Working Bouvet with the Innovative and Cheap

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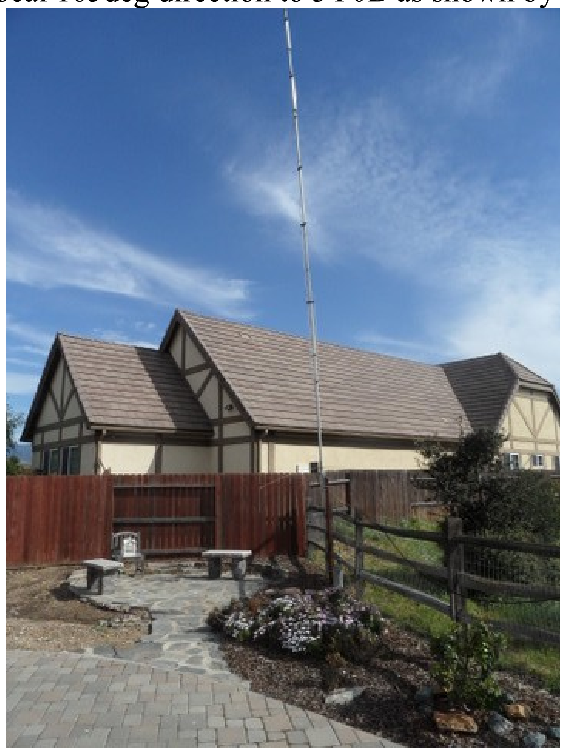
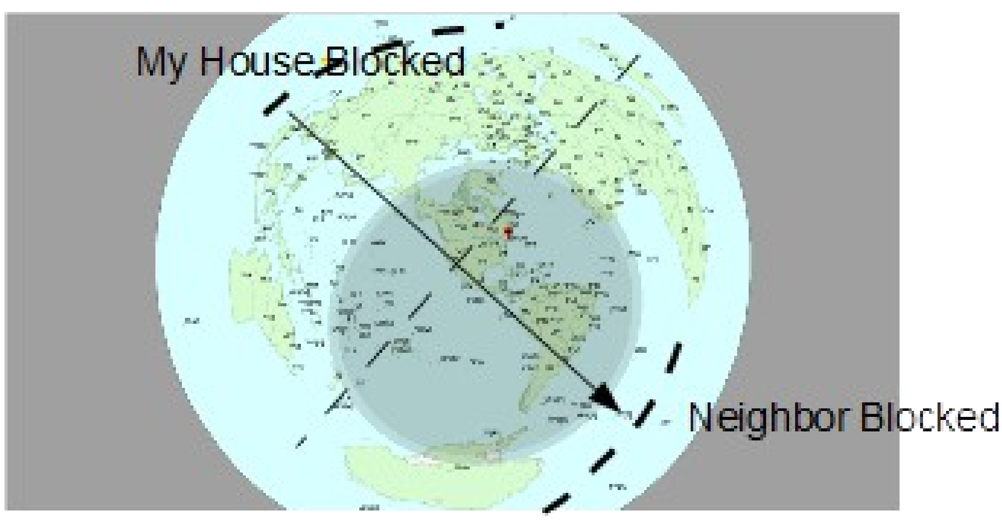
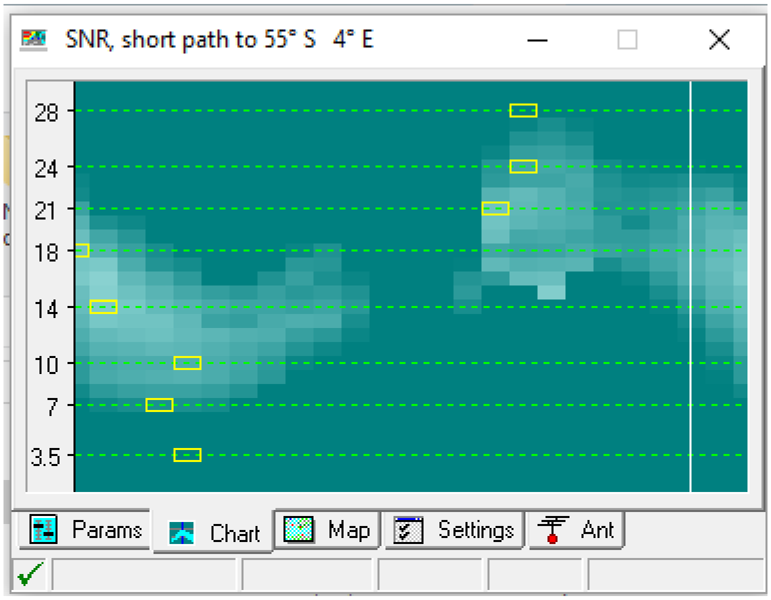
Trying to work the upcoming early 2018 Bouvet Dxpedition for an all time new one (ATNO as we say) is a serious challenge for those with only a ground mounted trapped vertical which is right behind a neighbor's house toward the local 165deg direction to 3Y0B as shown by a DX Atlas image.





