PML COMPLETE FAQ

2/24/07

Information Layout In This FAQ

The information in this FAQ is laid out alphabetically. The headings for each section, such as PML AIRFRAMES FAQ, are in all-capital letters to help you find each section in the clickable Table of Contents/Index on the left side of the screen.

For more information on any of the systems or components discussed in this FAQ, always refer to the appropriate page on the website at www.publicmissiles.com. Nearly all details available for any of these components or systems (such as length, weight, wall thickness, etc.) are shown on the website page where the component or system is sold.

Each Mini-FAQ as available on that item's page in the webstore begins on a new page in this Complete FAQ. This aids in being able to maintain the document and set up a structure that makes the PDF file easily searchable.

PML ADHESIVES FAQ

We say so in all our kit instructions, but make sure you lightly sand any area to be bonded! This is important to get a good "bite" on the materials for the epoxy, and will dramatically increase the strength of your finished rocket!

Adhesives/Epoxy

- PML epoxy is competitively priced. Also, buying PML epoxy is a convenience to the customer; you can get everything you need for your high-power kit from one place.
- We recommend using our epoxy because it's known to work well. We've used it on kits and prototypes we've built.
- PML can answer questions on our epoxy because we use it and have experience with it. We can't answer questions about epoxy from other manufacturers.
- PML does not recommend use of CA (cyanoacrylate, "super glue") in most of our kits. Experienced modelers may find uses for CA, but do not use it in our kits unless specifically instructed to do so, or unless you know for sure from experience that it's OK. CA should never be used as a replacement for epoxy; it should be used as an assembly aid as opposed to as the main bonding agent (unless specified otherwise in the kit instructions). NEVER use CA on or near piston strapping or shock cords. The CA may attack the strapping and dramatically reduce the strength.
- General Rule of Thumb: Slower setting time epoxy = stronger finished kit
- 5 min. epoxy can be used on all PML kits due to the precision fit of components and interlocking design, but 12 min. is often recommended for those who don't have the experience to complete a procedure before the 5 min. type sets up. We recommend 12 minute or 30 minute epoxy for all "super-strength" needs.
- Finishing epoxy:
  - More brittle, but also more sandable.
  - Is very thin, and good to use when fiberglassing because it wets the 'glass cloth well.
  - Should not be used for structural work.
  - It takes 12-24 hours before fully setting up and becoming sandable.
- Mix ratio of the epoxy provided with the Nimbus 'Glassing Kit is 4 parts white to 1 part clear.
- When you see "lightly sand fillets" in our instructions, it means don't sand with too much pressure. High pressure will generate heat and gum up the epoxy while sanding.
- Most brands of epoxy adhesive bond well with no adverse affect to Quantum Tubing. The bonding area must be sanded prior to applying epoxy. Follow the suggestions in "Do's and Don'ts" in the Airframe FAQ Quantum Tubing section.
- Scuff all areas where epoxy will be with 120-grit sandpaper. This includes motor mounts, fins, INSIDE the airframe, etc. Use 220 or 320 on surfaces that will be painted.

Fiberglass Nosecones

If using epoxy in a fiberglass cone to retain nose weight, do just a little at a time, allowing the epoxy to cool between batches. This will prevent the resin used in manufacture of the cone from breaking down due to the heat of the setting epoxy. When you put a lot of quick set epoxy into the tip of the cone the heat generated during curing can exceed 200 degrees F. The resin the cone is made of begins to deteriorate at 170 degrees. Better yet, use a slow-setting (24-hour) epoxy or our Two-Part Expanding Foam (sold on the Adhesives page of the webstore).

PML Two-Part Expanding Foam

This foam is great for fin encapsulation, securing noseweight, etc. It's especially handy for those tight situations where you just can't get into the airframe to get nice internal fillets on your fins, or when you know your rocket is going to see super-heavy-duty flights and you want every bit of strength you can get. PML Expanding Foam is a simple, inexpensive, and easy way to do it.

There is a PDF document on the Adhesives Page of our website explaining how to use the Expanding Foam. The website PDF mentions that open flame and hot-wire cutting can produce dangerous fumes, but the heat of a motor casing next to the foam is not a concern.

Don't be fooled into thinking the expanding foam in a can you can buy at the hardware is the same stuff...it isn't. The main problem with it is, unlike our foam, it needs air to cure, which you don’t have inside the rocket in a foam-filled area. The can foam often doesn't completely cure, or even can stop curing, and reactivate months later when you get the rocket in the hot sun. PML foam stops expanding after 4-5 minutes. It will NOT expand any more with heat, sunlight, etc.

The PML Expanding Foam features are:

- Expands up to 25 times its liquid volume. (Dependant on temp. and humidity)
- High temp formula. Perfect for fin root encapsulation.
- High adhesion rate.
- Two equal part (by volume) mix ratio.
- Does not need air contact to cure.
- Fast curing.
- Light weight.
- Easy to cut and sand. Very carvable.
- Shelf life of 1 year at moderate (70-80 F) temps. 2 yrs if kept cool and dry
- Great for strengthening thin wall nose cones or securing nose weight.

However, take care when using the foam in large batches, as it generates enough heat in large batches to deform a fiberglass nosecone. We recommend multiple smaller batches (about 4-6 ounces at a time) to fill large areas.

PML AIRFRAMES FAQ

Airframe Tubes

Our tubing is specified by ID. Be sure to add 2x the wall thickness if you need to determine the OD. Stock, full length tube length tolerance: -0.00, +0.25".

Airframe Selection Criteria

Quantum Tube airframes are the best choice for most sport rocketry applications. QT is very easy to work with and finish, with no spiral grooves to fill. It's very strong for most rocket flying, and is also very forgiving to the impacts of rough landings. However, QT is NOT a replacement for fiberglassed phenolic; it is simply an easier-to-use material in applications that do not require the specific features of phenolic. PML parts such as nosecones, centering rings, couplers, etc., all fit QT just as well as they fit phenolic. However, there are some limitations with QT:

1. It comes only in 2.1, 2.5, 3.0 and 3.9" diameters
2. It is not intended for near-mach (transonic) or above-mach (supersonic) flights. (See our online FAQ for information on mach and near-mach flying)
3. It is not intended to be used as a base for fiberglassing, Kevlar, or other typical tube-strengthening methods.
4. It is not intended for use in minimum-diameter rockets (rockets where the airframe IS the motor mount; the motor casing touches the airframe directly)

If your rocket does not fit any of the above special applications (and about 90% of most fliers' rockets don't), QT's right for you.

Phenolic airframe tubing is the "staple" of high-power rocketry. It was first introduced because it is much stronger than cardboard tubing, with almost 5x the compression strength. It also comes in all sizes, from 1.1 to 11.4". It fits all PML components such as nosecones, centering rings, and etc. perfectly. It is also a very good base for rockets that will require the strengthening of fiberglass, Kevlar, carbon fiber, or similar materials. For this reason, we recommend phenolic as the appropriate tubing for rockets that are 6.0, 7.5, or 11.4" in diameter, or rockets that will require strengthening for the rigors of transonic or supersonic flight. We also recommend phenolic for transonic or supersonic flights in kits of 2.1" diameter, as phenolic can withstand those flights without strengthening in most instances.

Fiberglassed phenolic is THE choice when high-stress flights of transonic, supersonic, or "BIG-motor" flights are planned. Level 3 flights should all begin with fiberglassed phenolic as the airframe tubing, as should any rocket above 2.5" diameter that will fly greater than 950fps (see our online FAQ in the Kit Strengthening section for more). Fiberglassed phenolic tubing is extremely strong and able to handle nearly any flight profile you can imagine. PML fiberglassed tubes are manufactured using the latest high temperature compression process to guarantee superior laminate bonding and the best possible cloth to resin ratio (read: highest strength/lowest weight). It comes to you pre-

glassed, initially sanded, and almost ready to paint. If you want the best, or need ultimate strength, PML pre-glassed phenolic is for you.

QT Kits/Phenolic Kits

All kits from 2.1-3.9” diameter (except Nimbus) come standard in QT. All kits 6.0” and larger are phenolic, as QT is not available larger than 3.9”. Any of our QT kits can be special-ordered in phenolic. Contact "PML Central" about it at 586-421-1422 9-5pm EST Mon-Fri or pmlhighpowersales@compuserve.com for pricing and delivery details. (It usually costs a little more and takes longer since it's a special request).

Premium Kraft Phenolic Tubing

- Tests show nearly 5x greater compression strength than cardboard.
- Doesn’t fray when cut or “fuzz” when sanded.

Phenolic is more brittle than cardboard, but:

- Damage is localized; impact damage doesn’t “travel” up the tube like cardboard.
- No “accordion” damage like cardboard with compression loading; again, damage stays localized and is easily repaired by cutting off the damage and splicing on a new piece. Accordion damage ruins the entire tube with cardboard in most cases.
- Phenolic is waterproof; good for wet sanding or if rocket lands in water, or if rocket is lost and is exposed to the elements until found.

Real PML phenolic tubing has the PML logo printed inside the tubing. If it doesn’t have the logo, it’s not real PML tubing. Beware of imitations, because all tubes are not the same. One manufacturer’s 4” tube may not be the same size as another.

PML Tubing/Component Compatibility With Other Brands

We cannot tell you with certainty whether our tubing is compatible with that of another manufacturer. This also includes whether our couplers, nosecones, pistons, CPR parts, etc. will fit another manufacturer’s tubing. With the variation in tubing from one manufacturer to another, we simply cannot tell you with certainty if our components will match well with non-PML tubing.

PML Phenolic Tubing vs. “Flexible” Phenolic Tubing

The so-called “flexible” phenolic tubing available from others is nothing more than plain cardboard with an inside and outside skin of phenolic, or interlaced layers of phenolic and cardboard. In our testing, the tubing was not nearly as flexible as the claims would lead you to believe, and doesn’t have the characteristics of true PML phenolic that have made ours the industry standard for high power rockets for the last 10 years.

