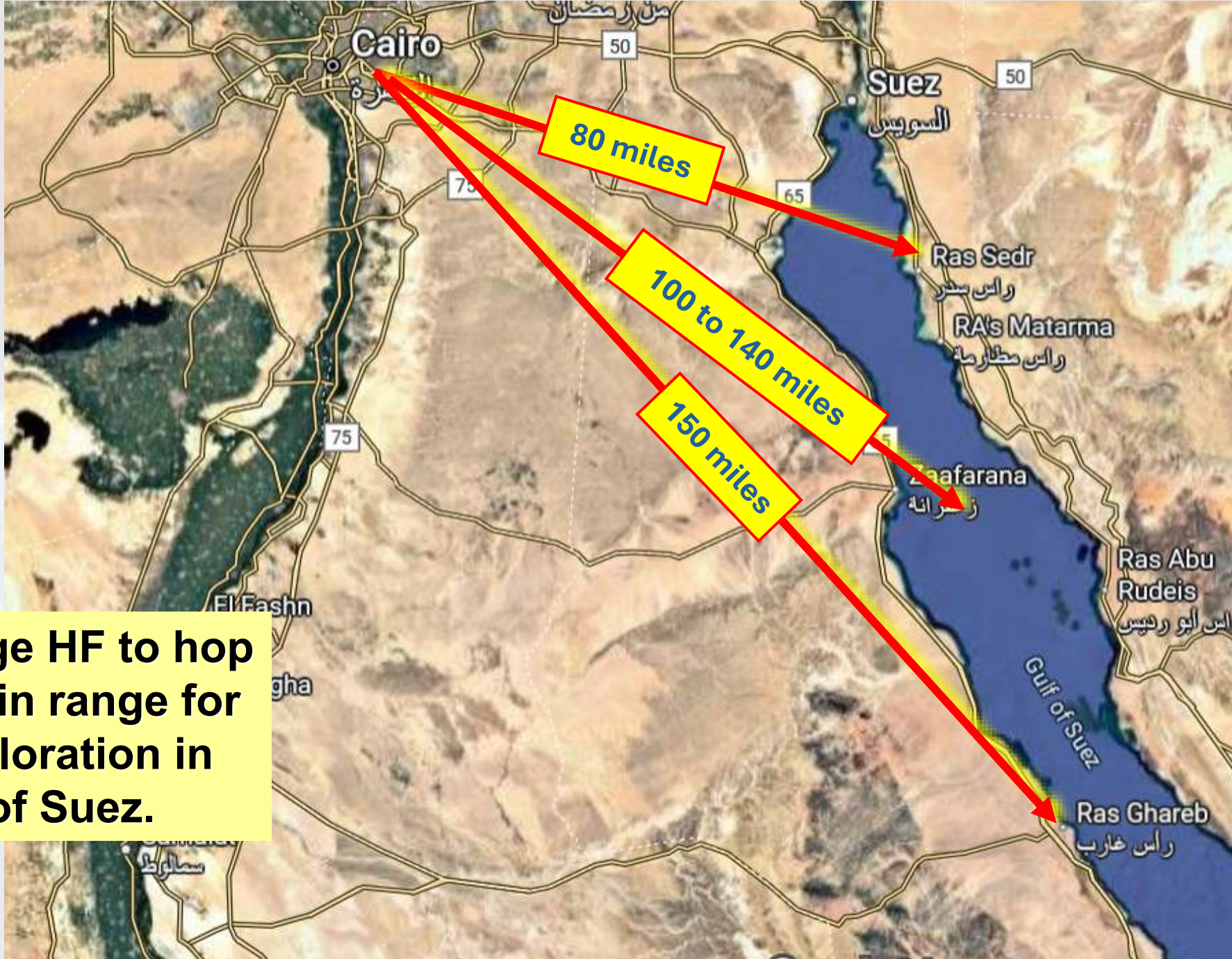
Reliable HF Propagation  
for  
State and Regional  
Emergency Communications

# Topics

- ❖ Capabilities of NVIS
- ❖ Antenna Terminology, Propagation Terminology, and Ionospheric Layers
- ❖ Why do we need NVIS?
- ❖ Defining NVIS.
- ❖ Relationship between Path Length and Maximum Usable Frequency (“MUF”).
- ❖ Relationship between Layer Height and MUF
- ❖ Required Take-off angles
- ❖ Signal to Noise Ratio (SNR)
- ❖ Antenna Efficiency
- ❖ Points to Ponder
- ❖ Summary

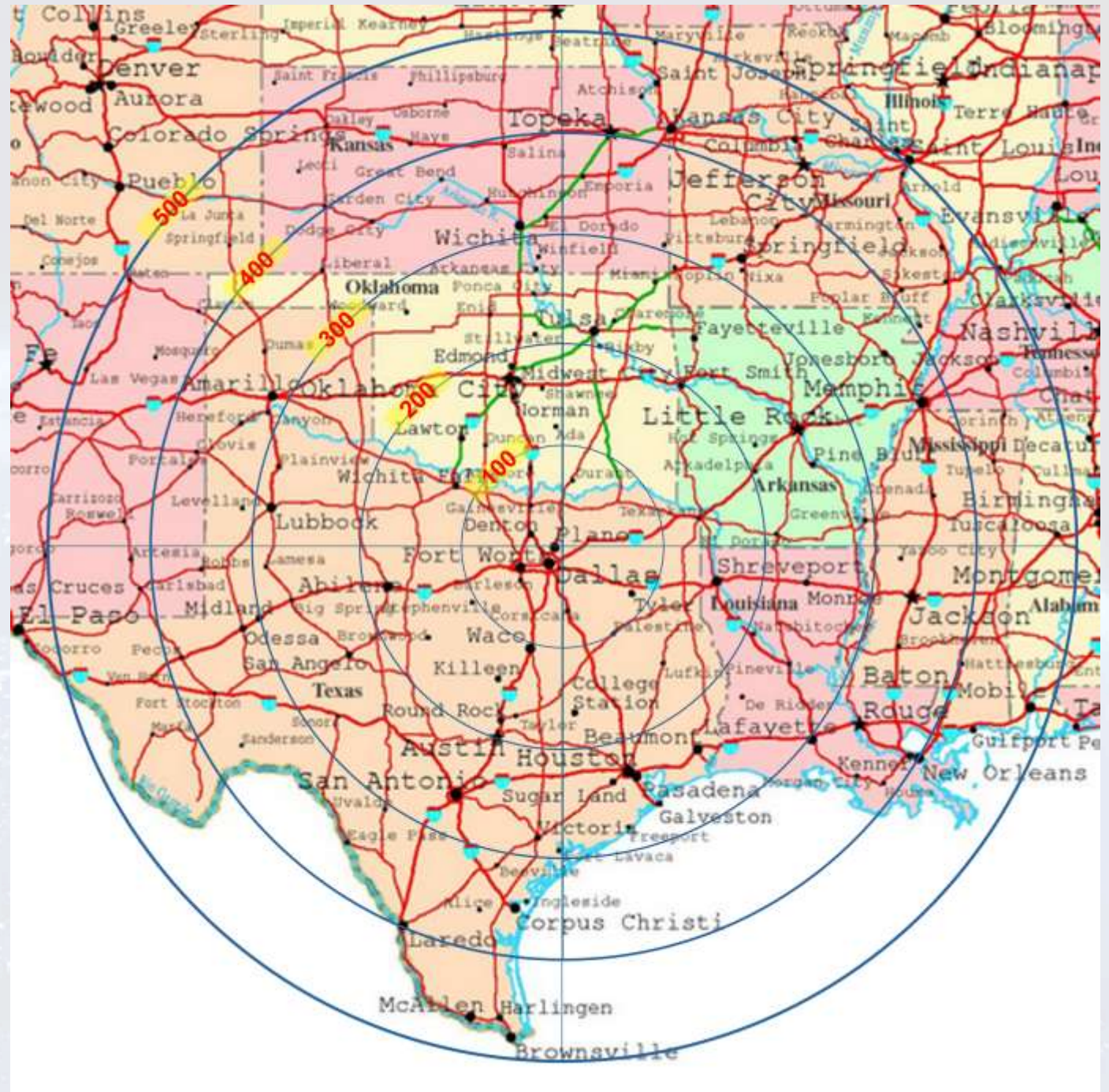
# Tactical and Strategic Encrypted Military Communications





**Short range HF to hop  
a mountain range for  
Gas exploration in  
Gulf of Suez.**

**Terrain Independent  
wide area  
communications within  
about 40 to near 500  
miles.**



# So, What can NVIS do?

- ❖ Connect sites on opposite sides of mountains.
- ❖ Connect and coordinate a wide network of stations.
- ❖ Use relatively low powered HF radios.
- ❖ Operate without commercial power.
- ❖ Operate without infrastructure.
- ❖ Use what we DO have.
- ❖ Use any available power source.
  - ❖ A vehicle – or pull the battery from a destroyed one.
- ❖ Charge Battery with:
  - ❖ Solar panel(s).
  - ❖ Wind power.
  - ❖ Anything that can turn an alternator. (e.g., a bicycle)



# Basic Propagation Terminology

**NVIS** is (0 to ~500 miles) *skywave* communication with high take-off angle.

**Take-off angle** is the *angle of launch and reception* at earth; the angle of the ray *for a specific path*.

**SSN** is Smoothed Sunspot Number.

**MUF** is Maximum Usable Frequency. That is, the highest frequency:

- Launched from “Point A” *that will be returned to earth at “Point B”*.
- *In other words:*  
*highest frequency refracted back to earth at THIS distance.*

**LUF** is Lowest Usable Frequency; the lowest frequency launched from “Point A” that will be returned to earth at “Point B” *with sufficient strength to overcome path loss and absorption*.

# Antenna Terminology

**Short Antenna** Any antenna length less than  $\frac{1}{4} \lambda$  (wavelength) for a monopole, or  $\frac{1}{2} \lambda$  for a dipole.

**Length is the Primary determinant of Feedpoint Resistance.**

This is the *Resistive* portion of impedance at antenna feedpoint.

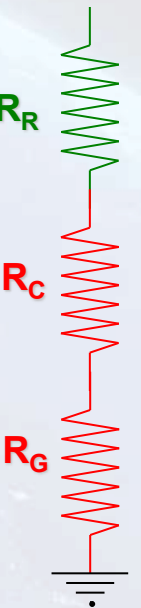
Feedpoint Resistance consists of:

**Radiation Resistance** (  $R_R$  ): (i.e., *pure resistance* that would dissipate same amount of power *actually radiated* by the antenna)

This is the *only* portion of impedance that results in radiation.

**Material Resistance and Coil Resistance** (  $R_C$  ): Resistance of antenna material and (for a loaded antenna) resistance of loading coil(s).

**Ground Loss** (  $R_G$  ): Portion of antenna feedpoint resistance that results from “warming worms”.



# Ionospheric Layers

**F2 Layer** -- Layer most responsible for HF communications.

- Virtual height falls between 200 and 550 km.

**F1 Layer** -- Lowest F layer, *present in daylight “split F” conditions.*

- Virtual height falls between 160 and 250 km.

**E Layer** Primarily a “spoiler” layer, impacting NVIS only in daylight.

- Virtual height falls between 95 and 120 km.
  - Sporadic E is useful for VHF/UHF long range and unpredictably occurs day or night.

**D Layer** Present only in daylight. Absorbs **low HF** range. Effect is greatest in summer, below 7 MHz.

- Virtual height falls between 50 and 90 km.
  - Doubling frequency **decreases** D layer absorption by a factor of four.
  - BUT the MUF **for that distance** must support that higher frequency.

# Why do we need NVIS ?

**ONLY** reliable mode for wide area Emergency Communication

- All commercial telephone services – including cellular - failed in the area struck by Katrina.
- All remained out for more than 10 days.
- Most repeaters in the area also failed.
- Louisiana statewide trunked system failed.
- NVIS HF radio provided the first (and, for many days, the only) communication to the outside world and within the disaster area.

**Regional nets:**

- Texas nets, Gulf Coast Nets, state RACES, ARES, SATERN, CAP, MARS, etc.

# NVIS is not...

- Defined by distance
- “Wires on the ground”
- “Warming Worms”
- Vertically polarized

# Near Vertical Incidence Skywave (NVIS)

This presentation will demonstrate that:

- NVIS is defined best by take-off angle
- A given path may be NVIS at some times, and non-NVIS at others
- Whether a path is NVIS or non-NVIS is dependent upon:
  - Smoothed Sunspot Number (SSN)
  - **AND** Season
  - **AND** Time of day
  - **AND** Chosen Frequency
- NVIS requires a Horizontal antenna
- NVIS antenna efficiency is **very** important
- There is an optimum height for an NVIS antenna

# NVIS Range Circles

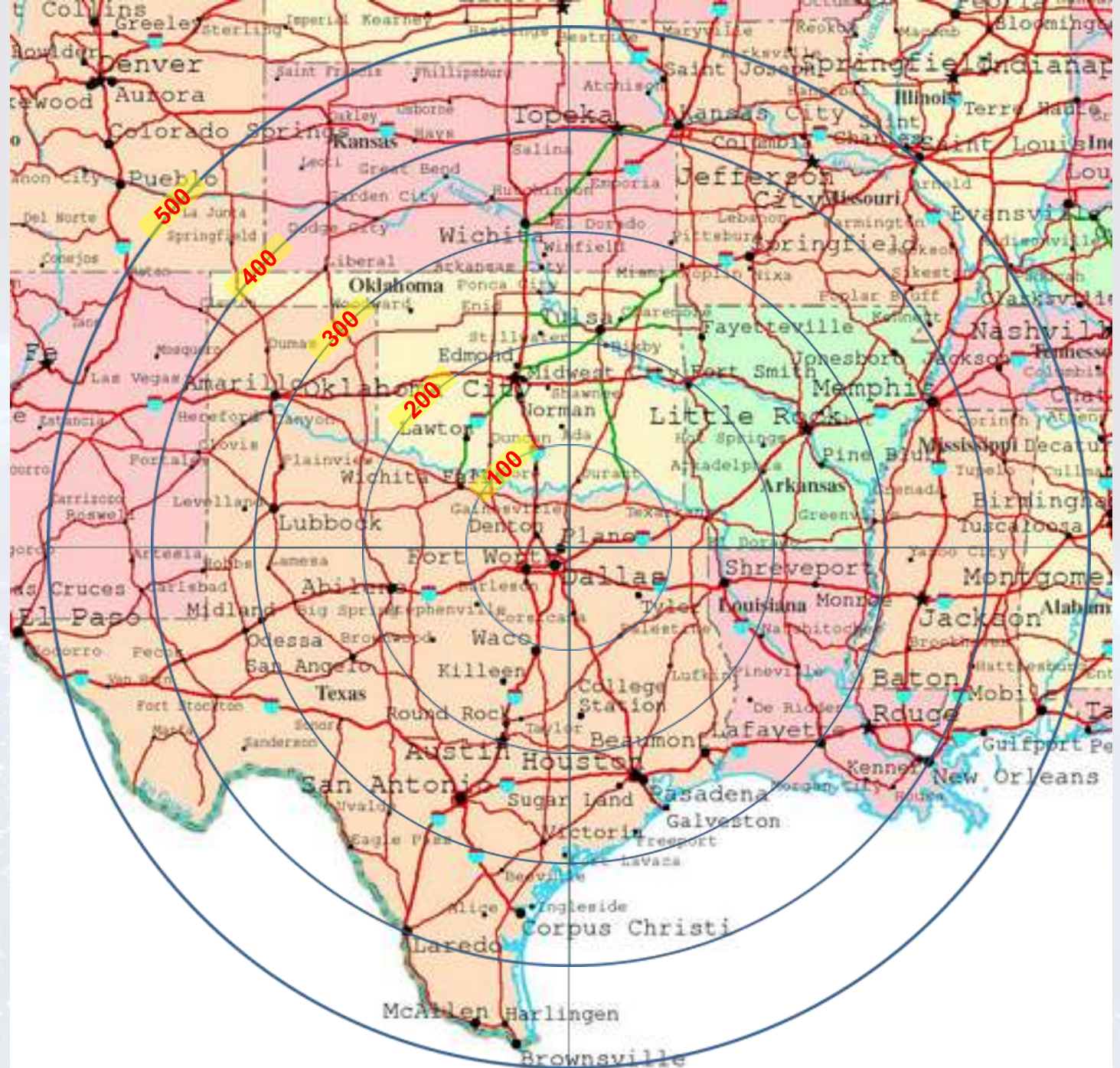
NVIS coverage from Richardson, TX:  
(Based upon 400-mile circle)

- Most of Texas
- All of Oklahoma
- All of Arkansas
- All of Louisiana
- Southwest Missouri
- Most of Mississippi

Including:

- Memphis, TN
- Kansas City, MO
- Topeka, KS

The 500-mile circle is  
“sometimes NVIS, sometimes not”



# Relationship between Path Length and MUF

For the same SSN, on the same date:

**Increase** in path length results in **increased** MUF for the path.

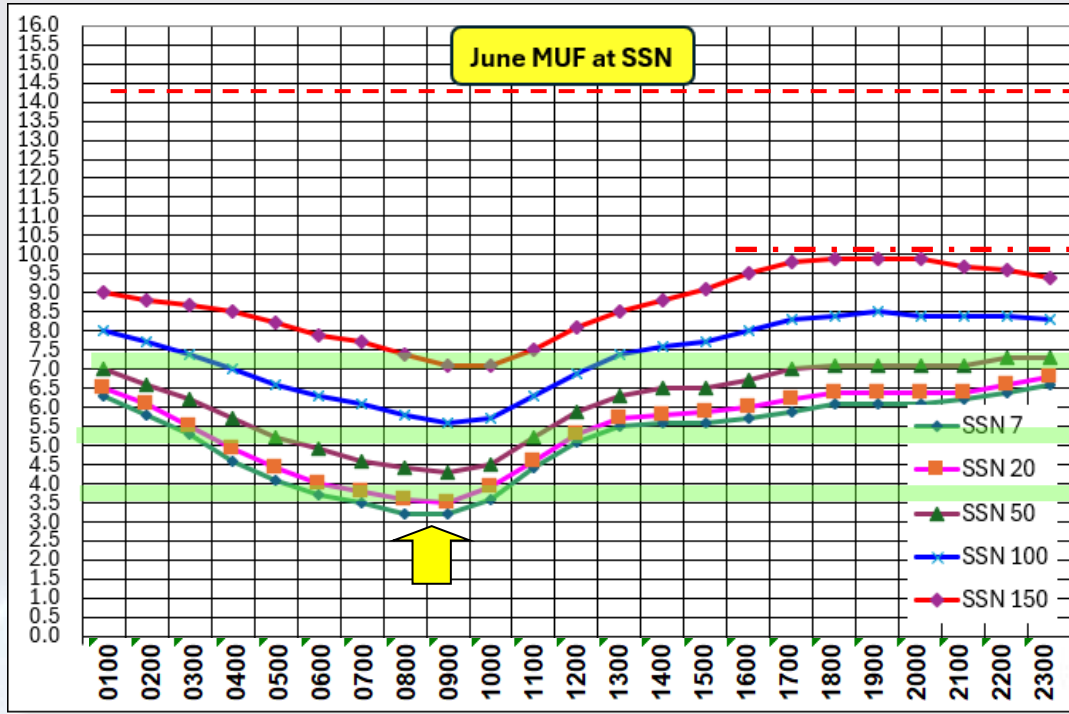
- **Increase** in path length results in **decrease** in angle of incidence at the refracting layer.



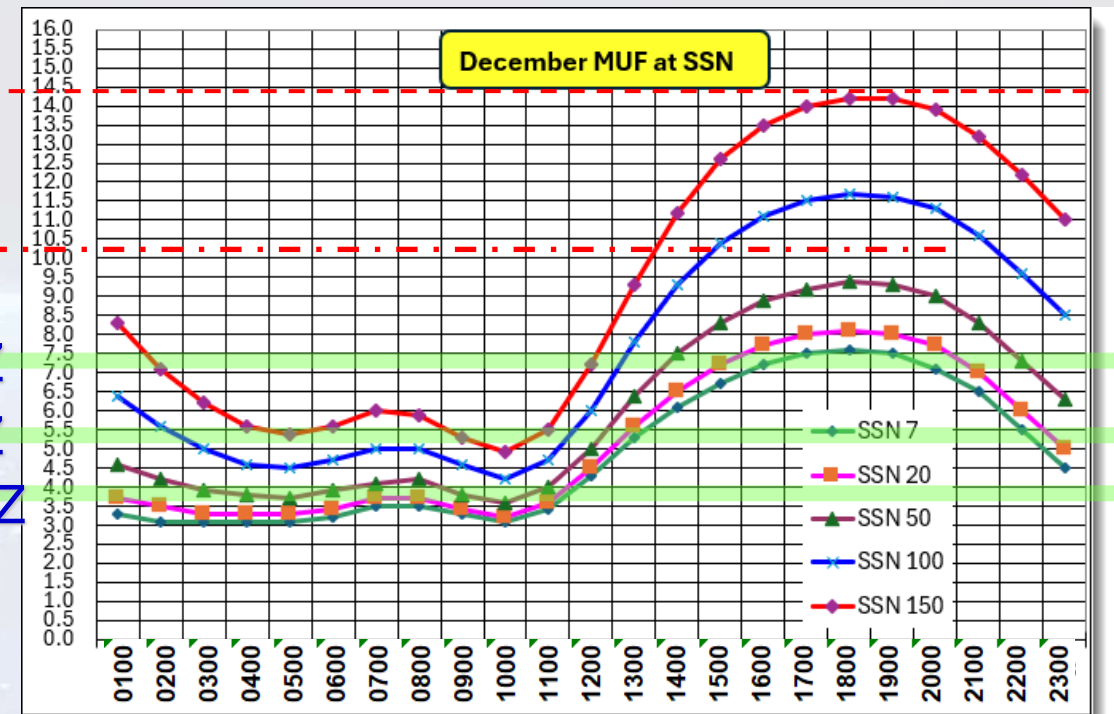
- Decrease in angle of incidence at the refracting layer allows same ion density to refract higher frequencies.

The *Virtual Height* of the refracting layer is:  
the altitude of an *imaginary* solid layer that **reflects**  
at the same angle as the *apparent* layer **refracts**.

# MUF Comparison – 2025 June vs December 50 mile path



June



December

All Ionospheric prediction charts prepared using free IONCAP / itsfh Version 16.1207W from the build listed below:

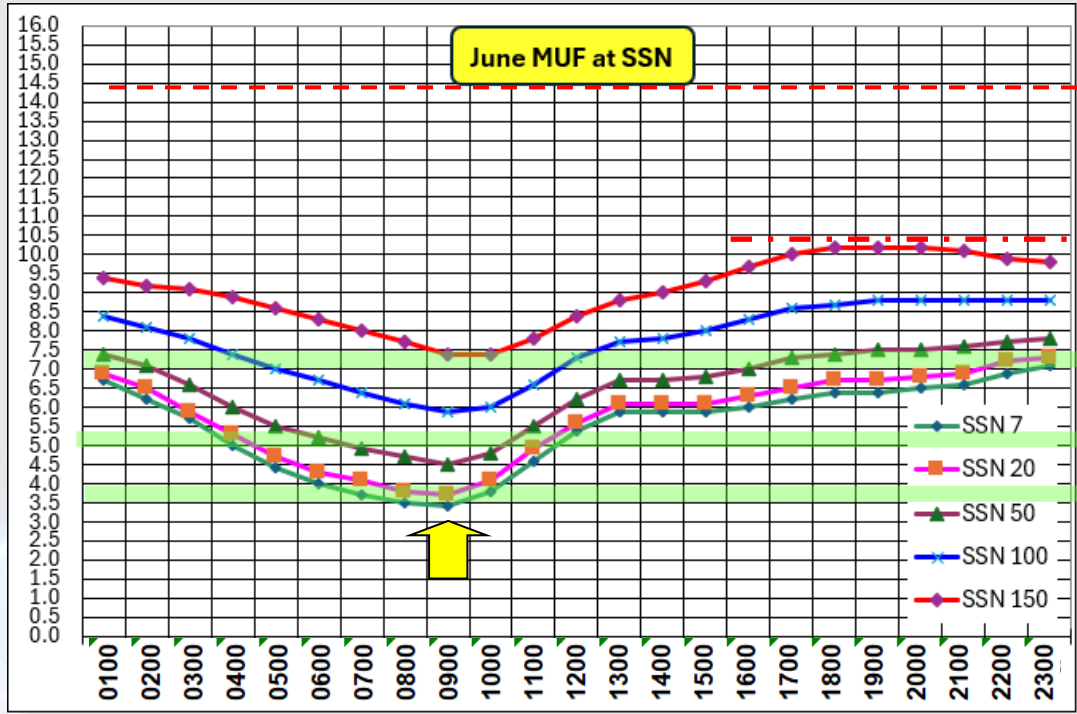
[https://greg-hand.com/versions/itsfhbc\\_180417a.exe](https://greg-hand.com/versions/itsfhbc_180417a.exe)

**NOTE: If you get a browser warning for the download, you safely may ignore it. <https://greg-hand.com/versions> is safe.**

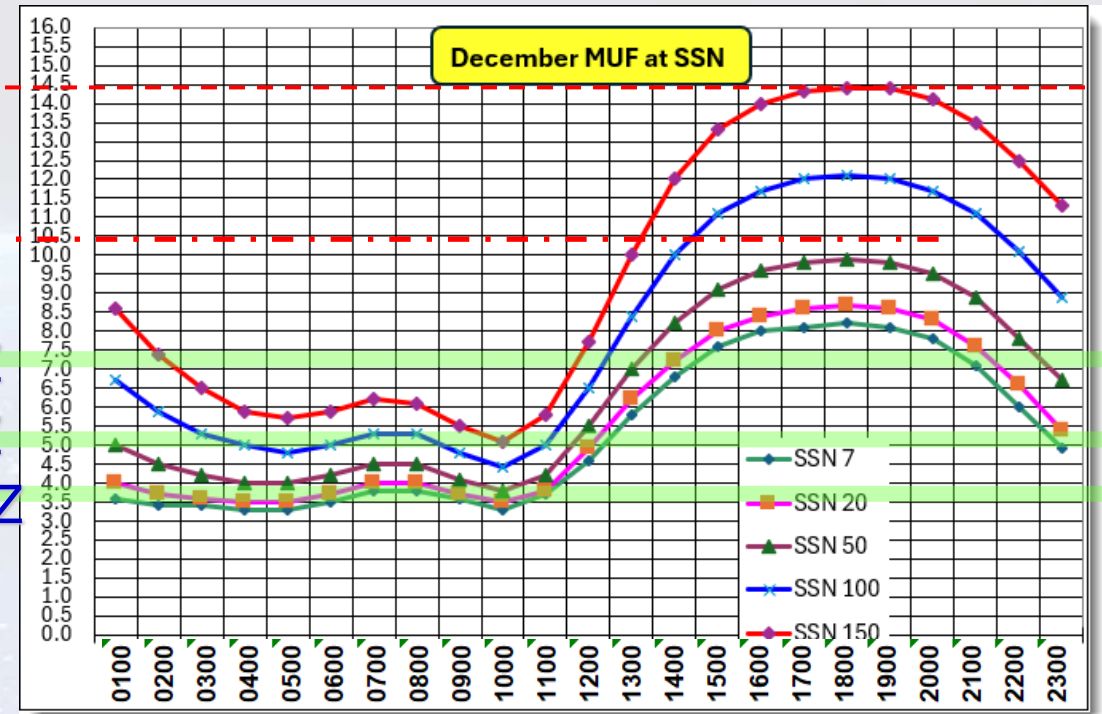
I have added links to the tools that I created to generate these charts on the last page, and on [www.NREGroupLLC.com](http://www.NREGroupLLC.com).