Prospects for success with this antenna seem slim, at best, since competition from good antennas will be stiff. An additional antenna seems called for, but there are constraints in space, costs and neighborhood good will. And best would be a temporary simple single band unit that can be readily removed before the neighbors get too testy.

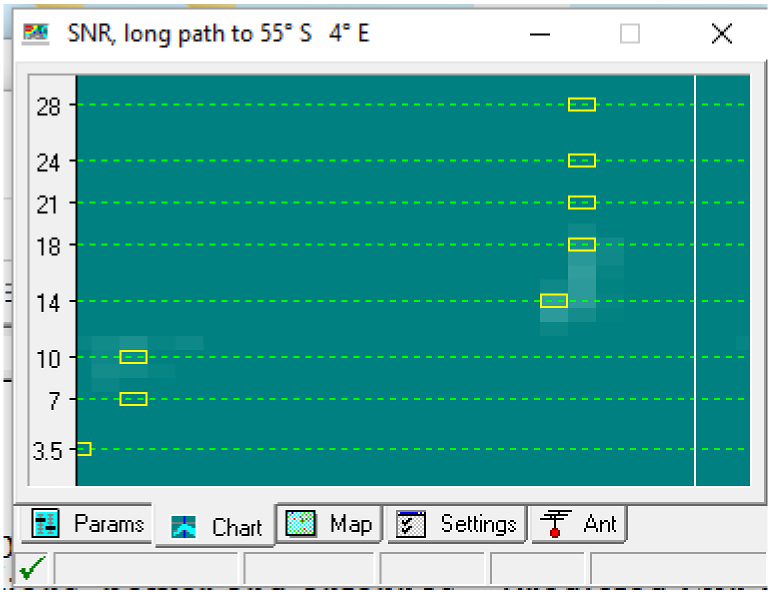
First, what band might be best?
The Ham CAP software, for example, provides propagation predictions between any pair of locations for all HF bands, given the solar conditions, power and antennas. Predicted Sun Spot Number for Jan 2018 is low and about 20. For nominal antennas and 500 watts the Ham CAP result for short path is



Band	Peak SNR
21	33dB
18	33dB
14	37dB
10	23dB

24 MHz may not really be available.

The corresponding long path result is not at all promising.



So the choices appear to be 21, 18 and 14 MHz by short path. While the highest peak, by 4 dB, is on 14 MHz, note that most DXers have triband or better antennas covering 14 (and 21) providing more unwanted competition. Higher frequencies are better if using a relatively low antenna due to the resulting lower elevation angle peak of the radiation, plus shorter antenna lengths are mechanically easier to deal with.

So the tempting choice is 18 MHz although a downside might come from worse than expected propagation support at higher frequencies if the SSN predictions turn out to be high. For a 18 MHz dipole, the full half wave element length is about 26 feet and that is managable with my space.

So What Antenna?