The flexibility features of the other tubing do not prevent damage, they simply “damage differently”. Our tubing takes a big impact to fail at all, and fails by obvious cracking or chipping. The competitors will fail through less impact specifically because of their “flexibility”. Their flexibility allows the tubing to flex and the layers to delaminate with an impact that our tubing would take without damage. Said another way, once you get to a certain point, our tubing will crack or chip, but ours will take a bigger hit for it to suffer

any damage at all. For this reason, we believe our tubing to be better overall because it can absorb the smaller impacts that will begin hidden structural damage with competitor's flexible phenolic tubing. Better to have an airframe chip or crack on the ground where you can see it and fix it first than to have the whole rocket destroyed under the stress of flight from hidden structural damage.

PML Pre-Glassed Tubing Service

PML offers a fiberglassing service for our phenolic airframe tubing. All tubing is vacuum bagged. The fiberglassing service leaves the tubes with a smooth finish, ready for priming and painting with little if any prepwork required. Our pre-glassed tubing is available on the Airframes section of the webstore.

- Airframe tubes 2.1" through 3.9" get 3 wraps of 6-oz. cloth.
- Airframe tubes 6.0" through 11.4" get two wraps of 16-oz. cloth.

Quantum Tube

These great airframe tubes are made in the USA from a special blended polymer that is extremely durable and easy to use. Quantum Tube can be squeezed, dropped, or even thrown and will not suffer any damage as can sometimes occur to cardboard or phenolic tube. You will find this new material easy to work with and very forgiving, even during those "less than perfect" flights. All components that fit PML phenolic tubing fit QT also.

- The Quantum Tube (QT) has been tested and found compatible with the following paints: lacquer, enamel, epoxy and urethane, as well as many different primers. As with any paint, apply several light coats allowing each to flash before re-coating.
- Most brands of epoxy adhesive bond well with no adverse affect to the tubing. The bonding area must be sanded prior to applying epoxy. Follow the suggestions in "Do's and Don'ts" below.
- The Quantum Tubes are molded in medium gray and have a glass smooth finish, with NO SPIRAL GROOVE! You no longer have to fill and sand the airframes to achieve the perfect finish.
- All QT part numbers will be prefaced with the letters QT, such as "QT-2.15".
- The Quantum Tubes are resistant to the heat of ejection charges. As with any tube, repeated ejections will leave a black, gritty residue inside the tube. To remove the residue simply wipe the tube interior with a wet cloth wrapped around a dowel or broom stick and allow to dry.
- QT can be cut easily by hand with a hacksaw, and cuts nicely with a power miter box or bandsaw as well.
- QT does not fiberglass well for body tube strengthening. We DO NOT recommend QT for 0.85+ Mach kit strengthening as mentioned elsewhere in this FAQ.

Some customers have thought that QT is a replacement for 'glassed phenolic. This is not the case! **Quantum Tubing is not intended for super-high-stress applications.** It is intended as a replacement for standard phenolic for sport rockets. QT makes it easier and faster for flyers to achieve a nice finish, and to eliminate some of the problems of plain phenolic in high-impact situations like landing on rocks, cold-weather flying, etc. **Fiberglassed phenolic is the best product for high stress flights.** Also, follow the

recommendations in the *Kit Strengthening* section of this FAQ if the flight will be near or exceed 0.85 Mach.

Do's and Don'ts for Quantum Tube (QT)

Do's:

- Before applying paint to the QT lightly sand the outside of the QT using 320 or 400 grit sandpaper.
- Sand the fin fillet area on each side of fin slots using 150-grit sandpaper before applying epoxy to fin and tube.
- Use the edge of an X-Acto knife to de-burr cut ends of QT. This will remove minor deformation of the ID of the tube when it is cut.
- Sand the inside area of the QT using 120 or 150 grit sandpaper wherever parts are to be epoxied to the QT. Sandpaper flappers on a drill, sandpaper glued to a large wood dowel, sandpaper on the end of a stick, etc. can be used to prepare the inside of the QT for epoxy.
- Using alcohol or mineral spirits will not damage the gloss finish on the QT.

Don'ts:

- Do not wipe or spill lacquer thinner or acetone on the Quantum Tube, either will melt or distort the tube.
- CA (cyanoacrylate, "super glue") may be used with QT, but only in "normal" amounts. Heavy amounts of CA may distort the QT.

Pistons, QT Tubing, and Cold Weather Flying

- The first time you fly a QT rocket in cold weather, take it with the piston OUT to the launch site with you, and set it outside while you're doing other things. Once the rocket's come to ambient temperature, try to fit the piston; it'll probably be too tight. Sand it until it has the nice slip-fit you'd expect. Voila...you're done. Your QT rocket is now ready to go now and forever. Basically once you sand the piston for cold flying conditions it'll fit well then, and also will be fine in warmer weather, as it's nearly impossible to sand a piston so much it's too loose. Think of it sort of like setting CG/CP...when you build the rocket, you add as much weight as the heaviest motor you'll fly to the tail, then adjust the noseweight once until it's right. It's something you do one time to make sure you're set for the future. Same thing with the piston.
- It's no secret that all materials get brittle in the cold, plastics in particular. It's not that QT becomes unusable at temps below, say, 30 degrees, it's just that it's not as forgiving when things go wrong as it is when it's warm. Customers have asked us to specify a temperature at which QT should not be flown, but there's no specific number to be given…you just need to realize that the colder it is, the more likely you'll have a problem with plastic cracking due to the cold. There is no perfect material but we truly believe our QT is the best all-around material for airframes on the market, especially for the price. If we thought there was something better, we'd be selling it.

Pressure Relief Holes

There are many debates about the necessity of pressure relief holes. We think it is only necessary in extremely fast-burn motors with rockets that will pass 5000' very, very quickly. If you are unsure or don't want to take any chances then drill the following holes: One 1/8" hole just above the uppermost centering ring of the MMT, one 1/8" hole near the top of the main airframe (but below where a coupler or nosecone shoulder might be), and one in the payload section. This should work with most sub-sonic rockets of 4" dia. or less.

Working with PML Airframe Tubing

Cutting Phenolic or Quantum Tubing

Cutting phenolic tubing is a little different than cutting cardboard. First of all, put away your X-ACTO knife and get an X-ACTO razor saw. It is possible to cut phenolic with a knife, but it will take a dozen or so passes to get through. You should use the razor saw to do almost all of your cutting. A hacksaw with a fine-toothed blade can also be used. A good tip to ensure a straight cut is to put an automotive-style hose clamp around the tubing when cutting to act as a guide for the hacksaw. If you have access to power wood working tools, they can be used to cut PML tubing. We have used band saws, miter saws and table saws, all with very good results. After cutting, it may be necessary to deburr the edges inside and out using 150 grit or finer sandpaper. This is especially true with QT, as the cutting process may "squeeze" the cut end ever so slightly, making it tight for inserting a nosecone or for inserting the piston. Deburring or chamfering the inside edge of a QT will eliminate those problems.

Filling Phenolic Tube Spiral Seams

Over the years, we have tried just about every kind of filler imaginable. Our favorite is Elmer's Professional Carpenter's Wood Filler. It is easy to apply, inexpensive, dries quickly, and sands easily. One can will finish at least 8 average rockets.

1. The wood filler sometimes is a little dry and chunky. It is water-soluble, so you can put some into a separate container and add water, literally a drop or two at a time! Water goes a long way in thinning the filler; if you make it too thin, add a little more filler and mix it up again.
2. Spread the filler over the areas you want to fill using a putty knife, your finger, or an auto body filler ("Bondo") spreader. (You can find Bondo spreaders in any automotive store or store like Kmart that has an automotive section). Using the spreader, push the filler into any seams or grooves you want to fill. Using the spreader will force the filler into the grooves and will scrape away any excess on the body tube outside the seams. Wipe off any globs that occur. Allow to dry for an hour.
3. Sand the filler with 120 grit sandpaper until it is even with the surrounding surface. Usually you will need a second coat, since the filler shrinks somewhat. After the second coat, let dry and resand.
4. If needed, you can apply a final coat using automotive spot putty, again available at automotive stores. Only squeeze out a little at a time and recap it, because the solvent in it evaporates quickly and any unused portion will become thick and globby. You

want the spot putty to be very spreadable, since it has a finer material grain size than the Elmer's filler and will provide a very smooth final finish.

5. Sand the entire surface smooth using 220 grit sandpaper. Do not apply any primer coat at this time as the epoxy used in assembly must adhere to the raw tubing.

Custom Work

Custom Tube Slotting

- Pricing of custom tube cutting and slotting is covered in the Airframes section of the webstore.
- There will be additional charges for the following slotting set-ups: Unequal slot spacing around circumference of tube, odd number of slots (except 1 and 3), and/or variations of slot width, length, or start point from one slot to the next on same tube.
- For tubes with four slots or less around the circumference of the airframe all slots have an overall slot length limit of 22". However, they must have 1" unslotted (skip) section for any continuous slot over 14". If there are more than four slots around the airframe, they must have 1" unslotted every 10". This is necessary because once the first slot or two is cut, it is difficult to keep the remaining slots straight due to the more-flexible tubing. Having a 1" skip section helps to be able to complete the remaining slots. (Example: You need three 19" slots. Since this slot is longer than 14", it must be interrupted for 1" at some point, such as making a 12" slot, a 1" gap, then a 6" slot. Your fin tang must be then be notched to bridge the gap, and a CR should be installed at the gap.)
- Dado slots for any tube size, in any length, and in any type cannot be wider than 0.125". This is because the wider the dado, the deeper you must go to get usable depth at the edges because the tube is round. With dados wider than 0.125" you have to go nearly through the tube to get well-defined edges.

<u>Slot Tolerances</u>

- The following slots are actually 0.015" larger than listed because of G-10 variations to ensure the G10 will fit even if it runs on the "high side" of thickness tolerances: 0.062", 0.093" and 0.125".
- The following slots are exactly as listed: 0.188", 0.25", 0.375", 0.5".
- Slot length tolerance: ± 0.062" for 3.9" and smaller. ± 0.125" for 6.0" and larger.

Slotting 3.9" tubes and smaller (PT and QT):

- Minimum start point from end of tube 0.375".
- Maximum uninterrupted slot length is 12" (except for 0.188" wide slots; the maximum slot length for these is 8"). If a longer slot is required, we must leave a minimum of a 1" gap in slot. (Example: You need a 14" slot. Since this slot is longer than 12", it must be interrupted for 1" at some point, such as making a 6" slot, a 1" gap, then a 7" slot. Your fin tang must be then be notched to bridge the gap, and a CR should be installed at the gap.)
- Maximum total slot length is 18" (again except for 0.188" wide slots; the maximum slot length for these is 8").

