

# Considerations for the S1B Altitude Event

Prepared by

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November, 2009



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*Note: This document contains opinions of Chris Flanigan.  
Others may have different views.*

# S1B REQUIREMENTS



# Requirements for S1B Vehicle

- **Smallest body diameter must be not less than 18 mm for at least 75% of the overall length of each stage**
  - **Rule 2.4.3**
- **Minimum diameter = 40 mm for at least of 50% of the overall length**
  - **Rule 2.4.4**
- **Minimum overall length = 500 mm (19.69 in)**
  - **Rule 2.4.4**
- **Maximum weight = 60 gr (2.116 oz)**
  - **Rule 5.3**



*Reference: FAI Code, 2009 Edition*

# 2009 EUROPEAN CHAMPIONSHIPS



# S1A and S1B Results from the 2009 European Championships



## 12<sup>th</sup> European Spacemodelling Championship

Irig, Serbia  
22. - 29.08.2009.

**Air conditions:**  
Temperature: 21-30°C  
Wind: 4-5 m/s from W  
Humidity: 40-24%  
Pressure: 1010 hPa  
Time: 25.08.2009.  
08:00-12:30h

### S1 – A Juniors

Final classifications – Individual:

No	SN	Name and Surname	NAC	FAI license	T U R N U S			res.	place
					1	2	3		
1	117	MIHALO PETROVIĆ	SRB	S667	0,0	323	DQ	323	1
2	7	JAN CHMELIK	CZE	CZE 1048	DQ	NC, 306	271	306	2
3	85	ANDREI PATRAU/TEANU	ROU	ROU 19	0,0	NC,298	DQ	298	3
4	87	ALEXANDRU NICA	ROU	ROU 2421	246	218	279	279	4
5	5	MARTIN PAVKA	CZE	CZE 1047	NC,NC	239	278	278	5
6	16	JAKUB FIALKOWSKI	POL	POL 6263	0,0	NC,269	DQ	269	6
7	111	MILAN PETKOVIĆ	SRB	S571	NC	NC,262	DQ	262	7
8	133	MICHAL POTFAJ	SVK	SVK 42-60	TL	TL,DQ	TL,259	259	8
9	56	DEMIS GAGANOV	RUS	RUS 145	0,0	TL,DQ	0	243	9
10	59	MAXIM DEMIDOV	RUS	RUS 01277	238,0	NC	DQ	238	10
11	18	MATEUSZ DYBA	POL	POL 6694	DQ	167,0	TL, 221	221	11
12	28	VLADISLAV GURBA	BLR	BLR 179	199,01	NC, 171	170	199	12
13	75	MYKOLAS TREIKAIŠKAS	LTU	LTU 559	TL	NC,193	137,0	193	13
14	74	AURIMAS PETKEVIČIUS	LTU	LTU 664	182,0	NC,189	NC,123	189	14
15	17	SZYMON BYRTEK	POL	POL 6225	DQ	DQ	182	182	15
16	131	ANNA MARIA ȘILAROVA	SVK	SVK 42-78	0,0	DQ	178	178	16
17	29	ARTSIOM RYBKO	BLR	BLR 180	NC,NC	164,0	146	164	17
18	43	ALEJANDRO FILLAT	ESP	2900	0,0	NC, 162	NC,TL	162	18
19	73	AUGUSTINAS VASILIAUSKAS	LTU	LTU 517	DQ	NC,137	158,0	158	19
20	30	DZIMITRY MAKSIMCHYK	BLR	BLR 194	NC	NC,NC	137	137	20
21	42	FRANCISCO PALOMAR	ESP	2674	0,0	TL,123	NC	123	21
22	130	MAREK DURAJ	SVK	SVK 42-49	0,0	DQ	TL,100	100	22
23	86	MIHA CONSTANTINESCU	ROU	ROU 78	DQ	DQ	TL,NC,98	98	23
24	112	VEŠNA KATANIĆ	SRB	S472	0,0	DQ	DQ	0	24
25	58	VADIM KRASOVSKIY	RUS	RUS 0119	0,0	TL	NC,TL,DQ	0	25
26	41	JESUS MORAN	ESP	2626	NC,TL	TL,DQ	DQ	0	26
27	6	JAN SRŠEN	CZE	CZE 1048	TL	TL,DQ	DQ	0	27

TL - track lost NC - No Close DQ - Disqualification GE - Crash of engine



## 12<sup>th</sup> European Spacemodelling Championship

Irig, Serbia  
22. - 29.08.2009.