It turns out that I have an unattached garage that on one side has an unobstructed view toward 165 degrees. Furthermore, the garage roof peak at 25 feet is nearly aligned with the desired direction so one could have a dipole or (mildly) inverted vee dipole above that roof as an option, broadside to the 165 degrees. Supports are available on both sides for dipole wires when using a mast attached to the end of the garage at the fascia at the peak by a wooden support without holes in the garage.

But why settle for a dipole when with one more element, you can have a fixed direction two element beam which adds about 4 dB to the gain. Using wires as elements makes construction relatively easy and light weight, but at the modest inconvenience of rope supports for the ends of the elements.

So the nominal plan is a wire beam in a gentle vee partly over the end of the garage. It will be supported by a surplus spider pole for a mast at 30 ft and that pole will be strapped to a wooden structure of a long 2X4 bolted to a long 2X2 wedged under the facia at the peak.

Antenna Design
EZNEC or MMANA can provide a basic tool for antenna development. To begin we consider a normal two element yagi with a driven element and a reflector (or director). The primary design goal is near optimal gain but with a boom that is as short as possible but still with gain. Furthermore, it would be good if the impedance can directly match 50 Ω coax without any complicating matching circuit. While

the antenna element lengths and boom length all impact operating frequency, gain and impedance, there are some differences. The gain (and front-to-back) are largely dependent on the relative reflector (or director) length. The boom length affects the impedance and, to somewhat lesser degree, the gain. The driven element largely controls the frequency of the useful impedance and thus the SWR. In addition, the passive element can be either a reflector or a director although they are only approximately symmetrical.

To illustrate some tradeoffs, we first consider boom lengths of of 6, 8 and 10 feet, all at 30' above a realistic medium ground in Figure 1. EZNEC is used to find the wire element lengths of a two element yagi that produce near maximum gain at a nominal elevation angle of 10 degrees and a minimum SWR at 18.1 MHz. The reflector length is held fixed at 2X13.4' for each, giving a near optimal gain for all, and the driven element length has varied a bit to be near the SWR minimum frequency. Note that at the 30' height, the peak emissions are at about 24 degrees elevation above the horizon, which is higner than ideal for long distance comunications. Whether you use the 24 degree peak or the more relevant value at 10 degrees probably doesn't matter much but it is good to remember that the lower angle radiation is what is important.

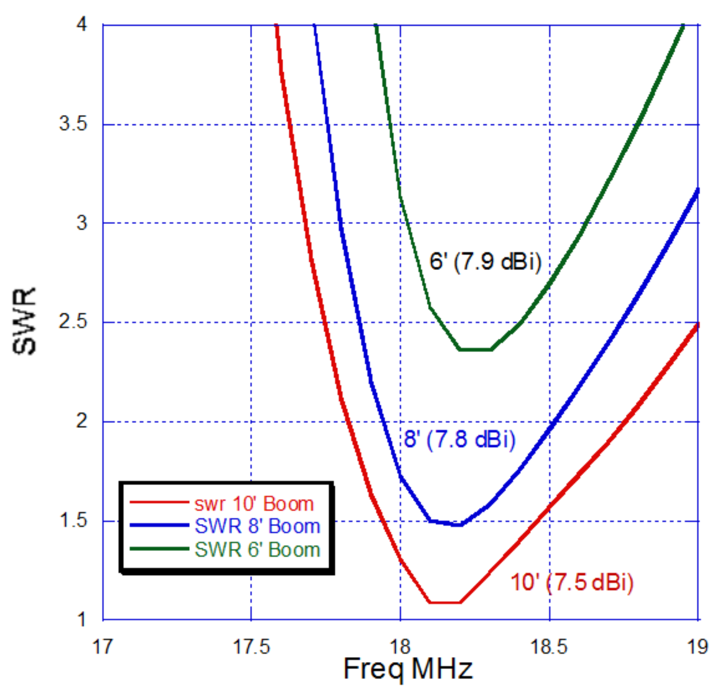


Figure 1. SWR sweeps for three boom lengths with peak gain elevation angle in parentheses.

