Level 3 Certification Proposal for Howard Druckerman

NAR 85721

Nimbus 2011

I Introduction

I A) General Description of Model

I A 1) The airframe for this rocket is an Ultimate Wildman, which is a 3FNC, 6 inch diameter, about 144 inches (12 feet) tall and containing a 98mm motor mount. The launch weight will be:

a.	Airframe (kit, Aeropack, rail buttons)	32 pounds
b.	Recovery (described in detail later)	12 pounds
c.	Motor, casing and adapter (described in detail later)	13 pounds
	Total estimated	57 pounds
		(Actual: 55 pounds)

I A 2) Certification motor is:

CTI Pro-75 5933M1770-P Skidmark in a CTI Pro 75 6G motor

Since it is possible that the field will not allow Skidmark motors, my backup will be:

CTI Pro-75 6162M1675-P Pink in a CTI Pro 75 6G motor and spacer

I B 1) Expected altitude from Rocksim is done 4 different ways: with both the Skidmark motor and backup pink motor, and at both the Wildman quoted weight and my expected weight. The Wildman weight should be optimistic, and the expected weight should be more realistic:

~~Skidmark and Wildman:~~	~~8690 feet in 20.6 seconds~~
Skidmark and expected:	6191 feet in 20.2 seconds
~~Pink and Wildman:~~	~~9570 feet in 23.3 seconds~~
~~Pink and expected:~~	~~6938 feet in 21.1 seconds~~

I C) All construction techniques are ones I have been tried successfully on previously built and flown rockets. There is one unique feature on this rocket that I have not tried before, the addition of two GPS sending units. These will be attached to recovery harnesses; one for the airframe and one for the nosecone.

I D) To reduce the possibility of electrical interference between the GPS sending units and the two altimeters in the avbay, the entire avbay will be internally wrapped to create a Faraday cage. The avbay will be wrapped ~~either~~ with ~~aluminum, copper, or~~ carbon fiber and will act as a shield to prevent the GPS sending unit signal from generating noise inside the cage. All e-match wires outside the cage will be kept to a minimum length and twisted to reduce their noise impact.

~~Note: cage material determination to be made later. I know I can do carbon fiber lining of tubes as I have done it, but if sticky aluminum or copper works just as well, it is less work. I already have sticky aluminum, and am looking to find copper; either will work.~~

<u>II Scale Drawing</u>

In the diagram section is the 2D drawing from Rocksim version 9 with dimensions added for the nosecone, airframe sections, avionics bay (avbay) and motor tube. I have confirmed these measurements with all the part of the kit that I already have. There is one minor difference between the Rocksim file obtained from Wildman and the actual; the nosecone was 30.5 inches long. This has been updated in the Rocksim model I will be using for all calculations. Rocksim was used to calculate the CP and then determine the CG. A second drawing shows the fin details.

III Construction Materials and Techniques (Construction Package)

III A & B) Airframe materials:

1. Body tubes	G10 fiberglass, ID 6.000 in, OD 6.170 in	Performance Rocketry
2. Coupler	G10 fiberglass, ID 5.775 in, OD 5.998 in	Performance Rocketry
3. Fins	G10 fiberglass, 0.250 in thick (nom) (3)	Performance Rocketry
4. Centering rings (CR)	Birch plywood, 0.500 in thick (nom) (3)	Performance Rocketry
5. Launch lugs (LL)	Nylon, Unistrut (~~2~~*3*)	Performance Hobbies
6. LL reinforcement	Hardwood, 2 in x 4 in (~~2~~*3*)	Custom
7. LL screw	1/4-20 x 2in flat head screw (~~2~~*3*)	McMaster-Carr
8. LL nut	1/4-20 T-nut (~~2~~*3*)	McMaster-Carr
9. Alternate LL	Nylon, extreme (1515 rail) (~~2~~*3*)	Performance Hobbies
10. Alternate LL screw	8-32 x 1- 1/2 in flat head screw (~~2~~*3*)	McMaster-Carr
11. Alternate LL nut	8-32 T-nut (~~2~~*3*)	McMaster-Carr
12. Reinforcement	Carbon fiber: braided twill (1 in, 2 in)	Soller Composites
~~13. Wear resistance~~	~~1.5 oz fiberglass~~	~~Fiberglass Warehouse~~
14. Adhesives	Epoxy and hardener, 5 & 15 min	Bob Smith Industries
	Epoxy 105, hardeners 205 & 206	West System
	JB Weld	Lowes
	Loc-Tite, blue	Lowes
	Hot melt glue	Lowes
15. Adhesive additives	Colloidal silica 406	West System
	Glass bubbles	Fiberglass Warehouse
	Chopped carbon fiber, 1/8 in	CST
16. Motor mount (MM)	G10 fiberglass, ID 3.900 in, OD 4.025	Performance Rocketry
17. Motor retention	RA98, 98mm flanged	Aeropack
18. Nosecone (NC)	Fiberglass w/gel coat, 5:1 ogive	Performance Rocketry
19. NC bulkplate	Fiberglass, 1/8 in	Performance Rocketry
20. NC bulkplate adapter	Douglas fir plywood, 0.500 in thick (nom)	Custom
21. Avbay bulkplates	Aluminum 1/4 thick, stepped (2)	Custom
22. Centering ring (CR)	*G10, 0.125 in thick (nom) (1)*	*Performance Rocketry*
23. Kevlar String	*Size 800 (225#) x 4 feet*	*The Thread Exchange*

III C) Construction

- Fin mounting will be the standard through the wall. This will be done by tacking the fins to the motor tube inside the airframe and then removing the fins and motor tube for reinforcement, as follows:

a) Motor tube will be slid into place in the aft airframe with one CR in front and behind the fin slots away from the fins, so that even after gluing of the fins, these will be free to slide. The aft CR should be covered with waxed paper to protect it as the CRs will be glued in place later. The aft end of the MM should be 0.5 inch below the aft end of the fins. (This will allow the aft CR to be up against the fins when it is finally glued in place.)
   a. *The fin slots needed filing to be wide enough and long enough to allow the fins to fit.*
   b. *The G10 CR was put on the bottom of the aft CR, so the MM needed to stick out 0.625 (0.500+0.125) inches.*

b) The root edge of the fin will be glued to the MM by sliding the fins through the slots in the airframe. The fins will be perpendicular to the airframe. Waxed paper lining the slots will prohibit any epoxy for gluing the fins to the airframe at this time. This is repeated for all 3 fins.

c) The fins will be numbered on both sides as will the airframe slots on both sides. A line will be marked on both sides of all fins showing where the fin contacts the airframe, for reference later.

d) The fin slots will be extended to the aft end of the airframe and the MM with fins and CRs will be removed.

e) Each fin/MM joint will be reinforced with 1 inch braided twill Carbon Fiber (CF), ensuring the CF is not high enough on the fins to interfere with re-inserting the fin assembly back into the airframe. Both sides of the fin joints will be reinforced.

f) Not required for fin mounting but must be done now:

   One end of a 14 foot piece of the Kevlar recovery strapping will be glued parallel to the fins outside the MM, starting at the forward end of the MM and stopping just above the aft end of the fins. The other end of this same strap will be glued to the MM, opposite to the already glued end, also on the outside of the MM.

g) The forward and middle CRs will be notched to fit the straps and then glued onto the MM; the middle CR just above the fins and the forward CR 0.75 in below the forward end of the MM. Fillets will be applied below the upper CR and above the middle CR, taking care to seal the joint. *2 inch CF braid was added for increased strength to all CR/MM joints.*
   ~~a) At this point the redundant harness attachment will be added. Before the CRs are installed, they will be stacked and 2 3/8 holes drilled in matching locations, roughly 180 degrees apart and not interfering with any fins.~~
   ~~b) Once the CRs are attached to the MM, then the following will be put through the holes (starting at the forward end): eye bolt, washer, washer, coupler nut, nut, washer, washer, nut, nut, washer, nut onto a piece of 3/8 all-thread. This will sandwich the two CRs and come just short of where the aft CR will be. Epoxy shall be used to prevent the joints from spinning.~~
   ~~c) Three additional "globs" of peanut butter epoxy with glass beads added will attach the all-thread to the MM: one between the forward and center CRs and two between the center CR and where the aft CR will be.~~

h) The fin assembly will be slid back inside the airframe, with the fins in the correct numbered locations. The aft CR will be wrapped with waxed paper and then slid in place.

i) One side at a time, the fin to airframe joint will be reinforced. First, peanut butter epoxy (with silica) will be spread along the fin joint and smoothed with a ½ inch dowel. This will allow the CF to curve gently at the base of the fin. Then the joint is covered with 2 inch braided twill CF and epoxy. The CF will extend to the aft end of the airframe. The piece removed from the airframe to allow sliding out will be repositioned where it was. The CF will be cut along the trailing edge of the fin and then folded flat onto the airframe to bridge the gap caused by the extension of the slots in the airframe. This will be wrapped and then tightened down against the aft CR ring with a band clamp around the airframe. Repeat this process for all 6 sides of fins. The gaps in the airframe will be filled in with the piece and covered by overlapping CF.

j) With the airframe standing on the aft end, epoxy thickened with glass beads will be carefully poured to seal the forward-most CR, until it is about 0.5 in thick and then allowed to cure. Then the aft CR is removed and then the airframe is placed on the forward end. Epoxy and glass beads will be poured between each of the fins, again about 0.5 in thick to seal the middle CR.

k) A small hole will be drilled between the forward and aft centering ring. With the airframe on the forward end, epoxy was injected to seal the aft end of the forward CR to the airframe and allowed to cure. Then the airframe was set on the aft end and epoxy was injected to seal the forward end of the center CR.

l) Not required for fin mounting but required now:

> The aft LL reinforcement composed of the curved hardwood and two T-nut is glued in place with the hole positioned 3 inches from where the bottom CR will go. It will be centered between the fins. Two holes (9/32 and 11/64) will first be drilled in the airframe and then a temporary nylon bolts and nuts will be used to hold the reinforcement in place during gluing. The nylon bolt is used just in case any epoxy gets on the bolt -- nylon is easily drilled out and then and anything accidentally glued can be easily be re-tapped for cleaning out the threads. There will be one hole for the Unistrut rail button *(lower)* and another hole for a 1515 rail button *(upper)*. The Unistrut rail uses a 1/4-20 x 2in screw and T-nut while the 1515 rail button uses an 8-32 x 1.5in screw and T-nut.

