Exploiting NVIS Propogation for RAYNET Operations Part II

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In the first article the author looked at the principles of NVIS showing the effect of the aerial height on the aerial polar diagram and gave the example of using the G5RV as an NVIS aerial as it was inexpensive to make and more importantly easy and fast to deploy.

In this second article we look at other aerials that can be used for both mobile deployment and for fixed station use, where the NVIS qualities can be further optimised. We also consider the parameter's that are important to consider when operating NVIS and the results of the 5MHz experiment.

In the first article (*RAY~Link Issue 71, April 2010*) it was stated that the NVIS aerial at 5 metres above the ground gives good results. The use of very low NVIS aerials is really only for covert operations where you do not want to give away your position or just can't have a high aerial.

The polar diagram of such an aerial has an egg shape and if the frequency is too high the signal can go straight through the F layers and be lost to space, the angle of transmission has an effect on this. A signal fired straight up is more likely to go through than one at an oblique angle. The Skip aerial working at the same frequency but a lower angle of radiation is still reflected back to earth as shown in *Figure 1*.

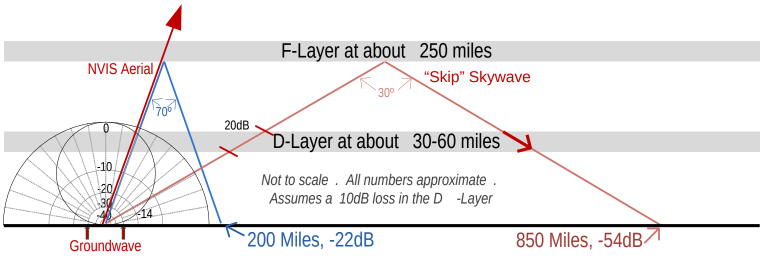


Figure 1

Parameters to monitor when operating NVIS

foF2 is one of the parameters to monitor when operating close NVIS. See *Figure 2*.

foF2 is the critical frequency of the F2 layer. It is the maximum frequency, which can be supported by the F2 layer when a wave is vertically incident upon the layer. Above this frequency the signal goes through the F layer and is lost.

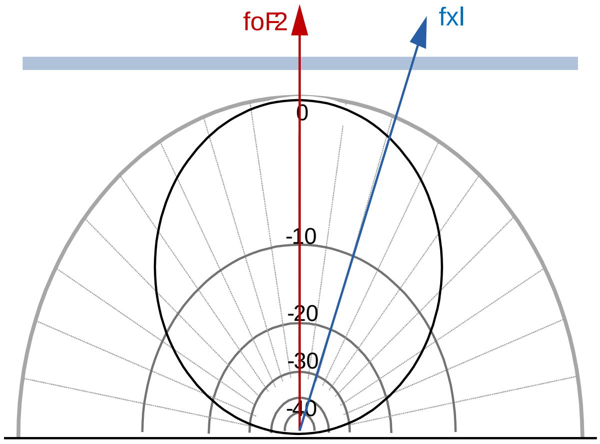


Figure 2

This parameter is the one to monitor if you are working a RAYNET group that is very close in miles but out of groundwave range due to hills etc.

The parameter **fxI** is defined as the highest frequency on which reflections from the F region are recorded, independent of whether they are reflected overhead or at oblique angle. You should take notice of this if working RAYNET groups at a greater distance up and down the country.

Other parameters also reported are of more use for a Skip - DX aerial:-

Sporadic E critical frequency, FOES
Maximum Usable Frequency MUF
This is the highest frequency for reliable radio communications by the ionosphere**. The median MUF** is the highest frequency that will be usable at a particular hour for at least 50% of the days of the month.
MUF (D) is the Maximum Usable Frequency related to Distance at low angle's of radiation when using a 'skip' aerial.
There are a number of sources on the Internet for monitoring foF2, you may be able to choose a monitoring station local to yourself for accurate information. The author prefers to use the Chilton atmospheric report, (*Figure 3*) which updates every 10 minutes, and also gives other useful parameters. Including fxI. This is available at:- [http://www.ukssdc.ac.uk/cgi-bin/digisondes/latest_view2gif .pl?Station=chilton.](http://www.ukssdc.ac.uk/cgi-bin/digisondes/latest_view2gif.pl?Station=chilton) (You need to register on line to receive this information.)