The 3 gains, in parenthesis, are similar, decreasing slightly with boom length, and the length of the DE ranges from 2X 13 to 12.8 feet with booms from 6 to 10 ft. However, the raw minimum SWR (relative to 50 ohms) is well over 2:1 for the 6 ft boom but near ideal at 10 ft. Overall this suggests a 6 ft boom is too short but 8 or 10 ft may be okay.

To illustrate some another tradeoffs, we next consider a nominal boom of 8', again at 30' above a realistic ground, and use EZNEC to find the wire element lengths of a two element yagi that produce a near maximum gain and/or a minimum SWR at 18.1 MHz.   Three cases (solid lines) are for Reflectors all with a DE of 2X12.9 ft. The fourth case (dashed green) is for a Director case with DE of 2X13.15' and Dir of 2X12.75' selected to provide similar SWR and gain. Of course, with a Director, the antenna must be pointed in the direction of the Director.

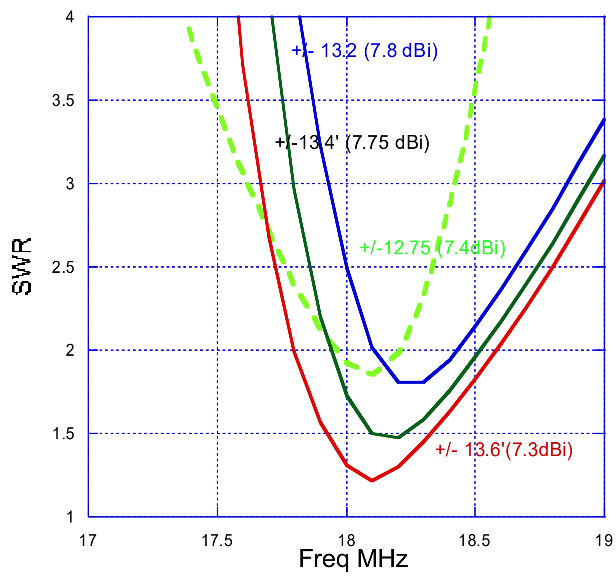


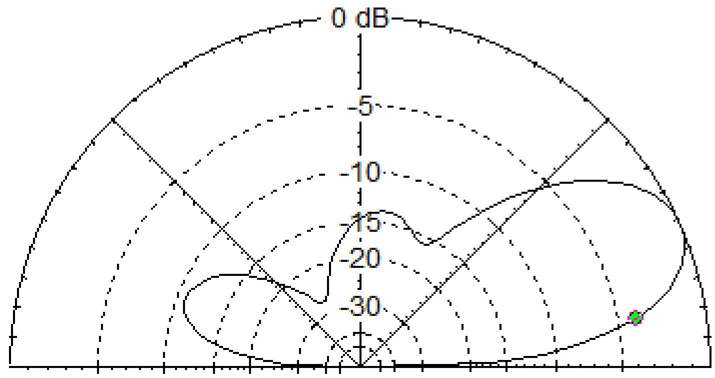
Figure 2. SWR sweeps for an 8' boom for three Reflector lengths with peak gain at elevation angle 10deg in parentheses plus for one Director case in green.

Generally the better SWR cases result in a slightly lowered gain while the Director case suffers in SWR and also a bit in gain. So the +/- 13.6' seems a reasonable choice for the Reflector, which is 0.7' longer than the DE half element. This changes a little bit when a somewhat drooping dipole is modeled later.

So my intial decision on boom length is 8', although 10' gets a better SWR, to minimize mechanical issues with a longer boom. An SWR of 1.5 is quite acceptable, especially with the matching capability of the Elecraft tuner on hand.

On Toward The Physical Antenna

Now we need to factor in the requirement that the antenna wire ends will need to be drooping a bit, since no 30' high supports are available, and adjust the wire lengths somewhat. After minor fiddling with EZNEC parameters, using a nominal wire angle of ~22 degrees droop below horizontal, it is found theoretically that a SWR of 1.5 can be found for a 8' boom with wire lengths of 2X13.1' DE and 2X13.6' REF but the gain at 10 degrees elevation is reduced somewhat to about 6.9 dBi from the 7.75 in the previous plot for the purely horizontal yagi. Here is the elevation pattern for the more realistic 2EL wire drooping yagi.



