

**Wildman Extreme**  
Tripoli L3 Certification Package  
**TRI 15508**

by  
Curtis Heisey

Feb 17, 2019

Tripoli Advisory Panel Sponsors:  
W. E. (Fred) Wallace , TRA 5763  
David Weber  
Mike Dutch  
Jim Livingston

## Overview

**My L3 rocket is a Wildman Extreme, a very tried and true 3 fins and a nose cone 4-in diameter fiberglass design. It is a dual deploy rocket, with drogue in the booster compartment, and main in the payload compartment. I added a machined thrust plate, and I glassed the fins, but these are they only mods to the kit. I used metal av bay bulkheads, which balanced the CG changed due to the glassed fins. The rocket will weight 17.7 lbs without motor or case and is 98 inches high. It will fly on a CTI 4-grain 75mm M1101. The simulated altitude is 12500 feet and Mach 1.06. My rockets tend to be “draggier” than the sim, so I doubt if it will hit Mach 1. Nonetheless, I have made design considerations for breaking the speed of sound (offset of shear pins and vent holes, strength considerations, etc.).**

**The drogue will deploy at apogee by a BP charge and an e-match. It will have two redundant BP charges. There will be 3 flight computers, Raven, Quantum and Telemetrum. The Main will deploy at 700 feet via a Tinder CO2 system. It will have two BP backups.**

### **Highlights:**

4.0 Diameter FB rocket, 98 inches in length

Booster: 58 inch long FB

Av bay: 11 inch FB coupler with 1 inch switch band

Payload: 24 inch FB

NC: 21 inch FB with Metal tip

4x ¼ inch Plywood fins, glassed, through the wall.

Weight: 17 lbs no motor or case, 29 lbs with motor

Launches on an 8ft 1515 rail

Practice flight on CTI K454m (54mm w/Aeropac adapter)

Stability : 4.26 cal

CG: 62.133 in CP: 79.457 in

Average Thrust: 102 lbs

Mass with motors: 21.1 lb

Thrust to weight ratio: 4.8

Altitude: 2356

Velocity off Pad 14.6 m/s

Max Velocity 116 m/s

Max acceleration: 49 m/s<sup>2</sup>

On CTI M1101 (75 mm

Stability: 2.82 Cal

CG: 68.016 in CP: 79.457 in

Average thrust: 250 lbs

Mass with motors 28.9 lb

Thrust to weight ratio: 8.7

Altitude 12502 ft

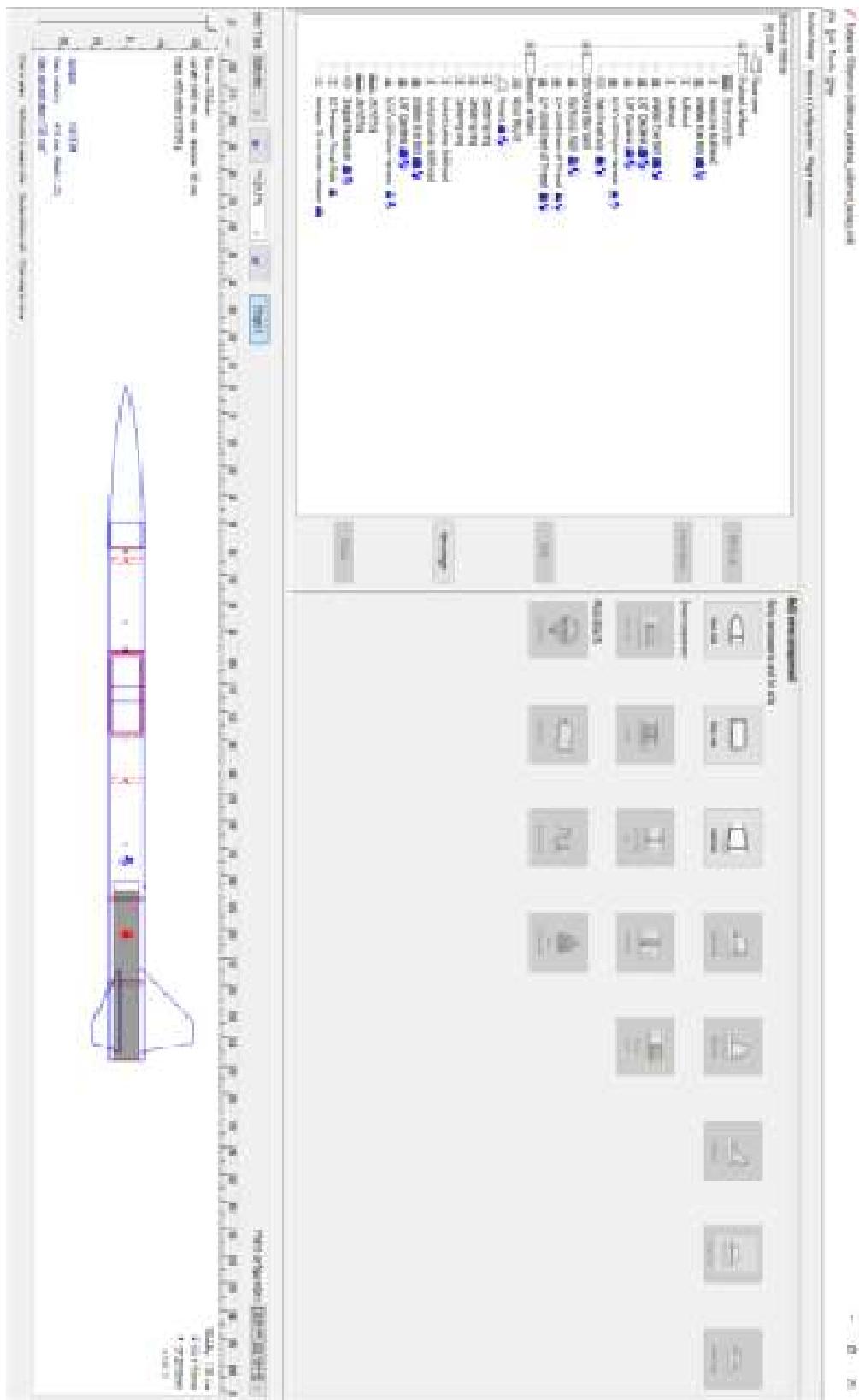
Velocity off Pad 21.6 m/s

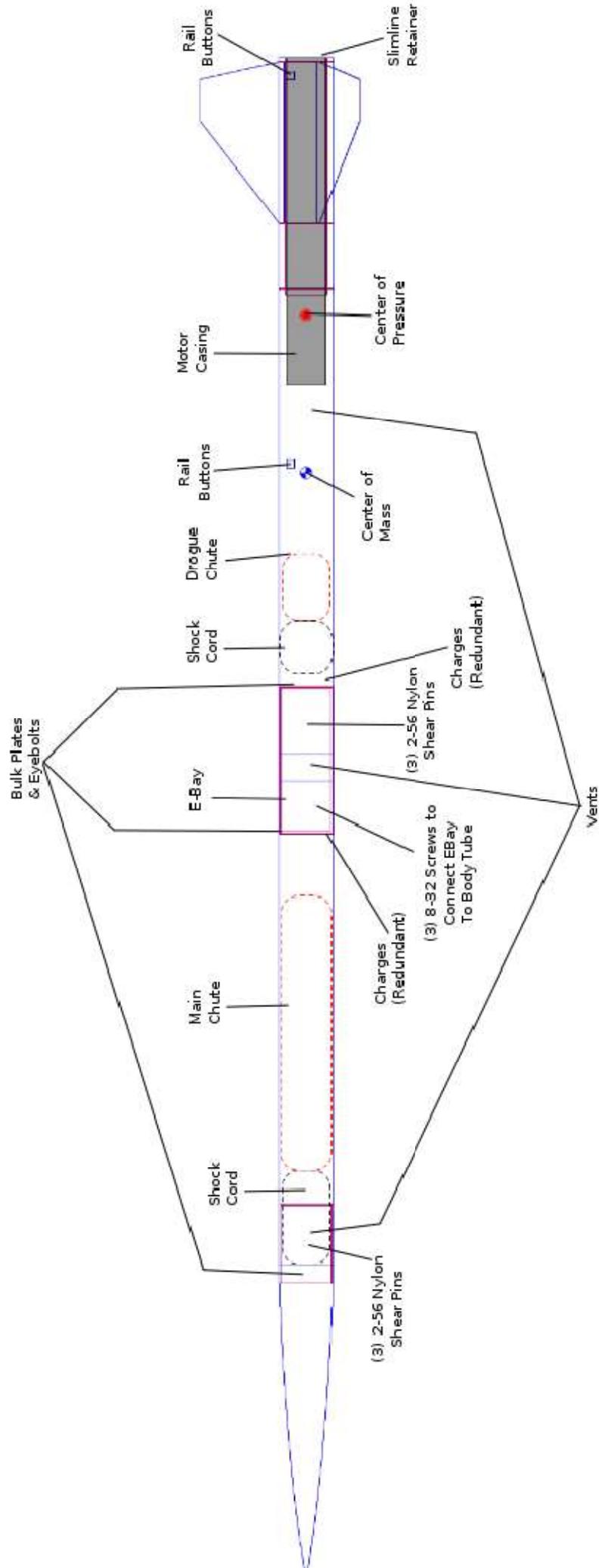
Max Velocity 345 m/s

Max acceleration 99.6 m/s<sup>2</sup>

OpenRocket Design and Sim

## Construction





## Set of parts



## Bill of Materials

Item	Supplier	P/N	URL
Wildman Extreme Kit	Wildman	4 in	<a href="https://wildmanrocketry.com/collections/wildman-4-inch-kits/products/wildman-extreme">https://wildmanrocketry.com/collections/wildman-4-inch-kits/products/wildman-extreme</a>
Thrust plate	SC Precision	113-080-054	<a href="http://www.scpconcepts.com/rocket-accessories.html">http://www.scpconcepts.com/rocket-accessories.html</a>
75 mm retainer	Aeropac	RA 75	<a href="https://aeropack.net/motorretainers.asp">https://aeropack.net/motorretainers.asp</a>
Stainless Steel Low-Profile Binding Barrels	McMaster-Carr	94887A142	<a href="https://www.mcmaster.com/94887a142">https://www.mcmaster.com/94887a142</a>
Super-Corrosion-Resistant 316 Stainless Steel Threaded Rods, 2 ft	McMaster-Carr	93250A440	<a href="https://www.mcmaster.com/93250a440">https://www.mcmaster.com/93250a440</a>
Av bay bulkheads	RocketJunkies	Custom	<a href="http://rocketjunkies.com/product/custom-aluminum-bulkheads/">http://rocketjunkies.com/product/custom-aluminum-bulkheads/</a>
304 Stainless Steel U-Bolt 1/4"-20 Thread Size, 7/8" ID (2)	McMaster-Carr	8889T41	<a href="https://www.mcmaster.com/8889t41">https://www.mcmaster.com/8889t41</a>
Charge Wells	RocketJunkies	3 Gram	<a href="http://rocketjunkies.com/product/3-gram-aluminum-charge-wells/">http://rocketjunkies.com/product/3-gram-aluminum-charge-wells/</a>
Drogue	Top Flight X form	24 inch	<a href="https://topflightrecoveryllc.homestead.com/page1.html">https://topflightrecoveryllc.homestead.com/page1.html</a>

