Chris Munson
Level 3 Documentation

“Howdy…

I’m Chris Munson from Rockdale (TRA #09654) and the Labrador with the spiffy orange shoes is Duke. Rags has put a lot of effort into our website, and I’m honored to be able to contribute towards it.

I attend most of the AARG launches, but rarely fly anything and this is why. I tend towards “tunnel vision” when it comes to focusing on projects or whatever it is I’m working on, and this has taken priority for the last couple of years.

My lovely bride Jeanie will laugh about how I’d say I wasn’t ever going to try for a Level 2, much less a Level 3.

Funny how all that works out.”

“Tumbleweed Connection”

Tripoli Rocketry Association Level III

Construction, Simulation & Flight Documentation

Chris Munson TRA #09654

Part 1: A Galaxy, Far, Far Away (The Eastern Slope of the Sierra Nevada - Mojave Desert)

“Tumbleweed Connection” is the Tripoli Rocketry Association Level III project I began in 2007, shortly after I certified Level II.

“Tumbleweed Connection” is based on a Performance Rocketry “Intimidator 5” all fiberglass, five inch diameter airframe kit. When I ordered the kit from Curtiss Turner, two changes to the stock kit were requested and received: an additional one foot length of airframe tubing and a two foot length of coupler tubing, rather than the customary one foot length.

I planned on cutting six inches from the coupler tubing to use as material to build a “piston” for main parachute deployment in customary two event recovery fashion. The additional six inches of coupler length at its center, was to allow room for camera/avionics equipment at the airframe junction.

The extra airframe tubing was to be cut exactly in half. One piece would be finished “slick” for covering the center of the airframe coupler, and the other would be an alternate, used for whatever windows and fairings the camera would require, should that design develop.

The kit as advertised

The kit as ordered and received

Nothing out of the ordinary was planned for recovery. This involved dual redundant altimeters providing a small drogue and streamer apogee deployment and a main parachute at a reasonable altitude, 1100 feet with an 800 foot back-up. As I had an amateur radio "technician" license, I purchased a Big Red Bee beacon for radio locating after landing. Since then, I have added an "EggFinder" GPS telemetry unit, so now have two trackers.

Karl Baumann and Mark "Dok" Hanson were my TAPs at this stage of the build, with significant additional mentoring by my Prefect (Tripoli Mojave Desert), Kevin Metzler.

In preparation for the build, I made some adhesive samples using scrap G-10 and the Hysol 9395 high temperature adhesive I planned to use for the fin can assembly. At the same time, I fabricated a "fin jig" to ensure proper fin alignment while the 98 millimeter motor mount and fins adhesive joints cured.

Adhesive Sample

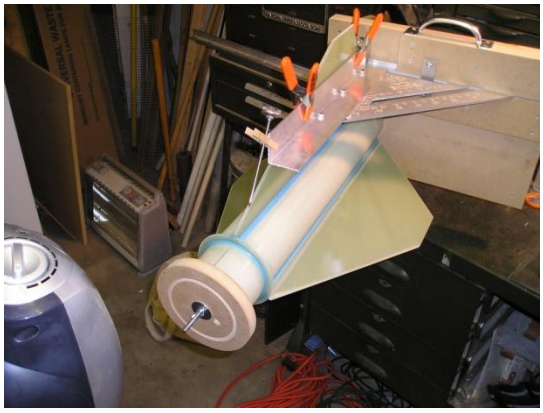
"Fin Jig"

The adhesive samples demonstrated remarkable strength, after slicing the samples into smaller pieces, the butt joints basically couldn't be snapped using our bare hands.

The fixture was checked for "squareness" and assembly began.

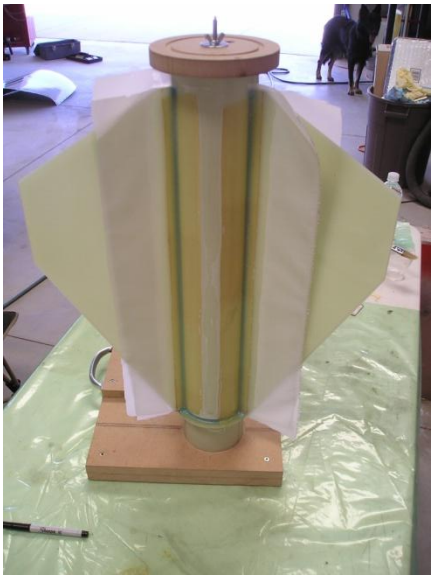
Measurements were made and the motor mount marked for centering ring, fins, and launch rail guide locations. After the centering ring adhesive cured, it was time to attach the fins. An interesting thing about Hysol 9395's cure time. It's several days at room temperature and 1 hour at 150 degrees F. I chose the elevated temperature cure.

First Fin



Third Fin

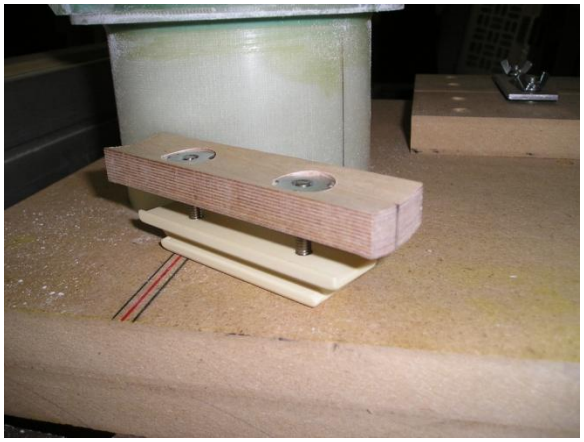
After ensuring that the fin adhesive was thoroughly cured, the joints and surrounding fin and motor mount areas were scuffed –up with 60 grit sandpaper in preparation for a reinforcement of Kevlar cloth tape, laminated with Aeropoxy brand epoxy. Like the Hysol adhesive, the Aeropoxy was chosen for its superior strength at elevated temperature. The Kevlar tape was applied using "Peel-Ply".



Kevlar Tape Reinforcement to Fin Can

After the Kevlar tape reinforcement was cured and the "Peel-Ply" removed, it was time to bond the rail guide backing reinforcement block to the motor mount tube. The block had been fabricated by laminating multiple layers of 1/32" hobby plywood together so that the half inch space between the motor mount tube and the inside of the airframe tube was filled. The curvature of the block was accomplished by clamping the multiple layers of 1/32" plywood between surrogate motor mount and airframe tubes.

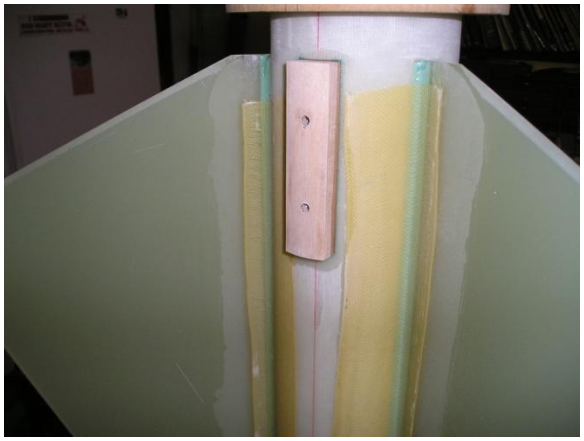
Plywood Clamp



Finished Backing Block

After the rail guide backing block was finished with “Tee Nuts” installed, it was carefully bonded to the fin can assembly showing care for the fin can centerline and location requirements of an aft centering ring.

Bonding the Backing Block



Backing Block Attached

At this point in construction, it was necessary to open the pre-slotted airframe so that the now assembled fin can could be slid into place. Clearances were checked and additional material was removed so the Kevlar tape on the fins would clear the airframe slots.

It was here that I switched to West Systems 105/209 adhesive and fillers for the remainder of construction.

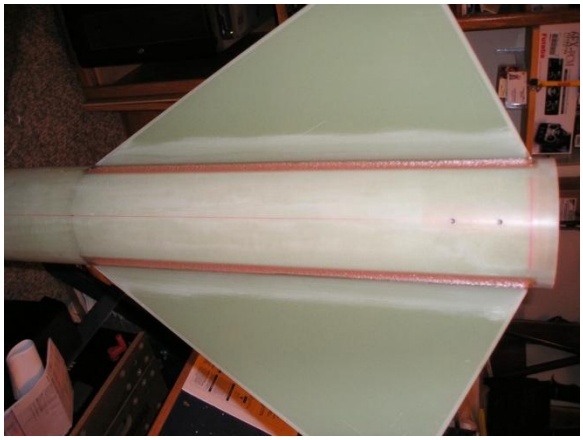
A five inch hose clamp was used with one of the kit’s G-10 centering rings for fixturing the fin can so that it’s forward ring could be bonded to the inside of the aft airframe section. After curing, the temporary aft ring was replaced with an inch thick, aircraft plywood centering

ring that had “Tee Nuts” installed to fit the hole pattern of an Aero Pack 98 millimeter motor retainer.

Temporary Clamping for Forward Centering Ring Bonding

Plywood Aft Centering Ring with Aero Pack Motor Retainer

After the aft centering ring bonding had cured, the exposed open fin slots on the aft centering ring were “dovetailed” and filled with West System 105/209 mixed with chopped fiberglass filler. Then it was time to reinforce the fin / airframe joints with two layers of fiberglass cloth tape.per side. First a filet of West Systems 105/209 mixed with West System 407 “micro balloons” was applied.after 60 grit “scuffing of the joint area. The Kevlar tape from the fin can that extended through the airframe fin slot was “captured” in the filet. After curing, the entire fin/airframe/joint area was “scuffed-up” again, and the reinforcing glass tape applied using “Peel-Ply”.



Fin/Airframe Joint Filet

Younger Old Guy “Glassing” Fin Joints

This is pretty much where the project “stalled”… I became heavily involved with the Friends of Amateur Rocketry and the adventure involved with navigating the California State Fire Marshall bureaucracy’s Cal Pyro licensing process (to legally fly “high-power”), retired, and moved to Central Texas, dragging a half-finished, Level III project with me.

Part 2: A Slow Start to a New Beginning (How in the Heck Can Grass and Weeds Grow This Fast?)

One of the many things I had promised myself when I had settled in Texas, was to buy some machine tools, primarily to do research rocketry. Sometime in 2011 or 2012, I ended up paying too much for an estate sale bundle of Chinese machinery, primarily a Harbor Freight Mill/Drill and a Harbor Freight 12" x 36" lathe.

I had started going to Austin Area Rocketry Groups (AARG) launches and some meetings and since I now had the previously mentioned machinery, I decided to put it to use by machining the avionics section/coupler end caps/ejection charge holders. At the time, it was more of an exercise in machining than any conscious formal restart to the Level III build.

I was proud of how the end caps turned out… "o" ring grooves and the lay-out of heavy duty screw terminal strips for charge initiators. Already having the design for the avionics section/coupler in my head, I ordered a 0.6" OD/0.1" wall carbon fiber tube for reinforcing/stiffening the coupler (bonded to the inner wall in three equally spaced locations) since I would be cutting openings in its center to accommodate any possible cameras. I also ordered high strength, ¼" "all-thread" to travel through the center of the carbon tubes, clamping the end-caps to the coupler.

