# **Rx antennas at IV3PRK: the Waller Flag**

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

#### **Rotatable Flag interactions with the Tx antenna**

My transmitting antenna is a top loaded, shunt-fed tower with four elevated 1/4 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 <sup>1</sup>/<sub>4</sub> 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 <u>www.n4is.com</u> : with over 11.5 dB of RDF, it can be compared to a rotatable broadside array of two 175 m. Beverages. But, as usual, <u>there is no free lunch</u> 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 <u>two good</u> <u>preamplifiers are needed</u> 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.

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

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

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	e Waller Flag	- Starting model -	Transmission	Lines SWEEP
	s wanter i lag	- otarting model	110113111331011	

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: N = 1000 (SQRT (L in mH / AL)) 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 : Np / Ns = SQRT (Zp / Zs), 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.

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		
Transm line: 100 ohm (2 x BC58)	450	500	- 57,04	19	00 72	21	- 69,26	11,42		
TI 1 to front loop $= 4.00$ m	475	500	- 56.74	20	73	32	- 68.50	11,05	18.4	1/1 8
TI 2 to rear loop rev phase $-4.00$ m	400	500	- 56 58	23	73	30	- 68.42	11,05	40,4	14,0
122 to real loop rev.phase = 4,00 m.	490	500	- 56.41	23	73	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	50.0	7.0
	600	600	- 56,08	23	74	19	- 67,82	11,74	56,8	7,0
	605	600	- 55,96	23	75 75	18	- 67,66	11,70		
	610	600	- 55,85 55,72	23	75 75	17	- 67,51	11,00		
	620	600	- 55,75	23	75	16	- 67,35	11,02		
	625	600	- 55,62	23	75	16	- 67.04	11,50	56.8	67
	630	600	- 55.41	23	81	15	- 66.88	11,55	50,0	0,7
	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 70	12	- 67,72	11,61		
	790	800	- 56,03	∠U 20	76	12	- 67,64	11,61		
	795	800	- 55,95	20 22	/b 75	12	- 67,55	11,00	66 4	67
	850	000	- 56.41	∠3 20	10 76	12	- 07,45	11,57	00,4	- 0,7
	875	000 000	- 56.07	20	76	11	67.57	11,47		
	880	900 900	- 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.

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

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

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.

File	File			gain	TO angle	Bearing	BW	FB	A	vg.gain	RDF
N4Flag_01b	On the A	n the Air model -		56,71	23	267	73	38	-	68,56	11,85
wires 12 - segm. 135	Beaming	Degrees	Γ						Γ		
WF alone, 12 m.lenght, 12 m.high		270	<i>i</i> -	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	1 -	55,92	22	0	78	20	-	67,43	11,51
TL1 100 ohm to front loop = $4 \text{ m}$ .		30	) -	55,94	22	30	79	21	-	67,44	11,50
TL2 to rear loop 180 deg. Rev. = 4 r	n.	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

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

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	g for best TL line lenght
	/ 0

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	fable 8: The Waller Flag - with its tower and boom/mast - plus the nearby Tx antenna and its 4 elevated radials											
File			gair	1	TO angle	Bearing	BW	FB	Avg.gain	RDF		
FLFlag_03	no intera	ctions =>	- 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 = 4,25r	n.	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 loadin	g	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 0, The Waller Flog	to tower and beem/most	plue the Ty enterna	"DETUNED" or	nd the come 4 alow	radiala
Table 5. The Waller Flag - On h	is lower and boom/mast.	· pius the 1x antenna	DETUNED a	nu the same 4 elev.	iaulais

File				TO angle	Bearing	BW	FB	Avg.gain	RDF
FLFlag_03	no interactions =>		- 55,4	42 20	272	80	37	- 66,91	11,49
wires 67 - segm. 264	Beaming	Degrees							
WF 12 m.l ength, 12 m.high		270	- 55,4	49 20	) 272	80	30	- 66,94	11,45
2 loops (4,27 x 2,00 m.) 5 m. sep.	ļ	300	- 55,4	47 22	304	81	29	- 66,95	11,48
Xfmr: 600/100 ohms	ļ	330	- 55,4	42 20	) 330	79	24	- 66,87	11,45
RL1= 580 - RL2 = 600		360	- 55,5	50 20	) 4	81	23	- 66,89	11,39
TL1 100 ohm to front loop = $4,00$ m.	I	30	- 55,4	47 20	30	81	24	- 66,80	11,33
TL2 to rear loop 180 deg.rev = 4,25m	<b>h</b> .	60	- 55,3	33 22	2 60	84	26	- 66,63	11,30
Added the wires of:	·	90	- 55,4	41 20	88	82	23	- 66,88	11,47
Tx antenna at a distance of 38 m.	ļ	120	- 55,6	39 22	2 122	81	25	- 67,26	11,57
and abt 140 degrees, with top loading	g	150	- 55,8	30 22	2 152	81	22	- 67,25	11,45
yagi, 28 m. high, and 4 elev. radials	-	180	- 55,5	51 20	) 180	79	26	- 66,97	11,46
TL3 short ckt 90 degr. on Tx ant.	ļ	210	- 55,2	28 22	208	82	23	- 66,75	11,47
-	ļ	240	- 55,3	33 22	232	81	27	- 66,73	11,40
	I	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.

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 = 4,25n	n.	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 loadin	g	150	-	55,65	22	148	79	23	- 67,29	11,64
yagi, 28 m. high, and 32 ground radia	als	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

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

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.



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.



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.





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.

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that, and can be rotated.

Luis IV3PRK