Rocket Model Construction Project for L3 Certification

by: José Luis Sánchez Lorente

TRA 10310

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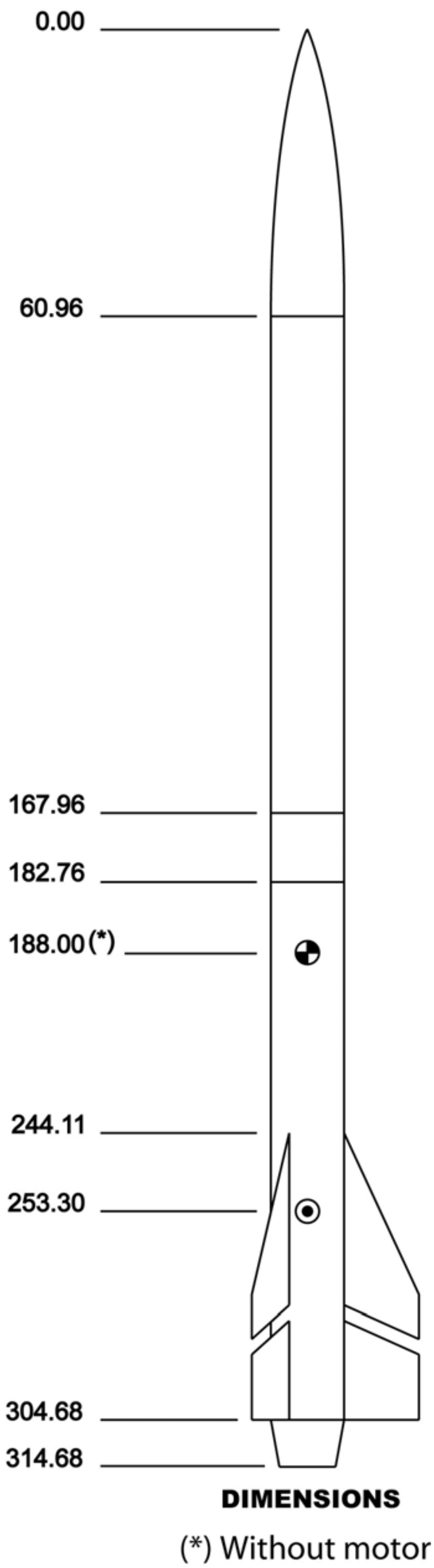
The scope of the current preliminary project is to establish the basic guidelines for the construction of a rocket model to obtain the L3 certification according to the **Tripoli Rocketry Association Inc.** standards.

The selected rocket model is an overdimensioned copy of the Public Missiles Ltd. Endeavour kit and fulfills the specifications required according to the Tripoli L3 certification standards. The basis for the selection of this model has been its easy construction process, solidness and flight characteristics. Its length / diameter proportions enable a suitable mass distribution and guarantee flight stabilitity.

Dimensions and technical characteristics:



Static:

Total length	3147 mm
Diameter	1590 mm
Wingspan	479 mm
Ramp rocket weight	21.3 Kg
Engine	Aerotech M 1297W

Dynamic:

Estimated resistance coefficient	0.75
Ramp exit speed	12.5 m/s
Estimated max. speed	213 m/s
Estimated max. height	2072 m
Estimated max. acceleration	8.8 g

Calculation of centre of gravity (c.o.g.) and centre of pressure (c.o.p.)

Rocksim 8 software has been employed for the centre of pressure calculation. The algorithm applied for the centre of pressure and stability calculations is based on the Apogee as well as the Barrowman methods. These calculations have been carried out considering different hypothesis of weather conditions, including circumstances where the launch of the rocket should be stopped according to the Tripoli standards.

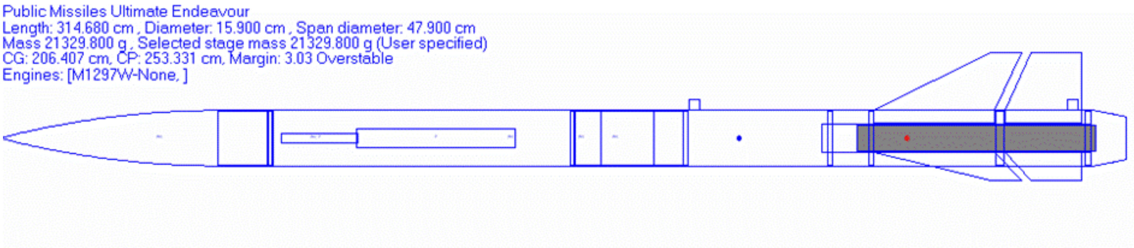


Fig. 1 Simulation CP and CG Rocksim.

Flight profile with the foresee engine for certification.

The simulation has been carried out in different wheather conditions to check the rockets flight stability in a wide range of posibilities. The following graph incudes some of the flight parameters carried out with this engine:

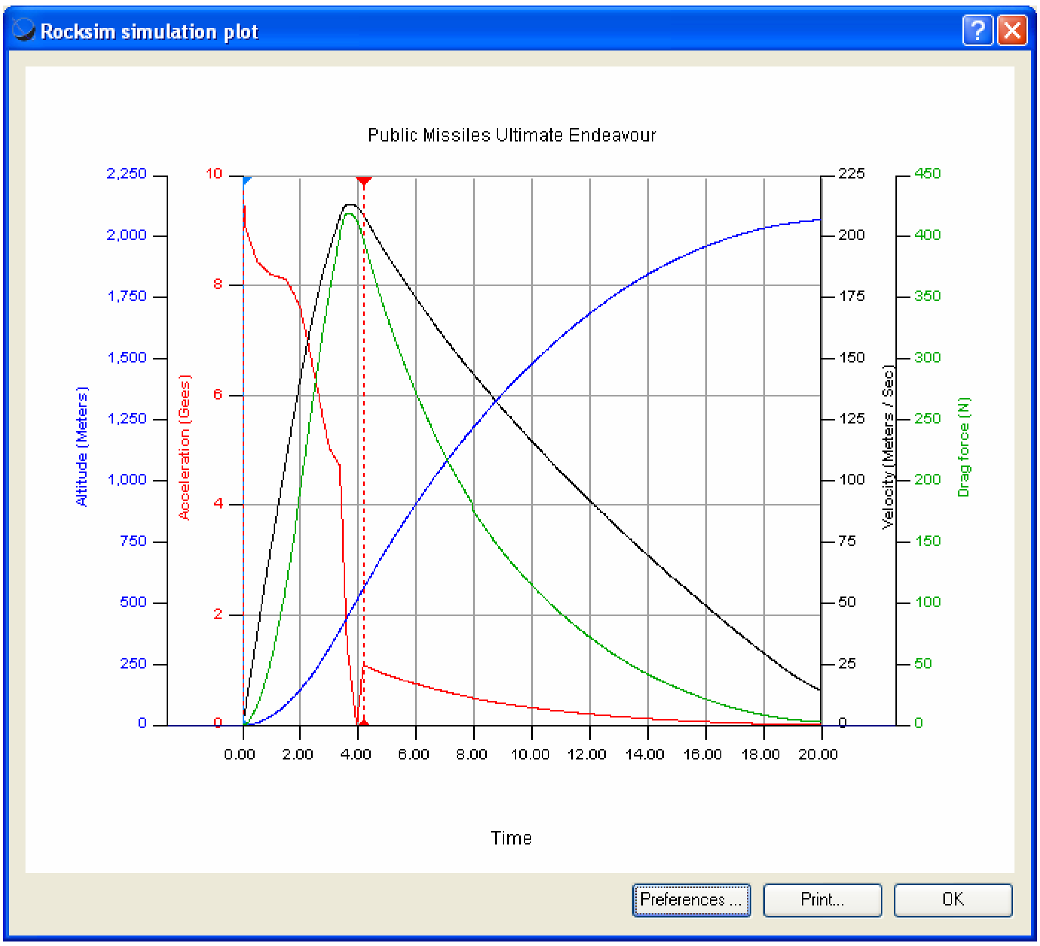
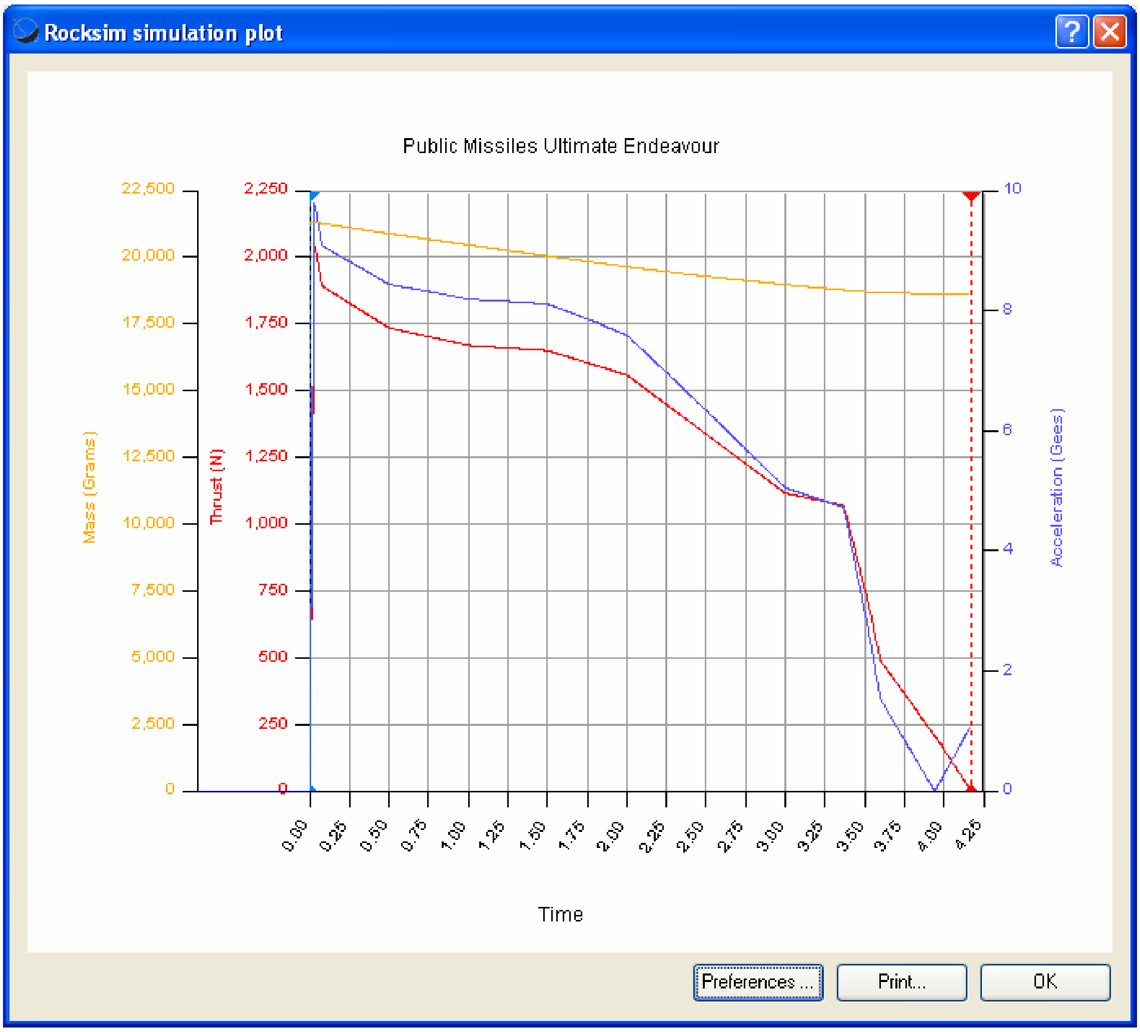