Main	Rocketman	8 ft Chute	<a href="https://the-rocketman.com/chutes-html/">https://the-rocketman.com/chutes-html/</a>
CO2 Ejection	Tinder Rocketry	Raptor	<a href="https://www.tinderrocketry.com/raptor-co2-ejection">https://www.tinderrocketry.com/raptor-co2-ejection</a>
Harness, Main	OneBadHawk	25 foot, 2 loop, Nomex stitched on	<a href="http://onebadhawk.com/716-tubular-kevlar--3-loop.html">http://onebadhawk.com/716-tubular-kevlar--3-loop.html</a>
Harness, Drogue	OneBadHawk	30 foot, 3 loop, Nomex stitched on	<a href="http://onebadhawk.com/716-tubular-kevlar--3-loop.html">http://onebadhawk.com/716-tubular-kevlar--3-loop.html</a>

### Misc Parts: RocketPoxy, Stainless D-rings Wildman directions

<https://www.dropbox.com/s/wi61fs84krcwl5/WM%20Standard%20Dual%20Deploy%20Build%20Instructions.pdf?dl=0>

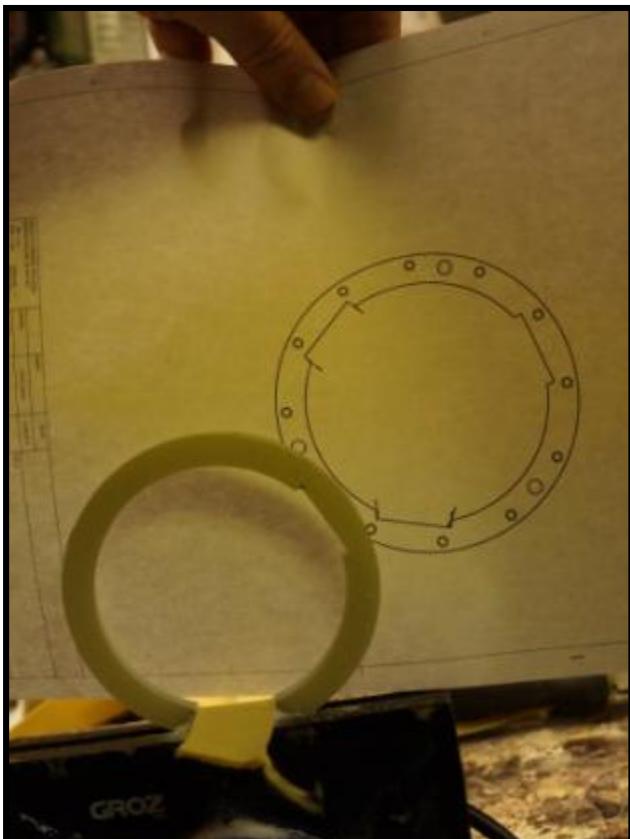
**Wash Parts and score edges**



**Glue bulkheads, NC coupler, and switch band with RocketPoxy**



## Glue Y-Harness



## Insert lower rail button



Stainless Steel Low-Profile Binding Barrels and Screws P/N 94887A142  
8-32 Thread Size, for 1/2"-3/4" Material Thickness

**McMASTER-CARR.**

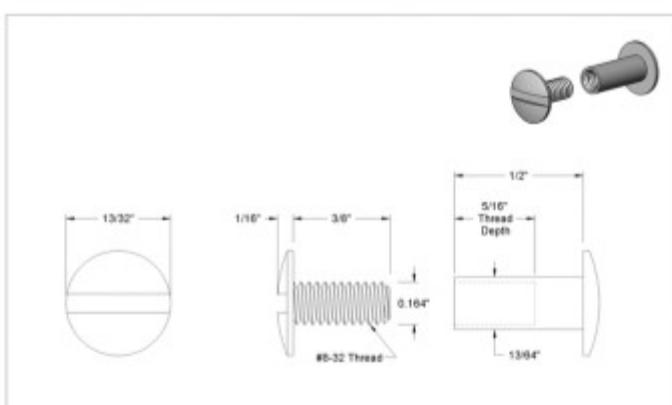
Find

### **Stainless Steel Low-Profile Binding Barrels and Screws**

8-32 Thread Size, for 1/2"-3/4" Material Thickness



Made from 18-8 stainless steel, these binding barrels and screws are chemical resistant and may be mildly magnetic. A thin head provides a nearly flush finish with the material surface. Barrel length and screw length are measured from under the head.



1/2"-3/4" Material Thickness

**McMASTER-CARR. U.S.A.** PART NUMBER **94887A142**  
©2011 McMaster-Carr Supply Company  
McMaster-Carr.com • 800.273.4389

**Glue motor mount tube in place**



### **Fin alignment:**

Vertical alignment is provided by slots in body. Radial alignment is provided by 3d printed fin jig.

Glue first fin in place using fin jig



Glue fins two and three in place

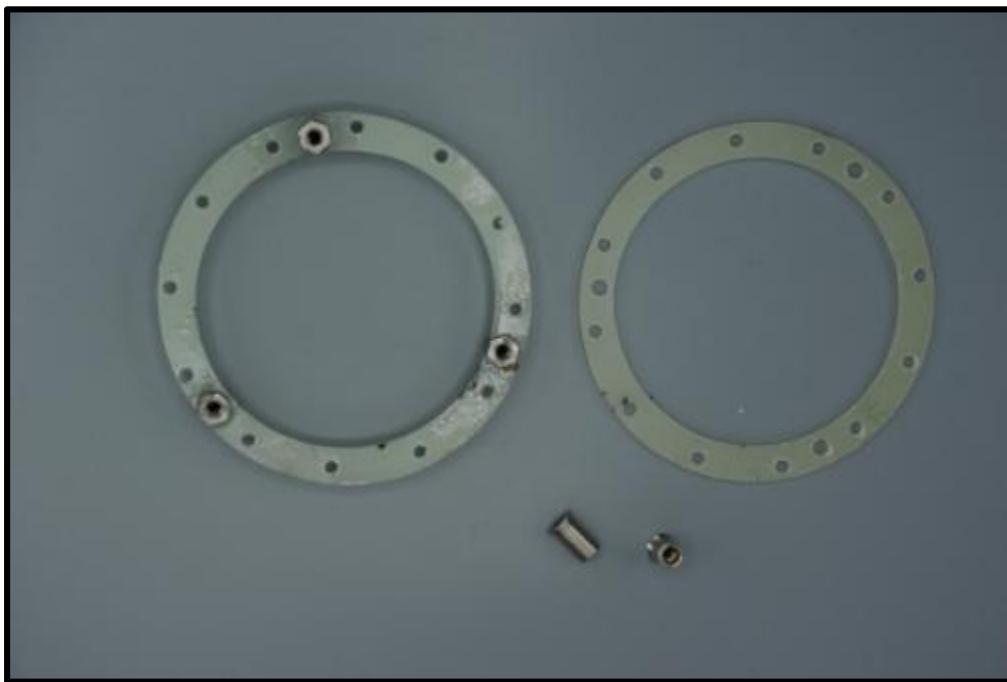


**Strengthen NC**



## Lower Bulkhead

The lower bulkhead is two FB centering rings. Drill holes in the bulkheads. Glue the press fits into the lower bulkhead. The bulkheads will make a sandwich to hold the press fits in place. They will hold the thrust plate on, so they must be strong. The press fits are glued, so they do not turn. This will allow bolts to be tightened.



Glue internal fillets between the inside edge of the fin and the motor tube



. Make sure the thrust ring has clearance to fit. Align the holes in the pair of lower bulkheads.



### **Booster details – thrust plate**

SC Precision thrust plate

Aeropac retainer for motor retention. FB tube for motor mount.





## Glass the fins

Glass the fins to the body tube to provide strength and maintain alignment.

Measure the carbon fiber cloth, peel ply, breather cloth, and sealant film.



Lay up the stack.



Apply resin (a similar fin shown here).



