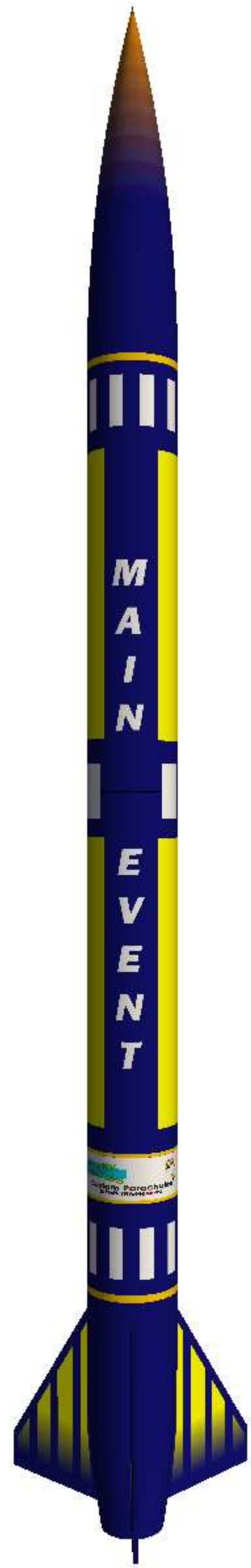

MAIN EVENT

Gene Engelgau

L3 Design and Specifications

_408-499-9050_

http://fruitychutes.com

_V2.1_

Gene's L3 – Main Event

Gene Engelgau – NAR L3 Rocket Design and Specifications
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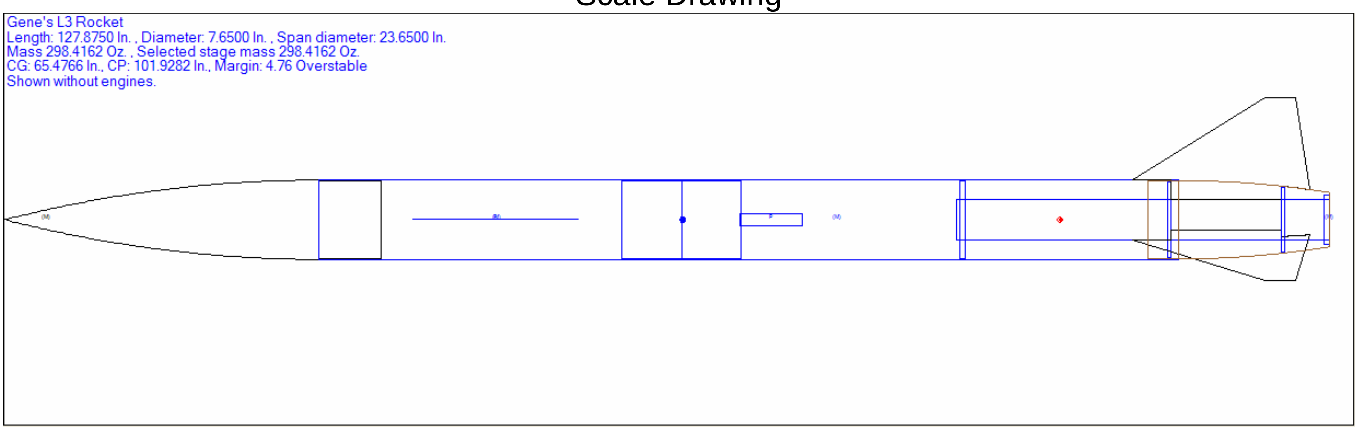
1) Introduction

For my L3 project the goal was to have a fun, reliable rocket that is a solid design, relatively conventional construction, easy to load-up and fly. Pervious experience includes a range of L2 projects including a 2 stage K to K projected called the Foley a Deux. Over the last year I have had very good luck working with altimeter controlled – dual deploy rockets. Much of the experience is on my EVE rocket. It's a nice 2.6" / 54MM rocket that just goes and goes. It's been really fun to fly and very reliable. I have quite a few good lights on my Talon 4 (five I think) and my 5.5" Jay Hawk. My goal for my L3 project is a similarly reliable vehicle.