Fig. 2 Flight profile.



Thrust to weight

Note:

This graphic was added to the project after it was finished by requirement of the TAP members.

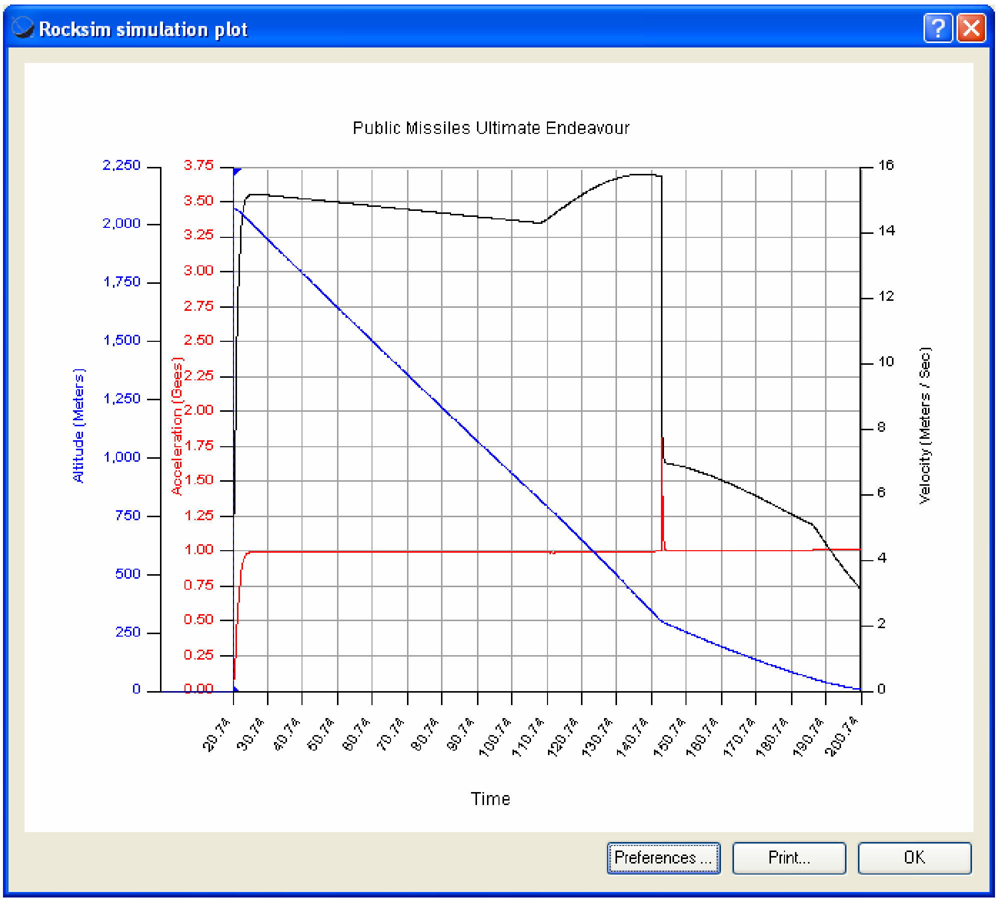


Fig. 3 Flight profile.

Engine block.

The engine block is composed of a 1297 W type M engine, a 75mm fenolic engine mount tube from PML, holed milled fins and five centering rings made of 3-layer birch-plywood - each one 5mm wide - all of them lined with fibreglass 280g/m^2 and epoxy, which confers extreme mechanical strength (see fig. 4).

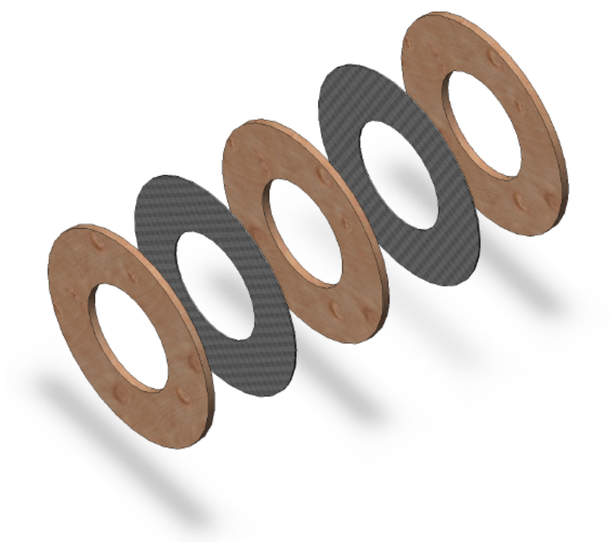


Fig. 4 Composition of the centering rings.

The centering rings are fixed to the engine mount tube with epoxy and are additionally joint to each other through M5 threaded steel bars. The whole assembly is kept together through nuts and washers. (See fig. 5)

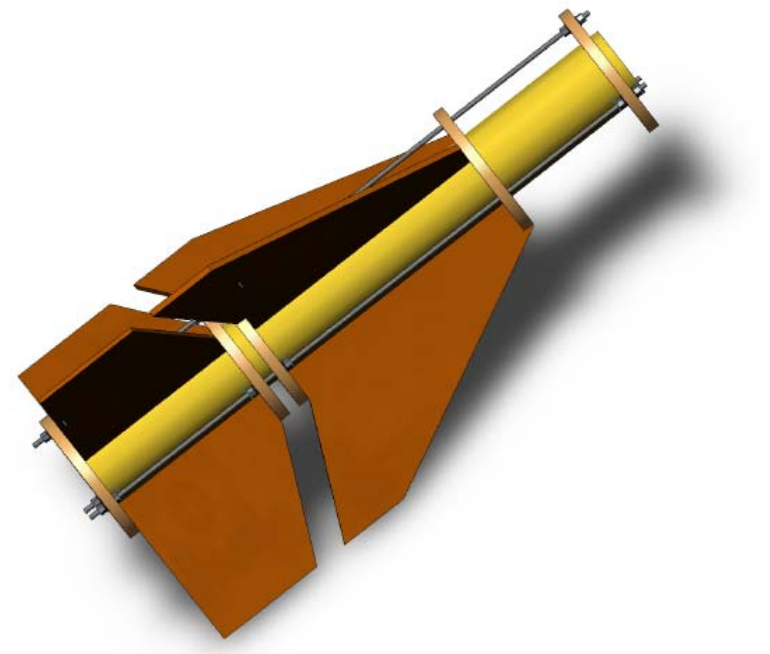


Fig. 5 Fins and engine-carrier set.

All the rings include a perimetral channel to enable the circulation of the epoxy resin during the process of fixing rings and airframe. The pushing ring, placed in the lower end of the rocket, is lined with carbonfiber and carries a 75mm engine holder from AeroPack Inc. The whole engine body includes a set of six aligned 2 by 2 fins in the respective holes of the centering rings, manufactured with aviation homologated birch-plywood (same type as the one employed for the construction of the rings). These are made of 2 layers of plywood, 3mm thick internally lined with glassfibre 280 g/m^2 and epoxy (see fig. 6).

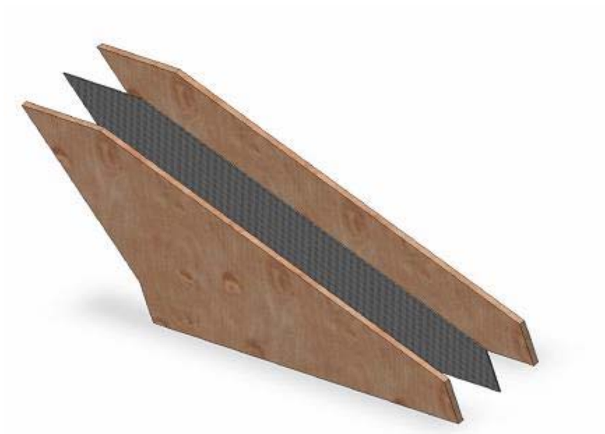


Fig. 6 Fins composition.