- The following slot widths are available for tubes 3.9” and smaller (PT, QT, and glass): 0.062”, 0.093”, 0.125”, 0.188” and 0.250”.
- For fiberglassed tubes only, 0.062” – 0.093” slot widths are available with a maximum of 10” slot length.
- For fiberglassed tubes only, 0.125” – 0.250” slot widths are available with a maximum of 18” slot length.

Slotting 6.0” tubes and larger:

- Minimum start point from end of tube 0.75”.
- Maximum total slot length is 26”
- The following slot widths are available for NON-glassed 6.0” and larger: 0.062”, 0.093”, 0.125”, 0.188”, 0.25”, 0.375”, and 0.5”.
- The following slot widths are available for fiberglassed tubes 6.0” and larger: 0.093”, 0.125”, 0.188”, 0.25”, 0.375”, and 0.5”.
- For fiberglassed tubes only, 0.093” slot widths are available with a maximum of 8” slot length.
- For fiberglassed tubes with slot widths from 0.125” – 0.5” the maximum slot length is 26”.

Custom Tube Cutting

- Tube cutting ± 0.050” for 3.9” and smaller.
- Tube cutting ± 0.125” for 6.0” and 7.5”.
- Tube cutting ± 0.25” for 11.4”

Kit Strengthening

Any of our kits that are 2.56" or greater that will reach equal or greater than 0.85 Mach need to be strengthened. Here are the calculations so you know the raw numbers:

Mach 1 @ STP (Standard Temperature & Pressure) = 1116 ft/s (fps) = 760.9 mph
1116 fps x 0.85 = 948.6 fps
760.9 mph x 0.85 = 646.7 mph

Therefore, PML kits 2.56" and larger should be reinforced for >950 fps or >650 mph flight. We feel that kits 2.1” and smaller can be flown without body tube fiberglassing, though all other items listed below should be done, as well as building the rocket with plenty of epoxy and good sanding of areas to be bonded.

As mentioned in the chart itself, the Motor Recommendations Chart is highlighted for kit/motor combinations that require strengthening. We recommend the following changes for any "yellow-highlight" kit and motor combination:

- Fully-glassed airframe, which requires phenolic as a starting point, not QT. **You must special-order your kit with phenolic as all kits 3.9” and under (except Nimbus) come standard with QT.**
- Thicker fins (0.063" should go to 0.093", 0.093" should go to 0.125")
- Fin-to-airframe joints should be glassed

- 30-minute epoxy should be used throughout the build.

Also, we say so in all the instructions, but **make sure you lightly sand any area to be bonded**! This is important to get a good "bite" on the materials for the epoxy, and is especially important in high-stress applications.

Something else to remember about strengthening your kits: you probably should upgrade one 'chute size to compensate for the weight of the 'glassing as well. A larger chute should also be considered due to the extra weight of many of the longer motor casings that will generate flight conditions where reinforcement may be required.

Nimbus 'Glassing Kit

When you purchase the Nimbus Fiberglassing Kit, the glass wrap kit supercedes/replaces the glass patches for the fins in the base Nimbus kit. Follow the fiberglassing kit instructions rather than applying the 'glass fin patches as discussed in the Nimbus instructions. The cloth in the Nimbus Fiberglassing Kit is 10 oz, and the mixing ratio of the two-part epoxy is 4 parts white to 1 part clear.

PML CENTERING RINGS and BULKPLATES FAQ

Centering rings

- Thickest and strongest in the industry. Precision made, guaranteed good fit.
- Birch plywood 3/16” thick up to and including 3.9” diameter; larger are 1/2” thick. Our ½” rings are made of 9-ply birch.
- Any hole pattern can be produced. See Custom Centering Rings in this FAQ.
- ID/OD tolerances for all centering rings and bulk plates is ± 0.010”.

Custom Centering Rings

- Need ring thickness, OD, number & ID of holes, & hole pattern/layout. 1/8" spacing minimum.
- No custom centering rings in 3.9” or smaller diameters will be made of ½” ply. If you feel you must have a thicker CR in 3.9” or smaller, order (2) 3/16” rings and epoxy them together.
- Custom centering rings are only made to fit PML tubing sizes.

Custom Cluster Centering Rings

- PML now offers a line of standard Cluster Centering Rings (CLCR) for 3.0” and 3.9” diameter Rockets.
- Cluster Centering Rings for 6.0”, 7.5”, and 11.4” are also available on a special order basis. Since there are literally hundreds of cluster combinations possible in these sizes, we cannot stock or even list all of the combinations. Turn-around time on the special order rings is usually 2 days.
- Use the Custom Centering Ring Form on the Custom Work or Centering Rings pages of our website when ordering the large cluster rings.
- On the 6.0” and 7.5” rings, the cluster holes are bored on a 4" diameter circle around the center hole. On the 11.4” ring, the cluster holes are bored on a 7.75” diameter circle around the center hole.

Bulkplates

A Bulkplate is simply a centering ring with no hole(s) in it. Same specifications and requirements as above.

Custom Bulk Plates

- Need OD & thickness. Specify holes/no holes in center for eyebolt (no charge for eyebolt hole).
- Maximum hole size in 6.0” bulkplate is 4.5”. Maximum hole size in 7.5” or larger bulkplate is 6” diameter.
- Bulkplates are only made to fit PML tubing sizes.

PML CLOSE PROXIMITY RECOVERY (CPR) FAQ

CPR – Close Proximity Recovery; PML exclusive system which deploys a small drogue chute at apogee to allow the rocket to descend quickly but stable, with the main chute(s) deploying at a user-selectable altitude AGL (above ground level).

IMPORTANT NOTE TO HELP PREVENT BLOWBY DAMAGE:

Through testing we've determined that customer complaints of black powder blowby is attributable in nearly every case to improper/incomplete prep of the charge cylinders.

In all CPR prep instructions there is a step (usually Step C) that states: **"Push a small wad of tissue into the hole using a pointed object. This will seal the hole and keep the black powder from leaking out."** In our tests we've determined that not performing this step completely is the #1 cause of BP blowby. *The wad of tissue referenced must be packed tight and must fill the hole completely.* Please take additional care in the future to check and recheck yourself on this important step. If our prep instructions are followed carefully and completely there is very little chance of any significant blowby.

CPR3000

What is CPR?

- CPR is an altimeter based, two-step parachute deployment system. Using a dual-deployment altimeter, the first chute (a small drogue) is deployed at apogee allowing for a fast but controlled descent. At a user-selectable approximately 200, 400, 600 or 800 feet, (refers to PML Co-Pilot altimeter) the altimeter fires a second charge deploying the main chute allowing for a soft landing.
- The altimeter is centrally located in a special compartment within the main airframe. The drogue chute is ejected from a split-point in the airframe just above the fin/motor section while the main is ejected at the nose cone. Both chutes are deployed using our exclusive Piston Ejection System.
- Once assembled, the altimeter/charge cylinder assembly can be easily moved to another CPR3000 rocket, making it easy (and cost-effective, since you only need one altimeter) to fly CPR3000.
- CPR 2.1 and 2.6 come with a 12' streamer (cut to desired length) instead of an 18" drogue chute, which comes with larger sizes. The chute is too large for these small diameters.
- A CPR-based rocket must always be flown with the electronics installed. A CPR-based rocket cannot be flown with motor-based ejection. This is because the fin section coupler/bulkplate assembly and the lower drogue piston block off the motor section from the rest of the rocket.
- PML offers both CPR-Equipped kits, and CPR Retrofit Kits for converting an existing PML kit or scratchbuild rocket for CPR. See the CPR Systems page in our

webstore for details, including a graphic showing what modifications are required to use CPR with many of our kits.

What is CPR3000?

- The most complete Close Proximity Recovery System ever. No need to purchase separate ejection systems, external safety switch, or drogue chute. Also includes a 16 page, fully illustrated, comprehensive assembly and user manual. These systems are perfect for retro-fitting into your existing rockets or for incorporating into your new designs.

Here's what you get:

- Complete altimeter bay assembly.
- Complete Threaded Airframe Coupler assembly made from 6061 aluminum with a blue anodized finish.
- All mounting hardware for the PML Co-Pilot or Transolve P6 altimeter. Mounts for Transolve P4, P5, Adept ALTS-25, and BlackSky ALTACC altimeters sold separately)
- Two complete ejection systems including charge canisters and holders. (Designed for E-matches. Charge cylinders for flash bulbs sold separately.) One set of fore and aft altimeter O-rings provided, whether a CPR-based full rocket kit or a CPR Retrofit kit for scratchbuild use.
- Dual piston systems.
- Drogue chute (or streamer) with tubular nylon shock cord.
- External safety switch and lead wires.
- 16-page fully illustrated comprehensive assembly and user manual.

See the CPR Systems page in our webstore for graphics and details.

IMPORTANT NOTE ON ALTIMETER FIT IN ALTIMETER BAY:

We've gotten reports of customers sometimes having difficulty getting the altimeter with O-rings fitted to slide into the altimeter bay properly. We've tested the fit of the CPR O-rings in the altimeter tube using both latest batches and older batches of parts. We've combined them in all combinations. In all cases the parts will NOT fit if no baby powder is used. With baby powder applied as per the CPR instructions provided with your CPR-Based kit or CPR RetroFit Kit, all parts fit perfectly, seal well, and slide smoothly.

MISCELLANEOUS CPR CUSTOMER QUESTIONS/INFORMATION

- Some customers have asked if the altimeter vent hole should be drilled through the airframe only (as our instructions tell you) or through the altimeter tube as well. The hole only needs to go through the airframe. The air passes through the airframe hole, works its way around the circumference of the altimeter tube and enters the altimeter bay through the large slot in the altimeter tube. Also, keeping the AF vent hole on the opposite side of the slot, as the instructions direct, provides a buffer against tiny spikes in the airflow for better altimeter operation.

