Analysis of Wallops Island Style Antennas for use in TIGER-3 Radar

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Introduction

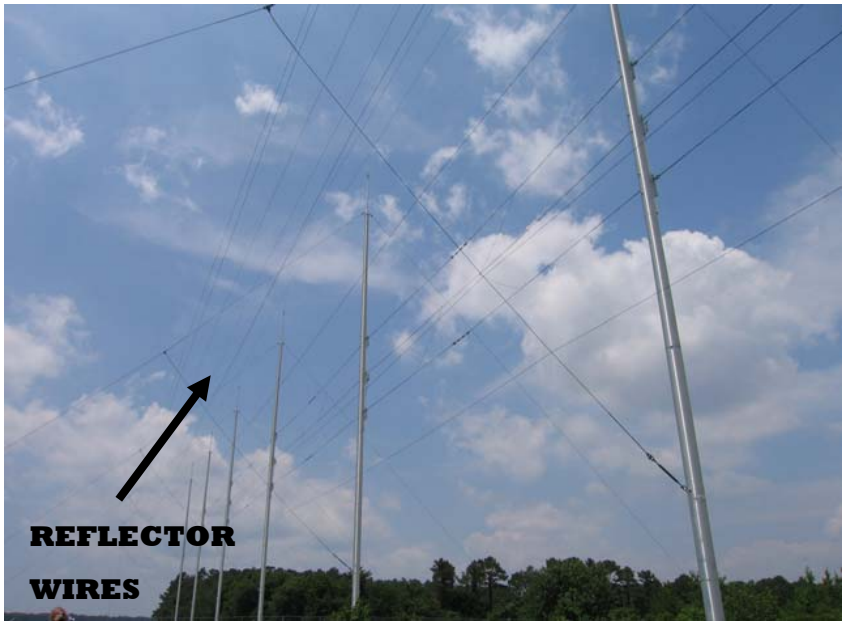
La Trobe University, the University of Newcastle and the University of Adelaide are planning to build a new digital SuperDARN HF radar at Buckland Park, near Adelaide in South Australia. Sabre log-periodic antennas were used for the construction of the Bruny Island and the Unwin (NZ) radars. By moving to a design similar to the one used in the Wallops Island SuperDARN radar, we hope to make significant cost savings in the order of $100K in the construction of the new radar.

Sabre “SuperDARN” log-periodic

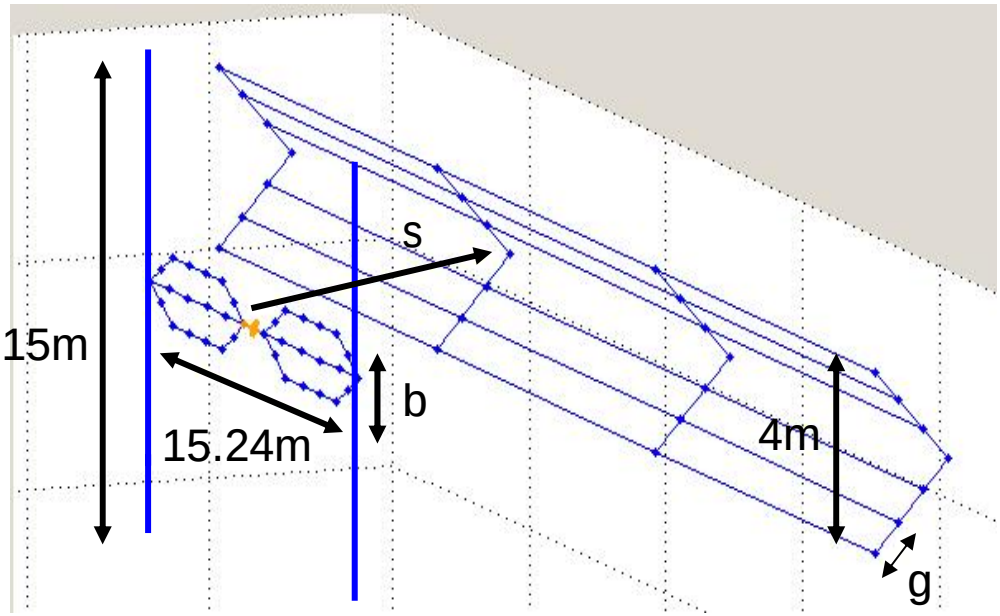
Using an antenna modelling program called SuperNEC which runs in conjunction with Matlab, analysis of the Wallops Island type bow-tie antenna has been undertaken and roughly analysed to determine its suitability for the new TIGER – 3 SuperDARN radar.