m) The final step for mounting the fins will be the gluing in of the aft CRs with all the holes and hardware necessary to mount the Aeropack retainer already mounted on the aft *wooden* CR. *The G10 CR is then glued below the wooden CR with through-holes already drilled for the Aeropack.* Any open areas in the airframe due to extending the slots should be filled with peanut butter epoxy (epoxy and silica). Any exposed holes in the Aeropack mounting hardware should be sealed with hot melt glue to allow it to be easily removed later.

a) Epoxy thickened with glass beads will be loaded (slobbered) against the bottom of the motor tube, fins and airframe. This will be thick enough to stay in place and not run out. The aft CR*s* ~~is~~ *are* then slid into place.
b) The entire airframe is then stood up allowing the epoxy to run aftward and everything is allowed to cure.
c) The airframe is then turned over onto the forward end and JB Weld is used to create the bottom fillet between the airframe and the aft CR, making sure it does not interfere with being able to install the Aeropack.
d) Once cured, install the Aeropack.

n) A middle launch lug reinforcement was added just above the forward CR using the same procedure as was done with the aft one.

o) The NC will be constructed with a custom NC adapter and a bulkplate. The adapter is a centering ring that is glued to the NC and the bulkplate bolted to the adapter. This will allow access to the NC later if necessary.
a) Kevlar string about 4 feet long had one end glued inside to the tip of the NC.
b) The outside diameter of the NC adapter will fit within the NC shoulder and be tapered ~ 1/16 in slightly toward the open end of the NC. The inside diameter of the NC adapter will be a hole to fit a 4 inch airframe. There will be six evenly spaced 0.250 in holes in the adapter and bulkplate drilled at the same time. In the adapter, each filled with a SS 1/4-20 bolt, 1.5 in long and a SS washer. The bolts will be held in place with epoxy.
c) The NC bulkplate diameter will be reduced enough to fit within the NC shoulder.
d) The NC adapter will be positioned about 0.50 in above the bottom of the NC, and perpendicular to the centerline of the NC. A few drops of 5 minute epoxy into the taper will hold the adapter inside the NC. Next, peanut butter epoxy will be put inside the adapter and used to seal the upper end of the joint between the adapter and NC. Once mostly cured, the NC is set point down and very watery West System epoxy is squirted carefully into the taper between the adapter and NC. The entire taper is filled and then this is allowed to cure.
e) A 1/4-20 eye bolt with body washer and shoulder nut are put through the center hole in the NC bulkplate, tightened and prevented from loosening with Loc-Tite. The bulkplate is then installed on the adapter with the eyebolt side out, 6 washers & nuts are installed, everything is tightened and Loc-Tite is applied.
f) Temporarily attach the forward end of the upper airframe to the NC and use tape to hold into place. Drill 4 #51 holes, 3 inches from the end of the airframe, 90 degrees apart. Remove the airframe, marking one hole on the inside of the airframe and the same hole on the NC as orientation marks. Tap the airframe holes with a 2-56 tap and then redrill the 4 NC holes with a 1/16 bit.

p) Avbay exterior construction will be done with the following steps:
a) Gluing the 6 inch coupler ring to the coupler, centered from both ends.
~~b) A second, identical LL reinforcement will be glued inside the coupler, identically as was done for between the fins. Two holes will then be drilled to match up with the holes in the reinforcement: 9/32 and 11/64 (for #8 screw).~~

c) ~~After all the recovery components are added to the aft avbay bulkplate, the bulkplate will be glued to the aft end of the coupler, about 1/2 inch from the bottom of the coupler. The 1 inch CF braid will be used to reinforce this bulkplate/coupler joint on the outside and a normal filet on the inside.~~

d) The upper airframe section will be temporarily slid onto the coupler and taped in place to prevent movement. Four 11/64 holes (for #8 screws) will be drilled about 3 inches above the base of the airframe, each 90 degrees apart. The same hole on the coupler and airframe will be marked as orientation marks (marked inside the airframe and outside the coupler).

e) The coupler slid out and each airframe hole will be covered with a conical washer epoxied in place using a tapered 8-32 nylon screw to ensure it is centered over the hole. When the epoxy is cured, remove the nylon screws.

f) The coupler is slid back onto the coupler with the right orientation and an 8-32 lock nut, with roughed up edges, is glued inside the coupler, using a combination of 5 minute epoxy and 15 minute epoxy with silica. Tapered nylon 8-32 screws will be used to hold the nut in place. Repeat this for the remaining 3 holes.

g) The entire coupler interior was lined with CF using a vacuum bag method.

h) A second, identical LL reinforcement will be glued inside the coupler, identically as was done for between the fins. Two holes will then be drilled to match up with the holes in the reinforcement: 9/32 and 11/64 (for #8 screw).

i) Four holes (*0.5 inch*) will be drilled as pressure equalization holes. Two will need to line up with the altimeter switches at approximately 180 degrees. The other two will be at approximately 90 degrees to the drilled holes.

j) Slide on the forward end of the bottom airframe and tape into place. Drill 4 #51 holes, 3 inches from the end of the airframe, 90 degrees apart. Remove the airframe, marking one hole on the inside of the airframe and the same hole on the coupler as orientation marks. Tap the airframe holes with a 2-56 tap and then re-drill the 4 coupler holes with a 1/16 bit.

III D 1) Cross section of fincan

See image section.

III D 2) Schematic of Avbay

See image section.

III E) Photographs of construction

See construction photos.

<u>IV Description of Recovery System Components and Operation</u>

IV B 1) Deployment Sequence

Deployment is dual deployment with completely independent redundancy.

- Primary altimeter is set to apogee and main at 1000 feet.
  - This is currently planned to be a Perfect Flight *Stratologger* ~~MAWD but this altimeter has not been flown yet. If I can not fly the MAWD altimeter before attempting certification, then my primary altimeter will be an RRC-2 mini which has flown many times.~~
- Backup altimeter is set to apogee plus 1 second and main at 800 feet.
  - This is currently planned to be a MARSA4 ~~but this altimeter has not been flown yet. If I can not fly the MARSA4 altimeter before attempting certification, then my backup altimeter will be an RRC-2 mini which has been flown many times.~~
- Apogee parachute is a 24 inch custom Nomex and Kevlar parachute along with an eight foot reflective Mylar streamer for visibility.
- Main deployment uses a custom made freebag. The nosecone and freebag use a ~~32~~ *44* inch Sky Angle Classic II parachute. This will deploy the main for the rest of the airframe, a Sky Angle Cert 3 XL parachute ~~and a Giant Leap slider~~.

Note: the size of the nosecone or main chute may get adjusted, depending on the nosecone or final rocket weight.

IV B 2) Recovery System Mounting

Both a 3 foot long strap and the 32 inch parachute will be connected to the NC ¼-20 eye bolt with a 3/16 inch quick link. Attached to the other end of the nylon strap is the custom freebag using another 3/16 inch quick link.

- *For flight, this nylon strap will be Z folded into a 5 inch length and then wrapped twice with masking tape. This is to prevent the cord from becoming entangled.*

The recovery harness between the main parachute and avbay will be a 30 foot long 1 inch Kevlar “Y” strap. The parachute end will use a 3/8 inch triangular quick link. The avbay end will use two 3/8 inch triangular quick links.

- Everything between the main parachute and the forward airframe is rated for approximately 2000 pounds working load.
- *For the flight, this will be tied loosely in a chain stitch to reduce the shock on the connectors.*

The aft airframe to avbay will be connected with another “Y” 1 inch Kevlar strap about 70 feet long. The aft end will be the single end using a square 3/8 inch quick link and the upper airframe connection will be use 2 triangular 3/8 inch quick links.

A loop about 2/3s of the way up this strap will be where the drogue chute will be connected. This will be done with a 1/8 quick link.

- *For the flight, this will be ~~tied loosely in a chain stitch~~ Z folded and taped to reduce the shock on the connectors.*

The avbay itself will be constructed with a 3/8-16 x 2 inch U-bolt on the bottom. This will be mounted on the aft end of the avbay and coupler nuts inside the avbay will connect this to two pieces of 3/8-16 all-thread, long enough to extend about 1 inch above the avbay forward lid. Two 3/8-16 eye nuts will be used to close the lid and connect to the upper harness.

- Note two eye nuts are used to prevent spinning from unthreading any one eye nut.

Recovery harness materials list, starting at the nosecone and working aftward, with all steel being stainless:

24. 1/4-20 eye bolt	qty: 1	McMaster-Carr
25. 1/4-20 body washers	qty: 2	McMaster-Carr
26. 1/4-20 flange nut	qty: 1	McMaster-Carr
27. 3/16 quick link	qty: 2	McMaster-Carr
28. 1/2 in. strapping	qty: 3 feet	Giant Leap
29. 32 in. parachute	qty: 1	Sky Angle
30. 6 in. Freebag	qty: 1	Custom
31. XL Cert 3 parachute	qty: 1	Sky Angle
~~32. 3-strap slider~~	~~qty: 1~~	~~Giant Leap~~
33. 3/8 triangular quick link	qty: 4	McMaster-Carr
34. 1 in. Kevlar webbing	qty: 30 feet	Wildman/McMaster-Carr
35. 3/8-16 eye nuts	qty: 4 *2*	McMaster-Carr
36. 3/8 washers	qty: 6	McMaster-Carr
37. 3/8 silicon seal washers	qty: 6	McMaster-Carr
38. 24 in. 3/8-16 all-thread	qty: 2	McMaster-Carr
39. 3/8-16 coupler nuts	qty: 2	McMaster-Carr
40. 3/8-16 wing nuts	qty: 2	McMaster-Carr
41. 3/8-16 x 3 in. U-bolt	qty: 1	McMaster-Carr
42. 3/8 triangular quick link	qty: 1	McMaster-Carr
43. 1 in. Kevlar webbing	qty: 70 feet	Wildman/McMaster-Carr
44. 1/8 quick link	qty: 1	McMaster-Carr
45. 24 in. Nomex parachute	qty: 1	Custom
46. 48 in. reflective streamer	qty:1	Custom
47. 3/8 square quick link	qty: 1	McMaster-Carr
48. 1 in. Kevlar webbing	qty: 14 feet	Wildman/McMaster-Carr
49. Nomex Parachute protector	*size: 18 in. sq.*	*Apogee Components*

And also needed for the avbay construction is:

50. Terminal strip, 2 pole qty: 4 Radio Shack
51. 2-56 x 1 in. rnd head screw qty: 4 McMaster-Carr
~~52. 2-56 nut qty: 4 McMaster-Carr~~
53. 10-~~24~~ *32* x 1in oval head screw qty: 4 McMaster-Carr
~~54. 10-24 lock nut qty: 4 McMaster-Carr~~
55. 1 in. CPVC end cap qty: 4 Lowes
56. #10 silicon sealing washer qty: 4 McMaster-Carr
57. 8-32x5/8 oval head screw qty: 4 McMaster-Carr
~~58. 8-32 lock nuts qty: 4 McMaster-Carr~~
59. #8 countersink washer qty: 4 McMaster-Carr

~~There will be redundant connections between the fincan assembly in case there is an issue with the Kevlar. The reason is that it is easy to do when the fincan is out, and much harder afterward.~~

~~60. 3/8-16x1 ¼ eye bolt qty: 2 McMaster-Carr~~
~~61. 3/8-16 coupler nuts qty: 2 McMaster-Carr~~
~~62. 3/8 washers qty: 8 McMaster-Carr~~
~~63. 3/8-16 nuts qty: 8 McMaster-Carr~~
~~64. 3/8-16 x 24 in. all-thread qty: 2 McMaster-Carr~~

Attaching the two terminal blocks to the forward bulkhead is done by ~~drilling a 1/16 hole and gluing a 2-56 nut underneath~~ *drilling a #51 hole and tapped with a 2-56 tap*. The blocks are then screwed into place, but could be replaced easily if necessary. The two CPVC pipe cap charge holders are done in a similar fashion except using 10-32 oval head screws, ~~10-32 nuts~~ *a 10-24 tap*, and silicon sealing washers to help prevent gas from entering the avbay. The wires are passed through the bulkhead and hot melt glue is used to seal the hole. This is done such that if there is a problem with the wire, it could be replaced. All 3/8-16 metal passing through the bulkhead is sealed with a 3/8 silicon sealing washer covered with a washer and a nut.

~~The aft~~ *Both* avbay*s are* ~~is~~ done in an identical manner except an aluminum U channel is added. The U channel consists of 2 pieces of 1 in x 1 in x 1-1/2 in angle aluminum bolted together with 4-40 screws and nuts. One piece of aluminum will have two 9/16 holes drilled in it. These holes are each filled with a 7/16 rubber grommet. Inside the grommets are female N power connectors with wires soldered to the terminals. These wires will pass through the holes in the bulkplate to power the e-matches. Matching male N power connectors on the avbay sled enable the power connections to be made by just sliding in the sled. Locking the sled into the avbay locks these connections.

Note: the forward and aft avbay ends were never glued to the coupler and both can be removed.

The sled for the avbay will be 1/8 plywood, cut to fit within the space allowed (approximately 5-1/2 in x 20 inch) and will be epoxied to ~~two~~ *four* brass tubes which will enable it to be slid over the two all-thread pieces within the avbay. The positioning of the tubes is done by placing them onto the all-thread and tacking the plywood onto these. 2oz fiberglass cloth is then laminated over the wood and brass tubing, for two reasons: ensure the tubing does not separate from the wood, and to insulate the tubing to preventing it from shorting to any of the electrical components. The two electrical switches will be connected attached to 1 inch angle aluminum which will be attached to the sled facing the holes in the pressure equalization holes in the coupler. The aluminum angle will be positioned after the bulk head and all-thread is permanently mounted, so the position of the switches can line up exactly with the holes.

The bottom *and top* edge*s* of the sled will have 2 male N power connectors glued with hot melt glue and then covered with a piece of 1/2 x 1/8 x 2 in. aluminum which will serve to lock these power connectors onto the sled. [Note: hot melt glue is used for two reasons: it fills the gaps easily and it is somewhat flexible when cool, enabling some flexibility when sliding in the power connector.

Two 9v battery boxes with the terminals aftward will be screwed to the plywood using 3 sets of 2-56 screws and nuts, ensuring there is enough space for a cable tie to go underneath. The cable tie is used to lock the battery in the battery box during flight. The altimeters will be attached using the manufacturers recommended screws [and nuts], using 1/4 in. nylon spacers. The altimeters will be mounted in the correct orientation according to the manufacturer. The only other addition to the sled will be two small cable clamps per altimeter which will be screwed to the sled, about 1/2 in. from where the wires will connect to the altimeter (one for power/switch and one for ematches). The wires will be put through these twice to serve as a strain relief and prevent any stresses on the wires from becoming a stress on the altimeter. Wiring is added with all connections joints soldered and covered with heat shrink tubing. The ends of wires being connected to the altimeter will also be tinned with solder. All wires will be twisted to reduce the affect of external noise. Long runs of wires that are completely within the sled will be glued to the sled about every 6 inches.

The additional components for the avbay include:

65. 1 in. x 1in. angle aluminum	qty: ~~2@1in, 2~~ *6*@1-3/4 in	Lowes, custom cut
66. 1/2 in x 1/8 in x 3 in AL	qty: 1	Lowes, custom cut
67. #4-40 x 1/2 in. rnd hd screw	qty: ~~6~~ *12*	McMaster-Carr
68. #4-40 nuts	qty: ~~8~~ *14*	McMaster-Carr
69. #4-40 x 1 in. rnd head screw	qty: 2	McMaster-Carr
70. 7/16 rubber grommets	qty: ~~2~~ *4*	McMaster-Carr
71. N power connector, female	qty: ~~2~~ *4*	Radio Shack
72. N power connector, male	qty: ~~2~~ *4*	Radio Shack
73. Cable clamp, 1/4 in.	qty: 4	Radio Shack
74. 110/220 power switches	qty: 2	Aerocon
75. Wire, #18	qty: 6 feet	Radio Shack, cut to size and soldered
76. 9v battery boxes	qty: 2	Radio Shack
77. #2-56 x 1/2 in screws	qty: 6	McMaster-Carr
78. #2-56 nuts	qty: 6	McMaster-Carr
79. 1/8 in. birch plywood	qty: ~6 in. x 24 in.	Lowes, custom cut

80. 3/8 brass tubing x ~~24~~ *12* in.   qty: ~~2~~ *4*   McMaster-Carr
81. 5-3/4 x 1/16 silicon O-ring   qty:~~1~~ *2*   McMaster-Carr

IV Additional Recovery System Information

Black powder for the main NC separation, 6 in. x 40 in. space, at 7lbs of pressure:

4.9g (estimated), includes enough to sheer 3 to 5 2-56 nylon screw sheer pins

This will be ground tested to confirm and will be about 5% above the minimum to reliably blow off the NC. The backup charge will be about 10% greater than the primary charge.

Actual testing indicated 1.0g of black powder was required to separate the NC to a distance of about 15 feet. The flight used 2g for the primary charge and 2.5g for the backup charge.

Black powder for apogee separation, 6 in. x 24 in. space, at 7 pounds of pressure:

2.5g (estimated), includes enough to sheer 3 to 5 2-56 nylon screw sheer pins

As with the main charge, this will be ground tested and will be set at 5% above the minimum for the main and 10% above for the backup.

Actual testing indicated 1.0g of black powder was required to separate at the coupler to a distance of about 4 feet. The flight used 2g for the primary charge and 2.5g for the backup charge.

Main parachute calculation:

Sky Angle Cert-3 XL for airframe, rated for 32.6 to 70.6 pounds

Rocksim estimates this to be 16 feet per second without the NC

Actual complete rocket weight, with motor was 55 lbs.

Sky Angle Classic II 32 in. for NC, rated for 2.1 to 4.4 pounds

Rocksim estimates this to be 18 feet per second @ NC = 3 pounds

This was increased to be a 44 inch chute because the Garmin DC40 tracker added another pound to the weight of the NC. In retrospective, it could have remained as the 32 inch parachute.

Pressure equalization hole calculation

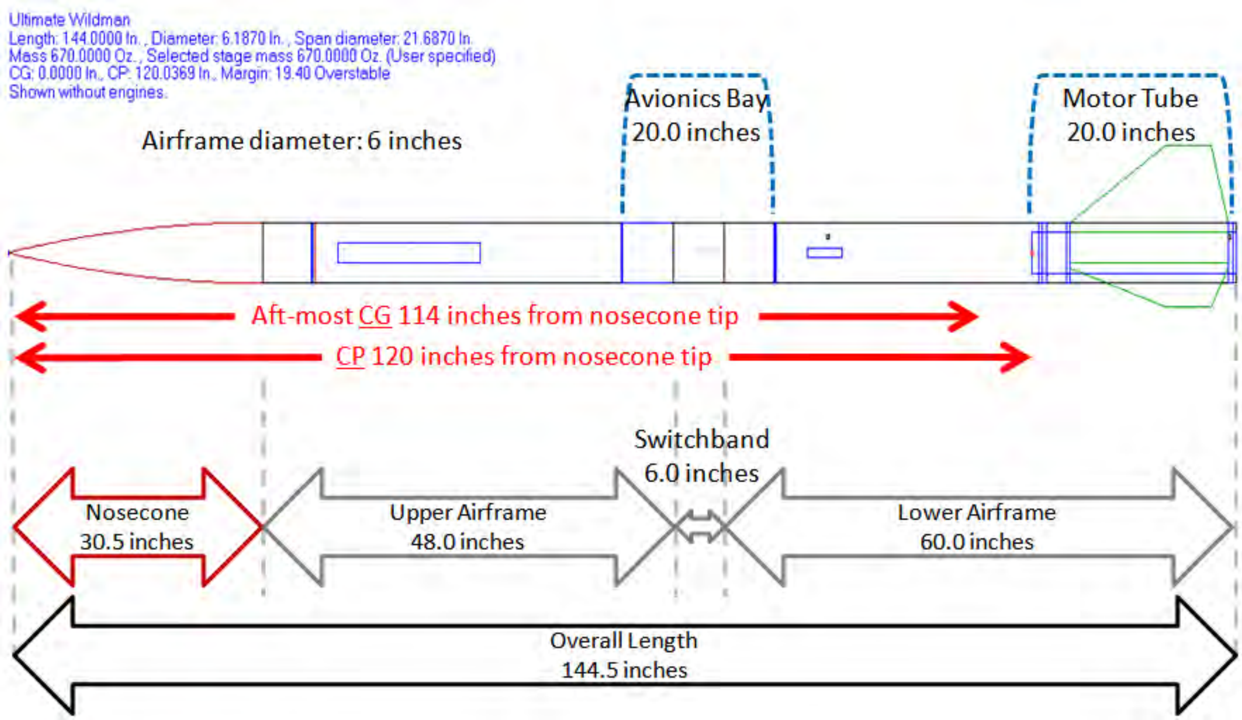
4 holes, 0.5 inch in diameter were used.