Mix the epoxy



Pump it down and let it cure overnight



Voila!! A beautiful fin



Tip-to-tip layer











## Treatment of edges



## Static Port sizing

<http://www.offwegerocketry.com/userfiles/file/Calculators/Static%20Port%20Holes.xls>

<b>Static Port Hole Calculator</b> by Gary Stroick				
<b>Constants</b>				
<b>Variables</b>	<i>Imperial</i>		<i>Metric</i>	
	<b>Values</b>	<b>Units</b>	<b>Values</b>	<b>Units</b>
Air Specific Heat Ratio	1.401			
Discharge Coefficient	0.62			
g	32.17404856	ft s <sup>-2</sup>	9.80665	m s <sup>-2</sup>
Gas Constant	89494.596	lbm ft <sup>2</sup> lb-mol <sup>-1</sup> K <sup>-1</sup> s <sup>-2</sup>	8.31432	N m mol <sup>-1</sup> K <sup>-1</sup>
Lapse Rate	-0.0019812	°K ft <sup>-1</sup>	-0.0065	°K m <sup>-1</sup>
One Atmosphere	29.92126	inHg	101325	Pa
One Mole Air Density	28.9645	lbm lb-mol <sup>-1</sup>	0.0289645	kg mol <sup>-1</sup>
<b>Conversion Factors</b>				
	<b>Values</b>	<b>Units</b>		
inHgtoPSF	70.7261873	lbf ft <sup>-2</sup>		
JouletoLAtm	0.0098692	J L <sup>-1</sup> Atm <sup>-1</sup>		
LitertoCubicInches	61.023744	in <sup>3</sup>		
MeterstoInches	39.37007874	in		
MeterstoFeet	3.280839895	ft		
<b>Enter Data Values into Turquoise Cells</b>				
Measurement System	Imperial			
<b>Anticipated Launch Parameters (Optional)</b>				
Highest Launch Temperature	49	°F	9.5 °C	
Lowest Launch Altitude	728	ft	253 m	
Maximum Velocity	1220.47	ft/s	122 m/s	
<b>Avionics Bay Parameters (Required)</b>				
Altimeter Bay Radius	2	in	7.4 cm	
Altimeter Bay Length	11	in	29.2 cm	
Number of Ports	3		4	
Atmospheric Pressure at Launch Altitude	29.12728582	inHg	98264.644 Pa	
Air Density (Dry Air)	0.075908705	lbm/ft <sup>3</sup>	1.2111212 kg/m <sup>3</sup>	
Atmospheric Pressure Change	0.01215%		0.0001216	
Pressure Equalization Rate	0.002688177	s	0.0081967 s	
Choked Threshold	1.893532653		1.8935327	
Altimeter Bay Volume	138.2300768	in <sup>3</sup>	5023.3815 cm <sup>3</sup>	
Air Mass	0.00607226	lbm	0.0060839 kg	
Mass Flow Rate	0.000274467	lbm/s	9.023E-05 kg/s	
<b>Size of Ports</b>	11/64 in			

Av bay:

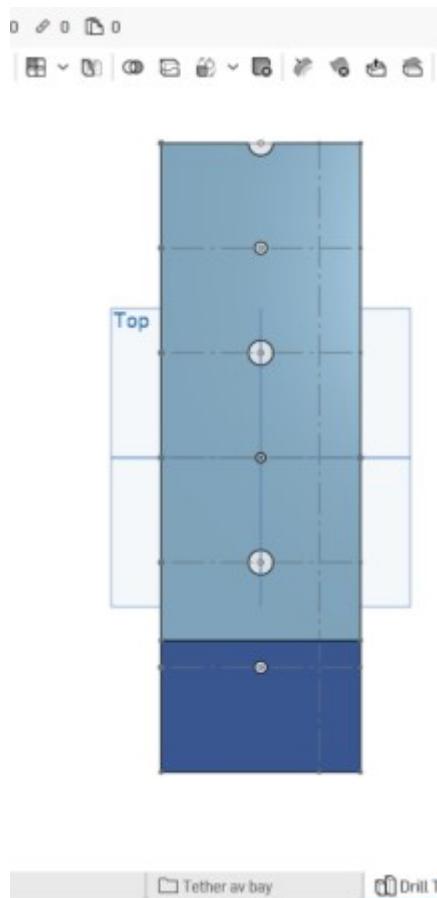
## Altimeter holes

Offset static port holes from NC bolts (so turbulence doesn't mess up altimeter) [Create CAD drill template](#)

Use #36 Drill (.1065) for 4-40 Nylon bolts so they press fit in snugly without threading

Use 3/32 Drill to tap NC screws for 4-40

Use 11/64 for 3 vent holes in the altimeter switch band



**AIRFRAME DIAMETER & DESIRED FORCE**

AIRFRAME DIAMETER	100lbs	150lbs	200lbs	250lbs
2.6"	19 psi	28 psi	38 psi	47 psi
4.0"	8 psi	12 psi	16 psi	20 psi
6.0"	3.5 psi	5.3 psi	7.0 psi	8.8 psi
7.5"	2.3 psi	3.4 psi	4.5 psi	5.7 psi

the size of the tube to be pressurized and *either* the size of your charge or the desired pressure. Pressing the appropriate button to the data entered will give you the missing piece of data. The maximum number of #2 and #4 nylon screw shear pins that can be will also be determined for either the calculated charge or pressure.

**Action Charge Calculator**Tube Diameter (in) Tube Length (in) Desired Pressure (suggest 8 to 15 psi)  Grams of 4F Black Powder  Number of 2-56 Nylon Screws (Shear pins) Number of 4-40 Nylon Screws (Shear pins)

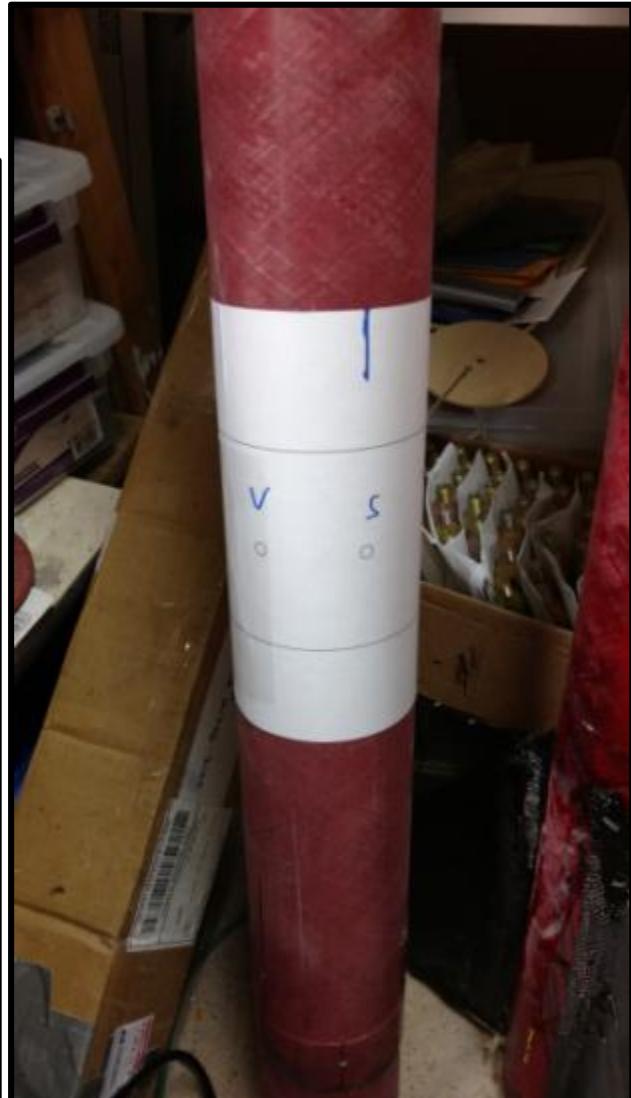
PSI gain

The image shows a calculator interface titled "Calculate Air Pressure at Altitude". It has three input fields: "Pressure at Sea Level" (14.70 psi), "Temperature" (15 °C), and "Altitude" (13000 m). A "CALCULATE" button is centered below the inputs. The result is displayed as "Air Pressure at Altitude = 2.40 psi".

Parameter	Value	Unit	Status
Pressure at Sea Level	14.70	psi	Default
Temperature	15	°C	Default
Altitude	13000	m	
<b>CALCULATE</b>			
Air Pressure at Altitude	= 2.40	psi	

## Drilling Vent Holes

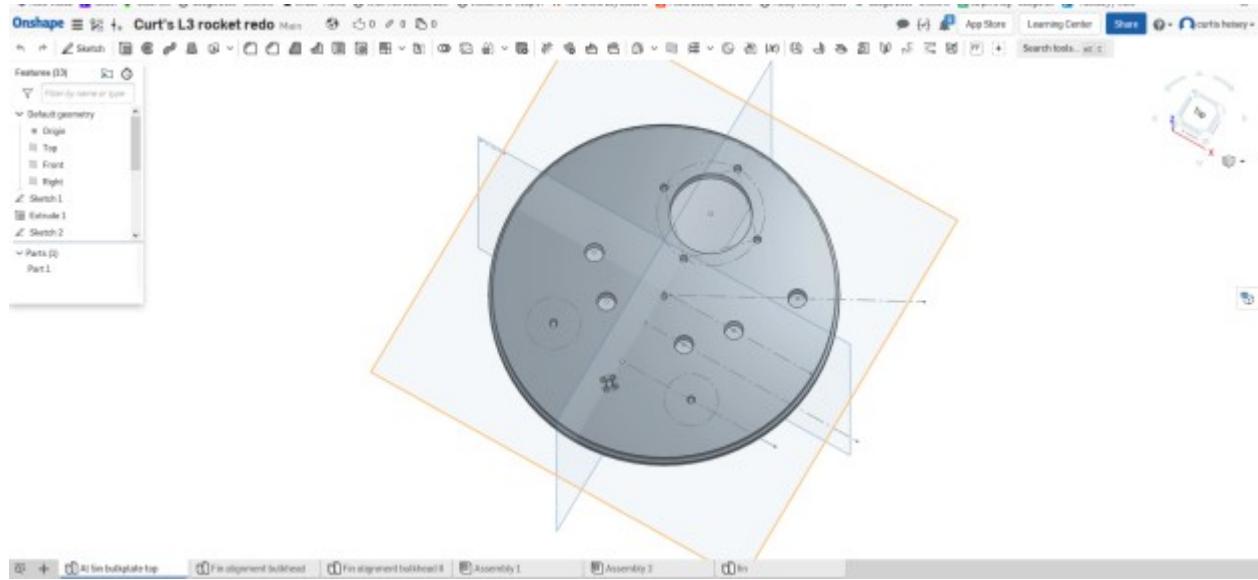
Measure the vent holes. Make sure vent holes and mounting nuts on NC do on align vertically