- Another question has been, “why is the drogue section of the rocket on the bottom and the main chute section on the top?” This is one of those questions where once you understand WHY, you will never forget the answer: Deploying the drogue from the nose could jerk the rocket enough to pull apart the lower section and deploy the main. Deploying the drogue from the middle doesn't jerk the nose away from the chute compartment.
- PML recommends that the fore and aft altimeter O-rings be used for only two flights, then thrown away and replaced with new O-rings. This will help ensure good sealing of the altimeter bay and protection of the altimeter from pressure spikes and black powder residue. We offer a 12-pack (6 fore, 6 aft) O-rings on the CPR/ERM of the webstore under part number CPR3K-OR-PK. One set of fore and aft altimeter O-rings is provided with the CPR3000 system initially, whether a CPR-based full rocket kit or a CPR Retrofit kit for scratchbuild use.
- “I ordered the charge cylinder for flash bulbs, but the flash bulb is very loose inside the charge cylinder.” Put a tissue "packing" around the flashbulb. Roll a small tissue square (preferably Estes wadding, since it's flameproof) about 1.5 x 1.5 into a tooth pick shape then form it into a ring and use a small screwdriver to pack it around the bulb once installed. Kind of like a tissue donut with the flashbulb in the "hole" of the donut.

CPR3000 and Hybrids

Using CPR3000 with a hybrid-based rocket is usually impractical, due to the excessive length that needs to be added to the rocket. CPR3000 requires nearly 3 feet to be added to a hybrid-based rocket, effectively putting it “out of bounds” for use with hybrid rockets. This is certainly true of PML’s hybrid-ready kits.

CPR3000 Component Weights

The following lists approximate weights (in ounces) for CPR3000 parts for use in RockSim or other simulation programs:

Aluminum Threaded Airframe Coupler	1.7
Aluminum Threaded Airframe Sleeve	0.6
Charge Holder	0.4
Charge Cylinder — Ematches	0.4
Charge Cylinder — Flashbulbs	0.6
Fore Altimeter Mount	0.6
Aft Altimeter Mount	0.3
Switch, 6 screws (4 alt, 2 sw.) & wiring	0.2

3 O-Rings	0.05

CPR-MAX

CPR-MAX = CPR3000 for Large-Diameter Rockets

- Our CPR system has been available in 2.1 through 3.9" diameter sizes for years. Our new CPR-MAX system was developed for 6” and 7.5” rockets. This system allows for redundant recovery system deployment for the purpose of safety and to protect your investment. If you`ve always wanted to add CPR3000-style recovery to your 6.0 or 7.5 inch kit, CPR-MAX is the answer!
- The CPR-MAX system uses the same components as the CPR3000 system, but in a special design configured for large-diameter 6- and 7.5-inch airframes. CPR-MAX also features twin-altimeter design, which can be used either as the backup required for Level 3 flights or as a safety backup for regular sport flying. NOTE: CPR-MAX does not REQUIRE the use of two altimeters. It can safely and effectively be flown with only one. The second altimeter is a redundancy feature, not a requirement.
- The CPR-MAX System contains nearly everything you need (altimeters, epoxy, ejection powder, and additional airframes, if required, not included) to convert your existing rocket or as an enhancement to your own design.
- The Bulldog, AGM-600 and Pterodactyl kits would require over 2 feet of airframe tubing to be added to use the CPR-MAX system, which would change their appearance so substantially that PML does not recommend CPR-MAX for these kits.
- The information below is intended as a guide for determining the proper amount of ejection powder used with various diameter CPR-MAX rockets using a piston ejection system and a 24” fore or aft recovery airframe:
    - 6.0” diameter – 1.0 to 1.3 grams
    - 7.5” diameter – 1.2 to 1.5 grams

CPR-MAX Component Weights

The following lists approximate weights (in ounces) for CPR-MAX parts for use in RockSim or other simulation programs. This does NOT include the weight of the pistons, KwikLinks, or piston straps, only the “core components” of the CPR-MAX system. The weight is for one part, so if more than one is used be sure to multiply the weight by the quantity of parts:

COMPONENT	QTY.	6.0	7.5
CT-6.0	1	10.75	15.75
CT-6.0x8”	1	6.9	10.2
CT-6.0x1.5”	2	1.3	1.9

PT-6.0x2”	1	1.5	2.3
Aluminum Threaded Airframe Coupler	2	1.7	1.7
Aluminum Threaded Airframe Sleeve	2	0.6	0.6
PT-1.5x10”	2	1.7	1.7
Birch Bulkheads/Mounting Plates	2	3.65	3.95
Charge Caps, Vinyl	4	0.05	0.05
Charge Holder	4	0.4	0.4
Charge Cylinder — Ematches	4	0.4	0.4
Fore Altimeter Mount	2	0.6	0.6
Aft Altimeter Mount	2	0.3	0.3
Switch, 6 screws (4 alt, 2 sw.) & wiring	2	0.2	0.2
O-Rings	6	0.05	0.05

CPR2000

- CPR2000 is designed to use the Transolve P4 or P5 altimeter or the Adept ALTS25. We do not currently offer adapters to use electronics from other manufacturers.
- CPR2000 components are still available on our webstore for customers who may own CPR2000 kits and need replacement parts.

Differences in Mounts for CPR2000 and CPR3000

The mounts for the CPR3000 (for Co-Pilot and P5 or P6) are just more robust. Basically the areas where the holes are located are thicker. If you tried to mount a Co-Pilot to a 2000 mount, not only would the holes not line up but also there’s more room than needed to clear the parts on the altimeter. On the other hand, if you tried to mount an ALTS2 to a 3000 mount, the holes would not line up and there would be interference between the mount and components on the altimeter.

PML Co-Pilot Altimeter for CPR3000

(See the Electronics page of our webstore for more details on each device and other devices that may not be covered here).

PML currently carries the PML Co-Pilot altimeter. The Co-Pilot altimeter was developed exclusively for Public Missiles Ltd. by Missile Works Corp., and was designed specifically for PML’s CPR3000 Recovery System (though it can also be used in other

applications as well, such as scratch-built deployment systems). The Co-Pilot is based upon Missile Works' RRC^2 altimeter. The Co-Pilot provides two-stage barometrically-controlled (pressure-sensing) deployment of rocket recovery systems and equipment.

Note Regarding CPR3000 and Altimeter Manufacturers

Some customers have asked why we chose to select the PML Co-Pilot and Transolve P6 as the standard altimeters that fit CPR3000, and the Transolve P4 or P5, Adept ALTS-25, and BlackSky ALTACC altimeters with our optional additional-cost adapters.

First, we believe very strongly in supporting our customers. PML has sold hundreds of CPR2000 kits that use the Transolve P4 or P5 or Adept ALTS-25 altimeter (and many of those altimeters to go with the kits as well). We want our current customers to have complete compatibility immediately. It makes sense for us and for them to use an altimeter they're already familiar with and is interchangeable between their current CPR2000 rockets and any CPR3000 systems they may choose to buy.

Second, the better question might be "How come the altimeter manufacturers don't make theirs fit CPR?" We're the only company that offers a standardized "ready out-of-the-box" dual deployment system, and we have over a thousand of these systems in the hands of rocketeers, so it would make sense for the altimeter manufacturer to make their product fit the rocketry system that's most likely to use their product, wouldn't it? In our opinion, it would make sense for the altimeter manufacturers to base their designs around fitting CPR, and the scratchbuilders not using CPR can design mounting schemes for their altimeters as they always have. We're in the rocket business, not the altimeter business, so we leave the altimeter issues to those that make them.

Third, as you know there are many different sizes and shapes of altimeters available, and it simply wouldn't be cost-effective for us to produce all the altimeter mounts to fit each and every altimeter someone might like to use since we'd sell very few of any particular adapter, not enough to offset the tooling cost of the adapter. It makes much more sense for the altimeter manufacturers to either

a) offer a version of their product ready-made to fit CPR systems, or

b) make altimeter mounts to fit CPR and sell them to promote use of their altimeters.

It's in their best interests to do either a) or b) to sell more of their altimeters, and to support their customer base (as we are with making CPR3000 compatible with what our customers already own. Our CPR3000 altimeter bay is already designed in anticipation of altimeter manufacturers "picking up the ball" by designing it long enough and wide enough to accommodate any altimeter on the market at the time of it's introduction. BlackSky has done so by making an adapter available for their ALTACC line of altimeters, which we now sell as well.

So, to summarize, we strongly believe in supporting our previous customers, and would expect that the altimeter manufacturers can and should do the same by making their products work with CPR, either through the base design or through offering CPR-compatible mounts for their products.

BlackSky AltAcc Adapter; Modifying AltAcc to work with CPR3000

PML now sells a BlackSky ALTACC adapter which fits all ALTACC models up to and including the 2C, the CPR3K-ALTACC-ADPTR, which is available on the CPR Systems Page of the PML website. If you have any questions about using the ALTACC with CPR3000, contact BlackSky. If you have an older ALTACC with a green board, 1/16" has to be sanded off each end of the board for the CPR3K-ALTACC-ADPTR brackets to fit.

Prior to the availability of the adapter some customers modified the CPR3000 mounts to fit the ALTACC. The following information about modifying the mounts for ALTACC is from a PML customer. We can neither confirm nor deny that it works, but provide it to you here for your reference.
+++
"I called and talked to Scott at Blacksky and he stated that all you had to do was cut or file four notches in the edge of the circuit board were the screws for the CPR mounting would engage and hold the altimeter in place.

The copilot altimeter has holes in the circuit board, but the AltAcc has 2 metal standoffs that normally hold it to the body tube. I took a triangular file and made 4 small notches to hold the altimeter to the CPR module.

The Alt Acc uses a jumper to turn the unit on & off. The system is normally armed by closing a screw on the circuit board (again via another hole in the airframe) and the status of the unit is determined by looking at a LED on the circuit board via a hole in the airframe.

I went a couple of steps further and wired the jumper block (on/off jumper) tothe CPR switch mounted on the body tube. This allows the AltAcc to be armed without accessing the altimeter directly. I also drilled another hole in the altimeter bay, so I could view the LED indicator, to determine the status of the altimeter."
+++

PML CUSTOM WORK FAQ

Custom Work

- All specifications/requirements for custom work are described in the FAQ for the item in question. For example: Custom airframe slots? See the Airframes FAQ. Custom centering rings? See the Centering Rings & Bulkplates FAQ.
- See our website at www.publicmissiles.com for current pricing on all custom work. Check the appropriate page for the type of custom part involved. Example: for custom centering ring hole boring, check the Centering Rings page.
- PML does not make custom nosecones.
- PML offers more custom work options than any other manufacturer. Most others only offer fins and centering rings.
- PML also offers quick turnaround time on custom work except for very unique items. Custom work is usually shipped within 48-72 hours of your order.
- There are no returns on custom items (unless we made a mistake). Custom items are by definition unique, specialized parts, and they cannot necessarily be resold to another customer.