Most of the components for this build were originally from Jeff Race's Polecat Patriot rocket. Also included in the purchase was an extra nose cone and coupler. I thought for some time if I wanted to just build it as is, but fundamentally not really liking the Patriot I decided to change it. A few things I don't like about it are that it has a big 7.5" airframe, but only a 75mm motor. After my L3 then what? Also the fins are actually pretty small, leading to stability concerns or the need for weight in the nose. Also construction of fins and rings are all from 3/8" ply and that causes the tail to be quite heavy. And what do I do with an extra nose cone?

So I decided to modify the rocket to 98MM (L3 attempt will be a 75mm though) and use the extra nose cone as a boat tail – I like Boat tails, makes the rocket more efficient. Adding the boat tail also lengthens the rocket some. To lighten up the tail I'm using honeycomb composite fins. There are four centering rings. Primary load bearing rings will be ½" birch-ply with carbon reinforcement. The other centering rings will be carbon lay-up over honeycomb to save weight while having great strength. Similarly I will attempt to save weight on the av-bay using carbon-composite end caps with birch inlays.

Scale Drawing



Revisions

1. 7/19/2008 V1.0 Initial draft
2. 7/24/2008 V1.1 Switched to dual ejection charges
3. 12/13/2008 V1.2 Update AV Bar Schematic
4. 2/8/2009 V2 Final weight and sims, changed motor to M1315
5. 2/28/2009 V2.1 Added nose weight, modified deployment parameters

6. 2) Information, Specifications and Overview

Name	Gene Engelgau	Notes:
Address	15266 Via Pinto Monte Sereno, CA 95030	
Length	128.375”	
Diameter	7.65”	
Dynamic Characteristics	All loaded assume a M1315 motor. Final project weights is measured	
Dry Weight	444oz (27.75lbs)	
Loaded	643oz 40.2lbs	
CG	71” dry	
CG Loaded	83”	
CP	91.75”	Barrowman
Stability Margin	1.03	Barrowman
Airframe Materials		
Nose Cone	Fiberglass	From Polecat Patriot
Tail Cone	Fiberglass	same
Upper Airframe	GL 7.5” Phenolic with fiberglass over it	Kevlar zipper protection on end
Lower Airframe	GL 7.5” Phenolic 9oz + 3oz S Glass vacuum bagged on	Kevlar zipper protection on end
AV Bay		
Coupler	GL 7.5” x 11.5” coupler, lined with 2 layers 6oz carbon fiber	Added 3/8” shoulder in each end with silicone gasket for sealing. End caps seal flush with the coupler.
End Caps	Composite laminate carbon fiber over Kevlar honeycomb. 3/8” ply at hardpoints	
Connecting Rods	4 – ¼” threaded rods + hardware	
U Bolts	2 – 5/16” U Bolts	
1 AV Sled	1 sheet carbon / plywood board	Brass sleeves on edge thread over connecting rods
Engine Mount, retainer, rings		
Mount tube	98mm x 3” Phenolic tubing	
Ring – top	3/8” carbon / honeycomb composite. Plywood hardpoints	
U Bolts	2 – ¼” U Bold mounted in ring hardpoints	
Ring – Fin upper	3/8” carbon / honeycomb composite	
Ring – fin lower	3/8” carbon / honeycomb composite	
Rings – aft	½” birch ply, carbon reinforced	
Engine retainer	Aeropac 98MM flanged retainer	
Fins		
Material	3/8” carbon / honeycomb composite, ply edging, all vacuum bagged	Fiberglass & Carbon reinforced connection points
Launch Lugs	5/16” Duralene (sp??) rail guides	Plan is to use Alan Thym’s 12’ tower
Resins		
Laminating	Fiberglast System 2000 - 20 and 60 min	
High strength structural	Aeropoxy structural resin	
Filler Epoxy	Aeropoxy Lite	
Other	Various other for non-critical use	