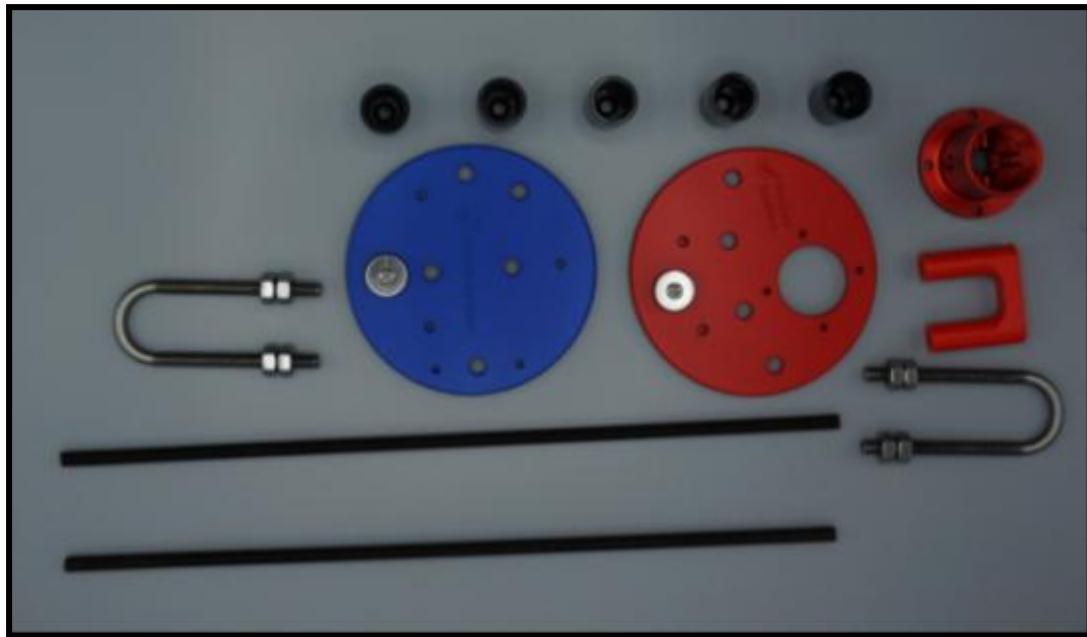


## Av bay Design

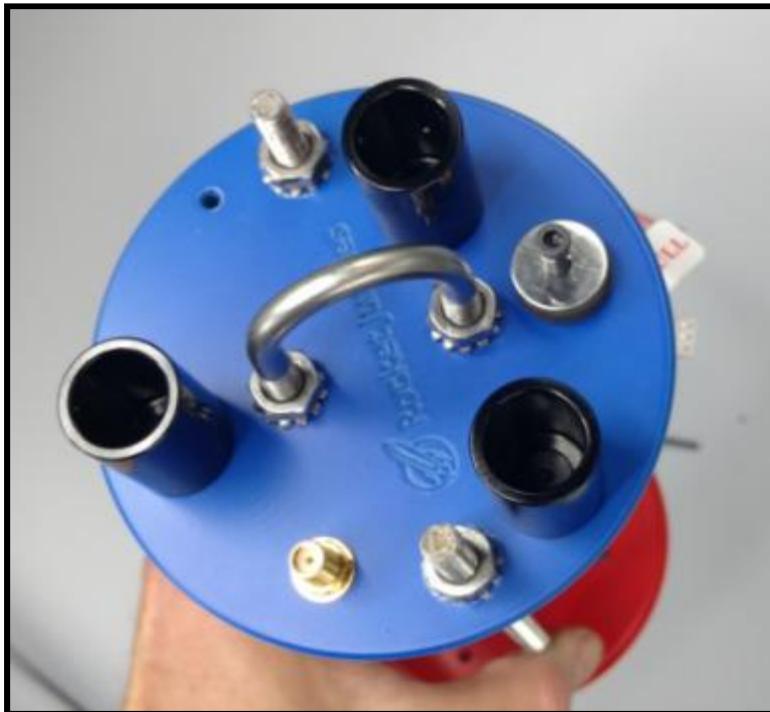
My CAD design for the altimeter bulkhead.

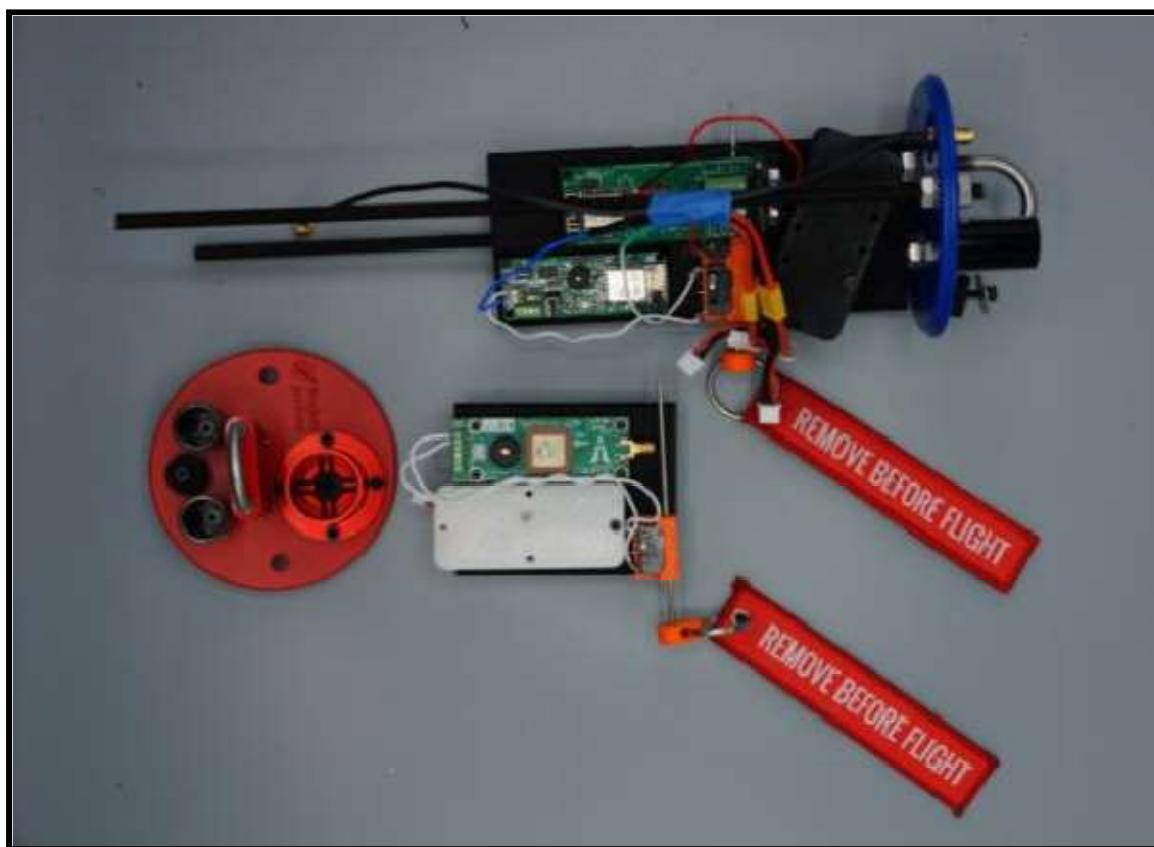
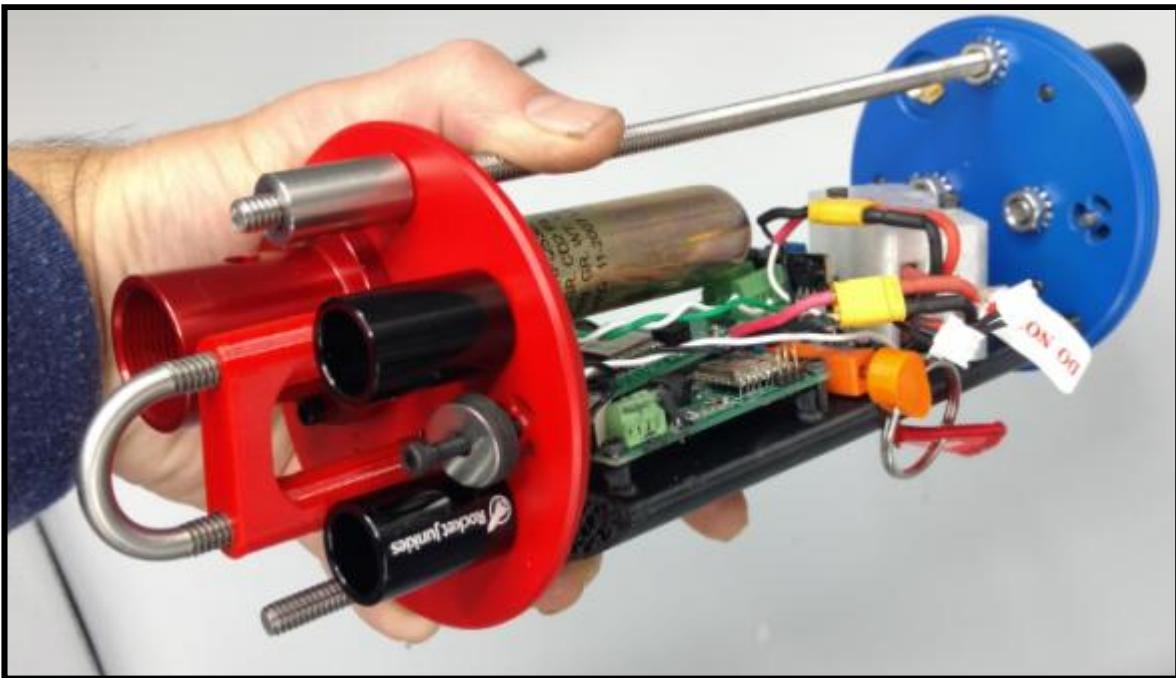