**Air conditions:**  
Temperature: 28°C  
Wind: 3 km/h from SW  
Humidity: 46%  
Pressure: 995 hPa  
Time: 25.08.2009.  
13:00-18:00h

### S1 – B Seniors

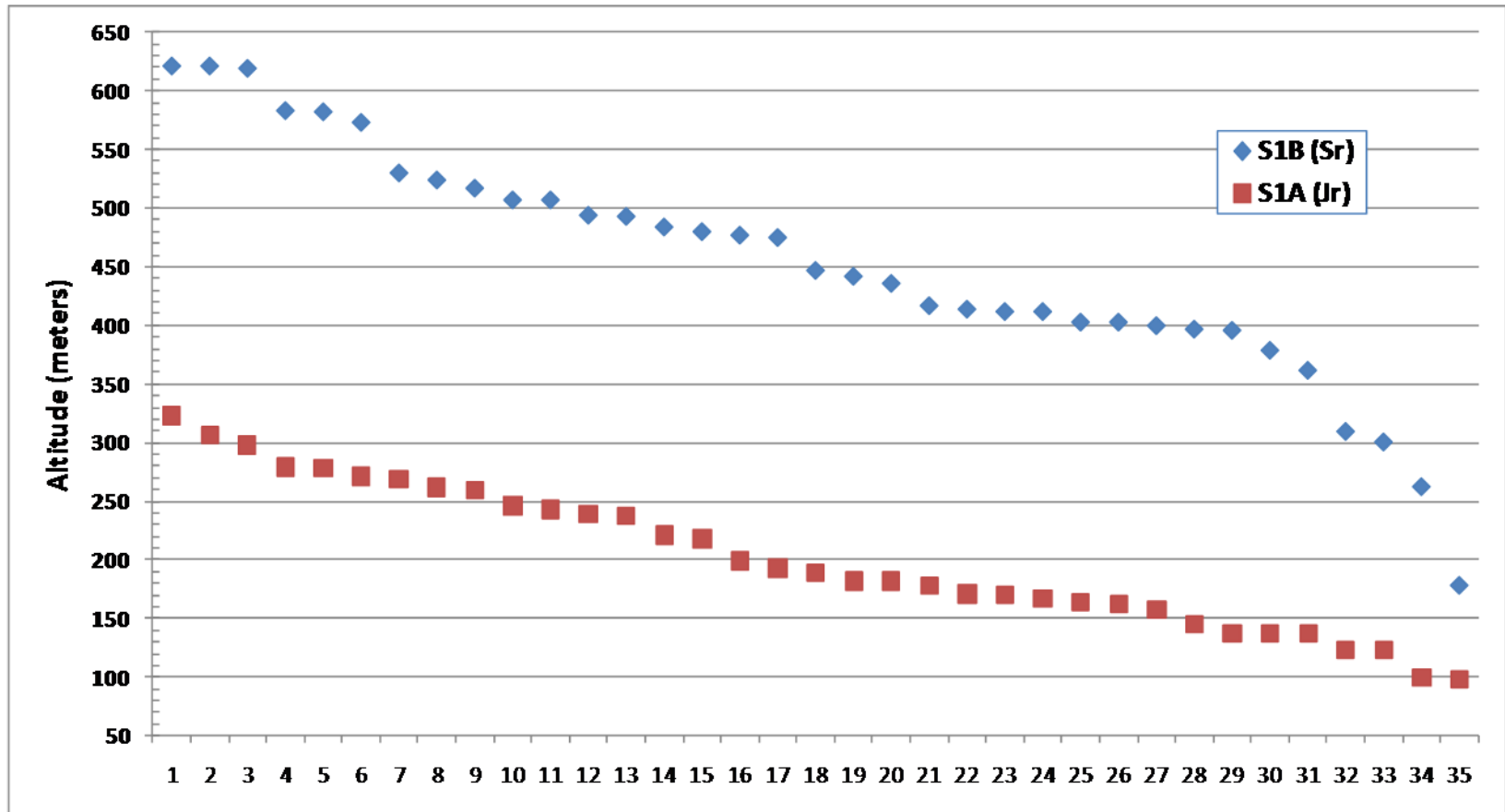
Final classifications – Individual

start num	Competitor	Team	FAI license	T U R N U S			res.	place
				1	2	3		
4	JAROSLAV CHMELIK	CZE	CZE 1046	DQ	621	NC	621	1
95	JOŽA ČUDEN	SLO	S5520001	0	621	TL	621	1
123	MILAN JAVORIK II	SVK	SVK 71-23	400	619	583	619	3
64	TOSHKO STOYANOV	BUL	BUL 00960	NC	582	403	582	4
8	ANTONIO MAZZARACCHIO	ITA	ITA-S1	DQ	517	573	573	5
45	SERGEY ROMANYUK	RUS	RUS 0251	530	DQ	TL	530	6
81	MARIAN KRALUSE	ROU	ROU 213	DQ	524	0	524	7
9	LESZEK MALMYGA	POL	POL 4578	DQ	507	TL, TL	507	8
91	STANIŠA PETROVIĆ	MKD	S 151	NC	DQ	507	507	8
125	MICHAL ŽITNAN	SVK	SVK 42-12	494	DQ	480	494	10
44	VLADIMIR MENSHIKOV	RUS	RUS 0348	484	NC	493	493	11
11	KRZYSZTOF PRZYBYTEK	POL	POL 3754	TL,DQ	477	447	477	12
79	FLORICA SERCAIANU	ROU	ROU 2396	475	NC	NC	475	13
66	SASHA STOYANOVA	BUL	BUL 00361	442	0	412	442	14
2	PAVEL BRONY	CZE	CZE 1044	436	417	403	436	15
1	BEDRICH PAVKA	CZE	CZE 1043	414	DQ	DQ	414	16
126	VASIL PAVLUK	SVK	SVK 26-14	NC,TL	397	412	412	17
78	LUCIAN SERCAIANU	ROU	ROU 228	396	NC	NC	396	18
105	BRANISLAV KRČEDIŇAC	SRB	S 209	NC	379	0	379	19
27	VALERY HRABOSKI	BLR	BLR 128	NC,NC	362	0	362	20
25	VLADZIMIR MINKEVICH	BLR	BLR 042	263	310	0	310	21
31	TREVOR SEABROOK	GBR	GBR 113101	NC,TL	301	DQ	301	22
26	ALEXANDR LIPAJ	BLR	BLR 071	179	0	DQ	179	23
10	SLAWOMIR LASOCHA	POL	POL 3896	DQ	DQ	TL	0	
32	NIGEL BATHE	GBR	GBR 063592	DQ	NC	0	0	
33	MIKE FRANCIS	GBR	GBR 039222	DQ	0	0	0	
34	JORDI ROURA FONT	ESP	ESP 708	0	TL	DQ	0	
39	ENRIQUE MORAN	ESP	ESP 2808	DQ	0	DQ	0	
38	ROSA SANZ	ESP	ESP 2899	NC	0	TL	0	
49	ALEXEY RESHETNIKOV	RUS	RUS 0340	DQ	TL,TL	NC	0	
65	BORIS LEKOV	BUL	BUL 00429	TL	DQ	DQ	0	
70	MAKSIM TIMOFEEV	LTU	LTU 284	NC,DQ	NC,DQ	DQ	0	
71	JURIS STRAZDAS	LTU	LTU 066	DQ	0	0	0	
72	EUGENIUS GUOBYIS	LTU	LTU 385	0	DQ	DQ	0	
89	GOCE JOSIFOVSKI	MKD	S 133	DQ	DQ	DQ	0	
90	GUGORČO ČEJKOV	MKD	S 127	DQ	DQ	DQ	0	
96	MIHA ČUDEN	SLO	S552018	TL	0	DQ	0	
99	TONE ŠJANEC	SLO	S552003	TL	0	NC,DQ	0	
104	MIRKO KATANIĆ	SRB	S 471	DQ	NC,TL	0	0	
106	VLADIMIR ČIPIĆ	SRB	S 040	DQ	TL	0	0	