This ionogram shows that foF2 at 14.30 on February 9th was at 5.6MHz and so the 60 metre band (5MHz) could be used. 40 metres (7MHz) would not be usable as it is above the foF2 frequency and so the signals would pass through the ionosphere and be lost to space.

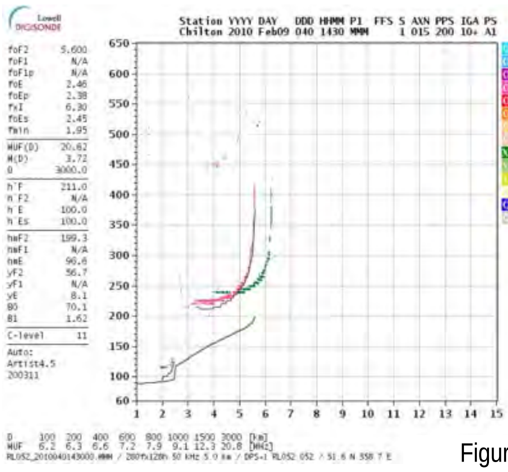


Figure 3

80 Metres would also be usable but there would be greater losses in the D layer compared to the preferred 60 metres.

The ionogram in *Figure 4* was taken at 23.30 on January 26th and at this time with foF2 at 2.75MHz and as 40, 60, and 80 metres are above foF2 it would be necessary to use 160 metres for close up NVIS communication.

Viewing the D MUF figures at the bottom of the diagram then 80 metres could be used to receive signals over 600 km distance.

Looking now at the ionogram (*Figure 5*) it is evident that for NVIS operation on a 24 hour basis it is necessary to change bands. This ionogram taken on 25th and 26th January 2010 shows foF2 in red and fxI in Blue. From this you can see that in January it is not viable to use 40 metres for NVIS and late at night and early morning of 26th 160 metres would need to be used. This ionogram is available from http://g4irx.nowindows.net/fivemegs/comparison.php

The same ionogram (*Figure 6*) taken on 8th and 9th March 2010 shows that 40 metres is still not viable apart from a short time at 10.30 on the 9th, 60 metres could be used most of the day with a change to 80 metres at 21.00 for the night until about 07.00 to 09.00 on the 9th march but with a change to 160 metres only needed for about an hour at 05.30 in the morning of the 9th March.