Altimeter settings:

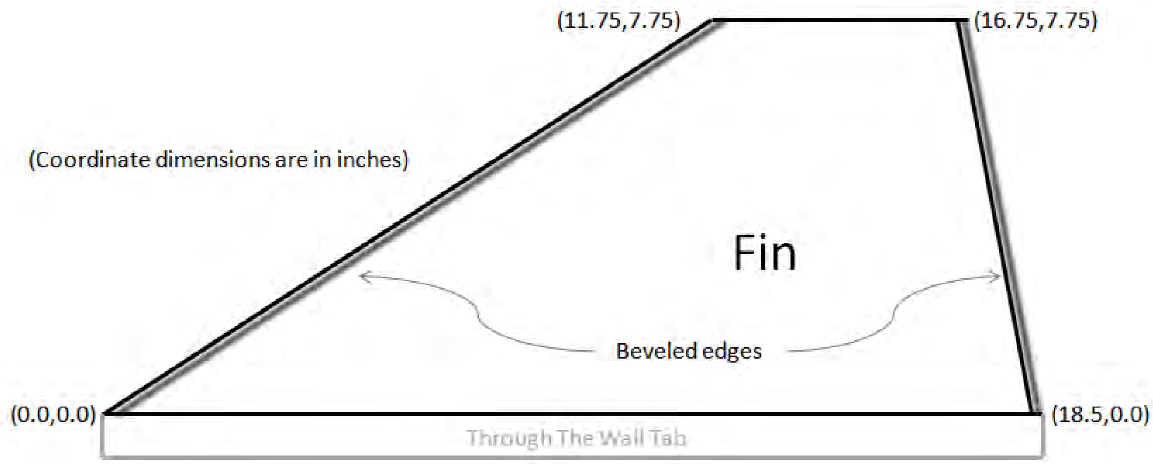
~~TBD (depends on altimeters)~~ *As described previously.*

Diagrams:

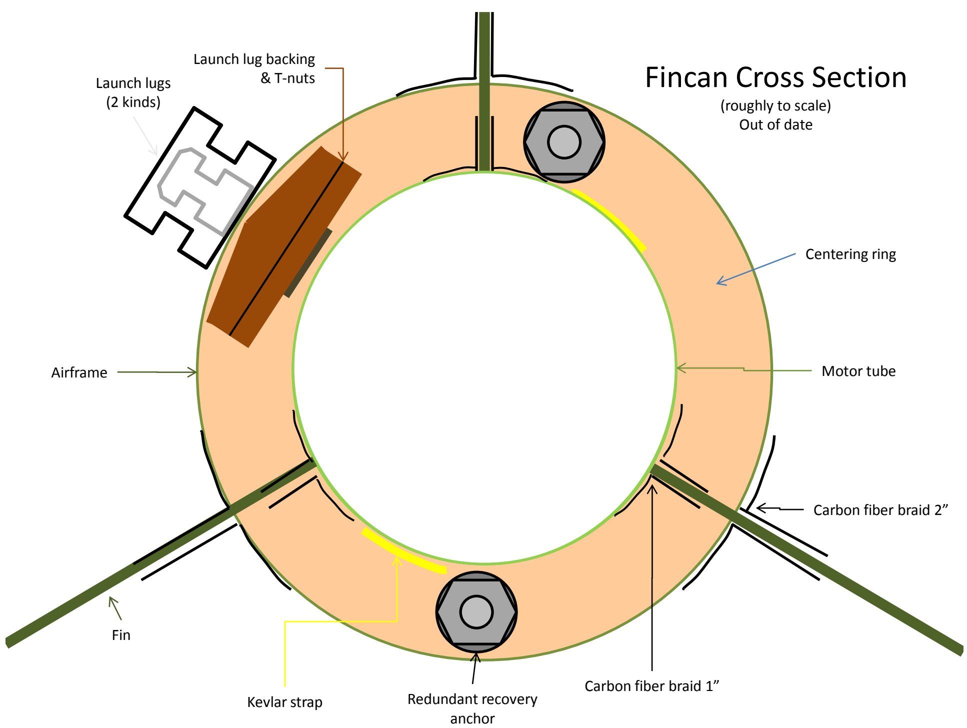
Overall Dimensions:



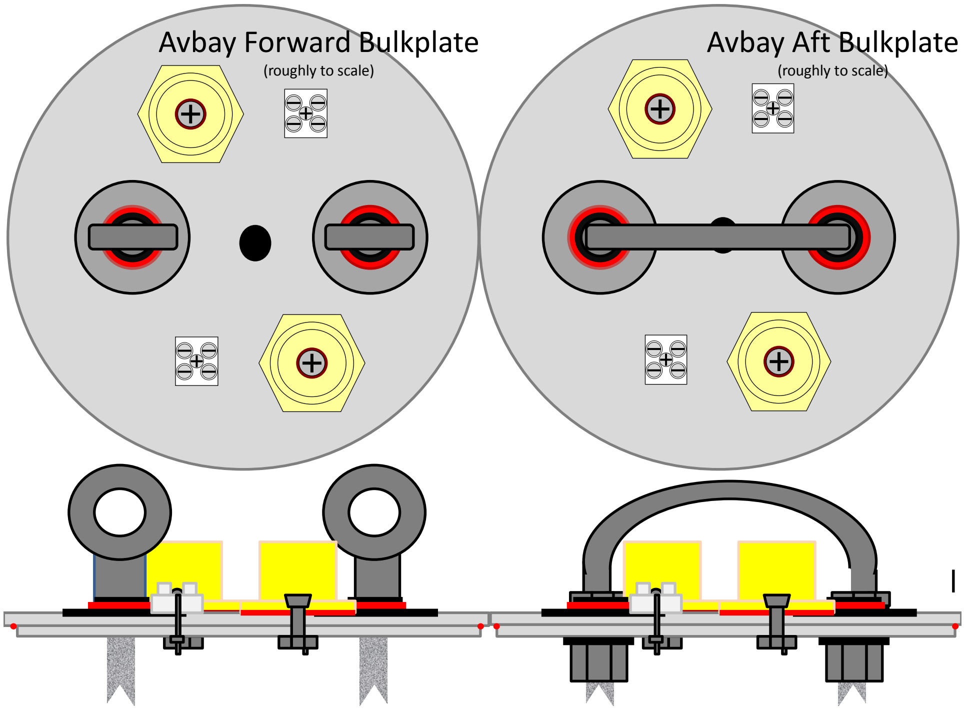
Fin Dimensions:



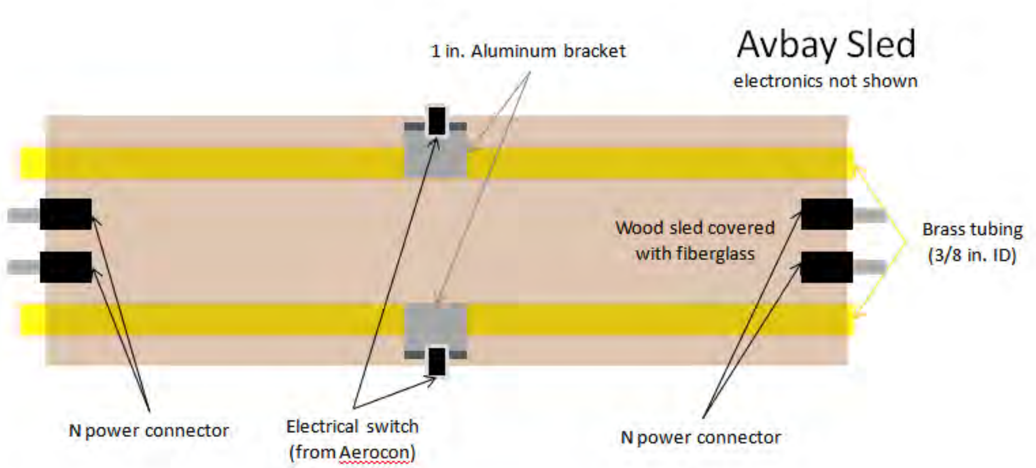
Fincan Cross-Section:



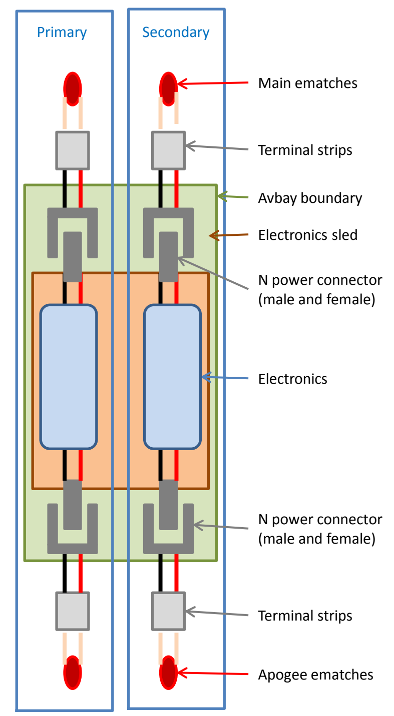
Avbay Bulkplates:

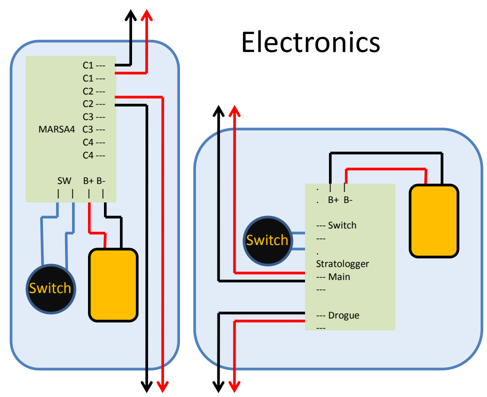


Avbay Sled



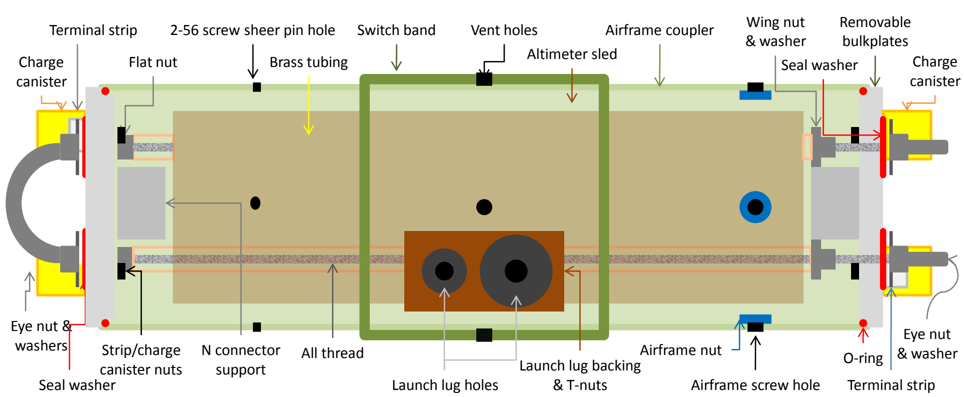
Avbay Electronics ~~(2 of the altimeter configurations will be used)~~:

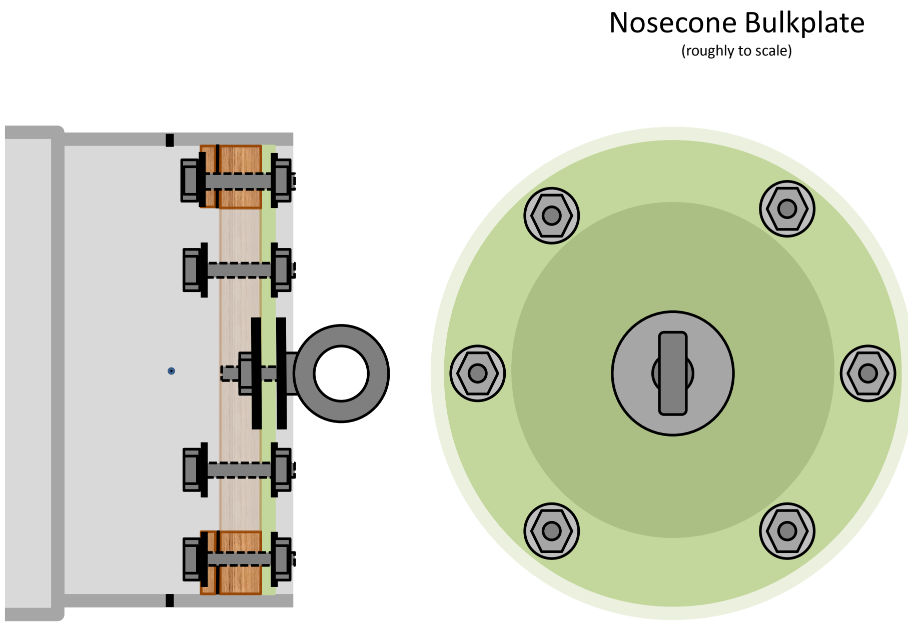




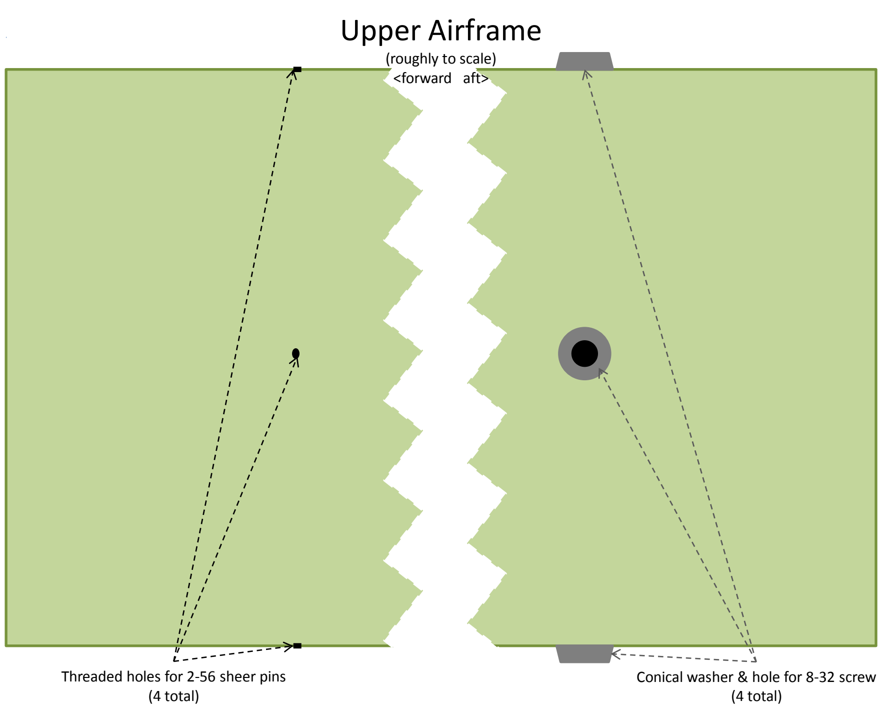
Avbay Section

No electronics shown
<aft forward>
(roughly to scale)

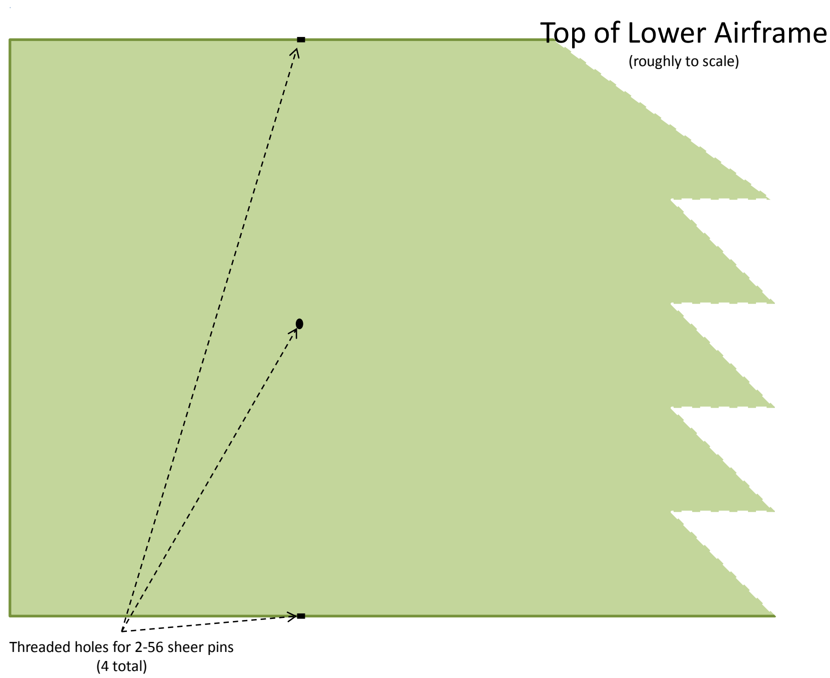




Upper Airframe:

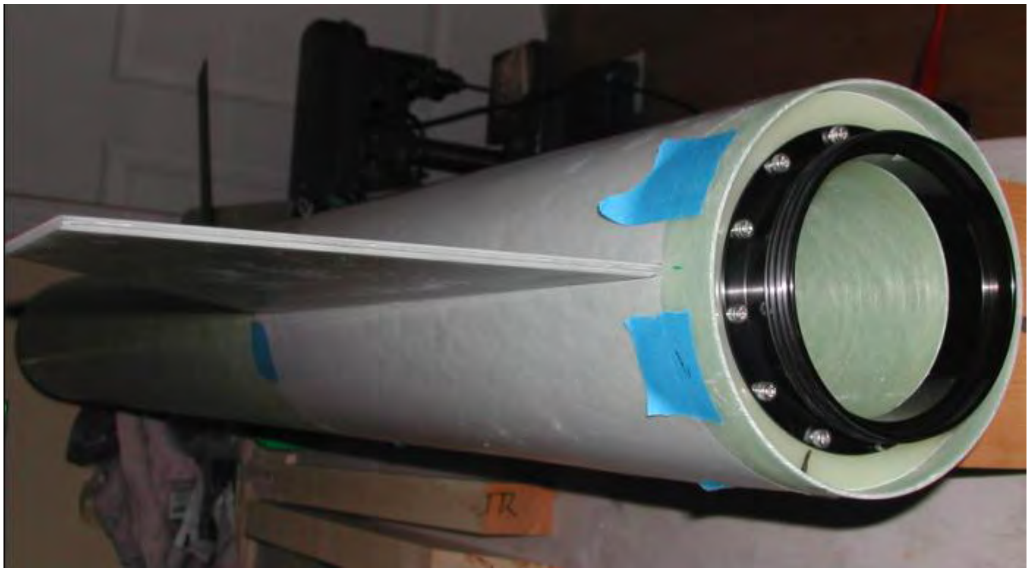


Lower Airframe (top):



Assembly Images:

Protecting the airframe with waxed paper prior to tacking fin to motor tube.



First fin tacked to motor tube; two more to go.

Applying CF over fin joint and removing extra epoxy with release fabric, batting and oak board. Oak compresses materials and is clamped to both the airframe and the fins. Five more to go.

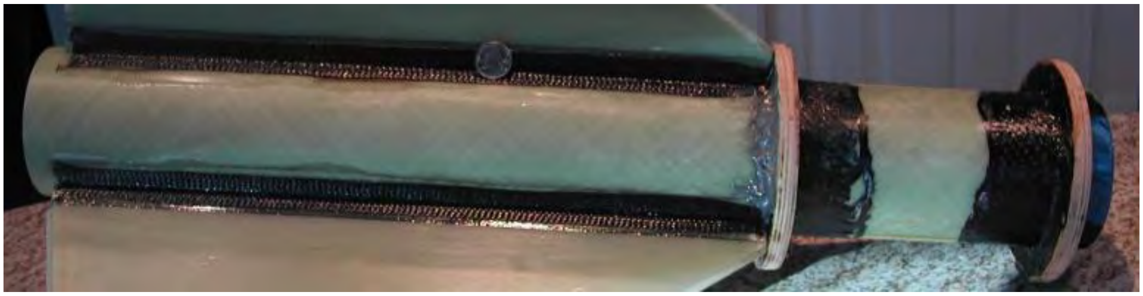
Applying CF reinforcement to another fin joint using the exact same process. Image from a different angle showing CR notched to fit Kevlar strapping for recovery and previous CF reinforcement.

Attachment of one side of the Kevlar recovery harness strap. Between the fins the same process was used with the release fabric, batting, waxed paper and oak board to compress and remove excess epoxy. Hockey tape used to hold Kevlar strap between centering rings.