At this point I would occasionally speak to Stu Barrett about "my Level III project" and he would encourage me and let me know that he would be there when I was ready to start. Then I disappeared into Central Texas to deal with goats, fences that kept washing out, and farm maintenance I could never seem to stay caught up on, occasionally showing up at AARG and Tripoli Houston launches, mostly to watch.

Sometime in late 2018 I realized that the task of bonding the carbon fiber tubes inside of the coupler/avionics section was not only intimidating me, it was also what was keeping the project from progressing any further.

I made multiple measurements, drew guide lines all over the coupler and the carbon fiber tubes, "scuffed the coupler locations and the tubes, then finally "tacked" them in place at the ends with cyanoacrylate glue. Once I was satisfied with all the locations, I finished bonding the carbon fiber tubes with West System 105/209 thickened with West System's 406 Colloidal Silica filler. I was pleased with the results.

Although one of the altimeters is WiFi controlled, all altimeters are physically switched… the master power disconnect switches will be Jolo Industries OS-120 screw switches, purchased from Aerocon. The switches will be mounted in a block of ½" thick G-10 fiberglass that I milled to match the inner radius of the coupler/av bay. The block itself will be centrally located in the "camera compartment" and bonded to the coupler's inner wall. The

switches will be soldered, “through-hole” style to a piece of prototype printed circuit board, which in turn will be attached to the previously described G-10 block with screws. This is to allow removal should repairs or upgrades ever occur. The prototype board allows the 20 gauge Teflon insulated interconnect wiring to be securely soldered in series with the switches.

There will be four master power switches. One will be strictly a “spare”, wired, but not connected, and the other three go to redundant altimeters. One of the altimeters will be an “Eggtimer Rocketry” WiFi controlled “Proton” with separate deployment power (two switches). The other will be a “Perfectflite Stratologger”. The Stratologger is the primary altimeter, drogue at apogee and main at 1100 feet. The Proton is the back-up, drogue at apogee +2 to 3 seconds and main at 800 feet.

All the electronics will be in the forward one-third of the coupler with the switch wiring being twisted into twisted-pairs. Likewise, the fore to aft interconnect wiring will also be twisted pairs. The wire bundles will be bonded to the inner coupler wall with “5 minute” epoxy. “5 minute” epoxy is easily removed with a heat gun and solder pick should repairs ever be needed.

The coupler/av bay will be separated into thirds, lengthwise, using half inch thick bulkheads made of aerospace aluminum honeycomb composite panel material that Kevin Metzler was kind enough to give me.

Lastly, the switch band cover to the coupler/av bay and the rocket’s forward airframe will be secured to the coupler/av bay using 100 degree 6-32 flathead screws, “Tinnerman” aircraft panel washers, and inner bonded “nut plates”. The second center cover is built with a 38 millimeter diameter optical window from Edmund Optics, and the camera fairing on the opposite side is a 3D printed unit from Additive Aerospace. The Additive Aerospace fairing houses a Mobius Maxi aft looking camera and the Edmund Optics window is for a GoPro Hero 5 Session, mounted for a horizontal view.

Coupler/Av Bay with End Cap Removed

Coupler/Av Bay Interior

OS-120 Master Power Switch

Master Power Switch Block And Honeycomb Aluminum/Fiberglass Bulkhead

Part 3: Let's Get This Done and Flown

It is now January of 2022 and what was written before, in the "future tense", is now finished. Jim Jarvis and Stu Barrett of the Austin Area Rocketry Group (AARG) are my official TAPs. The rocket is finished and full up ejection testing and avionics function/interference testing has been successfully accomplished.

At this point I will do my best to accurately describe the finished airframe and recovery system, explain the reasoning behind particularly significant elements of the design and build, provide RockSim based flight simulations, and include those "check lists" to be used for pre-launch assembly and final arming once on the rail.

The original plan was to use two Public Missiles (PML) 1515 sized Linear Rail Guides to mate with the launch rail… one at the far aft of the booster section and one as far forward as wouldn't interfere with the Avionics Bay/Coupler. Both TAPs pointed out the disadvantages of aligning rail guides as opposed to rail buttons when sliding the rocket onto the launch rail, and the potential for damage and aborting the launch for repairs. It was also strongly recommended that the forward button be installed roughly two feet from the aft end of the booster, rather than almost three and a half feet forward. This was to allow the rocket to gain a bit more launch rail speed before losing the support of the forward button. Lab Rat Rocketry provided me with a 3D printed, conformal backing-nut that allowed me to install a rail button at the two foot point, with no more modification than to drill a hole for the rail button screw. I'm leaving the original third forward button in place for additional support with the option of removing it and installing a low profile screw in its place, should alignment become a problem.

Having found out the hard way that Central Texas has the potential for rockets to sink in farmer's water "tanks" (stock ponds), I designed the nosecone to contain the GPS and radio trackers as a sealed unit. The EggFinder GPS and the BigRedBee 70 cm tracker are contained in a polyethylene unit made from a commercially available "pool noodle". That in turn is attached to four fiberglass rods connected to an aft nosecone bulkhead. The bulkhead and nosecone are connected together with ten 6-32 machine screws and nutplates, sandwiching a rubber gasket in between to make the nosecone water tight and able to float. Hopefully it won't be necessary.

Tracker Housing / Nosecone Bulkhead

Nosecone / Bulkhead Mount

After the two honeycomb bulkheads had been securely bonded to the inside of the Avionics Bay / Coupler, and the Master Power Switch block bonded centrally on the inner wall of the coupler, the Switch Assembly was mounted to the block and the eight wires as a cable routed through the forward inner bulkhead, into the altimeter area.

The wiring for the aft aluminum end cap was soldered to the appropriate terminal block connections, and after careful cleaning and inspection, "potted" using 5 – minute epoxy. Once cured, "o – rings" were installed on the end cap and the wiring, as a cable, was routed through the two honeycomb inner bulkheads, into the altimeter area.

Altimeter area with routed Master Power
and aft end cap terminal block cables

The aft one third of the coupler is essentially empty except for the the drogue ejection cable running the length of the coupler. The middle one third houses the power switches and the mount for the GoPro camera. As previously mentioned, the "Switch Band" cover has access holes for the power switches, a window for the GoPro, and a shroud for the Mobius Maxi camera.

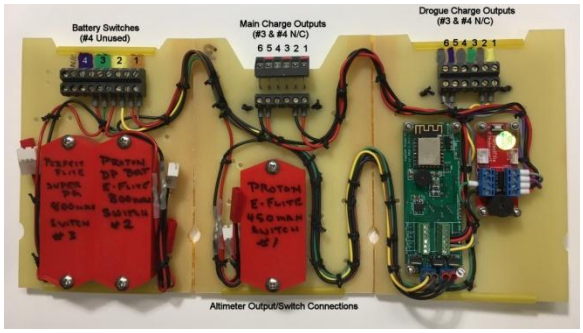
GoPro Mount
(Power Switches and Aft End Cap Cable in Background)

Switch Band / Camera Cover

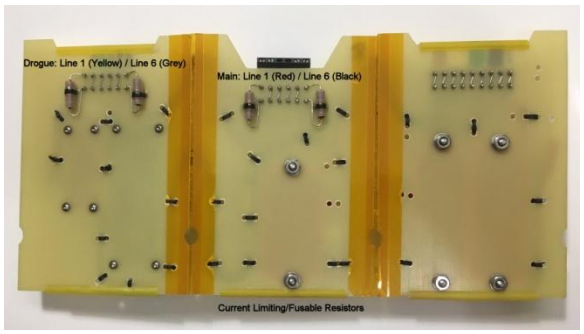
The forward one-third of the coupler houses the two altimeters and batteries, mounted on a three piece G-10 "sled" that folds into a triangle to save space. As previously mentioned, the Proton is configured to use two "switched" batteries as a safety feature (eliminating the chance of the deployment computer "browning out" from the load of firing the apogee charge). As an after-thought, TE Connectivity brand 1.3 ohm 3 watt "fusible" resistors were connected in series in all four deployment firing lines. Should a short occur during a charge firing, the altimeter won't end up damaged.

Three evenly spaced 5/32" holes lead into the altimeter housing, through the upper airframe and coupler wall for air pressure monitoring.

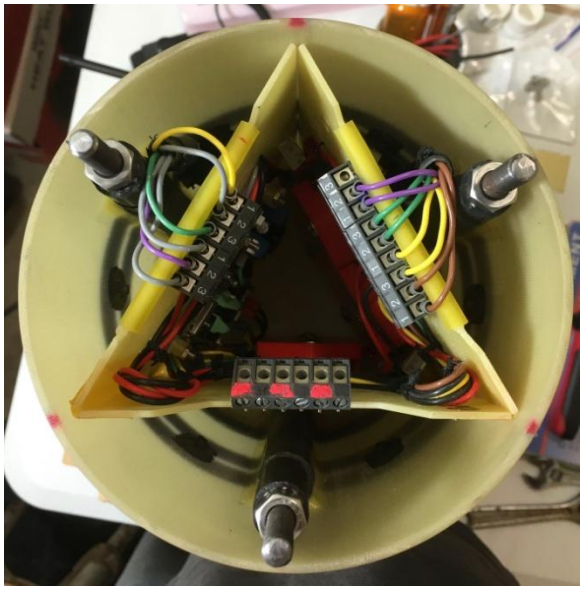
The forward aluminum end cap is removable, though requiring care due to the main charge wiring that connects to a terminal strip on the altimeter sled. That same wiring is soldered to the "outside" terminal block, and like the aft aluminum bulkhead, is "potted" using 5 – minute epoxy. Also like the aft end cap, it has a 3/8" forged eye-bolt for recovery harness attachment screwed into it, backed up with a lock nut and cotter pin and covered with heat-shrink tubing to protect fingers and any loose wires. Again, like the aft end cap, two machined aluminum "charge wells" are attached to the outside wall. These are for the deployment and redundant deployment charges.