TL - track lost NC - No Close DQ - Disqualification GE - Crash of engine



# S1A and S1B Results from the 2009 European Championships



# 2009 Results – S1B

- **Visual impression of S1B results graph...**
  - One group of S1B flights went to ~400 meters
  - Another group of S1B flights went to ~500 meters
  - Only three few flights exceeded 600 meters
- **Questions**
  - Is >600 m flight feasible?
  - Were >600 m altitudes due to tracking anomalies?
  - Is piston launcher or staging “enhancement” required to achieve super altitudes?
    - Black powder or pyrodex added to assure ignition of piston launcher and/or staging may add performance





# EUROPEAN AND U.S. ENGINES



# U.S. Small Engine Selection Is Limited

Type Designation	Manufacturer	Dimensions (mm)	Impulse (N-sec)	Propellant Mass (g)	Tested By	Contest Approved	Sport Use Ends
S 1/8A.2 (MicroMaxx)-1	Quest	6 x 26	0.2	0.4	NAR	No	
S 1/8A.5 (MicroMaxxII)-1,NE	Quest	6 x 26	0.31	0.5	NAR	Yes	
<b>Type Designation</b>	<b>Manufacturer</b>	<b>Dimensions (mm)</b>	<b>Impulse (N-sec)</b>	<b>Propellant Mass (g)</b>	<b>Tested By</b>	<b>Contest Approved</b>	<b>Sport Use Ends</b>
S 1/4A3T-3	Estes	13 x 45	0.62	0.8	NAR	Yes	
<b>Type Designation</b>	<b>Manufacturer</b>	<b>Dimensions (mm)</b>	<b>Impulse (N-sec)</b>	<b>Propellant Mass (g)</b>	<b>Tested By</b>	<b>Contest Approved</b>	<b>Sport Use Ends</b>
S 1/2A3T-2,4	Estes	13 x 45	1.25	2	NAR	Yes	
S 1/2A6-2	Estes	18 x 70	1.25	2.6	NAR	Yes	
<b>Type Designation</b>	<b>Manufacturer</b>	<b>Dimensions (mm)</b>	<b>Impulse (N-sec)</b>	<b>Propellant Mass (g)</b>	<b>Tested By</b>	<b>Contest Approved</b>	<b>Sport Use Ends</b>
S A3T-4	Estes	13 x 45	2.5	3.3	NAR	Yes	
S A6-4	Quest	18 x 70	2.5	3.5	NAR	Yes	
S A6-4	Quest	18 x 70	2.3	3	NAR	Yes	
S A8-3,5	Estes	18 x 70	2.5	3.3	NAR	Yes	
S A10T-3,P	Estes	13 x 45	2.5	3.8	NAR	Yes	
<b>Type Designation</b>	<b>Manufacturer</b>	<b>Dimensions (mm)</b>	<b>Impulse (N-sec)</b>	<b>Propellant Mass (g)</b>	<b>Tested By</b>	<b>Contest Approved</b>	<b>Sport Use Ends</b>
S B4-2,4	Estes	18 x 70	5	6	NAR	Yes	
S B6-0	Estes	18 x 70	4.9	5.6	NAR	Yes	
S B6-0,4	Quest	18 x 70	5	6.5	NAR	Yes	
S B6-2	Quest	18 x 70	5	6.5	NAR	Yes	
S B6-2,4,6	Estes	18 x 70	5	5.6	NAR	Yes	



