Flags at IV3PRK: from West Coast to Florida models

Upgrading from the rotatable Flag by W7IUV, and the original K6SE design,
to the “Waller Flag”, an end-fire rotatable two loops array by NX4D and N4IS.

Part 1 - Modeling with EZNEC

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The antenna’s scene environment

In the “Study on interactions between antennas on low bands” of summer 2004, I modeled with Eznec+ my receiving antennas (9 Pennants, a low dipole and the 4 mini-square array), all together with the Tx antenna and its radials. I realized that I should have detuned the shunt-fed tower and, first of all, obliged to replace the four elevated radials with an “on ground system” .

But “on the field” results confirmed that my southernmost Rx antennas were badly affected by the noise from surrounding utility lines (Pennants in the north group are always quieter than those in the southern group). All the feed-lines are deeply buried, but no way.

Later on, I bought another small field to the south of my property, and installed there a K9AY loop (150 meters of new coax cable): it worked as it should, with a good F/B in the four directions, but the noise level was still worse.

Fig.1 - IV3PRK 160 m. antennas: in front the K9AY loop, than the 4-squareRx mini-array, the southern group of Pennants, the shunt-fed tower and, on the back, the rotatable Flag

The W7IUV rotatable Flag

So I decided to go "above" that noisy power line and I build, and put on an old small telescoping tower, the W7IUV rotatable Flag: Bingo! That's became my best receiving antenna and I'm using it 95% of the time.
Much better and quieter than any other, despite its feedline lays on the roof and not underground as those of the Pennants.
It has a broad cardioid lobe and a deep null which I usually keep towards the Tx tower and thus preventing me to listen to Africa.
With Eznec+ I start modeling the Flag in the air (primary trace); than I added its supporting tower with metal mast and boom (red trace) and finally I shifted it 40 cm. from the mast (green trace which superimposes on the first).

Fig.2: The W7IUV rotatable Flag at IV3PRK

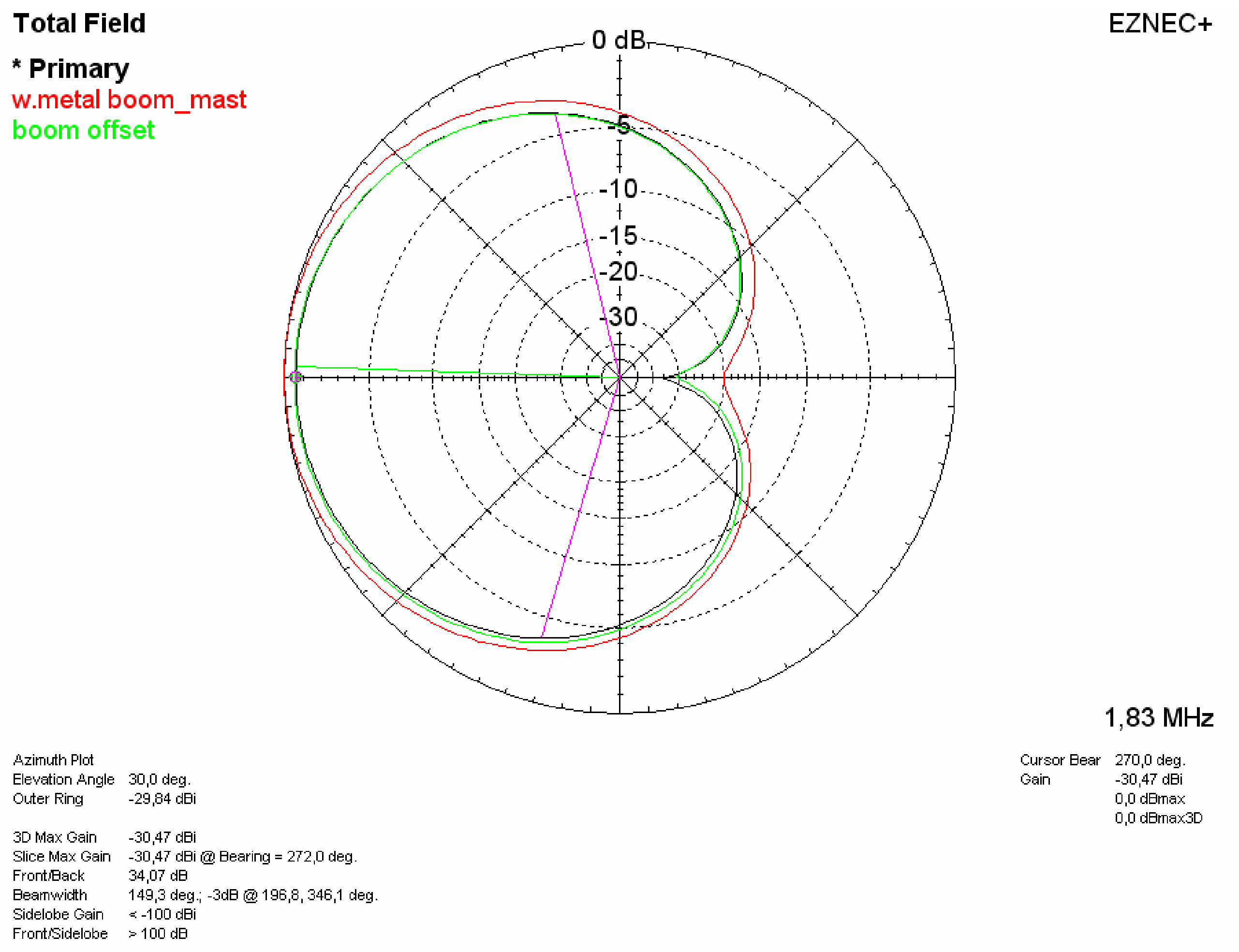

Fig.3: The W7IUV rotatable Flag, from free on the air to its tower/mast final setup at IV3PRK

In the elevation plots for the same sequence we see how the red back lobe has been reduced again by the boom offset.
The final numbers of my Flag <u>resulted the following:</u>
Dimensions: 4.27 x 8.84 m.
Load resistor: 945 ohm
Matching transformer: 3 by 12 turns on a binocular BN73-202.
Gain: -30 dB
Take-off angle: 30 degrees
Beamwidth: 150 degrees
Front to Back: 30 dB
RDF: 7.84 dB

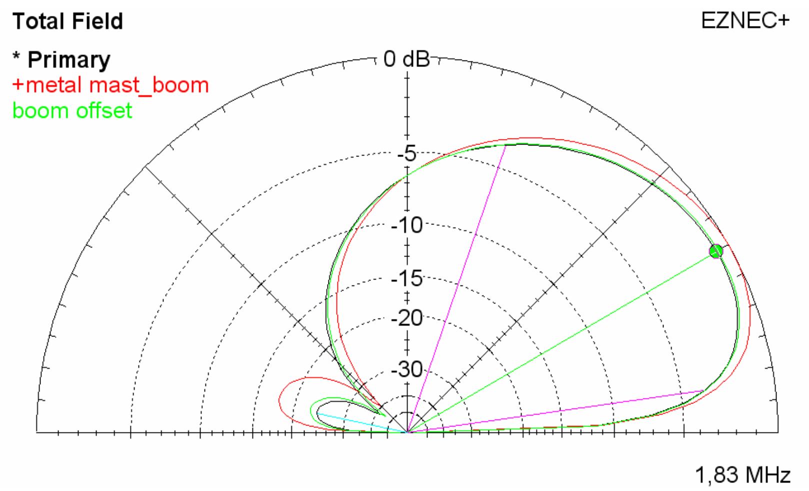

Fig.4: Elevation plot of the W7IUV rotatable Flag at IV3PRK

<u>**Rotatable Flag interactions with the Tx antenna**</u>

My transmitting antenna is a top loaded, shunt-fed tower with four elevated ¼ wave radials, at a distance of 28 meters from the rotatable Flag.
I included it into the Eznec model and rotated the Flag wires in 30 degrees increments to see which were the effects of the nearby Tx antenna.
As expected, and as it is in the reality, the RDF and specially the FB deteriorate very much when the Flag is facing the Tx antenna; on some bearings, the pattern is totally destroyed. In the next plots we see the difference between the patterns of the Flag alone (primary black trace), and when facing the Tx tower (red trace).