Altimeter "Sled" (unfolded)



Altimeter "Sled" Back

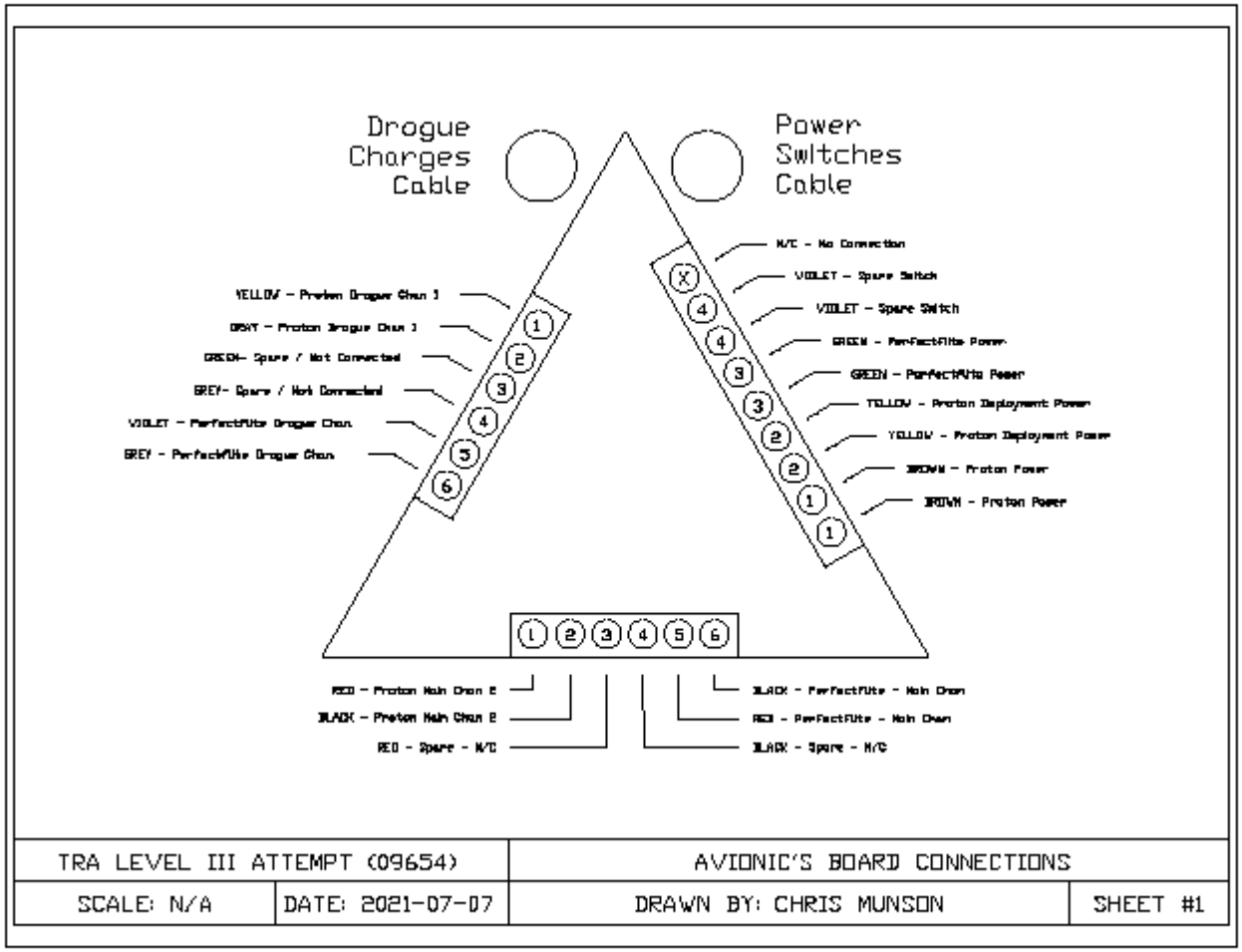


Altimeter Sled (folded & installed)

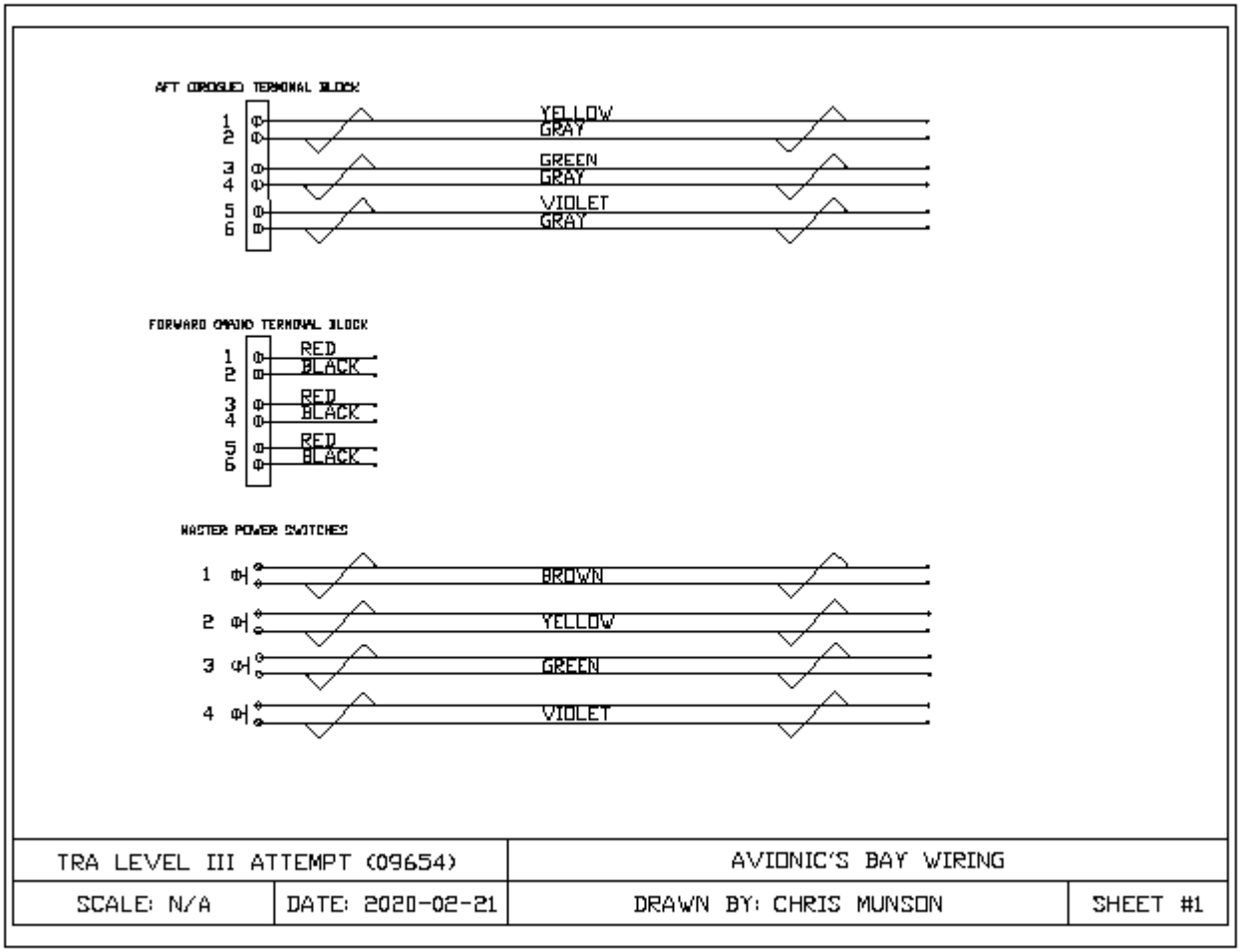
Forward Aluminum End Cap

When everything has been installed, "o-rings" are placed over each end of the three lengths of "all-thread", nuts and lock-nuts tightened to close the assembly.

The following are the interconnect diagrams for the wiring in the avionics compartment.



TRA LEVEL III ATTEMPT (09654)		AVIONIC'S BOARD CONNECTIONS	
SCALE: N/A	DATE: 2021-07-07	DRAWN BY: CHRIS MUNSON	SHEET #1


AFT OMNIDIRECTIONAL TERMINAL BLOCK
1
2
3
4
5
6
YELLOW
GRAY
GREEN
GRAY
VIOLET
GRAY
FORWARD OMNIDIRECTIONAL TERMINAL BLOCK
1
2
3
4
5
6
RED
BLACK
RED
BLACK
RED
BLACK
MASTER POWER SWITCHES
1
2
3
4
BROWN
YELLOW
GREEN
VIOLET
TRA LEVEL III ATTEMPT (09654)
AVIONIC'S BAY WIRING
SCALE: N/A
DATE: 2020-02-21
DRAWN BY: CHRIS MUNSON
SHEET #1

The eyebolts on the end caps of the Av Bay / Coupler will be connected to eyebolts on the motor and the forward airframe piston with OneBadHawk Kevlar recovery harnesses. Both are 7/16" with the aft harness being a three loop, 30 feet long, and the forward harness being a two loop, 25 feet long. Using the pre-sewn loop in the two harnesses, they will be attached to the Av Bay / Coupler's eye bolts using "Lark's Head Knots"… no fastening hardware required. The forward loop of the forward harness will be attached to the piston the same way, as the piston uses a forged eyebolt and forged eye nut which can be disassembled at pre-launch.

The third loop on the aft harness will be located closer to the Av Bay / Coupler for attachment to a one foot Kevlar Rocketman drogue as this rocket is not a "zipperless" design. The drogue will have a 6" x 10' streamer attached to it's top loop and rolled around it as a flame shield.

With the exception of the drogue to streamer link and the previously mentioned "Lark's Head Knots", all recovery interconnections will use "lifting grade" screw pin shackles. Once tightened, the pins will be safety tied using 1/8" Kevlar through the pin hole. The streamer to drogue connection will use a small "quick link" that has had Vibra Tite thread locker applied to it. The eye bolt/eye nut connection at the piston will also use Vibra Tite for security, and an additional lock nut.

Both Kevlar harnesses will have a Kevlar "sock" covered cushion secured to the harness where the harness contacts the airframe under tension. The cushion is meant to protect the airframe from a "zipper" during a extreme recovery deployment.

Both Kevlar harnesses will be "Z-Folded" and masking taped to help bleed-off deployment shock and protect the airframe.

Between the nose cone and the piston, the recovery harnesses are made of nylon webbing, attached and "safetied" with "lifting grade" screw pin shackles. The main parachute is a 14 foot diameter Rocketman standard parabolic, deployed out of a Rocketman deployment bag that uses a 3 foot pilot chute.

The nose cone is attached to a separate harness from the main parachute in a "V" configuration off the piston, preventing the two from entangling. The nosecone harness will be moderately "Z-Folded" and taped to cushion it from an abrupt shock at the end of it's harness.

Page 10 makes mention of the 5/32" altimeter vent holes… in addition; there is a 5/32" pressure bleed hole in the aft airframe section, just aft of the forward rail button, and, one in the forward airframe section, just aft of the nosecone shoulder. A 5/64" hole is through the piston stop, between the piston and the Av Bay / Coupler.

After researching the use of "shear pins" in High Power Rocketry, and building a test fixture to actually obtain values, I decided on two 0.060" red Deutsch connector sealing pins for the aft section to AvBay / Coupler junction, and three 4-40 screws for the nose cone.

"Shear-Pin" Test Fixture
(Three pins shown for clarity… not for actual testing)

The measurement was made using my neighbor's digital deer scale by fixturing everything between the table and base of my drill press, recording with a video camera to capture the exact value when the test pin sheared, and using the drill press table adjustment crank to "load" the pin and fixture. Since the pins sheared at two points with the fixture, the actual value was shear load/2.

The red Deutsch connector sealing pins have an average shear value of 20.15 pounds, so 40.3 pounds for the two and the black nylon 4-40 screws break at 42.5 pounds average, or 127.5 pounds total.

Full-up ground ejection testing was conducted on the grass in our back yard. I consulted the online calculators and being as I was coming up with quantities of black power that had me concerned I would destroy my Level 3 project, on the ground, without it ever flying, I decided I would start very conservatively… less than 2 grams of 4F.

Before starting the actual testing, I wanted to make sure the way I had my charge canisters configured was safe. I was using the same type of plastic caps that AeroTech uses on their 29 and 38 millimeter RMS forward closures for motor ejection. I loaded three grams of 4F with a "Firewire Initiater", secured it with an orange plastic cap, suspended it over a five gallon plastic bucket, and fired it with a wireless system I "cobbled together". After blowing a hole through the bottom of the bucket, I decided to switch to air conditioning aluminum tape to seal up the charge canisters.