50 miles – Richardson - Sherman

# MUF Comparison – 2025 June vs December 170 mile path



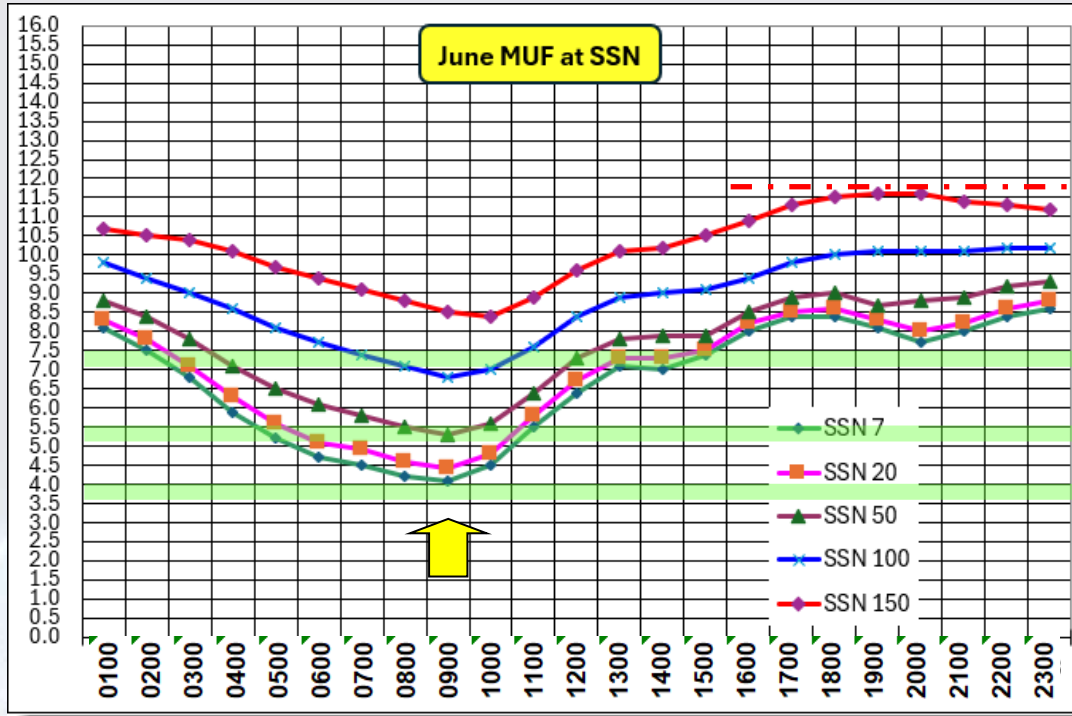
June



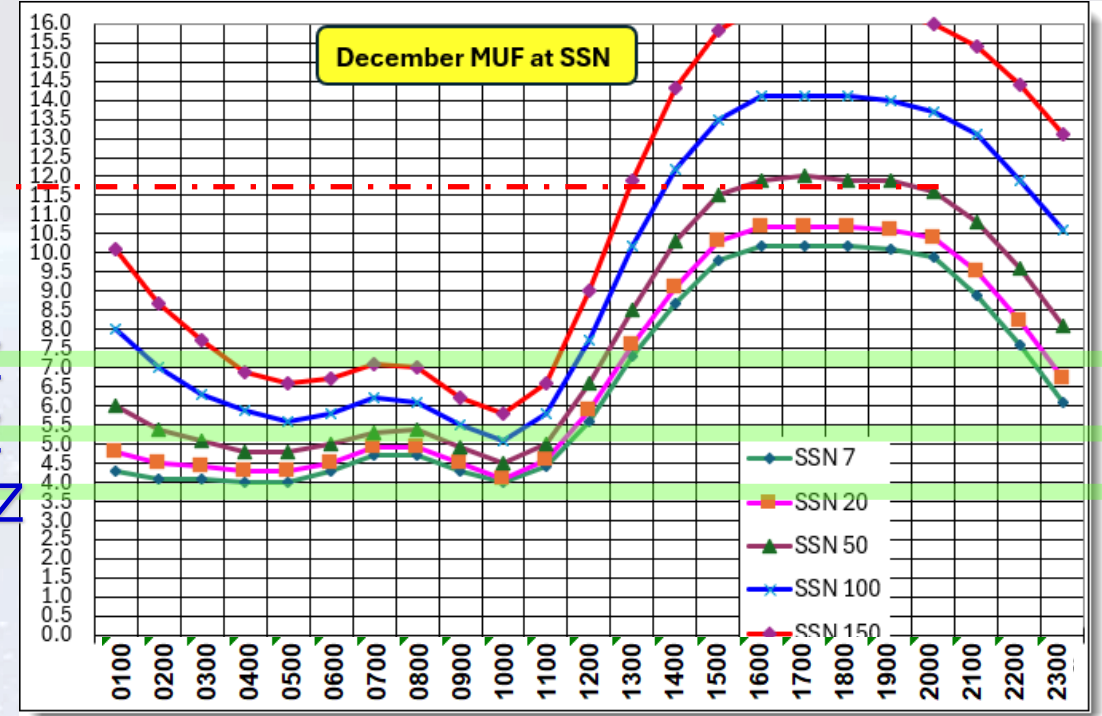
December

170 miles – Richardson - Austin

# MUF Comparison – 2025 June vs December 350 mile path



June



December

350 miles – Richardson – Corpus Christi

# Relationship between Virtual Height and MUF

Increase in SSN results in **increase in Virtual Height** at the MUF.

At any SSN:

- Virtual Height for any frequency is maximum when frequency is **equal** to MUF.
- Virtual Height for any frequency **decreases** when MUF exceeds that frequency

Also note that there is a “Daylight Hump” in Virtual Height.

- This “hump” is centered on local Solar Noon.
- It is prominent during Winter.

# Relationship between Virtual Height and MUF

## 50 miles – Richardson - Sherman

Chart for SSN = 7

MUF (MHz)	UTC	CDST	Vir Ht @MUF	Vir Ht @1.8 MHz	Vir Ht @3.9 MHz	Vir Ht @ 5.2 MHz	Vir Ht @ 7.3 MHz
6.5	0100	2000	378	125	245	271	0
6.3	0200	2100	371	257	247	277	0
5.8	0300	2200	371	241	254	295	0
<b>5.3</b>	0400	2300	<b>374</b>	240	267	<b>351</b>	0
4.6	0500	2400	379	243	290	0	0
4.1	0600	100	384	249	337	0	0
3.7	0700	200	388	255	387	0	0
3.5	0800	300	390	257	389	0	0
3.2	0900	400	389	259	0	0	0
3.2	1000	500	388	262	0	0	0
3.6	1100	600	388	275	387	0	0
4.4	1200	700	390	121	306	0	0

MUF BELOW 4 MHz

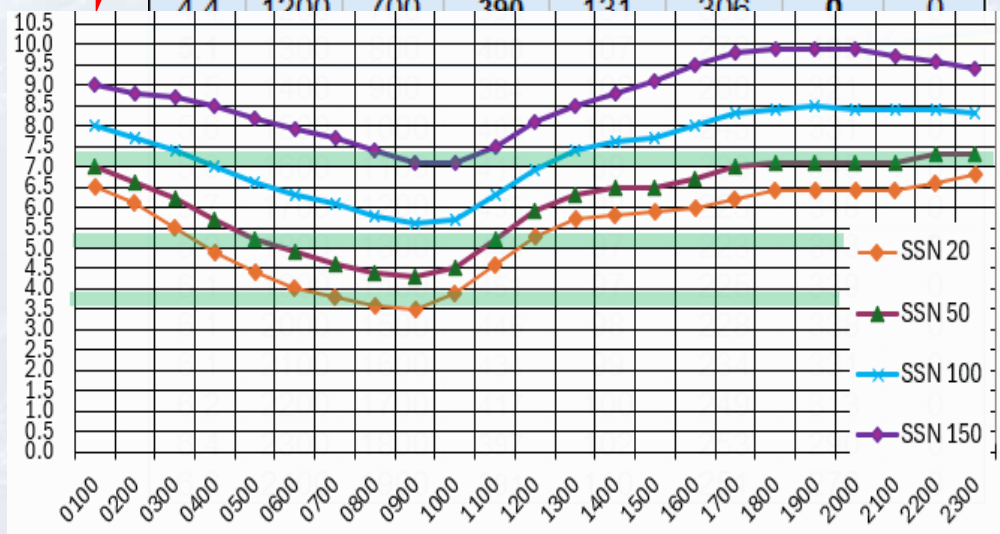


Chart for SSN = 50

MUF (MHz)	UTC	CDST	Vir Ht @MUF	Vir Ht @1.8 MHz	Vir Ht @3.9 MHz	Vir Ht @ 5.2 MHz	Vir Ht @ 7 MHz
7.3	0100	2000	409	132	254	273	393
<b>7.0</b>	0200	2100	<b>404</b>	281	255	278	<b>402</b>
6.6	0300	2200	405	259	262	290	0
6.2	0400	2300	408	254	271	307	0
5.7	0500	2400	413	255	283	338	0
<b>5.2</b>	0600	100	<b>418</b>	258	297	<b>417</b>	0
4.9	0700	200	421	265	311	0	0
4.6	0800	300	422	265	323	0	0
4.4	0900	400	422	267	336	0	0
4.3	1000	500	420	274	342	0	0
4.5	1100	600	418	306	317	0	0
<b>5.2</b>	1200	700	<b>420</b>	116	288	<b>419</b>	0
5.9	1300	800	432	103	276	326	0
6.3	1400	900	431	100	252	311	0
6.5	1500	1000	455	99	230	325	0
6.5	1600	1100	475	98	223	337	0
6.7	1700	1200	489	97	225	340	0
<b>7.0</b>	1800	1300	<b>496</b>	96	222	336	<b>492</b>
7.1	1900	1400	493	96	224	340	526
7.1	2000	1500	485	97	232	342	518
7.1	2100	1600	472	98	228	337	472
7.1	2200	1700	454	99	232	320	491
7.3	2300	1800	434	101	255	299	419
7.3	2400	1900	422	106	262	277	388

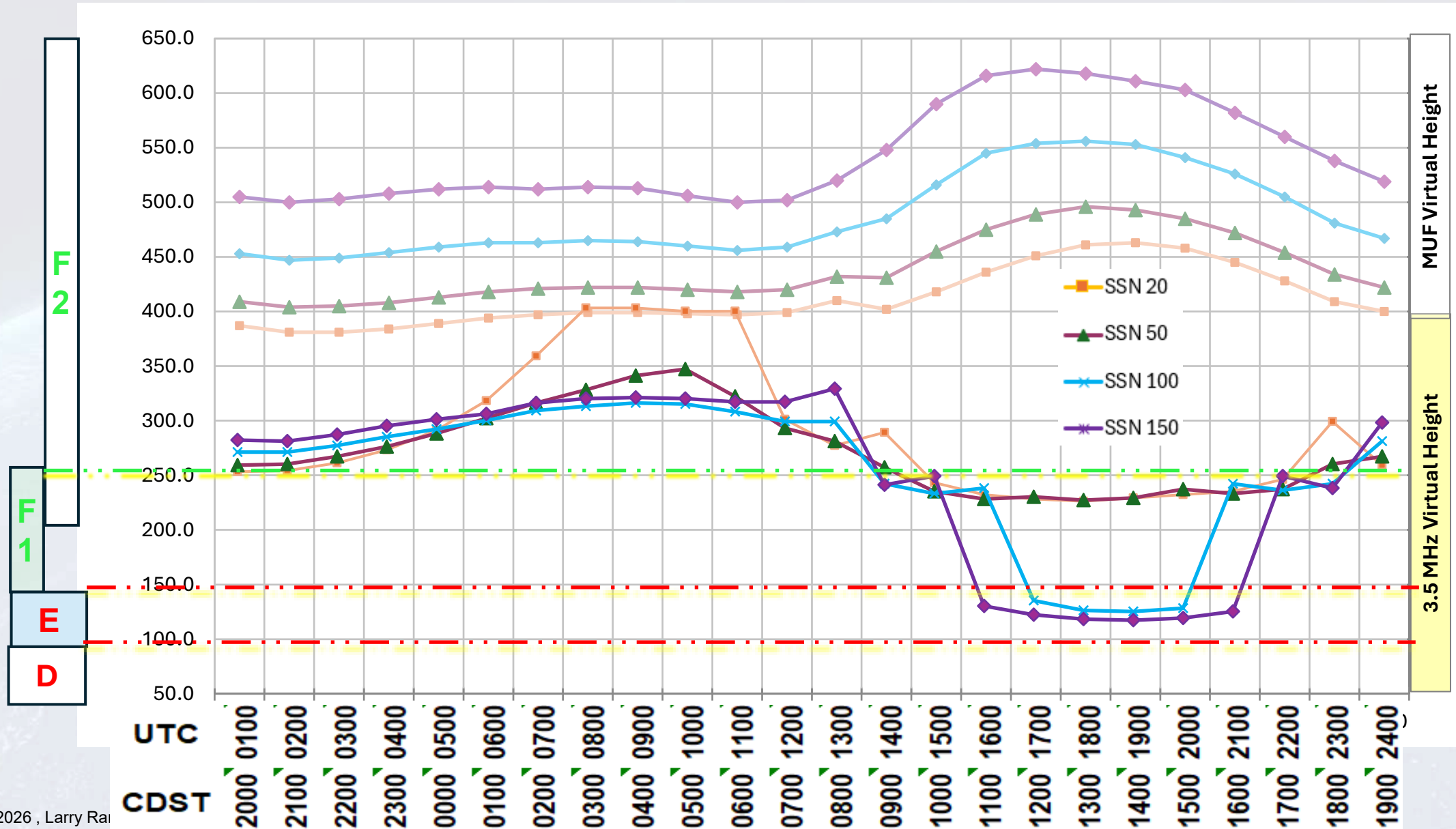
MUF falls to 7 MHz

MUF falls to 5.2 MHz

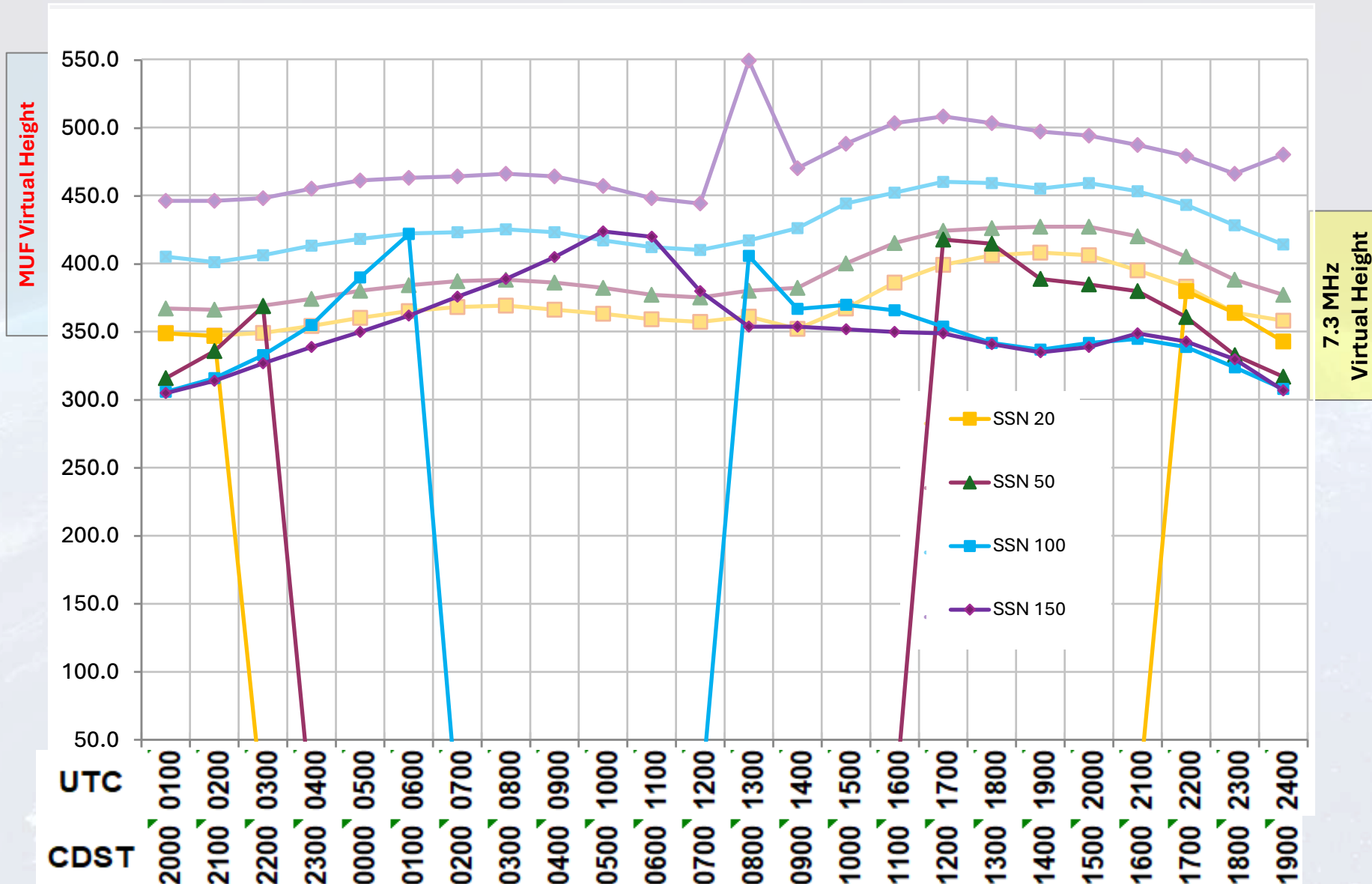
MUF rises to 5.2 MHz

MUF rises to 7 MHz

# Virtual Height @ 3.5 MHz – June DAL-Sherman (50-mile path)



# Virtual Height @ 7.3 MHz – June DAL-AUS (170-mile path)

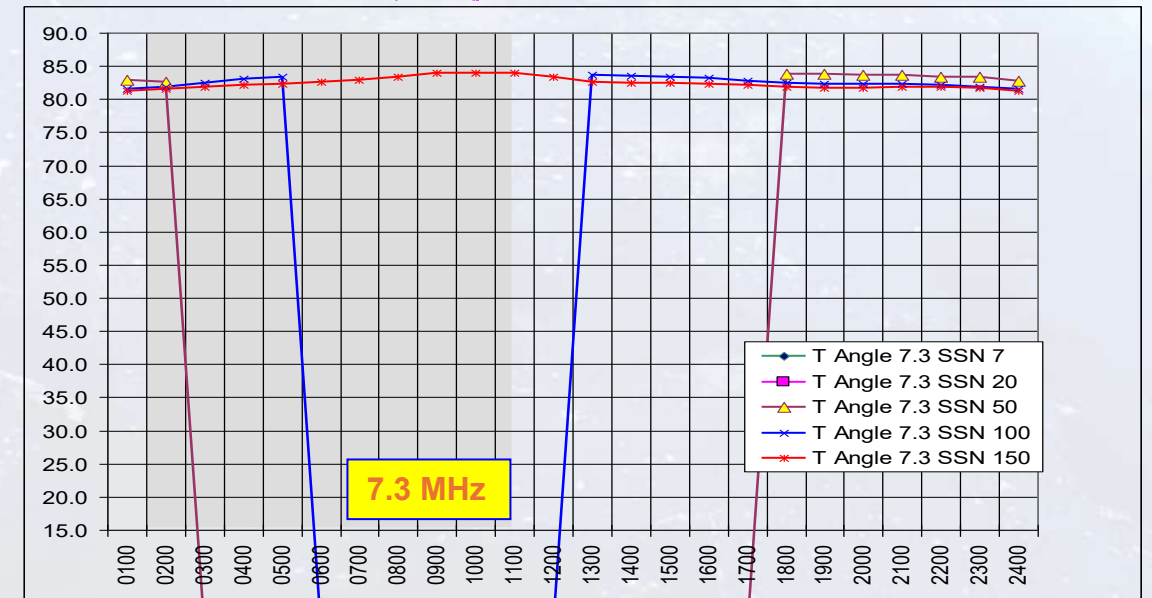
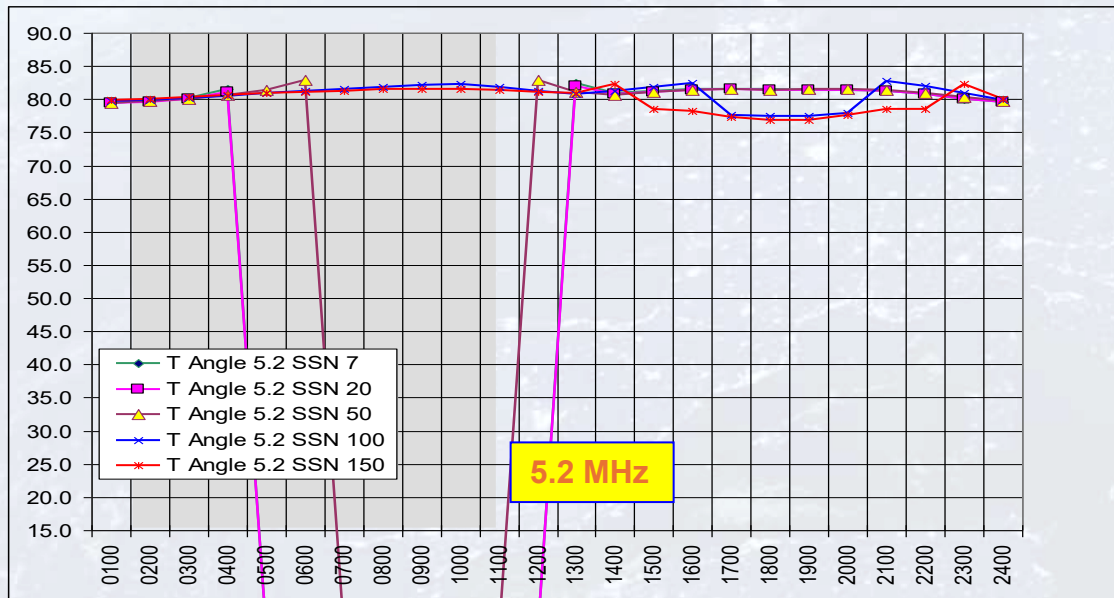
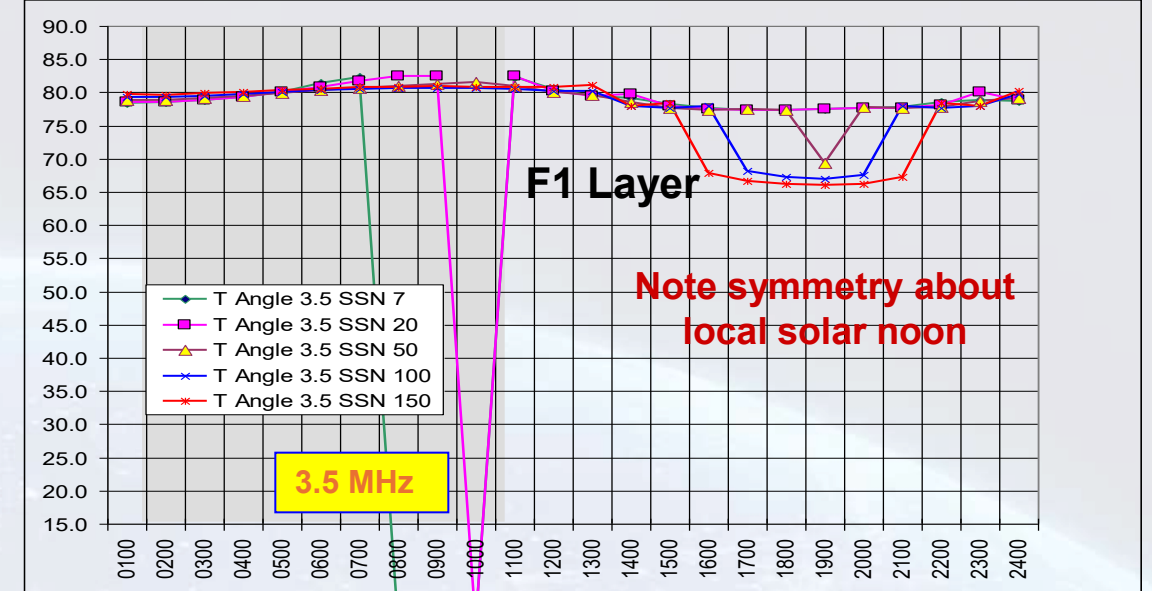
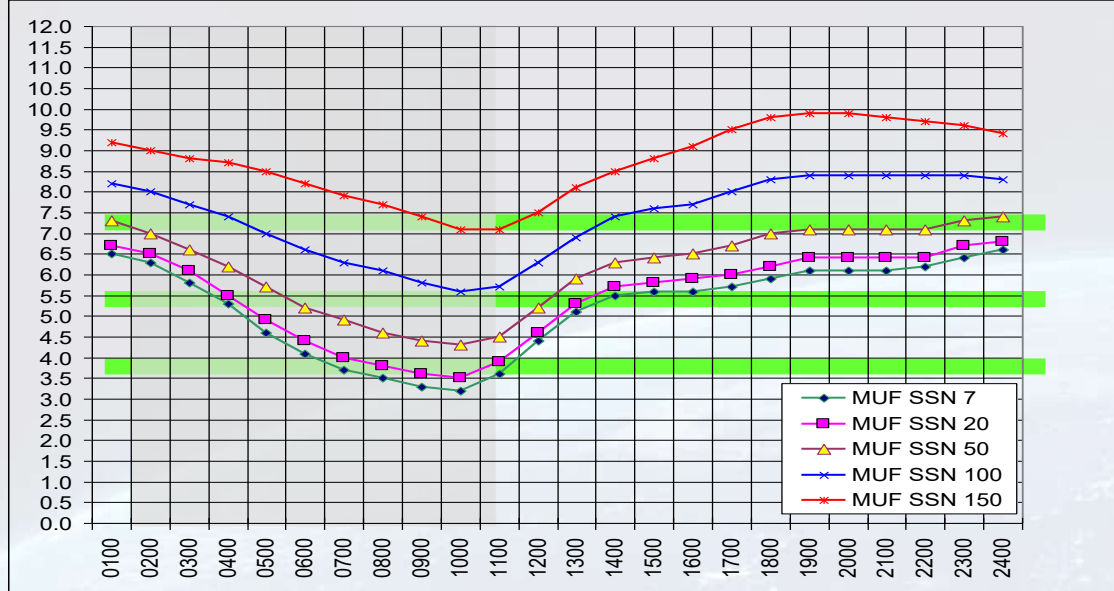