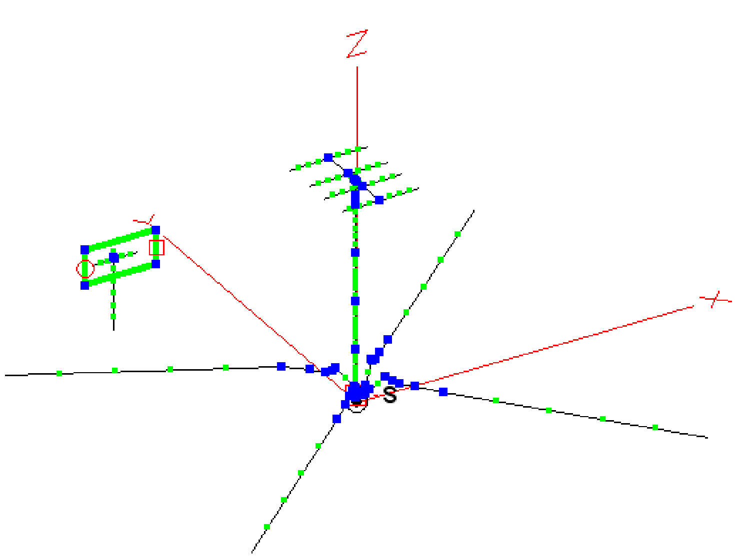

Fig.5: Eznec "View antenna" snapshot

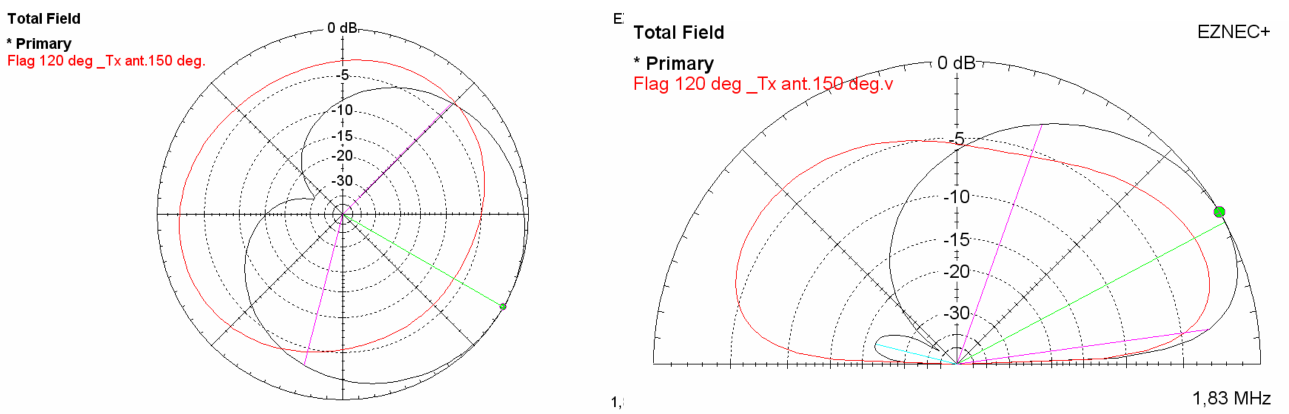

Fig.6: Azimuth and Elevation pattern deterioration of the Flag when facing the Tx antenna

Tower detuning

In order to see the Tx antenna detuning effect, I added, in the Eznec model, a ¼ wavelength shorted stub (an high impedance) at the base of the tower. The offending vertical obstruction, (offending during reception, of course), disappears and I summarized the behaviour of the two highlights in the following Excel graphs.

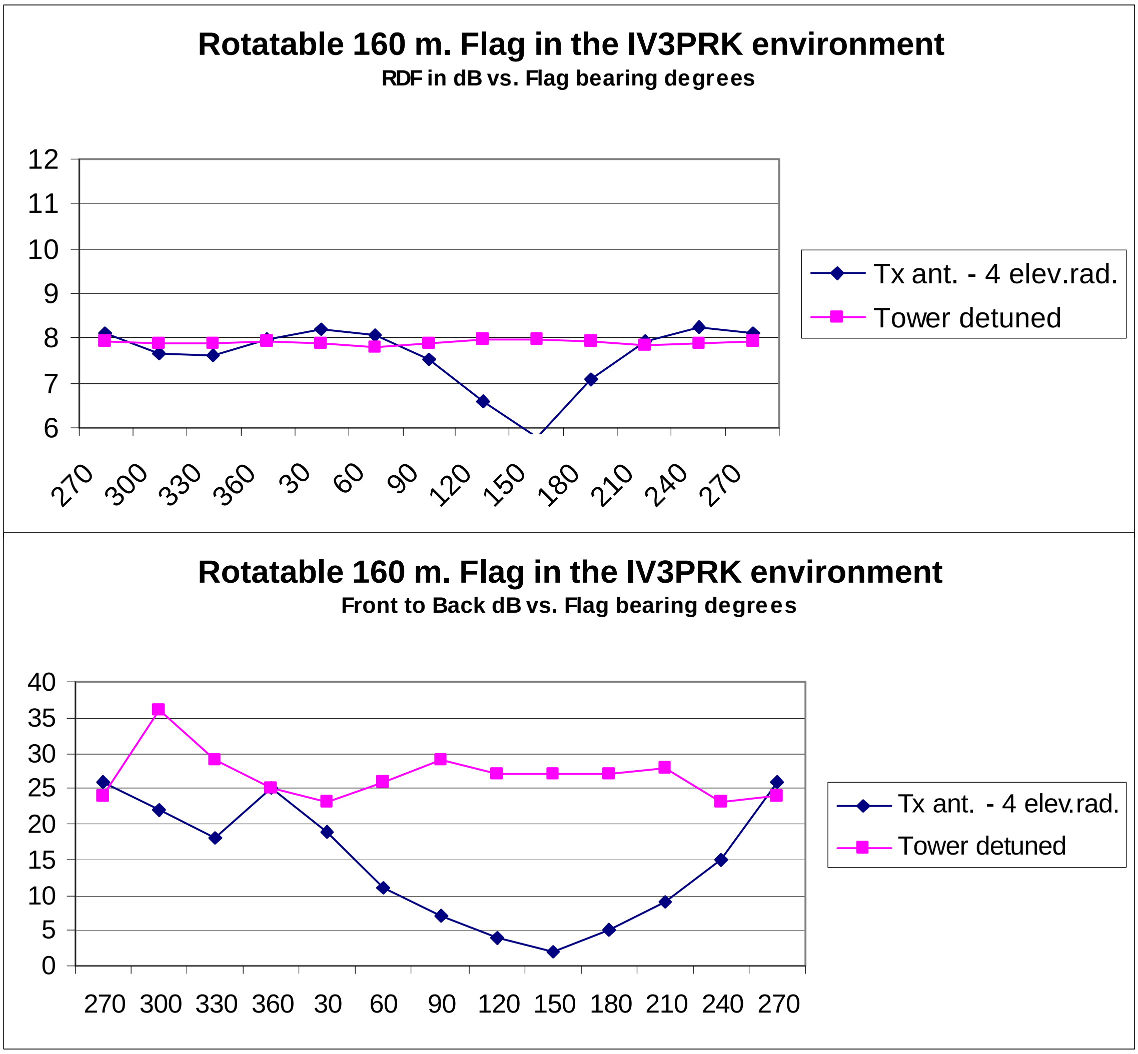

Fig.7: Rotating with Eznec the W7IUV Flag before and after detuning the Tx antenna

While the RDF remains fairly flat, ranging from 7.81 to 7.96, the Front to Back still shows some minor variations due to the elevated radials; a strange positive effect is given at 300 degrees bearing by the radial in that direction and beneath the Flag.

Of course detuning the “real” Tx antenna is not that easy as with the Eznec model: connecting and switching a 90 degrees coax cable at the feedpoint does not work. It’s a must now to learn the method used by Tom, W8JI or Carlos, N4IS, and climb the tower for the mechanical work.

The Waller Flag

After hearing directly how well Jose Carlos N4IS was listening DX stations on 160 m. from southern Florida, also in the spring/summer season, and knowing the success achieved in a few years by Doug NX4D himself, I was attracted by their receiving antenna.

It is a rotatable end-fire close array of two Flags, originated by Doug Waller NX4D and thus named “The Waller Flag” by Jose Carlos N4IS, who built a couple of them with improvements.