Good deployments were achieved for drogue and main deployment using 2.6 grams (40 grains) and 2.125 grams (32.8 grains), respectively. 3.24 grams (50 grains) and 2.6 grams (40 grains) was settled on as the respective back-up charges after consulting with my TAPs.

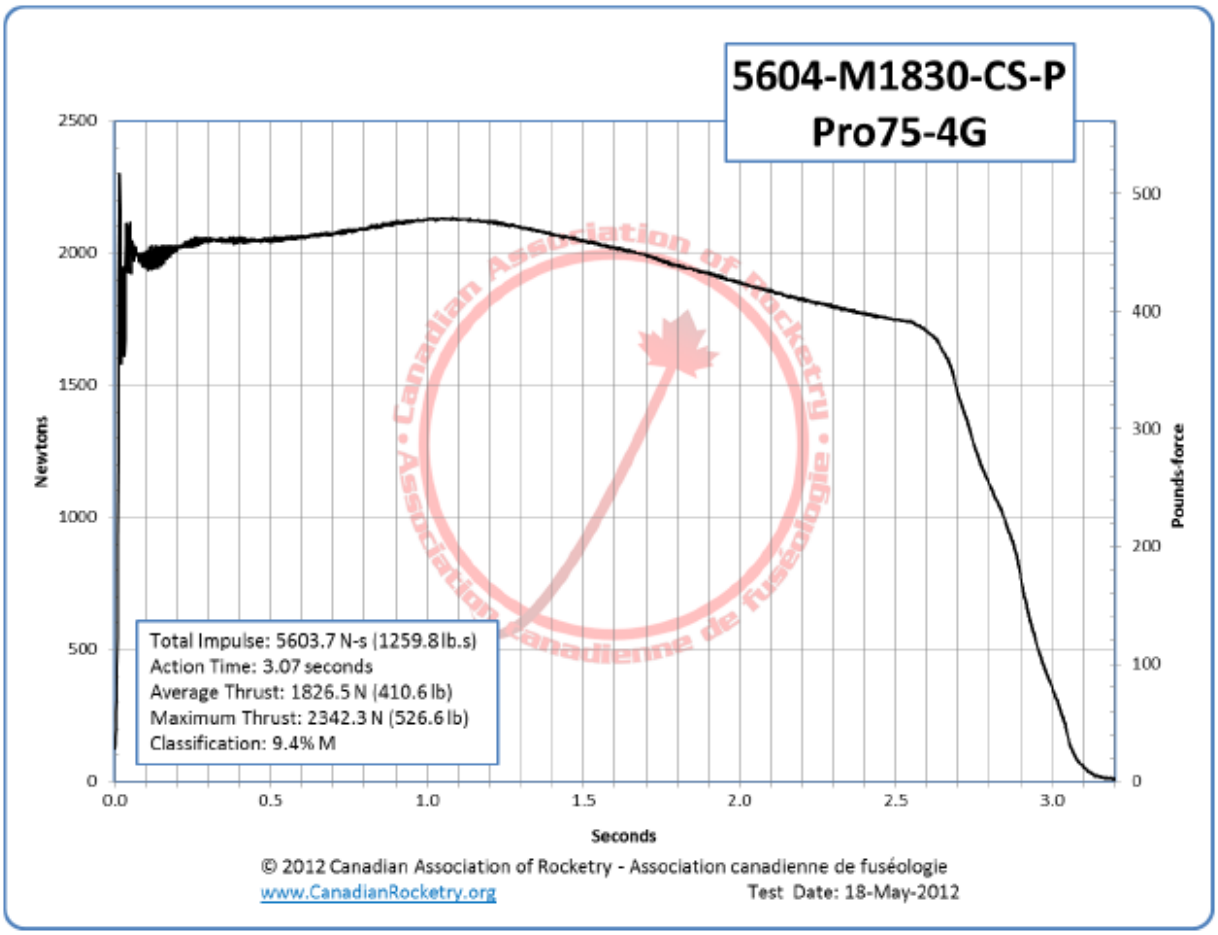
Once deployment testing was finished, the rocket got it's paint job. Between the narrow Texas humidity/temperature "window" and the skill level of the painter (me), it actually turned out quite well.

"Tumbleweed Connection" will fly on a 75 millimeter, 4 grain, Cesaroni M motor. It's a "C-Star", M1830 rated as slightly less than a 10% full M. It will use an AeroPac 75mm to 98mm motor adapter to fit in "Tumbleweed Connection's" 98mm motor mount.

Pro75 5604M1830-P

Motor Data

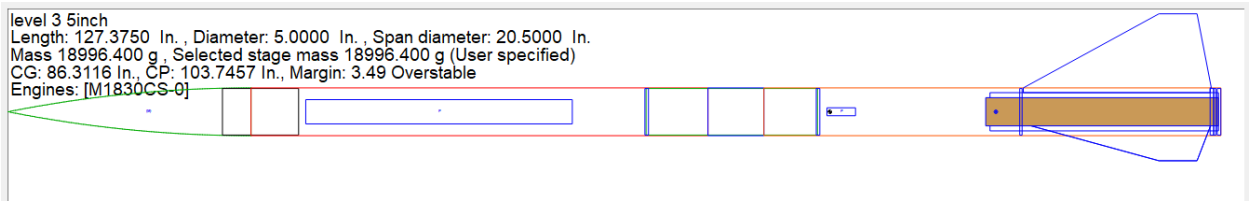
Brandname	Pro75 5604M1830-P	**Manufacturer**	Cesaroni Technology
Man. Designation	5604M1830-P	**CAR Designation**	CTI 5604-M1830-CS-P
Test Date	4/13/2012		
Single-Use/Reload /Hybrid	Reloadable	**Motor Dimensions mm**	75.00 x 621.00 mm (2.95 x 24.45 in)
Loaded Weight	2542 g	**Total Impulse**	5603.7 N-s (1259.8 lb.s)
Propellant Weight	2542 g	**Maximum Thrust**	2342.3 N (526.6 lb)
Burnout Weight	1858 g	**Avg Thrust**	1826.5 N (410.6 lb)
Delays Tested	plugged	**ISP**	224.8 s
Samples per second	1000	**Burntime**	3.07 s
Notes	9.4% M		



With the motor installed, ready for launch, "Tumbleweed Connection" weighs very close to 42-1/2 pounds. Maximum launch "Thrust-to-Weight" ratio works out to 12.39 to 1 and average "Thrust-to Weight" will be a dynamic 9.66 to 1, approximately.

A big part of the Level 3 process was learning how badly I had assumed that by building a "kit", I really didn't need to concern myself with monitoring stability while building, as long as the "center-of-gravity" was a respectable distance forward of the "center-of-pressure".

Once finished, Rocksim showed that "As Built", with motor installed, ready for launch, "Margin-of-Stability" was almost 3-1/2 to 1, which it "flagged" as "overstable".



"Overstable" Original Build

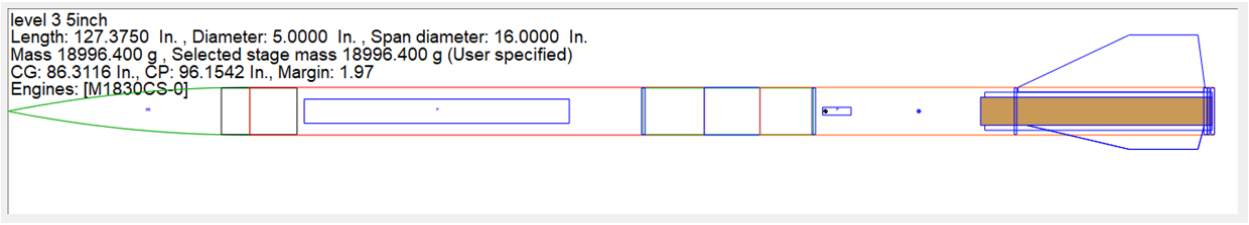
After discussing this with my TAPs, Jim Jarvis recommended that I trim the fin tips after simulating the change to the fin "semi-span" in Rocksim. Although the idea was painful

considering how the rocket had a nice paint job, I ended up trimming 1-5/16” from the tips. This left a “semi-span” of 5-1/2”… safely larger than the airframe diameter of 5”.

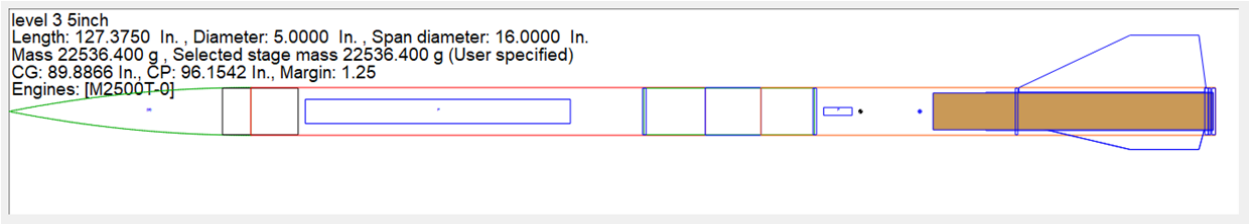
I built a fixture that safely allowed me to cut the G-10 fin tips with a fine toothed hacksaw, and then clean up the rough edge with a sanding block. A little touch-up paint on the cuts, and no one would be the wiser.

Removed Fin Tips and Fixture

Re-running the Rocksim simulation brought me good news. With the M1830 motor, the “Margin-of-Stability” had decreased to 1.97 and simulating for a possible future launch with an Aero Tech M2500, getting a value of 1.25. In both cases the rocket simulates as “Stable”.



Stability Margin with Trimmed Fins – M1830



Stability Margin with Trimmed Fins – M2500

Lastly, the flight simulation showed good numbers for altitude, velocity, and acceleration. At an approximate apogee of 7500 feet, we were safely lower than the club’s FAA waiver.