Electronics		
Primary controller	G-Wiz HCX – accelerometer based apogee, baro main	
Backup controller	Perfect Flight miniAlt/WD (25K' altitude), barro apogee and main	
Tracking	Beeline GPS	
Recovery		
Drogue	3' Fruity Chute	Estimated, target 50fps drogue descent
Main	108" Fruity Chute	Estimated, target is 17fps descent speed
Rigging	1" tubular nylon. ½" Kevlar harness to U bolts. Total of 50'.	
Protection	Two 24" Nomex Fruity Chute protectors	

3) Certification Flight Overview

The certification flight will use a M1315. Estimated altitude will be about 11K feet. Drogue deployment at apogee, main at 1200'. Cert flight planed for Mar 2009 Snow Ranch. Also plan to use Alan Thym's 12' launch tower.

4) Construction Overview

The rocket is a conventional dual deployment design with the top section holding the main chute and the bottom section holding the drogue. Much of the detail of the components in already outlined in section 2. Additional details follows:

Composites Construction Overview - To keep weight down carbon laminated honeycomb will be used for fins, some centering rings and the AV bay end caps. This is especially important to keep the aft end light so no or minimal nose weight will be needed.

Caps and Ring Construction – These will be four layers of 6oz 3K carbon fiber fabric per side vacuum bagged over .3" Kevlar honeycomb. All mounting points will be reinforced with 3/8" birch ply hardpoints. This allows the bolts to be cinched tight without crushing the honeycomb core. Strength testing indicated that the carbon caps and rings will be higher strength to 3/8" birch ply at 30% less weight. This is based on weight load testing of 200 lbs.

Fins – Fins will use GL 3/8" honeycomb core material. These are edged with 3/8" bass wood that is shaped to provide an airfoil (more or less). Then they are vacuum bagged with 2 layers of 3K carbon twill. Over this is 6oz and 3oz S glass to provide a good surface to finish.

Fin mounting will be traditional through-wall design with composite reinforcement for both the connection to the motor mount as well as the airframe.

AV Bay – This is lined with 2 layers 6oz carbon fabric that is "balloon" pressed against the walls. The AV Bay will use composite caps as described above.

Airframe – The upper airframe is stock Polecat Aerospace 7.5" tubing. This tubing comes pre-laminated with fiberglass gelcoat. The lower airframe is GL 7.5" phenolic. This will be vacuum bagged with 9oz glass, and 3oz S glass as a surface veil. The vacuum bag has the advantage of minimizing the amount of resin needed.

The upper ends of each airframe will have additional Kevlar toe wound into a routed shoulder. Before lamination a .050" shoulder is cut into the end of each airframe. The end is then capped. The tube is then vacuum bagged. This will help reinforce the airframe against a possible zipper.

Total of 3 .25" vent ports are provided on the lower and upper airframe.

Nose Cone and Tail Cone – These are both Polecat Patriot nosecones. The tail cone is a standard PC nosecone that is bobbed.

The shock-cord attachment to the nosecone will be to a plywood / composite disk epoxied near the top of the cone.

5) Recovery System

Recovery is traditional drogue at apogee, with main deployment at altitude.

Connection and Separation Points - The rocket has four major components and two flight separation points. This details the method of connecting these sections

- **Nose cone to upper airframe** – The upper airframe holds the main parachute. A common problem is early main deployment caused by the inertia of the nose cone and parachute popping off the nose cone upon the drogue deployment shock. To stop early deployment the nosecone will be sheer-pinned to the upper airframe with four 4-40 nylon screws. At about 76lb* / pin (max) to break this allows for up to 304lbs of force needed to separate the nose cone. The pressure needed to break the pins is:

  304lb force / Nose cone cross-sectional area = 304 / (7.5 * 7.5 * 3.14159 / 4) = 6.88psi.

  Using an effective volume of 25.75” (measured) and 7.5” dia this calculates to a 4.04G charge (Info-central) will give 6.88psi. Info Central also calculated this to break five 4-40 pins (because they use 60lb break force). To have a safety margin a **4.5G charge** will be used. This will be ground tested.