All the electrical and mechanical details are on his web page www.n4is.com : with over 11.5 dB of RDF, it can be compared to a rotatable broadside array of two 175 m. Beverages. But, as usual, there is no free lunch with antennas and its drawback is a very low signal level, around “– 55 dB”, which is about 40 dB lower than the Beverages. Hence, not only one, but two good preamplifiers are needed and be very careful against common noise entering the coax cable.

Modeling with EZNEC

I wanted to upgrade my rotatable W7IUV Flag into the new Waller Flag and thus the starting point and constraints were the physical dimensions of the boom and the fiberglass spreaders. First step was to choose the phasing line lengths to the two loops and these results are summarized in the following table.

Table 1: The Waller Flag - Starting model - Transmission Lines SWEEP

File	TL1 mt.	TL2 mt.	gain	TO angle	Bearing	BW	FB	Avg.gain	RDF
N4Flag_0	4,00	3,00	- 58,02	20	267	68	**15**	- 69,86	**11,84**
wires 8 - segm. 120	4,00	3,25	- 57,49	20	267	70	**16**	- 69,37	**11,88**
WF alone: 12 m.length , 12 m.high	**4,00**	**3,50**	**- 56,99**	**20**	**267**	**71**	**17**	**- 68,86**	**11,87**
2 loops (4,27 x 2,00 m.) 5 m. sep.	4,00	3,75	- 56,53	20	267	76	**18**	- 68,34	**11,81**
Xfmr: 600/100 ohms	4,00	4,00	- 56,08	23	269	74	**19**	- 67,82	**11,74**
Load resistor RL1= 600 ohm	**4,00**	**4,25**	**- 55,65**	**23**	**267**	**75**	**20**	**- 67,30**	**11,65**
Load resistor RL2= 600 ohm	4,00	4,50	- 55,24	23	267	81	**20**	- 66,80	**11,56**
Transm. line: 100 ohm (2 x RG58)	4,00	4,75	- 54,85	23	267	82	**21**	- 66,31	**11,46**
TL1 to front loop	4,00	5,00	- 54,48	23	267	82	**22**	- 65,84	**11,36**
TL2 to rear loop reversed phase	4,00	5,25	- 54,13	23	267	83	**23**	- 65,39	**11,26**
	4,00	**5,50**	**- 53,79**	**23**	**267**	**84**	**24**	**- 64,95**	**11,16**
	4,00	5,75	- 53,47	23	267	86	**25**	- 64,53	**11,06**
	4,00	6,00	- 53,16	23	267	87	**25**	- 64,12	**10,96**
	4,00	6,25	- 52,86	23	267	88	**26**	- 63,73	**10,87**
	4,00	6,50	- 52,57	23	267	88	**27**	- 63,35	**10,78**
	4,00	6,75	- 52,29	23	267	89	**28**	- 62,99	**10,70**
	4,00	7,00	- 52,02	23	267	90	**29**	- 62,64	**10,62**
	4,00	7,25	- 51,76	23	267	93	**30**	- 62,31	**10,55**
	4,00	7,50	- 51,51	23	267	95	**31**	- 61,98	**10,47**
	4,00	7,75	- 51,27	23	267	96	**32**	- 61,67	**10,40**
	4,00	8,00	- 51,03	23	267	96	**33**	- 61,36	**10,33**
	4,00	8,50	- 50,58	23	267	97	**36**	- 60,79	**10,21**
	4,00	9,00	- 50,15	23	267	98	**38**	- 60,25	**10,10**
	4,00	10,00	- 49,37	23	267	101	**36**	- 59,26	**9,89**

My preferred area is the green shadowed, with the choice for TL1=4,00 m. and TL2=4,25 m. It’s a compromise between maximum RDF - but with an high angle secondary lobe, (red line and red pattern below) and higher Front to Back - but with a broader lobe and a decreasing RDF (blue line and blue pattern).

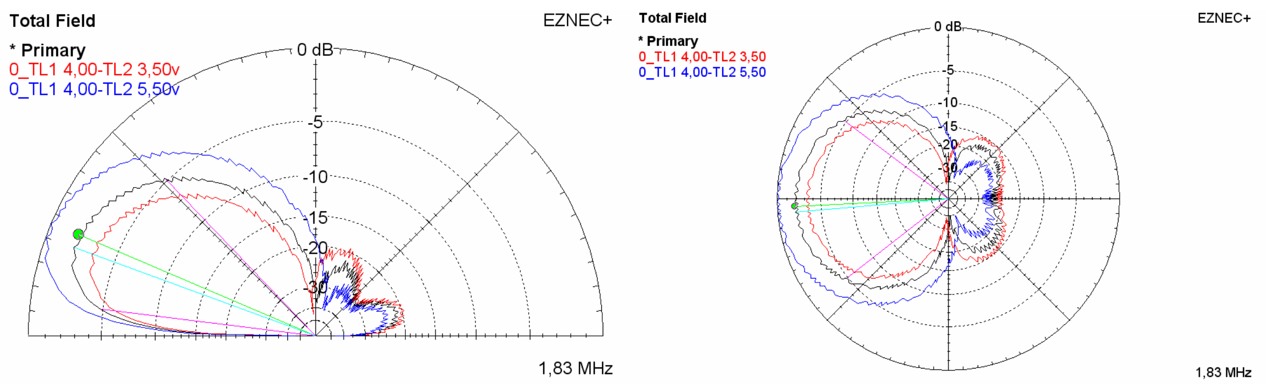

Fig.8: The Waller Flag alone in the air as from Table 1: primary pattern is for TL1 = 4,00 m. and TL2 = 4,25

In any case the phasing lines are NOT critical, as Table 2 shows the same results for one meter longer lengths on both sides.

Table 2 - The Waller Flag - Starting model - Transmission Lines SWEEP

File	TL1 mt.	TL2 mt.		gain	TO angle	Bearing	BW	FB		Avg.gain	RDF
N4Flag_0	5,00	2,00	-	63,08	26	153	56	**9**	-	70,72	**7,64**
wires 8 - segm. 120	5,00	2,50	-	62,01	19	269	54	**9**	-	71,19	**9,18**
WF alone: 12 m.length , 12 m.high	5,00	2,75	-	61,20	19	269	68	**10**	-	71,24	**10,04**
2 loops (4,27 x 2,00 m.) 5 m. sep.	5,00	3,00	-	60,45	19	269	60	**11**	-	71,17	**10,72**
Xfmr: 600/100 ohms	5,00	3,25	-	59,77	19	269	60	**12**	-	70,97	**11,20**
Load resistor RL1= 600 ohm	5,00	3,50	-	59,14	19	269	65	**13**	-	70,67	**11,53**
Load resistor RL2= 600 ohm	5,00	3,75	-	58,55	19	269	66	**14**	-	70,28	**11,73**
Transm. line: 100 ohm (2 x RG58)	5,00	4,00	-	57,99	20	267	68	**15**	-	69,84	**11,85**
TL1 to front loop	5,00	4,25	-	57,47	20	267	70	**16**	-	69,35	**11,88**
TL2 to rear loop reversed phase	**5,00**	**4,50**	**-**	**56,98**	**20**	**267**	**71**	**17**	**-**	**68,85**	**11,87**
	5,00	4,75	-	56,52	20	267	76	**17**	-	68,33	**11,81**
	5,00	5,00	-	56,08	23	267	74	**19**	-	67,82	**11,74**
	5,00	5,25	-	55,65	23	267	75	**20**	-	67,31	**11,66**
	5,00	5,50	-	55,25	23	267	81	**20**	-	66,82	**11,57**
	5,00	5,75	-	54,87	23	267	82	**21**	-	66,33	**11,46**
	5,00	6,00	-	54,50	23	267	82	**22**	-	65,87	**11,37**
	5,00	6,25	-	54,15	23	267	83	**23**	-	65,42	**11,27**
	5,00	**6,50**	**-**	**53,82**	**23**	**267**	**84**	**24**	**-**	**64,98**	**11,16**
	5,00	6,75	-	53,50	23	267	86	**24**	-	64,56	**11,06**
16ft - 23ft NX4D design ===>	5,00	7,00	-	53,19	23	267	87	**25**	-	64,16	**10,97**
	5,00	7,25	-	52,89	23	267	88	**26**	-	63,77	**10,88**
	5,00	7,50	-	52,60	23	267	88	**27**	-	63,40	**10,80**
	5,00	7,75	-	52,33	23	267	88	**29**	-	63,04	**10,71**
	5,00	8,00	-	52,06	23	267	90	**29**	-	62,69	**10,63**
	5,00	8,50	-	51,55	23	267	95	**31**	-	62,03	**10,48**
	5,00	9,00	-	51,07	23	267	96	**33**	-	61,42	**10,35**
	5,00	10,00	-	50,19	23	267	98	**38**	-	60,30	**10,11**

Impedance matching

A very useful feature of the new EZNEC 5 version is the possibility to add to the model transformers and other impedance matching objects, and to analyze the antenna system as a whole.