Bow-tie with corner reflector

Wallops Island



Our Model



For initial values rough approximations of the Wallops Island antenna were used. Fixed values of the model include : bow-tie length = 15.24m, reflector aperture angle = 90°. Masts will be 15m (18m if necessary) with a reflector attached by guy ropes.

S = distance between the feed and the corner of the reflector.

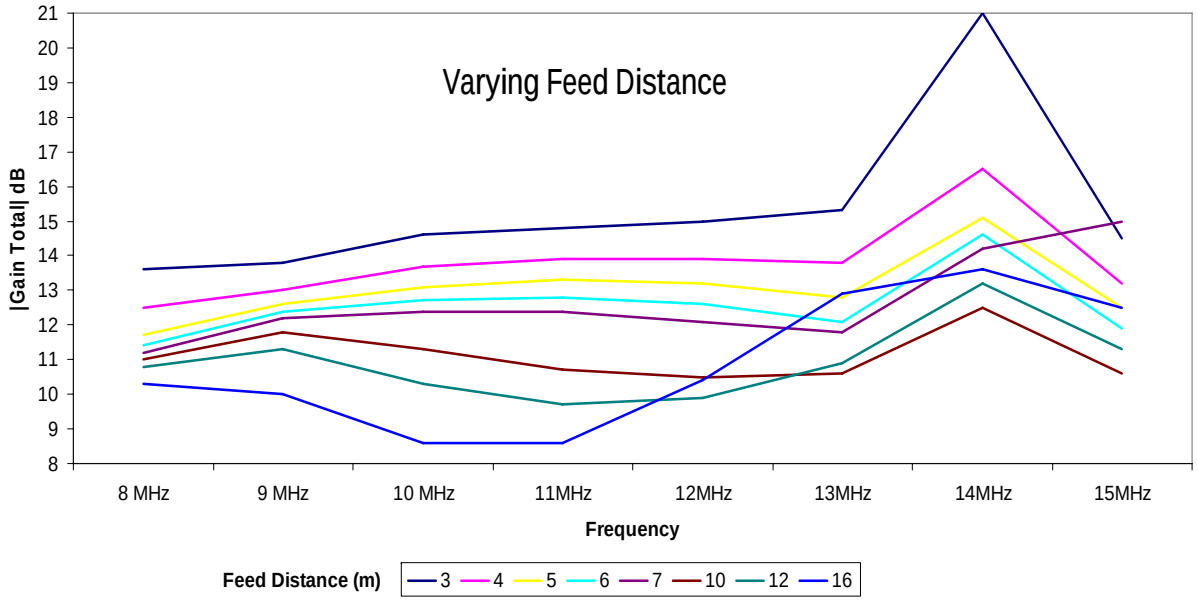
g = separation distance between reflector wires

b = bowtie width

Varying the feed distance

Several antenna parameters were varied in order achieve a 12dB gain across the 8-18MHz band and a satisfactory radiation pattern.

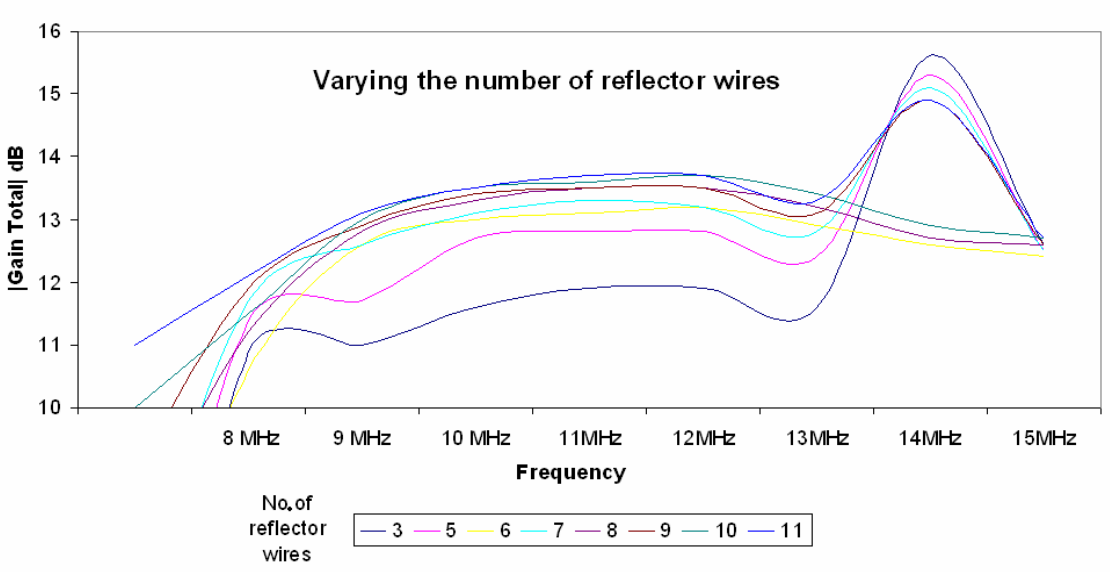
First modelling was conducted by varying the S (feed distance) value. All other values were fixed as follows : 6 reflector wires, g = 0.66, b = 2m