No "A" or "1/2A" booster engines

# “Delta” Engines Are Ideal for S1

**Rocksim - engine selections**

Motor mount: 10.5 mm - 3/4B1-7

Manufacturer filter:   Exact match.

Diameter filter: Show all engines.

Type filter:

	Mfg. name	Engine code	Diameter mm	Length In.	Burn Sec.	Total impulse N-Sec.	Average thrust Newtons
0	Delta	1/4A7	10.50	1.4173	0.30	0.600	2.000
1	Delta	1/3A7	10.50	1.4173	0.39	0.800	2.051
2	Delta	1/2A7	10.50	1.4173	0.59	1.200	2.034
3	Delta	A1	10.50	1.4173	2.00	2.423	1.212
4	Delta	A2	10.50	1.4173	1.44	2.400	1.667
5	Delta	3/4B1	10.50	2.1654	2.80	3.700	1.321
6	Delta	5/6B1	10.50	2.1654	3.40	4.150	1.221
7	Delta	7/8B1	10.50	2.1654	3.90	4.350	1.115
8	Delta	B1	10.50	2.1654	4.13	4.800	1.162
9	Delta	B2	10.50	2.1654	2.95	4.800	1.627

Ejection delay in seconds: None

Ignition delay in seconds: 0.00

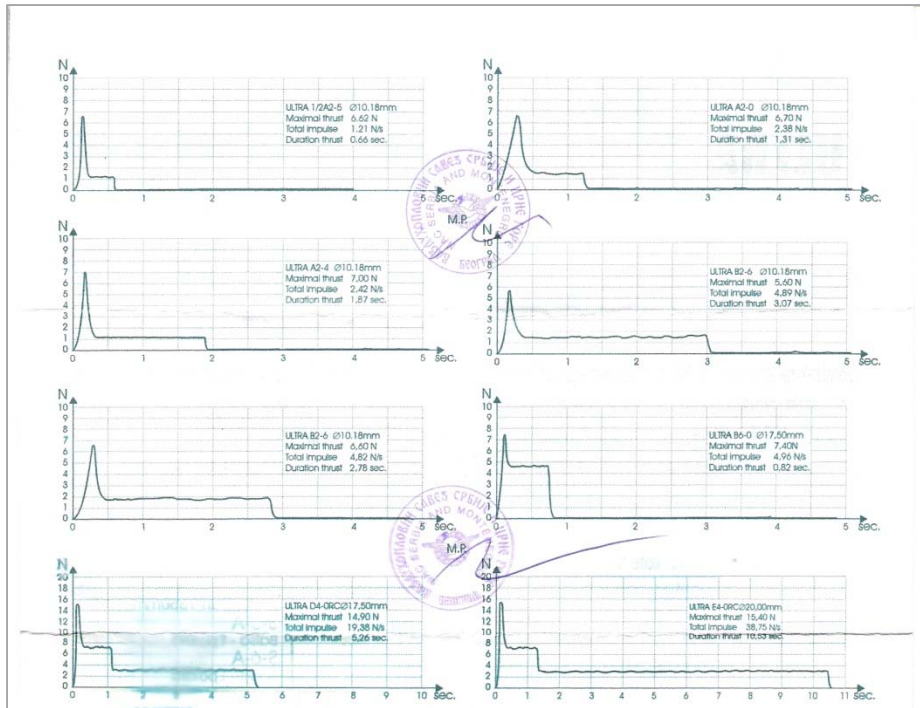
Engine overhang: 0.7500 In.