Thus I placed, where they have to be, two Xfmrs designed to transform the loop impedance of 600 ohms (Zp) to characteristic impedance of 100 ohms (Zs) of the phasing lines made up with two RG58 cables in parallel. At the "T" junction, where one of the lines is reversed, we find 50 ohms with a satisfactory SWR of 1 : 1,2.

To calculate the real transformer I used the following procedure:

1. The reactance of the windings should be at least four times the impedance the winding is designed to look into.
   So, 600 x 4 = 2400 ohms of reactance for the primary. Using 1.8 MHz as the minimum frequency, the inductance would need to be: L = 2400 / 2 x pi x 1.8MHz.
   So: 2400 / (6.28 x 1.8) = 212 microhenry.
2. To find the number of turns the formula is: <u>N = 1000 (SQRT (L in mH / AL))</u>
   I have two ferrite cores available: the FT114-77 toroids with AL = 1140, and the preferred binoculars BN73-202 with AL = 8500.
   So, N = 1000 (SQRT (0.212 / 1140) = 13.65 turns on the primary for the FT114-77
   Or, N = 1000 (SQRT (0.212 / 8500) = 5.00 turns on the primary for the BN73-202.
3. To find the number of turns on the secondary the formula is : <u>Np / Ns = SQRT (Zp / Zs)</u>,
   So: Np / Ns = SQRT (600/100) = 2.45, which is the ratio of the primary to secondary turns.
   Thus, Ns = 13.65 / 2.45 = 5.57 turns on the secondary of the FT114-77 core
   Or, Ns = 5.00 / 2.45 = 2.04 turns on the secondary of the BN73-202, much better.
   It is easier to wind a small <u>binocular core with only five and two turns</u> and that's definitely my choice, according also to the W8JI advice on the 73 material.

Tweaking the model for best Front to Back

The following table summarizes many runs at the search of the load resistor values which give the highest Front to Back ratio, provided the desirable RDF already reached.

It is confirmed once again that the Waller Flag "wants to work" in every case, but the green shadowed areas are better and for sure, with this model (clear in the air without any supporting structure), the best combination is found with 500 ohms on the front loop and 520 on the rear one.

In the last two columns we see the impedance, always with an acceptable SWR, found on the feeding point at 100 ohm phasing lines junction.

Table 3: The Waller Flag - Starting model - LOAD Resistors SWEEP

File	RL1	RL2	gain	TO ang.	BW	FB	Avg.gain	RDF	Imped. R.	Imped. jX
N4Flag_0	350	400	-58,39	19	66	**10**	-69,09	**10,70**		
wires 8 - segm. 120	375	400	-57,11	23	70	**15**	-68,77	**11,66**		
WF alone: 12 m.length , 12 m.high	385	400	-56,66	23	73	**17**	-68,41	**11,75**	40,3	21,0
2 loops (4,27 x 2,00 m.) 5 m. sep.	390	400	-56,44	23	73	**17**	-68,21	**11,77**		
Xfmr: 600/100 ohms	395	400	-56,24	23	73	**17**	-67,98	**11,74**		
Load resistor RL1 on front loop	400	400	-56,04	23	74	**17**	-67,75	**11,71**		
Load resistor RL2 on rear loop	450	500	-57,84	19	68	**17**	-69,26	**11,42**		
Transm. line: 100 ohm (2 x RG58)	475	500	-56,91	20	73	**31**	-68,74	**11,83**		
TL1 to front loop = 4,00 m.	480	500	-56,74	23	73	**32**	-68,59	**11,85**	48,4	14,8
TL2 to rear loop rev.phase = 4,00 m.	485	500	-56,58	23	73	**30**	-68,42	**11,84**		
	490	500	-56,41	23	74	**26**	-68,24	**11,83**		
	495	500	-56,26	23	74	**24**	-68,06	**11,80**		
	500	500	-56,10	23	74	**22**	-67,87	**11,77**	49,2	14,2
	500	515	-56,56	23	74	**31**	-68,41	**11,85**		
	500	**520**	**-56,71**	**23**	**73**	**38**	**-68,56**	**11,85**	**49,9**	**13,5**
	500	525	-56,86	20	73	**33**	-68,70	**11,84**	50,0	13,4
	505	525	-56,71	23	73	**37**	-68,55	**11,84**		
	500	550	-57,61	19	69	**19**	-69,18	**11,57**	51,0	12,7
	530	550	-56,66	20	75	**26**	-68,51	**11,85**	52,0	11,0
	550	600	-57,39	20	70	**18**	-69,03	**11,64**	54,4	9,3
	555	600	-57,25	20	71	**19**	-68,95	**11,70**		
	560	600	-57,11	20	71	**20**	-68,86	**11,75**		
	565	600	-56,97	20	73	**21**	-68,76	**11,79**		
	570	600	-56,83	20	75	**21**	-68,64	**11,81**		
	575	600	-56,70	20	75	**21**	-68,52	**11,82**		
	580	600	-56,57	20	76	**21**	-68,39	**11,82**	55,4	8,2
	585	600	-56,44	20	76	**20**	-68,26	**11,82**		
	590	600	-56,32	20	76	**19**	-68,11	**11,79**		
	595	600	-56,20	23	74	**19**	-67,97	**11,77**		
	600	600	-56,08	23	74	**19**	-67,82	**11,74**	56,8	7,0
	605	600	-55,96	23	75	**18**	-67,66	**11,70**		
	610	600	-55,85	23	75	**17**	-67,51	**11,66**		
	615	600	-55,73	23	75	**17**	-67,35	**11,62**		
	620	600	-55,62	23	75	**16**	-67,20	**11,58**		
	625	600	-55,51	23	75	**16**	-67,04	**11,53**	56,8	6,7
	630	600	-55,41	23	81	**15**	-66,88	**11,47**		
	635	600	-55,30	23	81	**15**	-66,72	**11,42**		
	640	600	-55,20	23	81	**14**	-66,56	**11,36**		
	650	600	-55,00	23	81	**13**	-66,25	**11,25**		
	650	700	-57,02	20	73	**15**	-68,66	**11,64**	60,4	2,0
	670	700	-56,58	20	76	**15**	-68,32	**11,74**		
	675	700	-56,48	20	76	**15**	-68,22	**11,74**		
	680	700	-56,38	20	76	**15**	-68,12	**11,74**		
	685	700	-56,28	20	76	**15**	-68,01	**11,73**		
	690	700	-56,18	20	76	**15**	-67,89	**11,71**		
	695	700	-56,09	23	74	**15**	-67,78	**11,69**		
	700	700	-55,99	23	74	**15**	-67,66	**11,67**		
	725	700	-55,54	23	81	**14**	-67,05	**11,51**		
	750	800	-56,69	20	76	**12**	-68,27	**11,58**		
	775	800	-56,27	20	76	**12**	-67,89	**11,62**		
	785	800	-56,11	20	76	**12**	-67,72	**11,61**		
	790	800	-56,03	20	76	**12**	-67,64	**11,61**		
	795	800	-55,95	20	76	**12**	-67,55	**11,60**		
	800	800	-55,88	23	75	**12**	-67,45	**11,57**	66,4	-6,7
	850	900	-56,41	20	76	**10**	-67,88	**11,47**		
	875	900	-56,07	20	76	**11**	-67,57	**11,50**		
	880	900	-56,00	20	76	**11**	-67,50	**11,50**		
	885	900	-55,94	20	76	**11**	-67,43	**11,49**		
	890	900	-55,87	20	76	**11**	-67,36	**11,49**	69,8	-13,5

So, keeping now the load resistors fixed, I swept again the phasing line lengths at the search of any possible further improvement. Increasing the length of TL2 produces a broader forward lobe, with a better FB, but reduces the RDF. Making TL2 shorter than TL1 produces a narrow forward lobe, with enhanced RDF, but also the rise of an undesirable high angle back lobe.