# Relationship between MUF and Take-off Angle

- For a given path and frequency, the take-off angle varies:
  - Greatly with seasons (driven by layer differences)
  - Slightly because of day and night variations
  - Markedly during daylight if the frequency is well below the MUF
  - Within narrow limits if the frequency is near and below the MUF
- The required take-off angle for any “frequency X” **decreases** when the MUF rises past that frequency

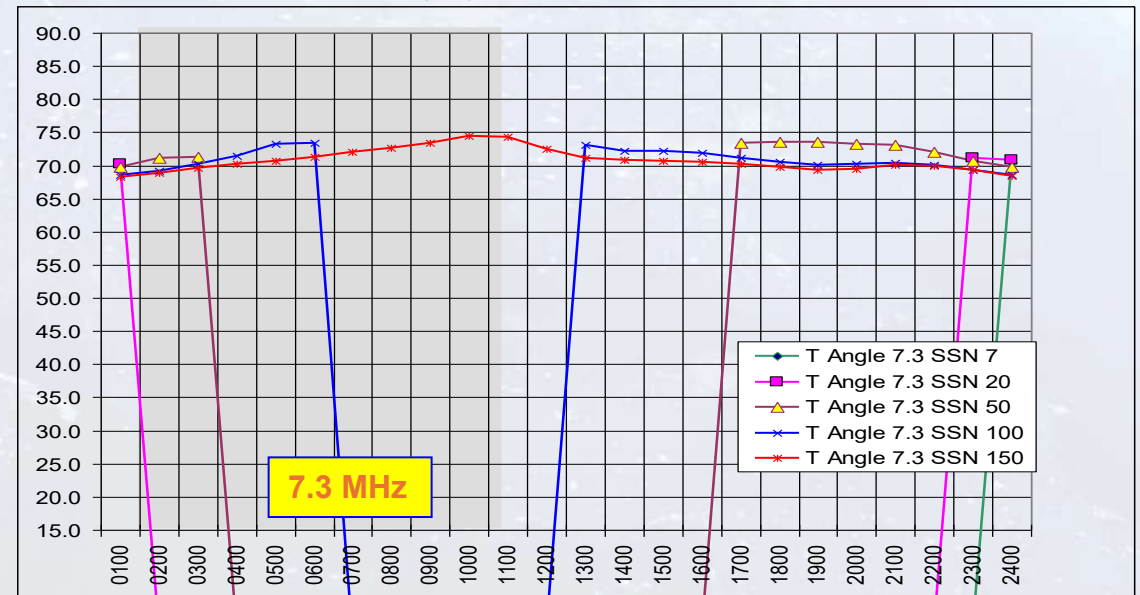
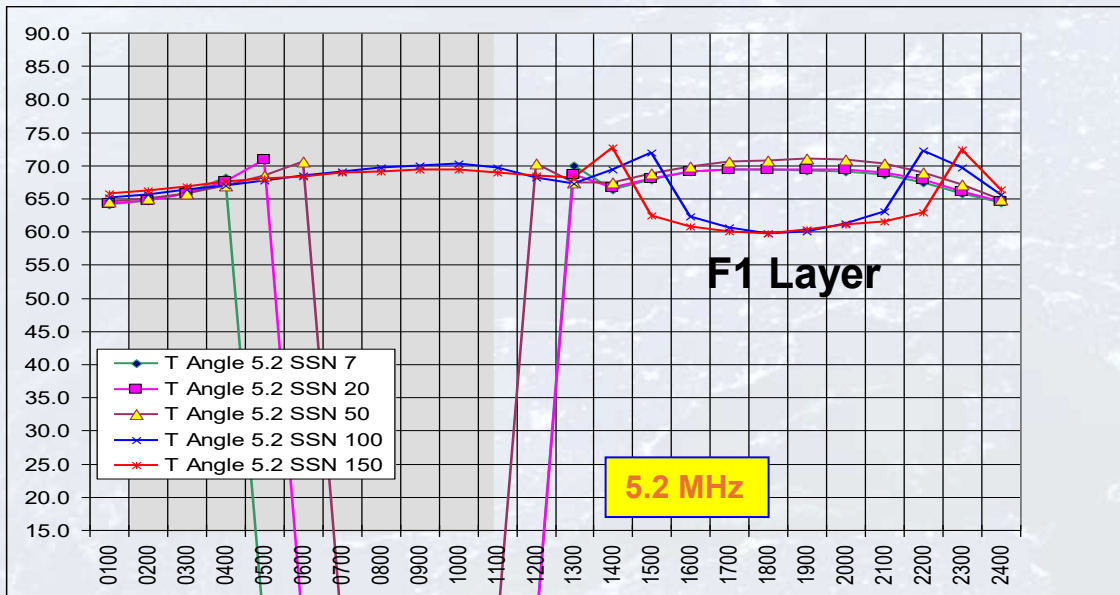
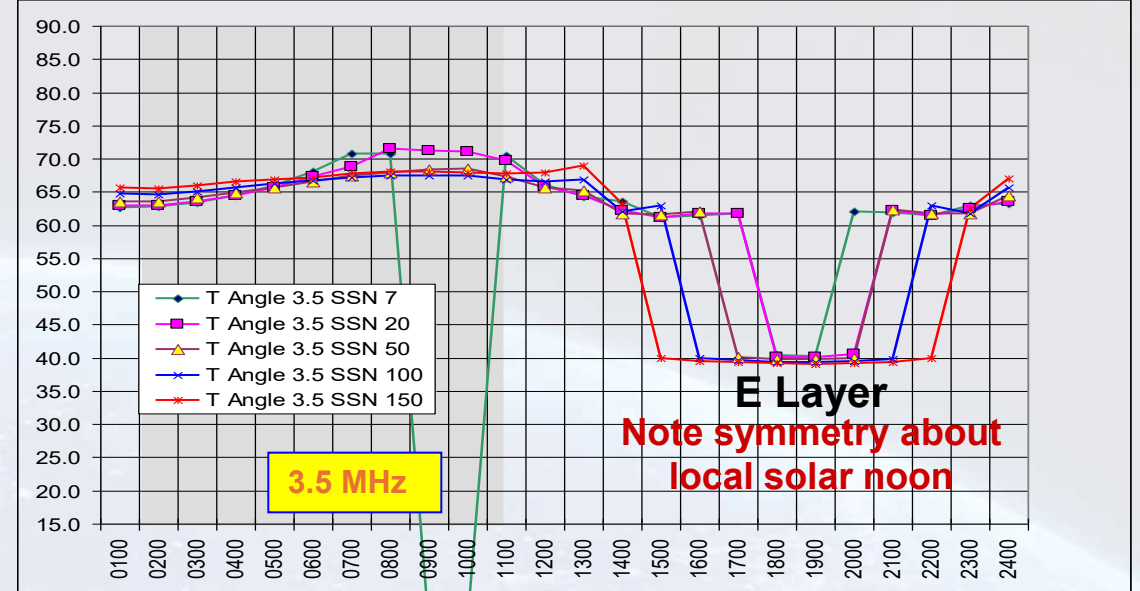
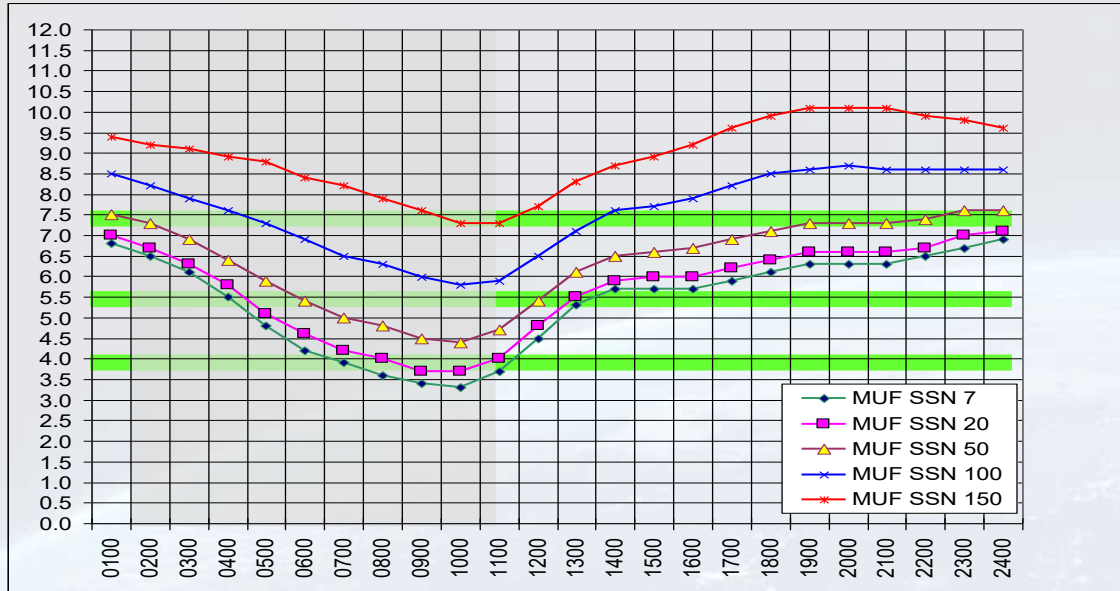
# MUF and Take-off Angle SSN=7 to SSN=150

## DAL – Sherman (50 mile path - June)



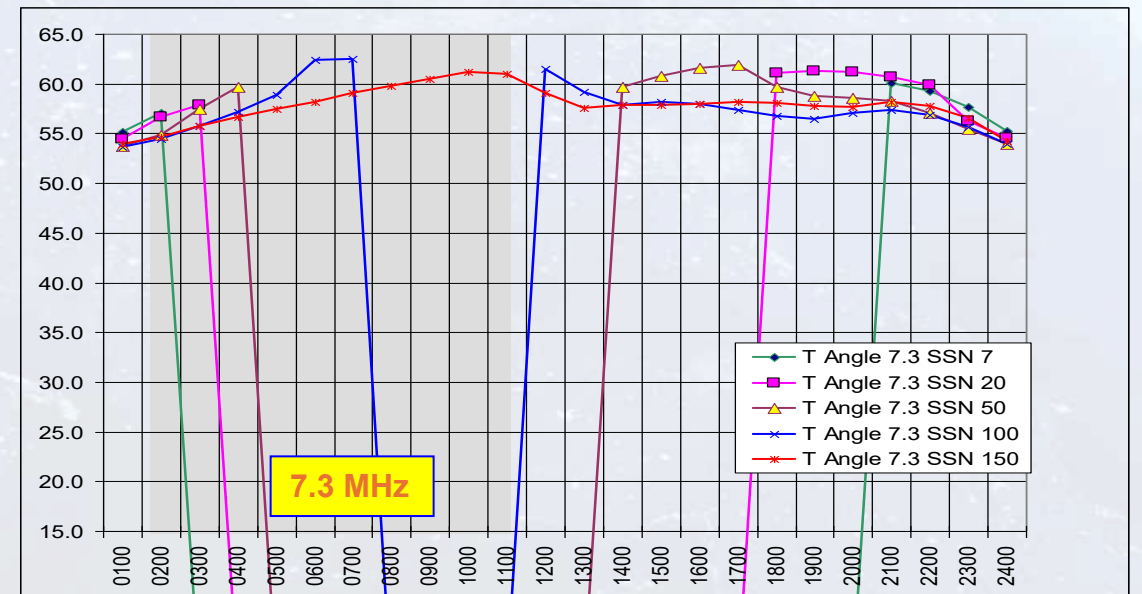
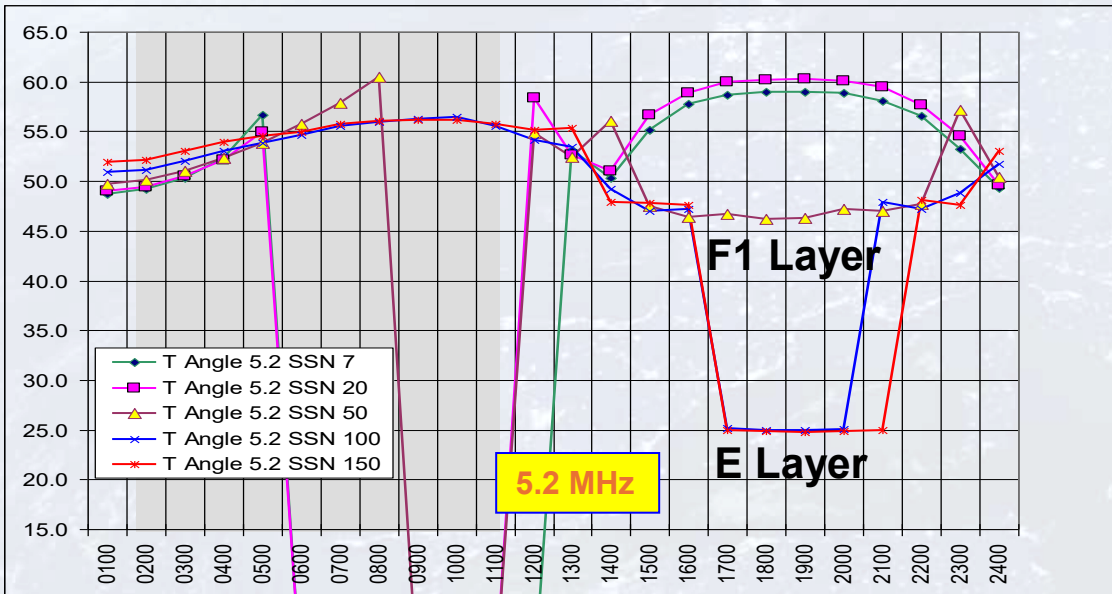
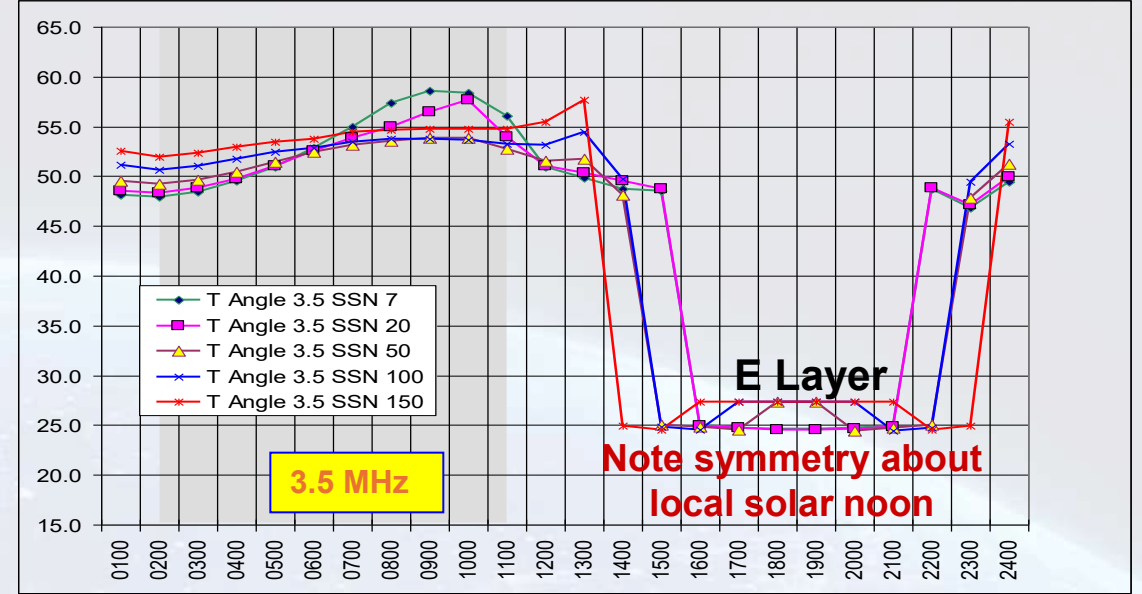
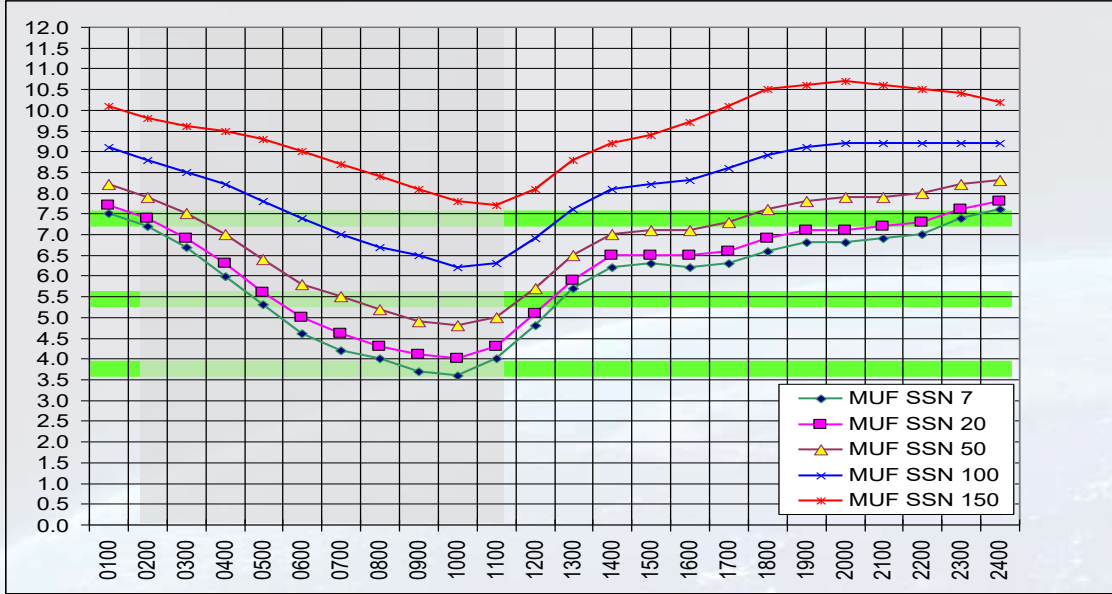
# MUF and Take-off Angle SSN=7 to SSN=150

## DAL – Bryan (150 mile path - June)



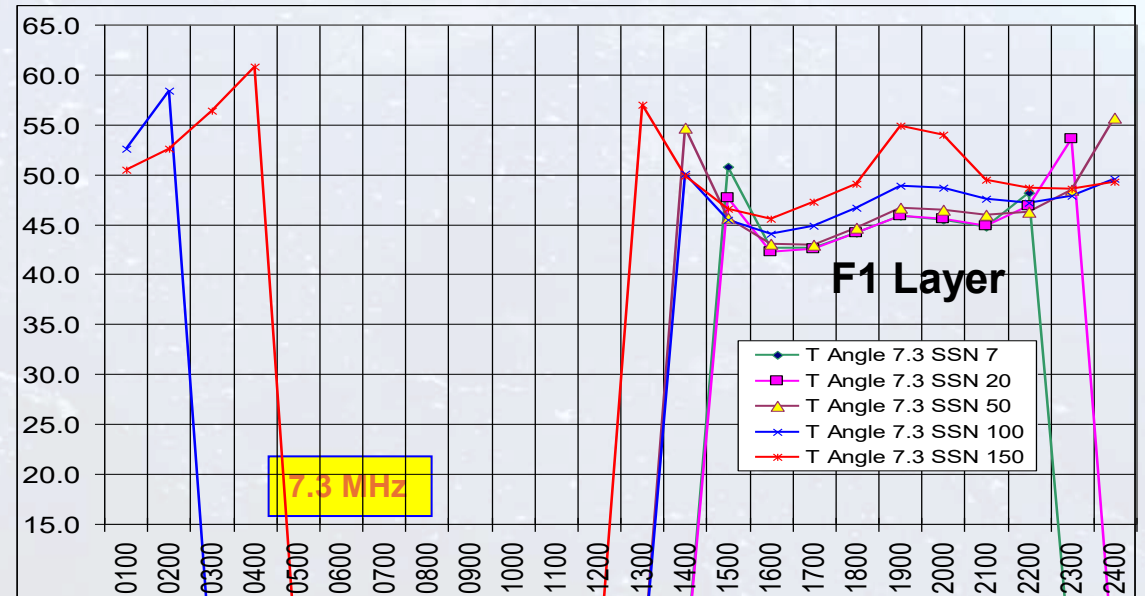
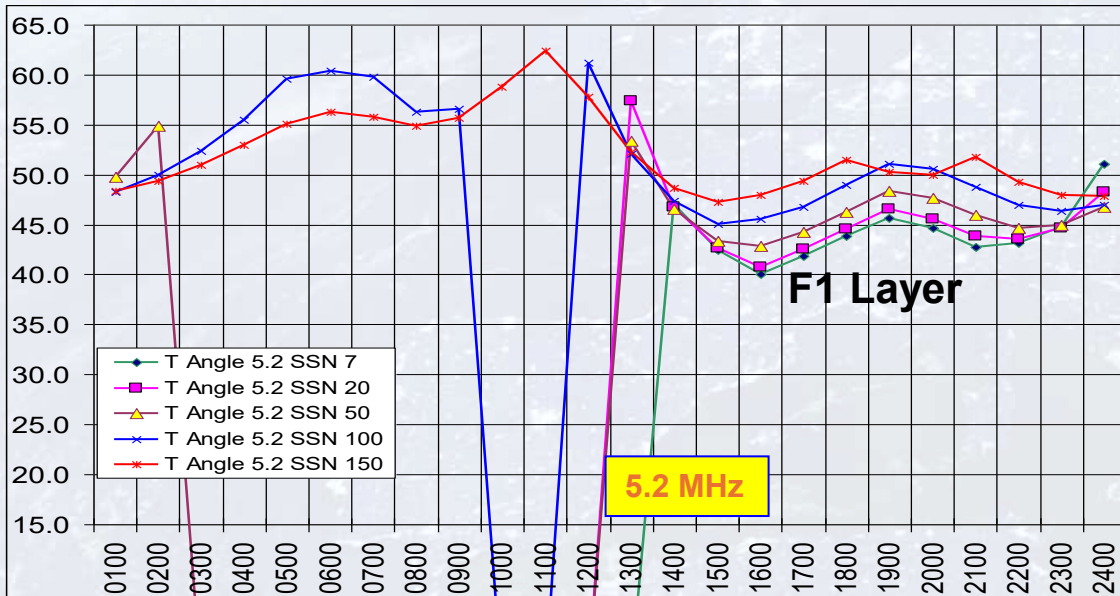
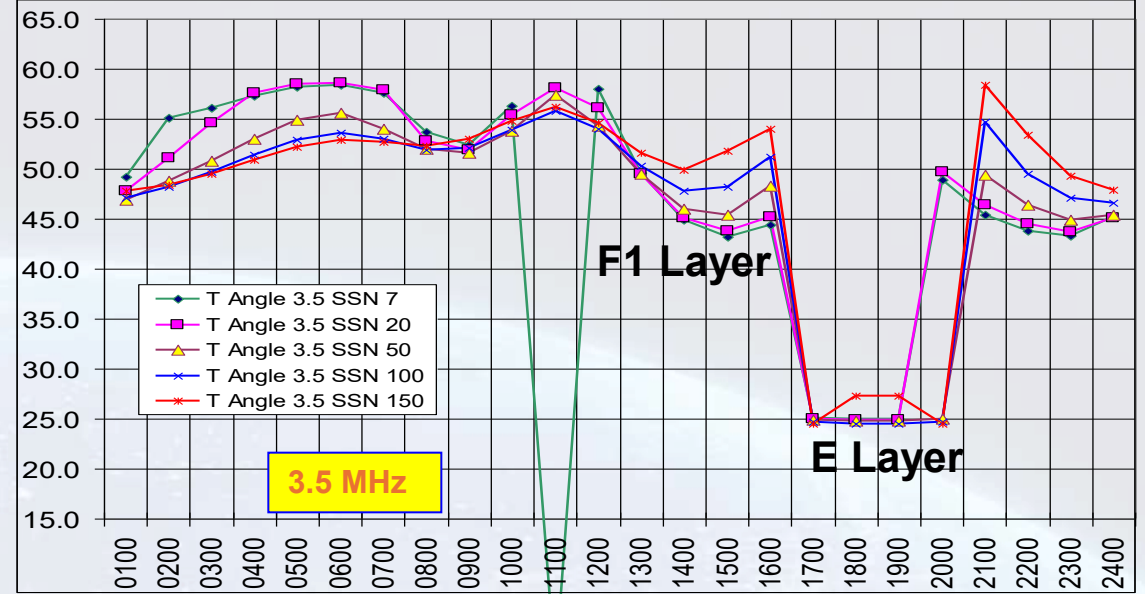
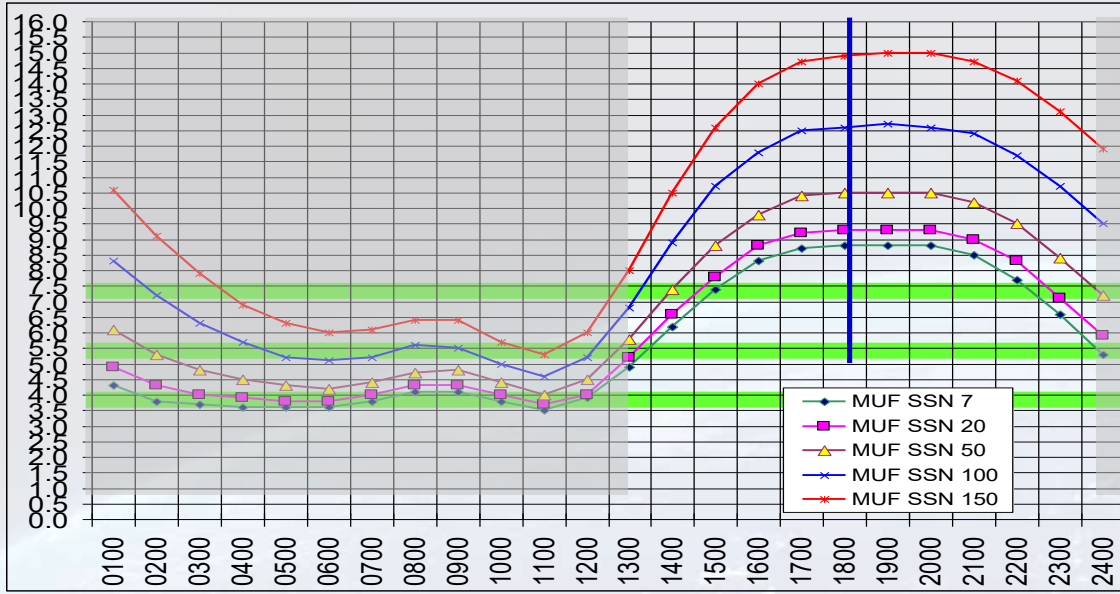
# MUF and Take-off Angle SSN=7 to SSN=150

