

Supplementary Materials

The Effects of Clipped Delta Fin Modifications on a Model Rocket's Performance

This supplementary document contains the complete trial-by-trial simulation data and full parameter trade studies referenced in the main manuscript. Tables S1–S3 provide all 27 individual trials per fin (nine per motor across three motors). Tables S4–S6 provide the complete thirteen-point sweep-angle trade studies, and Tables S7–S9 provide the complete eleven-point center-of-gravity trade studies used to identify each fin's optimum.

Trial	Launch Angle (°)	Wind Speed (m/s)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)	Traj.–Launch Angle Diff. (°)	Norm. Alt. per Impulse (s/kg)
Clipped Delta — Motor G40-4W								
1	0	0	470	93	0.057	1.96	0.0351	
2	0	2	468	92.9	6.15	1.96	3.8	
3	0	4	462	92.7	11.05	1.96	6.84	
4	3	0	468	93	7.04	1.96	1.34	
5	3	2	461	92.9	13.709	1.96	5.49	
6	3	4	457	92.8	15.24	1.96	6.46	
7	-3	0	468	93	6.25	1.96	0.85	
8	-3	2	469	92	2.23	1.96	1.61	
9	-3	4	466	92.6	4.7	1.96	0.1	
Average			465.44	92.77	7.38	1.96	2.95	4.70
Clipped Delta — Motor G80T-4								
1	0	0	731	134	0.079	1.92	0.0338	
2	0	2	729	134	6.93	1.92	2.96	
3	0	4	722	133	12.4	1.92	5.35	
4	3	0	729	134	8.51	1.92	0.64	
5	3	2	722	134	15.77	1.92	3.76	
6	3	4	709	134	22.65	1.92	6.73	
7	-3	0	729	134	8.49	1.92	0.63	
8	-3	2	731	134	2.25	1.92	2.08	
9	-3	4	728	134	4.84	1.92	0.93	
Average			725.56	133.89	9.1	1.92	2.57	5.46
Clipped Delta — Motor HP-G75M								
1	0	0	628	121	0.36	1.92	0.17	
2	0	2	626	121	6.3	1.92	2.98	
3	0	4	620	120	11.5	1.92	5.5	

Trial	Launch Angle (°)	Wind Speed (m/s)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)	Traj.–Launch Angle Diff. (°)	Norm. Alt. per Impulse (s/kg)
4	3	0	625	121	8.06	1.92	0.82	
5	3	2	620	121	14.16	1.92	3.72	
6	3	4	611	120	18.78	1.92	6	
7	-3	0	626	121	7.33	1.92	0.47	
8	-3	2	627	121	2.14	1.92	1.99	
9	-3	4	625	121	4.51	1.92	1.86	
Average			623.11	120.78	8.13	1.92	2.61	5.41
Total Averages			604.7	115.81	8.2	1.93	2.71	5.19

Table S1. Clipped Delta — full 27-trial results.

Trial	Launch Angle (°)	Wind Speed (m/s)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)	Traj.–Launch Angle Diff. (°)	Norm. Alt. per Impulse (s/kg)
Fin B — Motor G40-4W								
1	3	0	469	93	6.57	1.21	1.051043979	
2	3	2	466	93	10.42	1.21	3.433099625	
3	3	4	466	92.8	8.48	1.21	2.242962767	
4	0	0	469	92.9	0.055	1.21	0.03392107704	
5	0	2	469	92.9	4.92	1.21	3.035814612	
6	0	4	468	92.7	3.81	1.21	2.355538575	
7	-3	0	469	93	6.62	1.21	1.081925909	
8	-3	2	470	92.9	2.37	1.21	1.538151441	
9	-3	4	470	92.9	3.1	1.21	1.087729861	
Average			468.44	92.9	5.15	1.21	1.76	4.73
Fin B — Motor G80T-4								
1	3	0	732	134	8.45	1.18	0.6154536156	
2	3	2	727	134	13.33	1.18	2.709089853	
3	3	4	725	134	13.41	1.18	2.743467839	
4	0	0	734	134	0.079	1.18	0.03377885704	
5	0	2	733	134	5.23	1.18	2.236813869	
6	0	4	731	134	5.87	1.18	2.510700634	
7	-3	0	732	134	8.5	1.18	0.6368755257	
8	-3	2	733	134	3.34	1.18	1.5717334	
9	-3	4	733	134	3.48	1.18	1.511852743	

