Level 3 Certification Project - July 2015
Tim Van Milligan - NAR 35872

Project Name: LifeProof Rocket

Advisors: James Russell (L3CC)

Introduction:

The LifeProof Level 3 certification project consists of a 8-inch diameter G10 fiberglass airframe, capable of accommodating up to a 98mm M-impulse+ motors. It is a 4-fin design, with lower and upper payload sections for drogue and main chute recovery gear. Topped with a 4-1 ogive nose cone, giving the rocket an overall length of 125.5 inches. Dry weight, including recovery gear and electronics, is approximately 61.2 pounds).

Because this is a heavy rocket, it will separate into two pieces for descent. At apogee, the rocket will separate in two. Each of the sections will fall from the apogee point under drogue until it reaches 800 feet. At that point, the main parachute of the fin section will open, and the upper portion of the rocket will separate. Both the e-bay section and the nose cone will come down on a single chutes.

While the rocket is not novel, it will be carrying 8 cell phones strapped to the outside of the rocket. These are being provided by Otter Products, as part of a promotional campaign they are having for their newest cell phone case. It will also carry two Go-Pro cameras. The cell-phone cameras will not be functional, as they automatically shut off after 5 minutes of recording time. There will be no time to turn them on and launch the rocket.

Certification motor: Cesaroni M1450 Classic
Projected Max Altitude: 6,371 feet AGL
Drogue deployment: Apogee
Main deployment: 750 ft. AGL

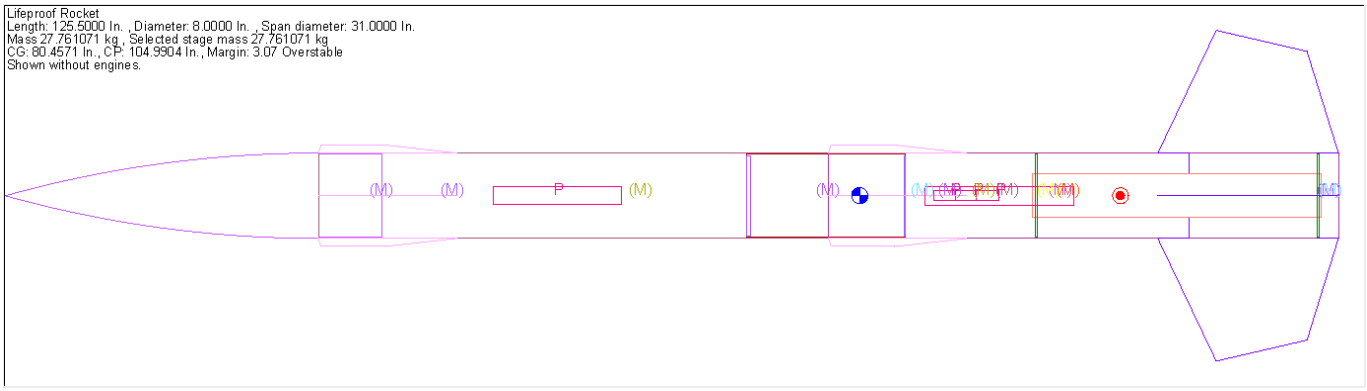


Figure 1 - Dry Weight

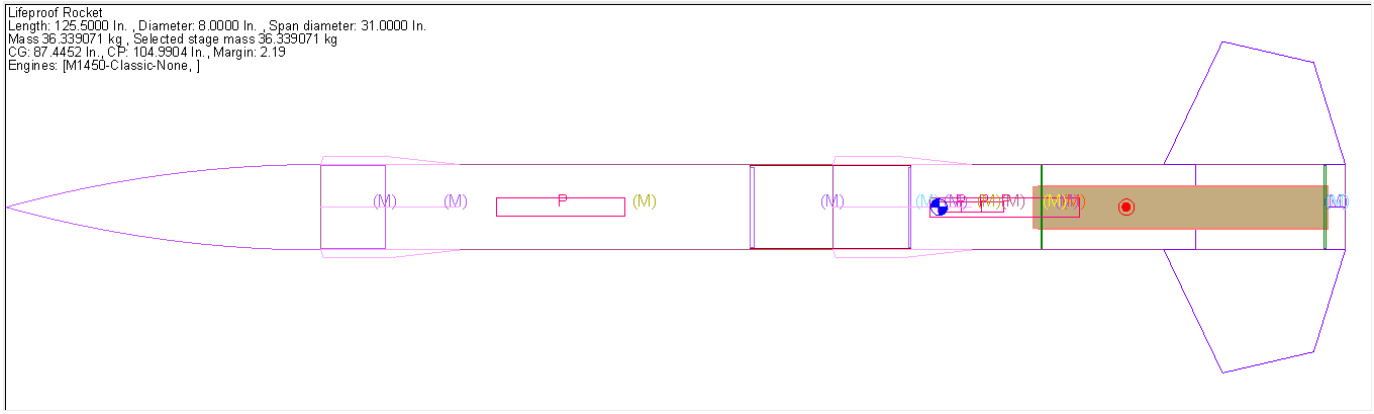


Figure 2 - Loaded Weight (M1450-Classic)

Preliminary Flight Simulation Data:
Center of pressure: 104.99 inches (RockSim V9.4.0f194)
Center of Gravity: 87.44 inches (RockSim V9.4.0f194)
Mass at liftoff: 36.34 Kg (80.1 lbs) (RockSim V9.4.0f194)
Total impulse: 9955.75 N-sec.
Burn Time: 6.87 seconds

Component descriptions:

Nose cone:

Type: Performance Rocketry fiberglass Shape: 4:1 Ogive with rounded tip
Length: 29.5 inches
Shoulder: 6.000 inches

Upper airframe (main payload) tube:

Type: Performance Rocketry G10 fiberglass
Outside diameter: 8.0 inches
Inside diameter: 7.812 inches
Length: 46 inches

Drogue recovery:
Chute type: Fruity Chutes
Chute size: 24 inches
Harness: 1500lb-test Kevlar

Main recovery:
Chute type: Fruity Chutes
Chute size: 72 inches
Harness: One-Bad Hawk, Tubular Nylon, 3/4” wide X 25 Feet (2-loops)

Avionics Bay:
Type: Peformance Rocketry G10 fiberglass
Outside diameter: 7.75 inches

Inside diameter: 7.5 inches
Length: 15 inches

Bulkheads:
0.125 inches G10 thick X 7.5” backed with 0.25 inch baltic birch plywood recessed inside coupler.

Forward Section Flight Computers:
Primary: PerfectFlight StratoLogger
Backup: AltusMetrum Telemetrum

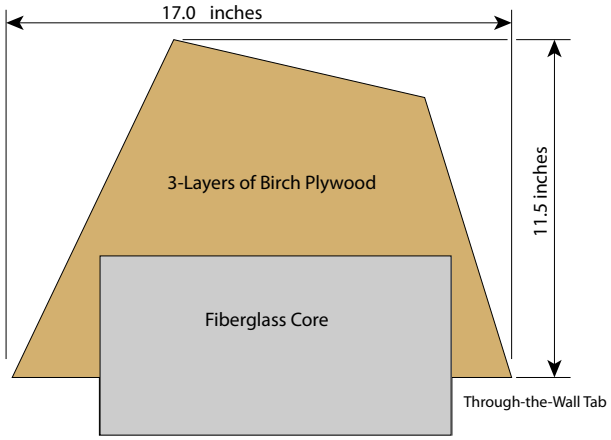
Switches: Simple spring loaded push-button switch

Fincan airframe tube:
Type: Performance Rocketry G10 fiberglass
Outside diameter: 8.0 inches
Inside diameter: 7.812 inches
Length: 48 inches

Motor mount:
Type: Performance Rocketry G10 fiberglass
Outside diameter: 4.07 inches
Inside diameter: 3.89 inches
Length: 27.14 inches

Motor Mount Centering rings (2)
Type: Performance Rocketry G10 fiberglass
Outside diameter: 7.75 inches
Inside diameter: 4.07 inches
Tickness: 0.125 inches

Fins (4 each):
Core: 0.125 inch Performance Rocketry G10 fiberglass sheet
Outer Laminate: 0.125 inch Baltic Birch Plywood. Applied to the fiberglass core with West Systems Epoxy
Total Fin Thickness: 0.4 inches thick



Drogue recovery for fin-can section:

Chute type: Fruity Chutes
Chute size: 24 inches
Harness: 1500lb-test Kevlar

Main recovery for fin-can section:

Chute type: Fruity Chutes
Chute size: 84 inches
Harness: One-Bad Hawk, Tubular Nylon, 3/4" wide X 25 Feet (3-loops)

Aft Section Flight Computers:

Primary: PerfectFlight StratoLogger CF
Backup: AltusMetrum EasyMini

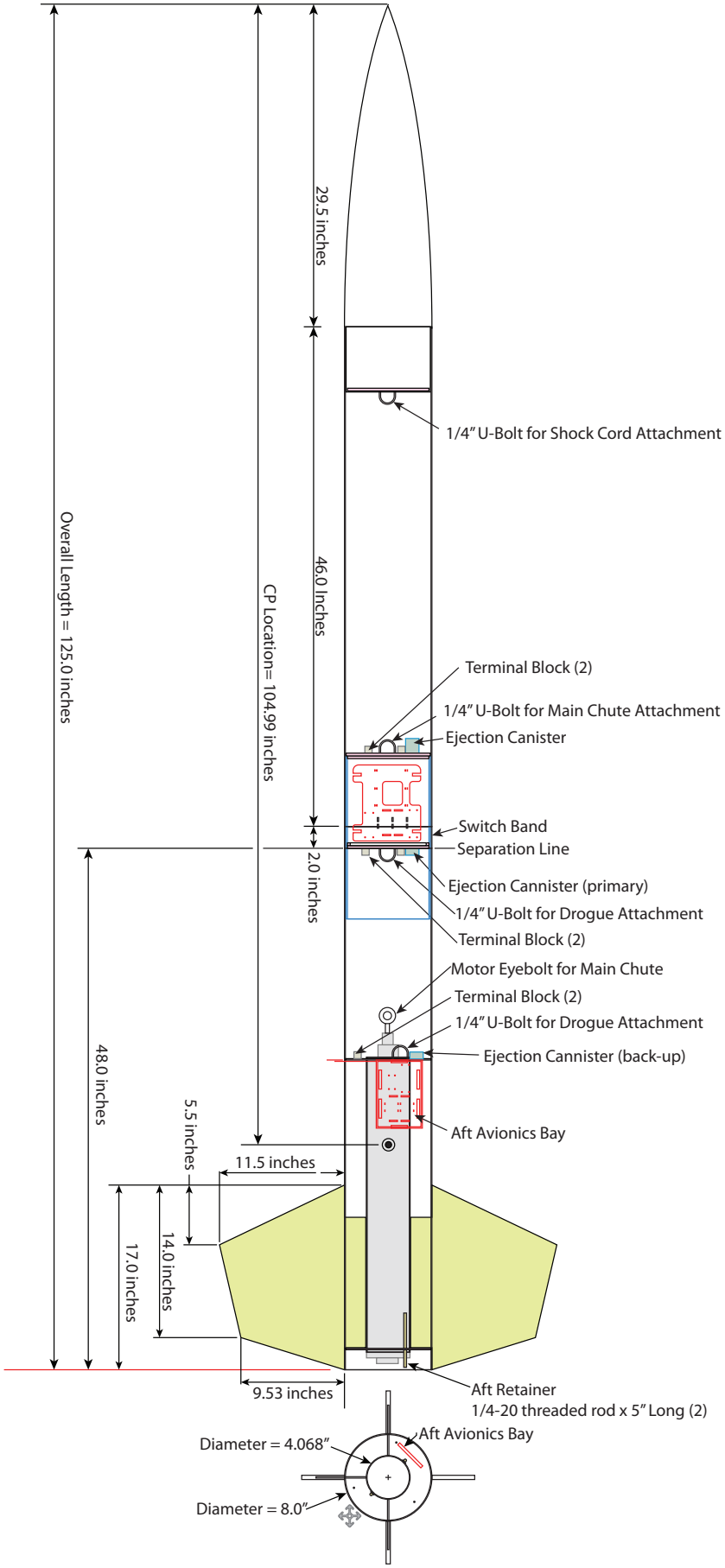
Main Recovery Deployment Mechanism

Type: Tether Release
Manufacturer: Tender Descender L3
Method: Two Tender Descenders will be linked in series to release the main chute for the fin can unit. Two were used for redundancy. Either device can release the main chute.

Aft Avionics Bay:

Type: Custom Made Plywood Sled. Bonded to the inside of the tube, just below the forward centering ring. Access to the avionics bay is through a hatch cut through the side of the fiberglass tube. The hatch is secured with four 4-40 machine screws. See the photos of the aft avionics bay.

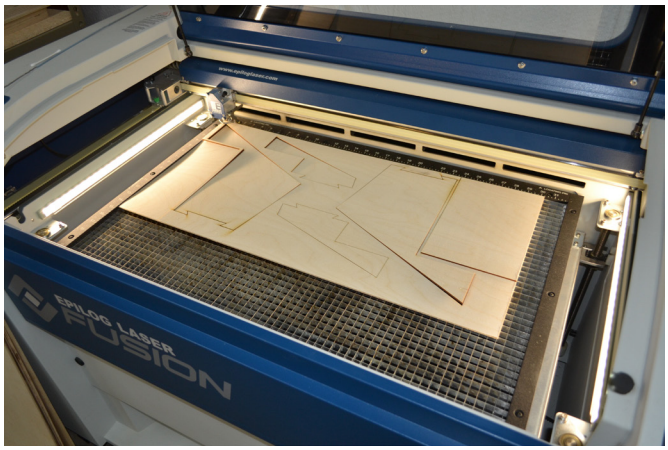
Overall Dimensional drawing:



Construction Package

The four slots in the fiberglass tube were cut using a 1/8” router bit and a Ted Macklin Slot Machine.

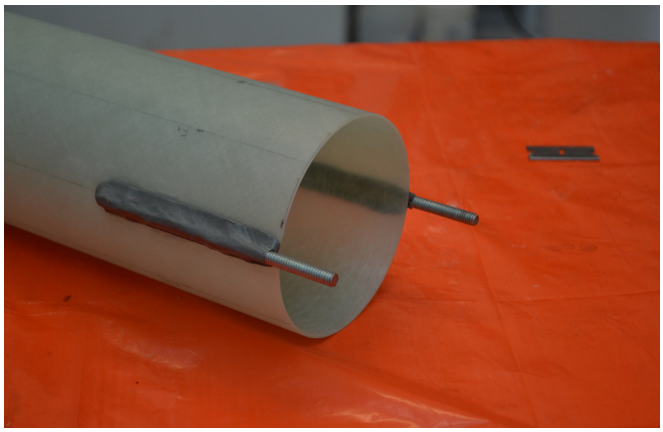
The fins are built up using a 1/8” fiberglass core. A pattern was used to position the fiberglass correctly so all the fins would be identical.



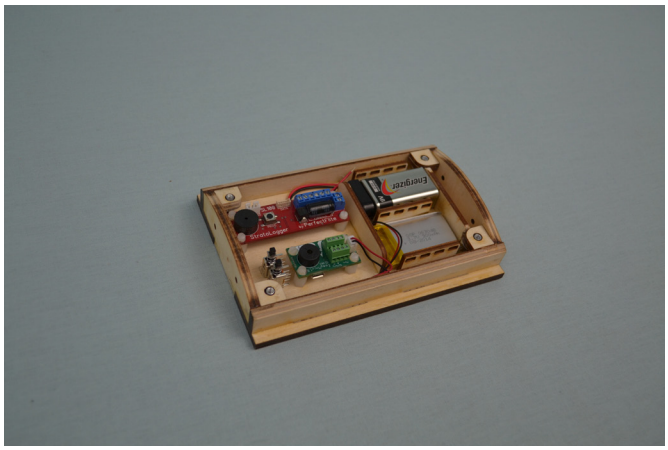
The plywood skins were cut using an Epilog laser-cutter. Since the fins were larger than a sheet of wood, they had to be cut like a jigsaw puzzle and pieced together. This did allow the grain to be optimized for maximum strength.

The plywood skeleton is placed around the fiberglass core piece and tacked in place with super glue.

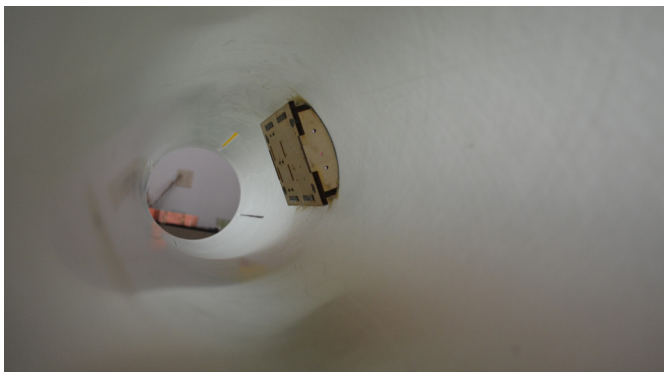
The plywood skins were bonded to the core piece using West Systems epoxy. Only one side could be completed at a time. They were pressed under heavy weights to insure the fins were flat.



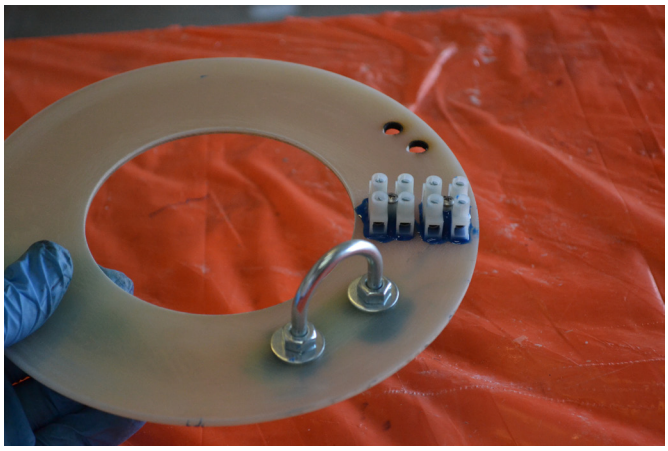
The motor retention system is styled after the Cosmodrome kits. It consists of a 5 inch piece of 1/4-20 All-Thread that is epoxied to the aft end of the motor tube. Fix-It epoxy clay was used here.