18.1 MHz

Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	180.0 deg.	Gain	7.75 dBi
Outer Ring	11.64 dBi		-3.9 dBmax
			-3.9 dBmax3D
3D Max Gain	11.64 dBi		
Slice Max Gain	11.64 dBi @ Elev Angle = 24.0 deg.		
Beamwidth	27.7 deg.; -3dB @ 11.5, 39.2 deg.		
Sidelobe Gain	0.83 dBi @ Elev Angle = 158.0 deg.		
Front/Sidelobe	10.81 dB		

Of course, if you simply cut an antenna to the calculated wire lengths, there is an excellent chance that the performance will be less than expected. To minimize this potential problem, one approach is to first trim the DE alone to be similar to the calculated values by adjusting the length for the DE alone With a proper VNA you can directly measure the impedance at the feed point and use that as the basis. If your VNA-like instrument is an antenna analyzer, say made by MFJ, a modified approach may be needed. This is because with a upscale VNA you can "cal out" the coax feedline but with an antenna analyzer the impedance you measure is from the combination of antenna and feedline. While it is possible to remove the feedline effects at each frequency by calculation if you know the feedline properties well enough, this is not trivial and fraught with uncertainty. However, the SWR is (nearly) independent of the feedline if your SWR reference is, say, the 50 Ohms of the cable in use.

So you can measure the SWR at the TX end of the feedline and compare with the calculated variation with frequency. If luck is on your side, the measurement will resemble the SWR calculation. You can then trim the DE taken alone to have a minimum SWR at the model frequency for minimum SWR for the DE alone which is 18.35 MHz with a SWR of 1.2. To be safe we start with a 14' length for the DE intending to trim it back to get 18.35.

Then the REF can be made that 0.5 feet longer than the DE on each half. When the full antenna is assembled at 30', the SWR can be measured to verify that it has a reasonable value around 18.1 MHz compared to the full model. If needed, the DE length can then be adjusted somewhat to shift the best SWR point. This will hardly affect the gain.

But Is It Really Worth It?
The basic hypothesis here is that an antenna in the open but of modest height may be superior to one behind a 25' tall house. While that seems likely, some actual data on the benefit would be nice before commiting to the full project.

This was done by first putting up only the DE and tuning the length to minimum SWR near 18.1 MHz (more trimming will be needed later to get to the target 18.35 for the DE alone as needed for the full antenna).

After an initial conservative trim to 13'1" the minumum SWR of 1.2 was at 17.4 MHz and a then foldback of the insulated wire of 8" brought it to 1.2 at 18.1. The lengths of the physical wires are about 4% shorter than the theoretical ones which is likely due to the insulation that was not included in the EZNEC modeling.

So now we have mildly drooping dipole at 30' across the peak of the 25' tile-roofed garage approximately broadside toward Bouvet. Since 3Y0B is not yet available some surrogates are needed. In the direction of 165 deg CE and LU are close and KL is in the opposite direction which is blocked somewhat for the vertical by the edge of my house.

A choke was added to avoid common mode currents using 10 turns of the RG8X coax near the feedpoint with a diameter of about 5 inches. This provides an inductance of ~ 1000 ohms.

During three days of sporadic observations two CE stations of useful strength were found two different times. In all cases it was found that these stations has a ~10dB+ difference favoring the clear dipole over the blocked vertical. A KL station was heard three times with a ~5dB+ difference favoring the dipole which was also true for JA and VR. For directions other than along the dipole near broadside and for which there is no blockage, the two antennas were generally comparable. Measurements were taken from the eyeball estimated peak of the spectra shown on a Elecraft P3 and uncertainty is perhaps +/-2 dB.

So we conclude that there is potential benefit for Bouvet even with a dipole - and the addition of a second element for a 2EL Yagi would get another ~ 4 dB so this all seems worthwhile.