We welcome customers forwarding us RockSim files of their projects, as it sometimes helps us understand what you're after. However, YOU STILL MUST PROVIDE US A DETAILED PARTS LIST OF WHAT YOU NEED, INCLUDING CUT LENGTHS, DIAMETERS, ETC. YOU MUST PROVIDE US WITH THE SAME LEVEL OF DETAIL AS IF YOU HAD NOT INCLUDED THE ROCKSIM FILE. We will not "decipher" the RockSim file to determine exactly which parts it contains. Look at the RockSim file as a way to help us ***understand*** your parts list, not a way to ***produce*** your parts list and measurement data.

PML ELECTRONICS FAQ

Onboard Electronic Devices (Altimeters, Timers, Etc.)

(See the Electronics page of our webstore for more details on each device and other devices that may not be covered here).

PML currently carries the Co-Pilot altimeter. The Co-Pilot altimeter was developed exclusively for PML by Missile Works Corp., and was designed specifically for PML's CPR3000 Recovery System (though it can also be used in other applications as well, such as scratch-built deployment systems). The Co-Pilot is based upon Missile Works' RRC^2 altimeter (though it differs in important ways such as location of electronic components, which allow it to fit CPR systems). The Co-Pilot provides two-stage barometrically-controlled (pressure-sensing) deployment of rocket recovery systems and equipment.

PML also carries the AccuFire Timer, made exclusively for PML by G-Wiz Partners. The AccuFire is an adjustable (0-25 sec.) post-motor-burnout timer. Like the G-Wiz LC, LC Deluxe, and MC, AccuFire uses a progressive launch detect algorithm. The timer must "see" either 2g for 0.5 seconds, or 4g for 0.25 seconds, or 8g for 0.125 seconds to determine that launch has occurred and begin monitoring for motor burnout. Accelerometer-based detection of motor burnout occurs upon detection of deceleration (negative g's) after launch detection; the timing to the firing event begins at motor burnout. The AccuFire uses a standard 9VDC battery as a power source, and provides an output current to the pyro channel of up to 1.25A. Also, the AccuFire is NOT affected by hybrid motor harmonics; it's completely safe to use with hybrids.

IMPORTANT CUSTOMER ALERT:

For the AccuFire to function as a 2nd stage ignition device, you MUST use:

1) BlackSky HiRMI Standard electric match (preferably dipped in pyrogen) or
2) DaveyFire N28F (preferably dipped in pyrogen).

For the AccuFire to function as an ejection charge initiator the following electric matches could also be used:

3) 1 or 2 above (without the pyrogen dip),
4) BlackSky HiRMI - Sensitive,
5) DaveyFire N28B, or
6) Oxral.

Other ignition devices *WILL NOT FUNCTION PROPERLY* with the AccuFire.

How Altimeters Work

The following is a generalized discussion of how the PML Co-Pilot and other barometric altimeters work. It is not intended to be absolutely or entirely accurate, just descriptive of basic operations as an educational tool.

The Co-Pilot, and all other barometric altimeters I know of, takes an air pressure sample when you first turn them on (and some like you to leave them on for a couple minutes so they can take multiple baseline readings). They then set themselves to say, "OK, this pressure reading I'll call zero". Doesn't matter what the actual launch site elevation is, it says, "OK, this is zero. I'll base everything I do from now on based on changes from this pressure reading". So, let's say your launch site is at 750 ASL (above sea level), and let's pick some arbitrary scale for altitude. Let's say it ranges from 0 at sea level to 10000 at 10 miles altitude. When you turn your altimeter on, it takes the pressure reading at your launch site, which being at 750' is, say, 15. It does it a few more times over the next few seconds...15, 15, 15. It says, "OK, I keep getting 15, so I'm now going to reset all my internal software to say "15 = 0". The next thing the Co-Pilot does is look for a pressure drop corresponding to 300' AGL to determine a launch has really taken place, so it should arm it's deployment circuits and look for apogee. So, now you launch, it sees 15-16-17-18- and up (let's say 17 equals 1050', or 300' above your launch site altitude). It says "OK, there's 17, that's 300' above the ground, so this is a real launch. I'm going to start running the software to monitor when to deploy my chutes now". OK, the rocket's still going up, is near the top of it's flight, and it sees 800-801-802 on our arbitrary scale. 802-803-804----804-803-802. "OK", it says, "I saw 804 as the highest reading I ever got, but now I see 803 and then 802. Must be I'm over apogee and falling back to earth. Deploy!"

Deployment Charge Igniter Selection

PML's Electronic Deployment Devices can work with flashbulbs, electric matches or igniters. Flashbulbs are not recommended, though, due to their much lower reliability and great variability in firing current requirements. Also, electric matches are preferred over igniters due to the relatively low current requirements compared to most igniters intended for motor ignition. The resistance reading of what you intend to use is important. Here's why:

E = I x R, where E is Voltage, I is Amperage, and R is resistance. We know the Voltage involved depending on the onboard battery. We also know from the specifications of the unit that the ignition device must fire with a certain amperage range. So, we need to find R, the Resistance, to determine which ignition device can work successfully with the device we intend to use. Below is an example of how to do the calculation, though if the manufacturer of the electronic device specifies requirements for the ignition devices connected to it, follow the manufacturer's specifications over the calculation.

> Co-Pilot Altimeter
> Battery = 9 volts
> Current = 1.25 amps
>
> E = I x R, 9 = 1.25 x R; rearranging, we get R = 9/1.25 or 7.2 ohms
> The ignition device must be 7.2 ohms or more to work properly with the Co-Pilot.

Igniter manufacturers will specify the electrical usability (ohms and volts) range for their devices; contact the igniter manufacturer for their specifications. We strongly recommend that you check each igniter you intend to use before flight to determine that it is good and within the ohm range needed. We also strongly recommend that you ground-test the electronic device you intend to use with the ignition device you intend to use before committing that combination for use in an actual flight. Ground testing instructions are included in our detailed instruction package provided with each of the Electronic Deployment Devices we sell.

Timer Ignition Device Selection

The AccuFire is designed to work with electric matches or igniters, and outputs up to 1.25 amps to the pyro circuit. Flashbulb-based igniters are not recommended due to their much lower reliability and great variability in firing current requirements. The AccuFire pyro channel (output circuit) is a closed-loop feedback amplifier with a limit of 1.25 amps current output.

IMPORTANT CUSTOMER ALERT:

For the AccuFire to function as a 2nd stage ignition device, you MUST use:

1) BlackSky HiRMI Standard electric match (preferably dipped in pyrogen) or
2) DaveyFire N28F (preferably dipped in pyrogen).

For the AccuFire to function as an ejection charge initiator the following electric matches could also be used:

3) 1 or 2 above (without the pyrogen dip),
4) BlackSky HiRMI - Sensitive,
5) DaveyFire N28B, or
6) Oxral.

Other ignition devices *WILL NOT FUNCTION PROPERLY* with the AccuFire.

Battery Testing is CRITICAL

One thing that is ***CRITICAL*** that many customers do not do is to test their battery before **EVERY FLIGHT**. Onboard electronics systems are very sensitive to appropriate voltage and current conditions; a just-slightly-weak battery can cause the electronics to fail. Given that you're flying hundreds of dollars of rocket, electronics, motor casing and motor reload, taking time to test your $1.89 battery makes sense (not only from a cost perspective, but from a safety perspective as well.) It always amazes me how someone can walk out to a launch pad carrying $500+ of rocket, motor and electronics but wants to "save money" on batteries or igniters/ematches on board! The short story is: make SURE you test your battery as noted in the manufacturer's instructions. Test a NEW battery when you get it as well (it doesn't happen often, but sometimes a battery is bad right out of the box), and test every battery before every flight. It's asking a lot of an inexpensive battery to run an onboard computer and fire two ematches every flight…make sure it can do it, and replace it often.

Ni-Cad Batteries for Electronic Systems
We recommend Radio Shack's Hi-Capacity Ni-Cad battery part# 23-299 as a good Ni-Cad for onboard electronic systems (unless specified otherwise by the instructions provided for the device).

Ematches vs. Igniters

The difference between ematches and igniters is that ematches are intended to ignite an easy-to-burn substance quickly, such as the BP used in rocket ejection charges. However, an igniter is intended and constructed to produce a large, hot ball of flame for an extended period (say, 0.5-0.75 seconds) to ignite a rocket motor. Ematches typically will not ignite motors unaided as they do not produce a hot enough flame for long enough, whereas igniters certainly could ignite BP. Another significant difference between them, which is critically important for onboard rocket electronic use, is their current requirements. Igniters typically require much more current than an e-match; the current requirements are usually more than altimeters can provide. Therefore, for onboard altimeters, which need to ignite deployment charges, ematches are needed. For staging timers, which need to ignite motors, igniters are needed. Be sure to always check to be sure an e-match or igniter will work with your onboard electronic device.

Our Magnelites are definitely igniters, and likely cannot be used in onboard systems due to the current requirements issue. The sample calculations above and manufacturer's recommendations can be used to determine if a particular e-match will work with your altimeter.

PML recommends that all flash bulbs and electric matches have the electrical wires twisted together until just before installation in the rocket system. This can help prevent accidental ignition of the device due to static discharge or radio frequency interference (RFI).

The Daveyfire N28BR Electric Match works perfectly with the CPR3000 system for parachute ejection charge ignition. The N28BR fits perfectly into the CPR3000 Ejection Charge Cylinder. Of course, the N28BR can also be used in scratchbuild ejection systems as well. (Not intended for motor ignition; our Igniters Page for Magnelite motor igniter kits).

The Daveyfire N28F Electric Match works perfectly with onboard staging timers for second stage ignition of G-80 single use motors. The N28F can also be used for ignition of other popular rocket motors. For best results for motor ignition, dip N28F one time into a Magnelite pyrogen mixture (sold on our Igniters page). (Electric matches will usually require extra pyrogen for successful motor ignition). CAUTION: When dipping take care so that resulting match head will pass easily into the motor grain hole. Blocking motor hole can cause over-pressurization of motor which can rupture motor.