From the plot it can be observed that S = 3, 4, 5 and 6 all exhibit around 12dB gain or more. Both the 3 and 4 meter S values have a large gain rise at 14MHz which causes undesirable lobes of radiation. Between the S = 5 and S = 6 values, S =5 was chosen purely because of its gain advantage.

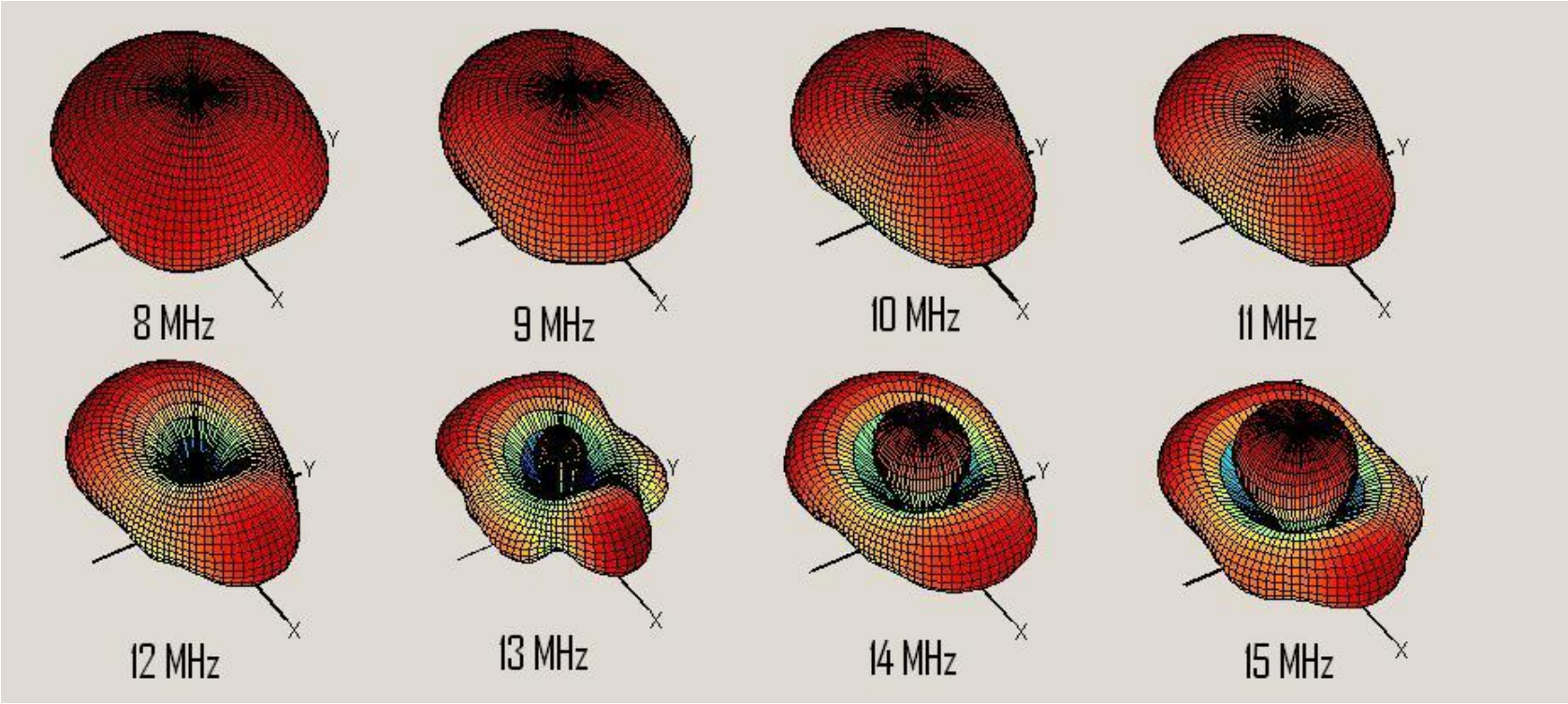
Varying the number of reflector wires

Reducing costs is of high importance therefore the amount of materials used to construct the new antenna should be kept to a minimum. Ideally the reflector would be a solid corner piece however, given it will be suspended 10-15m above the ground, wind loading would severely test the strength of the structure. Also, production of a solid corner piece would be time consuming and costly to install. A practical alternative is a reflector modelled with parallel wires to form the required shape. By using the same fixed values as previously and adjusting S to 5m several different cases were studied.