Table 4: The Waller Flag - Starting model - final TWEAKING on the TL lines

File	TL1 mt.	TL2 mt.	gain	TO angle	Bearing	BW	FB	Avg.gain	RDF
N4Flag_0	3,00	2,50	- 57,76	20	267	70	**30**	- 69,69	**11,93**
wires 8 - segm. 120	3,00	2,75	- 57,21	20	267	70	**31**	- 69,11	**11,90**
Only WF on 9 m.boom, 12 m.high	3,00	3,00	- 56,68	20	267	75	**33**	- 68,52	**11,84**
2 loops (4,27 x 2,00 m.) 5 m. sep.	3,00	3,25	- 56,18	23	267	74	**42**	- 67,93	**11,75**
Xfmr: 600/100 ohms	3,00	3,50	- 55,71	23	267	75	**44**	- 67,35	**11,64**
RL1= 500 - RL2 = 520	3,00	3,75	- 55,26	23	267	81	**44**	- 66,79	**11,53**
TL1 100 ohm to front loop	3,00	4,00	- 54,84	23	267	81	**42**	- 66,25	**11,41**
TL2 to rear loop 180 deg. phasing	3,00	4,25	- 54,45	23	267	82	**40**	- 65,64	**11,19**
	3,00	4,50	- 54,07	23	267	83	**38**	- 65,24	**11,17**
	4,00	3,00	- 58,97	19	269	65	**26**	- 70,70	**11,73**
	4,00	**3,50**	**- 57,77**	**20**	**267**	**69**	**29**	**- 69,70**	**11,93**
	4,00	3,75	- 57,22	20	267	70	**31**	- 69,14	11,92
	4,00	**4,00**	**- 56,71**	**23**	**267**	**73**	**38**	**- 68,56**	**11,85**
	4,00	**4,25**	**- 56,23**	**23**	**267**	**74**	**41**	**- 67,99**	**11,76**
	4,00	**4,50**	**- 55,76**	**23**	**267**	**75**	**44**	**- 67,43**	**11,67**
	4,00	4,75	- 55,33	23	267	78	**44**	- 66,88	**11,55**
	4,00	5,00	- 54,92	23	267	81	**43**	- 66,36	**11,44**
	4,00	5,25	- 54,53	23	267	82	**41**	- 65,85	**11,32**
	4,00	5,50	- 54,16	23	267	83	**39**	- 65,37	**11,21**
	5,00	4,00	- 58,92	19	269	65	**26**	- 70,67	**11,75**
	5,00	4,50	- 57,76	19	269	68	**29**	- 69,70	**11,94**
	5,00	4,75	- 57,23	20	267	70	**31**	- 69,15	**11,92**
	5,00	**5,00**	**- 56,74**	**23**	**267**	**73**	**38**	**- 68,60**	**11,86**
	5,00	**5,25**	**- 56,26**	**23**	**267**	**74**	**41**	**- 68,04**	**11,78**
	5,00	5,50	- 55,81	23	267	75	**44**	- 67,49	**11,68**
	5,00	5,75	- 55,39	23	267	78	**45**	- 66,96	**11,57**
	5,00	6,00	- 54,98	23	267	81	**43**	- 66,45	**11,47**
	5,00	6,25	- 54,60	23	267	82	**41**	- 65,95	**11,35**
	5,00	6,50	- 54,24	23	267	82	**40**	- 65,48	**11,24**
	5,00	7,00	- 53,56	23	267	84	**37**	- 64,59	**11,03**

The choice depends on local situations and personal needs. My priority is to keep as low as possible the high angle signals of European nearby stations, so I must stay in the black highlighted rows.

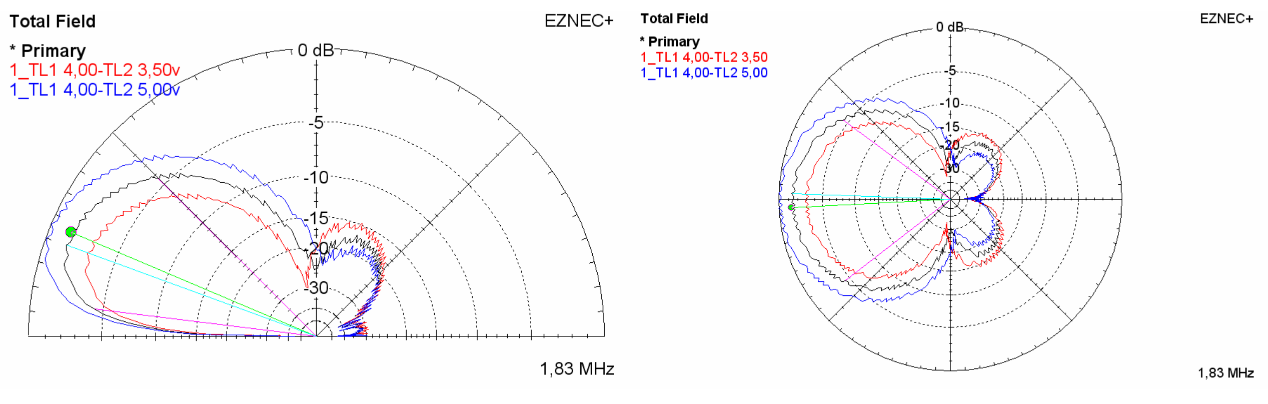

Fig.9: The Waller Flag alone in the air as from Table 4: primary pattern is for TL1 = 4,00 m. and TL2 = 4,25

Putting the Waller Flag on its supporting tower and mast

Now let's model the WF with its supporting tower and the boom/mast. No difference with a boom offset, like for the original Flag, so it's mechanically easier to put it directly on the mast.

Table 5: The Waller Flag - centered on its tower and boom/mast

File		gain	TO angle	Bearing	BW	FB	Avg.gain	RDF
N4Flag_01b	On the Air model	**- 56,71**	**23**	**267**	**73**	**38**	**- 68,56**	**11,85**
wires 12 - segm. 135	Beaming Degrees							
WF alone, 12 m.lenght, 12 m.high	270	- 55,88	20	272	77	**21**	- 67,38	**11,50**
2 loops (4,27 x 2,00 m.) 5 m. sep.	300	- 55,93	22	304	78	**20**	- 67,42	**11,49**
Xfmr: 600/100 ohms	330	- 55,85	20	330	78	**22**	- 67,37	**11,52**
RL1= 500 - RL2 = 520 ohms	360	- 55,92	22	0	78	**20**	- 67,43	**11,51**
TL1 100 ohm to front loop = 4 m.	30	- 55,94	22	30	79	**21**	- 67,44	**11,50**
TL2 to rear loop 180 deg. Rev. = 4 m.	60	- 55,89	22	60	79	**21**	- 67,40	**11,51**
	90	- 55,92	20	88	79	**22**	- 67,43	**11,51**
	120	- 55,89	22	122	80	**21**	- 67,38	**11,49**
	150	- 55,90	22	152	78	**20**	- 67,41	**11,51**
	180	- 55,83	20	180	78	**21**	- 67,39	**11,56**
	210	- 55,88	22	208	79	**20**	- 67,40	**11,52**
	240	- 55,87	22	232	78	**21**	- 67,32	**11,45**
	270	- 55,91	20	272	77	**21**	- 67,42	**11,51**

The added metal structure deteriorates the FB and the RDF parameters, so we have to tweak the model again.