Other Ignition Devices

- We also offer the Robby's Rockets Loadable Ejection System (LES) kit for those who prefer flashbulb ignition. This kit comes with everything you need for ten ejection charges using flashbulb ejection ignition, except the FFFFg ("4F") black powder, which can be purchased locally in sporting goods or gun shops, especially those that cater to antique firearms such as muzzleloaders. Everything but the prewired flashbulbs can be used over and over again. This kit is intended primarily for CPR2000-based rockets.
- However, we recommend use of electric matches over flashbulbs for onboard electronic systems. Flashbulbs are not recommended due to their much lower reliability and great variability in firing current requirements.

CPR2000 and CPR3000

A CPR-based rocket must always be flown with the electronics installed. A CPR-based rocket cannot be flown with motor-based ejection. This is because the fin section coupler/bulkplate assembly and the lower drogue piston block off the motor section from the rest of the rocket.

- PML doesn't sell an altimeter housing kit, but we do have an altimeter and LES tube mounting kit that goes along with our CPR2000-based systems. Many have used this system in their scratchbuild electronic-deployment rockets. Check out the website at www.publicmissiles.com in the CPR Systems section. Also, check out the Dec. 97 issue of High Power Rocketry Magazine. There's a good article on how to make a Self-Contained Altimeter Bay that'll make the altimeter easily removable to switch back and forth between rockets. However, you'll have to modify the HPR Magazine design slightly due to differences in altimeter layout from the ALTS2 altimeter used in the article design.

Fitting ST-2 Timer to IS3000

The PML AccuFire is the recommended staging timer for the IS3000 system; the two were designed together to complement each other. The Transolve ST-2b will also fit directly. The ST-2 can be used if the customer drills holes in three of the corners of the board. However, using an ST-2 can be potentially unsafe as it only has one set of two screw terminals, requiring the customer to install a switch in series with the electric match to safe the system from firing on the ground. Everything else uses off-board power and will not fit the IS3000 system.

Customer Q&A and Miscellaneous Co-Pilot Information

1. **Q:** "…there was a cold solder joint on one of the sensor leads..."
   A: Customers have noted that they think that some of the joints on the Co-Pilot are cold-soldered (i.e. bad connections). The sensor, terminals, and discharge capacitor are all hand-soldered so they will look different than the wave-soldered joints. Only the circuit side components can be placed for wave soldering, and the sensors cannot be washed, hence they are added post wave. The joints may appear cold, but they likely are not. Remember these are plated feed-thru holes,

so the surface pad condition in no way visually indicates the integrity of the joint.

2. **Q:** "I recently bought a Co-Pilot and powered it up for the first time today and seem to have a problem. It does not detect continuity on either the drogue or main outputs, when in input test mode it sees all five switches but not the main or drogue but when in the output test mode it works properly and fires both outputs, when first turned on with a e-match in both outputs the unit does not beep indicating no continuity. Am I doing something wrong or do I have a problem with my copilot?"
   A: Your battery voltage is too low. The continuity circuit bias voltage is unable to operate the circuit on a weak 9V battery (approximately 8V give or take). Your Co-Pilot is working exactly as designed; it's "trying to tell you something" by not going into certain operational modes properly. You need to read and follow the instructions about testing the battery, even if it's a brand new battery right out of the box. You MUST test your battery every single time you're going to use the Co-Pilot. Very cheap insurance considering a $2.50 battery can make the difference between getting your multiple-hundreds-of-dollars of rocket and hardware back.
3. **Q:** Reading through the manual, I was trying to find some sort of 'rule-of-thumb' for using the Mach Delay, and a description of what could likely happen in the following scenarios:
   a) transonic to sonic flight w/o Mach Delay
   b) transonic to sonic flight w/ Mach Delay but delay time too short
   c) transonic to sonic flight w/ Mach Delay but delay time too long
   A: a) You run the risk of mach pressure spiking.
   b) Same as a)
   c) Not a problem *unless* delay exceeds time to apogee
   One could also reverse these scenarios (sonic to transonic) and the same would still hold true.
4. **Q:** "When not using the Co-Pilot for deployment, is it best to fly with main and drogue connectors closed or open circuit? Does it have an impact on battery life?"
   A: It will work in either configuration. If the outputs are open then no audible chirping on the pad, if shorted then the unit will chirp. The battery will be used up a bit sooner if the outputs are shorted. Leave one output shorted and the other open for the best of both. The MosFET outputs of the Co-Pilot utilize an internal crowbar circuit to limit current flow, so it makes them immune to shorts. Opens are a "don't care" since no current flows.
5. **Q: "**Has PML considered using a RCA jack (normally closed) in place of the SPST switch? Using a RCA plug allows a measure of safety...(remove me prior to launch) and a pressure relief hole."
6. **A:** We've considered it, but the RCA plugs can be less durable over time than a "real" switch. Also, you need to mount the switch such that the movable "leaf" will be forced INTO contact by the G forces of launch (rather than 180 deg. from that where the launch will try to separate the switch). Also, the size of the altimeter pressure hole would determine the size of the plug needed, so you'd need to maybe use a "big" plug on a small rocket to get the size of the plug hole

you need. One other thing is that all altimeter manufacturers I'm aware of recommend that the pressure relief hole(s) be smooth and flush to the airframe. All RCA plugs I've seen use a threaded "ring" to tighten them on, which makes a turbulence-inducing obstruction right before the hole, and also by definition makes the hole not flush to the airframe.

7. **Q:** I just noticed browsing Missile Works web site that the Co Pilot is ~25 bucks more than an RRC2. What makes the Co-Pilot worth the extra bucks besides the PML brand name?

A: -- Designed specifically to interface with the CPR-3k system
-- Minor revision to apogee detection software
-- Better layout of terminals for easier connections.
-- Clear markings for all connections and switches.
-- Lower altitude main chute deployment range available.
-- Superior documentation (instructions).

8. **Q:** What is the Co-Pilot's altitude report-out accuracy?
A: The software interpolates and reports to the nearest foot. On a low flight it is easily within 5% (2K AGL) and the accuracy increases from there as peak altitude increases, then it rolls off again. Missile Works states that +/- 3% is a typical accuracy (3-5K AGL). No barometric unit we know of for HPR currently compensates for local ambient pressure conditions, so as that fluctuates you'll get some slight variance in readings (only for extreme fluctuations).

PML G10 FINS FAQ

Fins

Material and Usage

- G10 is a highly compressed fiberglass laminate in a high-temp epoxy resin. It looks very similar to computer circuit board material. It is extremely tough, waterproof, and solvent-proof. It is very rigid, yet has just enough flex to keep it from snapping under most loads. When scuffed with sandpaper, epoxy bonds readily to it, and primers and paints adhere well to it too. Fins can be made much thinner (much less drag) when made of G10, and still be stronger than most other materials, especially wood. It is a very consistent material and does not have any of the hidden structural flaws that wood may have.
- PML was the first to use G10 fiberglass for fin material. G10 was exclusive to PML for many years, though now other manufacturers have recognized the benefits and offer it as well.
- G10 is used on every PML kit. Most other manufacturers use wood, especially in larger sizes.
- All PML kits except minimum diameter use through-the-wall-to-the-motor-mount fin mounting design for strength. Minimum diameter kits use dado slots in the body tube, with fiberglass reinforcing patches for the fin-to-tube joints. (**Dado** – A groove or "channel" that does not go all the way through a tube. Used in minimum-diameter kits for fin mounting; also used for some canard-type fins.)

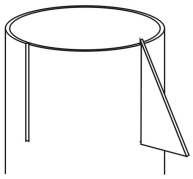
Building/Construction

- G10 is sanded most easily using 80-120 grit cloth-backed aluminum oxide sandpaper.
- Scuff all areas where epoxy will be with 80-120 grit sandpaper. Use 220 or 320 on fin surfaces that will be painted.
- G-10 is extremely abrasive! Do not try to cut it with common shop tools, as it will damage or destroy most common blades very quickly. The cost of having PML make your G-10 fins for you on custom jobs is probably cheaper than buying the tools that will allow you to cut the G-10 yourself.
- Fins leading/trailing edges do not need to be shaped. Simply lightly sand the edges to remove any manufacturing burrs. If you do choose to shape the fin edges, protect your power tools from the abrasive sanding dust, and wear a dust mask!

Mounting

- Be sure to apply epoxy fillets to the fins at all three of the following areas: Motor Mount, inside airframe where fin passes through slot, outside airframe/fin joint.
- People have asked how to make internal fillets to the fins deep up into the airframe. One technique we've had luck with is to use a piece of 1/4", 3/8", or 1/2" dowel as appropriate. Mix your epoxy and "load up" the end of the dowel with a blob of epoxy, then stick the dowel into the airframe and onto the fin joint you're working on. After

depositing enough epoxy in this fashion, you can then pull the dowel toward you, making a fillet with the "fingertip-shaped" round profile of the dowel. It may be beneficial to use masking tape to cover the inside of the bottom of the airframe and the outside of the motor mount tubing while applying the epoxy inside. This will make it easy to peel off the tape to remove any epoxy drips that may get on the airframe and/or MMT and hinder you from installing the lower centering ring when your internal fillet work is done. Another easy and strong option is to use our Two-Part Expanding Foam available on the Adhesives page of the webstore. No internal fillets are needed! See the PDF on the Adhesives page for details on using the foam.

- Some customers are concerned that the small canard fins at the top of the Bullpuppy kit appear too long for the slot. This slight over-length is intentional. It would be difficult to fill in the slot and make it look good if the fin were too short, so we make them a touch long to ensure that will never happen. Go ahead and mount them, then when the epoxy has cured use sandpaper or a small file to knock them back flush with the top of the airframe.
- 
- Customers sometimes ask: "Is it OK to put the launch lug in the corner of a fin root and the main body? The instructions say to put it in-between two fins, but it would produce less drag near a fin root and would be stronger also." This can be done if you're careful, but by putting the lug at the fin root, you limit the size of the fillet. If you make the fillet too big, the epoxy will block the ends of the lug. Also, it just makes it harder to sand that area of the rocket while painting.
- One customer asked: "…and the upper fins have some small amount of twist in them." All flat stock materials are warped to some degree (and I mean ALL except glass as in window pane and stone) and G-10 is no exception. At PML we know how to cut the sheet so as to minimize the warpage.