The fin-can e-bay was made from 1/4” plywood. Here all the electronic pieces are fit-checked.

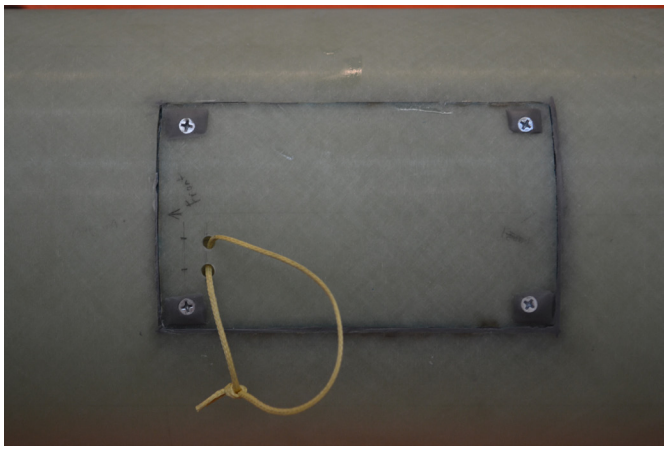


This view is looking inside the fin-can tube at the e-bay. To provide extra security, RocketPoxy fillets were applied to three sides. The forward edge (show) butts agains the fiberglass centering ring, so it didn’t get an RocketPoxy fillet.



This is the forward motor-mount centering ring. A set of terminal blocks and a U-bolt were attached and permenently affixce with RocketPoxy. The U-bolt is a back up attachment point for the recovery system. The primary is the forged eyebolt on the front of the motor casing.

A square cut-out was cut into the fin-can tube using a Dremel. The opening is just a bit smaller than the ebay. The ebay was tacked in place with Fix-It epoxy and allowed to cure overnight.



Once the e-bay was firmly in place, the hatch cover was positioned, and four corner screws were added to keep it in place for flight. The kevlar cord was a temporary way to pull the hatch cover off. The holes allow for venting of the altimeters, and to access the push switches to turn them on for flight.

The forward centering ring was bonded to the motor mount tube using RocketPoxy. Fillets of epoxy were placed on both sides of the ring.

The motor tube and forward centering ring were bonded into the tube using RocketPoxy. The aft ring was not glued in yet, but was used to temporarily align the motor tube while the epoxy hardened. A day later, the first fin was installed. Fix-It epoxy clay was buttered on the bottom of the thru-the-wall tab, and pressed against the motor tube.

The second fin was installed and epoxied in place. Again, a template was used to make sure the fin was perpendicular to the tube.

Before the aft centering ring was applied, RocketPoxy (purple color) was smeared inside the tube, and along the edges of the fin tabs.

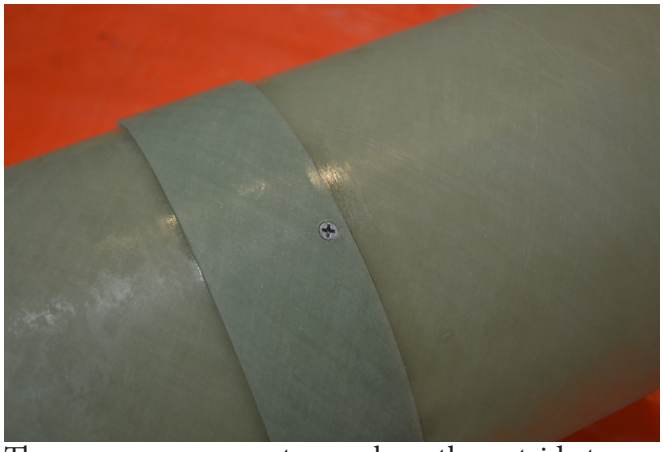
To make sure the fin was perpendicular to the tube, a simple cardboard pattern was positioned around the tube to hold the fin while the epoxy cured. You can see the aft centering ring was temporarily installed to hold the motor tube in the fin can.

Here is a photo showing all the fins installed in the rocket. The first layer of internal fillets was applied (the RocketPoxy was colored a mustard-yellow). Once this was cured, the rocket was rotated 180°, and the other side of the fin tabs got internal fillets of RocketPoxy. At this point, there were internal fillets on the outer tube, and the motor tube.

The aft centering ring was slid into place, and external fillets of RocketPoxy were applied.

External fin fillets were applied one side at a time to the root edge. Epoxy used: Glenmark Rocket-Poxy. Each fin root was dyed a different color just so I could see which order I did them in.

I made a 1/4” thick plywood centering ring as a stop for the aft bulkhead in the front av-bay. Three 8-32 machine screws were installed from the outside in order to prevent it from sliding forward. This view looks aft through the coupler.

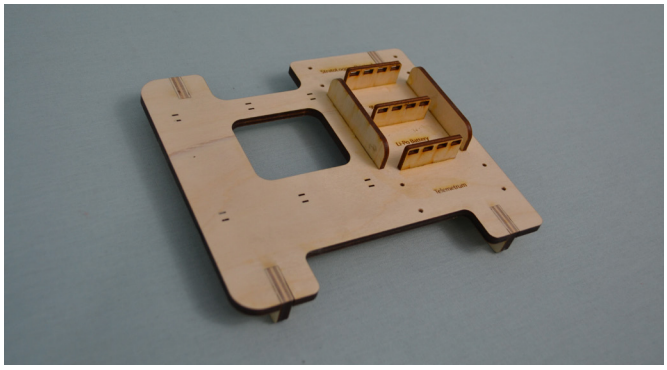


The screws were counter-sunk on the outside to reduce drag. Later they will be filled with epoxy.

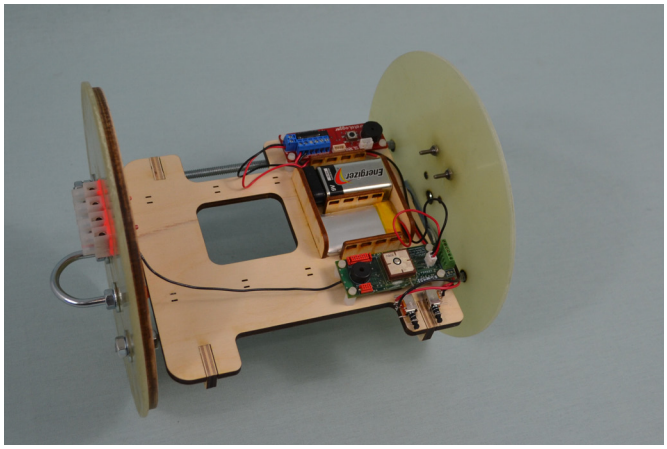
To further reinforce the ring, a fillet of Glenmark RocketPoxy was applied over the exposed screws. This is the same view as shown above.

The cell-phone mounting fixtures are readied for installation with a coat of RocketPoxy.

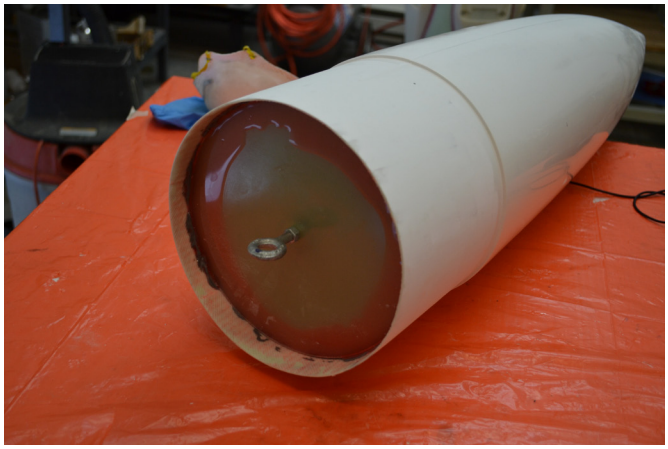
The cell-phone mounting fixtures are positioned on the rocket and held with tape until the epoxy cures.