Fins will be fixed to the engine mount tube in the existing ring holes; afterwards they will be lined “tip to tip” with 280 g/m^2 fibreglass and epoxy, including the engine-carrier. In the fins assembly process a pattern shall be employed so as to ensure a correct alignment of them.

Booster and fins.

Fig. 7 Aligned down fins and glued of fins and center ring with epoxi.

Fig. 8 Aligned of the upper fins.

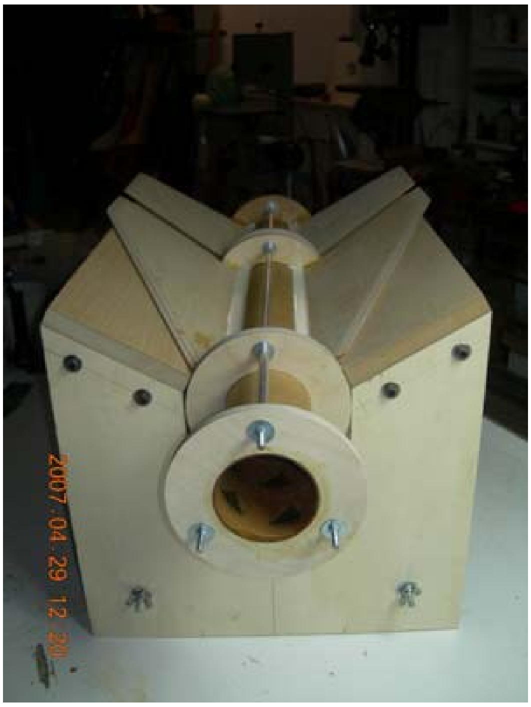


Fig. 9 Fillets have been applied before glassing, see the stain bars of distribution of efforts.

Fig. 10 6 oz. glass cut, and ready to be laminated.

Fig. 11 Detail of assembly of fins.

Fig. 12 Upper rail button of Delrin material.

Fig.13 75 mm Aero Pack motor retainer.

Fig. 14.- Down rail button of Delrin material.

Airframe.

The aiframe is made up of two 6" fenolic material pipes (150mm). The lower one with a length of 1069 mm, the upper one of 1219 mm, both assembled by a PML tube coupler used as electronic bay as well. The joint of the two sections of the airframe to the tube coupler is fixed by sixteen M5 DIN 7991 stainless steel AISI 304 INOX 18/10 A-2 screws. All the pipes that conform to the airframe are externally vacuum lined with 2-layers of 280g/m^2 fibreglass and epoxy reinforcement. See fig. 15 to 21.

Laminated of airframe with fiber glass and epoxi.

Fig.15 Epoxi impregnating of the 6 Oz fiber glass.

Fig. 16 Rolled of the glass.

Fig. 17 Adjustment of the fiber glass.

Fig. 18 Second fiber glass laminate.

Fig. 19 Rolled of pil ply for better finished final.

Fig. 20 Vacuum bagging.

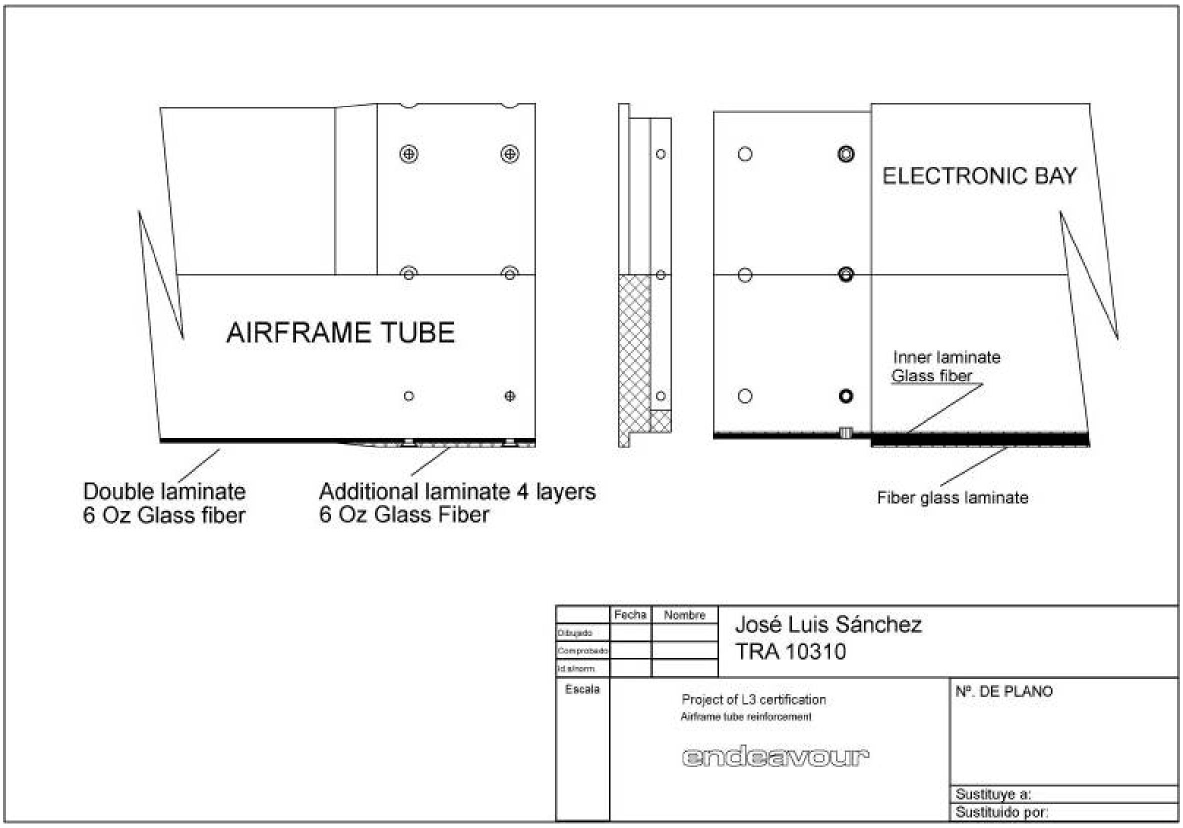


Fig. 21 Reinforcement airframe.

Electronic bay.

The electronic bay and the tube coupler (named as asembly pipe as well) is made up of a 12" length fenolic pipe from PML, Ref. CT-6.0, and an outer section of the airframe pipe of 150mm length, ref. PT6, coaxially fixated to itself and both centered. Both the inner and the outer surface are lined with 280 g/m^2 fibreglass and epoxy.

The caps of the bay are made up with the same construction process as the fins and centering rings, being 3 layers of 5mm aviation plywood fixed plates lined with fibreglass and epoxy on both sides. The locking system of the caps is made by male / female ends.

Both caps have attached in their inner side a rectangular section 10x10mm alluminium ring, fixed with eight M5 DIN 7991 stainless steel AISI 304 INOX 18/10 A-2 screws, with the aim of holding the assembly screws and the two sections of the airframe.

The set caps are closed by means of four M5 threaded bars covered by 6mm thick brass pipes, which at the same time support the lectronic plates. The upper caps of the electronic bay incorporate two holes for the routing of the pyrotechnic expulsion system, as well as the parachute (shock cord) anchor systems consisting of 2 M6 stainless steel U-Bolts of 22kN strength and a retainer ARRD. As shown in Figure 22, 27 to 30.

Fig. 22 Electronic bay.

Fig. 23 M10 aluminum nut.

Fig. 24 Aluminum plate.

Fig. 25 Riveted nut M4 epoxied.

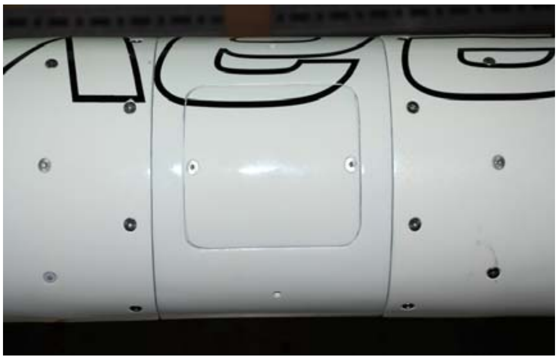


Fig. 26 A close up of the 32 M4 stainless machine screws Din 7991 used to attach the airframe and coupler.

Fig. 27 The internal power section bay, in the left side of the image the rail button support.

Fig.28 The internal altimetter bay computer section. Two RDAS Installed.

Fig.29 Altimetter bay finíshed
A close up of the M4x20 stainless steel machine screws Din 7991 used to attach the airframe and coupler.