The minimum amount of reflector wires required to give a 12dB + gain is 6. Although using more than 6 wires would giver higher gain this would require more materials and construction time, ultimately increasing costs.

Radiation Patterns

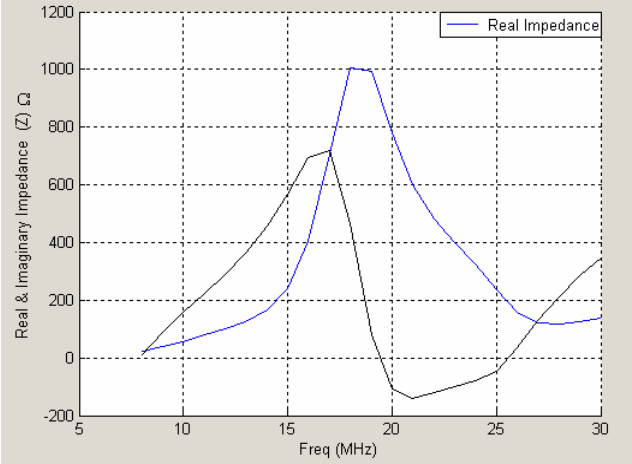


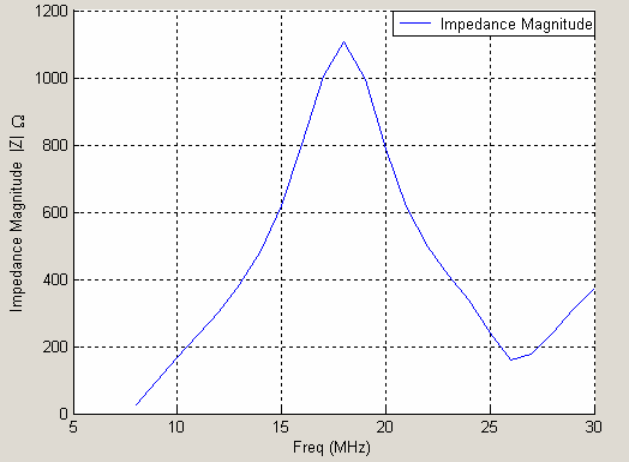
3-D radiation patterns exhibited by a bow-tie antenna with the following parameters:

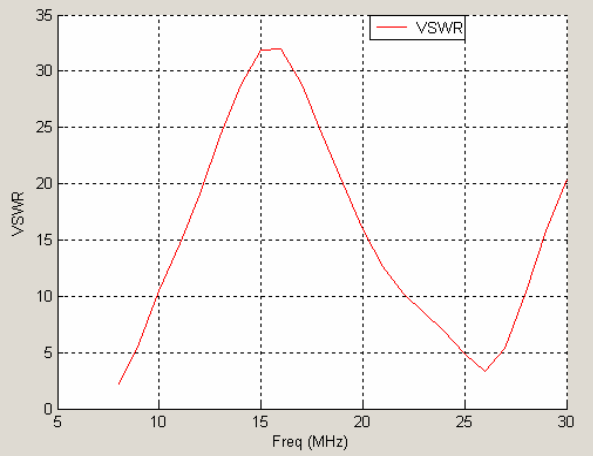
S = 5m, angle of reflector = 90, w = 4m, b = 2m, g = 0.66m, number of reflector wires = 6

Front-to-Back ratio is approximately 3dB (needs improvement)