Table 6: The Waller Flag - centered on its tower and boom/mast - now tweaking for best F/B

File	RL1	RL2	gain	TO angle	Bearing	BW	FB	Avg.gain	RDF
On the air model ==>	**500**	**520**	**- 56,71**	**23**	**267**	**73**	**38**	**- 68,56**	**11,85**
wires 12 - segm. 135	Sweeping Loads								
WF alone, 12 m.lenght, 12 m.high	500	520	- 55,91	20	272	77	**21**	- 67,42	**11,51**
2 loops (4,27 x 2,00 m.) 5 m. sep.	550	600	- 56,56	20	272	76	**19**	- 68,01	**11,45**
Xfmr: 600/100 ohms	555	600	- 56,43	20	272	77	**21**	- 67,93	**11,50**
TL1 = 4m. TL2 = 4m.	560	600	- 56,30	20	272	77	**23**	- 67,84	**11,54**
TL1 100 ohm to front loop	565	600	- 56,18	20	272	77	**25**	- 67,75	**11,57**
TL2 to rear loop 180 deg. phasing	570	600	- 56,06	20	272	77	**29**	- 67,64	**11,58**
	575	600	- 55,94	20	272	77	**32**	- 67,53	**11,59**
	580	**600**	- 55,82	20	272	77	**37**	- 67,41	**11,59**
	585	600	- 55,71	20	272	77	**37**	- 67,29	**11,58**
	590	600	- 55,60	20	272	80	**32**	- 67,16	**11,56**
	595	600	- 55,49	20	272	80	**29**	- 67,03	**11,54**
	600	600	- 55,38	20	272	80	**26**	- 66,90	**11,52**
	600	605	- 55,49	20	272	80	**28**	- 67,04	**11,55**
	600	610	- 55,59	20	272	80	**31**	- 67,16	**11,57**
	600	615	- 55,70	20	272	78	**34**	- 67,28	**11,58**
	600	620	- 55,80	20	272	77	**33**	- 67,40	**11,60**
	600	625	- 55,90	20	272	77	**30**	- 67,51	**11,61**
	600	630	- 56,01	20	272	77	**27**	- 67,61	**11,60**
	600	640	- 56,21	20	272	77	**23**	- 67,79	**11,58**

The choice here is straightforward: increasing both load resistors by 80 ohms we recover the same Front to Back and about 0.10 dB in the RDF. Let's try again to improve also this last parameter.

Table 7: The Waller Flag - centered on its tower and boom/mast - last tweaking for best TL line lenghts

File	TL1 mt.	TL2 mt.	gain	TO angle	Bearing	BW	FB	Avg.gain	RDF
FLFlag_02.EZ	**5,50**	**4,00**	**- 58,74**	**20**	**272**	**67**	**28**	**- 70,45**	**11,71**
wires 12 - segm. 135	5,25	4,00	- 58,19	20	272	70	**30**	- 70,00	**11,81**
WF 12 m.lenght, 12 m.high	5,00	4,00	- 57,67	20	272	72	**32**	- 69,51	**11,84**
2 loops (4,27 x 2,00 m.) 5 m. sep.	4,75	4,00	- 57,17	20	272	75	**34**	- 68,99	**11,82**
Xfmr: 600/100 ohms	4,50	4,00	- 56,70	20	272	76	**36**	- 68,47	**11,77**
RL1= 580; RL2 = 600 ohms	4,25	4,00	- 56,25	20	272	77	**37**	- 67,94	**11,69**
TL1 100 ohm to front loop	**4,00**	**4,00**	**- 55,82**	**20**	**272**	**77**	**37**	**- 67,41**	**11,59**
TL2 to rear loop 180 deg. phasing	**4,00**	**4,25**	**- 55,42**	**20**	**272**	**80**	**37**	**- 66,91**	**11,49**
	4,00	4,50	- 55,03	24	270	82	**29**	- 66,42	**11,39**
	4,00	4,75	- 54,66	24	270	82	**29**	- 65,94	**11,28**
	4,00	5,00	- 54,30	24	270	83	**29**	- 65,48	**11,18**
	4,00	5,25	- 53,95	24	270	85	**28**	- 65,04	**11,09**
	4,00	**5,50**	**- 53,62**	**24**	**270**	**88**	**28**	**- 64,62**	**11,00**

The RDF could be increased only on the side of TL1 lengthening, but with the undesirable rise of the high angle back lobe (red pattern). On the other side, stretching TL2, the RDF decreases further, with a broader beamwidth and an higher forward TO angle.

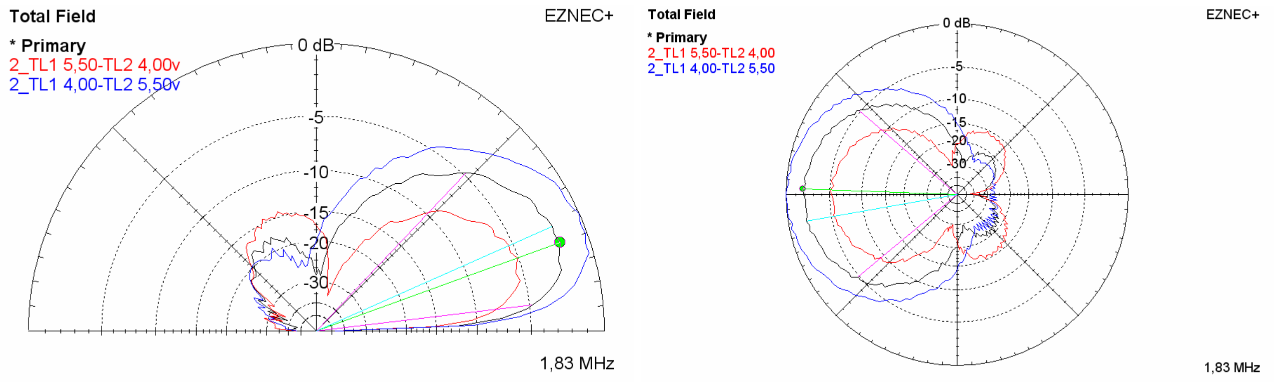

Fig.10: The Waller Flag on its tower as from Table 7:   primary pattern is for TL1 = 4,00 m. and TL2 = 4,25

Interactions with the transmitting antenna

Now let's add to the Eznec model all the wires forming the Tx tower, with its loading Yagi and the 4 elevated radials, as in Fig.5, and rotate the receiving antenna every 30 degrees.

More drastically than the standard Flag, due to its sharper lobe, the Waller Flag seems to be acceptable only when beaming on the opposite side of the Tx tower. Other than in West and North West direction, the lobe is mostly destroyed.

Table 8: The Waller Flag - with its tower and boom/mast - plus the nearby Tx antenna and its 4 elevated radials

File		gain	TO angle	Bearing	BW	FB	Avg.gain	RDF
FLFlag_03	no interactions =>	**- 55,42**	**20**	**272**	**80**	**37**	**- 66,91**	**11,49**
wires 67 - segm. 264	Beaming Degrees							
WF 12 m.l ength, 12 m.high	270	- 56,77	20	272	74	**15**	- 68,38	**11,61**
2 loops (4,27 x 2,00 m.) 5 m. sep.	300	- 54,22	22	304	86	**19**	- 65,30	**11,08**
Xfmr: 600/100 ohms	330	- 53,73	20	330	89	**17**	- 64,49	**10,76**
RL1= 580 - RL2 = 600	360	- 55,58	22	0	79	**23**	- 67,12	**11,54**
TL1 100 ohm to front loop = 4,00 m.	30	- 58,43	20	22	78	**8**	- 68,60	**10,17**
TL2 to rear loop 180 deg.rev = 4,25m.	60	- 58,32	20	62	83	**7**	- 68,21	**9,89**
Added the wires of:	90	- 56,47	20	82	84	**13**	- 67,12	**10,65**
Tx antenna at a distance of 38 m.	120	- 55,73	24	98	121	**5**	- 63,74	**8,01**
and abt 140 degrees, with top loading	150	- 56,10	24	168	188	**3**	- 62,93	**6,83**
yagi, 28 m. high, and 4 elev. radials	180	- 56,12	20	194	94	**9**	- 65,60	**9,48**
	210	- 57,41	20	218	77	**12**	- 68,52	**11,11**
	240	- 58,68	20	232	79	**7**	- 68,61	**9,93**
	270	- 56,73	22	274	73	**16**	- 68,33	**11,60**

But let's see what happens with Tx antenna detuning: just added in Eznec an high impedance, 90 degrees stub, on its feeding point.