Help  OK Cancel



**Small size (10.5mm diameter)**  
**Unique fractional “A” and “B” engines**  
**Long delay times**

# Serbian "ULTRA" Engines Are An Alternative





## MODELARSKA RADIONICA MODEL MANUFACTURE

Čipčić Miodrag, Srbija i Crna Gora, 23300 Kikinda, Ivana Jakićeva 35  
Tel.: ++381-(0)230-426-777 ; mob. ++381-(0)64-160-2171  
E-mail: ultra9@ptt.yu


**Specifikacija modelarskih raketnih motora F.A.I.4.d**  
Model rocket engines specifications of F.A.I. code 4.d

Modelarski raketni motori "ULTRA" su motori namenjeni za lansiranje raketnih modela po pravilniku F.A.I. deo 4.d. Raketni motori se moraju čuvati u originalnom pakovanju na sobnoj temperaturi, dalje od izvora toplote i otvorenog plamena. Proizvođač isključuje mogućnost samozapaljenja do temperature 80°C. Pri lansiranju modela koristiti elektro kabel duzine 10 metara min. Na prostoru ne manjem od 100x100 m. Zabranjuje se svako otkvaranje ili naknadno punjenje motora. Deca iznad 8 godina starosti dozvoljeno rukovanje uz prisustvo starije osobe.

Model rocket engines "ULTRA" are engines designed for discharging the rocket models according to the regulations of F.A.I. chapter 4.d. Model rocket engines have to be kept in the original package on the room temperature, far from issue of warmth and opened flame. The producer excludes the possibility of autoinflammation under 80°C. Electro-cable of min. 10m length must be used while discharging, in the space not smaller than 100x100 M. Any opening and additional filling up the engines are forbidden. Handling, under supervision of adults allowed to the children over the age of 8.

To motors	Ugostan impulse	Najveći polniak	Srednji polniak	Vreme izlaza	Masa goriva	Prečnik izlaza	Prečnik i duzina	Otvorenost izlaza	Ukucana maza	Cena	Vrsta goriva
Engine type	Total impulse	Maximal thrust	Average thrust	Operation time	Propellant weight	Case diameter	Case length	Grain	Grain weight	EURO	Propellant type
ULTRA 1/A2-5	1,25	6,62	2,00	0,66	1,50	10,18x36	0,1,2,3,4,5	3,80	1,20	1,20	Crni barut Black powder
ULTRA A2-3	2,50	7,00	1,33	1,87	2,00	10,18x36	1,2,3,4,5,6	4,15	1,85	1,85	Composito
ULTRA A2-4	2,30	6,70	1,50	1,31	3,00	10,18x36	0	5,00	1,40	1,40	Crni barut Black powder
ULTRA B2-3	5,00	5,60	1,62	3,07	4,00	10,18x55	2,3,4,5,6	6,50	2,20	2,20	Composito
ULTRA B2-5	5,00	6,80	1,79	2,78	5,00	10,18x80	3,4,5,6	9,80	2,00	2,00	Crni barut Black powder
ULTRA B5-0	5,00	7,40	6,04	0,82	6,00	17,50x50	0,3,5,7	12,00	2,00	2,00	Crni barut Black powder
ULTRA D4-0	20,00	14,90	3,80	5,26	18,45	17,50x85	ORC. 3,5,7	25,00	1,00	1,00	Composito
ULTRA E4-0	40,00	15,40	3,79	10,53	24,90	20,00x98	ORC. 3,5,7	44,00	5,50	5,50	Composito

**Modeli Modeli:**  
S-8-E  
RC Rocket glider-carbon  
Wing span-1350mm-50gr.  
S-3-A  
S-3-A  
S-3-A  
Balica - EPP



Poprečni presek ULTRA motora  
Cross section of ULTRA engine

February, 2005

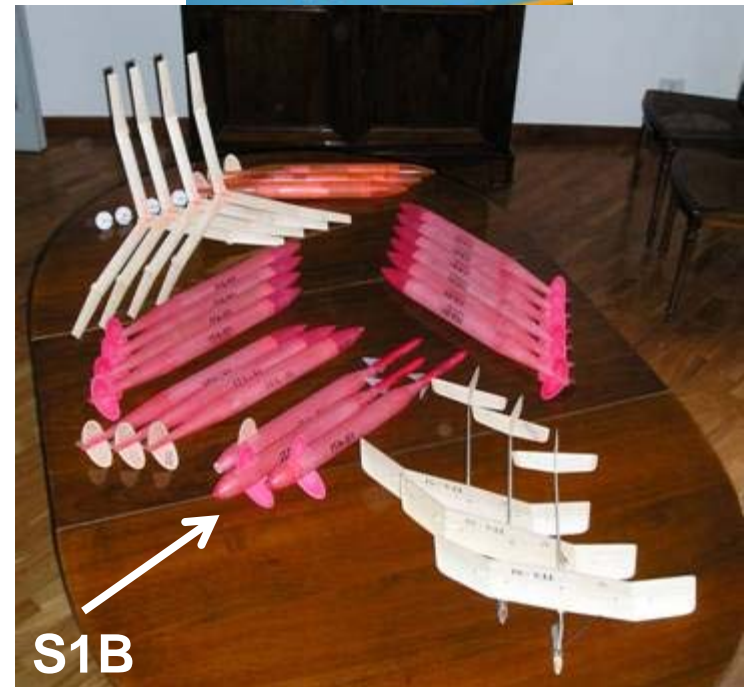


# VEHICLE SIZING OPTIMIZATION



# Considerations for an Optimum S1B Vehicle

- **Maximize altitude**
  - Engines
  - Drag
  - Weight
  - Launcher & staging
- **Satisfy requirements**
  - $\geq 500$  mm length
  - $\geq 40$  mm diam for 50% of total length
  - $\geq 18$  mm diam for 75% of length of each stage