Simulation	Results	Engines loaded	Optimal delay	Max. altitude Feet	Max. velocity Miles / Hour	Max. acceleration Gees	ocity at deploym Miles / Hour	st launch guide d Miles / Hour	WeatherCocking
0		[M1830CS-0]	17.52	7474.51	581.05	11.22	21.82	48.55	Safe

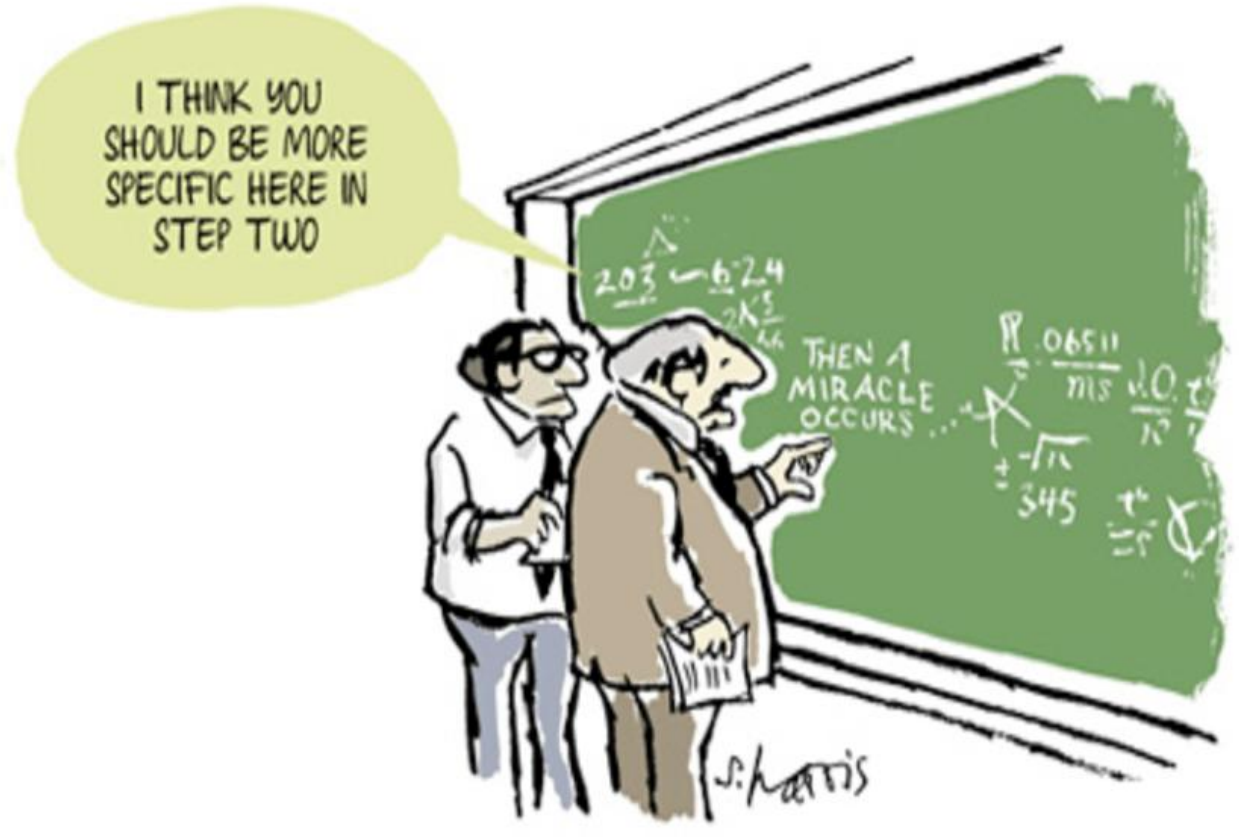
M1830 Flight Simulation

Due to the number of avionics devices transmitting at launch, Stu Barrett strongly recommended that I perform a full-up RF interference test. The six instruments are a EggFinder GPS telemetry unit in the nosecone transmitting at 923 MHz and a BigRedBee 70cm beacon set to transmit at 433.95 MHz, also in the nosecone. Approximately 4 feet aft of the nosecone is a Perfectflite Stratologger altimeter, a EggTimer Proton altimeter controlled with WiFi commands, a GoPro Hero 5 Session camera, remotely controlled in the WiFi part of the spectrum, and finally a Mobius Maxi camera which is WiFi "capable", but will be manually controlled.

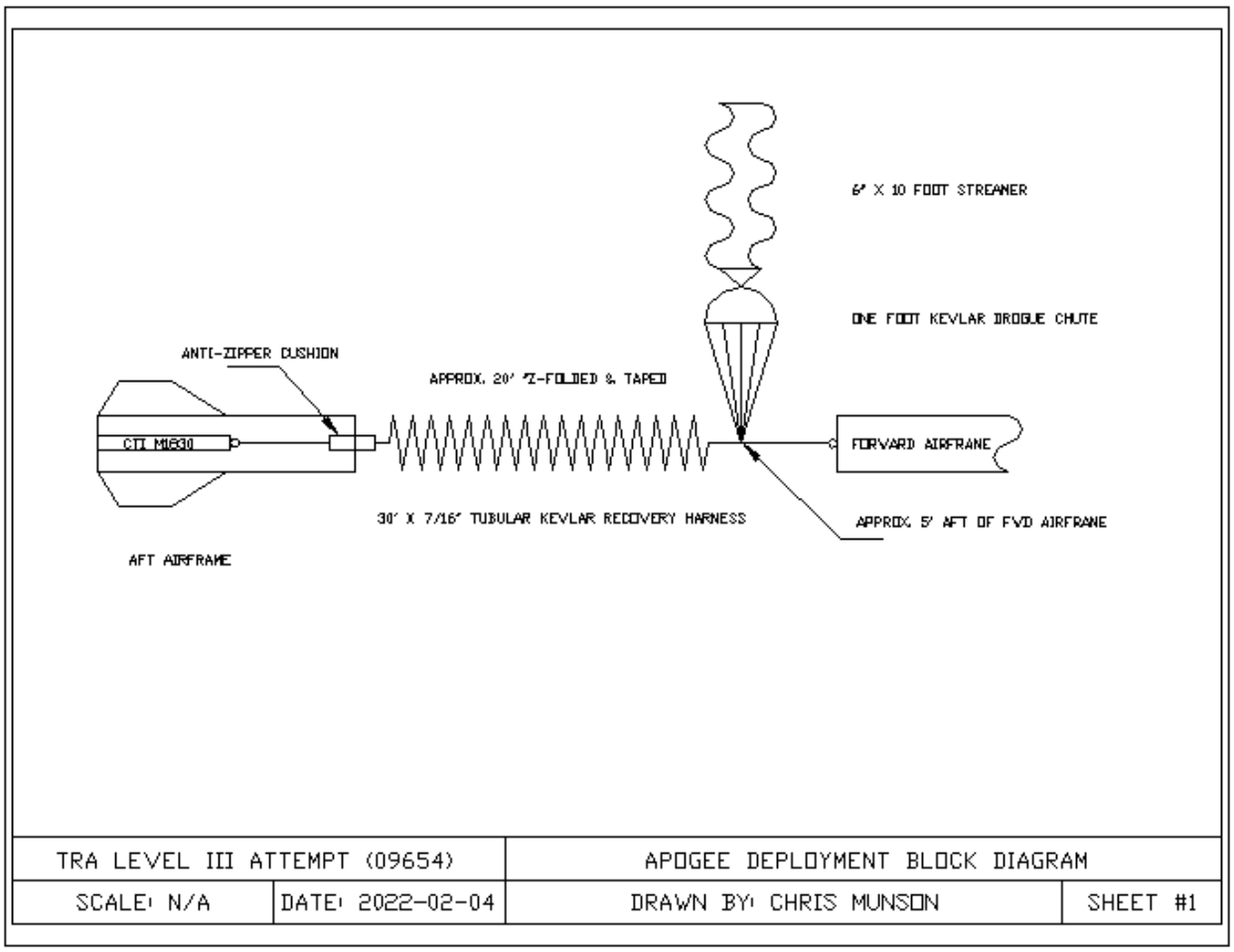
The Lithium Polymer (LiPo) batteries powering the altimeters, the GPS and beacon were charged to approximately 70% of full charge (for safety reasons) and the two cameras fully charged. Four Aerocon e-match heads (primary and redundant), soldered to 6" leads, but with no pyrogen, were first checked with an ohm meter and then connected to the apogee and main terminal strips at the ends of the AvBay / Coupler. All the potential vacuum leaks were sealed, all the electronics were energized, and a vacuum cleaner applied to a single port. Although not much altitude was achieved, everything behaved with no sign of interference, and all e-matches fired.

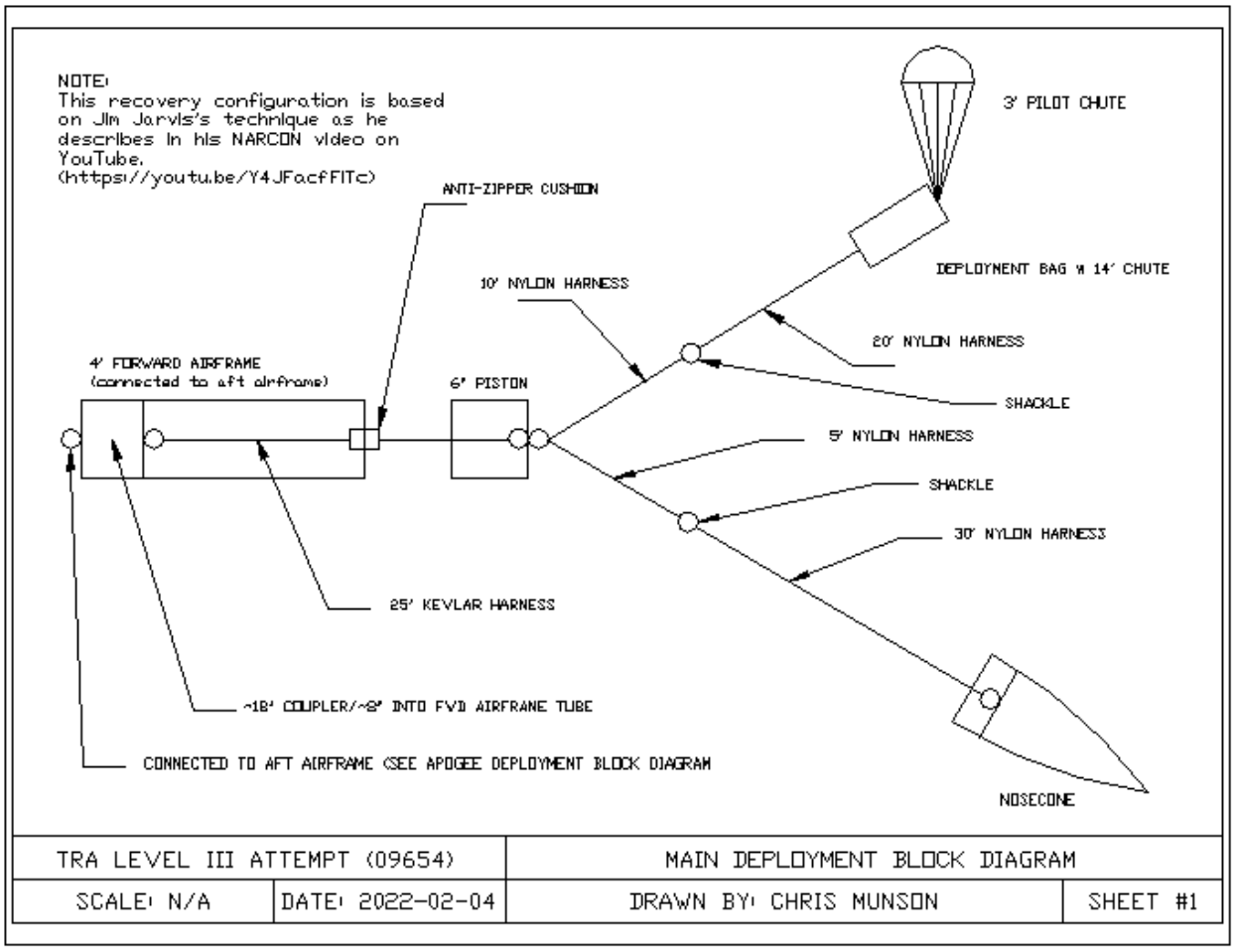
Confident that no RF interference exists, a final test using just the AvBay / Coupler and the actual Firewire Initiators to be flown was performed. All four Initiators fired… quite spectacularly.

It was pointed out that the entire recovery process has been somewhat "glossed over", so it's reasonably easy to sum it up in three drawings, the first of which is probably familiar to those in the aerospace disciplines:



The following two deal with the issue more seriously…





At this point, assuming TAP concurrence, "Tumbleweed Connection" is ready for flight. What follows is an appendix consisting of Cesaroni motor assembly instructions, product notes, AND Aerotech grain bonding instructions (as the Cesaroni documents as included in this document are particularly illegible, the entire appendix will also be attached as separate files). Following those are three checklists. First is the home pre-launch preparation checklist. Second is the launch site assembly/preparation checklist. Third and final is the pad checklist.