Trial	Launch Angle (°)	Wind Speed (m/s)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)	Traj.–Launch Angle Diff. (°)	Norm. Alt. per Impulse (s/kg)
Average			731.11	134	6.85	1.18	1.62	5.5
Fin B — Motor HP-G75M								
1	3	0	628	121	7.59	1.17	0.5963690676	
2	3	2	624	121	12.2	1.17	2.786762903	
3	3	4	622	121	12.77	1.17	3.058117252	
4	0	0	630	121	0.068	1.17	0.03219928274	
5	0	2	628	121	4.48	1.17	2.121849371	
6	0	4	627	121	4.98	1.17	2.358790064	
7	-3	0	628	121	7.67	1.17	0.6343261147	
8	-3	2	629	121	2.89	1.17	1.631400413	
9	-3	4	628	121	4.47	1.17	0.8828890588	
Average			627.11	121	6.35	1.17	1.57	5.44
Total Averages			608.89	115.97	6.12	1.19	1.65	5.22

Table S2. Fin B — full 27-trial results.

Trial	Launch Angle (°)	Wind Speed (m/s)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)	Traj.–Launch Angle Diff. (°)	Norm. Alt. per Impulse (s/kg)
Fin C — Motor G40-4W								
1	3	0	462	92.7	6.74	1.65	1.169521152	
2	3	2	456	92.6	13.04	1.65	5.095341378	
3	3	4	448	92.4	17.06	1.65	7.639679977	
4	0	0	464	92.7	0.056	1.65	0.03461233924	
5	0	2	461	92.6	6.42	1.65	3.975531602	
6	0	4	456	92.4	10.59	1.65	6.581153436	
7	-3	0	462	92.7	6.79	1.65	1.200507647	
8	-3	2	463	92.6	1.76	1.65	1.910943366	
9	-3	4	460	92.4	4.03	1.65	0.5002677545	
Average			459.11	92.57	7.39	1.65	3.12	4.64
Fin C — Motor G80T-4								
1	3	0	715	134	8.59	1.77	0.6754362487	
2	3	2	708	134	16.28	1.77	3.978248975	
3	3	4	697	134	22.18	1.77	6.527582389	
4	0	0	718	134	0.076	1.77	0.0324961155	

Trial	Launch Angle (°)	Wind Speed (m/s)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)	Traj.–Launch Angle Diff. (°)	Norm. Alt. per Impulse (s/kg)
5	0	2	714	134	7.98	1.77	3.414111983	
6	0	4	708	134	13.71	1.77	5.872403866	
7	-3	0	715	134	8.64	1.77	0.6968595919	
8	-3	2	717	134	2.12	1.77	2.093491639	
9	-3	4	714	134	5.24	1.77	0.7589070601	
Average			711.78	134	9.42	1.77	2.67	5.35
Fin C — Motor HP-G75M								
1	3	0	615	120	7.74	1.61	0.6981450089	
2	3	2	609	120	13.78	1.61	3.594012067	
3	3	4	602	120	18.22	1.61	5.73318588	
4	0	0	617	120	0.068	1.61	0.03246761013	
5	0	2	615	120	6.11	1.61	2.918572104	
6	0	4	610	120	10.65	1.61	5.091699591	
7	-3	0	615	120	7.78	1.61	0.7172836609	
8	-3	2	617	120	2.13	1.61	1.982946503	
9	-3	4	615	120	3.01	1.61	1.562680116	
Average			612.7	120	7.72	1.61	2.48	5.32
Total Averages			594.56	115.52	8.18	1.68	2.76	5.1

Table S3. Fin C — full 27-trial results.