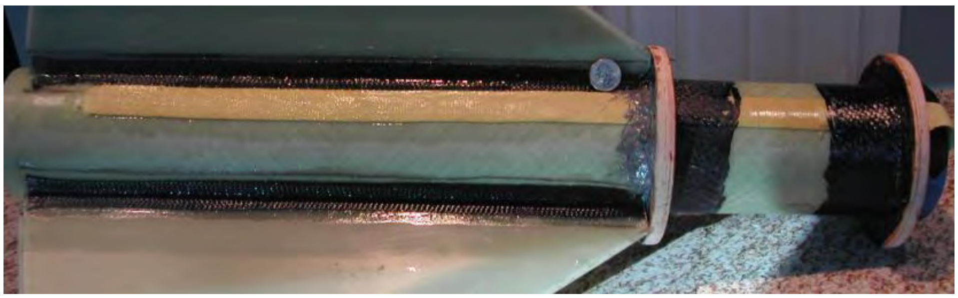
Applying CF to CR-motor tube joint to forward CR. Same process as with fin reinforcement except over curved surface. 1/8 plywood used to compress against CR and both steel clamp and red strap clamp to compress over motor tube. See the middle CR at toe bottom to see what first CR reinforcement looks like.

[You can never have enough clamps.]

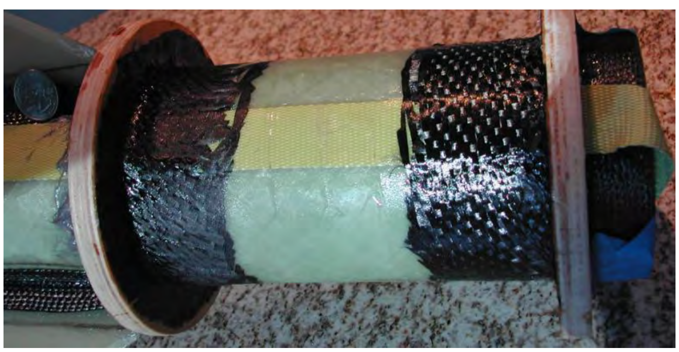
Completed side one of three including epoxy/CF/glass beads/colloidal silica filet on aft side of middle centering ring and one of the two recovery harness attachments on the bottom.



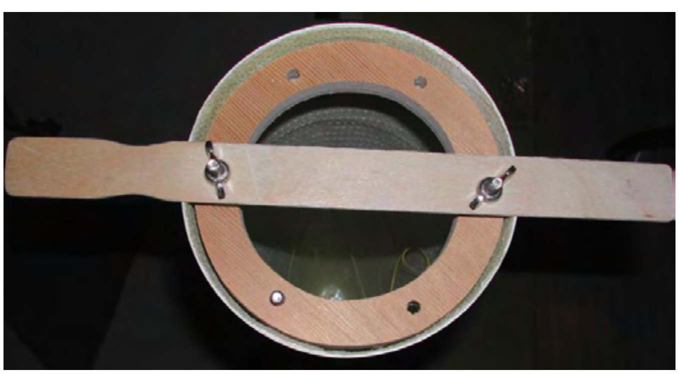
Side two of three (notice no Kevlar strapping)



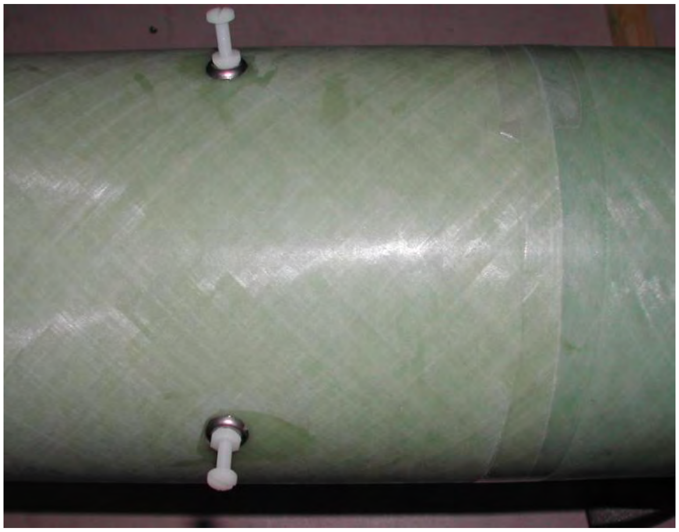
Side three of three (notice Kevlar strapping on top)



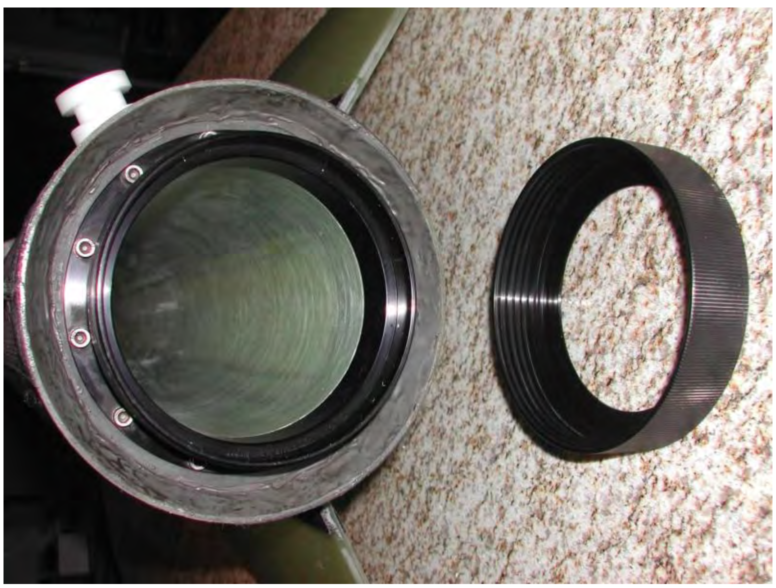
Closeup of CF reinforcement of CR-motor tube joints.



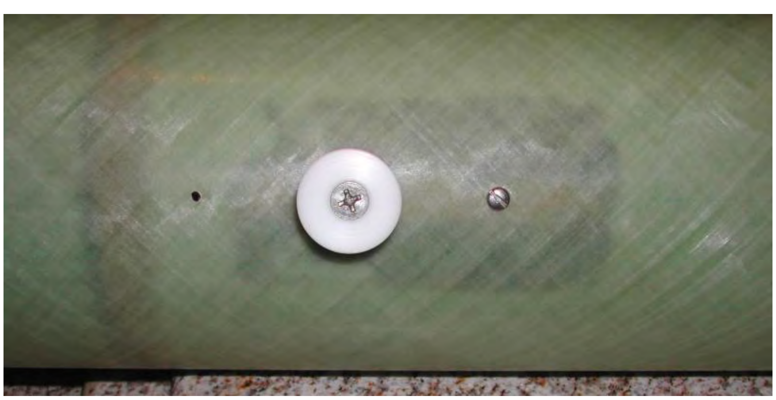
How the nosecone bulkplate attachment ring was held in place while being tacked. The entire joint between ring and the nosecone was filled with epoxy after the tacking was complete.



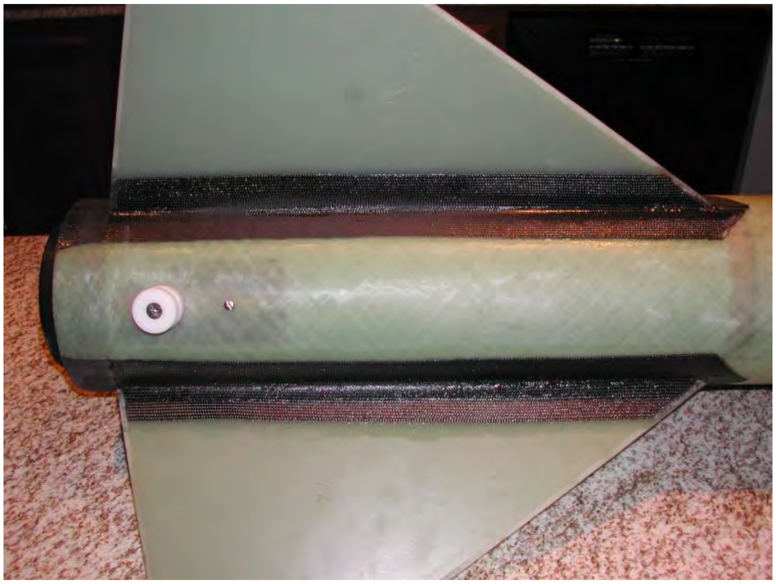
This is the joint between the coupler/avbay on right and the payload bay. There are nuts glued inside the coupler and now the tapered washers are being added. Nylon screws are used with tapered nuts to get the centering of the washers to match exactly. The nylon is also useful because: 1) small bits of epoxy do not stick well and 2) if you accidentally do glue in the nylon screw, it is much easier to drill out the nylon compared to a steel screw.



Aft end of the airframe showing how the G10CR was glued in place and the Aeropack attachment. The aft-most Unistrut button is also shown.

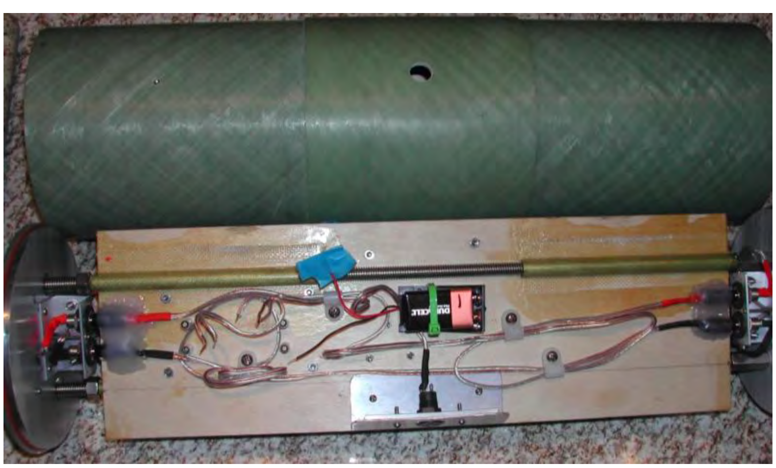


This airframe view is with the aft to the left and shows just above the forward CR. Outside the airframe, starting at the aft is: 1/8 vent hole, Unistrut rail button, and screw plugging optional 1515 rail button hole. Through the airframe, it is possible to see the forward CR and the rail button reinforcement.



This is the completed fincan section attached to the airframe. All three sides are identical, with only one side having the Unistrut rail button, launch lug reinforcement and screw. Notice the CF braid to reinforce the fin to airframe joint and how the CF braid wraps around the bottom of the fins.