- **Upper Airframe to AV-Bay** –The upper-airframe will be held to the av-bay with 6 6-32 (I think) countersink machine screws. The screws will seat into the AV bay sealing shoulder using 6-32 T-nuts.

- **AV-Bay to Lower Airframe** – The lower airframe will hold the drogue chute. This needs less sheet pin strength to hold together and will use 3 4-40 pins. Again about 76lb* / pin (max) to break this allows for up to 228lbs of force needed to separate the nose cone. The pressure needed to break the pins is:

  228lb force / Nose cone cross-sectional area = 228 / (7.5 * 7.5 * 3.14159 / 4) = 5.16psi.

  Using an effective volume of 21.25” (measured) and 7.5” dia this calculates to a 2.5G charge (Info-central) will give 5.16psi. Info Central also calculated this to break four 4-40 pins. To have a safety margin a **3.5G charge** will be used. This will be ground tested.

*** Reference http://www.feretich.com/Rocketry/Resources/shearPins.html for sheer force needed for various nylon screw sizes.**

Main chute - The main is a 108” custom chute. Target descent speed is about 17fps, and no more than 20fps.

Drogue chute - This will be a custom Fruity Chute of 3’ diameter. Target drogue descent speed is between 40 to 50 fps.

Rocksim can predict descent speed for a given weight and size chute within about 5% by setting the parachute Cd to 1.5. This value has been proven accurate over the course of many flights under various conditions.

Deployment Charge Configuration - There will be one primary and one backup charge per parachute deployed. Deployment charge size is already outlined above. Since there are two altimeters there will be separate circuits and low-current e-matches into each charge. Further each circuit will use two e-matches wired in parallel. All e-matches are pre-screened to assure approximately 1 ohm resistance. The e-match head uses 60 gauge Nichrome and is equivalent to Davie First Fire low current marches. This double match scheme has been proved reliable over the course of more than 50 deployment firings and is 100% reliable in firing the charge. Average fire current is about 180ma per match which is very low. The altimeters are capable of about 3 – 5 amps / pyro-channel giving a hefty safety margin for firing.

Recovery sequence – This will be to fire the drogue charge at apogee and separate the upper and lower airframe for drogue deployment. There will be a 45’ 1” tubular nylon shock cord between the sections to allow for deceleration.

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The drogue will be attached within 6’ of the upper section. This offsets the upper and lower airframe while descending so they don’t swing into each other. The rocket should fall at about 40 – 50 fps. At 1200’ the main charge will fire, pop the nose cone off and deploy the main chute. The nose-cone is connected to the upper airframe on a 30’ shock cord of 1” tubular nylon. The main chute will connect within 6’ of the nosecone. Final descent will be about 17fps. Both shock cords will be braded to help absorb separation energy.

Control Devices – As listed in section #2 deployment will be via two independent commercially available altimeters. Both units are well tested and regarded in the rocket community.

- G-Wiz HCX – Apogee is based on inertial apogee determination. Baro is used to determine main. The G-Wiz allows separate batteries for CPU and the Pyro channels. These will both be fresh 9V cells and changed between every flight.
- Perfect Flight miniAlt/WD – Apogee and main are both based on baro. The miniAlt uses a single 9V battery. But it has a very large capacitor to power it during firing and has proven very reliable.

Device Configuration – This outlines the configuration used for the control devices.

- HCX – This will be configured for drogue at inertial apogee with a 2 sec delay. The added two seconds gives the MAWD a chance to fire first so there is less of a chance of both charges going off at the same time. Baro-main will be at 1200’. Configuration is done via the G-Wiz flight view software. The HCX is not affected my Mach effects.
- miniAlt (MAWD) – This is configured via dip-switches. The drogue pyro channel is always at baro-apogee. The main is configurable to as low as 300’, and in 200’ increments above that. This flight will use 900’ to assure that both main charges do not fire at the same time. Additionally mach-delay will be set for 10 seconds. The flight could get close to mach 1 around 3 – 4 seconds into the flight. Apogee is not expected until 24 seconds into flight. Using 10 seconds allows for a range of larger motors and even with a N2000 mach will not last past 8 seconds.