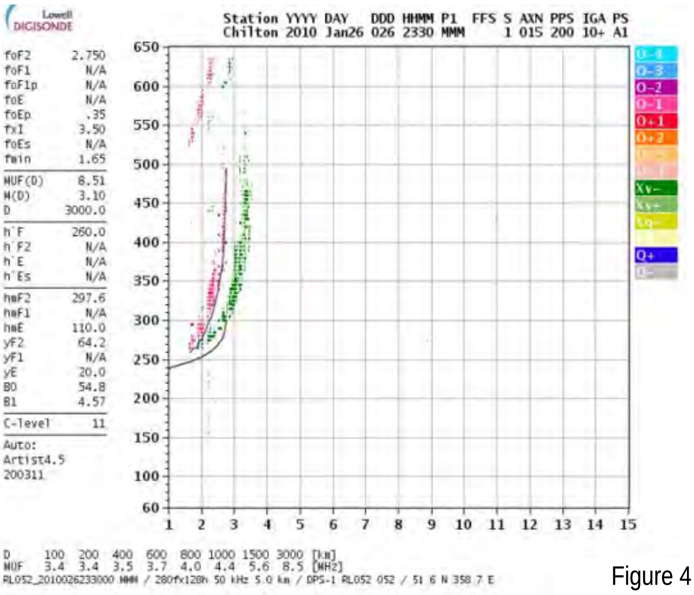


Figure 4

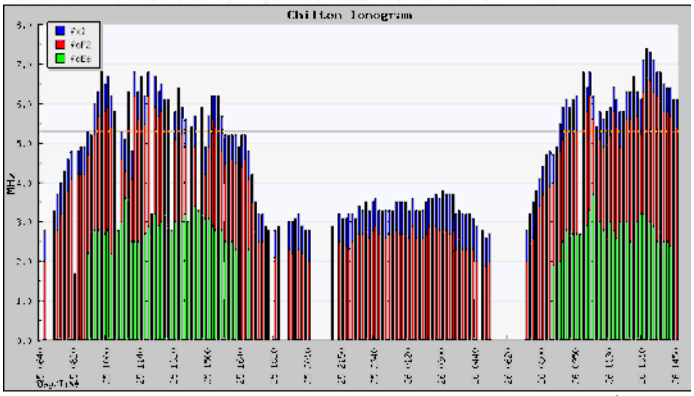


Figure 5

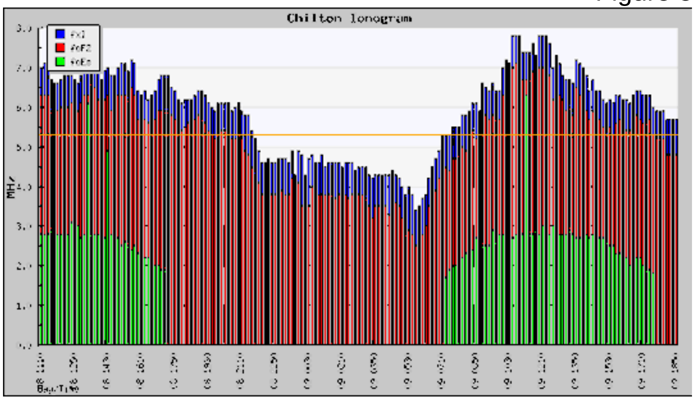


Figure 6

Aerial Choice for Portable Operation

In the first article the G5RV was covered as a good option for multi band NVIS operation, but being non-resonant it is a compromise between one aerial covering many bands and as such has to use an autotuner for quick tuning.

A more efficient aerial giving improved results being a resonant dipole, but by the nature of optimised, close NVIS operation the aerial has to cover 40,60,80 and if 24-hour operation is needed, 160 metres too.

For RAYNET portable operation a multiband dipole gives good NVIS results.

The author uses an insulated mast (*Figure 7)* in the form of 2 x 2.75 metre 68mm down pipes giving a height of 5.5 metres. These are connected together using coach bolts. They fit in a standard car and can be assembled very quickly.

Figure 8 overleaf shows the configuration used using a BU50 Balun at the centre of the 3 dipoles.

The length per element is as follows:-

40 Metres 7.02MHz 10.38 metres / element

60 Metres 5.368MHz 13.60 metres / element

80 Metres 3.65MHz 20.04 metres / element

Nylon Cord

The use of counterpoise wires is optional for fixed installations but is useful where ground conditions need to be improved. Each counterpoise wire is 6cm apart and laid on the ground. They should be 5% longer than the aerial elements. (*Figure 8 overleaf*.)


Figure 7

When constructing this aerial there will be interaction between the band sections and an aerial analyser like the miniVNA can be used to confirm exact frequency, depth of resonance, impedance etc. (*Figure 9*.)

It is best to resonate the lowest frequency first, and then the higher frequencies in turn. Some retuning may be necessary and should be done in the final height and configuration of the aerial.

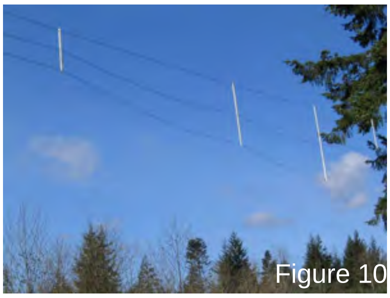


Figure 10

Making sure that there is at least a 30^0 angle between each element can reduce interaction between bands.

In an installation where the aerial elements have to be in the same direction the 30º angle between the bands can be achieved using a vertical spreader as shown in *Figure 10*.

Alternatively a horizontal spread can be used as outlined in the aerial shown in *Figure 11*.