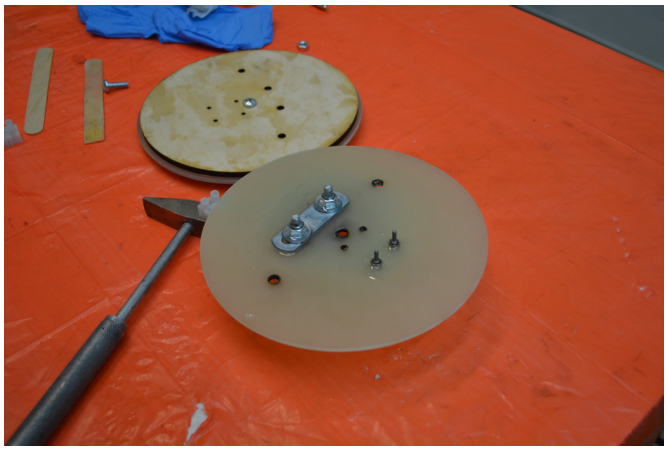
This is the sled for the electronics in the forward av-bay. The excess plywood was cut away to remove as much weight as possible without sacrificing strength. The sled is modeled after the e-bay kits from Mad Cow rocketry.



Test fit of all the electronics on the forward av-bay sled.

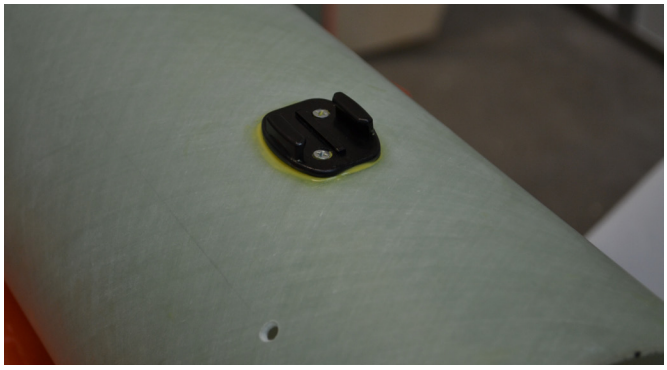


The nose cone's bulkhead was secured with two types of epoxy. A shelf was made with Fix-it Epoxy clay to preventit from sliding forward. Then West Systems epoxy was poured around the permieter to keep it from moving aft.

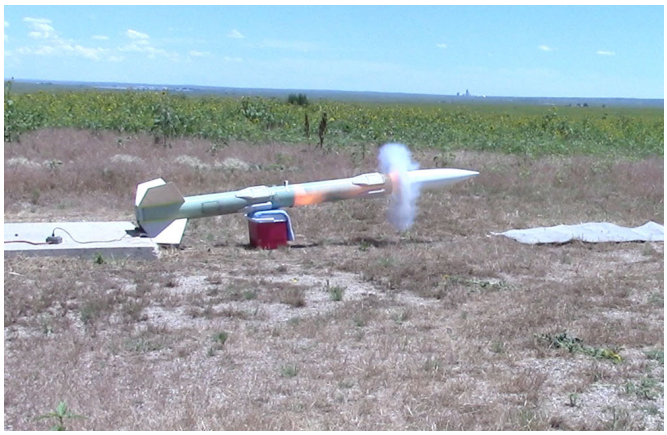


The bulkheads for the forward av-bay. The bulkhead in the background goes on the front of the av-bay. A plywood disk epoxied to one side allows the disk to self-center on the end of the av-bay. The aft bulkhead goes inside the coupler, so it doesn't need the extra plywood disk.

The av-bay bulkheads were completed by mounting the ejection charge wells to the outer faces. They were secured with small screws as well as Rocket-Poxy.

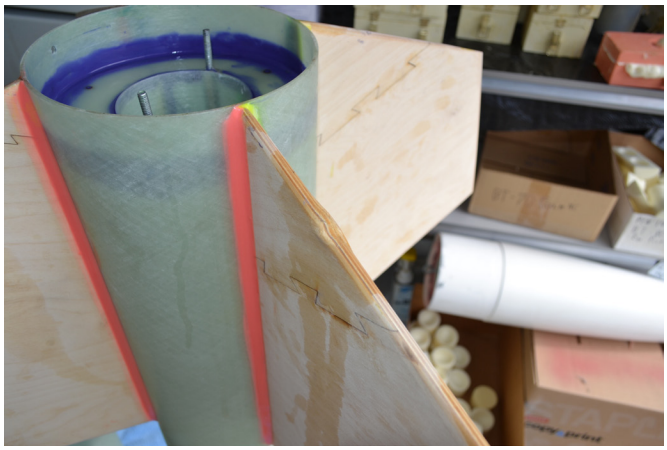


The Go-Pro's mount was attached to the tube with screws through the tube, as well as Rocket-Poxy. The screws were cut off to prevent them from interfering with the av-bay's installation



Separation test performed on Saturday, July 11 at Hudson Ranch near Pueblo, Colorado. This test verified that the ejection charges were powerful enough to separate the rocket into its descent pieces.

A couple of clamps were used to compress the plywood where they were damaged during the separation test. Once back in position, the wood was reinforced with thing CyA adhesive. The remaining depression was filled with Fix-It Epoxy clay and then sanded smooth when it was cured.



Two fins had cosmetic damage on the trailing edges. It occured when the rocket recoiled into the concrete pad that was used as a backstop. The two motor retainer bolts also splayed out (apart) during the test. It was a result of the washers acting as wedges against the rocket casing. The key will be to keep the washers flat on the bottom of the motor casing during the actual launch. I may also use some safety wire to act as restraint to keep them from bending outward.

Painting the rocket with sandable primer.

Parachute Descent Calculations

Descent velocity = $V = \sqrt{\dfrac{8\,m\,g}{\pi\,\rho\,C_d\,D^2}}$

Where:

$\pi = 3.1415$

$\rho = 1.22\ Kg/m^3$ (Density of air)

m = descent mass of rocket section

$g = 9.8 m/s^2$ (gravitational accleration)

$C_d = 2.2$ (coefficient of drag of a toroidal shape parachute)

D = diameter of parachute (in meters)

For the lower section...

m = 17.314 Kg (dry mass, including phones and spent motor casing)

D = 2.4384 m (96 inches)

$$V = \sqrt{\frac{8\,(17.314\ Kg)\,(9.8\ m/s^2)}{\pi\,(1.22\ Kg/m^3)\,(2.2)\,(2.4384m)^2}}$$

V = 5.2033 m/s

V = 11.639 mph

V = 17.07 ft/sec

For the Upper section...

m = 12.1895 Kg (dry mass, including phones and parachutes)

D = 2.1336 m (84 inches)

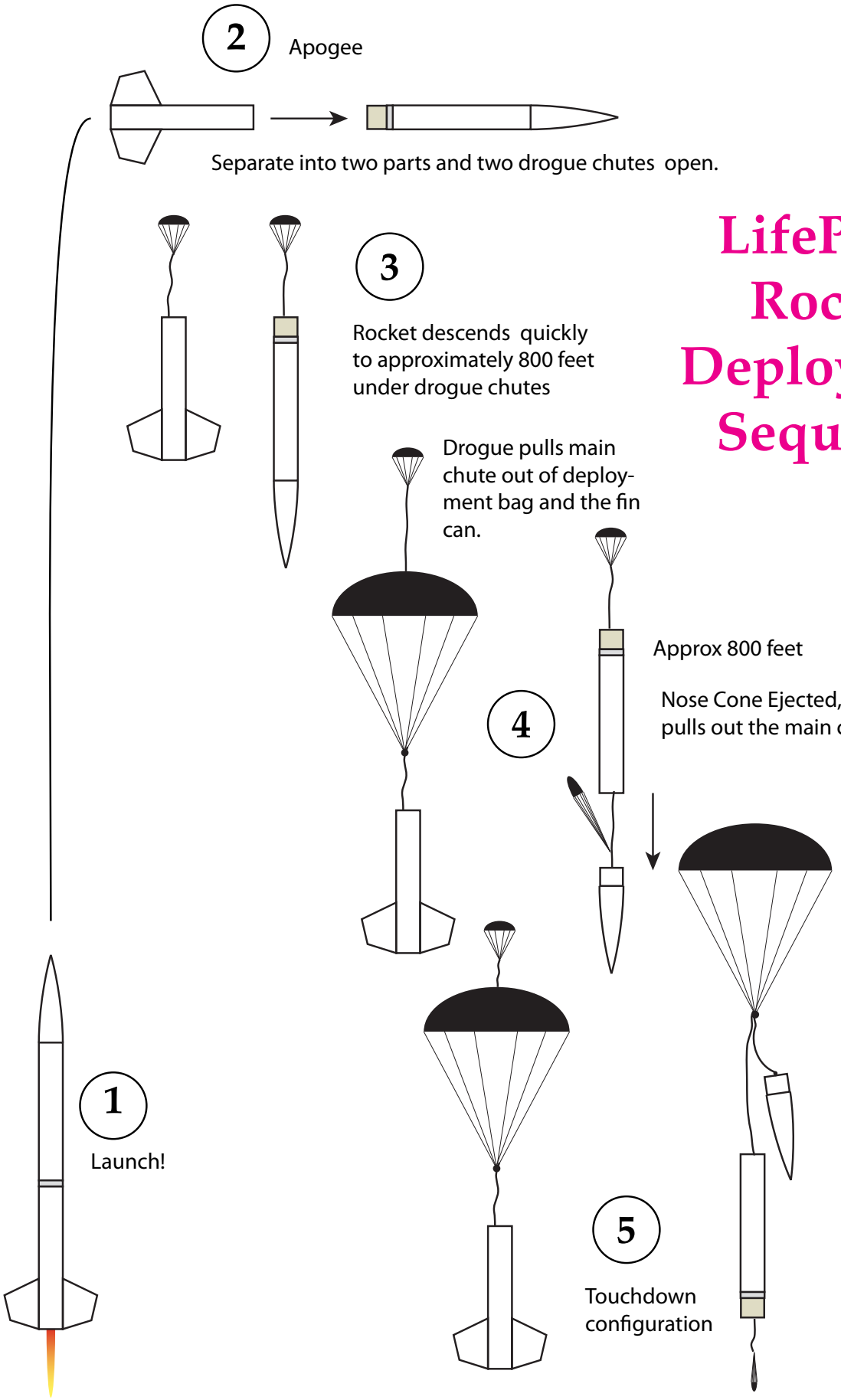
$$V = \sqrt{\frac{8\,(12.1895\ Kg)\,(9.8\ m/s^2)}{\pi\,(1.22\ Kg/m^3)\,(2.2)\,(2.1336m)^2}}$$