Altimeter bay hardware



Assembled Bulkheads

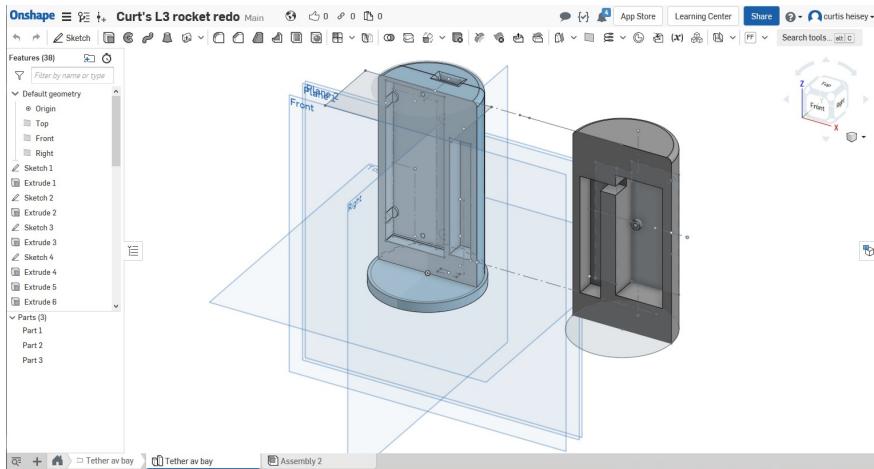




## NC Tracker

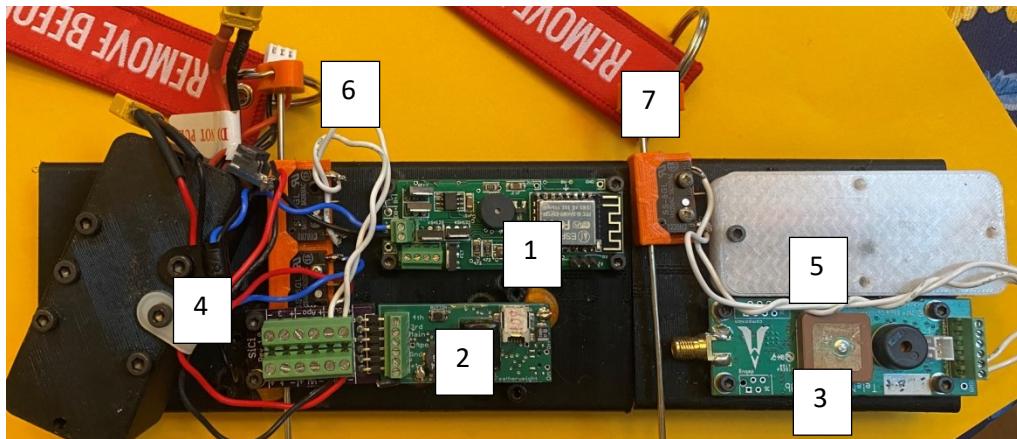
### Tether av bay

Custom 3d printed of my own design



## Altimeter Layout and Channel programming

Top view of the altimeter bay



Eggtimer Quantum (1)

Raven (2)

TeleMetrum (3)

Batteries (two) for Eggtimer and Raven altimeters (4)

Battery for TeleMetrum (5)

Pull switches (two) for Eggtimer and Raven (6)

Pull Switch for TeleMetrum (7)

Screw terminal are positioned toward their respective assignments (e.g, main connections are located on the right)

All the altimeters can be turned on off from their battery connections via LabRat pull switches. In addition, the Eggtimer altimeters require wi-fi remote arming. The TeleMetrum has a data link to an antenna dongle.

## Altimeter Programming

Apogee:

BP charge with 2 BP backups

Main:

Tinder CO2 with 2 BP backups

Altimeter	Output Channel	Function
Eggtimer quantum, Quantum_18A11	D- Apogee+1s #1	
Raven	M- Main 700 CO2 Ignitor #1	
	1 Apogee	
	2 Main 672 CO2 Ignitor #2	
	3 Apogee + 2s	
	4 Main 480	
Telemetrum	D – Apogee + 3s M – Main 600	
Eggtimer RF in NC	N/A	Telemetry only

Tracker: AltusMetrum, Eggtimer RF in NC

BP: 3grams with 3 4-40 shear pins

<http://www.rimworld.com/nassarocketry/tools/chargecalc/index.html>

## Lab Rat Pull switches



Telemetrum battery is 1S LiPo 600 mAh

600mAh 1S LiPo Battery 3.7V 50C JST-PH 2.0 PowerWhoop mCPX Connector for Inductrix FPV Plus Tiny 7 RC Micro FPV Quadcopter Drone

[https://www.amazon.com/gp/product/B077PRY7K3/ref=ppx\\_yo\\_dt\\_b\\_search\\_asin\\_title?ie=UTF8&psc=1](https://www.amazon.com/gp/product/B077PRY7K3/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1)



Weight: 15g(0.03lb), Size: 8x18x60mm(0.31x0.71x2.36inch)  
Work with Tiny 7 and Inductrix FPV Plus etc.  
600mAh 1S 50C LiPo w/ Ultimate size

\* JST-PH 2.0 AKA mCPX, Powerwhoop Connector

Egg timer batteries are 2S LiPo 450 mAh

Tattu 4 Packs 450mAh 7.4V 75C 2S LiPo Battery Pack with XT30 Plug - Long Size for H Frame and BETAFPV 2S Whoop

[https://www.amazon.com/gp/product/B07K18DJG5/ref=ppx\\_yo\\_dt\\_b\\_search\\_asin\\_title?ie=UTF8&psc=1](https://www.amazon.com/gp/product/B07K18DJG5/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1)

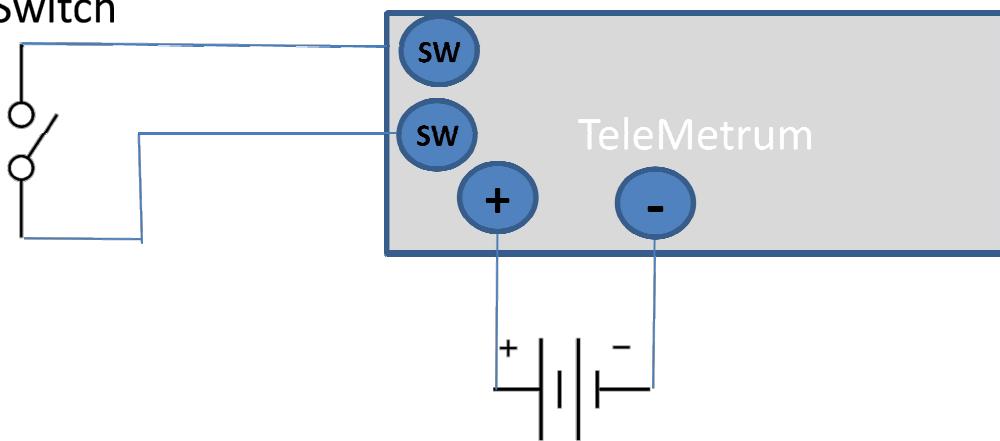


## Telemetrum Channel Connections



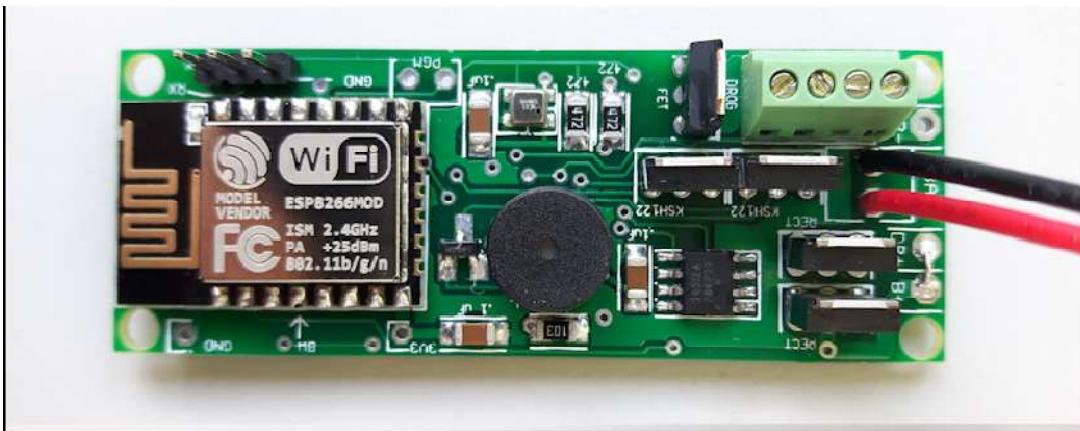
Terminal #	Terminal Name	Description
1	Switch Output	Switch connection to flight computer
2	Switch Input	Switch connection to positive battery terminal
3	Main	Main pyro channel common connection to battery
4	Main	Main pyro channel connection to pyro circuit
5	Apogee	Apogee pyro channel common connection to battery
6	Apogee -	Apogee pyro channel connection to pyro circuit

### Pull Switch

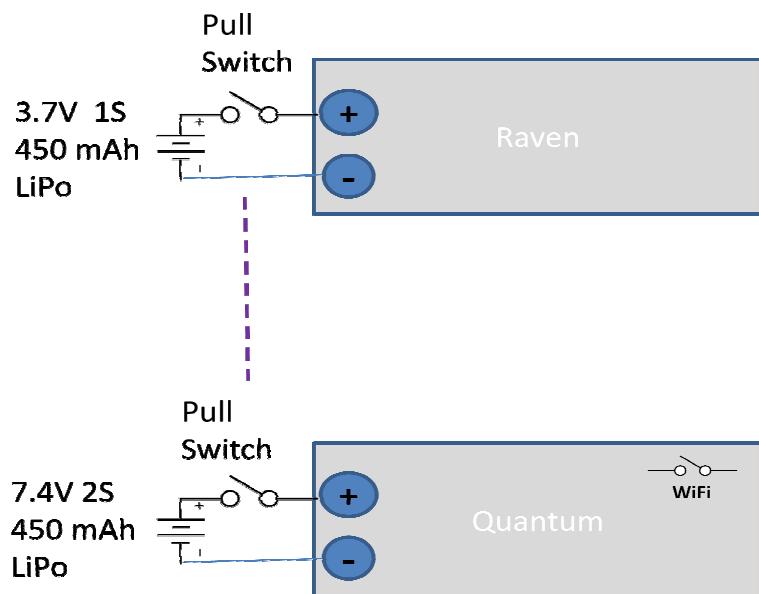


3.7V  
300 mAh  
LiPo

## Eggtimer Quanum Channel Connections

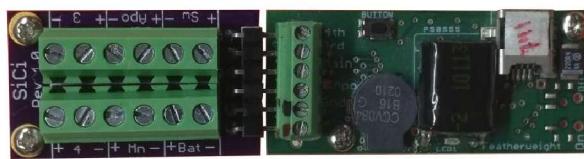
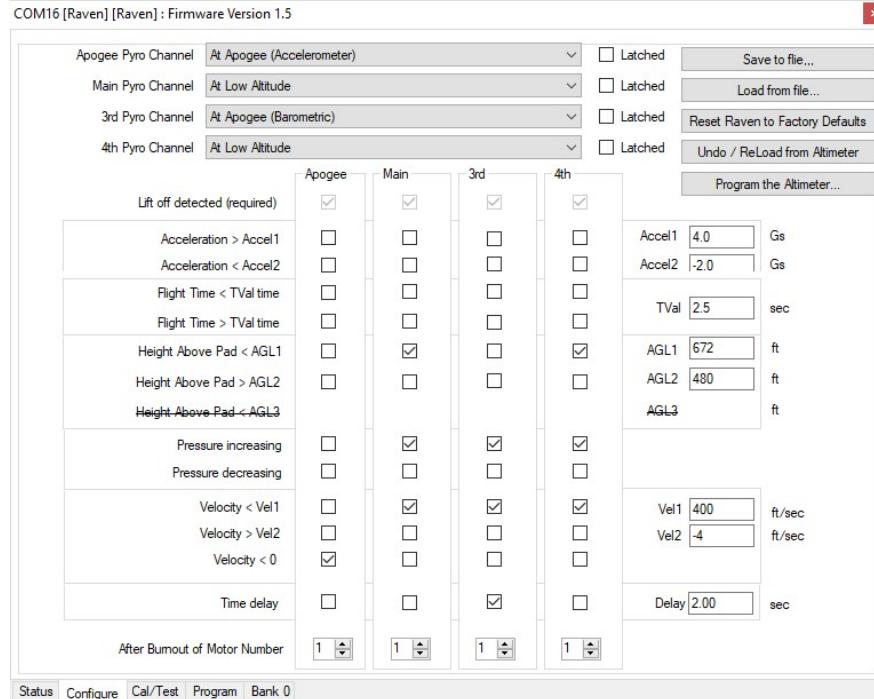