Table 9: The Waller Flag - on its tower and boom/mast - plus the Tx antenna "DETUNED" and the same 4 elev.radials

File		gain	TO angle	Bearing	BW	FB	Avg.gain	RDF
FLFlag_03	no interactions =>	**- 55,42**	**20**	**272**	**80**	**37**	**- 66,91**	**11,49**
wires 67 - segm. 264	Beaming Degrees							
WF 12 m.l ength, 12 m.high	270	- 55,49	20	272	80	**30**	- 66,94	**11,45**
2 loops (4,27 x 2,00 m.) 5 m. sep.	300	- 55,47	22	304	81	**29**	- 66,95	**11,48**
Xfmr: 600/100 ohms	330	- 55,42	20	330	79	**24**	- 66,87	**11,45**
RL1= 580 - RL2 = 600	360	- 55,50	20	4	81	**23**	- 66,89	**11,39**
TL1 100 ohm to front loop = 4,00 m.	30	- 55,47	20	30	81	**24**	- 66,80	**11,33**
TL2 to rear loop 180 deg.rev = 4,25m.	60	- 55,33	22	60	84	**26**	- 66,63	**11,30**
Added the wires of:	90	- 55,41	20	88	82	**23**	- 66,88	**11,47**
Tx antenna at a distance of 38 m.	120	- 55,69	22	122	81	**25**	- 67,26	**11,57**
and abt 140 degrees, with top loading	150	- 55,80	22	152	81	**22**	- 67,25	**11,45**
yagi, 28 m. high, and 4 elev. radials	180	- 55,51	20	180	79	**26**	- 66,97	**11,46**
TL3 short ckt 90 degr. on Tx ant.	210	- 55,28	22	208	82	**23**	- 66,75	**11,47**
	240	- 55,33	22	232	81	**27**	- 66,73	**11,40**
	270	- 55,46	20	272	83	**30**	- 66,91	**11,45**

Wow! The offending Tx antenna disappeared and the Waller Flag recovered its behaviour and a clean pattern in every direction. A few dB a still missing in the FB, but this is not an issue.

Anyway remember that the elevated radials were so detrimental on all my Pennants that every effort in tower detuning had no effect unless changing the ground system, so I modeled also this situation, to see if I could get any further improvement.

Table 10: The Waller Flag - on its tower - plus the Tx antenna "DETUNED" and a new "on ground" radial system

File			gain	TO angle	Bearing	BW	FB	Avg.gain	RDF
FLFlag_04	no interactions =>		- **55,42**	**20**	**272**	**80**	**37**	- **66,91**	**11,49**
wires 166 - segm. 503	Beaming Degrees								
WF 12 m.l ength, 12 m.high		270	- 55,44	24	270	79	**24**	- 66,86	**11,42**
2 loops (4,27 x 2,00 m.) 5 m. sep.		300	- 55,56	22	304	80	**29**	- 67,06	**11,50**
Xfmr: 600/100 ohms		330	- 55,54	20	330	78	**32**	- 67,09	**11,55**
RL1= 580 - RL2 = 600		360	- 55,55	22	0	81	**27**	- 67,00	**11,45**
TL1 100 ohm to front loop = 4,00 m.		30	- 55,36	22	30	81	**26**	- 66,80	**11,44**
TL2 to rear loop 180 deg.rev = 4,25m.		60	- 55,19	22	60	82	**34**	- 66,66	**11,47**
Added the wires of:		90	- 55,38	20	88	80	**28**	- 66,87	**11,49**
Tx antenna at a distance of 38 m.		120	- 55,62	22	122	80	**24**	- 67,21	**11,59**
and abt 140 degrees, with top loading		150	- 55,65	22	148	79	**23**	- 67,29	**11,64**
yagi, 28 m. high, and 32 ground radials		180	- 55,37	20	180	79	**28**	- 66,93	**11,56**
TL3 short ckt 90 degr. on Tx ant.		210	- 55,15	22	208	82	**32**	- 66,61	**11,46**
		240	- 55,19	22	232	81	**26**	- 66,62	**11,43**
		270	- 55,44	20	270	79	**24**	- 66,86	**11,42**

Only a negligible improvement, not worth the hard work of laying down a serious ground system, at least as receiving is concerned. On the transmitting side, of course, the antenna efficiency would be surely improved but, as long as I can work every Dx station heard, I can keep my four elevated radials without disturbing or damaging the green lawn. (Since my retirement, gardening became my first activity).

The most meaningful data of tables 8, 9 and 10 are better shown with the two graphs here on the right.

No doubt that detuning the Tx antenna is a "must", but radials placement has some random effect only on the front to back ratio.

The main parameter of RDF *Receiving Directivity Factor* is mostly flat and unaffected by radial system.

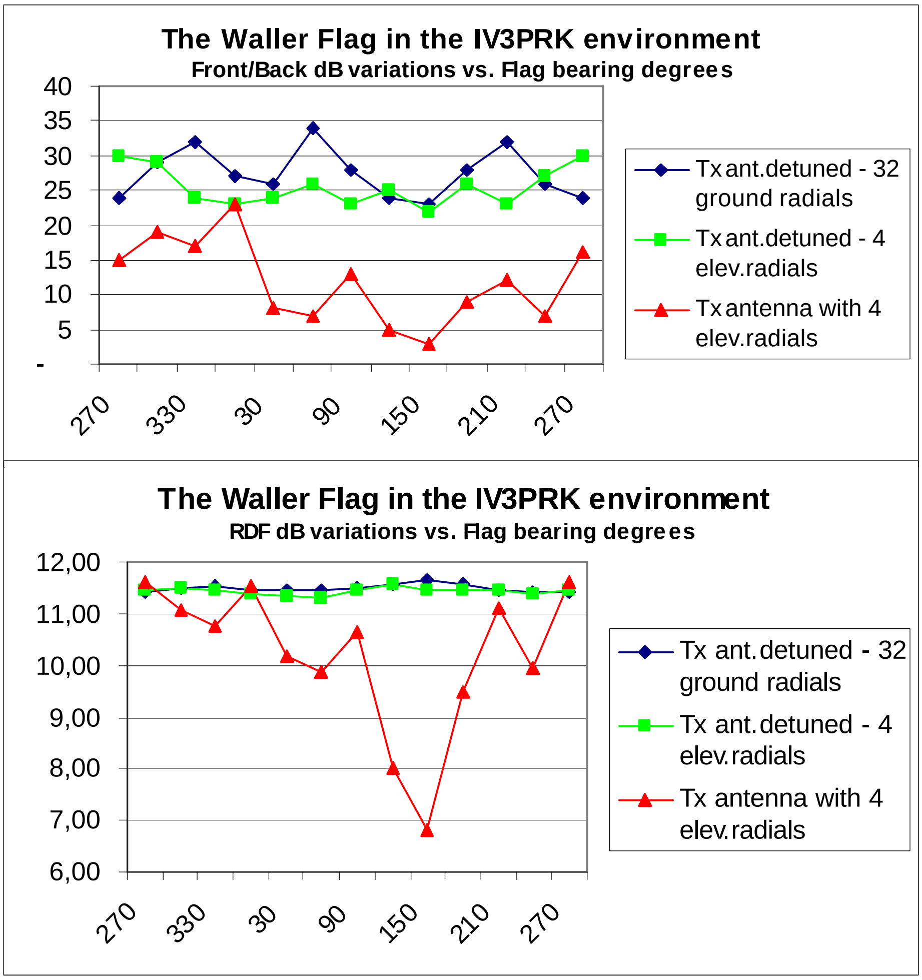

Fig.11: Rotating with Eznec the Waller Flag

The Waller Flag compared to the original Flag

Following are the snapshots of the Eznec patterns for both the Flags in the same IV3PRK environment, that is after detuning the nearby transmitting antenna.