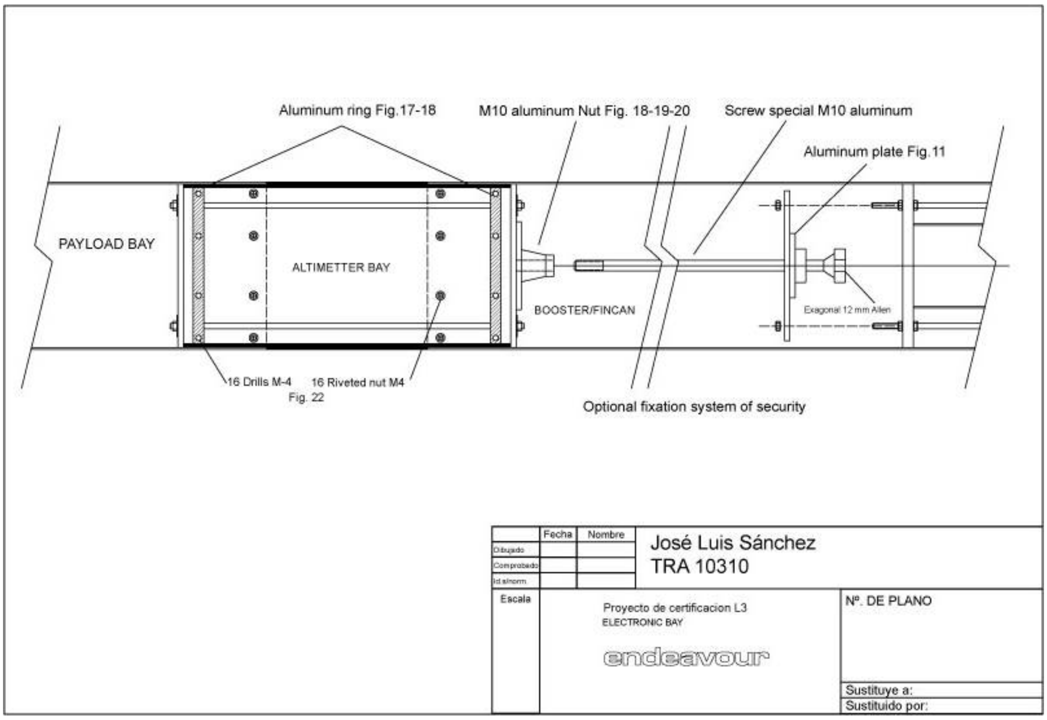


Fig. 30 Bay of the electronics and system of the fixation to the booster.

Aviónics.

The rocket incluyes a TINY R-DAS model flight computers from AED Electronics and a altimeter Perfecflite with redundant working configuration for the recovering devices, two 433 MHz band beacons for the radiolocation of the main body of he rocket and the nose cone, both separately and with a power supply unit.

Both the electronic systems and the energy source are placed inside the electronic bay, mounted over the type FR4 circuit board, with its corresponding independent swithches for each device, as well as safety switches for the assembly for arming of the ignition system of the injectors (and LED’s indicating the state of the system). (See Fig. 31, 32, 33, 34).

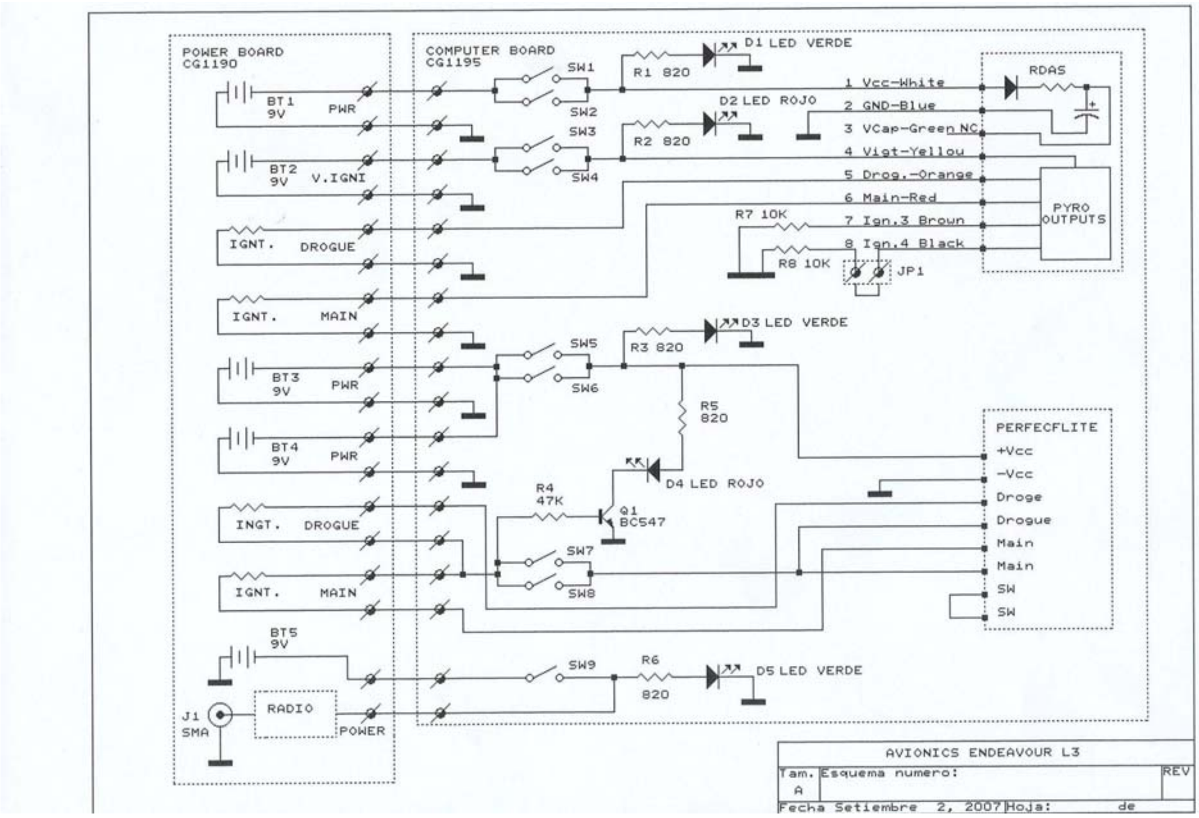


Fig. 31 Schematic diagram of the altimeters connection.

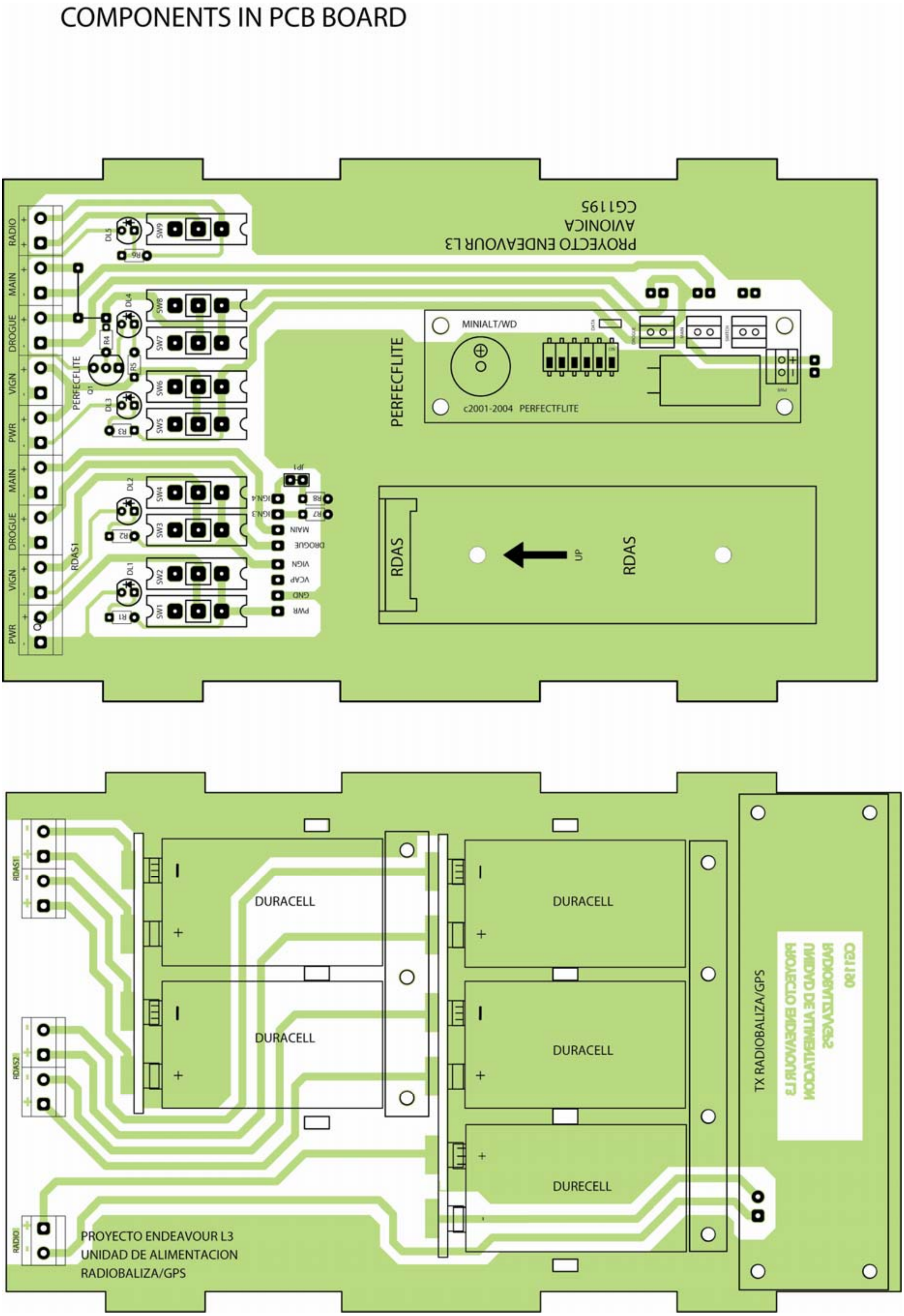


Fig. 32 Component in PCB board

Fig. 33 Power board.

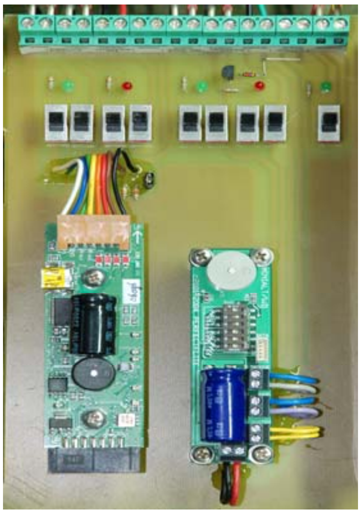


Fig. 34 Computer board.