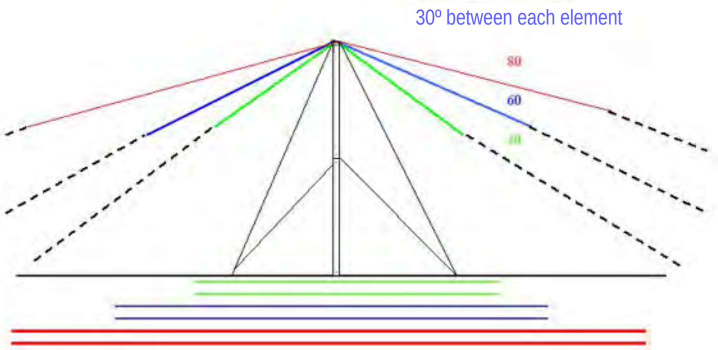


Figure 8

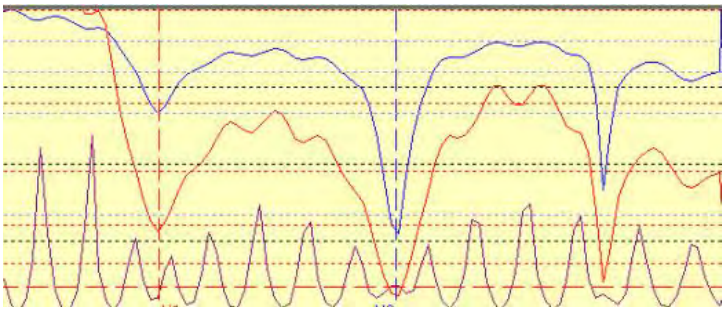


Figure 9

Multiband inverted V aerial

The multiband inverted V aerial shown in *Figure 11* is good for RAYNET portable operation.

This uses the 5.5 metre downpipe mast The lower section of the mast is guyed to make it upright and the aerial elements and nylon cord support the top part of the mast.

Each element is separated from the next by an angle of 60 degrees to stop the interaction between resonance's mentioned earlier.

If groups are using the same configuration then for best results align the 60 metre section in an east west direction, and the other alignments follow and are in the same orientation as other stations.

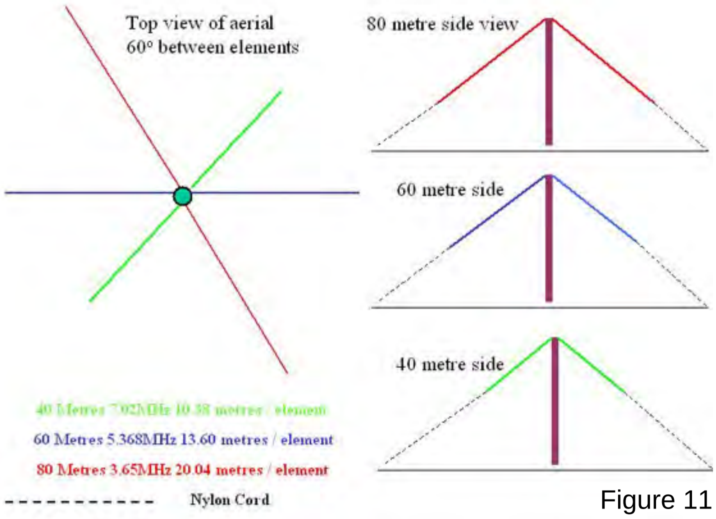


Figure 11

The 5MHz Experiment (60 metres)

The RSGB's 5MHz Experiment has now been extended for another 5 years and so RAYNET should make use of this band for NVIS daytime operations.

The 5MHz Experiment is a large-scale propagation and aerial experiment in which all can contribute through logging their normal contacts on one or more of the channels.

It is necessary to apply using a OfW285Application for a new or updated 5 MHz Notice of Variation (NoV) to an Amateur Radio (Full) Licence

http://licensing.ofcom.org.uk/binaries/spectrum/amateur-radio/apply-for-a-licence/ofw285.pdf

Once the NoV is received you can either modify an existing rig or purchase one of the many ex army rigs that cover the 5MHz band.

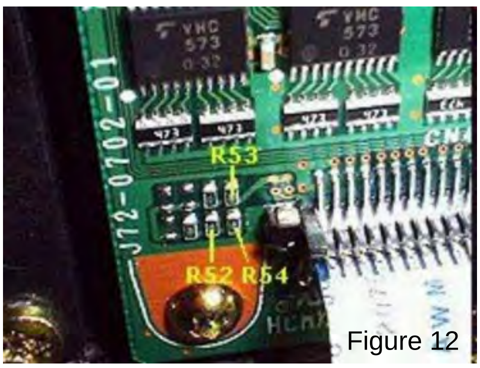


Figure 12

←

In my case I modified my Kenwood TS2000. (*Figure 12*).
*Remove R52 to expand the RX frequency. *Remove R53 to expand the TX frequency. *Remove R54 to expand the features. (Cross-band Repeat, SkyCommand, External Remote and etc.)

The 5Mhz band is allocated seven spot frequencies used on a shared basis with other services. The channels are allocated a two-letter identification and Channel FC is used for beacons and the monitoring of beacons. See *Figure 13* overleaf.