Fin Tolerances

- Variations in G-10 thickness: +0.012" / -0.003" (PML sends back to manufacturer any G-10 with greater variations.) A very small degree of warpage is common with G-10 (but nowhere near the degree of warpage in any wood product) and does not adversely affect the aerodynamics of the rocket.
- Fin dimension tolerance (stock and custom) ± 0.050. Matched fin sets accuracy ± 0.010 (FYI: a human hair is about 0.004).

Custom Fins

- You **MUST** use the custom fin template downloadable on either the Custom Work or Fins page of our website for a custom fin order. Be sure to fill it out completely to avoid delays.
- Minimum custom fin size is 2" by 1", maximum size is 48" by 36".

Kit Strengthening

As mentioned on the first page of the Motor Recommendations Chart on the Specs Page of the website, chart cells are highlighted for kit/motor combinations that require strengthening. We recommend the following changes for strengthening:

- Fully-glassed airframe, which requires phenolic as a starting point, not QT. **You must special-order your kit with phenolic as all kits 3.9” and under (except Nimbus) come standard with QT.**
- Thicker fins (0.063" should go to 0.093", 0.093" should go to 0.125")
- Fin-to-airframe joints should be glassed
- 30-minute epoxy should be used throughout the build.
- Some customers have asked if they can “double-up” or “sandwich” two pieces of G10 to create a super-thick fin for very high impulse flights. We don’t recommend it; at high speed airflow can split them.

PML GENERAL ASSEMBLY & PAINTING/FINISHING FAQ

General Assembly Tips

We say so in all our kit instructions, but **make sure you lightly sand any area to be bonded**! This includes fins, airframe (inside and out), motor mount, etc. This is important to get a good "bite" on the materials for the epoxy, and is especially important in high-stress applications. It takes very little extra time to do this, and the sanding dramatically improves overall strength. Don't skip the sanding!

1. After filling tube seams as described in the Airframes FAQ under *Filling Phenolic Tube Spiral Seams* (unless you're using our Quantum Tube, which has no seams), assemble according to the kit instructions. We recommend using a quality epoxy in all gluing procedures (see the Adhesives FAQ for details). Be sure to apply epoxy fillets to all critical areas, especially the fins.
2. Spray the entire rocket with a scratch filling sandable primer. Let dry, then sand with 220-grit sandpaper. Keep repeating the spraying and sanding process until all defects are gone. Some people use alternating coats of gray and white primer to help identify particularly high or low areas. Use white primer as the final coat for rockets you intend to finish in light colors—especially white and the various fluorescent colors. Gray is better for rockets you intend to finish in dark colors. It is all right to sand through the primer except on the last primer coat. Also, the last primer coat may be sanded with even finer sandpaper. Even better is using a green 3M ScotchBrite pad.
3. Now is the time to touch up any dings that may have occurred during assembly. Dab a bit of automotive spot putty on the affected area, let dry and sand smooth.

Final Finishing/Painting

- Stay with the same brand of paint throughout the process; primer, base color, accent colors, and clear coat. Paints seem to work best as a "system", so use those from the same company to ensure compatibility. We've had good luck with Krylon, and it comes in a wide variety of colors. However, the relatively new Krylon latex enamel sprays can be rather "globby". Be sure to test them first before using them on your big project!
- Some customers have noticed unpainted QT yellows slightly after long exposure to sunlight. Here's why: Prolonged exposure to UV will make any plastic brittle. This may take years, though. Modern plastics like QT may also have some UV blocking additives blended in to delay the deterioration further. The color pigments in the plastic are the first to break down, hence the yellowing. Paint stops the breakdown process.
- DO NOT skimp on the "shake the can for at least two minutes after the ball rattles" step! This is a mistake many people make. If you need to, stand in front of a clock while you shake the can. Getting all the paint in the can well mixed is a very

important step that should not be rushed! Also, as it notes on the can, shake it for a few seconds every minute or so while you're painting to help keep it well mixed.

- Four or five light coats are better than one or two heavy coats. You will reduce the risk of runs and sags in the paint dramatically, and it will dry faster as well.
- For the very first coat, apply a very light coat of your base color. You're really not trying for any color coverage at all, just getting a bit of the paint stuck to the surface of the rocket to allow the subsequent coats to bond to it. Allow this coat to dry for about 5 minutes before applying more coats. This first very light coat seems to "set the stage" for following coats so they won't run as easily.
- For the best finish, let each coat dry and sand lightly with 320 or 400 grit sandpaper; you should let each coat dry overnight before sanding. Also, wet sanding is best to sand paint because the water acts as a lubricant and a coolant, and flushes away the paint that's sanded off, keeping the sandpaper cleaner. Make sure you have sandpaper that's made for wet-sanding, and dip it in the water bucket at least every 30 seconds or so.
- Apply the last color coat as heavy as possible without running or sagging. There's no way to say how much is too much or too little; it's just something you develop with practice. This is another reason to stick with one brand of paint, because you develop a feel for how the paint sprays and adheres to other layers and can learn how much is just enough before it will run.
- Let the paint cure for at least 48 hours before handling! This is difficult to do, but will really pay off in the long run. Even though the paint feels dry, it is still quite soft underneath the top layer and will be easily damaged until it's fully cured.
- Once the paint has cured you can apply your decals or self-adhesive Monokote accent stripes (available at most hobby shops). Many hardware stores also carry various colors of vinyl tape, what most people call electrical tape. We've used red, blue, green, yellow, and white, as well as the usual black electrical tape for stripes. It's a little thicker than Monokote or paint for stripes, but is very fast and easy. If using water-type decals, wet the area where the decal goes with slightly soapy water to make positioning the decal easier. This is NOT recommended for the decals from PML; they are self-adhesive and the soapy water will make them not stick.
- PML offers both replacement decal sheets for our kits, as well as PML logo decals on the Decals Page of our webstore. Customers often order AMRAAM or Bulldog decal sheets for their scratchbuild military-look rockets, as those sheets have items that can be used to mix 'n' match a military look to your own design.
- We recommend a clear coat of some sort to help protect the decals as well as "seal" their edges to help prevent them peeling off. There are three general gloss levels of clear coat spray available (in order of decreasing gloss):
    - — Crystal Clear: very shiny, glossy finish; almost a "wet" look
    - — Matte (or Satin): not shiny, but not extremely flat/dull
    - — Testor's Dullcote: very flat, dull finish; most "realistic" look to missiles, etc.
- When using any clear coat, put on only VERY thin, light coats, and wait at least 5 minutes between coats. The clear coat can damage your decals or paint if you put it on too heavily or don't wait long enough between coats! This is especially true for the first coat; you can go a little heavier after the first one is dry. There seems to be something about the solvent used in the clear coat that will "eat" the decals or base

paint if there's too much clear coat on at a time. Please…go easy on the clear coat! Don't let this deter you from using the clear coat; it really is a benefit to use it. Just go easy. Usually 2 coats are sufficient, though some people use three.

- Also, be sure to always test clear coating metallic paints. Often clear coats will dull the metallic look you are trying to achieve. From the Ask Krylon feature of Krylon's website:

"The only product you want to top coat the metallics with is the Krylon Living Color Latex Enamel Paint. It will darken the paint a few shades but it will keep the metallic look. If you use any of our lacquer clears the metallic look will be completely stripped out."

PML GENERAL INFO FAQ

Getting Started In Higher-Power Rocketry

If you're completely new to rocketry as a hobby, the National Association of Rocketry (www.nar.org) "specializes" in the beginning hobby rocketeer and the rockets best for getting started. We'd recommend a visit to the NAR site to start off. One of the other great places to "surf around", whether you're new to rocketry or have flown lots of model rockets and are ready for something bigger is www.rocketryonline.com. This site has all kinds of information and links about hobby rocketry, including higher power. However, you're here to see what PML has to offer, so below are some of the typical questions and answers for people just getting into high-power rocketry:

What Do I Need to Get Started in High-Power Rocketry?

Many people see that PML offers kits and single-use 29mm motors, but also ask about launch pads, launch controllers, bigger motors, flying fields, etc. High-power rocketry is a little different than model (A through D motors) and midpower (E through smaller G) rocketry. The equipment is larger (and more expensive), the flying fields must be bigger (and therefore harder to find), and there are regulations governing where large rockets can be flown and what altitudes are allowed.

We always recommend joining a NAR (National Rocketry Association) or TRA (Tripoli Rocketry Association) club in your area. They'll already have the launch equipment, they'll have suitable launch fields lined up, they'll know local regulations, they'll already be filing the paperwork necessary to fly big rockets ("FAA waivers") and they'll also be more than willing to help you out. Besides, it's always more fun to fly with other people that enjoy the hobby (and can help you out as you move along), so joining a club is the way to go in keeping costs down, finding good flying fields, and complying with regulations.

Be sure to visit the www.nar.org and www.tripoli.org websites. They have detailed information about local clubs, the motor certification process (required for flying H motors and above), and much more. Really, join a club…it'll make your higher-power rocketry experience a LOT easier and more fun!

I've Flown Lots of Model Rockets; What's a Good "Starter" Kit for Higher Power?

As far as getting started into high power, take a look at our 29mm motor AMRAAM-2, Callisto, Io, or Tiny Pterodactyl, which fly on F and G motors (F and G being the next step to the "lower edge" of high power). Or, try the 38mm X-Calibur or Small Endeavour (or the 38mm Callisto or Io) with our ADPTR-38/29 optional motor adapter. That way you can fly it on 29mm F and G motors, then move to 38mm H and I when you're ready. You might also like the Bullpuppy. The military styling is cool, and it too can be flown on some 29mm motors with a ADPTR-38/29 installed, but is built with a 38mm mount so you can fly H and I on it when you're ready. Or you can fly our Bullpuppy 2.1 on 29's.

Callisto, Io, Phobos, Ariel, they're all popular kits and would be good starters. The best bet is to take a look at the Motor Recommendations Chart (click on Specs Page on our website) at the kits that will fly on Gs (and maybe some F's) and small H motors, and then look at which one of those you might like. The KitSpecs Chart (also on the Specs Page of the website) lists all the detailed information about all PML kits.