Impedance and VSWR



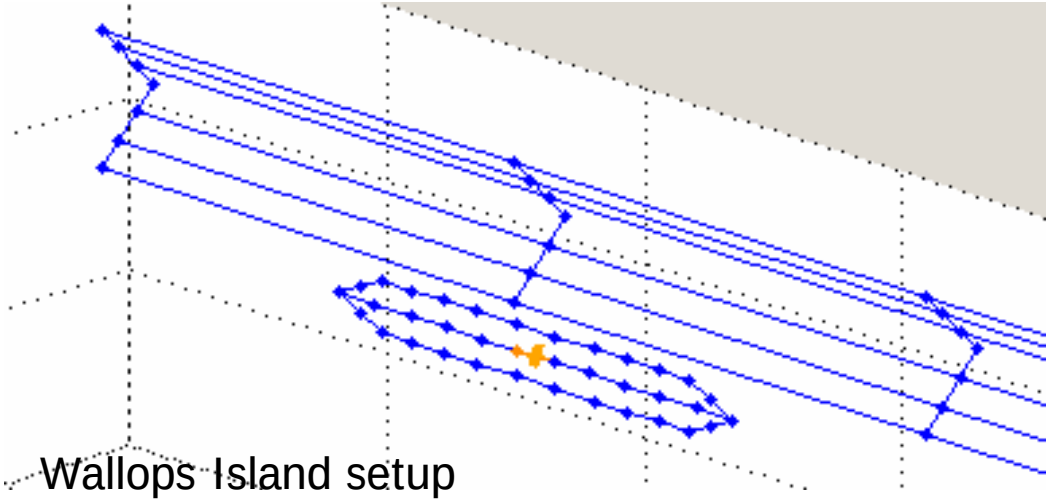




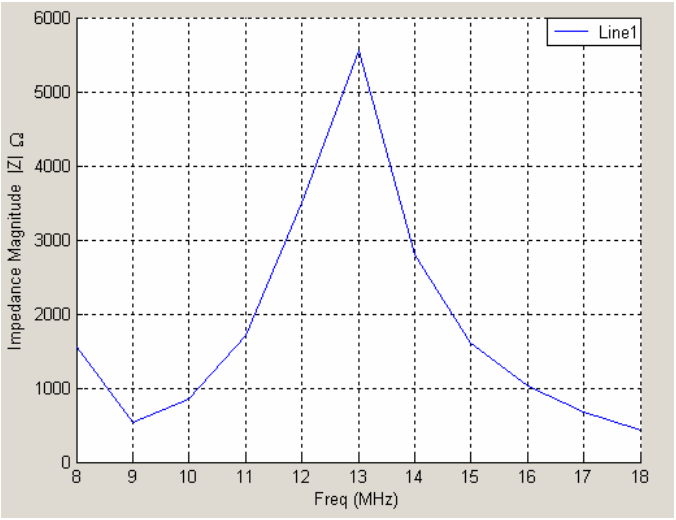
From our current analysis the modelled bowtie antenna produced a large variation in impedance as well as huge VSWR. To date we have not ascertained if this is a problem with the construction of the model in SuperNEC or if the bow-tie naturally exhibits such a impedance. If this is the case, the impedance would have to matched with an RLC circuit using Smith charts.

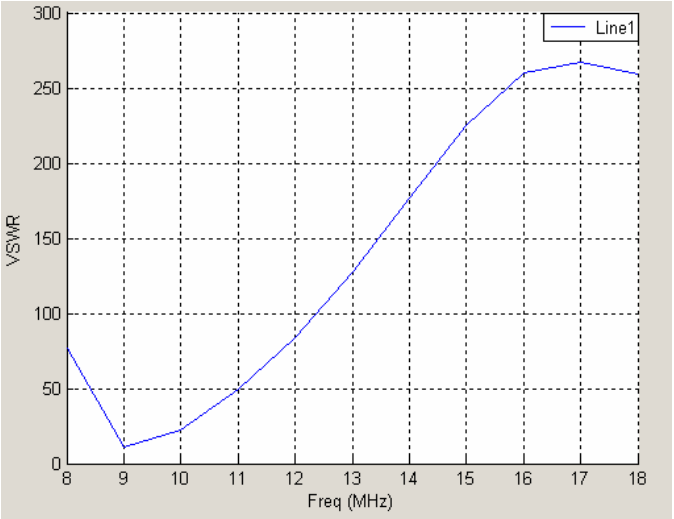
A new model with vertical segments in the bow-tie is being analysed to conclude if it will yield improvements.

Folded Bow-tie with corner reflector



Wallops Island setup





- Similar radiation pattern
- Average gain 2 dB less
- Impedance significantly increased
- VSWR increased x 10

Conclusion

- Simpler antenna construction leading to cost savings
- Antenna design exhibited sufficient gain levels
- Adequate radiation patterns
- Front-to-Back ratio needs improvement
- Vertical lobe in radiation pattern needs reduction at higher frequencies
- Impedance and VSWR needs further work
- Further analysis, varying w (reflector width), angle of reflector and wire radius needs to be conducted
- Looking at alternate implementations with vertical segments in bow-tie