V = 4.99 m/s

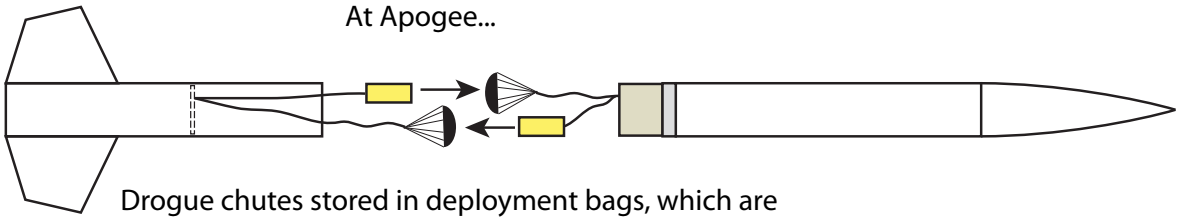
V = 11.16 mph

V = 16.37 ft/sec

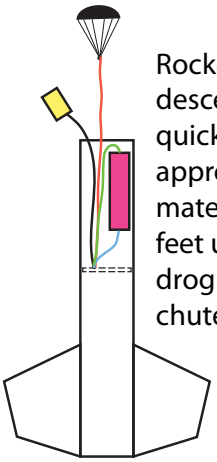
LifeProof Rocket Deployment Sequence



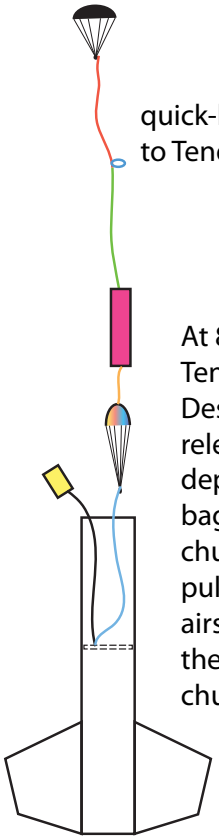
LifeProof Rocket Fin-Can Rigging



Drogue chutes stored in deployment bags, which are attached to the opposite section of the rocket. When rocket separates, it pulls out the deployment bag into the air stream to unfurl it. Deployment bags are tied to the u-bolts on the bulkheads of each section.

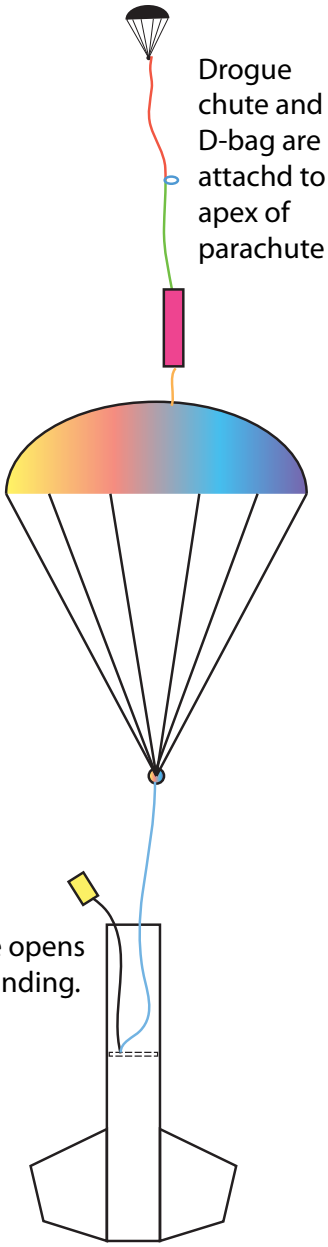


Rocket descends quickly to approxi-mately 800 feet under drogue chutes



quick-link attached to Tender Descender

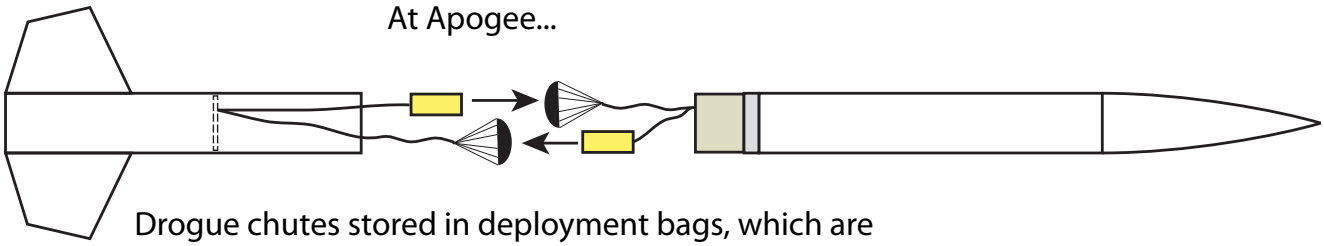
At 800 feet Tender Descender releases the deployment bag of the main chute. It is pulled into the airstream by the drogue chute



Drogue chute and D-bag are attachd to apex of parachute

Main chute opens for a safe landing.

LifeProof Rocket Forward Section Rigging

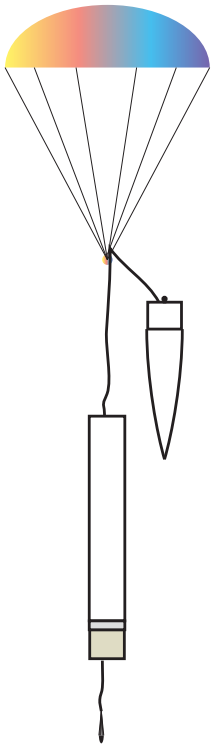


Drogue chutes stored in deployment bags, which are attached to the opposite section of the rocket. When rocket separates, it pulls out the deployment bag into the air stream to unfurl it. Deployment bags are tied to the u-bolts on the bulkheads of each section.

Rocket descends quickly to approxi-mately 800 feet under drogue chutes

Approx 800 feet

Nose Cone Ejected and pulls out main chute



Main chute opens fully. The body tube reorients itself. The drogue chute collapses.

Main Parachute Rigging for Front Section of the Rocket

1/4” quick-link attached to a forged eyebolt on the base of the nose cone.

Fruity Chutes 84” Toroidal shaped parachute

1/4” quick-link to attach to the swivel on the parachute.

1” wide X 25-feet long nylon shock cord - three sewn loops. (One Bad Hawk)

24” X 24” Nomex heat shield. Parachute is wrapped in this to provide needed heat protection. Manufacturer: Sunward Aerospace

1” Wide X 24” Long Nomex shock cord protector. Manufacturer: Sunward Aerospace

1/4” quick-link attached to the U-bolt on the front end of the avionics bay bulkhead.

Parachute Rigging for Aft Section of the Rocket (Pre-Release of Main Chute)

24” Drogue Chute with swivel. Manufacturer: Fruity Chutes

9-feet of 1500# test kevlar cord. Tied to swivel on forward end, and tied to the Tender-Descender quick-link on the other end.

1” wide X 25-feet long nylon shock cord - three sewn loops. (One Bad Hawk)

1/4” quick-link attaches the swivel on the end of the suspension lines of the parachute to the black shock cord.

Nomex parachute deployment bag. Manufacturer: LOC Precision.

Fruity Chutes 96” diameter Toroidal shaped parachute inside deployment bag.

1” Wide X 24” Long Nomex shock cord protector. Manufacturer: Sunward Aerospace

Tender Descender (L3) from Tinder Rocketry. Releases at main chute ejection (approx 800 feet AGL). Attaches to the U-bolt on the forward bulkhead of the fin-can section.

1/4” quick-link attaches the black shock cord to the U-bolt on the forward bulkhead of the fin-can section.

Sequence of Main Chute Deployment from Aft Section

#2) Drogue Chute extends further from the fin can. It pulls out the deployment bag from inside the fin can.

#4) Drogue Chute continues to pull, and extends the shroud line first. Then it pulls the parachute out of the deployment bag.