Appendix Follows

Pro75® High-Power Reloadable Rocket Motor Systems

FOR USE ONLY BY CERTIFIED HIGH-POWER ROCKETRY USERS 18 YEARS OF AGE OR OLDER

FLAMMABLE MATERIAL – KEEP AWAY FROM OPEN FLAME, CIGARETTES OR OTHER HEAT SOURCES AT ALL TIMES

USE WITHIN 1 YEAR OF MANUFACTURING DATE

TEMPERATURE RANGE: -5 to 30°C

Read this BEFORE you start assembly:

- If you have any questions or require assistance, please contact your dealer. If you are unable to resolve your questions or problems then please contact the manufacturer directly. Assistance is available Mon – Fri : 9am – 4:30pm at (905) 827-2570. Ask for Pro75 motor products technical support.
- Read all instructions carefully and be sure you fully understand each step before proceeding with motor assembly.
- **Make sure to also read the Pro75 Product Notes for reload specific instructions. Your reload may require bonding of grains into the case liner. For moonburner reloads there are also separate moonburner instructions for gluing the grains.**
- Inspect the components of your reload kit carefully before you start assembly. DO NOT use any parts that appear damaged or faulty in any way.
- Do not tamper with or modify the hardware or reload kit components in any way. Not only will this void all product warranty, it could cause catastrophic failure of your motor system and result in damage to your rocket vehicle, launch equipment and create a hazard to persons or property.
- Reload kit components are designed for ONE USE ONLY, and may not be reused. Reuse of any of these components could result in motor failure and will void product warranty.
- Follow the safety code and all rules and regulations of your sport rocketry association. Also ensure that you are in compliance with all local, state/provincial, and federal laws in all activities involving high power rockets and rocket motors.
- Parts checklist:

Pro75® hardware components (if used):

- ✓ Appropriate size of motor case
- ✓ Forward closure
- ✓ Nozzle holder
- ✓ Threaded retaining rings (2)

Reload kit components:

- ✓ Case liner (phenolic tube)
- ✓ Nozzle
- ✓ Forward insulator disk
- ✓ P75 ORK (o-ring kit)
- ✓ P75 TSI KIT (smoke tracking grain/insulator & igniter kit)
- ✓ Propellant grains (check reload kit package for number and type required for your motor)

Assembly instructions

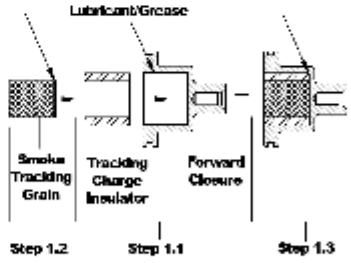
- Be sure to follow the correct instructions for the brand of motor hardware you are using!
- Step 1 is the same for both brands of hardware.
- All o-rings are pre-lubricated at the factory where required.
- Three o-rings are supplied in the P75-ORK o-ring kits. The two larger o-rings are used with both Pro75® and RMS® hardware. The small o-ring is only used with Pro75® hardware.
- Do not apply lubricant to the grain spacer o-rings, they are for spacing only.
- Phenolic and phenolic/paper components such as the nozzle and case liner tube are brittle and can be cracked, broken or otherwise damaged by excessive force or impact. Please be careful during handling and assembly. If you suspect a part has been damaged in any way, STOP and do not proceed with assembly and especially firing until inspected and replaced if necessary.

1. **Forward Closure Assembly**

1.1. Apply a light coating of o-ring lubricant or grease to the inside of the cavity in the forward closure. Insert the smoke tracking charge insulator into this cavity and ensure it is seated fully.

1.2. Apply a liberal layer of grease or o-ring lubricant to one end of the smoke tracking grain. Be sure the entire face is coated.

1.3. Insert the smoke tracking grain into the smoke tracking charge insulator, coated end first. Push the grain in with sufficient force to fully seat it and spread the lubricant as shown. The excess lubricant will help prevent gas leakage forward as well as protecting the forward closure from heat and combustion products from the smoke tracking charge.



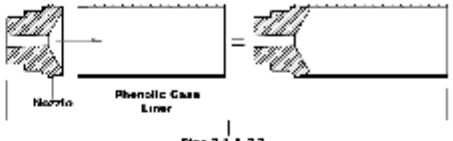
You may now proceed to the remainder of the instructions for your brand of motor hardware.

Step 2 is for Pro75® hardware users.

Step 3 is for RMS™ hardware users.

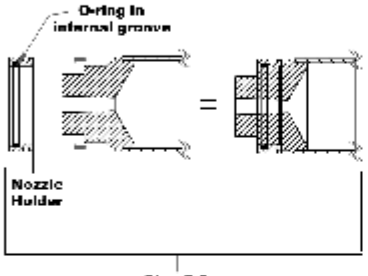
2. **Motor Assembly: Pro75® Hardware.**

Before proceeding, inspect the external o-ring grooves on the forward closure and nozzle holder, as well as the internal groove on the nozzle holder. Clean thoroughly if necessary to remove ALL combustion residue and debris. Also ensure that the inside of the motor case has been thoroughly cleaned.



Step 2.1 & 2.2

2.1. Check both ends of the phenolic case liner to ensure that the inside ends have been chamfered or deburred. If not, use a hobby knife or coarse sandpaper to remove the sharp inner edge to allow components to be inserted easily.



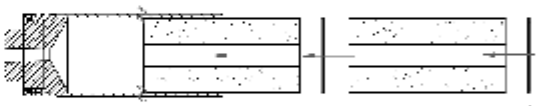
Step 2.3

2.2. Fit the nozzle to one end of the paper/phenolic case liner tube. It may be a snug fit. Push it carefully but with sufficient force to seat the shoulder on the nozzle all the way into the insulator tube.

2.3. Locate the smaller o-ring in the P75-ORK o-ring kit. Fit the o-ring to the internal groove of the nozzle holder. Push the nozzle holder over the nozzle until fully seated. Apply additional lubricant to the nozzle exit section if necessary to facilitate assembly.

2.4. For steps 2.5 – 2.6 work with the nozzle/case liner assembly and motor case horizontally on your work surface.

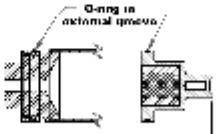
2.5. Insert one propellant grain into the forward end of the case liner and push it a short way into the tube. Fit one grain spacer o-ring to the top face of the grain, ensuring it sits flat on the end of the grain. Insert the second grain, push it in a short ways, then add another grain spacer, and so on until you have loaded all propellant grains into the case liner.



Step 2.5

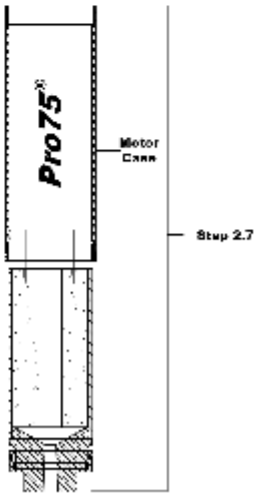
2.5.1. There should be sufficient space after the last grain is inserted to fit the last spacer in place so that it is flush or extends only slightly from the end of the tube. If it extends out by more than 1/3 of its own thickness, remove it and do not use. Only this spacer may be omitted and only if necessary to fit.

2.6. Carefully install the two larger o-rings into the external grooves of the nozzle holder and forward closure. Handle these components with care from this point on so as not to damage or contaminate the o-rings.



Step 2.6

2.7. Place the case liner/nozzle assembly on your work surface with the nozzle end down, and slide the motor case down rear end first (end with thrust ring) over the top of the liner towards the nozzle. **Note:** a light coat of grease on the liner exterior will aid assembly, disassembly and cleanup!



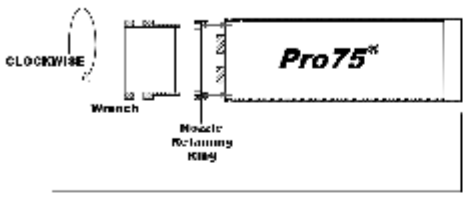
Step 2.7

2.8. Lay the motor case assembly down horizontally, and push on the nozzle ring until the assembly is far enough inside the case that the threads are partly exposed and the screw ring can be threaded into the rear of the case. Don't push on the nozzle itself as you will push it out of the nozzle holder.

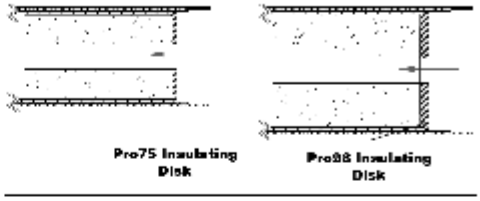
2.9. Screw in the nozzle retaining ring using the supplied wrench, pushing the nozzle/nozzle ring/case liner assembly forward as you proceed. Screw it in *only until the retaining ring is*

exactly even with the end of the motor case - do not thread it in as far as it will go. Then, back the retaining ring out one half of a turn.

2.10. Fit the forward insulating disk to the top of the case liner, checking that the top grain spacer (if used) is still properly in place



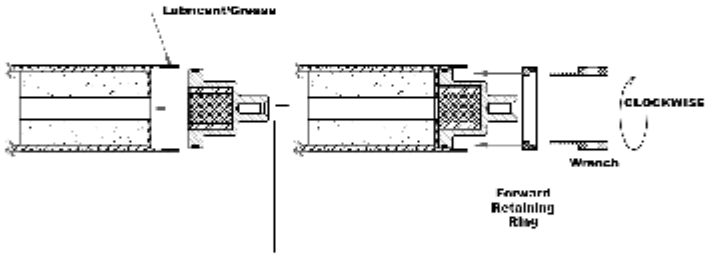
Step 2.9



Step 2.10

2.11. Verify that the inside of the motor case is clean ahead of the liner assembly before proceeding. Wipe with a clean rag, tissue or wet-wipe if required. Apply a light coat of silicone o-ring lubricant onto this area after cleaning.

2.12. Insert the assembled forward closure into the top of the motor case, pushing it down carefully with your fingers until you can thread in the retaining ring. Thread in the forward retaining ring using the wrench, until you feel it take up a load against the top of the case liner. At this point the ring should be approximately flush with the end of the motor case, or slightly submerged. If it extends out the case at this point by more than about one half a turn, check the nozzle end to make sure the ring is not screwed in too far forward. If so, unscrew the nozzle retaining ring another half turn and screw the forward closure retainer in further.



Step 2.11 & 2.12

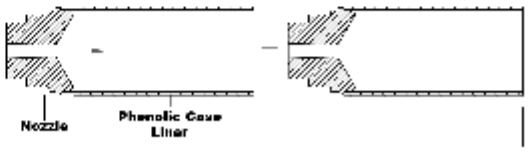
NOTE: It is best to have the forward closure retaining ring flush or slightly submerged and the nozzle retaining ring protruding by a half turn or so, than vice versa. There is more tolerance for o-ring location at the nozzle end. There will always be some minor variation in the length of internal components due to manufacturing tolerances.