Competitive FAI models by Antonio Mazzaracchio

[http://www.antoniomazzaracchio.it/index\\_file/Page1007.htm](http://www.antoniomazzaracchio.it/index_file/Page1007.htm)



# The Fundamentals

- Staging required for a high performance S1 vehicle
  - Drop the large 40mm booster stage as soon as possible
- Upper stage should be minimum size
  - Minimize drag
- Upper stage should have optimum weight
  - Tracking powder (if optical tracking)
  - Altimeter (if electronic tracking)
- Vehicle should use optimum engines
  - “Delta” engines: [1/4A + 7/8B] or [1/2A + 3/4B]
- Vehicle should have high but not necessarily ultimate reliability
  - Three opportunities to make a qualified flight



# Use Excel Spreadsheet with “Solver” Optimizer to Minimize Surface Area

## CONSTRAINTS (REQUIREMENTS)

Smallest body diameter must be not less than 18 mm for at least 75% of the overall length of each stage (2.4.3)

Minimum diameter = 40 mm for at least of 50% of the overall length (2.4.4)

Minimum overall length = 500 mm (19.69 in) (2.4.4)

Maximum weight = 60 gr (2.116 oz) (5.3)

	Length	Diam - Aft	Diam - Fwd	Fraction	Area	Factor	Factored Area	Length (in)
<b>STAGE 1</b>								
Boattail	81.43	10.5	40		6,564.3			3.206
Cylinder	250.00	40	40	0.500	31,415.9			9.843
Transition	18.27	40	18		1,943.2			0.719
Subtotal	349.7				39,923.4	0.1	3,992.3	13.768
<b>STAGE 2</b>								
Boattail	0	18	18		0.0			0.000
Cylinder	114.3	18	18	0.760	6,463.5			4.500
Nose	36.0	18	0		1,049.2			1.417
Subtotal	150.3				7,512.7	0.9	6,761.4	5.917
<b>TOTAL</b>								
Total	500				47,436.1		10,753.8	19.685

denotes optimized cell

Assume that weight and drag are proportional to surface area

Can try other values using *S1B\_Optimization.xlsx*

Note: solution says optimum Stage 2 has no boattail



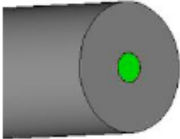


# DRAG REDUCTION

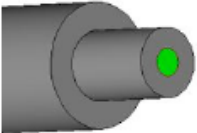


# Bob Parks Examined Extending the Engine to Reduce Base Drag

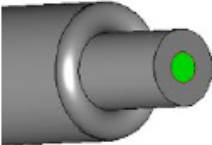
Configurations analyzed



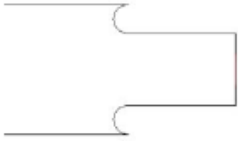
Standard 18mm base  
The green dot is the nozzle exit area



Engine extended 15mm  
From base



15mm extension with "wave"



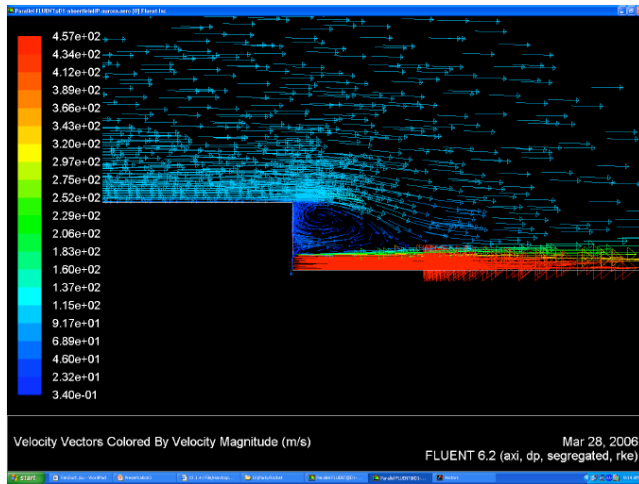
Wave base cross section

The diagram illustrates four configurations of a rocket engine base. The first is a standard 18mm base with a green dot at the nozzle exit. The second is an engine extended 15mm from the base. The third is a 15mm extension with a 'wave' feature. The fourth is a cross-section of a wave base, showing a wavy profile on the base of the engine.