Fig. 35 Emitting module of the nose cone 433 Mhz.

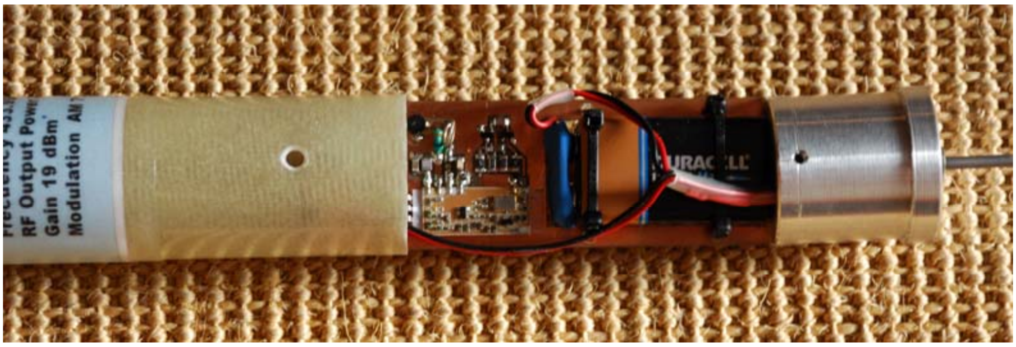
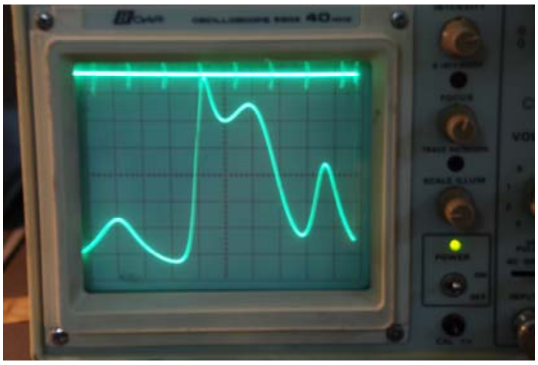
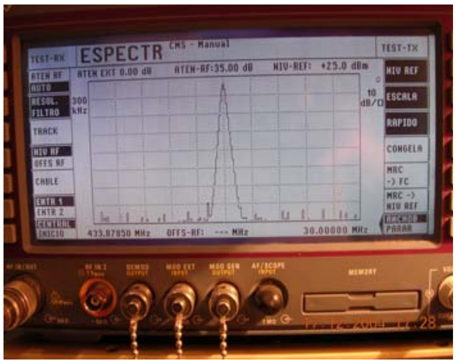


Fig. 36 Internal view emitting module of the nose cone 433 Mhz.



Fg. 37 Calibrated of the antennas.



Fg. 38 Calibrated of the emitter.

Recovery.

The design of the recovery procedure is a double expulsion system based on a single liberation with split up of the nose-cone at the apogee height. The details of the process are as follows:

When the rocket reaches its apogee height the nose-cone is detached from the body with a pilot parachute which, at the same time, takes out and open out the drogue. The ARRD retains the main parachute till reaching the selected height. At this point the flight computer activates the pyrotechnic charge of the ARRD releasing the retainer, letting the drogue take out the main parachute bag, and open it out smoothly and in a controlled manner.

The pilot parachute is 24” diameter, the drogue is a SkyANgle Classic 52”, and the main parachute is a SkyAngle Cert-3 XXL one. According to the result of the simulations and calculations carried out with the specific Jordan Miller software for this specific type of parachute, the dropping speed of the rocket with Classic 52 is 13.16 m/s. After the releasing of the nose-cone, the dropping speed of the main body of the rocket with the Skyangle cert-3 is 4 m/s (See Fig.39).

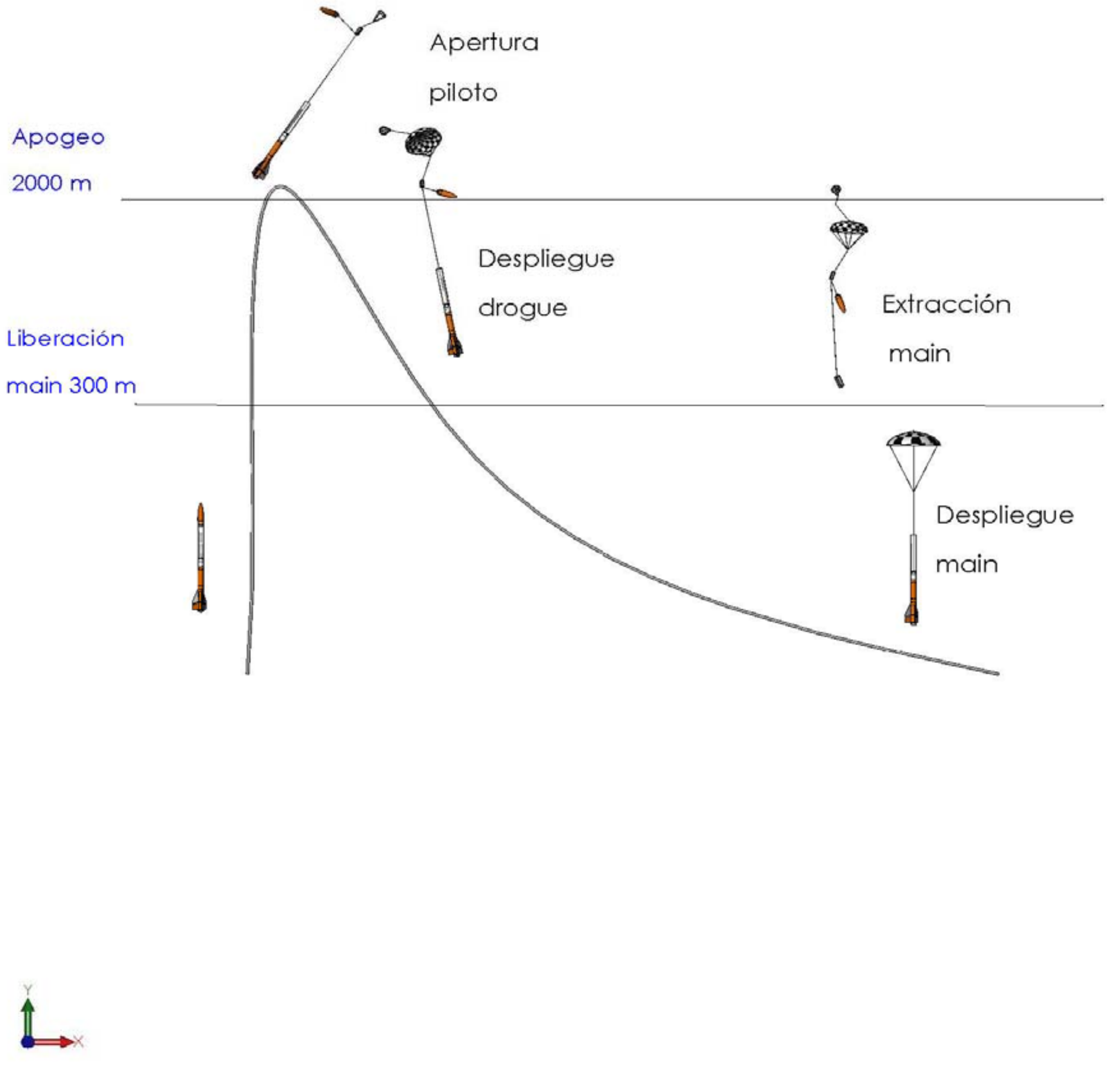


Fig. 39 Recovery procedure.

All the parts of the rocket´s recovery system, including both the parachutes and the joint ropes, are fire-resistant because of their fireproof Nomex fabric..The released bags are fire-resistant as well.

The ropes joining the parachute and the ”shock cord” parts of the airframe are 19mm braided polyamide ROCA tubing tapes with a breaking point of 10.6 kN. The joints for the different parts are made of 25 kN breaking point CE certified galvanized Faders steel shackle.