Furthermore, we should be able to verify some aspects of the performance of the Yagi by using the gain and F/B expectation compared to the CE and KL relative strengths data mentioned above. That would be good since rotation of thisYagi is hardly practical.

Testing the 2 Element Wire Yagi
In preparation for adding an element, the DE alone is folded back and trimmed to get a minimum SWR at 18.3 MHz (the target for use as part of the 2el) and the REF wires are the same but with an additional 6" added to each half. The half lengths are then 12'5" plus a 4" fold for the DE and 12'11" plus a 4" fold for the REF. All folds are using insulated wires.

The full 2El was then raised and the SWR at the end of 100' of RG8X found to be a minimum at 18.24 MHz with SWR of 1.4, with only a slight SWR increase at 18.1.

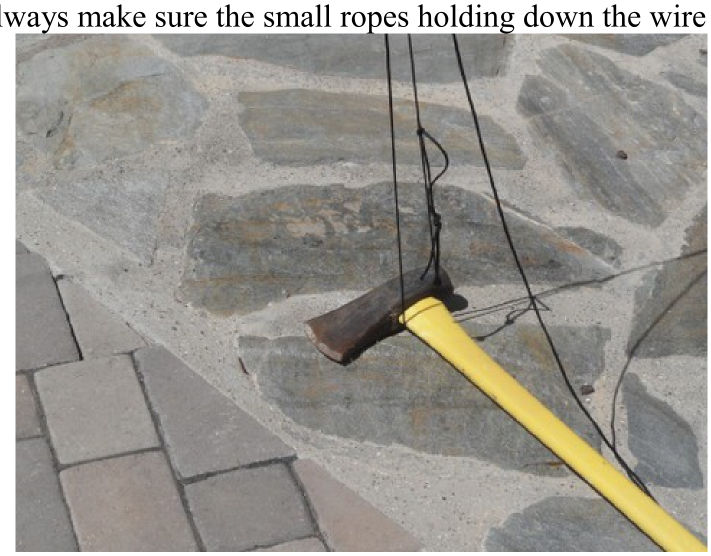
No KL was available at that time but several JAs were on (off the back). For the dipole, the JAs were about 5 dB better than the vertical but for the 2EL off the back JAs and VRs were now just 0 dB or no better than the vertical. This suggests the Gain//F/B of the 2EL is significant (although perhaps a somewhat short of the theoretical value for F/B) which would give a difference of about 9 dB rather than the 5 dB observed. CE (same station as before) and LU stations off the front were monitored and found to be +15 dB relative to the +10 db difference for the dipole vs vertical. This difference, +5dB, is similar to the theoretical relative gain of about +4 dB for a 2EL vs a dipole. So we conclude that the 2EL antenna performs much as expected and has a significant benefit over the blocked vertical toward Bouvet. The "data" are provided in tabular form in Table 1.

Table 1. Differences between wire antennas and the reference blocked vertical.

Observed Transmitter Prefix	Drooping Dipole @ ~165 deg	2 EL Drooping Yagi @ ~165 deg
JA, KL direction	+5dB	+0dB (off back)
CE, LU	+10dB	+15dB (off front)
PP5	n/a	+12dB (off front)
to the East	+0dB	+0dB

The EZNEC calculated gains of the two antennas along the boom direction at 10 degrees elevation are: the drooping dipole 2.75 dB front and back; and for the 2EL front +6.9dB and back -5.8dB. So the ideal case would give the 2EL a 4.1 dB advantage off the front and the dipole a 8.6 dB advantage off the back. The CE/LU data examples suggest a ~5 dB advantage to the 2EL off the front and the JA/KL cases suggest a ~5 dB advantage to the dipole, rather than the theoretical 8.6. This latter difference is not too surprising due to the sensitivity of F/B to antenna details. For Bouvet, the actual F/B plays little role once you have the gain.

But whatever you do, always make sure the small ropes holding down the wire elements are secure.



The Outcome

TBD