In the picture, Drogue channel is on left, main is on right



## Raven Connections

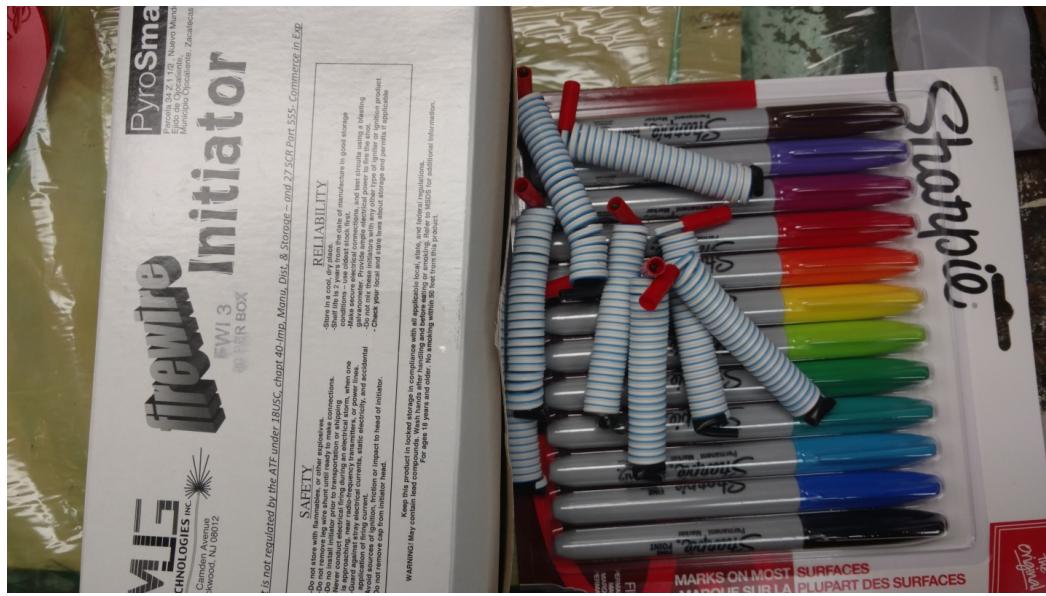
Raven	1 Apogee	
	2 Main 672 CO2 Ignitor #2	
	3 Apogee + 2s	
	4 Main 480	



## Igniters

MJG Firewire

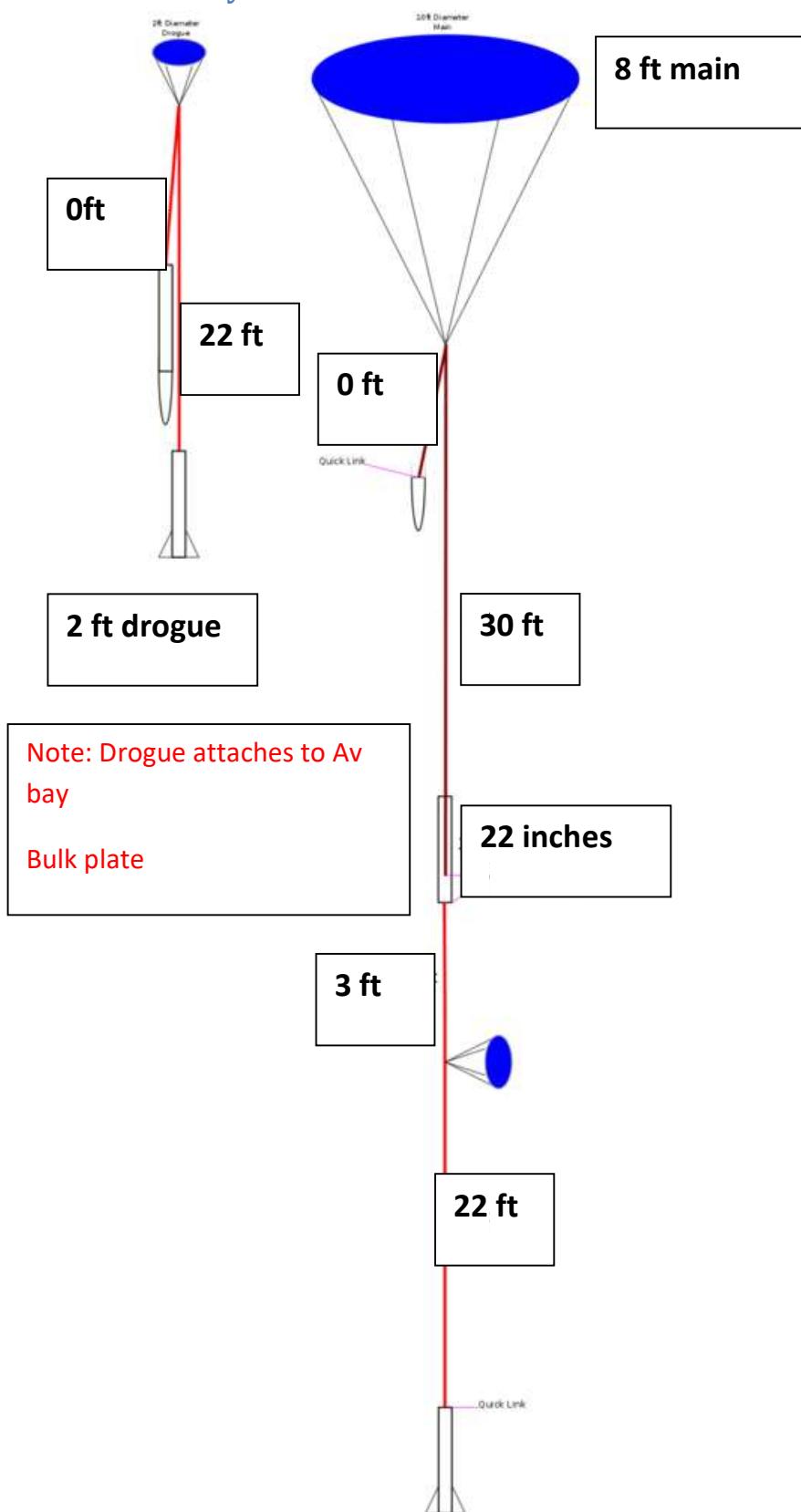
Use sharpies to color code the ends.



## Tinder CO2 Raptor



## Recovery:



**Drogue:**

24 inch Top Flight Ultra-X extra heavy duty lines  
<https://topflightrecoveryllc.homestead.com/page1.html>

**Main**

Empty rocket is ~ 20 lbs, so that should give 20 ft/s on 8 ft main.

**Pilot:**

20% of main = 1.6 ft

Parachute	Description
Drogue	2ft w/reinforce lines ~ 70 ft/sec
Main	<b>8Ft. Standard Parachute - Rocketman</b> Weight of parachute: 10oz Package Volume: $4.0''D \times 6.5L'' = 81.68''^3$ Descent Rate: 15ft/sec: 12.0lbs 17ft/sec: 15.0lbs 20ft/sec: 20lbs 25ft/sec: 30lbs