Angle (°)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)
30	456	92.3	7	1.65
34	458	92.4	6.9	1.75
38	459	92.5	7.16	1.83
42	460	92.6	7.61	1.87
46	461	92.6	7.22	1.9
50	463	92.7	7.01	1.92
54	464	92.7	6.48	1.92
58	464	92.8	6.74	1.9
62	465	92.8	6.21	1.9
66	466	92.9	6.38	1.88
70	467	92.9	6.17	1.84
74	467	92.9	5.57	1.78
78	468	92.9	5.76	1.71

Table S4. Clipped Delta — full angle trade study (13 angles, G40-4W motor).

Angle (°)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)
30	460	92.5	5.62	1.37
34	461	92.5	6.94	1.42
38	462	92.6	6.83	1.43
42	464	92.7	6.62	1.41
46	465	92.7	6.3	1.37
50	466	92.8	5.85	1.3
54	468	92.8	5.3	1.19
58	469	92.9	4.49	1.05
62	470	92.9	3.19	0.89
66	471	92.9	1.07	0.673
70	127	76.3	19.02	0.398
74	65.1	63.1	16.66	0.039
78	48.2	55.6	15.65	-0.443

Table S5. Fin B — full angle trade study (13 angles, G40-4W motor).

Angle (°)	Max Apogee (m)	Max Velocity (m/s)	Stability (cal)	Lateral Velocity (m/s)
102	461	92.6	1.79	6.72
106	460	92.6	1.79	6.73
110	460	92.5	1.77	6.74
114	459	92.5	1.76	6.73
118	458	92.5	1.74	6.71
122	458	92.4	1.71	6.69
126	457	92.4	1.68	6.65
130	456	92.3	1.65	6.6
134	455	92.3	1.6	6.54
138	454	92.2	1.55	6.44
142	453	92.2	1.48	6.33
146	452	92.1	1.4	6.19
150	450	92	1.29	5.99

Table S6. Fin C — full angle trade study (13 angles, G40-4W motor).

CG (cm)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)
11.5	461	92.6	6.84	11.4
16.4	461	92.6	7.04	10.4
21.2	460	92.6	7.23	9.45
26.1	460	92.6	7.41	8.47
31	460	92.6	7.61	7.5
35.9	460	92.6	7.86	6.52
40.7	460	92.6	8.07	5.55
45.6	460	92.6	8.18	4.57
50.5	460	92.6	8.12	3.6

CG (cm)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)
55.4	460	92.6	7.73	2.62
60.2	461	92.6	6.42	1.65

Table S7. Fin C — full center-of-gravity trade study (11 CGs).

CG (cm)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)
11.5	468	92.9	5.9	11
16.4	468	92.9	6.04	9.99
21.2	468	92.9	6.18	9.01
26.1	468	92.9	6.3	8.04
31	468	92.9	6.49	7.06
35.9	468	92.9	6.64	6.09
40.7	468	92.9	6.77	5.11
45.6	468	92.9	6.8	4.14
50.5	468	92.9	6.67	3.16
55.4	468	92.9	6.11	2.18
60.2	469	92.9	4.4	1.21

Table S8. Fin B — full center-of-gravity trade study (11 CGs).

CG (cm)	Max Apogee (m)	Max Velocity (m/s)	Lateral Velocity (m/s)	Stability (cal)
11.5	467	92.9	7	11.7
16.4	467	92.9	7.36	10.7
21.2	466	92.9	7.69	9.93
26.1	466	92.9	7.94	8.79
31	466	92.9	8.2	7.81
35.9	466	92.9	8.34	6.84
40.7	466	92.9	7.36	5.86
45.6	466	92.9	8.12	4.89
50.5	466	92.9	7.67	2.93
55.4	466	92.9	7.57	2.3
60.2	468	92.9	7.07	1.96

Table S9. Clipped Delta — full center-of-gravity trade study (11 CGs).