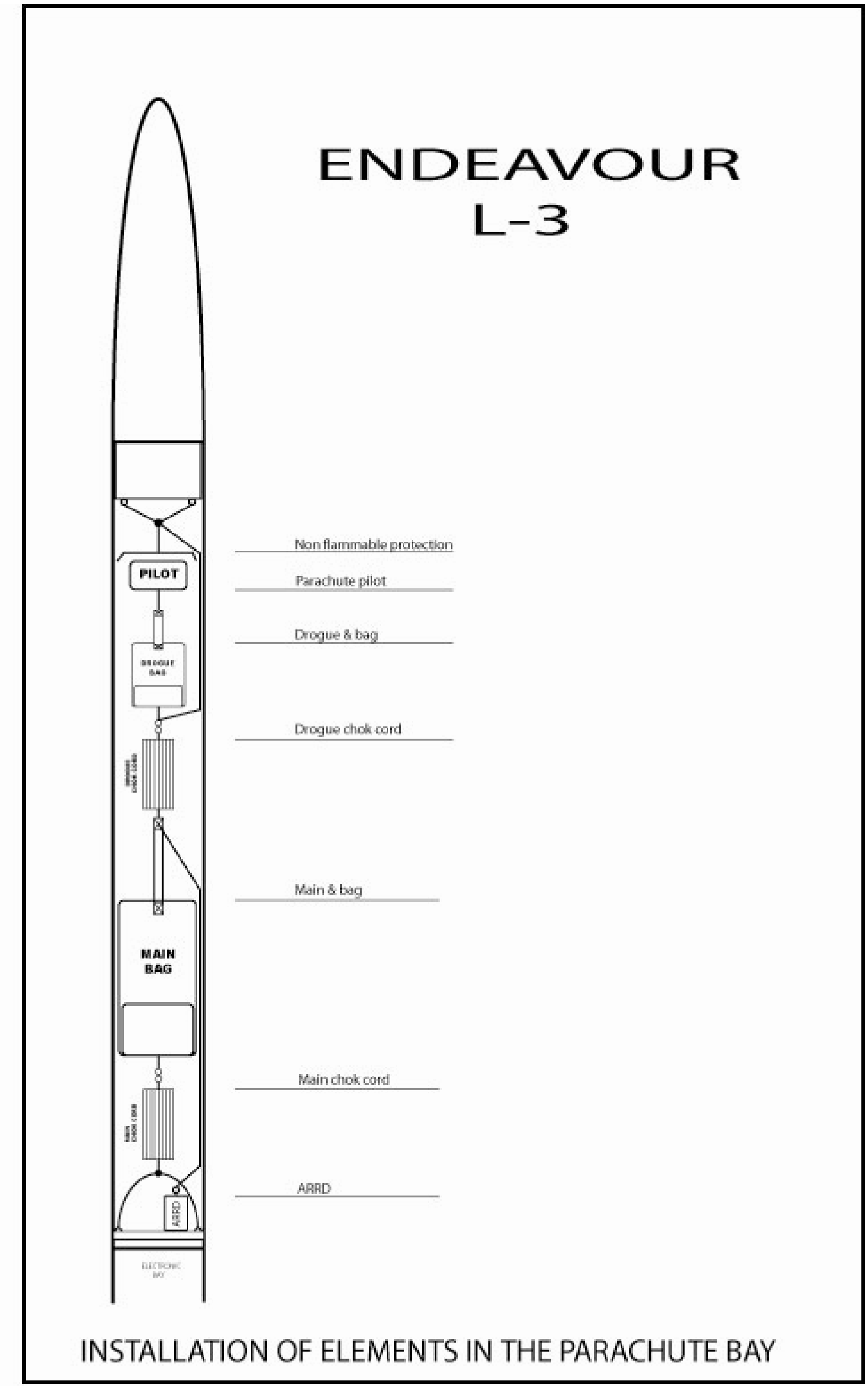


Fig. 40 Parachute bay.

Ejection system.

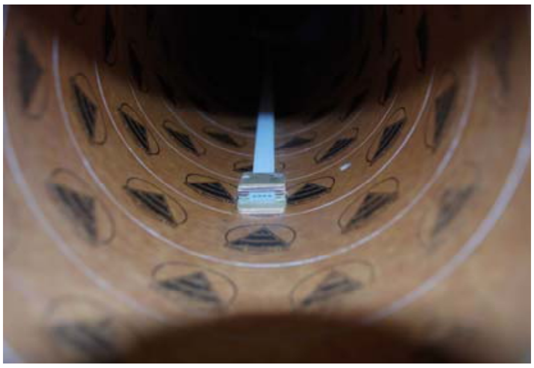


Fig. 41 Connector line altimetter.

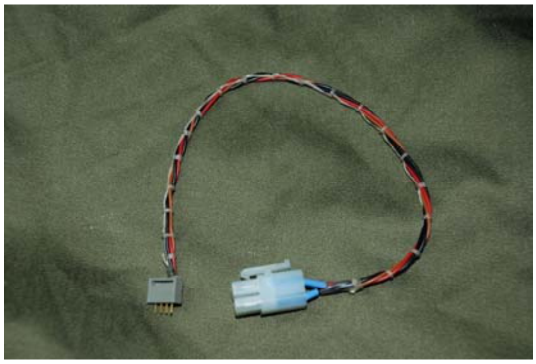


Fig. 42 Cable of connection with the nose.

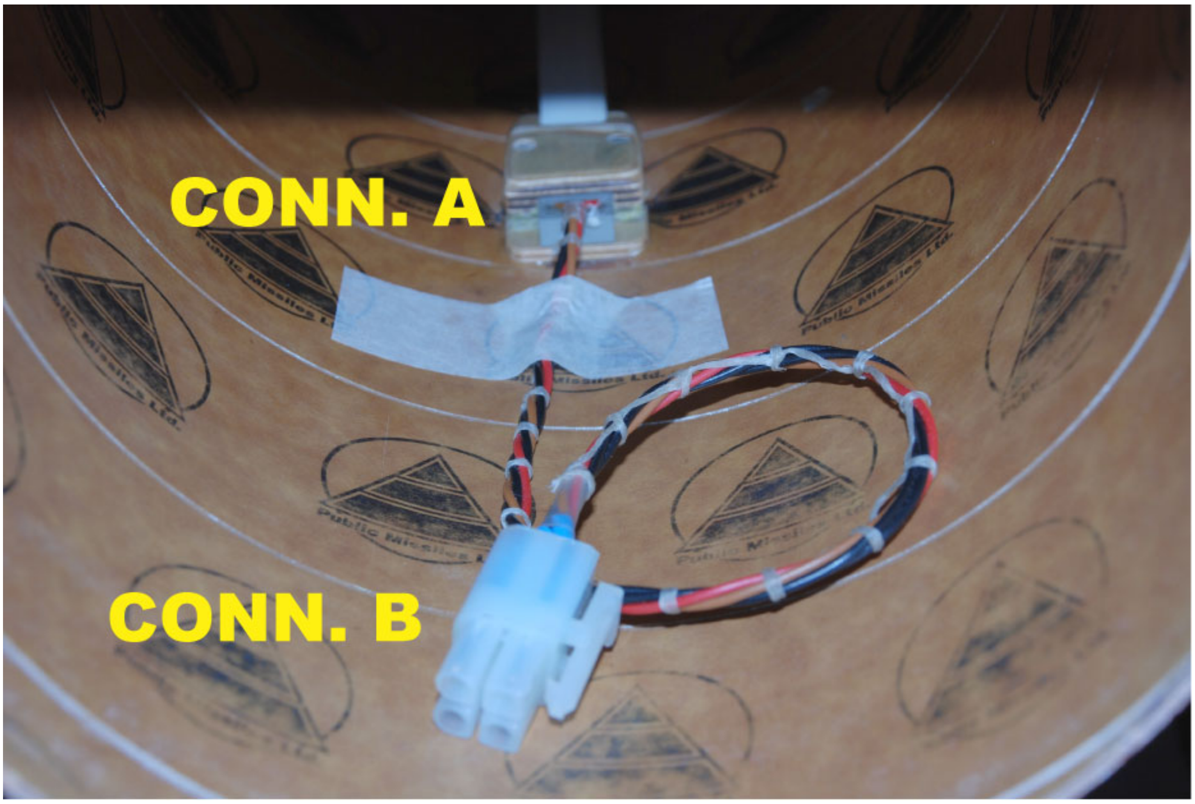


Fig. 43 Inner view of the airframe and ejection connectors of the nose cone.

Connector “B” is connected to the base of the nose cone and is blocked. The connector “A” is connected with the line of the altimeters and it does not have retention mechanism, the acceleration of the takeoff of the rocket works to maintain this connection, with the force of the ejection of the nosecone, connector “A” will be set free. See Fig. 43.

Ejection charge:

The quantity needed for apogee deployment has been calculated as usual using the gas law (pV=nRT).

The formula hes been simplified:

$$\mathbf{m = Cp * D_2 * L}$$

Where:
Cp = pressure coefficient coming from the constant value R * T
D = Diameter of the section to be pressurized.
L = lenght of the section to be pressurized.

Calculations has been done for pressure value 7 PSI (0,48 Bar) on the nosecone base. The following value have been obtained:

0.48 bar = 200 Pound = 3,31 gr of BP 3.5 gr. rounded

Nose cone.

The nose cone is a PML fibreglass FN-6.0 comercial model. The highest perimeter of the basis shall be oversezised with fibreglass and gel-coat, till it levels the fuselage lined perimeter. The cap of the nose-cone, supplied by the same manufacturer as well, shall be reinforced with lined fibreglass and epoxy and using ¼”U-Bolt for the hook of the line. It is necessary to reinforce the neck of the nose cone by fixing the cap with screws.

A second location radio-beacon shall be installed inside the nose-cone. (See Fig. 44, 45,48,)

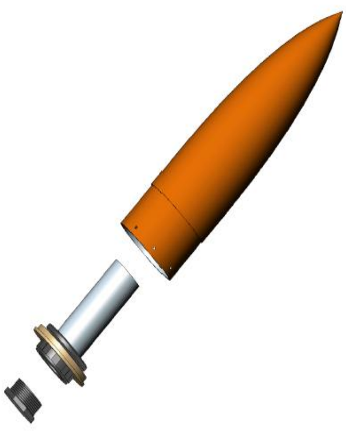


Fig. 44 Nose cone.

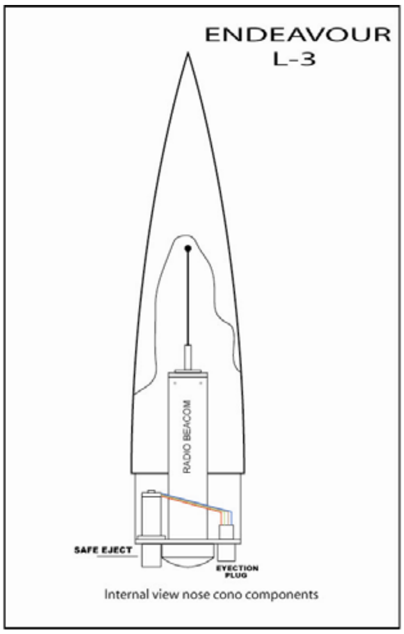


Fig. 45 Internal nose cone components.

Fig. 46 Base of the nosecone.