## Ready For Ground Testing



## Ground Testing

Main – CO2 ejection successful test 11/17/2019



Drogue – BP ejection successful test 11/21/2019



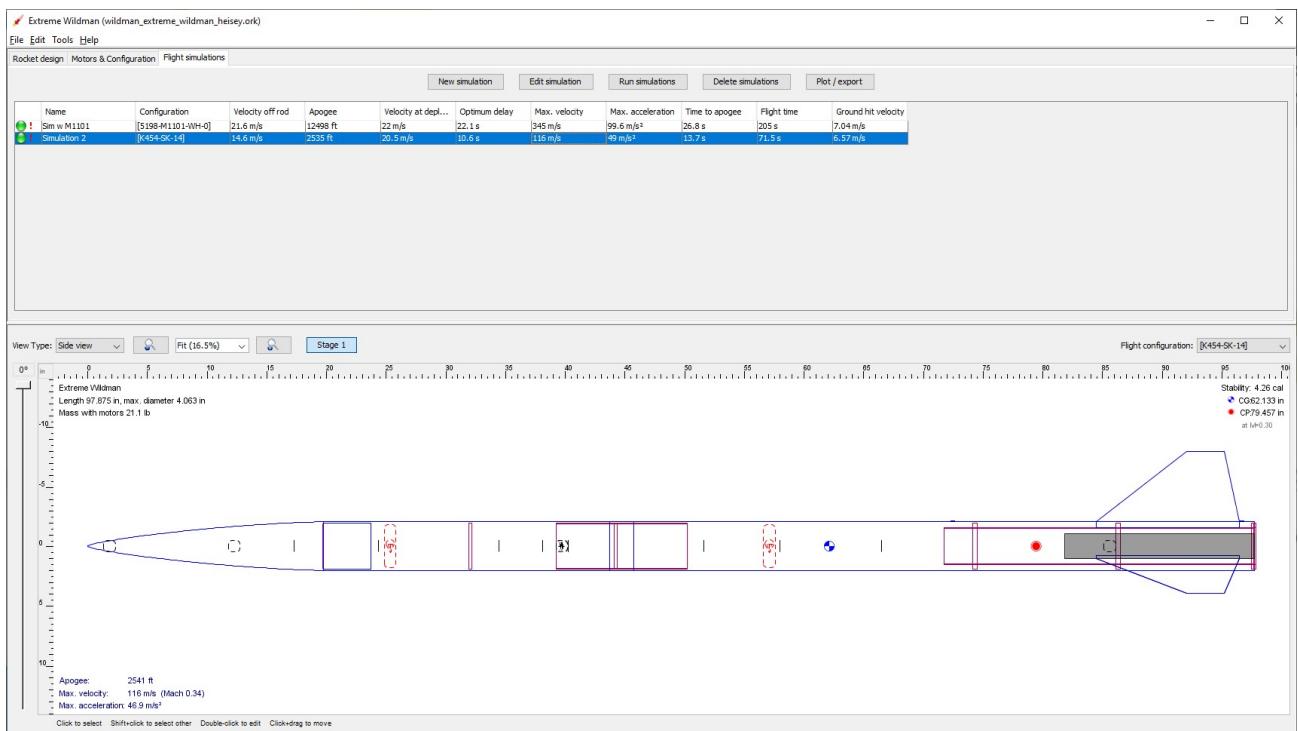




## Shakedown Flight on a "K"

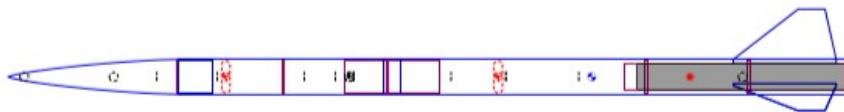
CTI K454 54 mm w/ 76-54 Aeropac Adapter

Sims to 2500 feet



## Flight stability

### Rocket Design



Extreme Wildman

Stages: 1

Mass (with motor): 13105 g

Stability: 2.82 cal

CG: 1728 mm

CP: 2018 mm

#### 5198-M1101-WH-0

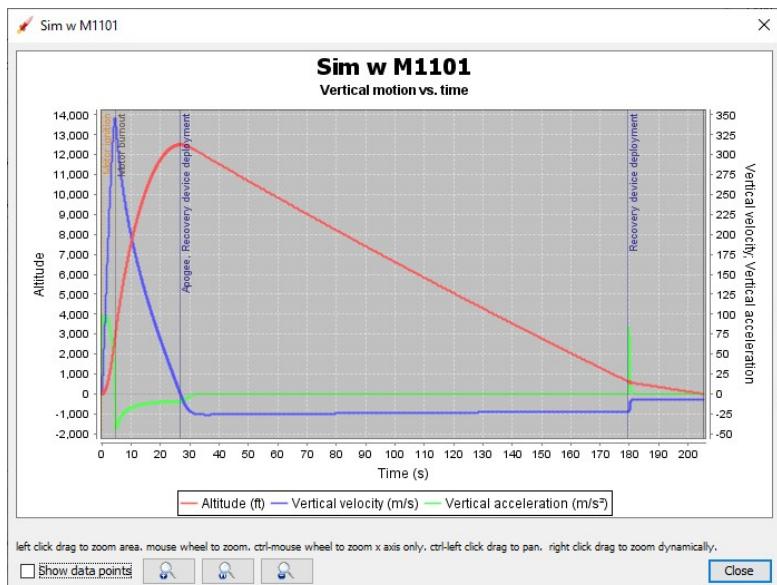
Altitude 12498 ft  
Flight Time 20.5 s  
Time to Apogee 26.8 s  
Optimum Delay 22.1 s  
Velocity off Pad 21.6 m/s  
Max Velocity 34.5 m/s  
Velocity at Deployment 22 m/s  
Landing Velocity 7.04 m/s

Motor	Avg Thrust	Burn Time	Max Thrust	Total Impulse	Thrust to Wt	Propellant Wt	Size
5198-M1101-WH	1111 N	4.68 s	1437 N	5200 Ns	8.65:1	3096 g	75/621 mm

#### K454-SK-14

Altitude 2535 ft  
Flight Time 71.5 s  
Time to Apogee 13.7 s  
Optimum Delay 10.6 s  
Velocity off Pad 14.6 m/s  
Max Velocity 116 m/s  
Velocity at Deployment 20.5 m/s  
Landing Velocity 6.57 m/s

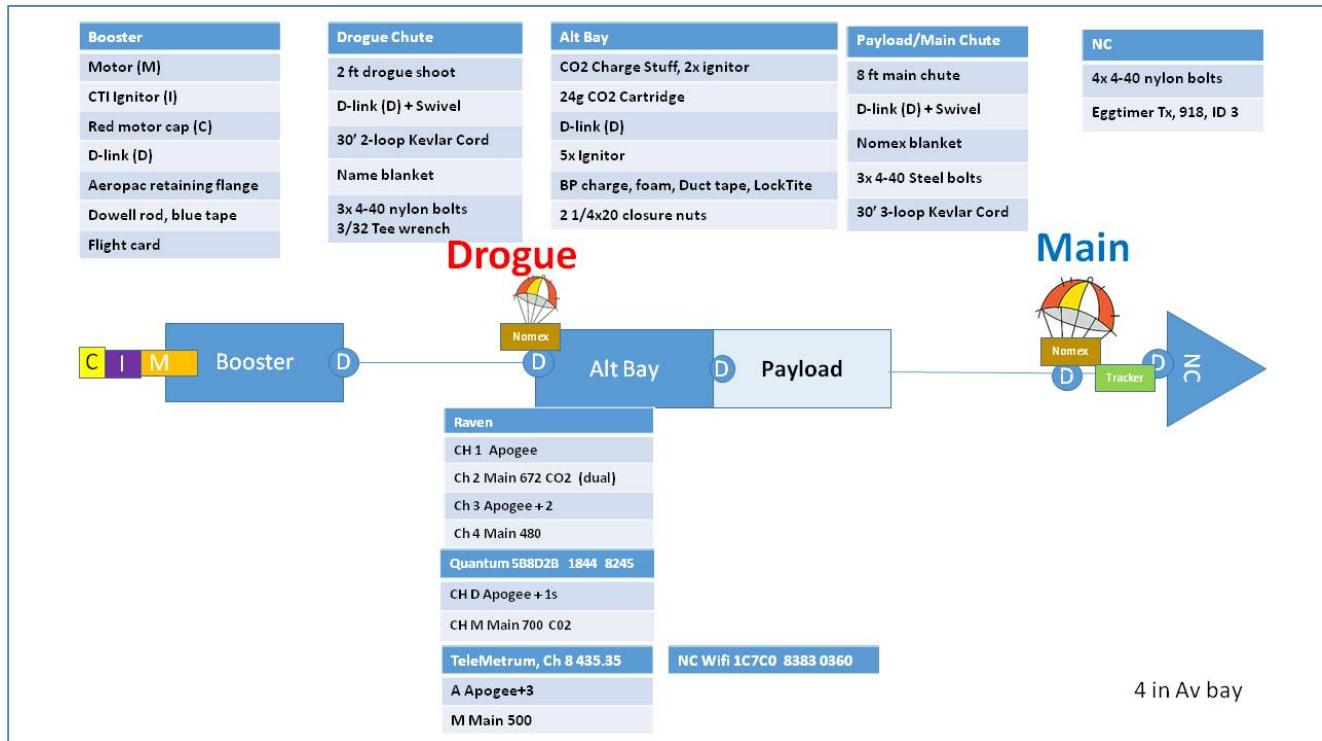
Motor	Avg Thrust	Burn Time	Max Thrust	Total Impulse	Thrust to Wt	Propellant Wt	Size
K454-SK	458 N	2.97 s	586 N	1364 Ns	4.88:1	821 g	54/404 mm



## Checklists

Full Checklist Forthcoming

Visual Checklist



## **Acknowledgements**

I used Mark McCord's L3 cert package as an outline

<https://docs.google.com/document/d/1i4anunZXsiG7dyIP78nmFN7WJrSK-7uAgVvensHU9ok/edit>

And "dsigma"

[https://github.com/dsigma/l3\\_rocket\\_certification/wiki](https://github.com/dsigma/l3_rocket_certification/wiki)

## **Tripoli L3 Forms and Application**

### **Pre-Flight Data Capture Form**

<http://www.tripoli.org/Portals/1/Documents/Certification/TAPPrecFlightDataCaptureForm.pdf>

### **L3 Application**

[http://www.tripoli.org/Portals/1/Documents/Certification/Universal\\_Certification\\_Form.pdf](http://www.tripoli.org/Portals/1/Documents/Certification/Universal_Certification_Form.pdf)

## Appendix- Parts to keep track of

Push pin Core Pin (5/64 or 2mm)

0.074" Diameter, 2-1/2" Long

<https://www.mcmaster.com/98378a510>

Female Threaded Round Standoff

18-8 Stainless Steel, 1/2" OD, 1" Long, 1/4"-20 Thread Size

<https://www.mcmaster.com/91125a412>

Drill bit for tight 4-40 clearance

Black-Oxide High-Speed Steel Drill Bit

Wire Gauge 36, 2-1/2" Overall Length

<https://www.mcmaster.com/2901a21>

Stainless Steel Low-Profile Binding Barrels and Screws

8-32 Thread Size, for 1/2"-3/4" Material Thickness

<https://www.mcmaster.com/94887a142>

Press-Fit Threaded Standoffs

with Open End, 18-8 Stainless Steel 0.165" OD, 5/8" Long

Thread Size 4-40

<https://www.mcmaster.com/93090a651>

Nylon Socket Head Screws

4-40 Thread Size, 1/4" Long

<https://www.mcmaster.com/95868a256>

Pixel Shutter Remote Control TW-283 Series 3.5mm Off Camera Shutter Connecting Cable Cord 3.5mm-S1 Camera Connecting Plug for Sony Cameras

[https://www.amazon.com/gp/product/B07GWJHZ46/ref=ppx\\_yo\\_dt\\_b\\_asin\\_title\\_o08\\_s00?ie=UTF8&psc=1](https://www.amazon.com/gp/product/B07GWJHZ46/ref=ppx_yo_dt_b_asin_title_o08_s00?ie=UTF8&psc=1)