A view inside the coupler. This shows the CF wrapping, the inside view of the launch lug reinforcement, how the CF is used to hold the 8-32 nuts in place and the vent holes.

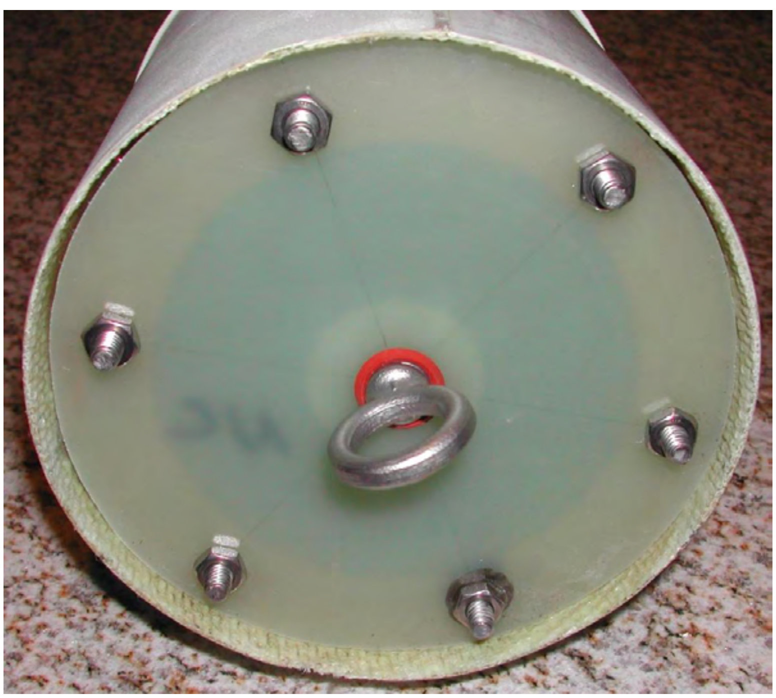


The completed coupler with the vent holes and aluminum top and bottom, along with the completed avbay sled. Only the altimeters are missing.

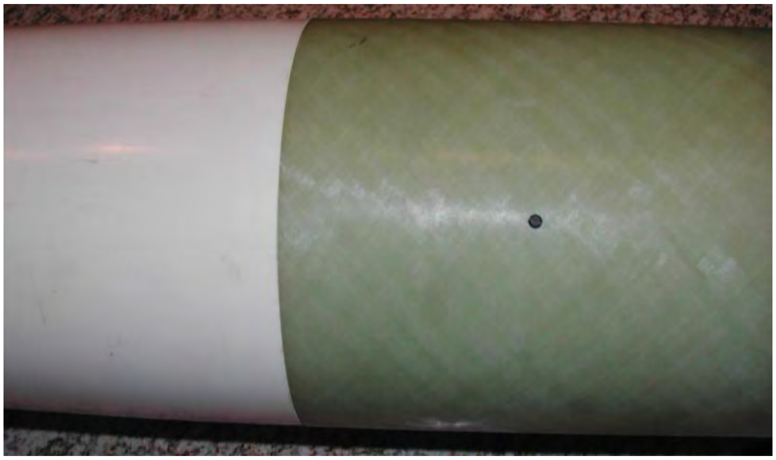
The airframe coupler, looking at the arming switch inside. The arming switch is attached to the avbay sled and is one of two. They are 180 degrees apart so only one is visible at a time. Also visible on the left (forward) is a hole and 8-32 nut inside the hole, used for attaching the upper airframe to the coupler (1 of 4). Barely visible on the right (aft) is a 1/16 inch hole for the 2-56 sheer pin (1 of 4).

Aluminum avbay forward cover, showing terminal blocks, charge holders, and recovery harness holders (2).

Aluminum avbay aft cover showing terminal blocks, charge holders and U-bolt.



Nosecone bulkplate.



Nosecone attached to forward end of the upper airframe and showing the 2-56 sheer pins.

Aft end of the upper airframe showing the tapered washers used to hold the screws for connection to the coupler. The 1/8 inch vent hole is also visible on the right. Through the fiberglass, you can see what appears to be a dark section at the end of the tube. This is an orientation mark to indicate the orientation of the airframe to the coupler.

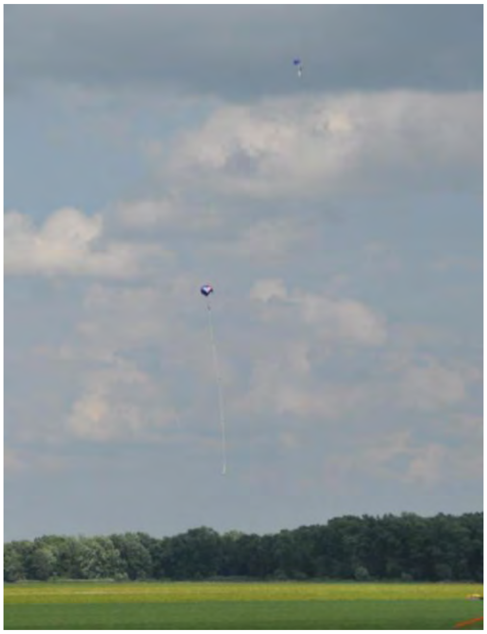
The three rail buttons are in exact alignment and orientation. 1010 rail buttons and a 1010 rail were used to see if the alignment was good; which it was. On the coupler, it is possible to see the same alignment mark for the coupler to be aligned with the upper airframe.

Checking to see that the rail fit; which it did. The camera angle makes it appear as though the rod is not straight relative to the rocket. In actuality, the two are parallel.

The recovery system components and the airframe. The upper airframe is missing. From left to right:

Nosecone with 44 inch Sky Angle chute and 3 foot shock cord attached. Attached to the shock cord is the deployment bag. Next is the Sky Angle XL Cert 3 chute with the “Y” shock cord and parachute protector attached. On the other end of the shock cord is the forward end of the avbay. Attached to the aft end of the avbay is the center shock cord, which is attached to the fincan shock cord. In the middle of the aft shock cord is the 24 inch parachute and streamer. The streamer is a Mylar “WELCOME HOME” banner which has been reinforced with fiberglass strapping tape. The tape is also used to create a loop at the bottom for connecting to the recovery system.

Certification Day:



Actual Altimeter Readings:

- MARS4A: 5706 feet
- Stratologger: 5670 feet

Thanks to the following people for making my L3 possible:

Scott T, Kevin O, Tom O, Jeff O, Dave L, Matt R, Tim L, Mike D, Bill C, Paul M, David J

Appendix A: About the Rocketeer

Beyond my flying my own rockets, there are many things I do for rocketry. I am the president of the Champlain Region Model Rocket Club (CRMRC). When I took over the club about 4 years ago, most of the original members who started the club had lost interest. The club was down to 3 active members, with only 1 L1. The club now has 13 active members (2-L3, 7-L2, 4-L1, and 3-L0 looking to be L1). During that time, I: was the impetus for myself and 2 other CRMRC to write an article in Sport Rocketry on "Cold Weather Flying," obtained a NAR grant for the CRMRC used club funds to get basic safety equipment (fire extinguisher, first aid kit, air horn, anemometer), helped run 16 outside launches (Boy Scouts, Cub Scouts, Stern's Center for Language and Learning, 4H, Libraries across Vermont), given rocketry talks to the several groups (Vermont Astronomical Society, Mt. Mansfield Fine Scale Modelers, Green Mt. RCers) and a safety demonstration to my local fire department. As part of this, I developed the CRMRC Flying Saucer kit which kids decorate a paper plate, a motor tube is attached, and then flown almost anywhere. The club has sold and flown over 300 of these, exposing many kids to rocketry. I also work to keep the CRMRC moving forward and have expanded our launch capabilities as we have needed them.

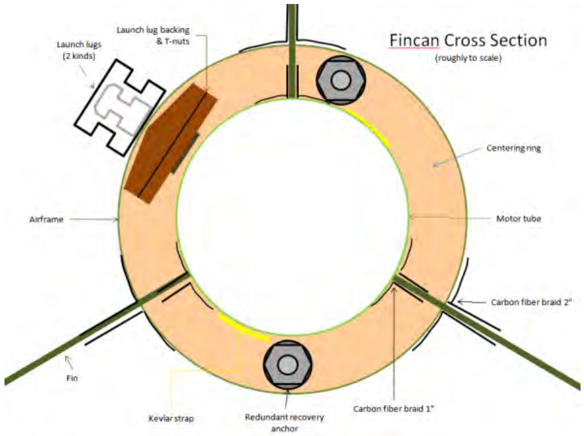
At regional launches, NERRF, NYPower, and LDRS 28, I go a day early to help set up. This is how I know my L3CC as I worked with him to stake out the slots for LDRS 28.

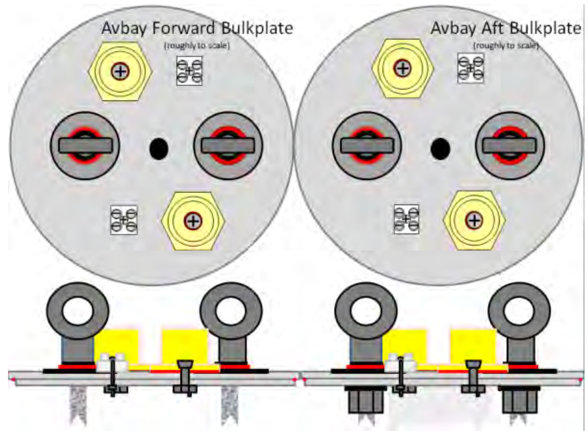
So what makes me think I am ready for L3, besides having set aside the money for all the parts? Two years ago, my L2 project was a modified PML 1/4 Patriot with redundant dual deploy. Ever since then, every kit that is big enough (more than 2.6 inches) has been built with the capability of dual deploy and rockets 4 inches or bigger have the ability to fly with redundant dual deploy. I have used a Transolve P6, G-Wiz MC2, Perfect Flight RRC-2 mini, and John's MARSA4 in my rockets. All spring, summer and fall, I fly dual deploy whenever I can (in winter, the electronics and batteries have too many issues so I avoid this when the temperature is below freezing). My largest rocket is 5 inches by 84 inches and was first flown at LDRS 28. Since then, it has flown 8 times, from baby J to some of the largest Ks. Every rocket I build is done slightly different as I experiment with various techniques and configurations. I am currently very comfortable with the way I construct airframes and have not had an airframe problem. I am also encouraged with how reliable the electronics and dual deploy works. I have used freebags, streamers, and parachutes with great success.