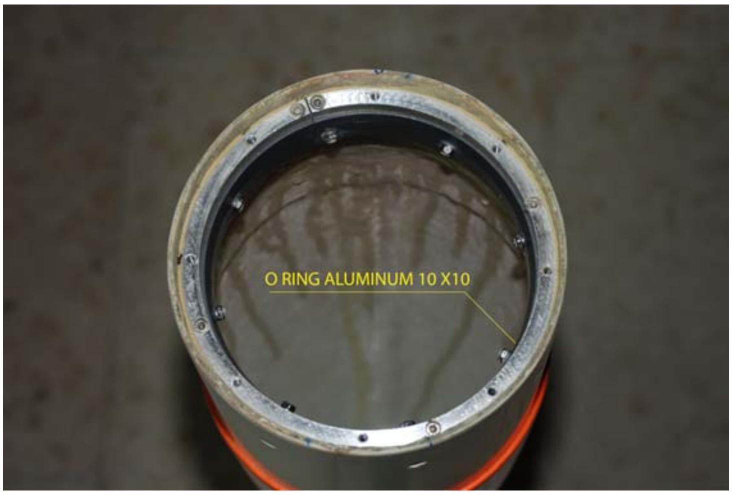


Fig. 47 Fixation element bulkhead.

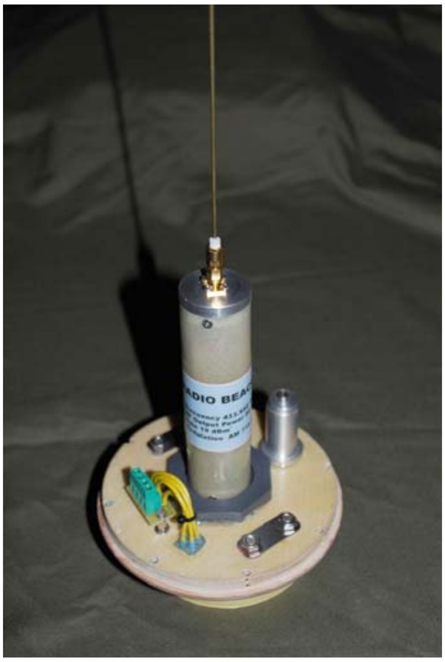


Fig. 48 Inner view of te nose cone.

Fig. 49 Terminal blocks ejection charge.

Tail cone.

An alluminium “tail cone” installation has been foreseen in the stern of the rocket, to improve the aerodynamic conditions of it.

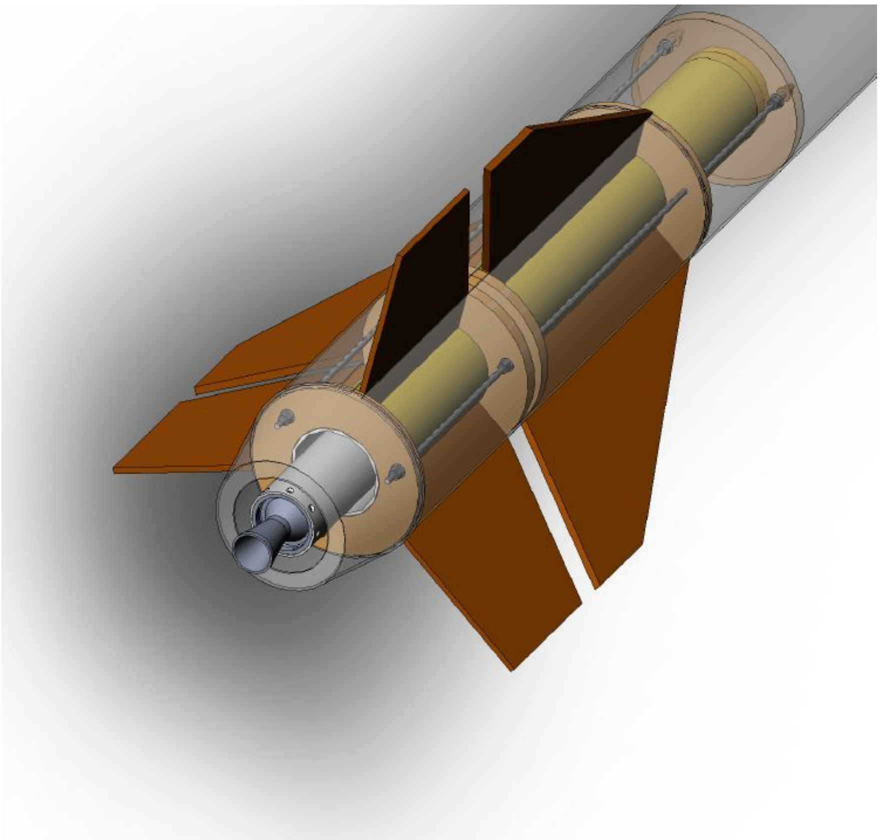


Fig. 50 Engine block and tail cone.

Fig.51 Turned of the tail cone of aluminium.

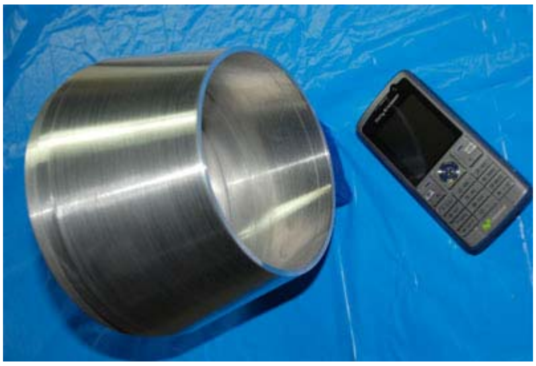


Fig.52 The finished of tail cone.

Paint.

Fig. 53 Painted of the polyurethane primer.

Fig. 54 Painted of the finished painting white of polyurethane.

Fig. 55 Decals.

Finish.

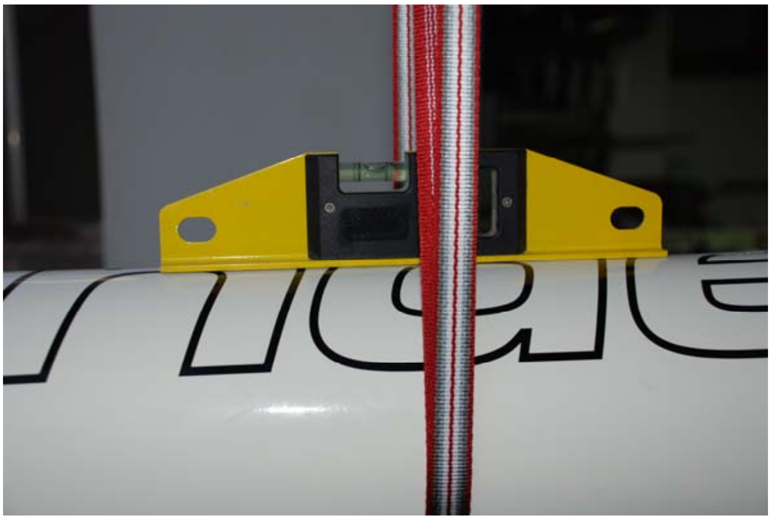


Fig. 56 In search of the CG.

Fig. 57 Equilibrated.

Endeavour L3 finished

Fig. 58 Endeavour finished

Other documents:

LISTING OF MATERIALS

Description	Manufacturer	Type	Qty
General:			
Button rail mat. Delrin	Custom		2
Upper airframe length 107 cm. fenolic	Public Missiles	PT-6.0	1
Lower airframe length 121.92 cm fenolic	Public Missiles	PT-6.0	1
Upper fins plywood laminated glassfiber & epoxi	Custom	Aircraft Plywood 9 mm	3
Lower fins plywood laminated glassfiber & epoxi	Custom	Aircraft Plywood 9 mm	3
Parachute SkyAngle Clasic II	B2Rocketry.Co	52” Drogue	1
Parachute SkyAngle XXL CERT3	B2Rocketry.Co	Main	1
Parachute Pilot	Aerazur	OTAN 15A/802	1
Parachute protector 7”	Custom	Nomex (Dupont)	1
Chock Cord 9/16” tubular 1500 lbs Drogue Bag 150 cm	Paragear	W9550WH	1
Chock Cord 19 mm tubular 1600 daN Drogue 550 cm	Roca		1
Chock Cord 25 mm tubular 1870 daN Main 550 cm	Roca		1
Chock protector of Nomex	Top Flight	60”	1
Quick-link pilot	B2Rocketry.Co	4 mm	1
Quick.link	B2Rocketry.Co	8 mm	5
Quick link	B2Rocketry.Co	9/32” Delta	2
Swivel	B2Rocketry.Co	12/0	2
1.25 mts Wire Red AVG 0.85	Showa		1
1.25 mts Wire Black AVG 0.85	Showa		1
1.25 mts Wire Black AVG 0.85	Showa		1
1.25 mts Wire Brown AVG 0.85	Showa		1
Connector male 5 gold contac	Socapex		1
Subassembly electronic bay			
Tube coupler fenolic	Public Missiles	CT-6	1
Bulkhead Aircraft Plywood 15 mm glassfiber laminated	Custom	Aircraft Plywood 15 mm	2
Electronic bay separador fenolic 14,8 cm	Public Missiles	PT-6	1
30 cm Stainless Steel thread bars	Inoxiber	M5	4
Stainless Steel Hex nut M5 A2-70	Inoxiber	DIN 934	12
Stainless Steel washer M5	Inoxiber	DIN 125	8
Stainless Steel lock washer M5	Inoxiber	DIN 127	8
Stainless Steel lock nut M5	Inoxiber	DIN 985	4
Stainless Steel machine screws M4x25 A2-70	Inoxiber	DIN 7991	24
Aluminum alloy ring 10x10x150 mm (See fig. 27-28)	Custom		2
Special nut M10x 80 mm aluminium alloy (See fig. 23)	Custom		1
Aluminum support botton rail 28x20x12 M8	Custom		1
Stainless Steel U bolt M8		Nautical	2
Stainless Steel Hex nut M8 A2-70		Nautical	2
Stainless Steel cable grips M8	custom		2
Female connector 5 gold contact	Socapex		1
ARRD	Black Sky		1
PCB flight computer (To see subassembly)	Custom	CG	1
PCB Power unit (To see subassembly)	Custom	CG	1
O rings 1x150 mm	Custom		2
Stainless Steel machine screws M4x15 A2-70	Inoxiber	DIN 7991	32
Subassembly booster			
75 mm MMT length 750 mm	Public Missiles	PT-3	1
Rings Aircraft Plywood 12 mm Glassfiber laminated	Custom	152 mm-80mm	1
Rings Aircraft Plywood 15 mm Glassfiber laminated	Custom	152 mm-80mm	4
Stainless Steel thread bars 80 cm	Inoxiber	M5	3