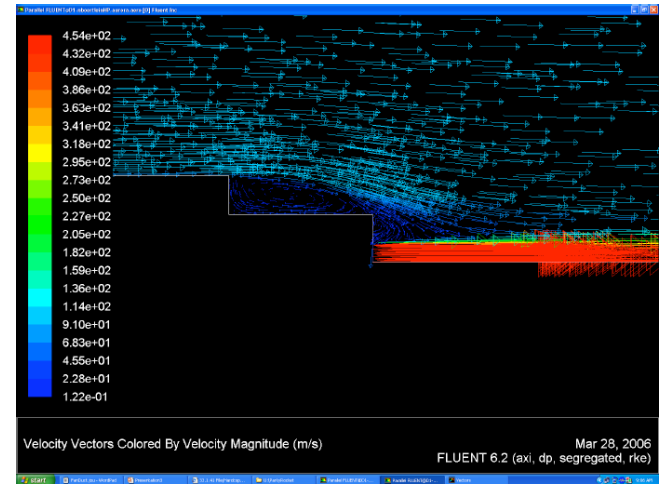


# Bob's CFD Analysis Using FLUENT

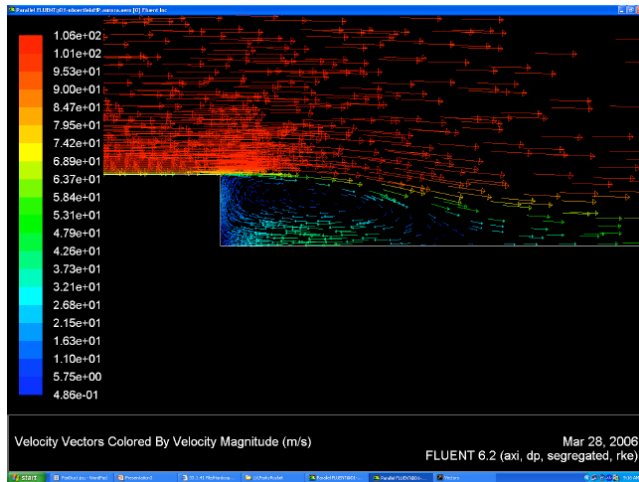
Basic Configuration,  
Plume On



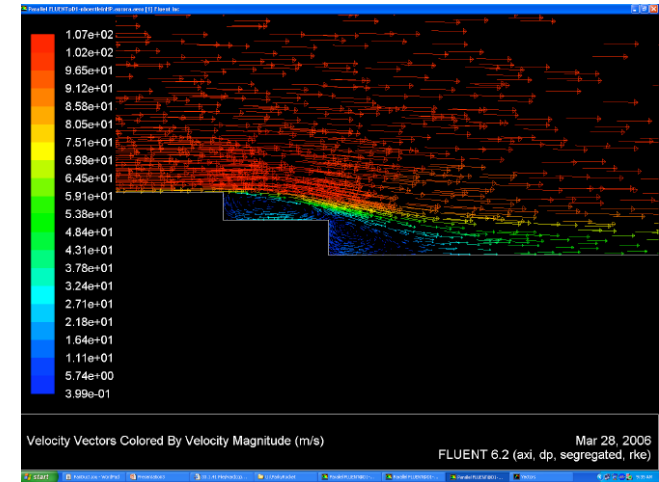
Extended by 15 mm,  
Plume On



Basic Configuration,  
No Plume



Extended by 15 mm,  
No Plume



100 m/s flight speed  
4 mm diameter exit plume



# Extended Engine Reduced Base Drag

Case	Base Drag (N)	Base Cd
Basic, with plume	0.554	.355
Basic, no plume	0.285	.183
Extended, plume	0.325	.208
Extended, no plume	0.239	.153
Wave, plume	0.323	.207
Wave, no plume	0.237	.152



Extended engine produces a boattail-like effect

# Comments by Bob Parks

The non thrusting base drag Cd of .18 is right in the middle of the test data in “Fluid Dynamic Drag” by Hoerner. Having analysis match test data is always encouraging!

With the engine thrusting, the base drag nearly DOUBLES. With the typical Estes engine base shape, it could be even worse due to the recessed nozzle. I don't know what current 10mm competition engines look like... but expect similar problems.

Extending the engine isolates most of the base area from the plume jet pumping effect, which gives a substantial drag reduction when thrusting. There is a slight reduction in coast drag.

The engine was extended 15mm aft of the base for this. From the flow pattern images, if a 20mm extension is possible, it might work even better. I do not know how long the motors are.

The aft engine location means that larger fins are needed, but the fin drag penalty is very small compared to the base drag decrease



# ROCKSIM RESULTS



# Use RockSim to Simulate European S1B Results

The screenshot displays the RockSim software interface. The main window shows a 3D wireframe model of a rocket. The left sidebar contains a hierarchical tree of components, including a main rocket assembly and a booster assembly. The right sidebar features a table of 'Add new components' and a list of control buttons.