## DAL – San Antonio (250 mile path - June)



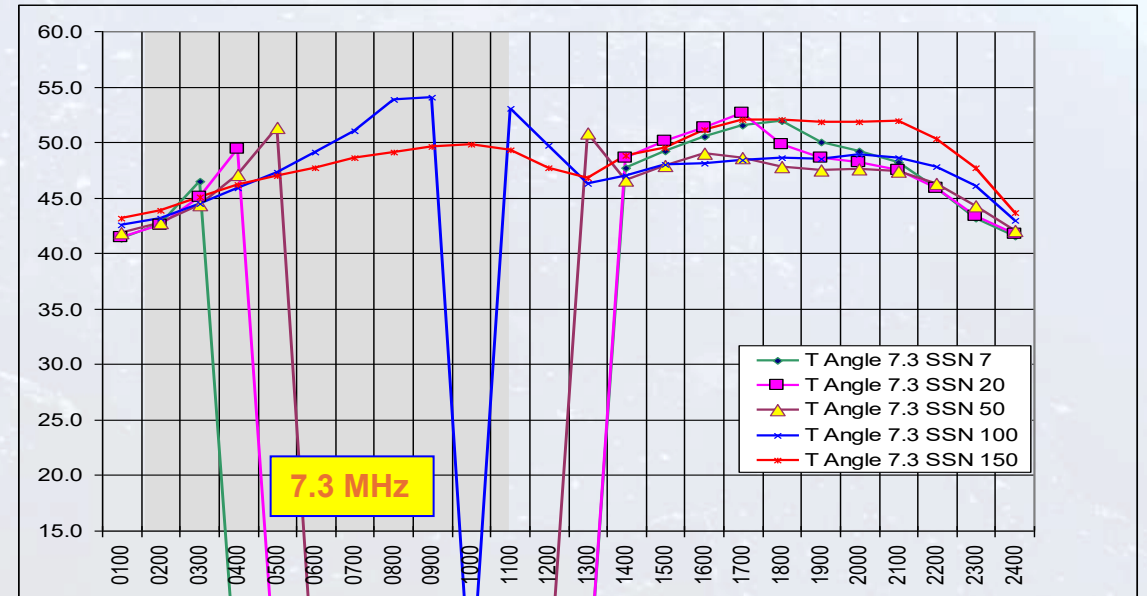
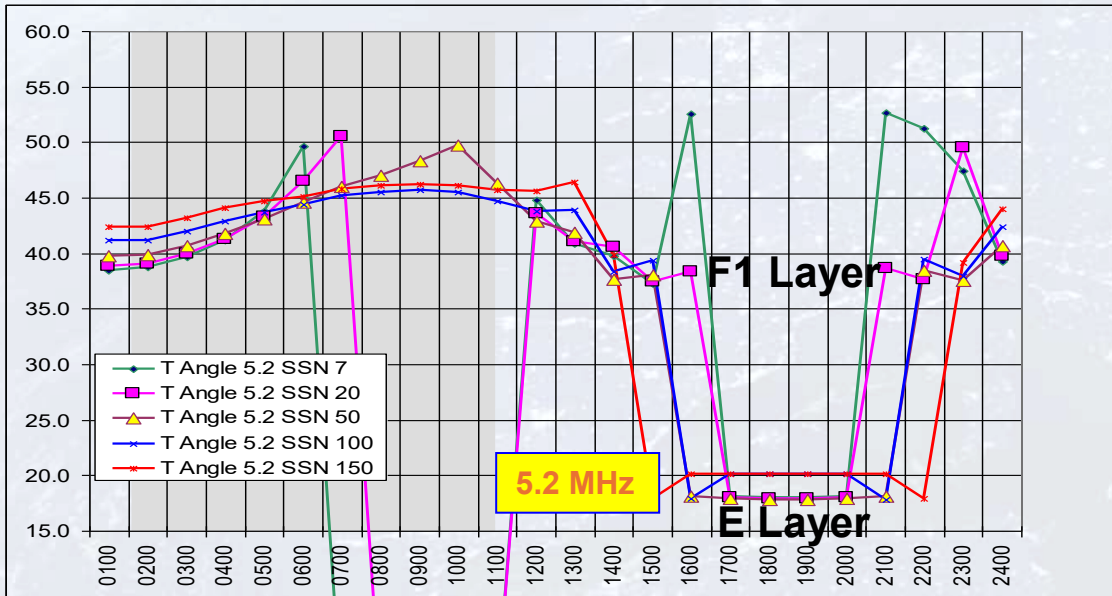
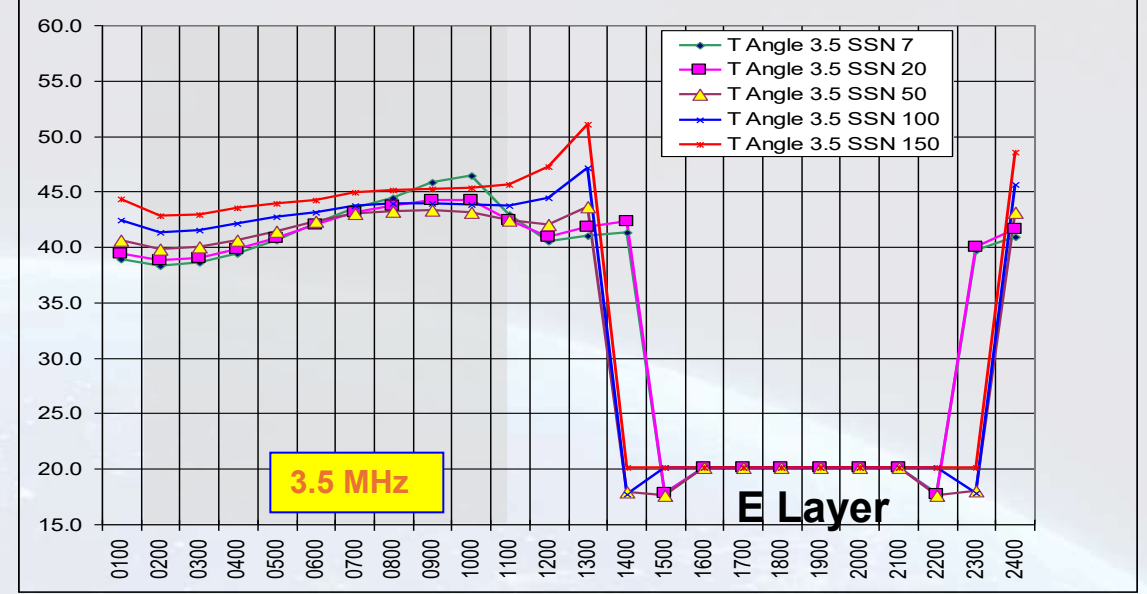
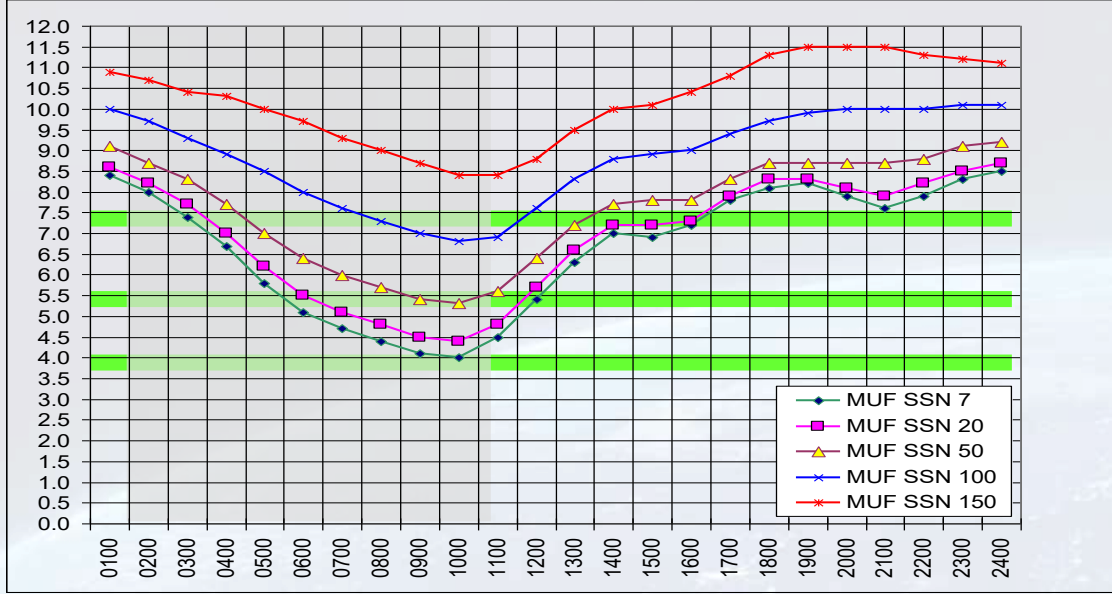
# MUF and Take-off Angle SSN=7 to SSN=150

## DAL – San Antonio (250 mile path - December)



# MUF and Take-off Angle SSN=7 to SSN=150

## DAL – Corpus Christi (350 mile path - June)



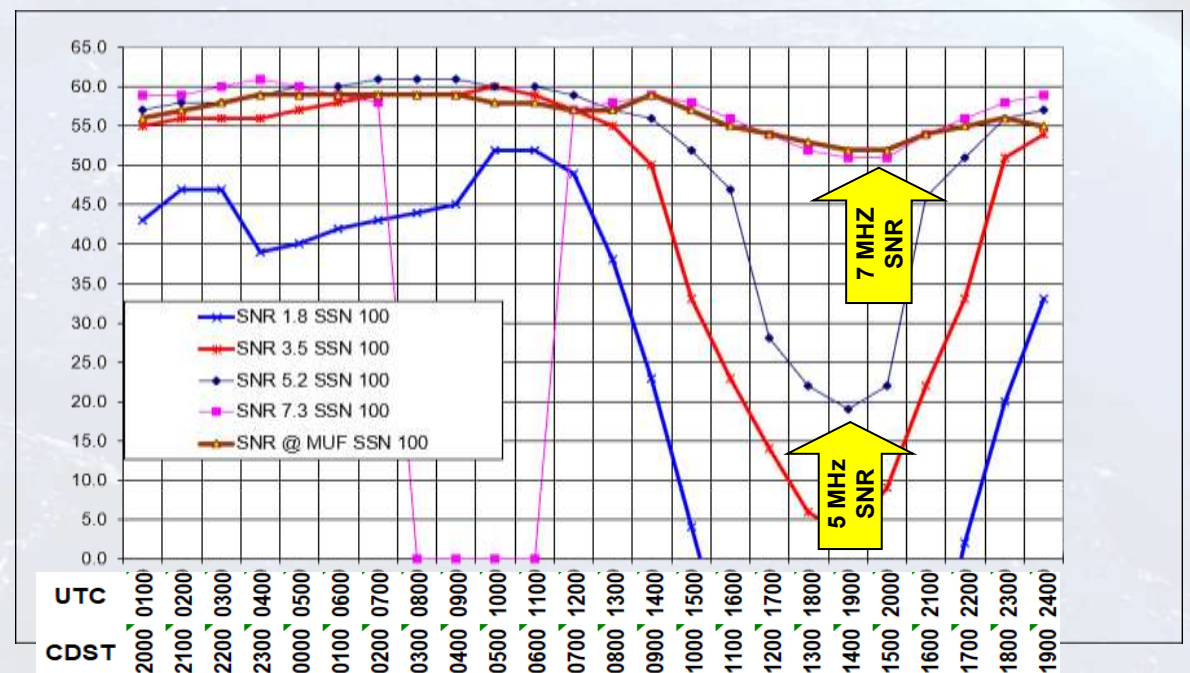
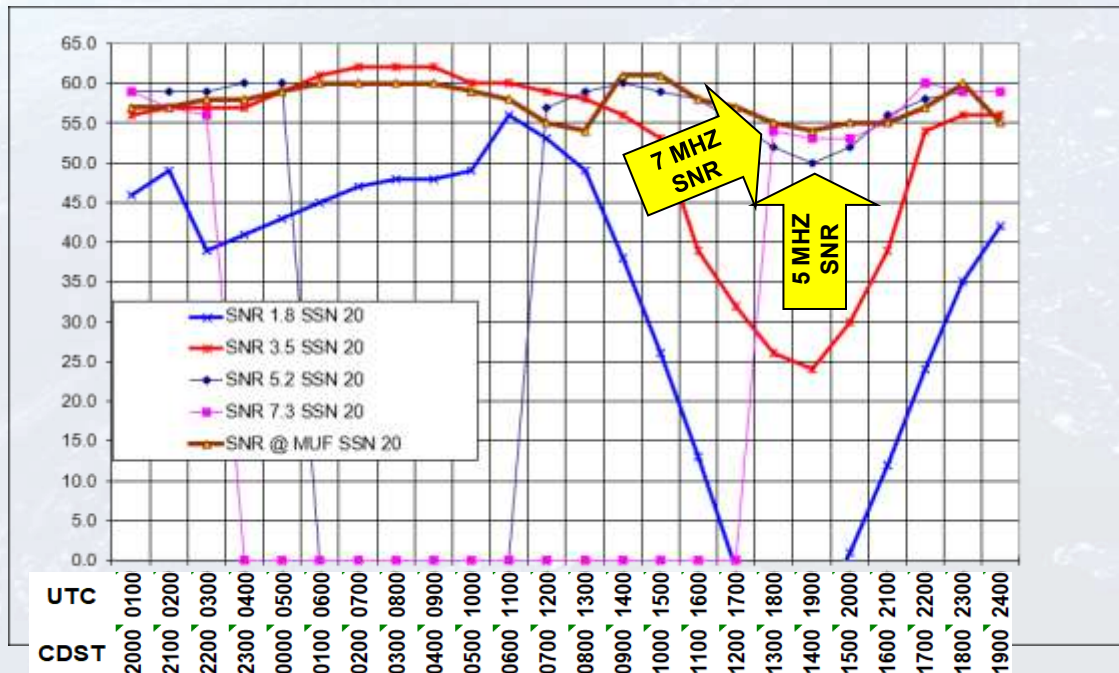
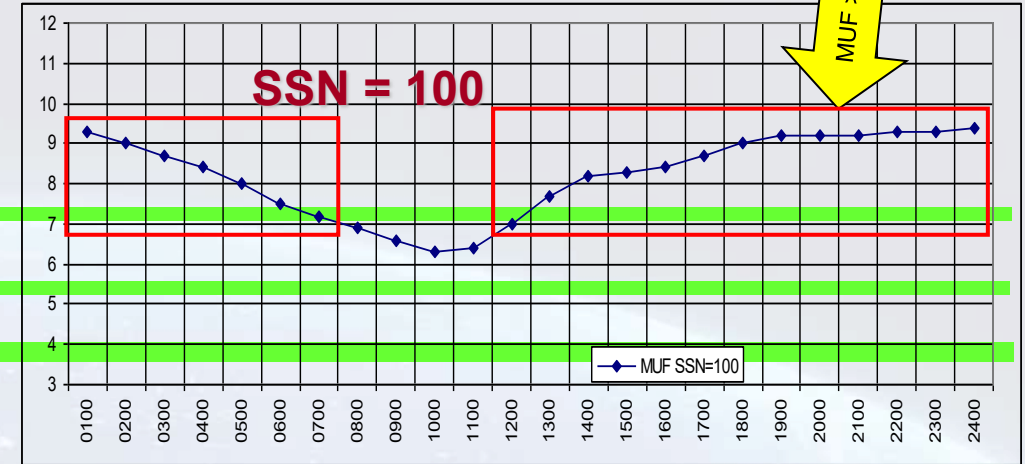
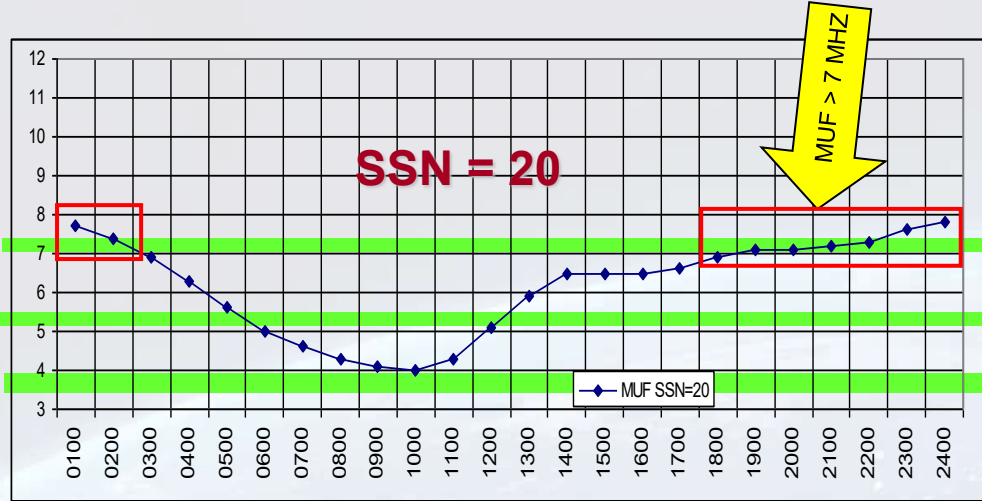
# Relationship between MUF and Signal-Noise Ratio (SNR)

For any given path, the SNR is highest at the MUF

- SNR **decreases** as the frequency is **decreased** below the MUF
  - Stated another way:
    - As the MUF rises past a given frequency, the SNR on that frequency begins to drop
    - Amount by which SNR drops is directly related to:
      - Amount by which MUF exceeds the frequency.
      - AND the season of the year
- For equal SSN, SNR on any frequency is much higher in Winter than in Summer
  - MUF is higher during Winter daylight hours:
    - Because of greater ionization.
    - Earth is closer to Sun during Northern Hemisphere Winter.
  - Lower solar angle in Winter produces less D and E layer ionization, providing less signal absorption.