2.13. Skip ahead to Section 4, Preflight preparation.

3. Motor Assembly, RMS™ Hardware.

3.1. Check both ends of the phenolic case liner to ensure that the inside ends have been chamfered or deburred. If not, use a hobby knife or coarse sandpaper to remove the sharp inner edge to allow components to be inserted easily.

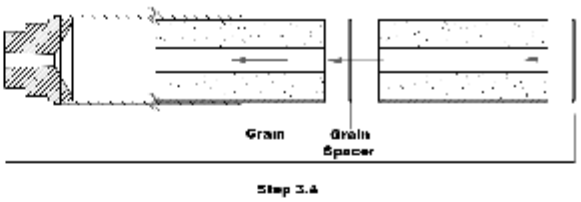
3.2. Fit the nozzle to one end of the paper/phenolic case liner tube. It may be a snug fit. Push it carefully but with sufficient force to seat the shoulder on the nozzle all the way into the insulator tube.



Step 3.2

3.3. For steps 3.4 - 3.8 work with the nozzle/case liner assembly and motor case horizontally on your work surface.

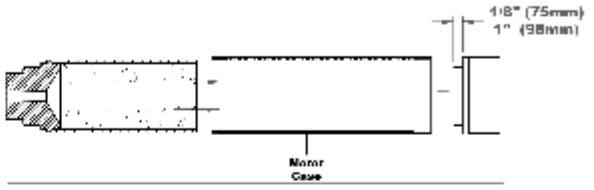
3.4. Insert one propellant grain into the forward end of the case liner and push it a short way into the tube. Fit one grain spacer o-ring to the top face of the grain, ensuring it sits flat on the end of the grain. Insert the second grain, push it in a short ways, then add another grain spacer, and so on until you have loaded all propellant grains into the case liner.



Step 3.4

3.4.1. There should be sufficient space after the last grain is inserted to fit the last spacer in place so that it is flush or extends only slightly from the end of the tube. If it extends out by more than 1/8 of its own thickness, remove it and do not use. Only this spacer may be omitted and only if necessary to fit.

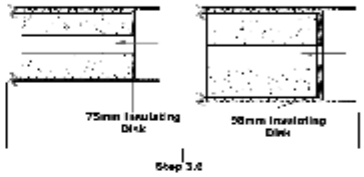
3.5. Slide the completed liner/nozzle/grain assembly into the motor case until the nozzle protrudes about 1/8" from the end of the case. Note: a light coat of grease on the liner exterior will aid assembly, disassembly and cleanup!



Step 3.5

3.6. Fit the forward insulating disk to the top of the case liner, checking that the top grain spacer (if used) is still properly in place.

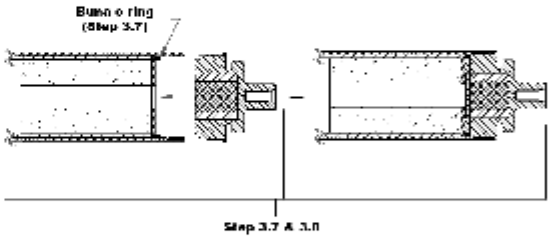
3.7. Place one of the larger pre-lubricated o-rings from the P75-O3K kit into the forward end of the case until it is seated against the forward insulator.



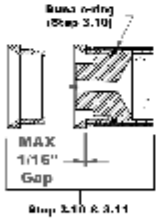
Step 3.6

3.8. Thread the completed forward closure into the forward end of the motor case by hand until it is seated against the case. NOTE: There will be considerable resistance to threading in the closure in the last 1/8" to 3/16" of travel, due to compression of the o-ring.

3.9. Hold the motor vertically on your work surface with the forward closure downwards, and push down on the nozzle to ensure the liner/nozzle assembly is seated fully forward.



Step 3.7 & 3.8



Step 3.10 & 3.11

3.10. Place the other identical o-ring into the groove in the nozzle.

3.11. Thread the aft closure into the motor case until it is seated. It is normal for a small gap (up to about 1/16") to remain between the closure and the end of the case, due to manufacturing tolerances or internal components. Note: There will be considerable resistance to threading in the closure in the last 1/8" to 3/16" of travel, due to compression of the o-ring.

3.12. Proceed to Section 4, Preflight preparation.

4. **Preflight Preparation.**

4.1. Prepare the rocket's recovery system, before motor installation if possible.

4.2. Install the motor in your rocket, ensuring that it is securely mounted with a positive means of retention to prevent it from being ejected during any phase of the rocket's flight.

4.3. **IMPORTANT: DO NOT INSTALL THE IGNITER IN THE MOTOR UNTIL YOU HAVE THE ROCKET ON THE LAUNCH PAD, OR IN A SAFE AREA DESIGNATED BY THE RANGE SAFETY OFFICER.** Follow all rules and regulations of your rocketry association, and/or the National Fire Protection Association (NFPA) Code 1127 where applicable.

4.4. Install the supplied igniter, ensuring that it travels forward until it is in contact with the forward closure. Securely retain the igniter to the motor nozzle with tape, or (if supplied) the plastic cap, routing the wires through one of the vent holes. Ensure that whatever means you use provides a vent for igniter gases to prevent premature igniter ejection.

4.5. Launch the rocket in accordance with all Federal, State/Provincial, and municipal laws as well as the Safety Code of your rocketry association, as well as NFPA Code 1127 where applicable.

5. **Post Flight Cleanup.**

Do not try to dismount or disassemble your motor until it has thoroughly cooled down after firing. Some components such as the nozzle may be extremely hot for some time after firing.

Perform motor cleanup as soon as possible after firing, however, as combustion residues are corrosive to motor components, and become very difficult to remove after several hours.

5.1. Unthread and remove the forward and rear closures. Remove the nozzle holder from the nozzle.

5.2. Remove the phenolic tracking smoke charge insulator from the forward closure.

5.3. Remove all o-rings.

5.4. Discard all reload kit components with regular household waste, after they have completely cooled down.

5.5. Use wet wipes, or paper towels or rags dampened with water or vinegar to thoroughly clean all residue, grease etc. off all hardware components. Pay close attention to internal and external o-ring grooves. A cotton swab or small stick of balsa is an excellent tool for cleaning these grooves.

5.6. Apply a light coat of grease or o-ring lubricant to all threaded sections and reassemble threaded components for storage.

MEANS OF DISPOSAL: The propellant grains, smoke tracking charge, and the igniter are extremely flammable and burn with an intense, hot flame. The remainder of the components are inert and may be disposed of with household trash. To destroy the flammable components, dig a shallow hole in the ground in a remote area, away from any buildings, trees, people, or any other combustibles. Place the propellant grains and smoke tracking module in the hole. Install the igniter into the core of one of the propellant grains and secure with tape. Ignite electrically from a minimum distance of 15 meters. Douse any smoldering paper residue and discard. Ensure that you are not in violation of any local or state regulations for this procedure. If in doubt, contact your local fire department. Please direct any questions regarding safe disposal to our technical support number on page one of this document.

First Aid: If ingested, induce vomiting. Burns from flames are to be treated as regular burns with normal first aid procedures. In either case, seek medical attention.

Cesaroni Technology Incorporated ("CTI") certifies that it has exercised reasonable care in the design and manufacture of its products. We do not assume any responsibility for product storage, transportation or usage. CTI shall not be held responsible for any personal injury or property damage resulting from the improper handling, storage or use of their products. The user assumes all risks and liabilities and accepts and uses CTI products on these conditions. No warranty either expressed or implied is made regarding *Pro75*® products, except for replacement or repair, at CTI's option, of those products which are proven to be defective in manufacture within one (1) year from the date of original purchase. For repair or replacement under this warranty, please contact your point of purchase. Proof of purchase will be required. Your province or state may provide additional rights not covered by this warranty.

- Check out our web site at http://www.Pro75.com for tech tips, FAQ's, user feedback and photos, or email us at Pro75@cesaroni.com
- For technical and warranty inquiries, please contact your Pro75® dealer.

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Pro75® Product Notes

Special Instructions (supplements standard Pro75® instruction sheets)

Scope

These notes supplement the standard Pro75® instructions for the following motors: K2000, L995, L1355, L1685, L3200, M1300, M1545, M1675, M2020, M2075, M2080, M2245, M2250, M3100, M3700

This note also explains the proper use of the Pro/38 casing spacer.

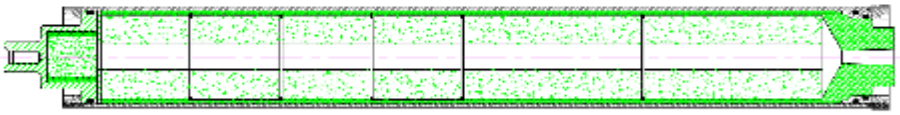
Pro75® motors using 'half' grains: L995, L1355, L1685, M2075

The L995, L1355 and L1685 Pro75® motors use 'half' grains. These grains are half-length of the regular grain length of Pro75® motors. The purpose of these grains is to improve the shape of the thrust curve and maximize the thrust at lift-off. Two 'half' grains with two spacer o-rings (stacked alternately) occupy the same length inside the motor as a single normal grain with its o-ring spacer.

When assembling motors with 'half' grains ensure that the short grains are loaded closest to the forward closure of the motor. All regular grains will be at the nozzle end. As with the regular grains, an o-ring spacer is placed between each grain.

The table below summarizes the number of regular and 'half' grains in the affected Pro75® motors:

L995: 2 regular grains, 2 'half' grains
L1355: 2 regular grains, 4 'half' grains
L1685: 2 regular grains, 6 'half' grains
M2075: 3 regular grains, 6 'half' grains

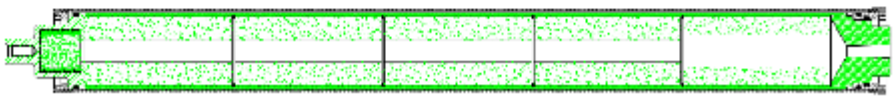


Assembled Pro75®-1G motor with four 'half' grains.

Pro75® motors with stepped grains: M1300 Dual Thrust™ and M2250 C-Star

Dual Thrust™ motors use two different propellant types: a fast burning single grain that creates the extra boost at lift off and slower burning grains that burn during the sustain phase. The fast burning propellant grain can be recognized by its red color and large port diameter. The M2250 C-Star motor has the same propellant formulation for all grains, but uses a bottom (base) grain with a larger bore.

When assembling motors with a stepped core, ensure that the base grain (with the larger center perforation = bore) is located at the nozzle end of the motor. It is required to bond the grains in the liner (see instructions in next section).



Assembled Pro75®-5G Dual Thrust™ motor.