**Components**

- Nose Cone
- Body Tube
  - Tracking Powder
  - Streamer
  - Engine Tube
  - Fins
- Booster
  - Fwd Adapter
  - Body Tube
    - Streamer
  - Boattail
  - Engine Tube
  - Fins

**Add new components**

Nose cone	Inside tube	Mass object
Body tube	Pod	Launch lug
Transition	Centering ring	Parachute
Fins	Coupler	Streamer
Custom fins	Bulkhead	Subassembly
Ring tail	Engine block	
Tube fins	Sleeve	

**Control Buttons:** Edit..., Delete, Show/hide, Move up, Move down, Split, Cluster...

**Simulation Results:**

S1B #6 - Simulated European Version - No Altimeter - Conical Transitions  
Length: 19.6968 In., Diameter: 1.5748 In., Span diameter: 3.5748 In.  
Mass 1.4715 Oz., Selected stage mass 1.4715 Oz.  
CG: 8.6913 In., CP: 12.6631 In., Margin: 5.40 Overstable  
Engines: [3/4B1-7, ][1/2A7-0, ]



Used program defaults for weight and drag calculations

# RockSim Results

Rocksimsim- C:/CCF/Model_Rockets/Designs/FAI/S1B/S1B_6/S1B_6a.rkt								Altitude (m)
File Edit View Rocket Simulation Help								
Rocket design attributes Rocket design components Mass override Cd override Flight simulations								
Simulation	Results	Engines loaded	Max. altitude Feet	Max. velocity Feet / Sec	Max. acceleration Feet/sec/sec	Time to apogee		
1	0	[1/2A7-0] [3/4B1-7]	2005.75	420.83	946.64	10.42	<b>623.3</b>	
2	1	[1/4A7-0] [7/8B1-7]	2241.25	418.41	907.10	11.31	<b>689.8</b>	
3	2	[1/2A7-0] [3/4B1-7]	1973.99	421.14	946.96	10.33	<b>599.5</b>	
4	3	[1/4A7-0] [7/8B1-7]	1827.99	424.79	910.60	10.27	<b>641.0</b>	
5	4	[1/2A7-0] [3/4B1-7]	1824.85	422.64	948.51	9.93	<b>516.3</b>	
6	5	[1/4A7-0] [7/8B1-7]	401.64	452.88	929.54	5.87	<b>489.2</b>	
7	6	[1/2A7-0] [3/4B1-7]	1189.45	430.20	956.29	8.25	<b>439.8</b>	
8	7	[1/4A7-0] [7/8B1-7]	288.62	455.86	932.01	5.21	<b>202.4</b>	
							<b>371.9</b>	

- **Simulations look at engine combinations and wind**
  - Simulations 1+2 = no wind
  - Simulations 3+4 = light wind (3-7 MPH)
  - Simulations 5+6 = slightly breezy (8-14 MPH)
  - Simulations 7+8 = breezy (15-25 MPH)



Note: Using U.S. engines (A10T and A3-4T), altitude is only ~1,200 ft (~370 m)



# Discussion of RockSim Results

- Rerunning the simulations provided similar results
  - More variation in the high wind conditions (as expected)
- 1/4A with 7/8B provided highest altitude
  - Needs very low winds to avoid weathercocking of booster
- 1/2A with 3/4B provides better reliability across wide range of wind conditions
- Aerodynamic stability margin varied widely depending if Barrowman or RockSim method used
  - Interference effects, fins on a boattail
- Additional weight in booster had small effect on maximum altitude
  - Consider electronic ignition of upper stage?



# SUMMARY AND DISCUSSION



# Summary and Discussion

- **It's feasible to achieve 600+ meter altitudes (\*)**
  - Need “Delta” motors and optimized upper stage
  - Optimized booster not as critical
- **Weathercocking critical for two stage vehicle**
  - Select motors based on wind conditions
  - *Consider bringing a single stage vehicle as a backup in case of high winds*
- **Consider extended engine in upper stage**
  - May reduce base drag by boattail-ish effect
- **Results based on 0.25 oz “payload”**
  - Tracking powder or lightweight altimeter
  - Effect of heavier altimeter unknown



(\*) Assumes that RockSim calculation of drag coefficient is correct

# S1 Might Be An Opportunity for the U.S.

- Reviewed issues of *Interspace* newsletter from January '06 through Autumn '09
- S1 is only reported for two European contests
  - 2006 WSMC S1B: 1<sup>st</sup> = 622 m, 2<sup>nd</sup> = 601 m, 3<sup>rd</sup> = 575 m
  - Other contest lists winners but not their altitudes
- Perhaps S1 isn't flown very often “over there”
  - Like in U.S., tracking events can be a lot of work
  - Timing events are easier
- The big challenge for U.S. will be practicing without having European engines available
  - Perhaps using electronic staging might be a good idea unless old stocks of A3-0 engines can be found



Note: old A3-0 engines can be legally flown via special process from NAR

# Altimeters Might Be a Wild Card

- It appears probable (but not certain) that some kind of electronic altimeter will be used for S1 (and S5?) at the 2010 WSMC
- We'll have to wait to see what is decided