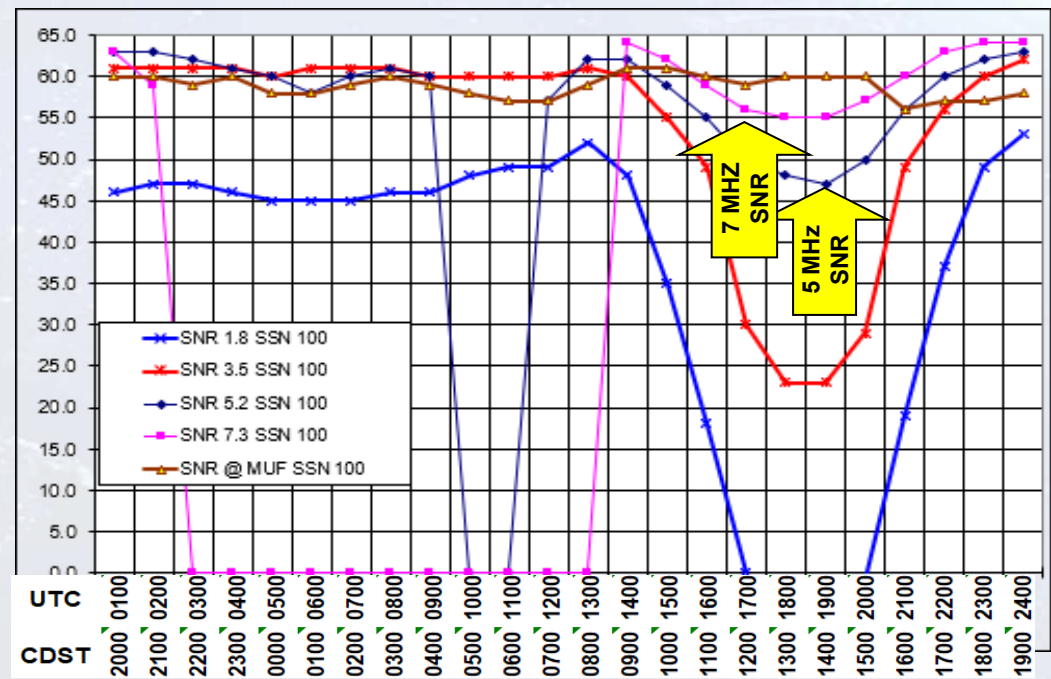
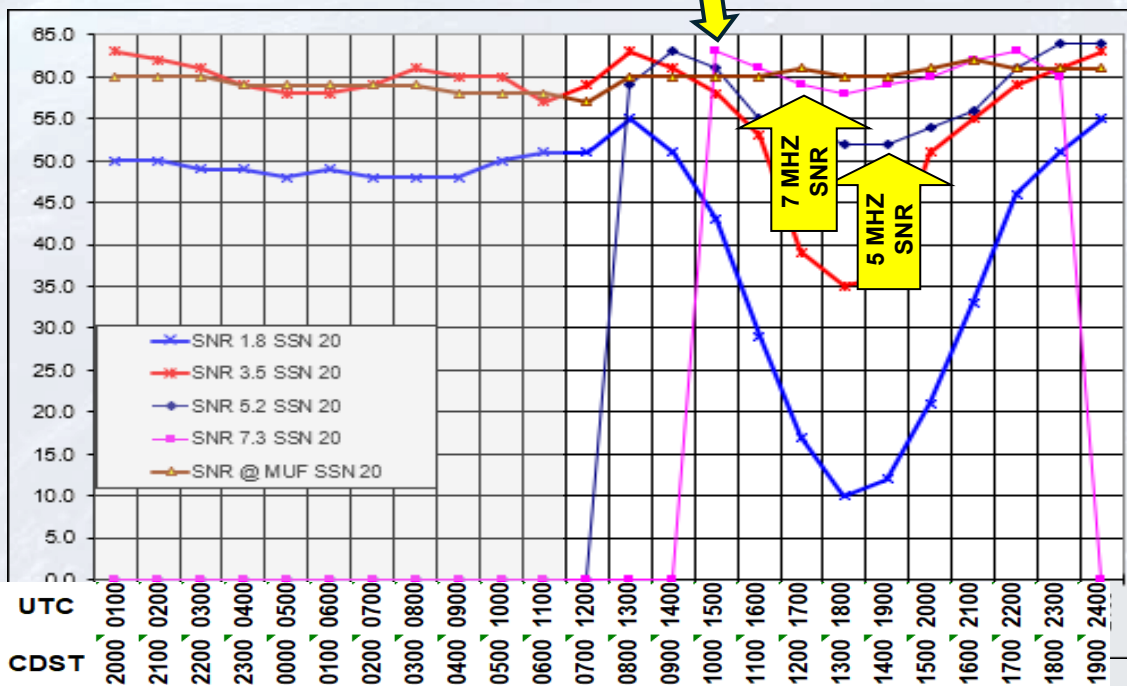
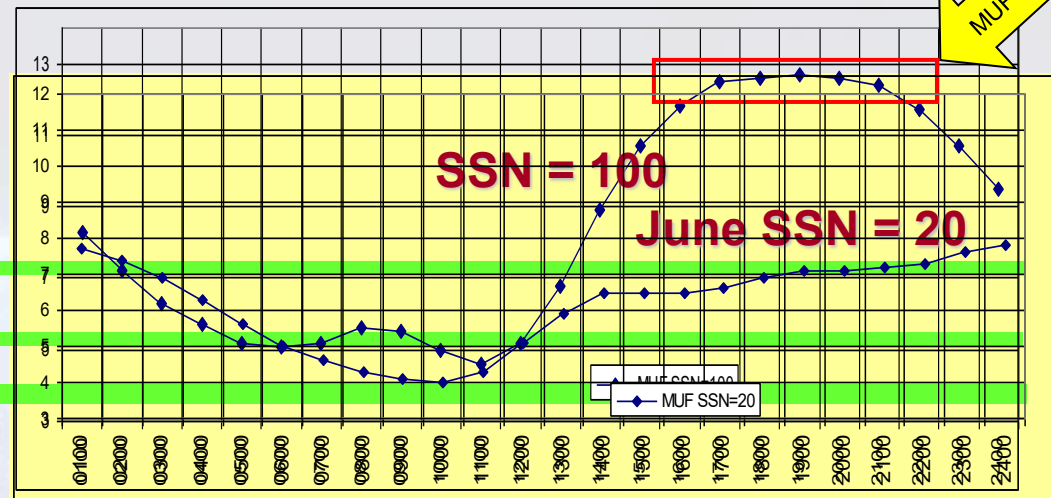
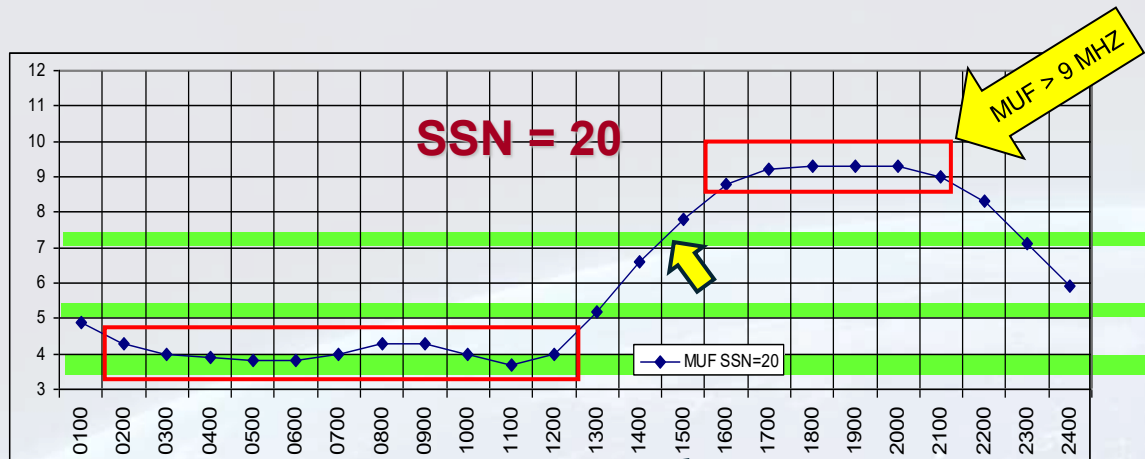
# SNR (dB) at SSN=20 and SSN=100 – JUNE

## DAL – SAT: 1.8 MHz to 7.3 MHz

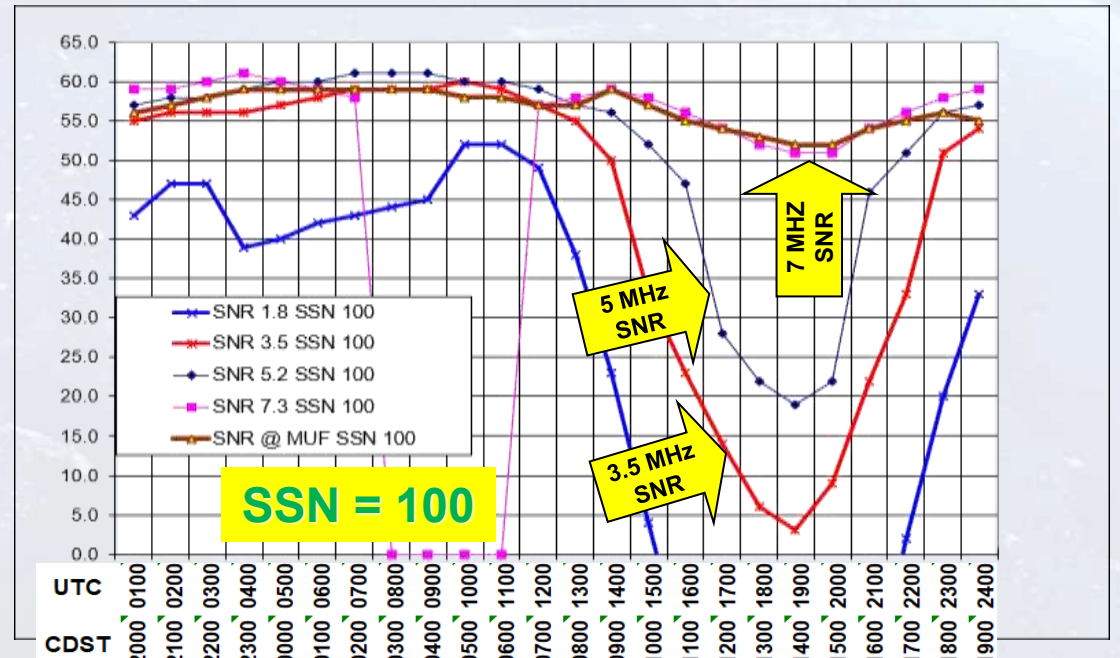
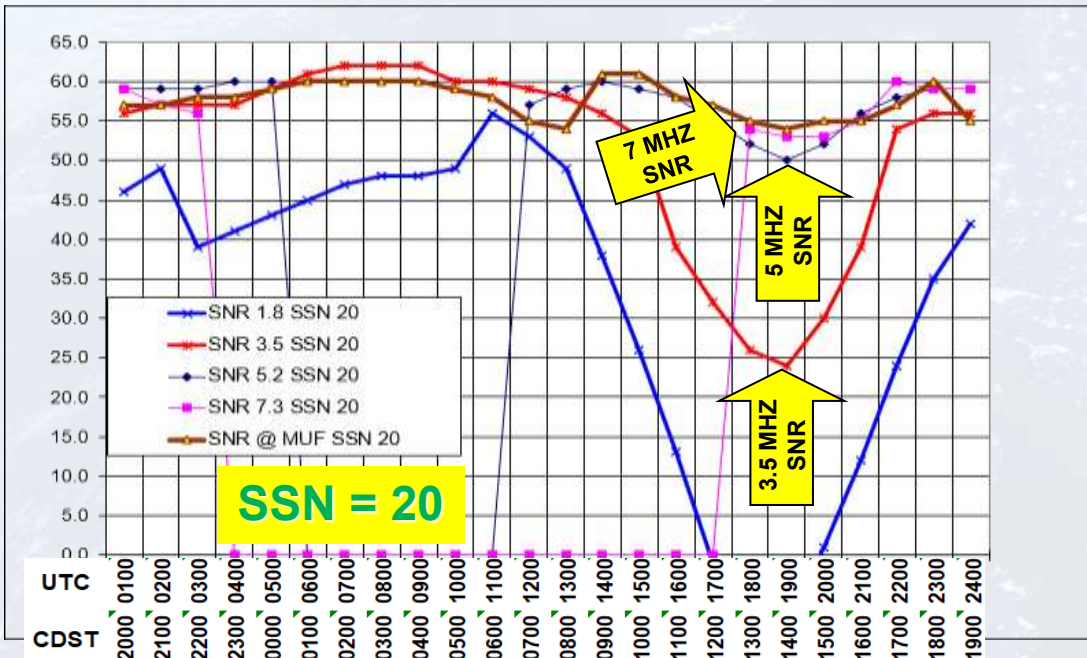
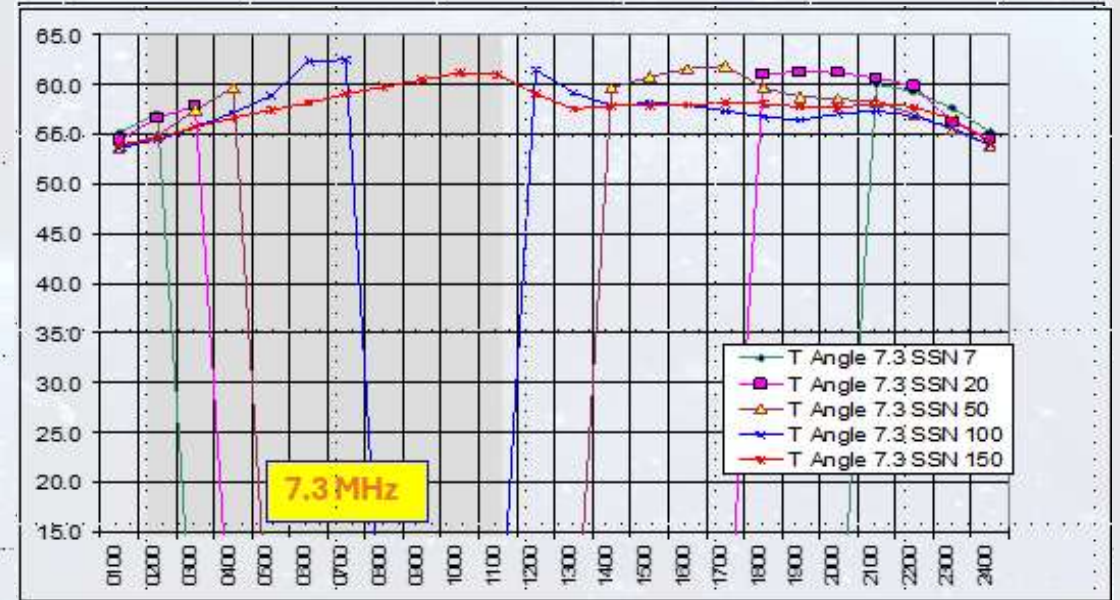
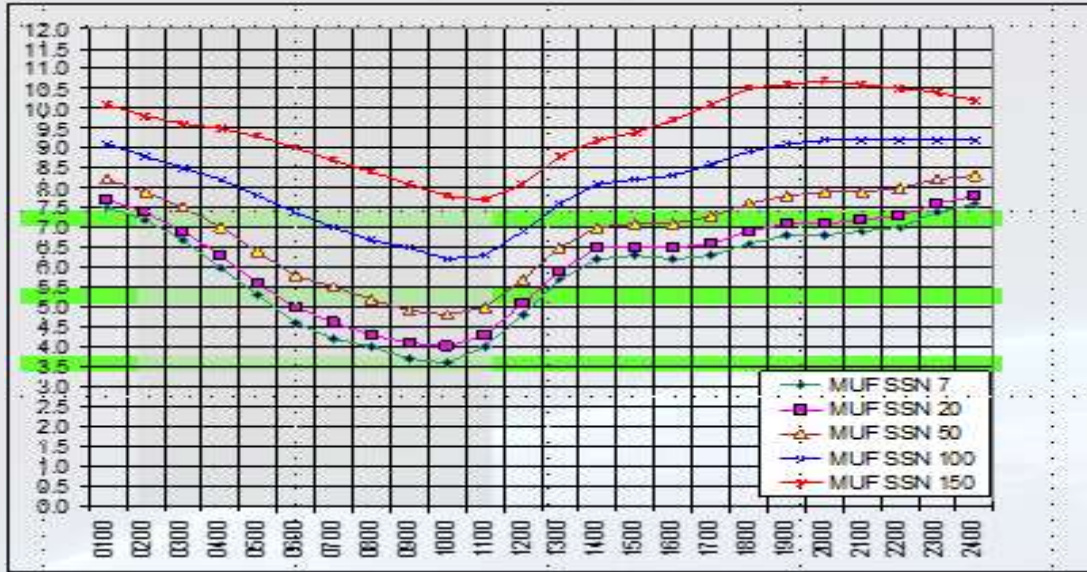


# SNR (dB) at SSN=20 and SSN=100 - DECEMBER

## DAL – SAT: 1.8 MHz to 7.3 MHz



# Pulling it Together: DAL – SAT June 1.8 MHz to 7.3 MHz

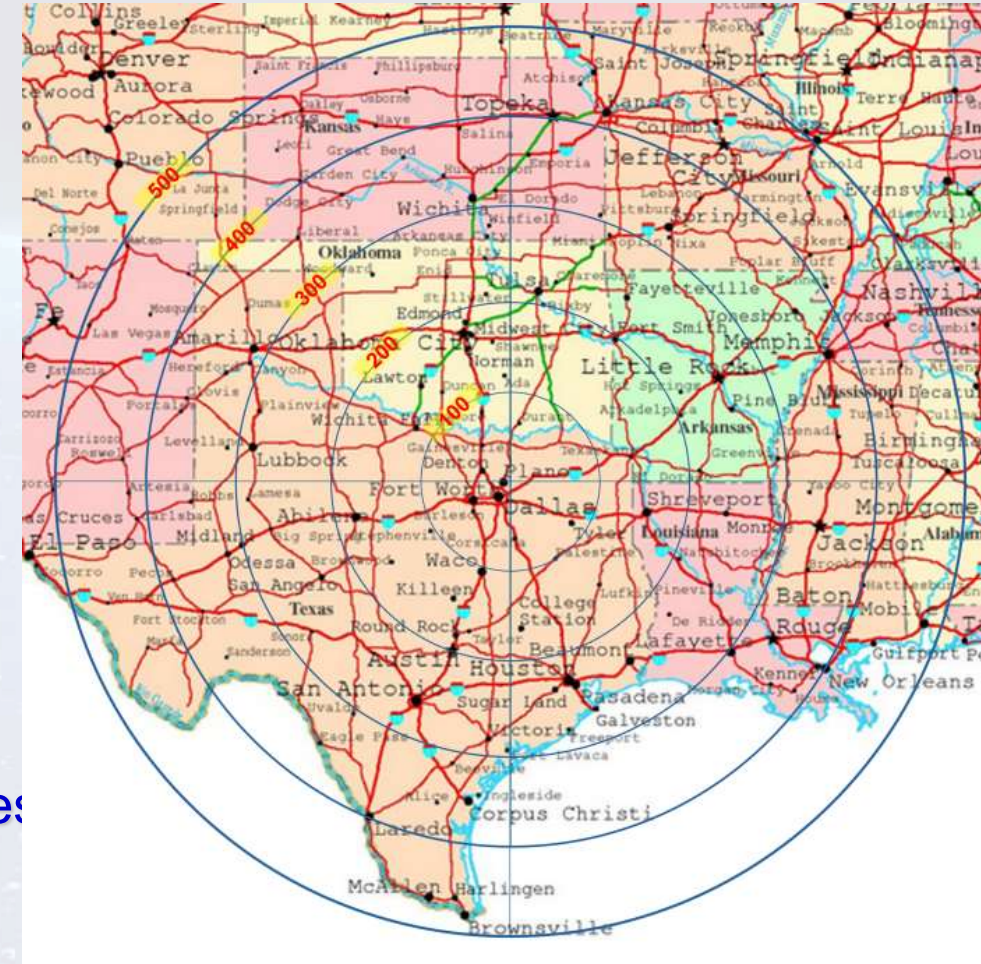


# Optimized Antenna Heights for NVIS

## Required take-off angles:

- Range from 40 to above 80 degrees
  - For path lengths of ~50 miles to 350 miles
- Take-off angles for short paths:
  - Are increasingly higher as distance decreases.
  - While the MUF is increasingly lower.
- One height provides optimized coverage for NVIS:
  - Take-off angles of 40 degrees to 90 degrees.
  - NVIS Range of 0 to ~ 350 miles.
  - Very good NVIS / non-NVIS coverage to ~500 miles
  - Transmit Power GAIN.

That height is  $1/8 \lambda$ .



# Optimized Antenna Heights for NVIS

## 1/8 $\lambda$ for various bands

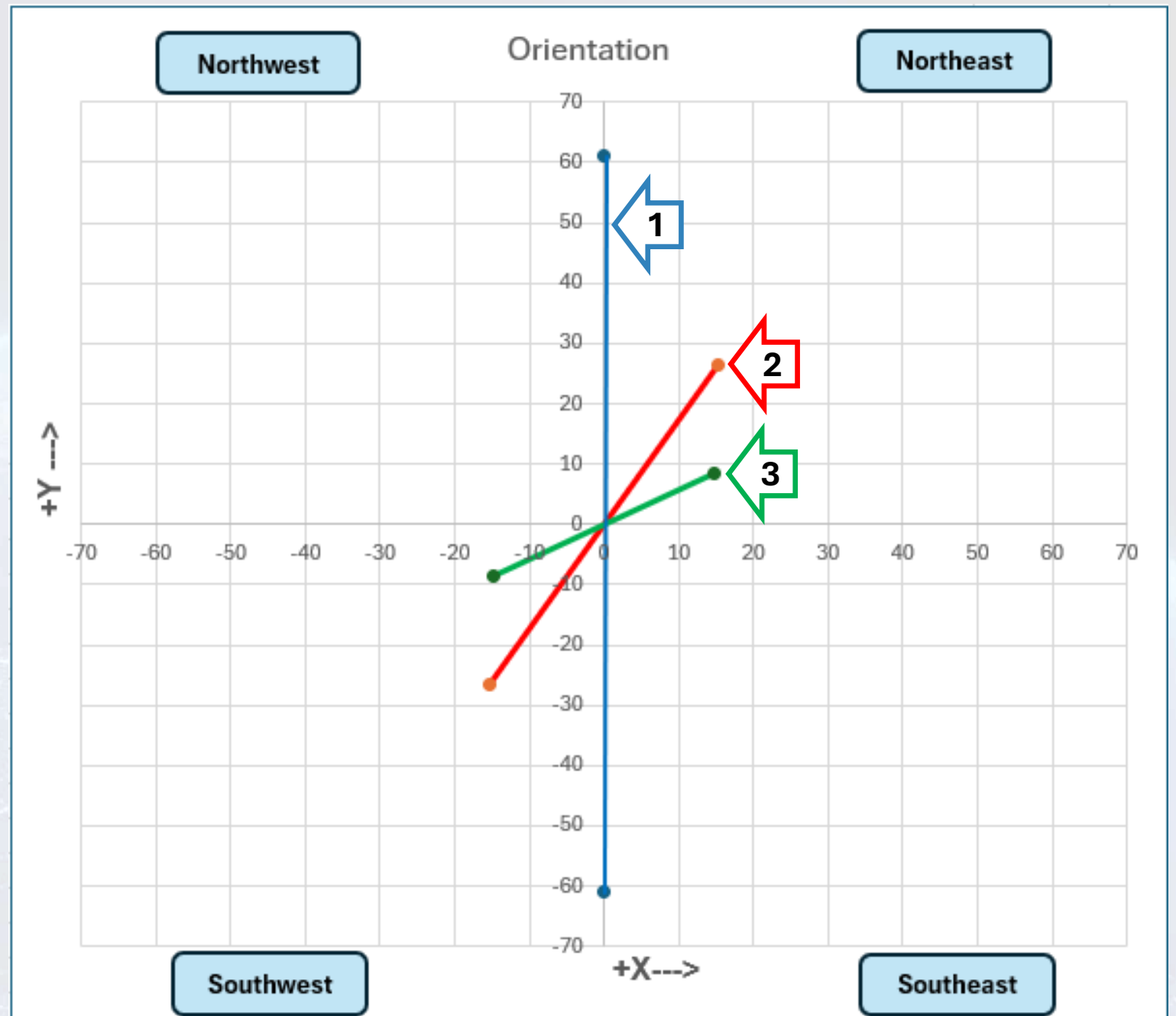
- 1.8 MHz ~ 60 feet
- 3.7 MHz ~ 30 feet (*normally* best nighttime NVIS band)
- 4.6 MHz ~ 25 feet (MARS / CAP)
- 5.2 MHz ~ 22 feet
- 7.2 MHz ~ 16 feet (*normally* best daytime NVIS band)
- 10.15 MHz ~ 11 feet (*maybe sometimes* NVIS)

**14 MHz is well above NVIS frequency range**

$\lambda \downarrow$ MHz $\rightarrow$	1.8	2.5	3.7	4.6	5.2	7.2	10.15	14.25
1/8 $\lambda$	63.61	45.80	30.95	24.89	22.02	15.20	11.28	8.04
1/4 $\lambda$	127.22	91.60	61.89	49.78	44.04	31.81	22.56	16.07
1/2 $\lambda$	254.44	183.20	123.78	99.57	88.08	63.61	45.12	32.14

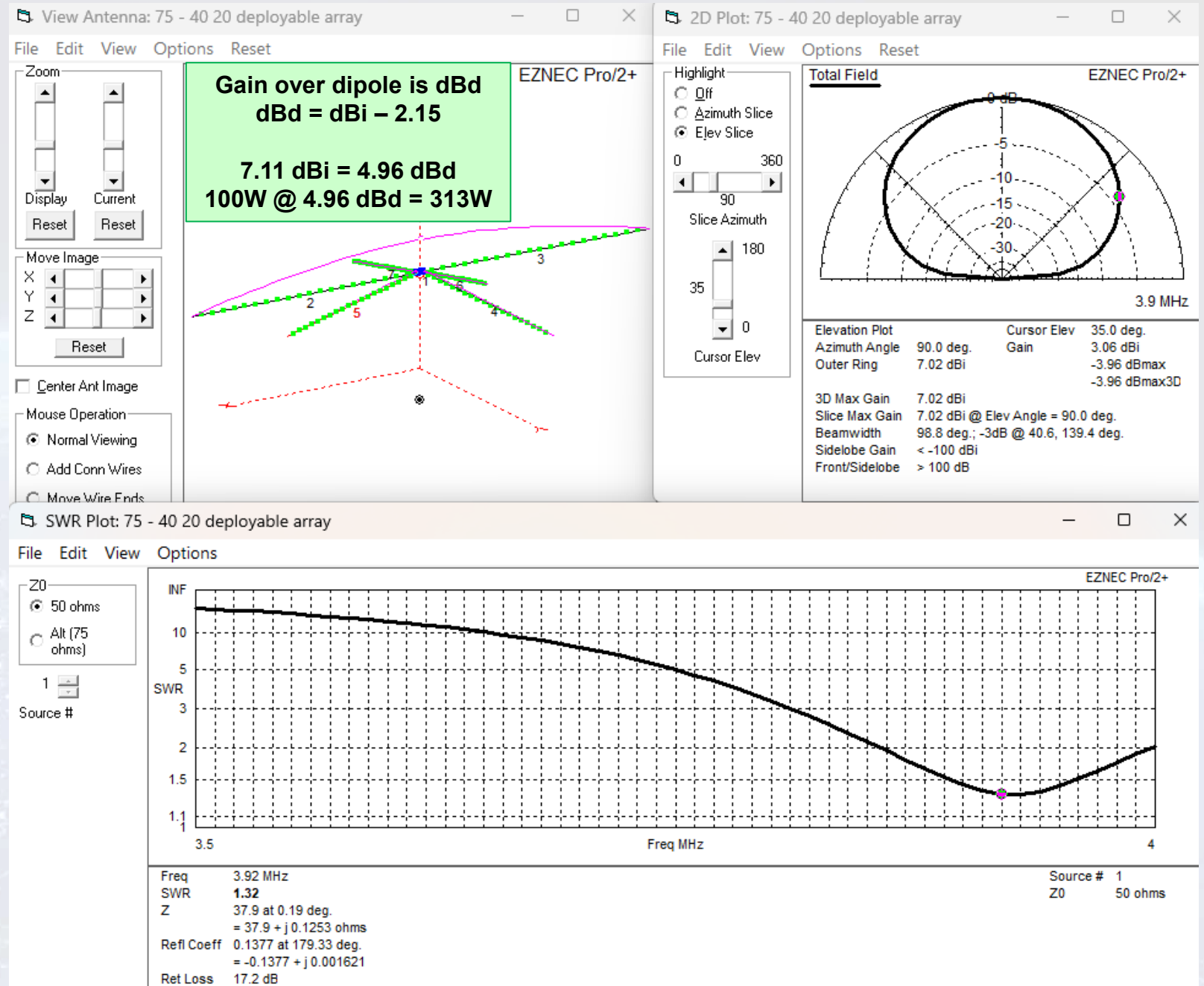
# Simple 75, 40, & 20 Wire Antenna

- ❑ Single 50 Ohm coax feed
- ❑ No tuner required
- ❑ 30° spacing between ends (min. up to 45° works)
- ❑ Dipole 1 is 75 meters
- ❑ Dipole 2 is 40 Meters
- ❑ Dipole 3 is 20 Meters