Mounting - The control devices are both mounted on a carbon honeycomb composite sled hung between two of the four threaded retainer bolts that hold the av-bay caps on. The sled will use brass tubing on the edges that thread over the bolts. The controllers are mounted on one side, and the batteries on the other. Lock-nuts will be used to keep the sled in the proper position between the end caps. Both units mount on 4-40 standoffs and use standard machine screws.

Control Switches - There will be four switches for the controllers:

- The G-Wiz uses 2 switches. The main switch is a rotary power switch that can simultaneously switch both CPU and pyro power sources at the same time. A second screw switch is used to control the pyro-shunt.
- The miniAlt will use two rotary switches. One for power, and the other as a shunt across both pyro channels.

The Rotary switches are made in Germany and are commonly used to configure AC devices to run on either 115 or 220 volts. The switch technique is well tested on a number of different rockets and many flights.

Pre-flight Ground Testing – All recovery systems will be tested prior to flight:

- The HCX used has been previously flown on at least 6 previous flights and is well tested.
- miniAlt – This will be baro-chamber tested using LED loads to verify firing.
- Drogue and main charges – The rocket and all recovery gear will be loaded into the rocket included pyro charges. All sheer-pins will be inserted. Both charges will be tested on the ground to assure separation. The drogue charge will be fired first. Next the main will be fired. The ground test will be video-recorded and analyzed to assure that the recovery gear is ejected properly and in a fashion that assures it will not tangle.

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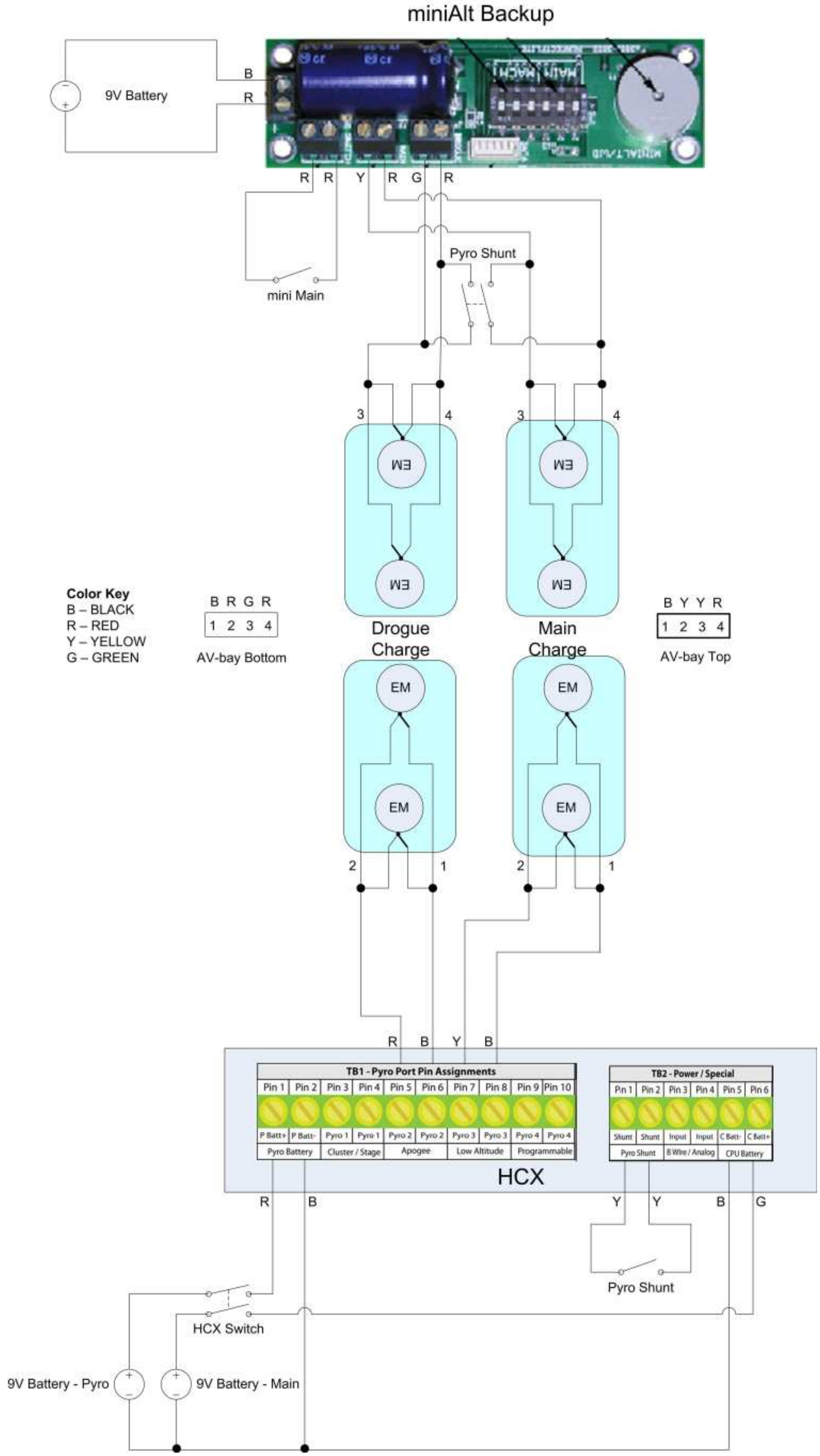
Schematic Diagram