#5) Once parachute is out, it inflates. There is a chord that attaches from the inside of the deployment bag to the top canopy of the parachute. This is what keeps the deployment bag and drogue chute from floating away separately.

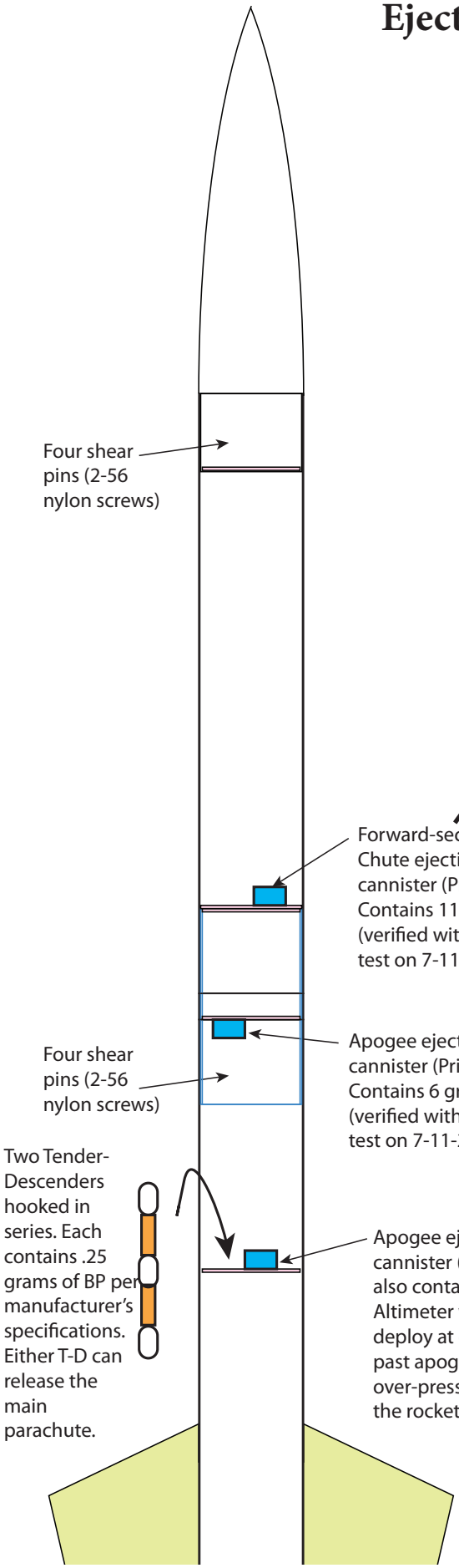
#3) Drogue Chute continues to pull, and completely unfurls all the shock cord.

#1) Tender Descender separates, releasing the quick link that is attached to the deployment bag.

Additional Recovery System Information

1. Upper section of the rocket is vented by four 1/16” diameter holes below the cell-phone mounting pads.
2. The nose cone is also secured by three 2-56 nylon screws that act as shear pins. A deployment test was accomplished on 7-11-2015 to verify that the ejection charge was strong enough to shear them and deploy the parachute.
3. The lower section of the rocket is vented by a single 1/8” diameter hole located below one of the cell phone pads.
4. There are four 2-56 nylon screws that act as shear pins. A deployment test was accomplished on 7-11-2015 to verify that the ejection charge was strong enough to shear them and separate the rocket into two sections.
5. Nomex cloths are wrapped around each parachute to protect them from the heat of ejection. The main chute on the lower section uses an Angel (LOC) deployment bag to ensure that it is pulled out of the rocket in an orderly deployment.
6. The two 24” Fruity Chute parachutes act as drogue chutes. Each is stowed in a deployment bag which is attached to the opposite side of the rocket than the parachute is secured to. For example, the drogue chute on the upper section is placed in a deployment bag that is itself attached to the lower section. At separation at apogee, the upper section ejects and pulls the deployment bag from the lower section, making sure that it is fully in the airstream so it can inflate.
7. The main parachutes are attached using 1/4” diameter steel quick-links. The upper section uses a 84” diameter toroidial shaped parachute from Fruity Chutes. The Lower section uses a 96” diameter toroidial shaped parachute which is also from Fruity Chutes.
8. The drogue chutes are 24” diameter, and are produced by Fruity Chutes. I chose them because they are some of the strongest chutes I’ve seen in that diameter.

Ejection Charge Calculations



Black Powder Ejection Charge Calculator

by Chuck Pierc

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Volume =	1597.7	in^3	4Fg Black Powder Gas Properties		
Dia =	7.75	inch	R =	22.16	ft*lbf/lbm/R
Lengh =	33.87	inch	Tc =	3307	R
			Conversions:	1 lbm = 454 grams	
				1 oz = 28.3 grams	

Calculation Mass of Black Powder for a desired Ejection Pressure

Desired Pressure =	14	psi	
mass BP =	11.55	grams	m=PV/R/T
Ejection F =	660.4	lbf	F=P*(pi/4)*d^2

Calculate Pressure for a known Quantity of Black Powder

Mass of BP =	0.75	grams	
Pressure =	0.9	psi	P=mRT/V
Ejection F =	42.9	lbf	F=P*pi*d^2

Calculate mass of BP for a desired Ejection Force

Ejection F =	99.0	lbf	
Mass of BP =	1.73	grams	m=F*(length)/R/T
Pressure =	2.1	psi	P=F/(pi/4*d^2)

Note: Yellow fields are input fields. Clear fields are calculated fields.

Black Powder Ejection Charge Calculator

by Chuck Pierc

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Volume =	913.3	in^3	4Fg Black Powder Gas Properties		
Dia =	7.75	inch	R =	22.16	ft*lbf/lbm/R
Lengh =	19.36	inch	Tc =	3307	R
			Conversions:	1 lbm = 454 grams	
				1 oz = 28.3 grams	

Calculation Mass of Black Powder for a desired Ejection Pressure

Desired Pressure =	14	psi	
mass BP =	6.60	grams	m=PV/R/T
Ejection F =	660.4	lbf	F=P*(pi/4)*d^2

Calculate Pressure for a known Quantity of Black Powder

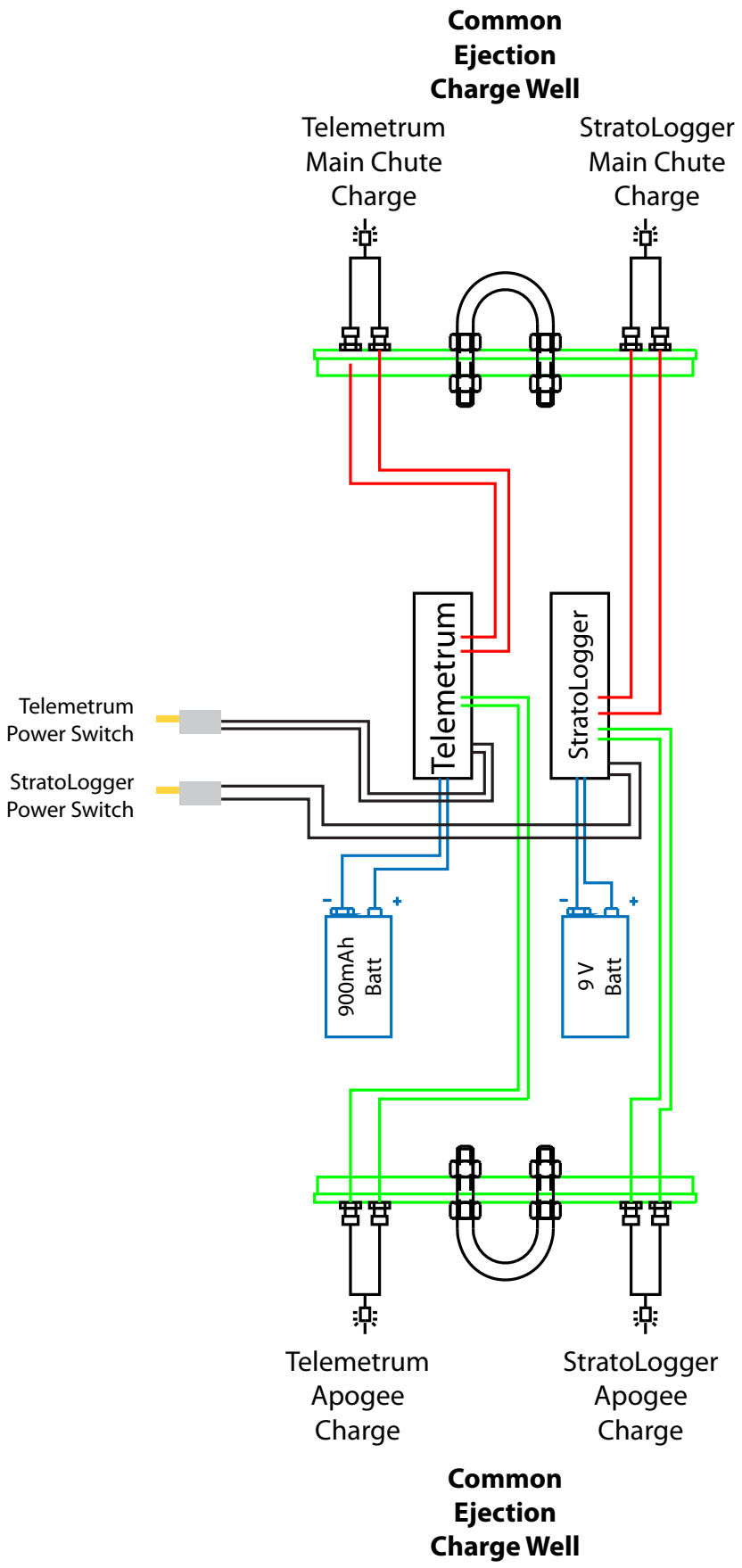
Mass of BP =	0.75	grams	
Pressure =	1.6	psi	P=mRT/V
Ejection F =	75.0	lbf	F=P*pi*d^2