## Appendix- Av Bay BOM

7.5inch Av Bay					
Quantity	Description	Part number	Vendor	URL	Notes
1	RocketJunkies custom drogue bulk head	N/A	RocketJunkies	<a href="http://rocketjunkies.com/">http://rocketjunkies.com/</a>	
1	RocketJunkies custom main bulk head	N/A	RocketJunkies	<a href="http://rocketjunkies.com/">http://rocketjunkies.com/</a>	
1	Custom printed av bed sled	N/A	Heisey	N/A	<a href="https://cad.onshape.com/documents/d28cea18ee96b2ab3ecad752/w/e8f1f35f333a0240054c5422/e/d49d5c8ff002b1b859eb6dba8">https://cad.onshape.com/documents/d28cea18ee96b2ab3ecad752/w/e8f1f35f333a0240054c5422/e/d49d5c8ff002b1b859eb6dba8</a>
5	Charge wells	3 gram	RocketJunkies	<a href="http://rocketjunkies.com/product/3-gram-aluminum-charge-wells/">http://rocketjunkies.com/product/3-gram-aluminum-charge-wells/</a>	Alternate: replace two with 8g
1	Feed-through grommet and washer	N/A	RocketJunkies		
1	custom 3d printed guillotine U-bolt clamp	N/A	RocketJunkies	<a href="http://rocketjunkies.com/">http://rocketjunkies.com/</a>	
1	RAPTOR Mounting Cap Assembly	N/A	Tinder Rocketry	<a href="https://www.tinderrocketry.com/raptor-co2-ejection-replacement-parts">https://www.tinderrocketry.com/raptor-co2-ejection-replacement-parts</a>	
1	Custom 3d printed battery lid	N/A	Heisey	<a href="https://cad.onshape.com/documents/d28cea18ee96b2ab3ecad752/w/e8f1f35f333a0240054c5422/e/d49d5c8ff002b1b859eb6dba8">https://cad.onshape.com/documents/d28cea18ee96b2ab3ecad752/w/e8f1f35f333a0240054c5422/e/d49d5c8ff002b1b859eb6dba8</a>	
2	1/4x20 Super-Corrosion-Resistant 316 Stainless Steel Threaded Rods 10 in	90575A224	McMaster-Carr	<a href="https://www.mcmaster.com/90575a224">https://www.mcmaster.com/90575a224</a>	Alternate: 12 inch 90322A656
1	304 Stainless Steel U-Bolt, 1/4"-20 Thread Size, 7/8" ID, 2 15/16" High	8889741	McMaster-Carr	<a href="https://www.mcmaster.com/8889741">https://www.mcmaster.com/8889741</a>	Main side U-bolt
1	304 Stainless Steel U-Bolt, 1/4"-20 Thread Size, 1" ID	8896103	McMaster-Carr	<a href="https://www.mcmaster.com/8896103">https://www.mcmaster.com/8896103</a>	Drogue side U-bolt
6	6-32 Alloy Steel Socket Head Screw, 7/16" length	91864A023	McMaster-Carr	<a href="https://www.mcmaster.com/91864a023">https://www.mcmaster.com/91864a023</a>	4 for Co2 Flange, 2 for feed-through
Female Threaded Round Standoff, 18-8 Stainless Steel, 1/2" OD, 1" Long, 1/4"-20 Thread Size	91125A412	McMaster-Carr	<a href="https://www.mcmaster.com/91125a412">https://www.mcmaster.com/91125a412</a>	For closing av bay	
Press-Fit Threaded Standoff, with Open End, 18-8 Stainless Steel 0.165" OD, 5/8" Long	93090A651	McMaster-Carr	<a href="https://www.mcmaster.com/93090a651">https://www.mcmaster.com/93090a651</a>	Help affix 3d sled to bulkhead	
Black-Oxide Alloy Steel Hex Drive Flat Head Screw, 8-32 Thread Size, 3/8" Long	91253A192	McMaster-Carr	<a href="https://www.mcmaster.com/91253a192">https://www.mcmaster.com/91253a192</a>	Attach charge cups	
2 Black-Oxide Alloy Steel Socket Head Screw, 4-40 Thread Size, 1/2" Long	91251A110	McMaster-Carr	<a href="https://www.mcmaster.com/91251a110">https://www.mcmaster.com/91251a110</a>	Help affix 3d sled to bulkhead	
1 SMA feed through	132170	Mouser	<a href="https://www.mouser.com/ProductDetail/Amphenol-RF/132170?qs=GAEplMZZmVlx3nhDDO4ANL75%252B5tbA9LuqnfFeUlwxE%3D">https://www.mouser.com/ProductDetail/Amphenol-RF/132170?qs=GAEplMZZmVlx3nhDDO4ANL75%252B5tbA9LuqnfFeUlwxE%3D</a>	Alternate: 135110-02-24.00	
21 18-8 Stainless Steel Hex Nut, 1/4"-20 Thread Size	91845A029	McMaster-Carr	<a href="https://www.mcmaster.com/91845a029">https://www.mcmaster.com/91845a029</a>		
5 8-32 Alloy Steel Hex Drive Flat Head Screws, 7/16 inch long	91253A193	McMaster-Carr	<a href="https://www.mcmaster.com/91253a193">https://www.mcmaster.com/91253a193</a>		
1 SMA Antenna, 400 MHz	ANT-433-CW-RCS	Mouser	<a href="https://www.mouser.com/ProductDetail/linx-technologies/ant-433-cw-rcs/?qs=K5t8V%252bWhtZeE4lPGCGaEg%3D%3D&amp;countrycode=US&amp;currenccode=USD">https://www.mouser.com/ProductDetail/linx-technologies/ant-433-cw-rcs/?qs=K5t8V%252bWhtZeE4lPGCGaEg%3D%3D&amp;countrycode=US&amp;currenccode=USD</a>	Alternate: 700 MHz	
1 LabRat Dual pull switch (includes mounting hardware)	Double Pull Pin Switch Kit	LabRat Rocketry	<a href="https://www.labratrocketry.com/product-page/double-pull-pin-switch-kit">https://www.labratrocketry.com/product-page/double-pull-pin-switch-kit</a>		
4 Black-Oxide Alloy Steel Socket Head Screw, 6-32 Thread Size, 1-1/4" Long, Fully Threaded	90044A112	McMaster-Carr	<a href="https://www.mcmaster.com/90044a112">https://www.mcmaster.com/90044a112</a>	Attach battery box	
2 Tattu 450 mAh 2s LiPo batteries w/XT30 plug	2S 450 mAh	Tattu/Amazon	<a href="https://www.amazon.com/gp/product/B07K18D1G5/ref=ppx_yo_dt_b_searchResults?asin_title?e=UTF8&amp;psearch=1">https://www.amazon.com/gp/product/B07K18D1G5/ref=ppx_yo_dt_b_searchResults?asin_title?e=UTF8&amp;psearch=1</a>		
8 Black-Oxide Alloy Steel Socket Head Screw, 4-40 Thread Size, 3/8" Long	91251A108	McMaster-Carr	<a href="https://www.mcmaster.com/91251a108">https://www.mcmaster.com/91251a108</a>	Attach altimeters to sled	
1 CO2 Cartridge, 1/2 thread, 23 grams	84203	Leland	<a href="http://lelandgas.com/small_high_pressure2.1.htm">http://lelandgas.com/small_high_pressure2.1.htm</a>	Size as necessary	
Misc	Multi-strand hook-up wire, XT30 plugs, solder, shrink tubing, cable ties, etc.				

## 3in Telemetry Extension sled

Quantity	Description	Part number	Vendor	URL	Notes
	3d printed 3in sled	N/A	Heisey	<a href="https://cad.onshape.com/documents/d28cea18ee96b2ab3ecad752/w/e8f1f35f333a0240054c5422/e/e08693ede2745acbf1e4969">https://cad.onshape.com/documents/d28cea18ee96b2ab3ecad752/w/e8f1f35f333a0240054c5422/e/e08693ede2745acbf1e4969</a>	
1	3d printed Custom battery holder	N/A	Heisey	<a href="https://cad.onshape.com/documents/d28cea18ee96b2ab3ecad752/w/e8f1f35f333a0240054c5422/e/e08693ede2745acbf1e4969">https://cad.onshape.com/documents/d28cea18ee96b2ab3ecad752/w/e8f1f35f333a0240054c5422/e/e08693ede2745acbf1e4969</a>	
1	TeleMetrum Altimeter	TeleMetrum	Altus Metrum	<a href="https://altusmetrum.org/TeleMetrum/">https://altusmetrum.org/TeleMetrum/</a>	
4	Black-Oxide Alloy Steel Socket Head Screw, 4-40 Thread Size, 3/8" Long	91251A108	McMaster-Carr	<a href="https://www.mcmaster.com/91251a108">https://www.mcmaster.com/91251a108</a>	Attach altimeter to sled
1	LabRat pull switch	Single Pull	LabRat Rocketry	<a href="https://www.labratrocketry.com/product-page/pull-pin-switch-kit">https://www.labratrocketry.com/product-page/pull-pin-switch-kit</a>	
1	600mAh 1S LiPo Battery 3.7V 50C JST-PH 2.0	1S 600 mAh	GNB/Amazon	<a href="https://www.amazon.com/gp/product/B077PRY7K3/ref=ppx_yo_dt_b_searchResults?asin_title?e=UTF8&amp;psearch=1">https://www.amazon.com/gp/product/B077PRY7K3/ref=ppx_yo_dt_b_searchResults?asin_title?e=UTF8&amp;psearch=1</a>	
1	SMA cable w/bulkhead to replace SMA feedthrough	135110-02-24.00	Mouser	<a href="https://www.mouser.com/ProductDetail/Amphenol-RF/135110-02-24.00?qs=2Fha2pyFaduitnkghHALrn1ETVi5yhKQUdW%2FSIu1r9pRW7T5bmsv">https://www.mouser.com/ProductDetail/Amphenol-RF/135110-02-24.00?qs=2Fha2pyFaduitnkghHALrn1ETVi5yhKQUdW%2FSIu1r9pRW7T5bmsv</a>	
Misc	Multi-strand hook-up wire, JST plugs, solder, shrink tubing, cable ties, etc.				

## Appendix – Weight Budget

Item	Weight		
NC	1506		
Payload	0	w NC	
NC Tracker	200	est	
Main	387		
Bag	50	est	
Cord	540		
D-rings	200	est	
Av bay w/CO2 and batteries	1159		
Drogue	409		
Av bay lid	238		
Booster	2970	est	
D-rings			
Nomex			
Cord	181		
aeropac	107		
thrust plate	107		
	8054	grams	17.74009

## Appendix – Eggtimer Assembly