6) Stability Evaluation

Launch Tower – It is expected to use Alan Thym’s 16’ launch tower equipped with 5/16” rail guides. The tower has been previously tested on a number of flights. It is very rugged including long struts for stability. Below is a picture of the tower with the Foley a Deux loaded up at Alan’s house.

A ladder is not needed for arming since the lattice of the tower can be easily climbed for arming.

Center of Pressure – Rocksim has indicated the CP is 102” back from the nose.

CG Analysis – Unloaded (without motor) CG is predicted to be 71”. CG with a M1315 is 83”.

Stability Margin – The stability margin with a M1315 is 1.03 (Barrowman method).

6) Expected Performance and Flight Profile

This section outlines the expected flight performance. Simulation data is from Rocksim 8.2.2f4

Gene's L3 – Main Event

Flight Profile – Acceleration, Velocity, Altitude, Cd

7) Rocket Construction Build Blog

The rocket construction will be documents on the Fruity Chutes website at:

http://fruitychutes.com/genes_l3.htm

8) Pre-launch & Assembly checklist

Inventory

- Motors Casings, or arrange to borrow ❑
- Grease ❑
- Inspect Parachutes (Main, Drogue) ❑
- Inspect Nomex blankets x 2 ❑
- Inspect Shock Cords x 2 ❑
- Inspect Fire Balls x 2 ❑
- Check inventory of Quick Links ❑
- Motor Retainer Cap ❑
- Motor Casing ❑
- 75 – 98mm adapter ❑
- M1315 Load ❑
- Motor Igniter ❑
- BP ❑
- E-matches (x 8 needed pre-soldered as 4 pairs) ❑
- 2 ohm simulated e-match loads for testing ❑
- 3 x 9v Batteries (2 HCX. 1 miniAlt) ❑
- Shear Pins (4 4-40 Nose Cone. 3 4-40 Lower Airframe) ❑
- 6 6-32 E-bay to Upper Airframe Attachment Screws ❑
- Saran Wrap ❑
- Masking Tape ❑
- Small Pliers ❑
- Small Screwdriver ❑
- Yasue HTX (for tracking) ❑
- Yagi Antenna (for tracking) ❑
- PicPac ❑
- Garmin GPS ❑
- Cables ❑
- Camera ❑
- Video Camera ❑
- New crew ❑

Gene’s L3 – Main Event

Checklist: Pre-Flight Prep

Check inventory .... ❑
Check batteries are new, V check.. ❑
Program HCX (inertial apogee + 2 sec, main @ 1200’) .... ❑
Double check miniAlt dip switches, 900’ main, 10sec mach delay.... ❑
Charge Big Red Bee Xmtr & GPS.. ❑
Charge HTX .... ❑
Charge camera & video camera.. ❑
Make two sets 4.5g BP Main Chute Charge, 2 pair matches .... ❑
Make two sets 3.5g BP Drogue Chute Charge, 2 pair matches .... ❑