# Simple 75, 40, & 20 Wire Antenna

- Single 50 Ohm coax feed
- No tuner required
- 30° spacing between ends (min. up to 45° works)
- Dipole 1 is 75 meters
- Dipole 2 is 40 Meters
- Dipole 3 is 20 Meters
  
- ~ 75 kHz bandwidth on 75



# What Do All Those Strange Numbers Mean?

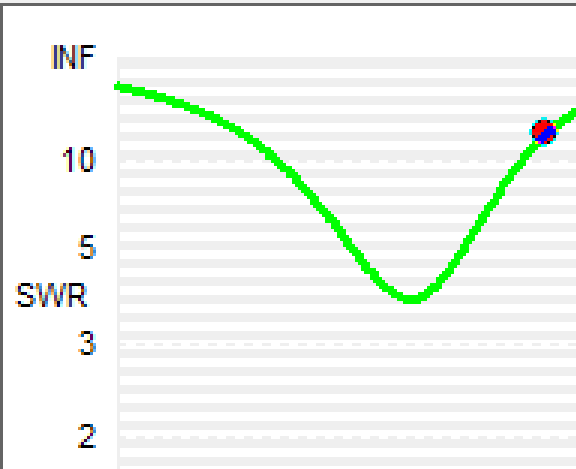
SWR Plot: NVIS deployable dipole

File Edit View Options

Z0

50 ohms

Alt (750 ohms)



1

Source #

**R = Resistive (a.k.a. "REAL")**

**X = Reactive (a.k.a. "Imaginary" or "Wattless")**

<b>R</b>	<b>X</b>	<b>Z</b>	<b>Phase</b>
106.9	-740.9	749	-81.79

This symbol  $\sqrt{\quad}$  = Square Root of

Simple:  $Z = \sqrt{R^2 + X^2}$

$X_L$  and  $X_C$ :  $Z = \sqrt{R^2 + (X_L - X_C)^2}$

If (and only if)  $X_L = X_C$  then  $Z = R$

Phase =  $ASIN(X/Z) * 180/pi()$

50	2	100	14.28	98.98	-81.79	14.28%	-8.45	85.72
<b>Volts</b>	<b>Amperes</b>	<b>Apparent Power</b> Watts (Volts x Amperes)	<b>Real Power</b> (P) Watts	<b>Reactive Power</b> (Q) VAR	<b>Phase</b> (Degrees) (Voltage vs Current)	<b>Percent Power Transmitted</b>	<b>dB Loss</b>	<b>Watts Lost</b>

**Z** → Freq 5.59 MHz

**Z** → SWR 13.9

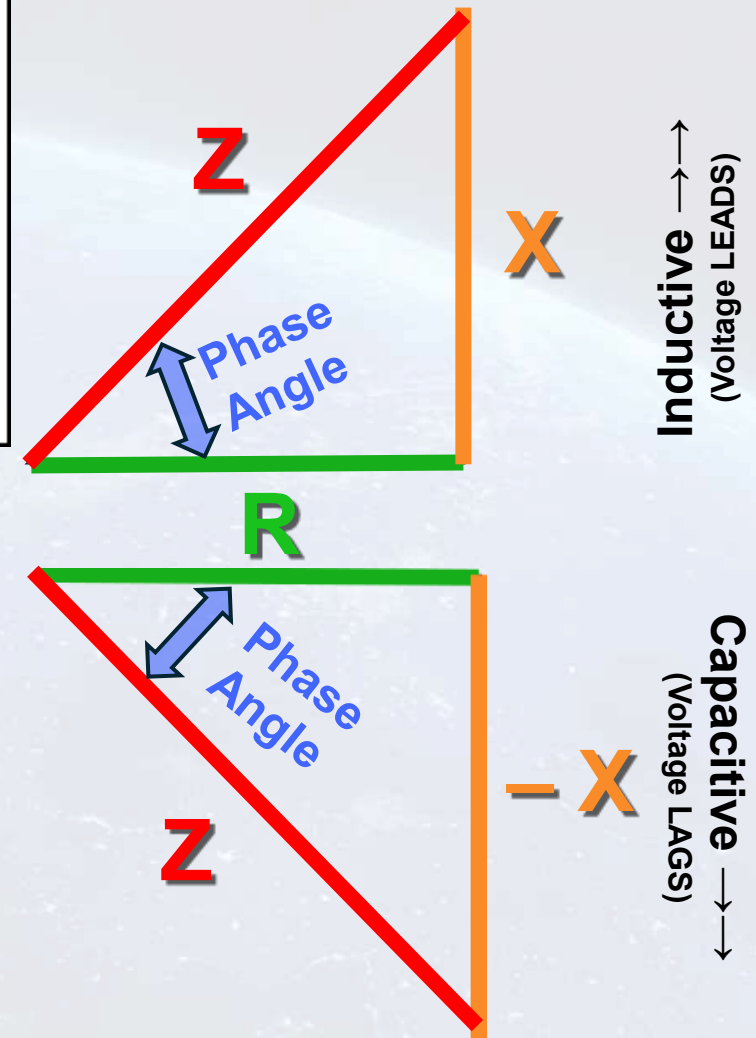
**Z** → 748.6 at -81.79 deg.

**R** → = 106.9 - j 740.9 ohms

Refl Coeff 0.8661 at -90.11 deg.  
= -0.00161 - j 0.8661

Ret Loss 1.2 dB

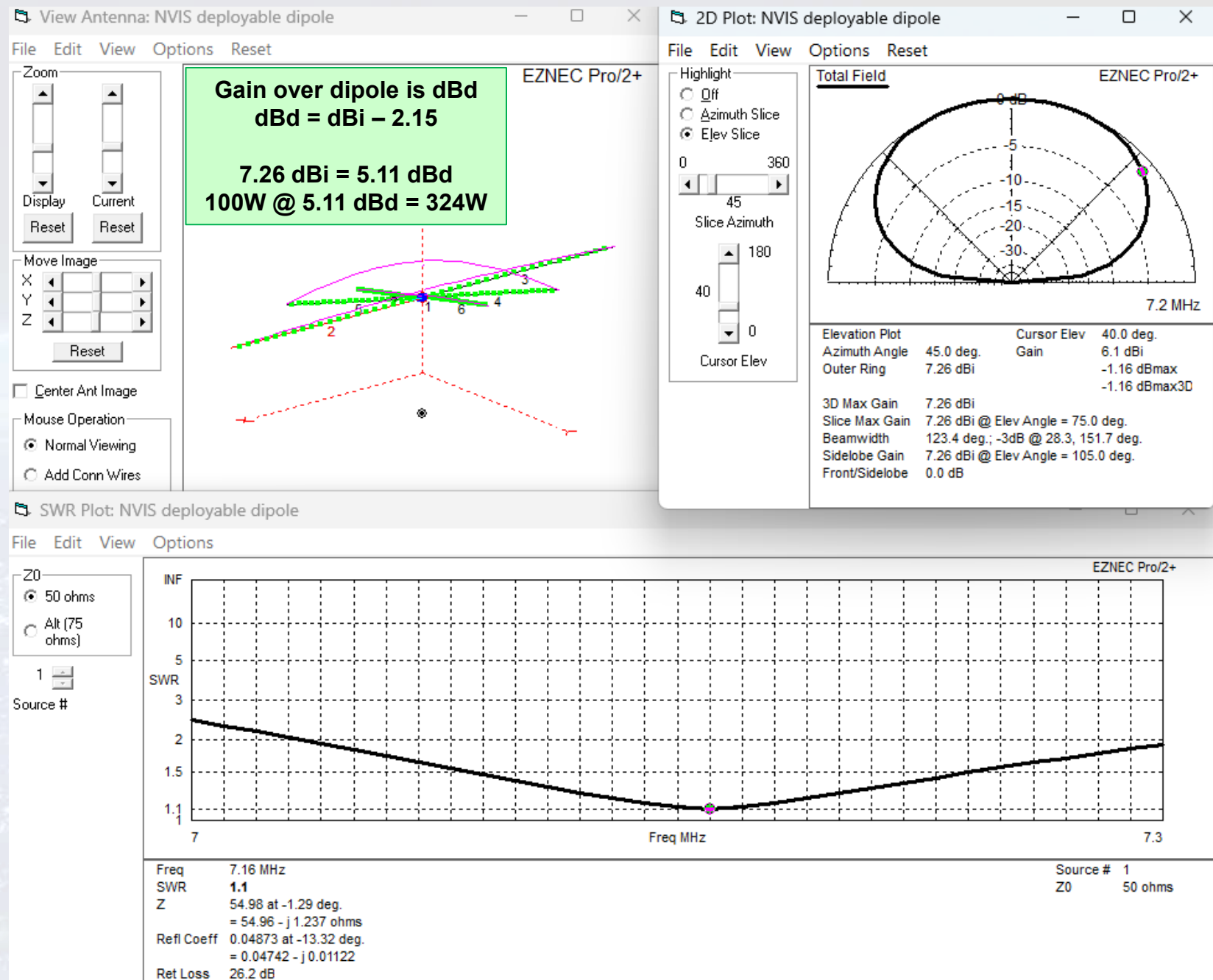
**Phase**



# Simple 75, 40, & 20 Wire Antenna

- Single 50 Ohm coax feed
- No tuner required
- 30° spacing between ends (min. up to 45° works)
- Dipole 1 is 75 meters
- Dipole 2 is 40 Meters
- Dipole 3 is 20 Meters

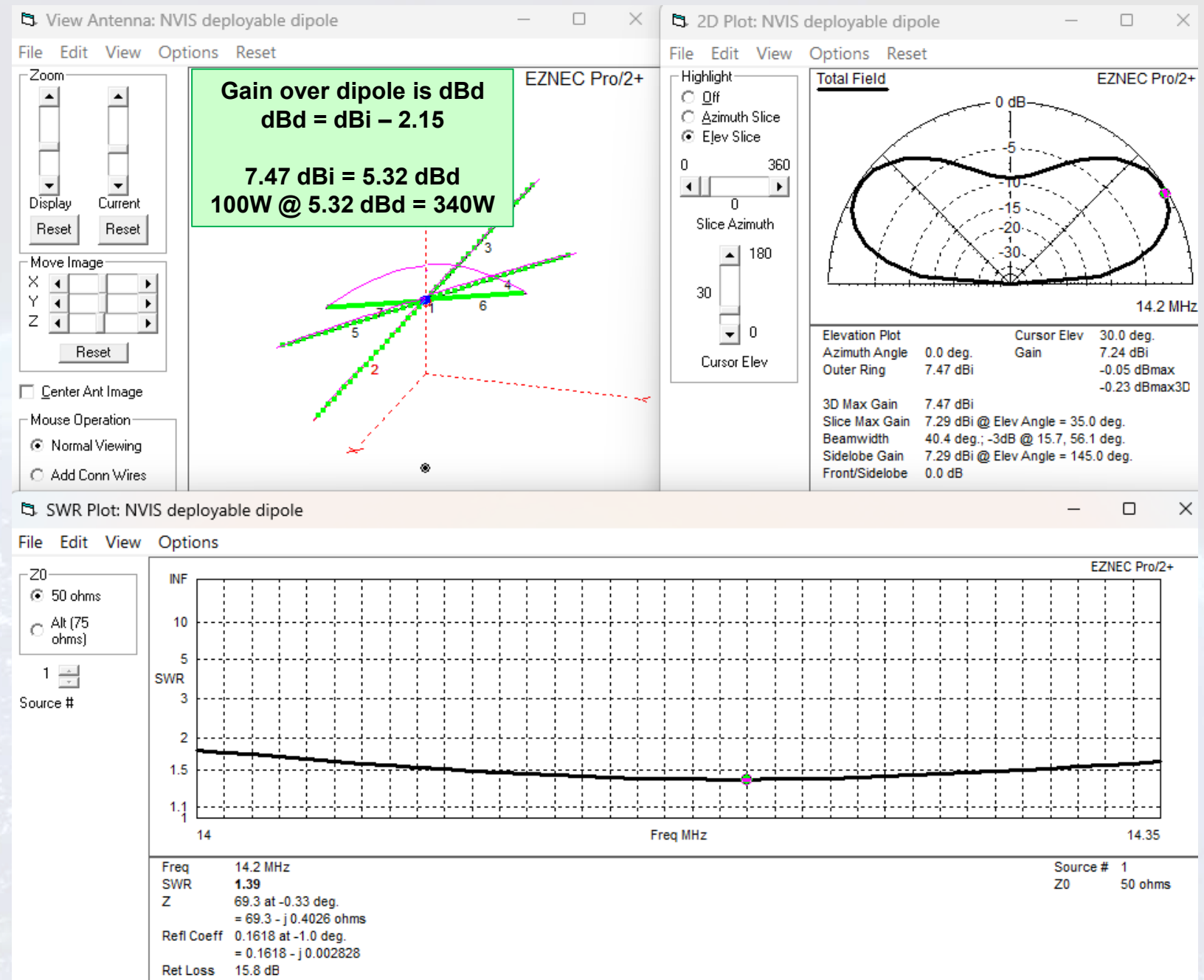
- ~ 75 kHz bandwidth on 75
- Full band coverage on 40
  - Dropping ends to 15 feet has 1 dB impact on gain.



# Simple 75, 40, & 20 Wire Antenna

- Single 50 Ohm coax feed
- No tuner required
- 30° spacing between ends (min. up to 45° works)
- Dipole 1 is 75 meters
- Dipole 2 is 40 Meters
- Dipole 3 is 20 Meters

- ~ 75 kHz bandwidth on 75
- Full band coverage on 40
  - Dropping ends to 15 feet has 1 dB impact on gain.
- Full band coverage on 20
  - 20 Meter element could be metal tubing ~ 17 ft/side

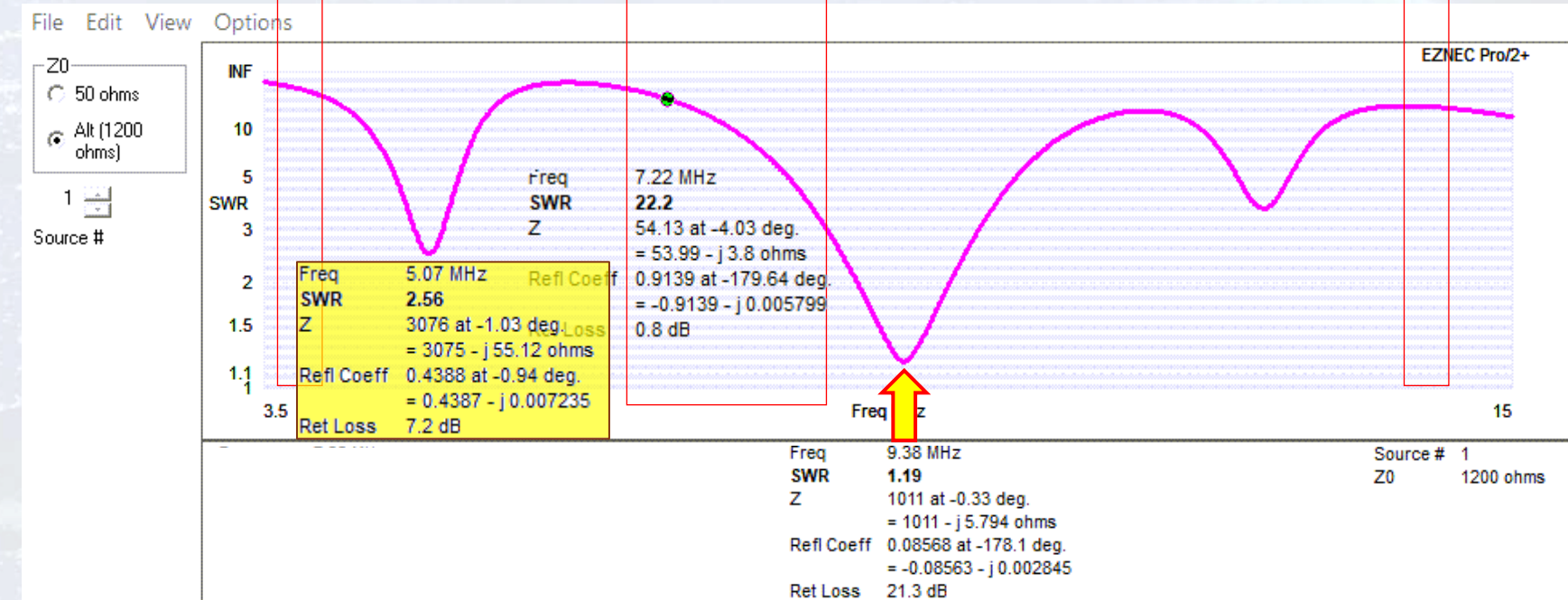
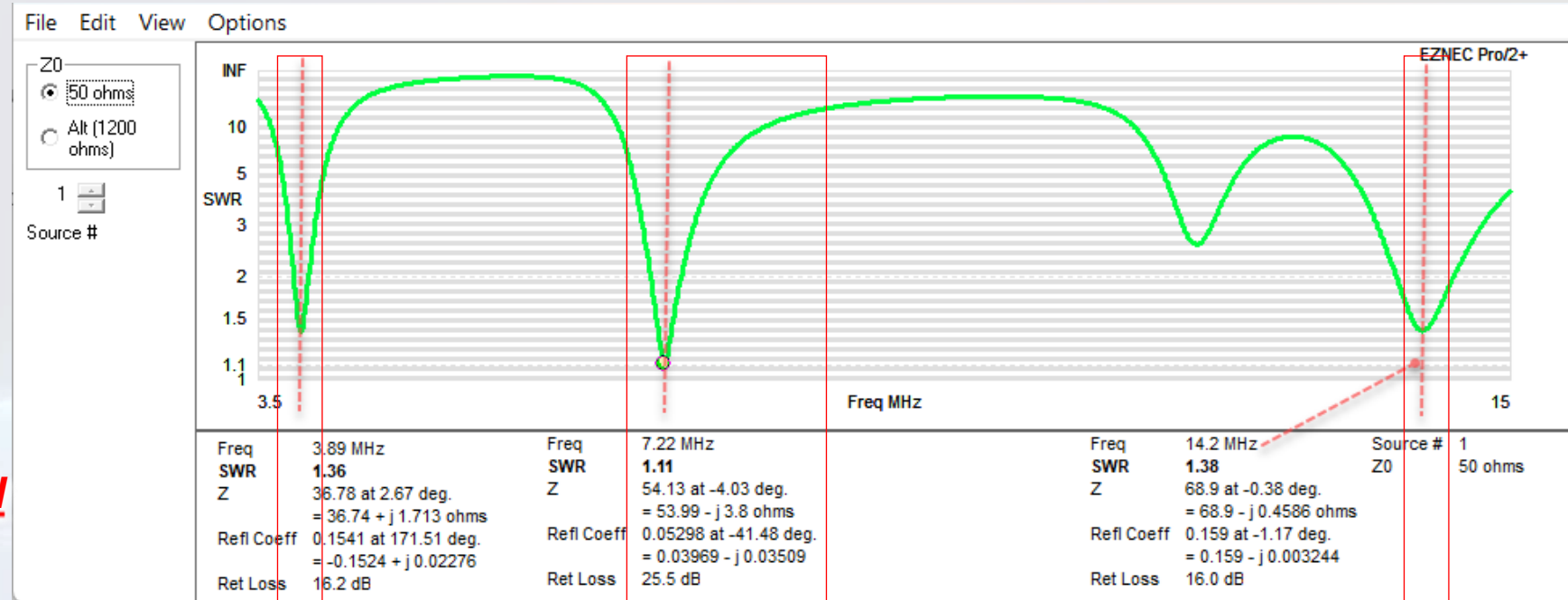


# Simple 75, 40, & 20 Wire Antenna

- ❑ 50 Ω Plot 3.5 to 15 MHz
- ❑ Lines indicate frequency listed below each point
- ❑ Impedance and SWR at each point are shown

## 1200 Ω feed

- ❑ **IMPEDANCE is unchanged**
- ❑ **SWR is changed**
- ❑ **Return Loss is changed**
- ❑ RESONANT at 9.38 MHz at impedance of 1011 Ω
- ❑ RESONANT at 5.07 MHz at impedance of 3076 Ω



# Simple 75, 40, & 20 Wire Antenna

- 50 Ω Plot 3.5 to 15 MHz
- Lines indicate frequency listed below each point
- Impedance and SWR at each point are shown

## 1200 Ω feed

- IMPEDANCE is unchanged**
- SWR is changed**
- Return Loss is changed**
- RESONANT at 9.38 MHz at impedance of 1011 Ω
- RESONANT at 5.07 MHz at impedance of 3076 Ω

**High SWR ≠ non resonance**  
(≠ means IS NOT EQUAL TO)

**Resonance occurs when Voltage and current are IN PHASE regardless of whatever impedance exists at that point.**

File Edit View Options

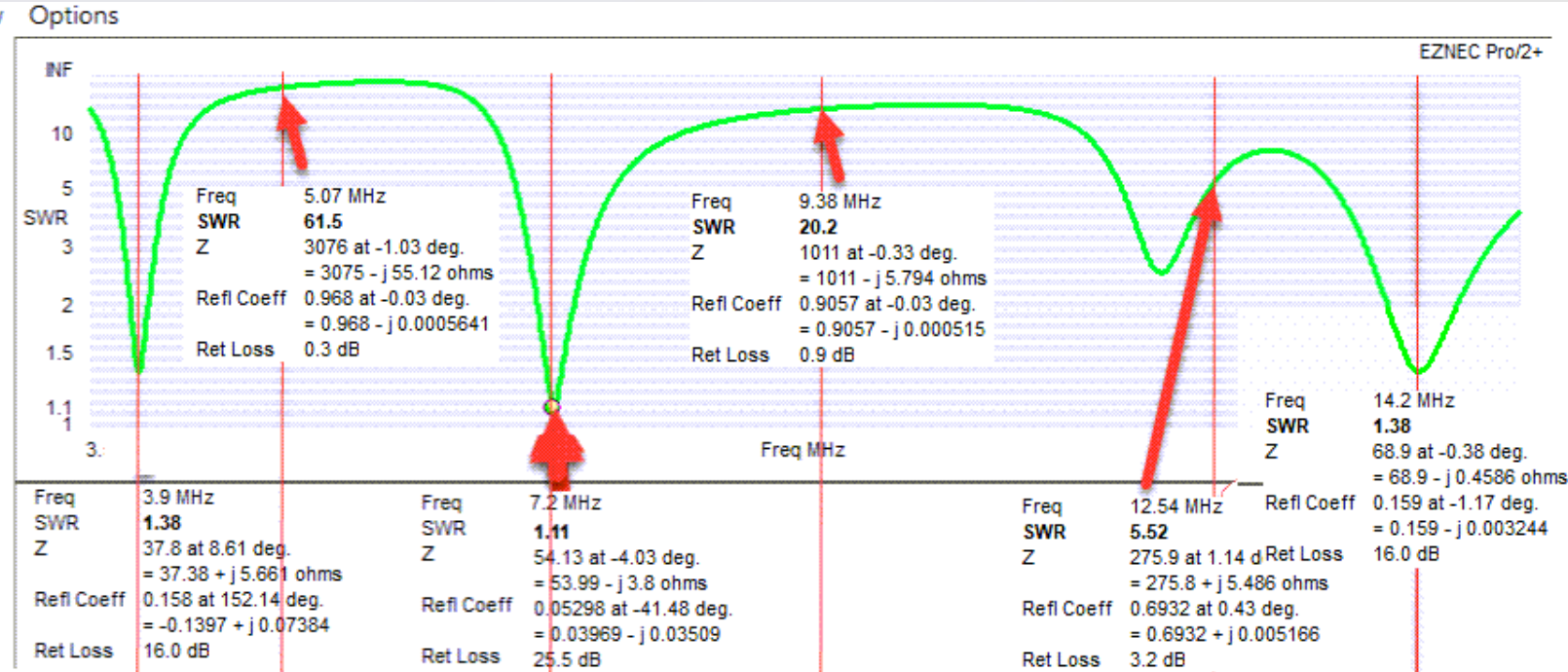
Z0

50 ohms

Alt (75 ohms)