→

The SINPO Code is the preferred reporting method for signals on the 5Mhz band:

S - Signal Strength - Simply the strength of the transmission

I - Interference - Interference from other stations

N - Noise - The amount of noise

P - Propagation - Whether the signal is steady or fades from time to time

O - Overall Merit - An overall score for the listening experience under these conditions

Figure 13 - 5Mhz Freq Allocation

Centre frequency kHz	USB carrier frequency kHz	Also known as
5260	5258.5	FA
5280	5278.5	FB
5290	5288.5	FC
5368	5366.5	FK
5373	5371.5	FL
5400	5398.5	FE
5405	5403.5	FM

Figure 14 - Results of 5Mhz Experiment

Aerial Comparison

Resonant Dipole (RD) -
Best received Result

Non Resonant Dipole (NRD) -
2nd best result

Vertical (V) -
3rd place

Other (O) - Worst Result

	Sent					Received	
	S	I	N	P	O	S	O
RD	4.43	4.71	4.37	4.41	4.44	4.50	4.54
NRD	3.91	4.57	4.06	4.30	4.07	4.43	4.49
V	3.89	4.55	3.83	4.05	3.85	4.12	4.04
O	4.11	4.79	3.98	4.22	4.26	4.06	4.29

- Dipoles "best" for received and transmitted sign and overall reports.
- Verticals more susceptible to noise than dipoles.

The best results for overall height at 5Mhz agree with the NVIS recommendations from the first article (RAY~Link, April 2010).

Signals Sent (Averaged)

Dip Ht (M) AGL	No of Messages	S	I	N	P	O
4	189	4.01	4.64	3.74	4.07	3.89
5	209	4.41	4.62	4.22	4.42	4.46
6	18	4.58	4.95	4.84	4.63	4.74
7	253	4.12	4.63	4.49	4.28	4.21
8	482	4.06	4.32	4.19	4.35	4.28
9	339	4.34	4.96	4.6	4.83	4.53
10	472	4.12	4.75	3.97	4.32	4.12

Signals Received (Avg)

Ht (Mtr)	S	O
4	3.86	3.81
5	4.61	4.69
6	3.92	4.17
7	4.28	4.39
8	4.57	4.63
9	4.42	4.54
10	4.7	4.65

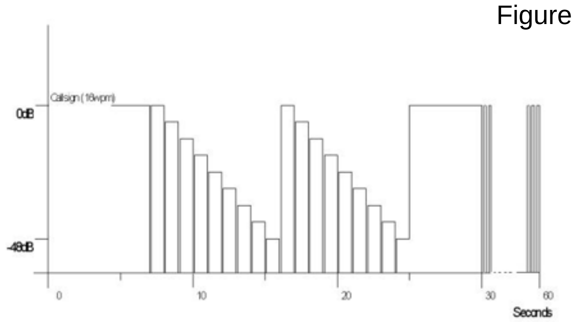
- No clear relationship with height, results probably not statistically significant; but
  - possible optimum around 5 mtrs
  - poor reciprocity between send and received reports
- Sample sizes quiet small and of poor diversity at some heights (9m data mostly from one station)
- Possible problems with interpreting height.

The 5MHz Beacons – Allow you to check your NVIS reception.

There are three identical propagation-studies beacons operating on **5.290MHz (Tune 5.2885 MHz).** GB3RAL is located at the Rutherford Appleton Laboratories, Oxfordshire.

GB3WES, located in Cumbria and GB3ORK located on the Orkney Isles. All three beacons transmit at a nominal power of 10W. All three transmit the sequence described by *Figure 15.*

Figure 15



The 5MHz Beacons

All three beacons transmit the sequence described in the Table at *Figure 15* at the time listed in *Figure 16*.

Figure 16

Stations transmit for these minutes past each hour:					
GB3RAL	RAD Oxfordshire	0	15	30	45
GB3WES	Cumbria	1	16	31	46
GB3ORK	Orkneys	2	17	32	47

The 5Mhz Beacon Monitoring Stations

http://g4irx.nowindows.net/fivemegs/comparison.php
There are three 5MHz Beacon Monitoring Stations available on the Internet based at GM4SLV, Shetland Islands, G3WKC at Newport Pagnell (Milton Keynes) and at G4ZFO on the Isle of Wight see *Figure 17*.