Calculate mass of BP for a desired Ejection Force

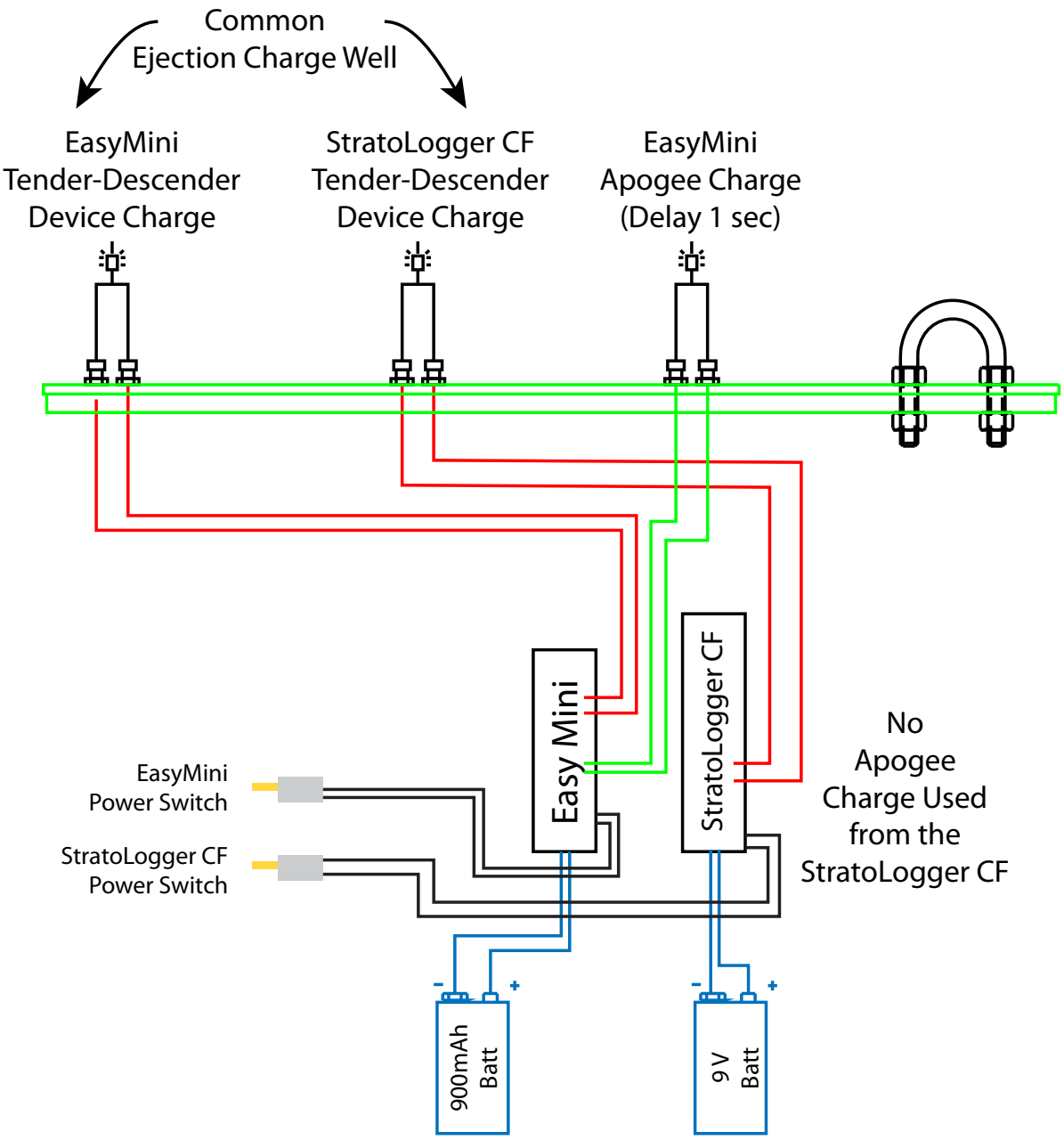
Ejection F =	99.0	lbf	
Mass of BP =	0.99	grams	m=F*(length)/R/T
Pressure =	2.1	psi	P=F/(pi/4*d^2)

Note: Yellow fields are input fields. Clear fields are calculated fields.

Forward Avionics Bay Wiring Schematic



Aft Avionics Bay Wiring Schematic



Electronics Normal Operation at Start-Up

StratoLogger CF (Newer model in forward e-bay)

On power-up. Listen for:

1. Long Dash

2. Three short blips - meaning the device is set for Main parachute to Deploy at 700 feet.

3. Long Dash

4. It will then beep out 7/10/10, indicating it is set for 700 feet.

5. Long Dash

6. The next sequence is the last flight altitude in feet. Currently is was 8085 feet

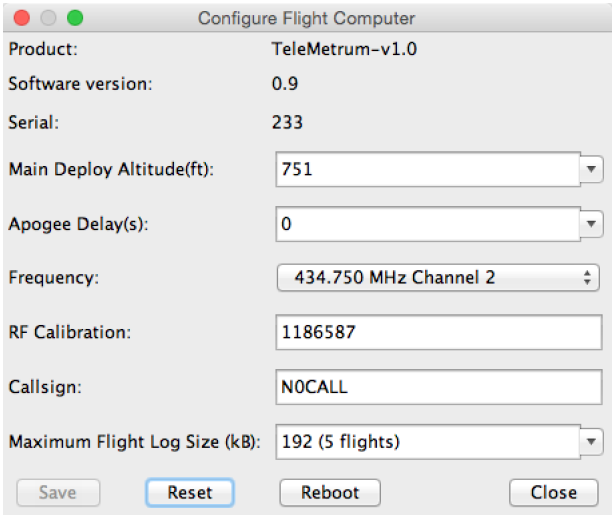
7. Long Dash

8. Next sequence is battery voltage: Should be 9/5, signifying 9.5 volts.

9. Continuity beeps that repeat continuously.
   A.) single beep - drogue OK
   B.) two beeps - main chute OK
   C.) Three beeps - both drogue and main chute have continuity
   D.) NO beeps - Nothing connected

Telemetrum

Drogue set for Apogee
Main Set for 751 feet



On power on, first set of numbers is the battery voltage: 3.7
When in the vertical orientation, listen for state: dit dah dah dit - Pad mode, ready to launch.

StratoLogger (older model in Fin-can)

On power-up. Listen for:

1. Long Dash

2. Three short blips - meaning the device is set for Main parachute to Deploy at 700 feet.

3. Long Dash

4. It will then beep out 7/10/10, indicating it is set for 700 feet.

5. Long Dash

6. The next sequence is the last flight altitude in feet. Currently is was 3620 feet

7. Long Dash

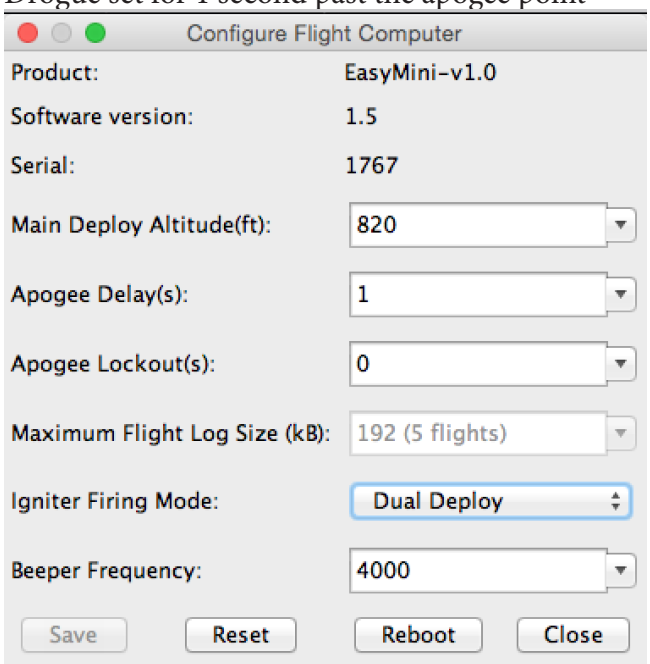
8. Next sequence is battery voltage: Should be 9/5, signifying 9.5 volts.