Stainless Steel Hex nut M5 A2-70	Inoxiber	DIN 934	27
Stainless Steel washer M5	Inoxiber	DIN 9021	27
Aluminium support button rail 28x20x12 M8	Custom		1
Motor retainer	Aero Pack Inc.	75 mm	1
Tail cone	Custom	Aluminum alloy	1
Aluminium plate (See fig.24)	Custom	Aluminum alloy	1
Special aluminium machine screws M10 (See Fig.30)	Custom	Aluminum bars	1
Subassembly Aviónica			
PCB FR4	Custom	CG1190	1
Terminal blocks C.I. raster 5.08	Phoenic Cont.	MKDS 1.5/2-5.08	9
Battery 9V Alkalina	Duracell	6LR61	5
Emitter 433 MHz.	Custom		1
PCB FR4	Custom	CG1195	1
Terminal blocks C.I. raster 5.08	Phoenic Cont.	MKDS 1.5/2-5.08	9
Slide Switch SPDT	C&K	1101	9
Resistor carbon film	Beyschlag	820 Ohm. 1/8W	5
Resistor carbon film	Beyschlag	47K Ohm. 1/8W	1
Resistor carbon film	Beyschlag	10K Ohm. 1/8W	2
Led diode 3mm	Kilbrigt	Verde	3
Led diode 3mm	Kilbrigt	Rojo	2
Jumper 2.54	Harvin		1
Subassembly cable ejection drogue (See fig.)			
Connector male 4 gold contact	Jermyn		1
Connector male with retaining four contac	Copain	620M04	1
Four twisted cables 30 cm AWG 29	Custom		1
Subassembly Nose cone			
Nose cone fiberglas	Public Missiles	FNC-6.0	1
Bulkhead Aircraft Plywood 15 mm glassfiber laminated	Custom	Aircraft Plywood 15 mm	1
Ubolt M6		Steel Zn	2
Aluminum alloy ring 10x10x150 mm (See fig.)	Custom		1
Safe eject	Custom	Aluminum	1
Connector female with retaining four contac	Copain	620F04	1
Terminal blocks C.I. raster 5.08 with PCB	Phoenic Cont.	MKDS 1.5/2-5.08	2
Emitter 433 MHz	Custom		1

LIST OF ASSEMBLY CONTROL
Check list

ITEM	OPERATION	PARTS	Chk
	NOSE CONE		
1	Mount ejection charge	1 Charge BP	
2	Mount igniters.	2 Davifire.	
3	Mount emitter battery.	1 Battery 9 V.	
4	Mount emitter.		
5	Verify function of the emitter.		
6	Close nose cone	8 Screw M3 Din 965.	
	ELECTRONICS BAY		
	Subsistema ARRD		
7	Mount igniters.	2 Davifire.	
8	Black powder.	0.05Gr.	
9	Lubricate o ring.	Lubricant	
10	Close and to verify the blockade of the piston rod.		
11	Close the superior bulkhead of the bay	1 Screw allen ¼" ,Din 912. 1 Washer Din 125. 1 Washer lock Din 127.	
12	Pass cables to the inner of the bay.		
	Baterías		
13	Mount batteries in the PCB board.	5 Bat. 9V.	
14	Verify voltajes and polarity.		
	Aviónica.		
15	Mount RDAS unit	2 Screw M3 Din 7985. 2 Washer Din 125.	
16	Connect RDAS.		
17	Mount Perfectflite unit.	4 Screw M3 Din 7985, 4 Washers Din 125.	
18	Connect cables to terminal blocks.		
19	Verify connections to terminal blocks.		
20	Verify function of both units.		
21	Verify 2º. deployment altitude adjusts at both units.		
22	Verify function of the emitter.		
23	Mount upper bulkhead electronics bay	4 Nuts M5 Din 934. 4 Washers Din125. 4 Washers lock Din127.	
	Connect cables to the terminal blocks		
24	RDAS apogee igniter		
25	Perfecflite apogee igniter		
26	Main RDAS igniter		
27	Main Perfectflite igniter		
28	Verify continuity of computers function.		

29	Install the unit into the bay.		
30	Mount lower bulkhead.	4 Nuts M5 Din 934. 4 Washers Din125. 4 Washers Lock Din127.	
31	Verify holes alignment		
	PARACHUTES		
32	Fold and mount main parachute in the bag.	Parachute SkyAngle Cert3 and bag.	
33	Fold and mount drogue parachute in the bag.	Parachute SkyAngle 52" and bag.	
34	Fold pilot parachute		
	ASSEMBLY OF THE ROCKET		
35	Mount electronic bay in the lower rocket's airframe (Booster)	16 Screws Din 7991.	
36	Mount upper button rail.	Button Rail. Screw M6 Din 912.	
37	Introduce reinforcement screw by the inside of the motor tube and screw it in an special nut down the bulkhead at the electronic bay.	Screw Al 10 mm. Special Tool.	
38	Hook the chock cord (L5) of main parachute in the u bolt in the electronic bay.	Snap Harness Delta 8 mm. Chock Cord nº.L5	
39	Hook the retention cord (L6) of the drogue in the bolt of the ARRD.	Snap Harness 8 mm Chock Cord nº.L6	
40	Pass both cords through the inner side of the upper airframe tube of the rocket. (Parachute bay).		
41	Connect the apogee ejectors to the electronic bay connector.		
42	Verify polarity of the connection.		
43	Mount upper tube of the rocket (avoid lines slide into the tube)	16 Screws M5 Din 7991.	
44	Hook main parachute to chock cord	Snap Harness Delta 8 mm.	
45	Hook the chock cord (L3) of the drogue parachute to the bag of the main.	Snap Harness 8 mm. Chock Cord nº. L3	
46	Hook the retention cord of the drogue (L6) to the junction of the main parachute's bag with the chock cord drogue (L3).	Snap Harness 8 mm.	
47	Dust gently with talc the outer side of the main parachute's bag.	Talc.	
48	Introduce main's bag into the parachute bay, sliding it carefully to the bottom.		
49	Hook the drogue parachute to it's Chock Cord (L3).	Snap Harness 8 mm.	
50	Hook the pilot parachute to the bag of the drogue parachute (L2)	Snap Harness 6 mm. Parachute 24".	

51	Introduce the nose cone's chock cord (L4) in the chock cord protector.	Chock cord L4. Chock cord protector.	
52	Hook the chock cord of the nose cone (L4) drogue's junction with it's chock cord (L3).	Snap harness 8 mm.	
53	Dust the inner sides of the parachute bay with talc.	Talc.	
54	Carefully introduce the chock cord, the drogue and the pilot parachute into the parachute bay.		
55	Hook the nonflammable protector discs to the nose cone (L4)		
56	Connect ejection apogee charges connector.		
57	Hook nose coneto it's chock cord.	Snap Harness 8 mm.	
58	Mount nose cone.		
	MOTOR		
59	Mount motor M1297W (following manufacturer instructions).	RMS 75-5120 M-1297W	
	LAUNCH PAD		
60	Place rocket in the pad, verify slide along the guides.		
61	Verify continuity and resistance value of the igniter	Tester	
62	Open electronic bay gate.	Screwdriver allen 2.5 mm	
63	Avionics connection, all switches ON		
64	Test continuity of ejection devices. Audible report.		
65	Close electronic bay gate	Screwdriver allen 2.5 mm	
66	Introduce igniter in the motor.		
67	Following LCO instructions.		

TAP Data Capture Form ENDEAVOUR: JOSE LUIS Level 3 Rocket (TRA #10310)		
NAME: José Luis Sanchez	ADDRESS: Las Alpujarras, 34 -04230 Huercal de Almeria España	PHONE #: 659445608
TRA #: 10310	LAUNCH LOCATION: Val del Ruz Neuchatel Suiza	DATE: 22/09/07
ROCKET SOURCE: Personal design	ROCKET NAME: Endeavour	COLORS: Orange & white
ROCKET DIAMETER: 6"	ROCKET LENGTH: 314,68 cm.	ROCKET WEIGHT LOADED: 21,328 Kg.
AVIONICS DESCRIPTION: RDAS TINY PERFECFLITE	MOTOR TYPE: AEROTECH M-1275-W	THRUST TO WEIGHT RATIO: 8.8:1
LAUNCHER REQUIREMENTS: 50 lb capable pad	LENGTH: 10'	
CENTER OF PRESSURE: 253,331 cm. from tip	HOW CALCULATED: RockSim 8	
CENTER OF GRAVITY: 206,408 cm. from tip	HOW CALCULATED: Measured	
MAXIMUM VELOCITY: 213.45 m/s	HOW CALCULATED: RockSim 8	
MAXIMUM ALTITUDE: 6.831'	HOW CALCULATED: RockSim 8	
WAS FLIGHT SUCCESSFUL:	YES:	NO:
TAP NAME: **Juerg Thuering**		
TAP NAME: **Frank De Brouwer**		
TAP NAME:		