1

Source #



File Edit View Options

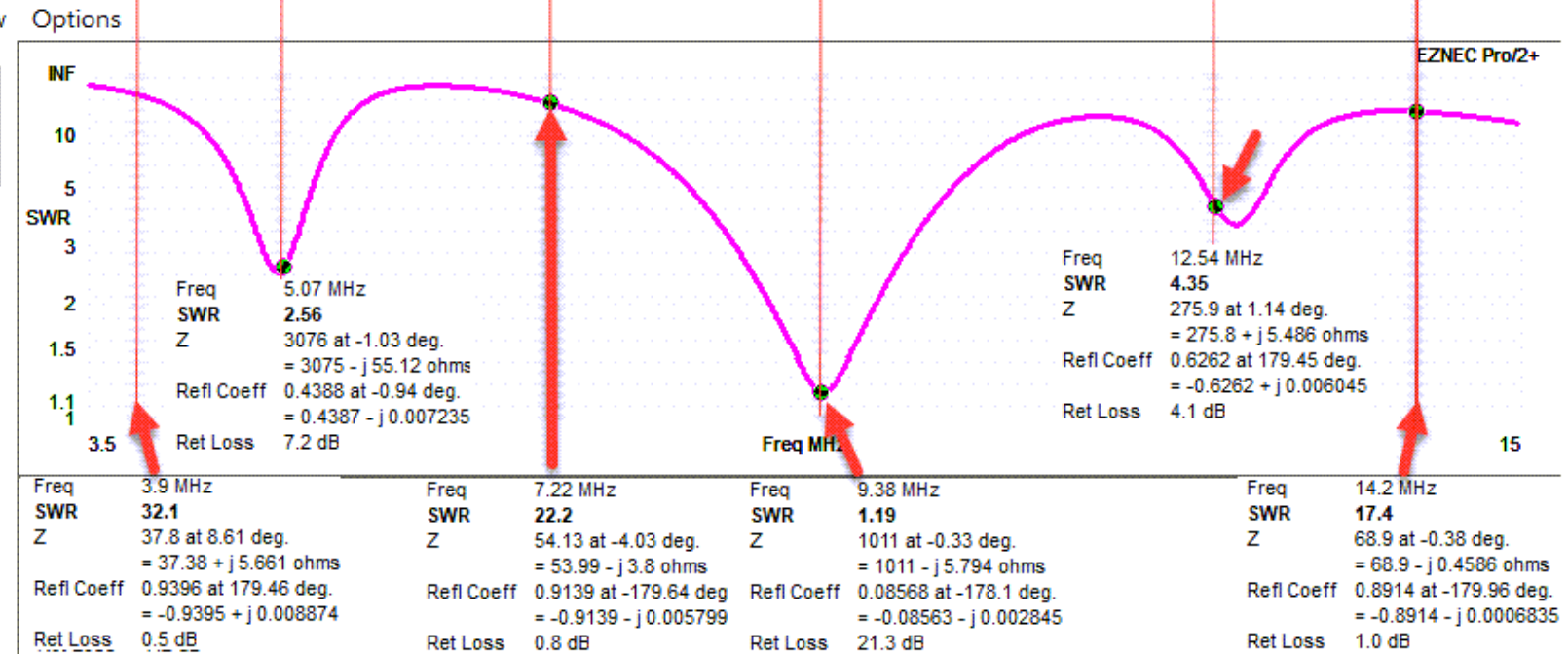
Z0

50 ohms

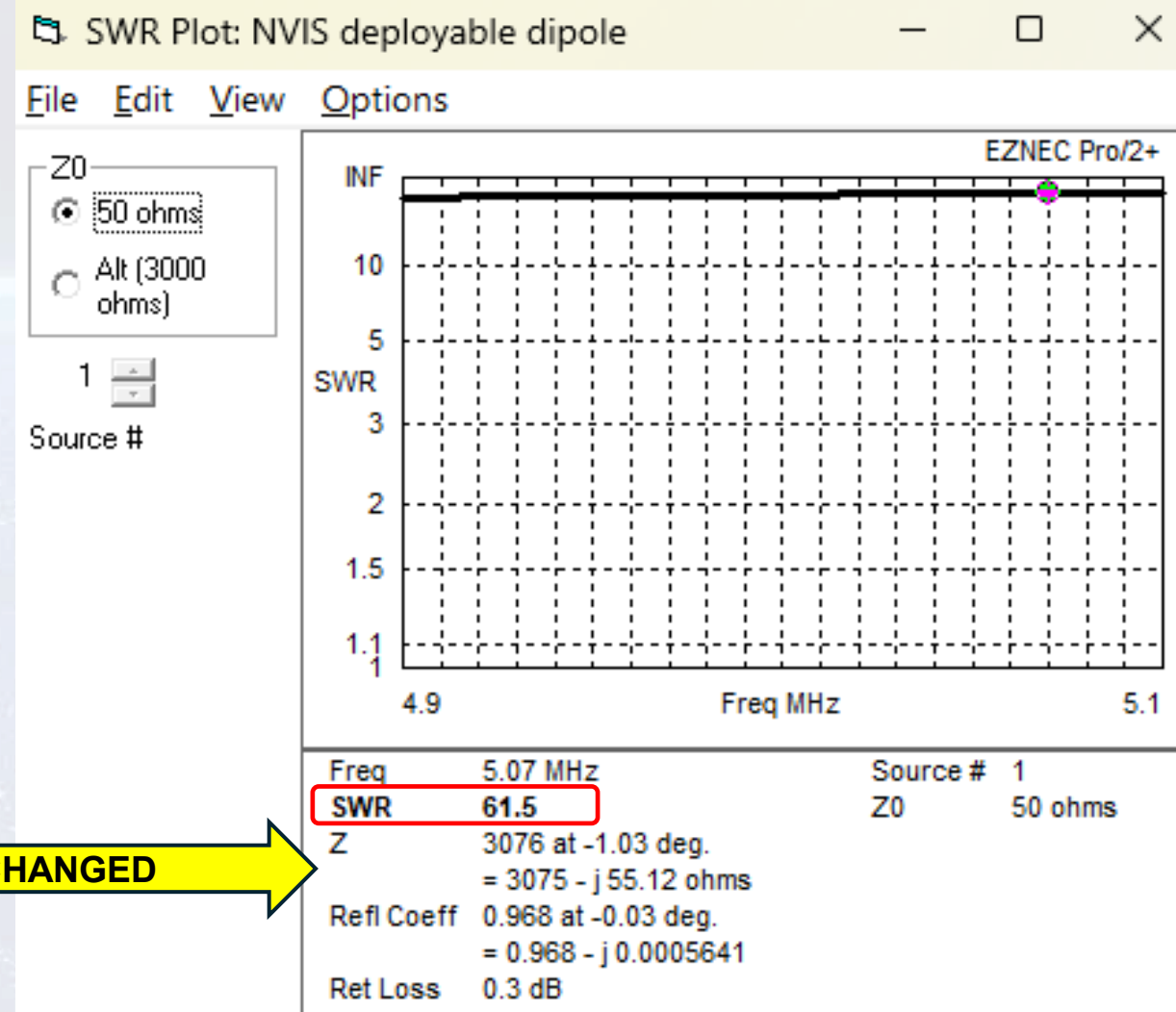
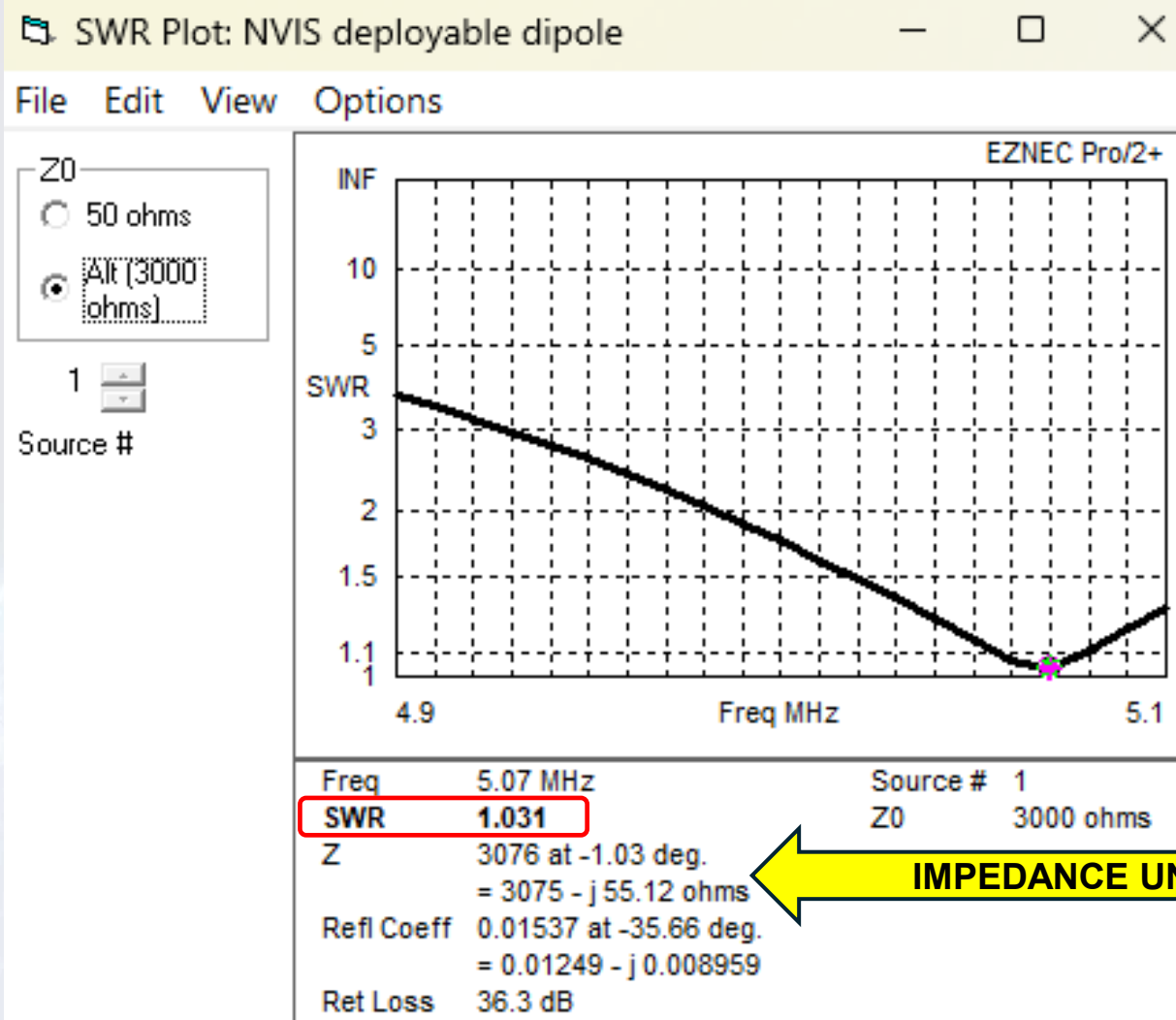
Alt (1200 ohms)

1

Source #



# Same Antenna – Same Frequency – Different Feed



← IMPEDANCE UNCHANGED →

# Antenna Efficiency for NVIS

## *Antenna Length improves $R_R$*

**Length** of antenna element is most significant factor for Radiation Resistance

- For a monopole,  $R_R = h^2 / 312$ 
  - $R_R$  is radiation resistance in Ohms
  - $h$  is the antenna length *in electrical degrees*
- Typical  $R_R$  for an 8-foot mobile whip at 7 MHz is  $< 3$  Ohms
  - For a 7 MHz dipole made of two mobile whips,  $R_R$  is  $< 6$  Ohms

Low  $R_R$  invariably means low antenna efficiency

- $R_R$  is **in series** with the coil loss ( $R_C$ ) and ground loss ( $R_G$ )
- 7 MHz efficiency of a two mobile whip dipole at 16 feet is **less than 10%**
- If lower, efficiency is much worse

**Your 100-Watt transmitter now equals 10 Watts or less !**

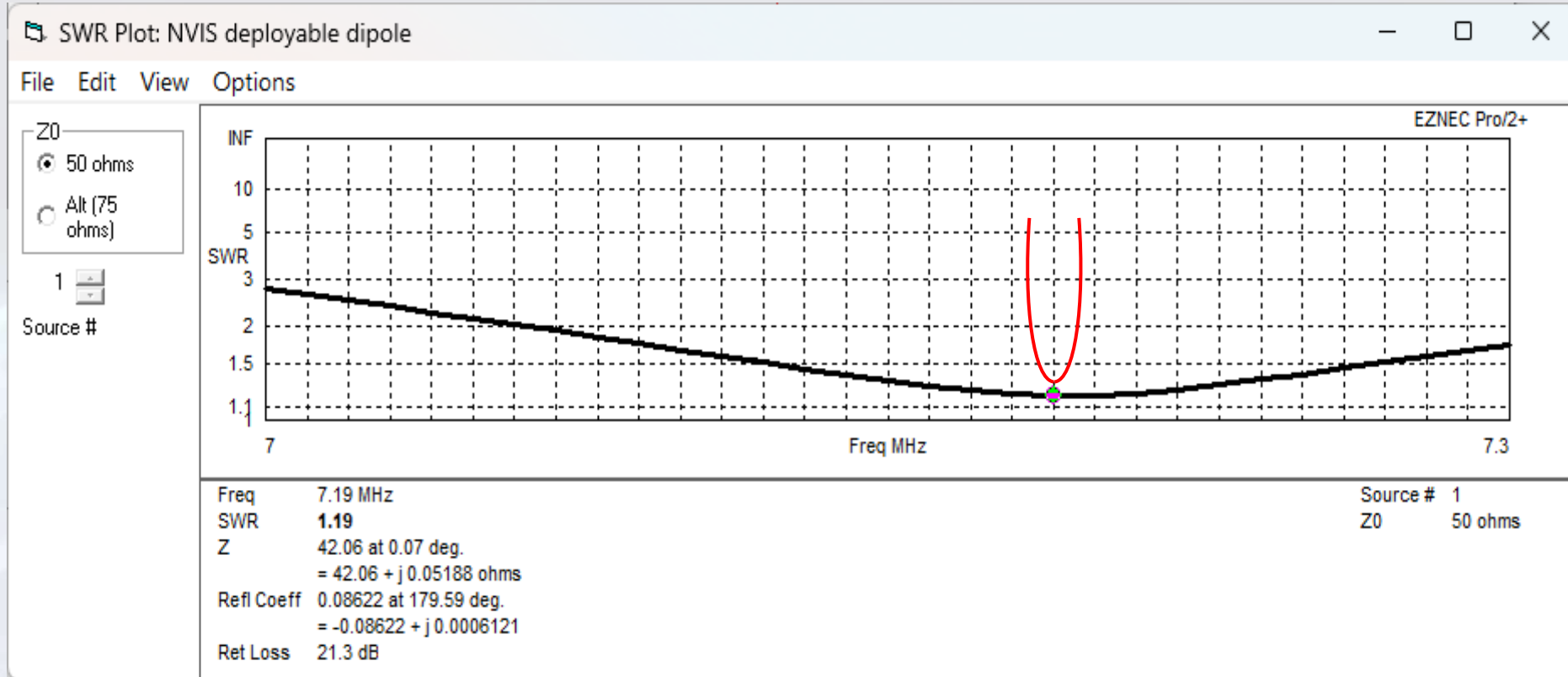
- 3.5 MHz efficiency of a two mobile whip dipole at 30 feet is **less than 5%**
- If lower, efficiency is much worse

**Your 100-Watt transmitter now equals 5 Watts or less !**



# Antenna Efficiency for NVIS

## Greater Antenna Length Yields Broad SWR



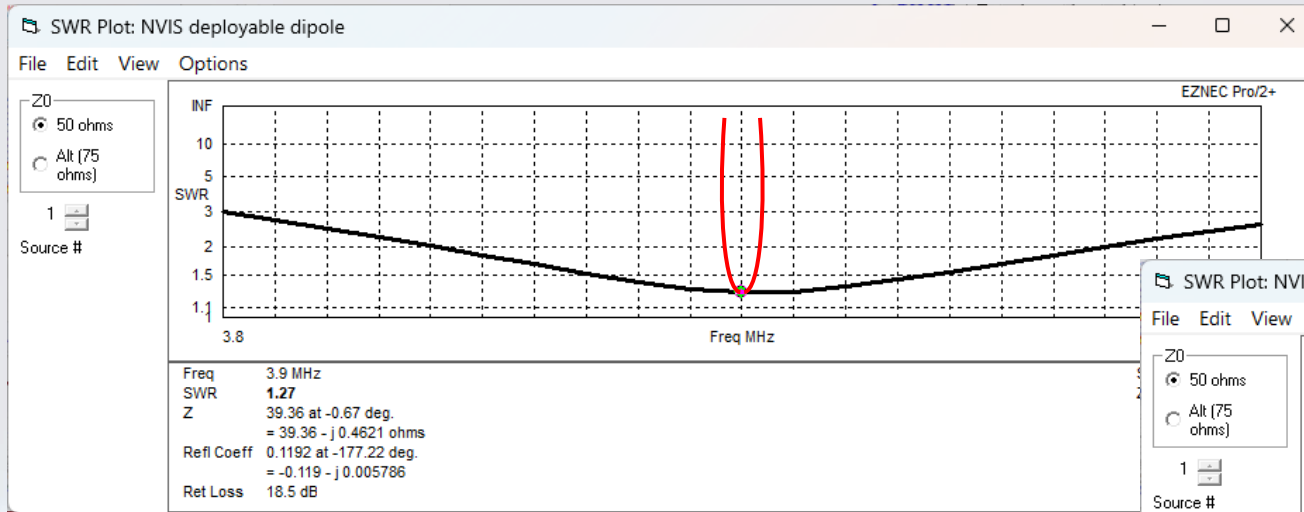
Full Size Dipole at 16 feet Resonant at 7.190 kHz  
32 feet 9 inches **per side** SWR < 1.8:1 across voice portion

**Typical mobile bandwidth shown in red.**

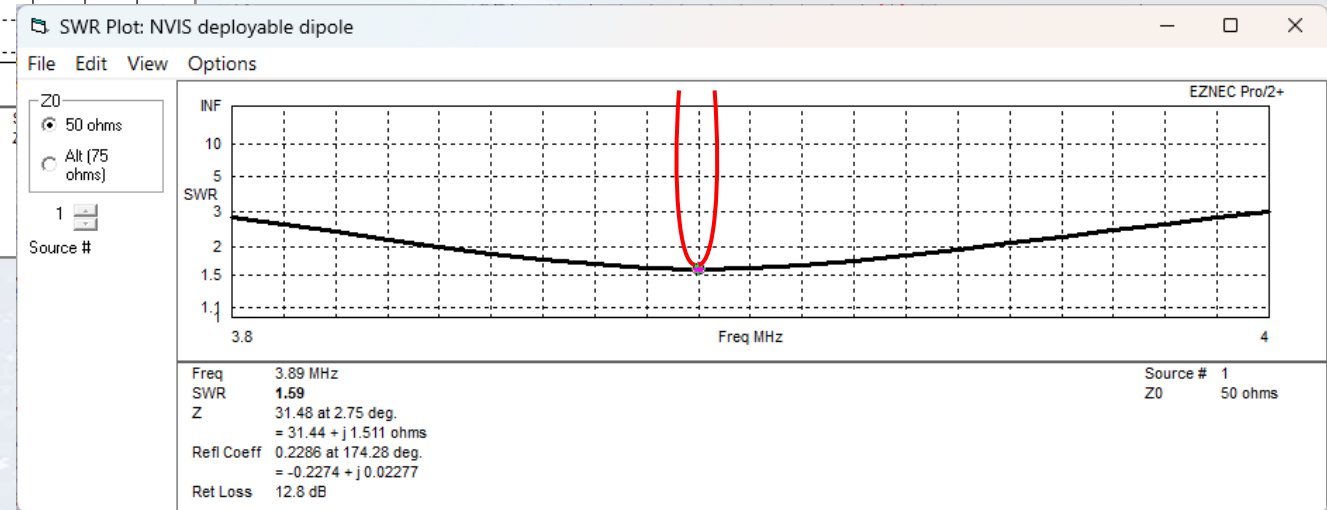
**The typical mobile antenna has a SWR bandwidth of < 20 kHz at 7 MHz.**

# Antenna Efficiency for NVIS

## Greater Antenna Length Yields Broad SWR



Full Size “flat-top” Dipole at 30 feet  
Resonant at ~ 3.9 MHz  
60 feet 6 inches **per side**  
SWR < 2:1 from 3.84 to 3.97 MHz  
Dipole SWR bandwidth = 130 kHz.



Full Size “Vee” Dipole  
Center at 30 feet, ends at 15 feet  
**Now** Resonant at ~ 3.89 MHz  
60 feet 6 inches **per side**  
Dipole SWR bandwidth = 110 kHz.

Typical mobile bandwidth shown in red  
The typical mobile whip has a SWR bandwidth of < 10 kHz at 4 MHz.

# Antenna Efficiency for NVIS

## Antenna Height

A properly designed NVIS antenna exhibits *gain* at all supported take-off angles:

- From near 3 dBd (dBd is gain over a dipole.)
- To as much as 5.3 dBd.

Both gain and efficiency of a horizontal antenna drop drastically as it is brought near earth.

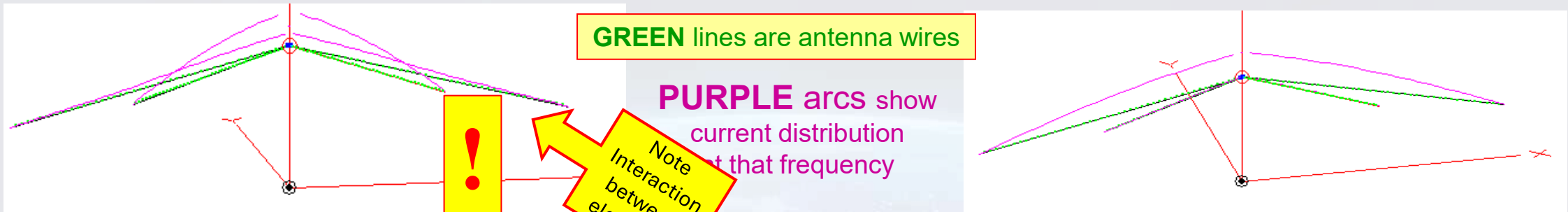
- Moving a 4 MHz half-wave dipole from 25 feet height ( $\cong 0.11 \lambda$ , which is below optimum) to 8 feet ( $0.035 \lambda$ ) results in a decrease in transmitted power of  $> 6$  dB (from  $> +3$  dBd to  $-3$  dBd)

**For a 100-Watt transmitter, that is a change from 200 Watts radiated to 50 Watts radiated!**

- Moving the antenna lower dramatically increases ground losses, and dramatically increases the attenuation both of transmitted and received signals:
  - Antennas are reciprocal devices: **Poor TX always is poor RX.**
  - A very low height full-sized dipole antenna usually has a relatively broad SWR curve, but is shifted in resonant frequency.
  - Feedpoint resistance is increased at very low heights, BUT
    - **The increase is because of ground loss.**

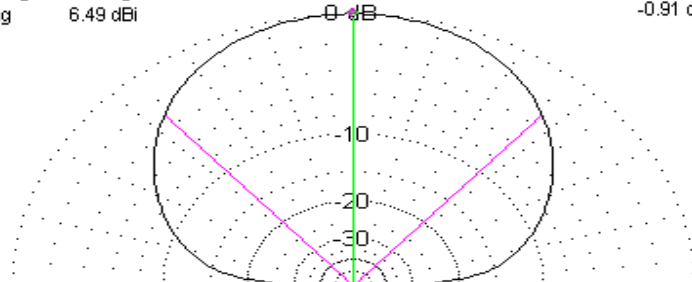
# 3.8 / 7.2 MHz “Double Vee” Dipole

Heights: 30 feet at Center, 15 feet at ends of 3.7 MHz elements  
 Ends of 7.2 MHz elements are 3 feet below 3.7 MHz elements



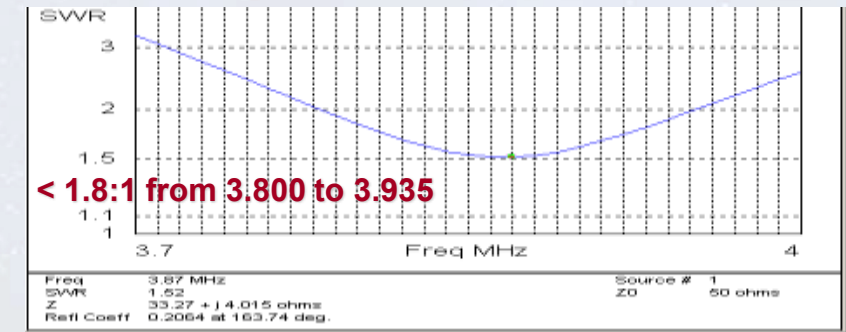
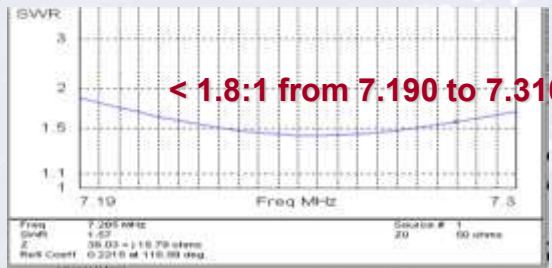
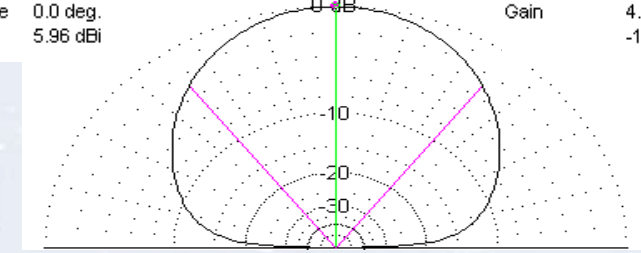
Elevation Plot  
 Azimuth Angle 0.0 deg.  
 Outer Ring 6.49 dBi