Checklist: Pre-RSO – Rocket Assembly

HXC Continuity Test(with shunts on, then off, 2 ohm load)............... ❑
miniAlt continuity Test (with shunts on, then off, 2 ohm load) .... ❑
Check altimeters are off .... ❑
Check altimeters are shunted .... ❑
Suspend two drogue 3.5G BP down into lower airframe cups .... ❑
Install two 4.5G BP into main chute cup .... ❑
Attach leads to terminals (two sets) .... ❑
Prep & install drogue chute .... ❑

- Roll and pack chute
- Install and Quicklink Kevlar Y harness and Nomex blanket
- Fold and tape 45’ shock cord
- Quicklink shock cord lower to harness
- Pack chock cord, then parachute into blanket
- Quicklink drogue to shock cord loop
- Insert into lower airframe assuring that blanket wraps around chute and shock cord

Attach e-bay to upper airframe with 6 6-32 machine screws............. ❑
Prep & install main chute .... ❑

- Roll and pack main chute
- Install and Quicklink Kevlar harness and Nomex blanket
- Fold and tape 25’ shock cord
- Quicklink shock cord to harness
- Pack shock cord, then parachute into blanket

- Quicklink main to shock cord loop
- Insert into airframe assuring that blanket wraps around chute and shock cord
- Quicklink upper end main shock cord to nose-cone U-bolt

Attach lower airframe to upper .... ❑

- Quicklink drogue shock cord to av-bay U-bolt
- Connect Drogue BP charges to terminals (two sets)
- Attach and shear pin lower airframe to e-bay......................... ❑

Build motor.. ❑

Prepare igniter – do not install yet! .... ❑

Final Assembly

Notify RSO in accordance with required launch waiver (if needed)... ❑

Fill Out Flight Card & paperwork, Take to RSO................................ ❑

Install Motor... ❑

GPS: Turn on & insert GPS in nose cone .... ❑

Sheer-pin nose cone with 4 x 4-40 pins .... ❑

Check GPS TX and Receiver, check waypoint in Garmin GPS .... ❑

Checklist: RSO

Have RSO Check.. ❑

Verify GPS Tracking System and Lock on waypoint .... ❑

9) Launch checklist

Checklist: Pad

Note: collect to take to pad: tape, screwdriver, pliers, camera, heavy wire-ties, motor igniter

Alan's Tower Pad: Tape top of rail to prevent airframe gouging........ ❑

Load on rail .... ❑

Activate miniAlt Altimeter. Check Annunciation................................ ❑

Open miniAlt Shunt, check annunciation... ❑

Activate HCX Altimeter. Check Annunciation.................................... ❑

Open HCX shunt.. ❑

Again Verify HCX Annunciation... ❑

Again Verify miniAlt Annunciation .... ❑

Insert igniter and check continuity.. ❑

DUMB ROCKET PICTURE.. ❑

Gene’s L3 – Main Event

Launch:

- Return to camp, verify radio tracking again, if no track abort launch. ❑
- Get cameras ready.. ❑
- Notify witnesses.. ❑
- Cross fingers, arms and toes .... ❑

5...4...3...2...1...LAUNCH!

10) Post Flight Checklist

Successful Launch

- Verify pyro charges burned .... ❑
- Count out and note altitude beep codes.............................. ❑
- Return rocket to camp... ❑
- Inspect for damage, if none get witness signoff .... ❑
- Later - Download all data to PC .... ❑
- Pop a bottle of wine to celebrate! .... ❑

Contingency – abort launch, misfire or other reason

- Unload gear and charges... ❑
- Unload motor and properly store for later............................ ❑

Contingency –crash

- Dig out of the ground or otherwise locate all components................. ❑
- Locate charges and dispose of .... ❑
- Do post-mortem analysis .... ❑
- Find a therapist .... ❑