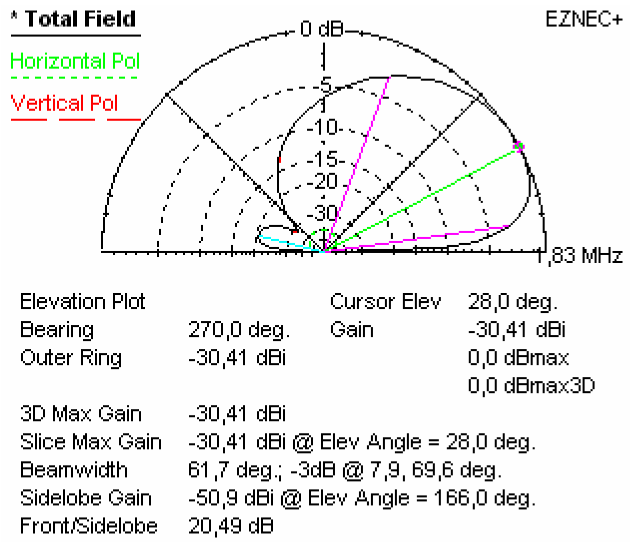

Fig.12: Original W7IUV Flag – Elev. plot

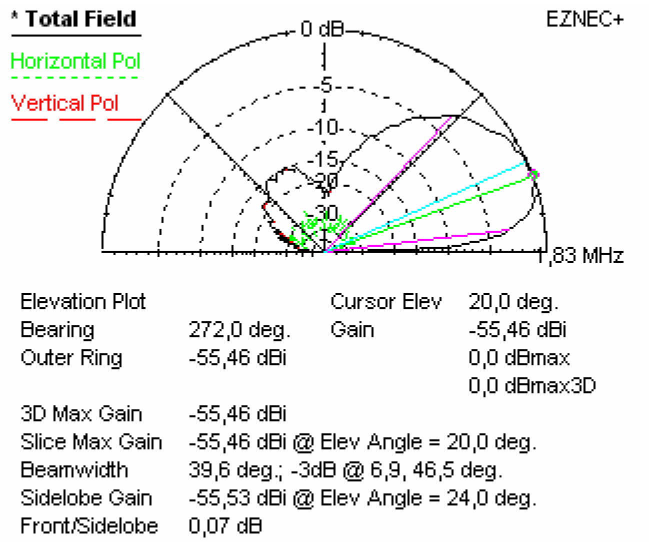

Fig.13: The Waller Flag – Elevation plot

The take-off angle is lower and the lobe is much sharper in the Waller Flag, favouring the long distance DX signals. In my personal situation it should be a great benefit in reducing the Russian and eastern European QRM while working Far East and the Pacific in the same direction. Unfortunately, compared to the single Flag, there is that high angle back lobe, caused by the close spacing of the two loops, and almost impossible to reduce.

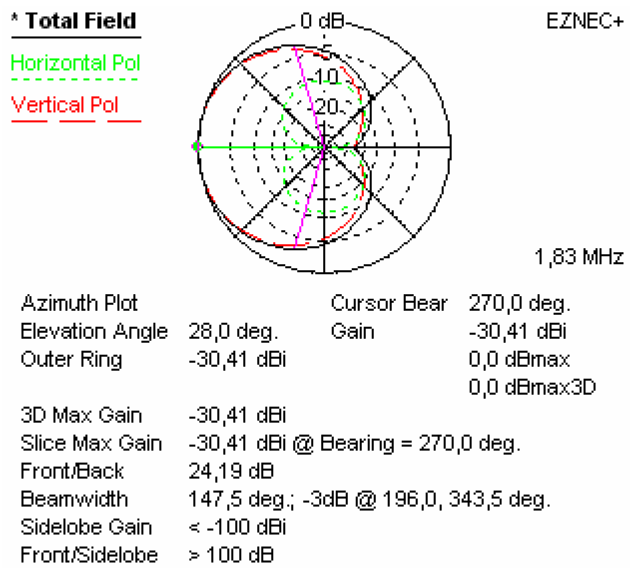

Fig.14: Original W7IUV Flag – Azimuth plot

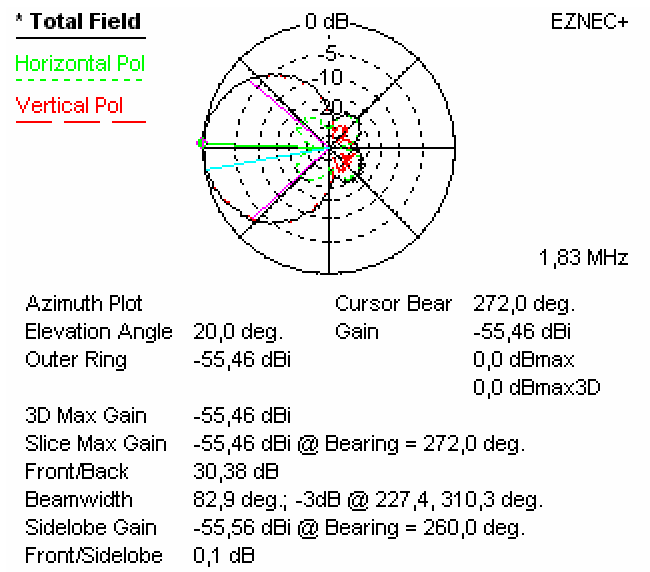

Fig.14: The Waller Flag – Azimuth plot

The azimuth pattern of the Waller Flag is also very good, only 83 degrees of beamwidth, better than a typical four square array but, as stated previously, there is a drawback which requires attention. The gain is 55 dB “negative”, thus 25 dB lower than on a single Flag, and we need two clean preamplifiers after being very careful with transformers to prevent noise entering the feedline.

The graphs on the right show the most meaning data of the two Flags taken every 30 degrees of rotation in the same environment.
The front to back ratio is a few dB's better for the original Flag in most of the bearing positions, hence meaningless.
Where we find a great marked advantage is in the RDF, the "Receiving Directivity Factor" with a stable difference of over 3.5 dB: awesome!
RDF has lately become the most important and direct parameter used in ranking receiving antennas.
On www.w8ji.com, the Tom's site, we see that a 1.75 wl Beverage has an RDF of 11.16 dB.
The Waller Flag is above that, and can be rotated.

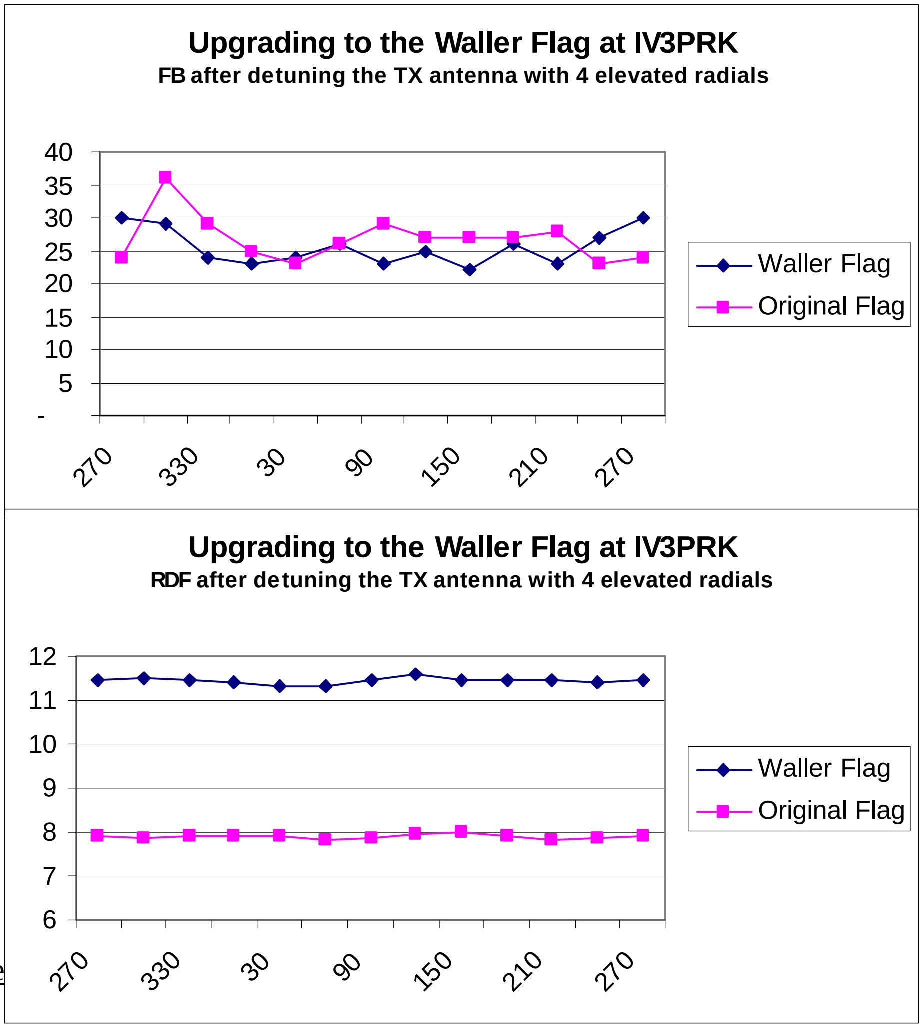

Fig.15: direct comparison between a single Flag and the Waller Flag

In the second part I will cover the building of the "real" antenna and its tests "on the air" but, in the mean time, on www.n4is.com can be found all the designs and construction details of the "Waller Flag".

Let me thank again Doug Waller, NX4D, and Jose Carlos, N4IS, for the correspondence and sharing with me all their findings.

August 2007

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