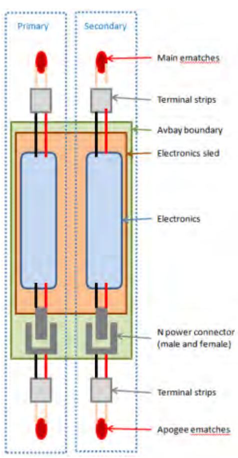
I have had my share of retired rockets too. Three Aerotech motor casings have either split or had the forward closure go; all were examined afterward and assembled correctly. One AT motor vectored out the side of the nozzle and the rocket spiraled. I have had one electronics failure where the altimeter was beeping properly on the pad, but no charges deployed. I have also had one where I forgot to turn on the altimeter and no charged deployed (the members of the club now always ask me if my altimeter is on). I have had several where the recovery components have tangled. The big thing is that I learn from these mistakes when I can. I know always check my electronics to be on and have improved how my recovery parts are folded and packed.

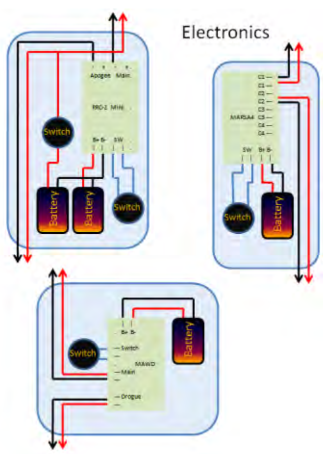
Howard Druckerman, NAR 85721

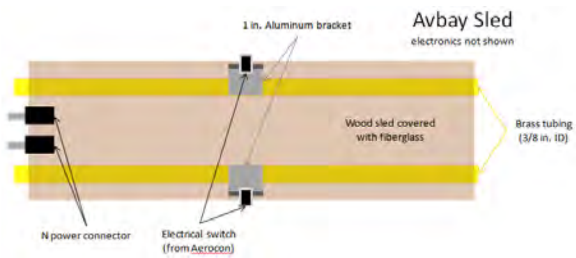
Appendix B: Old images which were part of the original submission but needed to be updated because construction varied from the original design.

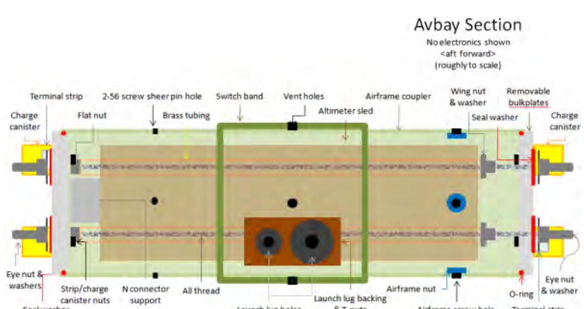






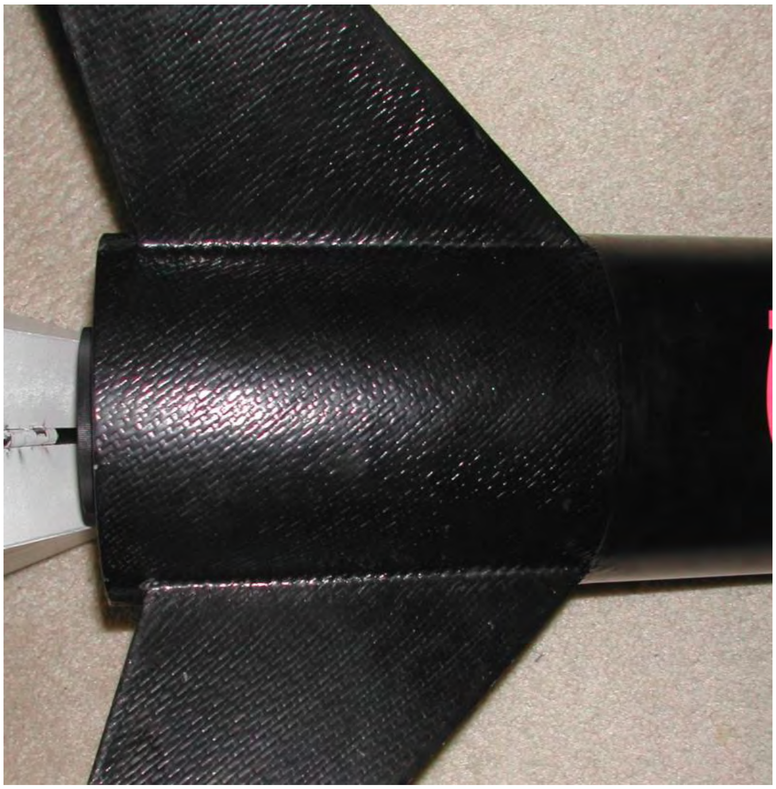






Appendix C: Images of previous construction projects prior to this are moved to here (so as not to be confused with the L3 construction):

Images of projects showing already used techniques:

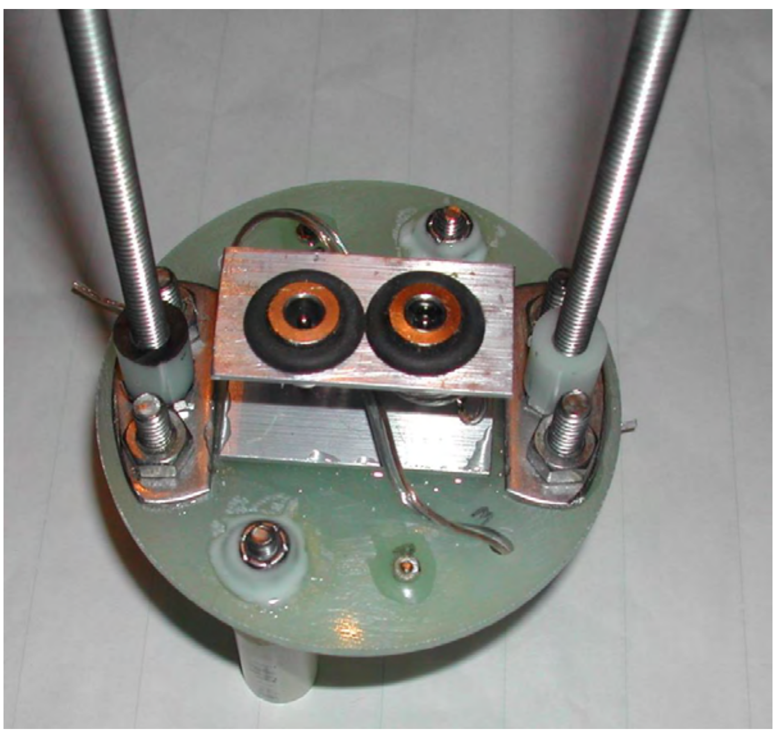


Fincan carbon fiber reinforcement on a 5 inch rocket, done as fin tip to fin tip [flown at LDRS 28]

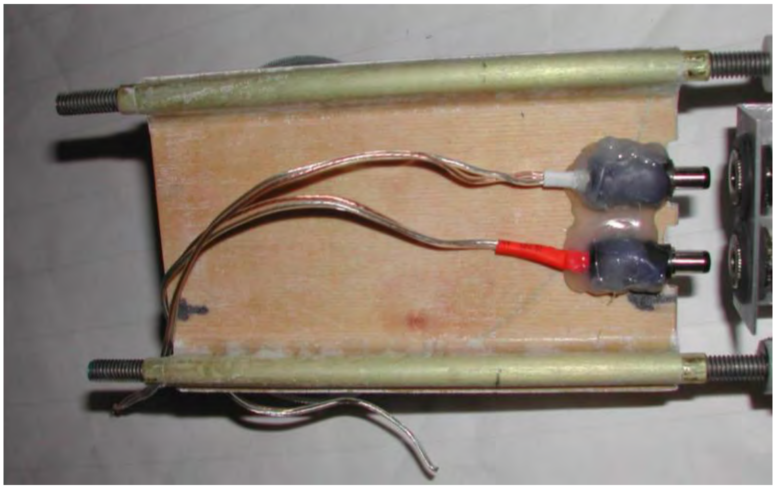
Upper airframe to coupler using 8-32 oval head screws and countersink washers, on same 5 inch rocket

Nosecone bulk plate attachment for 4 inch short/fat rocket with the capability of adding an avbay and forward tube, so needed the ability to add or subtract several ounces of weight at the top of the NC

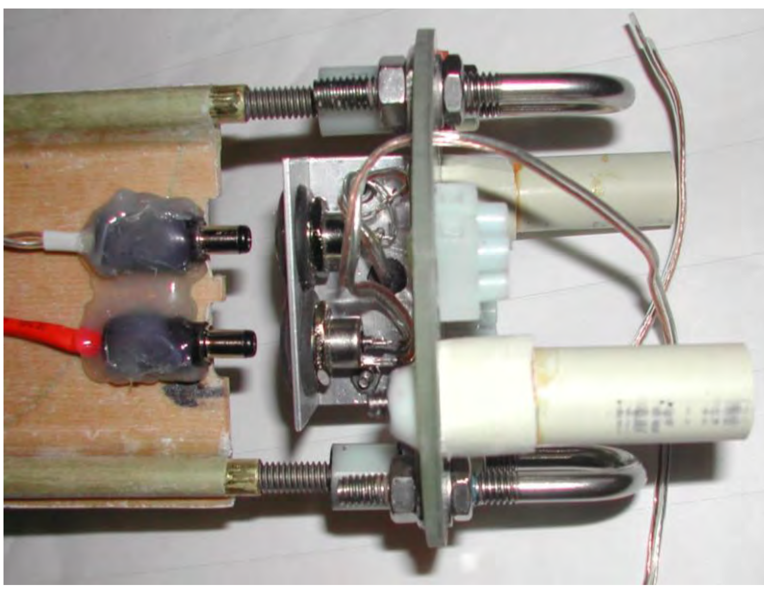
Forward avbay bulkplate for 4 inch rocket with slightly different rod and U bolt configuration than planned for Ultimate Wildman (wires not attached yet)



Aft avbay internal layout for 4 inch rocket showing N power connector support (wires not glued yet)



Avbay Sled on 4 inch rocket on all-thread, showing N connectors on aft bulkhead



Close-up of N Connector setup on 4 inch rocket and aft bulkhead (not yet glued into coupler)