9. Continuity beeps that repeat continuously.
    A.) single beep - drogue OK
    B.) two beeps - main chute OK
    C.) Three beeps - both drogue and main chute have continuity
    D.) NO beeps - Nothing connected

Easy-Mini Altimeter

Listen for:

Main Set for 820 feet
Drogue set for 1 second past the apogee point



On power on, first set of numbers is the battery voltage: 4.1
Listen for state: dit dah dah dit - Pad mode, ready to launch.

Pre-launch checklist:

- ❏ 1) Motor preparation - Follow CTI PRO-98 instruction sheet.
  - Motor preparation materials, e.g. lubricants, wet rag for cleaning inside of casing.
  - Tools for airframe assembly and inspection
  - Loose hardware (e.g. for motor retention, shear pins)
- ❏ 2) Install eye-bolt on forward end of motor using lock washer and safety nut
- ❏ 3) Install Engine Retainer System
  - Need: lock washers, Fender washers, Safety wire
- ❏ 4. Prep Parachutes for Fin Can - Inspect all components for damage (e.g. tears, burns, cuts)
  - ❏ A) Attach black shock cord to eyebolt on forward end of motor.
  - ❏ B) Attach kevlar from inside deployment bag to the top of the chute canopy.
  - ❏ C) Fold parachute and install into the Deployment bag
    - ❏ shake out lines
    - ❏ Tie lines at canopy skirt
    - ❏ Organize gores so they lay flat
    - ❏ Fold or roll sides in - Rectangular shape
    - ❏ Z-fold the crown line, and put into the deployment bag into the cap
    - ❏ Push canopy into the deployment bag - keep it organized as it goes in.
    - ❏ Test to make sure it wants to pop out.

❏ Lace the shroud lines into the outer straps, Make sure the center pull-down doesn't go under the loops.

❏ Take string off the shroud lines

❏ D) Attach green cord to the tender descender link

❏ E) Attach Kevlar cord from drogue chute to tender descender link

❏ F) Z-fold black shock cord and attach rubber bands as necessary. Make sure it will pull out easily.

❏ 5) Install Igniters and ejection charge into the Tender Descender. Attach the Tender Descender to the U-bolt using the 1/4" Quick Link.

❏ 6. Attach the upper sections deployment bag to the eyebolt on the U-bolt. Extend the bag out of the rocket tube.

❏ 7) Run the wires from Tender Descender to the terminal blocks.

❏ 8) Install apogee igniter into the ejection canister. Hook up leads directly to the Easy-Mini Altimeter.

❏ 9) Install the apogee deployment charge into the fin can ejection canister.
deployment charge in aft well. 6 grams of BP. Secure BP in well with dog barf and masking tape.

❏ 10) Put the deployment bag into the rocket. Put it on the opposite side of the ejection canister. Put a nomex heat shield between the ejection charge and the lines and chute.

❏ 11) Inspect recovery compartment one last time.

Drogue Chutes are installed last

❏ 12) Prep e-bay for the upper section of the rocket.

❏ A) Inspect all electronic hook-ups.

❏ B) Connect batteries

❏ C) verify/Secure Batteries with strong Zip ties

❏ D) Verify power switches are off

❏ E) Insert igniters into the terminal blocks, and put into ejection charge wells.

❏ F) Turn on electronics on at a time and verify battery capacity and continuity

❏ G) Turn off electronics - Verify safe

❏ H) Fill Apogee ejection canister with 6 grams of BP. Secure with dog barf and masking tape.

❏ I) Insert electronic sled into switch band/coupler section

❏ J) Connect the apogee connectors together, and put aft bulkhead on the all-thread rods. (Small screw driver may be required)

❏ K) Secure with washer and two nuts on each All-Thread rod. (adjustable wrench required)

❏ L) Fill main parachute ejection well with 10.5 grams of BP (this is reduced from test amount, because it was too strong previously.

❏ 13) Thread black shock cord through the forward tube, and connect the quick-link to the U-bolt on the forward end of the eBay.

❏ 14) Install the forward tube onto the shoulder of the e-bay. Secure with four screws.

❏ 15) Fold parachute and wrap in the large green nomex cloth.

❏ 16) Verify that the quick link on the parachute and the nose cone are secure.

❏ 17) Carefully fold parachute and shock cord and place into the forward tube.

❏ 18) Place nose cone on rocket, and secure with three shear pins.

Drogue Chute Installations.

❏ 19) Install quick-like from drogue parachute onto the aft U-bolt of the e-bay section.

❏ 20) verify/tie the deployment bag on the aft U-bolt of the e-bay section.

IMPORTANT!!!
❏ 21) Place the forward section's drogue chute into the free deployment bag that is attached to the aft section.
❏ 22) Place the aft section (the fin can) drogue chute into the deployment back that is attached to the forward section.
❏ 23) Verify that heat shields are between parachutes and the deployment charges. Take close-out photo of chutes in their deployment bags.
❏ 24) Place forward section on the fin can. Secure with four shear pins.
❏ 25) Verify CG location; is it forward of the aft allowable limit (96 inches from nose tip / 18.5" from separation line)?
❏ 26) Verify igniter is available for installation (not installed)
❏ 27) Turn on cell phones.
❏ 28) verify have launch pad tools (e.g. wrenches, allen wrenches, screw drivers, wire strippers, sheet to cover rocket.)

Go to the Launch Pad

❏ 29) Verify/adjust launch angle/trajectory

Once on the launch rail, turn on electronics, starting with the top eBay. Sequence is:

A) Telemetrum (the top switch hole).
B) StratoLogger CF (Bottom switch hole).
C) StratoLogger Original (Right switch hole on aft hatch
D) Easy-Mini

❏ 30) Verify telemetry from the Telemetrum.
❏ 31) Turn on Go-Pro Camera
❏ 32) Install Igniter, and go to ready position to launch
❏ 33) Verify Flight Witnesses are ready
Indicate flight readiness to LCO/RSO

Mis-Fire Procedure

❏ Turn off all the electronics. Verify none are active.
❏ turn off go-pro camera
❏ Remove igniter
❏ Recycle to step 25.

If the rocket has to be disassembled…

❏ verify that all altimeters are in the off mode.
❏ take back to the table and put in horizontal position.
❏ remove nose cone first.
❏ remove fin can shear pins.
❏ Remove metal screws holding forward section on coupler section.
❏ disconnect igniters from the terminal blocks on both ends of the eBay section
❏ ebay can now be disassembled and inspected.

Post Flight Checklist

- ❏ A) Verify all pyrotechnics are discharged
- ❏ B) Safe the pyrotechnic systems if live devices are present
- ❏ C) Attempt to identify the reason for the unfired pyrotechnic
- ❏ D) Record or save any flight data indicates that will be lost after power removal
- ❏ E) Remove power from electronic systems per disassembly procedure.

Stuff to bring:

shear pins
extra countersunk screws
nylon electronics screws
zip ties
Dog barf
Masking tape
rubber bands
Long 300lb kevlar string
Extra 900mAh battery charged
Extra 9V batteries
Safety glasses for myself and others around BP
Walkie-Talkies

Lifeproof Rocket - Simulation results

Engine selection

[M1450-Classic-None]

Simulation control parameters

- Flight resolution: 800.000000 samples/second
- Descent resolution: 1.000000 samples/second
- Method: Explicit Euler
- End the simulation when the rocket reaches the ground.

Launch conditions

- Altitude: 4500.00002 Ft.
- Relative humidity: 50.000 %
- Temperature: 45.000 Deg. F
- Pressure: 29.9139 In.

Wind speed model: Custom speed range

- Low wind speed: 8.0000 MPH
- High wind speed: 8.0000 MPH

Wind turbulence: Constant speed

- Frequency: 0.000000 rad/second

- Wind starts at altitude: 0.00000 Ft.
- Launch guide angle: 5.000 Deg.
- Latitude: 38.560 Degrees

Launch guide data:

- Launch guide length: 98.0000 In.
- Velocity at launch guide departure: 35.4681 MPH
- The launch guide was cleared at : 0.386 Seconds
- User specified minimum velocity for stable flight: 29.9996 MPH
- Minimum velocity for stable flight reached at: 70.1260 In.

Max data values:

- Maximum acceleration:Vertical (y): 20.517 geeHorizontal (x): 0.515 geeMagnitude: 20.517 gee
- Maximum velocity:Vertical (y): 425.8303 MPH, Horizontal (x): 8.1996 MPH, Magnitude: 425.8337 MPH
- Maximum range from launch site: 868.29963 Ft.
- Maximum altitude: 6371.03301 Ft.

Recovery system data

- P: 24" Drogue Parachute Deployed at : 20.656 Seconds
- Velocity at deployment: 1.4446 MPH
- Altitude at deployment: 6371.03298 Ft.
- Range at deployment: 47.71430 Ft.

Time data

- Time to burnout: 6.871 Sec.
- Time to apogee: 20.656 Sec.
- Optimal ejection delay: 13.785 Sec.

Landing data

- Successful landing