Pro75® motors requiring grain bonding:

K2000, L3200, M1300, M1545, M1675, M2020, M2080, M2245, M2250, M3100, M3700

The following motors require bonding of the grains in the liner: K2000/L3200 Vmax™, M1300 Imax™ Dual Thrust, M2250 C-Star™, M3100/M3700 White Thunder™, M2020/M2245 Imax™, M2080 Skidmark™, M1545 Green™, and M1675 Pink™. Bonding the grains in the liner prevents premature blowout of the grains under high acceleration loads or by high core mass flows. **DO NOT USE EPOXY FOR BONDING.**

The process for this is as follows:

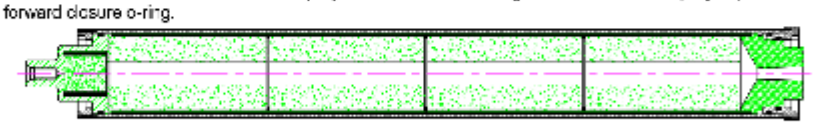
1. The preferred adhesive is Gorilla Polyurethane Glue or Elmer's Glue-All Max (not the white Glue Max!). A 2-oz bottle (e.g. Lowes SKU #: 152743, or Home Depot SKU # 837667) is sufficient for all Pro75 motors.
2. Apply adhesive on the outside (paper liner) of the first grain and use a small brush to spread it evenly. Ensure no adhesive is applied on the grain faces or bore of the propellant.
3. Push the grain in the liner **from the nozzle end** while twisting it. Twisting the grain while inserting it will properly distribute the adhesive. Push it about 1" into the liner.
4. Install a grain spacer o-ring.
5. Repeat steps 2-4 for all grains. Excess adhesive might be scraped off around the end of the liner. This can simply be wiped off.
6. Do not install a spacer o-ring between the bottom grain and the nozzle.
7. Re-install the nozzle and wipe off any excess adhesive.
8. Set the liner/grain assembly upright with the nozzle facing down.
9. Push the top grain down gently through the hole in the forward insulator plate.
10. Let the liner/grain assembly cure in an upright position.
11. Continue with the regular assembly process as outlined in the instructions.

Notes:

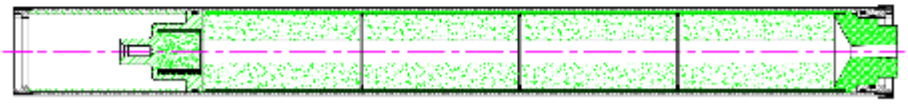
1. Do not insert the bottom grain from the forward closure end of the liner. Most adhesive will have been scraped off when the grain is pushed through all the way and it reaches the end of the liner.
2. For the Pink™ M1675 reload the red grain should be located at the nozzle end. (All other motors use identical grains.)
3. The M2245 Imax™ and M3700 White Thunder™ motor have four (4) longer grains and are bonded like any of the other motors listed above.

Pro75® casing spacers

Pro75® casing spacers allow the use of a reload kit intended for a smaller casing size to be used in the next casing size up. For example, a 3 grain reload kit can be used in a 4 grain casing. When assembling a Pro75® motor with a casing spacer, follow the regular instructions provided with the reload kit, and install the casing spacer between the forward closure end forward closure retaining ring as shown in the example below. Do not slide the forward closure all the way from the nozzle end. It is recommended to spray the inside of the casing with some silicone spray to prevent rolling of the forward closure o-ring.



Pro75®-4C reload in Pro75®-4C casing.



Pro75®-4G reload in Pro75®-5G casing using case spacer.

A 5GXL case can be spaced to a 6G case with a regular spacer. Up to two spacers can be used.

GRAIN BONDING INSTRUCTIONS

These Instructions Must Be Followed for This Reload Kit

Use a foaming polyurethane glue to bond the grains into the liner. We recommend a low-foaming polyurethane-based adhesive like "**Elmer's Glue-All MAX**" for this process. Wear disposable gloves during the bonding process.

1) **WIPE THE DUST** from the inside of the liner. This can be done with a dowel and a paper towel.

2) Open all the grain boxes and packages. **DRY FIT THE GRAINS** to verify they fit the liner. If the fit is too tight, peel the outer glassine layer in order to fit the grains into the liner.

3) **APPLY A THIN COAT OF GLUE** to the outside of the propellant grain. Avoid getting any glue on the face of the grain or inside of the core.

4) **PUSH THE GRAIN INTO THE LINER** from the nozzle end, **TWISTING THE GRAIN** as you push it into the liner. Push the grain in approximately 1" past the end of the liner.

5) **INSTALL A GRAIN SPACER O-RING**.

6) **REPEAT STEPS 4 AND 5** for the remaining propellant grains.

7) **REMOVE ANY EXCESS GLUE** from the phenolic liner before inserting the nozzle into the liner. **INSERT NOZZLE** once liner is free of glue.

8) **SET THE LINER AND GRAIN COMBINATION DOWN RESTING ON THE NOZZLE**. Be sure to support the assembly so that the liner and grain assembly do not fall over while curing.

9) **PUSH THE TOP GRAIN (FORWARD END) DOWN**. Wipe off any remaining glue from both the inside and outside end of the liner.

10) **LIGHTLY GREASE** the inside of the liner and install the seal disc assembly.

11) **LET THE GRAIN ASSEMBLY CURE** for about 12 hours.

12) After the grains are bonded into the liner, assemble the remainder of the motor per the motor assembly instructions.

Fig 1 Wipe any dust from inside of the liner

Fig 2 Apply glue to the grain

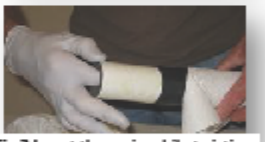


Fig 3 Insert the grain while twisting

Fig 4 Insert grain spacer O-ring

Fig 5 Stand assembly on nozzle end and let cure for 12 hours

Pre-Launch Preparation Checklist

1) One week prior to launch day - assemble CTI M1830 motor IAW:
   a) TAP and/or motor vendor instructions/suggestions
   b) CTI Instructions & Product Notes
   c) AeroTech Grain Bonding Instructions
   d) Install AeroPac 75mm to 98mm adapter IAW AeroPac instructions
2) Attach Kevlar harnesses to AvBay/Coupler eye bolts using "Larks Head" knots
   a) 3 loop aft harness is installed with third loop closer to AvBay/Coupler
   b) Attach "zipper" protection
   c) "Z-fold" harnesses with masking tape for shock absorbtion
3) Assemble recovery items that are forward of piston
   a) Parachute attached to/and loaded into deployment bag
   b) Pilot chute attached to deployment bag end
   c) Double check all nylon harnesses and attachments
   d) "Z-fold" and tape harnesses as needed
4) Two days prior to launch day - charge Lithium Polymer batteries
   a) Three altimeter batteries
   b) Two GPS tracker batteries (transmitter & receiver)
   c) BigRedBee beacon battery
   d) Charge 70cm HT
5) Assemble AvBay/Coupler two days prior to launch day
   a) Install charged batteries into altimeter sled
   b) Lock nuts for battery holders
   c) Secure battery cables and connectors
   d) Check all terminal strip screws for tightness
   e) Check/replace aft "all thread" "o-rings" & aft masking tape cap seal – install & tighten nuts/lock nuts
   f) Check power switches and install altimeter sled – connect wiring- tighten terminal strip screws
   g) Attach forward cap main deployment wiring – tighten terminal strip screws – install forward cap
   h) Install forward cap "all thread" "o-rings" – tighten nuts/lock nuts – apply masking tape cap seal – install "all thread" forward and aft plastic nut caps
6) One day prior to launch day, load deployment charges
   a) Assemble four "Firewire Initiators" for flight
      1) Cut leads to 5 inches – split / strip ends ~ 5/8"
      2) Measure resistance: ~ 1.3 ohms (discard if bad – replace)
      3) Twist leads with shunt wire loop and crimp into terminal lugs
   b) Aft primary drogue charge – from Stratologger
      1) Charge container adjacent to #5 & #6 Terminal Block connections
      2) 2.6 grams / 40.0 grains 4F black powder
      3) Attach "Firewire" lugs to #5 & #6 and route into black powder
      4) Pack wadding above black powder
      5) Secure and seal container with aluminum tape
      6) Secure "Firewire" leads as needed

c) Aft back up drogue charge – from Proton
    1) Charge container adjacent to #1 & #2 Terminal Block connections
    2) 3.24 grams / 50.0 grains 4F black powder
    3) Attach "Firewire" lugs to #1 & #2 and route into black powder
    4) Repeat steps 4) through 6) (5b above)
d) Forward primary main charge – from Stratologger
    1) Charge container adjacent to #5 & #6 Terminal Block connections
    2) 2.125 grams / 32.8 grains 4F black powder (2.2 Lee Powder Measure)
    3) Attach "Firewire" lugs to #5 & #6 and route into black powder
    4) Repeat steps 4) through 6) (5b above)
e) Forward Back-Up main charge – from Proton
    1) Charge container adjacent to #1 & #2 Terminal Block connections
    2) 2.6 grams / 40.0 grains 4F black powder
    3) Attach "Firewire" lugs to #1 & #2 and route into black powder
    4) Repeat steps 4) through 6) (5b above)

7) Charge Mobius Maxi, GoPro, and GoPro Remote control
8) Install Mobius into shroud and GoPro into mount… install switch / camera band with 2 fasteners
9) Store AvBay/Coupler in carrying case
10) Charge electric screwdriver
11) Charge iPhone & iPad
12) Load airframe and support equipment into vehicle except AvBay/Coupler, motor, and battery powered equipment

Launch Site Assembly / Preparation Checklist

1) Assemble trackers and nosecone
   a) Monitor 433.95 MHz for frequency usage
   b) Energize EggFinder GPS transmitter & receiver – wait for lock
   c) Energize BigRedBee
   d) Assemble and wrap tracking mount
   e) Secure assembly into nosecone
2) Assemble forward airframe assembly, piston, recovery gear, and AvBay/Coupler
   a) Attach piston to Kevlar AvBay/Coupler harness with "Larks Head" knot
   b) Secure piston "eye bolt / eye nut" and lock nut
   c) Attach parachute / nosecone harness to piston eye nut – secure shackle
   d) Ensure blue harness connected to parachute – secure shackle
   e) Ensure purple harness connected to nosecone – secure shackle
   f) Ensure pilot chute attached to deployment bag – secure
   g) Install nosecone and 3 @ black 4-40 shear pins
   h) Secure Kevlar harness and zipper cushion to piston eyebolt with tape
   i) Clip and remove shunts on main deployment charge initiators
   j) Mate forward airframe to AvBay/Coupler and secure with screws & washers
3) Assemble aft airframe, motor, recovery harness/drogue/streamer, and AvBay/Coupler
   a) Remove switch band from AvBay/Coupler, remove GoPro camera, configure for remote control, turn off with remote, reinstall and secure, install switch band with screws and washers
   b) Secure motor to Kevlar harness with shackle and secure
   c) Secure motor with AeroPac retainer
   d) Attach Kevlar drogue to harness third loop with shackle and secure
   e) Attach streamer to drogue loop and secure
   f) Roll streamer inside of drogue for deployment charge protection
   g) Clip and remove shunts on drogue deployment charge initiators
   h) Install AvBay/Coupler into aft airframe – use temporary shear pins

Pad Checklist

1) Load “Tumbleweed Connection” onto rail and raise to recommended launch angle
   a) If alignment is an issue, replace forward rail button with button-head screw
   b) Once secure, replace temporary aft shear pins with flight shear pins
2) Start the video cameras recording (remove Mobius lens cover)
3) Activate switches #1 & #2 for Proton “warm-up” – Connect to Wi-Fi
4) Activate switch #3 and listen for Stratologger “continuity” audio
5) Confirm Proton Channel # 1 is Drogue/Apogee +2 seconds, Channel # 2 is Main/800 feet, disable Proton mock Channel #3 (deployment battery SW #2 check) and arm Proton when ready – confirm arm status – disconnect and listen for “continuity” audio
6) Install motor ignitor and connect to firing system – check continuity
7) Return to firing line and report “ready” status