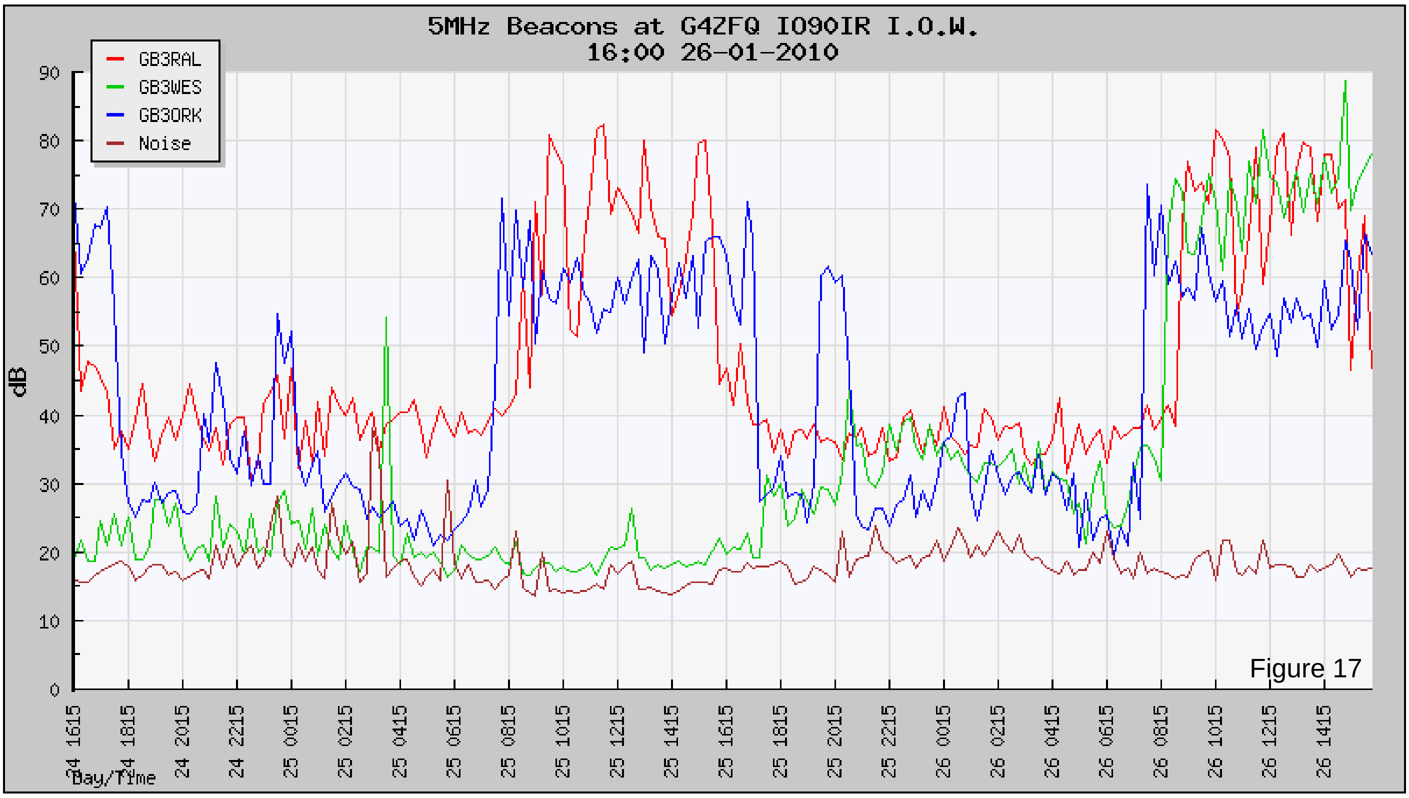


Figure 17

Conclusions and NVIS Trial

From the work done in testing NVIS operation a number of recommendations are concluded.

1. From the Aerial diagrams, and the 5 MHz trial overall results use a Resonant dipole Aerial with 1:1 Balun at 5 metres.
2. Due to effect of ground on aerial impedance Investigate effect of folded dipole.
3. Investigate improvements by counterpoise laid under each aerial (being 5% longer than the aerial elements).
4. At least one group member should Monitor foF2 on the Internet to agree the band of operation
5. Use 5MHz beacons to test your NVIS operation on 60 metres.
6. For best results make sure aerials in same orientation i.e. East-West (As Orkneys)
7. Agree to contact at a specific time, and (as learned from the 5MHz Experiment) a precise frequency using upper side band.
8. For portable NVIS operation the use of a multiband Inverted V NVIS aerial is preferred as it is quick to deploy.