Cursor Elev 66.0 deg.  
 Gain 5.57 dBi  
 -0.91 dBmax



Elevation Plot  
 Azimuth Angle 0.0 deg.  
 Outer Ring 5.96 dBi

Cursor Elev 66.0 deg.  
 Gain 4.68 dBi  
 -1.28 dBmax



# Flattop Dipoles

Heights: 30 feet for 3.9 MHz, 15 feet for 7.2 MHz

7 MHz elements are about 66 feet long angled 30 degrees of azimuth from 3.9 MHz elements

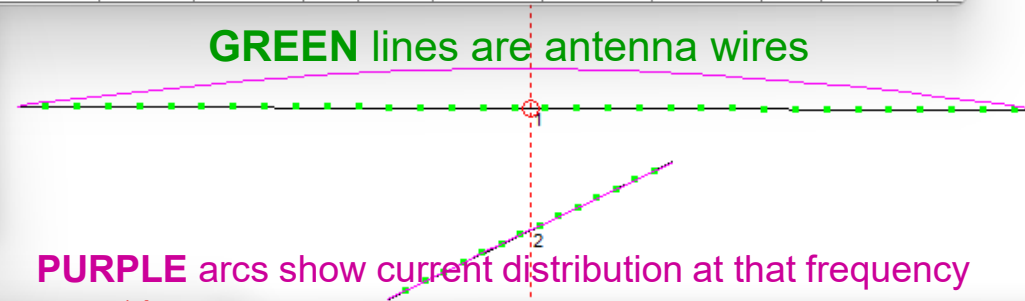
**3.9 MHz**

Gain over dipole is dBd  
dBd = dBi - 2.15

7.11 dBi = 4.96 dBd  
100W @ 4.96 dBd = 313W

Wires																
No.	End 1			Conn	End 2			Diameter (in)	Segs	Insulation			Wire Loss			
	X (ft)	Y (ft)	Z (ft)		X (ft)	Y (ft)	Z (ft)			Diel C	Thk (in)	Loss Tan	R (ohm-m)	Perm	Type	
1	-60.5	0	30		60.5	0	30	#12	33	1	0	0	1.74E-08	1	Copper	
2	16.4	28.4	15		-16.4	-28.4	15	#12	15	1	0	0	1.74E-08	1	Copper	

Sources							
No.	Specified Pos.	Actual Pos.		Amplitude	Phase	Type	
	Wire #	% From E1	% From E1	Seg	(V,A)	(deg.)	
1	1	50	50	17	1	0	I



GREEN lines are antenna wires

PURPLE arcs show current distribution at that frequency

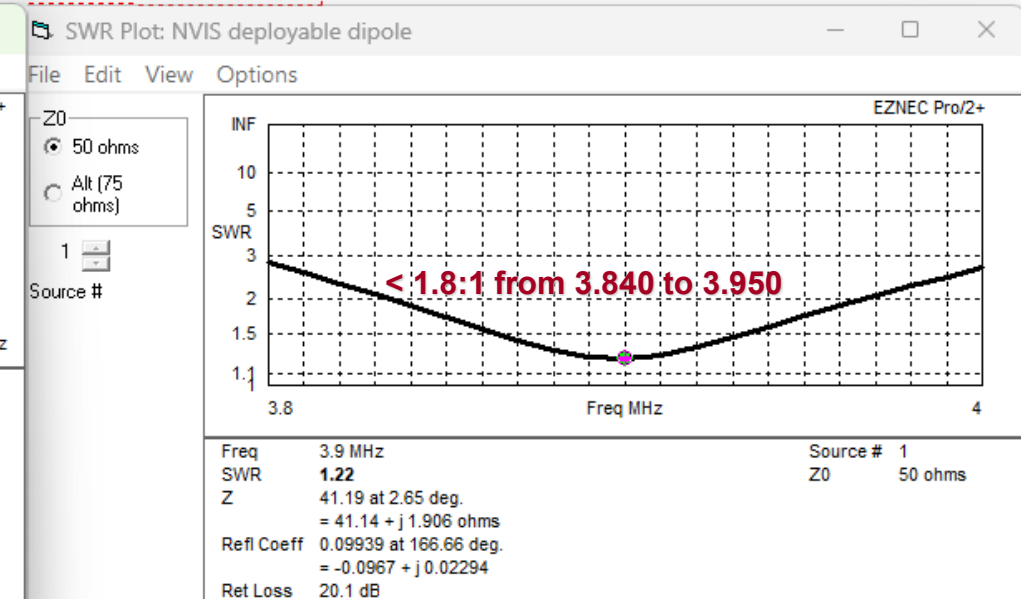
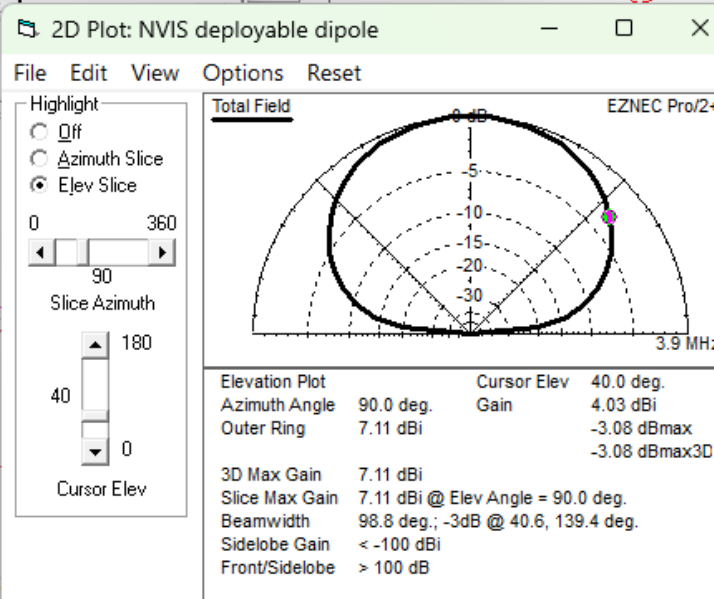
EZNEC Pro/2+ v. 7.0

File Edit Options Outputs Setups View Utilities Help

**NVIS deployable dipole**

- File: LAST.EZ
- Frequency: 3.9 MHz
- Wavelength: 252.198 ft
- Wires: 2 Wires, 48 segments
- Sources: 1 Source
- Loads: 0 Loads
- Trans Lines: 0 Transmission Lines
- Transformers: 0 Transformers
- L Networks: 0 L Networks
- Y Param Networks: 0 Y Param Networks
- Ground Type: Real/High Accuracy
- Ground Descrip: 1 Medium (0.0303, 20)
- Wire Loss: Copper
- Units: Feet
- Plot Type: 3D
- Step Size: 5 Deg.
- Ref Level: 0 dBi
- Alt SWR Z0: 75 ohms
- Desc Options
- Gnd Wave Dist: OFF

Average Gain = 0.729 = -1.37 dB



Antennas are fed INDIVIDUALLY – but a single feedline to a relay or switch at the antenna base would eliminate two long runs of coax.

# Flattop Dipoles

Heights: 30 feet for 3.9 MHz, 15 feet for 7.2 MHz

7 MHz elements are about 66 feet long angled 30 degrees of azimuth from 3.9 MHz elements

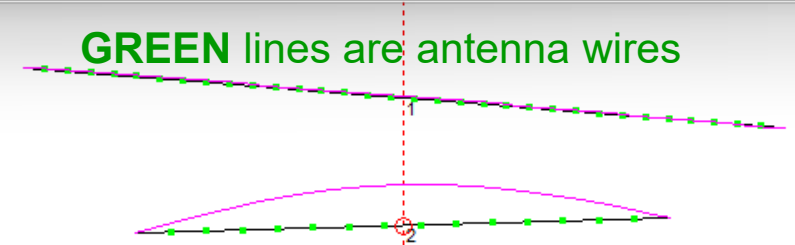
7.2 MHz

Gain over dipole is dBd  
dBd = dBi - 2.15

6.41 dBi = 4.26 dBd  
100W @ 4.26 dBd = 260W

Wires																	
No.	End 1				Conn	End 2				Diameter (in)	Segs	Insulation			Wire Loss		
	X (ft)	Y (ft)	Z (ft)			X (ft)	Y (ft)	Z (ft)				Diel C	Thk (in)	Loss Tan	R (ohm-m)	Perm	Type
1	-60.5	0	30			60.5	0	30		#12	33	1	0	0	1.74E-08	1	Copper
2	16.4	28.4	15			-16.4	-28.4	15		#12	15	1	0	0	1.74E-08	1	Copper

Sources							
No.	Specified Pos.	Actual Pos.		Amplitude (V, A)	Phase (deg.)	Type	
		Wire #	% From E1				
1	2	50	50	8	1	0	I



EZNEC Pro/2+ v. 7.0

File Edit Options Outputs Setups View Utilities Help

Open Save As Ant Notes

Currents Src Dat Load Dat FF Tab NF Tab SWR View Ant

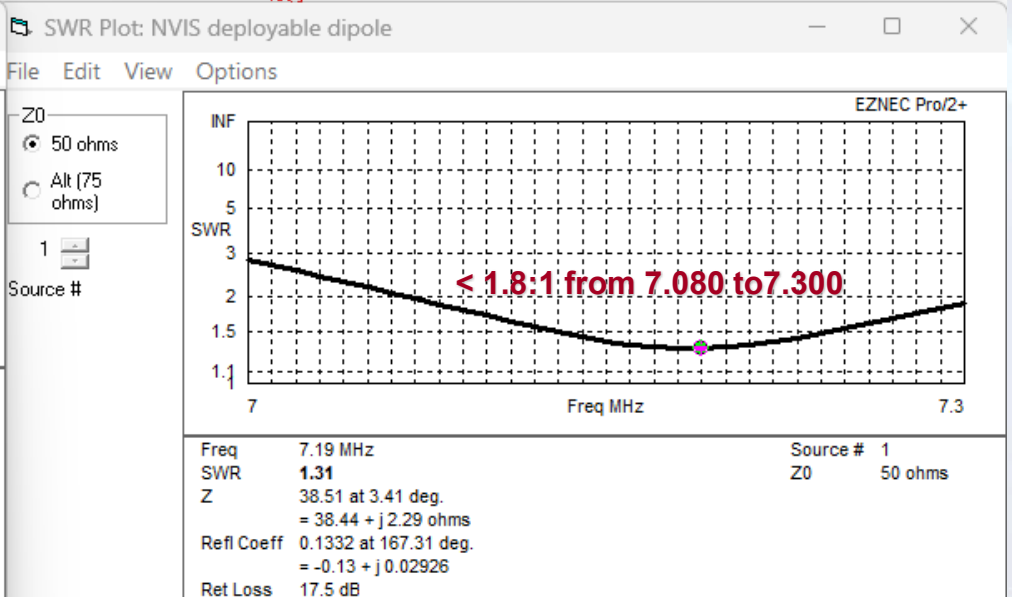
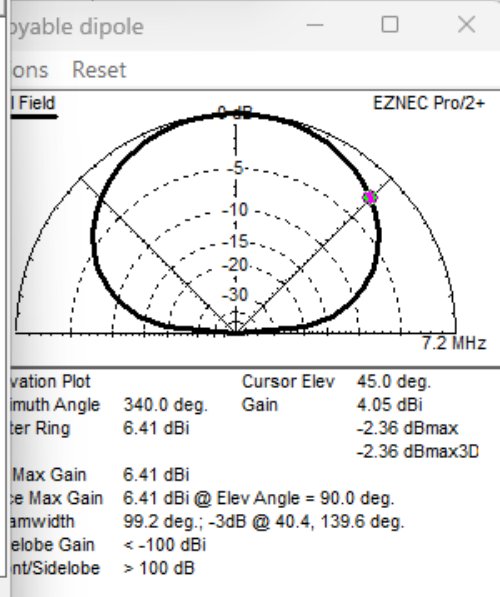
NEC-2D

FF Plot

**NVIS deployable dipole**

- File: LAST.EZ
- Frequency: 7.2 MHz
- Wavelength: 136.607 ft
- Wires: 2 Wires, 48 segments
- Sources: 1 Source
- Loads: 0 Loads
- Trans Lines: 0 Transmission Lines
- Transformers: 0 Transformers
- L Networks: 0 L Networks
- Y Param Networks: 0 Y Param Networks
- Ground Type: Real/High Accuracy
- Ground Descrip: 1 Medium (0.0303, 20)
- Wire Loss: Copper
- Units: Feet
- Plot Type: 3D
- Step Size: 5 Deg.
- Ref Level: 0 dB
- Alt SWR Z0: 75 ohms
- Desc Options
- Gnd Wave Dist: OFF

Average Gain = 0.626 = -2.04 dB *Model contains loss*



Antennas are fed INDIVIDUALLY – but a single feedline to a relay or switch at the antenna base would eliminate two long runs of coax.

# 3.9 / 7.2 MHz “Fan” Vee Dipole

Height: 30 feet at Center, 30 feet at ends. Elements are 30 degrees of *azimuth* from each other (minimum).

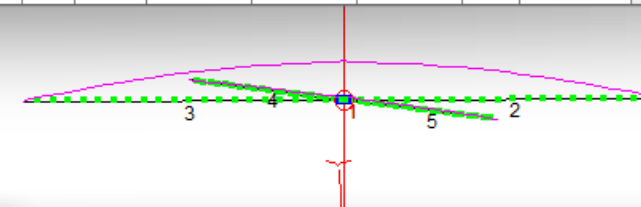
3.9 MHz

Gain over dipole is dBd  
dBd = dBi – 2.15

7.47 dBi = 5.32 dBd  
100W @ 5.32 dBd = 340W

Wires																
No.	End 1			Conn	End 2			Conn	Diameter	Segs	Insulation			Wire Loss		
	X (ft)	Y (ft)	Z (ft)		X (ft)	Y (ft)	Z (ft)		(in)		Diel C	Thk (in)	Loss Tan	R (ohm-m)	Perm	Type
1	-0.5	0	30	W3E2	0.5	0	30	W2E1	#12	3	1	0	0	1.74E-08	1	Copper
2	0.5	0	30	W5E1	60.5	0	30		#12	21	1	0	0	1.74E-08	1	Copper
3	-60.5	0	30		-0.5	0	30	W4E2	#12	21	1	0	0	1.74E-08	1	Copper
4	-28.8	16.625	30		-0.5	0	30	W1E1	#12	21	1	0	0	1.74E-08	1	Copper
5	0.5	0	30	W1E2	28.8	-16.25	30		#12	21	1	0	0	1.74E-08	1	Copper

Sources							
No.	Specified Pos.	Actual Pos.		Amplitude	Phase	Type	
	Wire #	% From E1	% From E2	(V, A)	(deg.)		
1	1	50	50	2	1	0	I



EZNEC Pro/2+

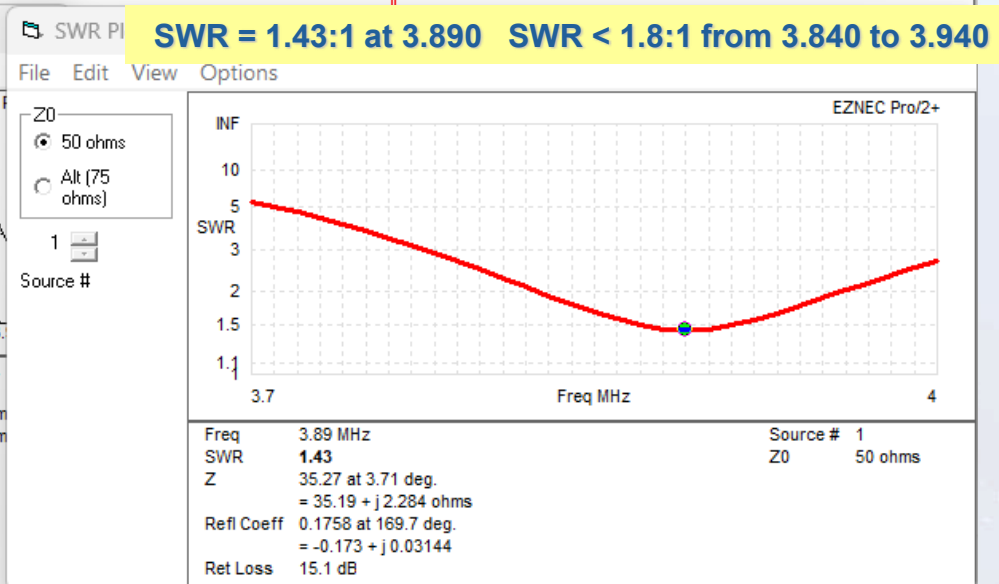
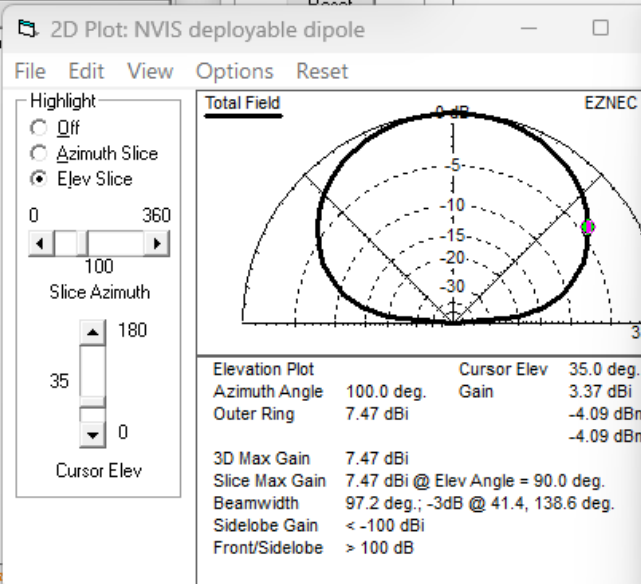
EZNEC Pro/2+ v. 7.0

File Edit Options Outputs Setups View Utilities Help

**NVIS deployable dipole**

- File: Crossed Dipoles at 30 deg 7 a
- Frequency: 3.9 MHz
- Wavelength: 252.198 ft
- Wires: 5 Wires, 87 segments
- Sources: 1 Source
- Loads: 0 Loads
- Trans Lines: 0 Transmission Lines
- Transformers: 0 Transformers
- L Networks: 0 L Networks
- Y Param Networks: 0 Y Param Networks
- Ground Type: Real/High Accuracy
- Ground Descrip: 1 Medium (0.0303, 20)
- Wire Loss: Copper
- Units: Feet
- Plot Type: 3D
- Step Size: 5 Deg.
- Ref Level: 0 dBi
- Alt SWR Z0: 75 ohms
- Desc Options
- Gnd Wave Dist: OFF

Average Gain = 0.793 = -1.01 dB



# 3.9 / 7.2 MHz “Fan” Vee Dipole

Height: 30 feet at Center, 30 feet at ends. Elements are 30 degrees of *azimuth* from each other (minimum).

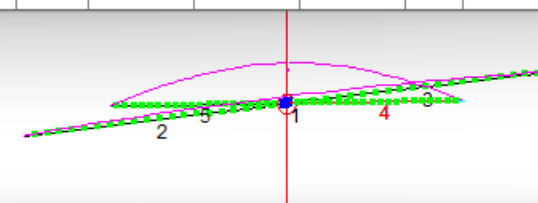
7.2 MHz

Gain over dipole is dBd  
dBd = dBi – 2.15

7.04 dBi = 4.89 dBd  
100W @ 4.89 dBd = 308 W

Wires																
No.	End 1			Conn	End 2			Conn	Diameter	Segs	Insulation			Wire Loss		
	X (ft)	Y (ft)	Z (ft)		X (ft)	Y (ft)	Z (ft)		(in)		Diel C	Thk (in)	Loss Tan	R (ohm-m)	Perm	Type
1	-0.5	0	30	W3E2	0.5	0	30	W2E1	#12	3	1	0	0	1.74E-08	1	Copper
2	0.5	0	30	W5E1	60.5	0	30		#12	21	1	0	0	1.74E-08	1	Copper
3	-60.5	0	30		-0.5	0	30	W4E2	#12	21	1	0	0	1.74E-08	1	Copper
4	-29	16.75	30		-0.5	0	30	W1E1	#12	21	1	0	0	1.74E-08	1	Copper
5	0.5	0	30	W1E2	29	-16.75	30		#12	21	1	0	0	1.74E-08	1	Copper

Sources						
No.	Specified Pos.	Actual Pos.		Amplitude	Phase	Type
	Wire #	% From E1	% From E1	(V, A)	(deg.)	
1	1	50	50	2	1	0



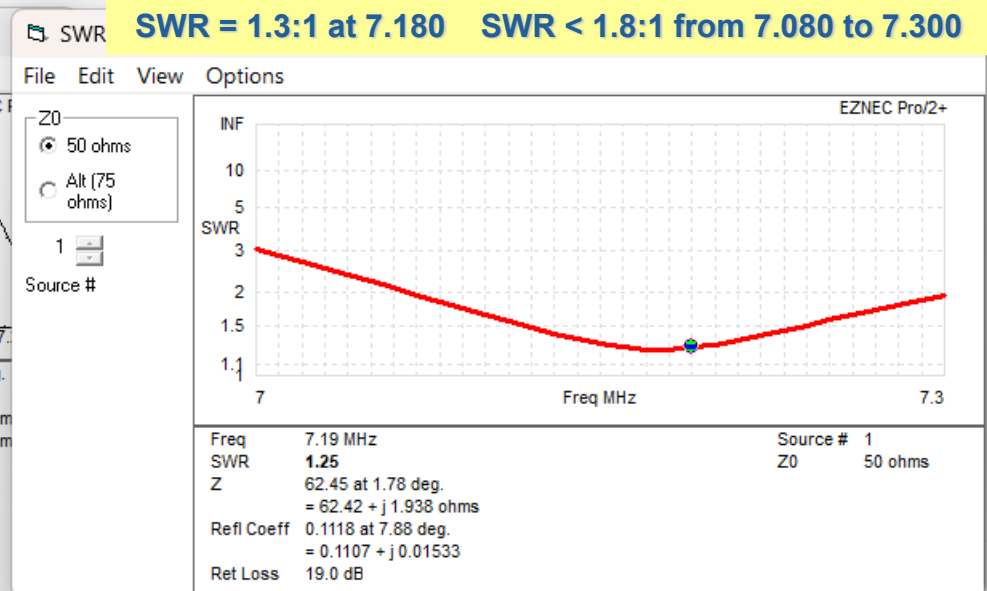
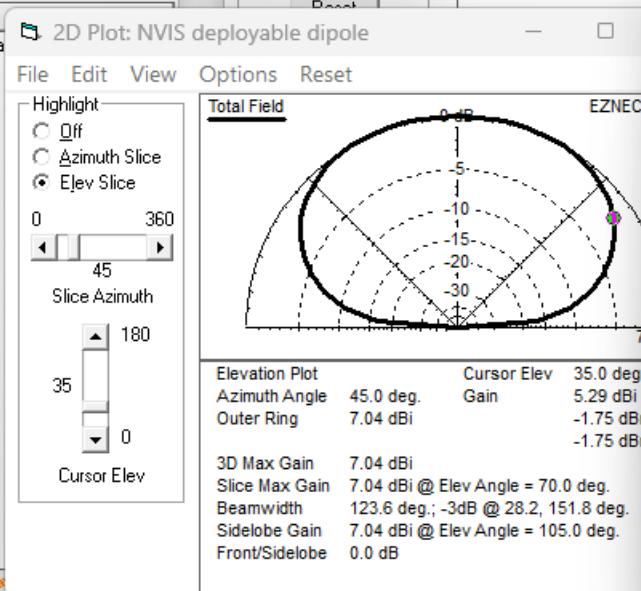
EZNEC Pro/2+

EZNEC Pro/2+ v. 7.0  
File Edit Options Outputs Setups View Utilities Help

**NVIS deployable dipole**

- File: Crossed Dipoles at 30 deg 7 a
- Frequency: 7.2 MHz
- Wavelength: 136.607 ft
- Wires: 5 Wires, 87 segments
- Sources: 1 Source
- Loads: 0 Loads
- Trans Lines: 0 Transmission Lines
- Transformers: 0 Transformers
- L Networks: 0 L Networks
- Y Param Networks: 0 Y Param Networks
- Ground Type: Real/High Accuracy
- Ground Descrpt: 1 Medium (0.0303, 20)
- Wire Loss: Copper
- Units: Feet
- Plot Type: 3D
- Step Size: 5 Deg.
- Ref Level: 0 dB
- Alt SWR Z0: 75 ohms
- Desc Options
- Gnd Wave Dist: OFF

Average Gain = 0.923 = -0.35 dB Model contains



# NVIS “Points to Ponder”

At 3.5 MHz, a full-size dipole installed at or near and above  $1/8 \lambda$ :

- Is *at very least* 10 times as efficient as a “two mobile whip dipole”
- Produces signal strengths (at the distant receiver) that are 18 dB to 24 dB greater (TX ERP is  $\cong$  24 dB greater: 300 W vs 5 W)
- Provides much greater Capture Area, so received signals are much stronger than those on a “two mobile whip dipole”

At 7 MHz, signal strengths from full-sized dipole at or near and above  $1/8 \lambda$ :

- Are 11 dB to 18 dB greater than those from the “two mobile whip dipole”
- TX ERP is  $\cong$  14 dB greater: 269 W vs 10 W
- Received signals are correspondingly stronger

When I easily can deploy an antenna that radiates from 250 to 340 Watts from my 100-Watt transmitter.....

- WHY would I use an antenna that makes that transmitter equivalent to 5 or 10 Watts?

Have I given myself the best chance of successful communication ?

# NVIS Summary

- ✓ Optimum NVIS antenna design is the polar opposite of DX antenna design.
- ✓ A height of  $1/8 \lambda$  results in optimum take-off angles and substantial antenna gain at those angles.
- ✓ Placing the antenna above  $1/8 \lambda$  results in lowered take-off angles that may not fully cover the required area, and in lowered gain.
- ✓ Placing the antenna too low results in “negative gain” (i.e., LOSS) for both TX and RX signals.
- ✓ Because most deployed stations will have no more than 100 Watts output, antenna efficiency is critical at ALL sites.

Efficiency is especially critical for deployed stations.

# Near Vertical Incidence Skywave (NVIS)



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