What PML Kit Should I Get for my Level 1 Flight?

I know it keeps coming up in this section of the FAQ, but the best is to take a look at the Motor Recommendations Chart on the Specs Page section of our website. See the kits there that will perform to a level that'd be good for the flying field you have available (basically look at the predicted altitude on, say, H128 (29mm) or H123 and H242T (38mm) motors, both popular Level One cert motors), then take a look at the webstore for what the kits look like and find one that "strikes your fancy". Some quick ones that come to mind are the Io, Callisto, Phobos, Quasar, Explorer, Black Brant VB, Ariel, Miranda, D-Region Tomahawk, Tethys, Small Endeavour, and X-Calibur. It really depends on the type of performance you want out of the rocket both for your L1 cert flight (under 2000' altitude and simple are our recommendations there) and for “fun flying” after you've achieved your L1. Some people who fly in the Midwest have smaller fields where altitudes and trees surrounding the field are a limiting factor and like to/need to keep the altitudes down, whereas people out West often have miles of uncluttered desert to fly on. So, it all depends!

I Want to Get a PML Kit That’ll Be Good for Level 1 AND Level 2

Really there are a number of PML kits that would work well for L1 and L2, but a lot of the decision depends on:

1) What you like as far as looks and features, and
2) The altitude waiver of the club you'll fly with at their field.

Take a look at the Motor Recommendations Chart on our Specs Page. It will tell you how each kit will perform on various motors. Obviously you'll want to pick one that'll stay under the waiver for your field when you fly it on the L2 motor you'd plan on using, yet can achieve an altitude that you like when flown on an L1 motor. Then when you've narrowed down which ones will fit the flying specs you'll need to meet, you can decide which one has the looks or other features you like. Some kits that quickly come to mind are: AMRAAM-4, Tethys, Endeavour, and Miranda. However, there are *many* PML kits that can “fill the bill” for L1 and L2, depending on your situation!

Contacting PML and Information Resources

- All telephone contacts (except fax: 24hrs./7days) are 9am-5pm EST Monday through Friday.
  Telephone 810-327-1710 or fax at 810-327-1712
  For ***orders only*** (no technical or order status questions, please): 1-888-PUBLICM
- Online at our web site: www.publicmissiles.com.
- All pricing information quoted in FAQs is subject to change. Always see the website for the latest prices. Our entire retail price list is available on the entry page to the Webstore section of the site, and the prices for individual items are listed next to the item in the webstore.

- Our catalog is FREE, and can be ordered at the above phone numbers or on the Hardware page of our website. (However, the website is always the "freshest" source of information, as the paper catalog can't be updated after it's printed, whereas the website is updated regularly).
- See the Contacting PML page of the website for how to direct your question to PML via email.

Services, Returns, Timing

- We nearly always ship within 24-48 hours after receipt of your order.
- Custom work is usually shipped within 48-72 hours of your order.
- Fiberglass nosecone and tube-wrapping orders usually ship within a week.
- Parts damaged in shipping will be replaced quickly.
- Return Policy: "If you don't like it, send it back!" Remember, mistakes may happen, but we will do whatever it takes to make the situation right with you. We are absolutely committed to your satisfaction. Always have been, always will.
- There are no returns on custom items (unless we made a mistake). Custom items are by definition unique, specialized parts, and they cannot necessarily be resold to another customer.
- The PML website always has the latest Warranty information (on the Warranty Policy page) and Shipping information (on the first page after clicking the Webstore button). Check there for questions on these items or for the latest information.

PML Email Newsletter

Public Missiles, Ltd. has an email distribution list for distributing information about new kits, new products, and new information direct to the rocketry community. People on this list will be the first to know about new products, sales, and other information of interest. There's no cost to you, and the list will only be used by PML to notify you of developments at PML. Your email address or other information will not be distributed by PML to other companies or organizations.

How do you sign up? Go to http://mx.blastzone.com/mailman/listinfo/pmlnewsletter to manage your PML News subscription. The above URL is also on our Newsletters page of our website at www.publicmissiles.com, so if you forget it some day in the future when you need to do something with your subscription just visit the Newsletters page.

Glossary/Abbreviations/Terminology/Misc.

BP – Black Powder; used for ejection charges.
CG – Center of Gravity; the point on an object where it balances, where all the weight seems to be centered. (See additional information under the section "Stability".)
CP – Center of Pressure; the point on a rocket where all the corrective action of the fins seems to be centered. (See additional information under the section "Stability".)
Dado – A groove or "channel" that does not go all the way through a tube. Used in minimum-diameter kits for fin mounting; also used for some canard-type fins.
G-10 – A type of fiberglass used in all PML kits for fins. Similar to circuit boards.
ID – Inside Diameter

KS – KwikSwitch; motor mounting system
LES – Loadable Ejection System; system used with altimeter for deployment charges
MMT – Motor Mount
OD – Outside Diameter
VHA – Very High Altitude; a line of PML kits. This abbreviation used on our website and our catalog.

Inches x 25.4 = Millimeters
Millimeters ÷ 25.4 = Inches
1 Pound = 4.45 Newtons
1 Pound = 16 ounces = 454 grams
1 Ounce = 28.3 grams
1 Kilogram = 2.2 Pounds = 35.2 ounces

Stability

Center of Pressure

CP stands for Center of Pressure. You're probably aware of the center of gravity; this is the point on a rocket (or any object) where all the weight seems to be "centered". The center of pressure is similar; it is the point on the rocket where the corrective force of the fins is "centered". The center of pressure must be a minimum of one body diameter **behind** the center of gravity on a rocket fully prepped for launch to ensure stability. CP doesn't vary; it's controlled by the design of the kit. CP specifications given in the PML catalog and on the website spec sheet are measured from the nose tip. However, you CAN vary CG, by adding more nose weight. That's why we specify CP in the charts, so the owner of the rocket can find their CG and compare it against the CP to see if they need to add some nose weight for stability.

A very generalized rule of thumb: CP moves about 75-80% of the length of airframe added to a rocket. Example: A rocket is "stretched" by adding 10" of airframe. The CP will move rearward about 7.5, around 75% of the 10" that was added.

A quick description of CG vs. CP and how to properly adjust the relationship can be found at www.rocketryonline.com. Go to the InfoCentral section, then to Rocketry Design, then to CG/CP Relation. The information is repeated below for your convenience. It is somewhat simplistic, but was intended to introduce the "newbie" to the concept of CG/CP:

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The CG (Center of Gravity) and CP (Center of Pressure) are very important fundamental design and flight parameters of any rocket, and have an important relationship to each other. The general relationship between the CG and CP is as follows: the center of pressure must be a minimum of 1 body diameter BEHIND the center of gravity on a rocket fully prepped for launch to ensure stability. Now we'll explain why it must be this way, and what you can do to make sure your rocket meets this requirement, whether it's a kit or a scratchbuilt design.

You're probably aware of the center of gravity (CG); this is the point on a rocket (or any object) where all the weight seems to be "centered". The center of pressure (CP) is similar; it is the point on the rocket where the corrective force of the fins is "centered". OK, now imagine just a simple stick, a piece of dowel 12” long. This is your “rocket”, with one end the nose end and the other the motor end. It weighs the same on the first 6” as it does on the rear 6”; that’s why the CG is exactly in the middle at 6”. That’s what the CG means, where the weight (or, more correctly, mass) of the item is centered. Now, drive an imaginary nail into your stick “rocket” into the table it’s sitting on right at that CG point of 6”. OK, now push on the front of the rocket, and it spins right at the nail, the CG. Push on the rear of the rocket, and it spins right at the nail, the CG. That’s a good way to think of the CG…it’s the “nail” that your real rocket will turn around in flight.

Now, think about if you put fins on the back end of your stick (rocket). Though it’s not completely true, say that the CP is exactly where you stuck the fins on your rocket (it’s true enough for this example). If that stick was flying through the air front end first, and wind pushes on the rocket, the fins will push on the stick. The stick will rotate around the “nail”/CG. Since the fins are on the back, the rocket straightens back out and continues nose forward. Now remove your imaginary fins from the back of the rocket and put them only on the front near the “nose cone” end of your rocket. OK, now it’s flying again, and wind pushes on the fins; push on the fins of your imaginary rocket. What happens? The nose of the rocket turns around the “nail”/CG, and the front end flips over and turns into the rear end. This is bad! Of course, you want the front end of the rocket to stay the front! That’s the general reason why the CG must be ahead of the CP… keeping the CP behind the CG makes sure the front of the rocket stays the front!

Many manufacturers specify the CP location on their kits. CP doesn't vary in kit rockets, it's controlled by the design of the kit. CP is affected by such things as the rocket’s body diameter, length of body, fin size, number of fins, and fin placement on the body tube. CP can’t be changed in kits. However, you CAN vary CG, by adding more nose weight. That's why the kit manufacturers specify CP, so the owner of the rocket can find their CG and compare it against the CP to see if they need to add some nose weight (to move the CG ahead of the CP) for stability.

The CG will be dependent upon how you build and use the rocket, which is why manufacturers usually don't specify CG. Some people really use a bunch of epoxy, others don't. It's variable enough on how the person builds the rocket, but even more so as what type of payload you have (if any). You can imagine that given the same kit design, if someone were carrying some complex and heavy video electronics that the CG would be dramatically different from someone who flies no payload at all.

Once a kit is built and ready to fly (with payload), CG location is most dependent on the motors used. Of course a G motor is much lighter than an I motor, but a certain kit may be able to use G’s, H’s, and I’s. The motor is obviously in the back of the rocket, and weight in the back of the rocket shifts the CG rearward, so the bigger (heavier) the motor, the worse the CG/CP relationship will be. Remember, CP doesn’t change…any weight added to the rear of the rocket will move the CG back (bad), and weight added to the front of the rocket will move the CG forward (good).

Mark the CP on the rocket, then mark a point at least one body diameter ahead of the CP. Make sure you prep the rocket as it'll be in flight (with the motor you intend to use installed, chute(s) installed, payload installed, etc.) before you do the CG/CP check. No need to add black powder to an altimeter or the delay area of a reload casing, or to put in igniters; they're not heavy enough to matter. Now balance the rocket "teeter-totter style" on a piece of dowel, back of a chair, something like that. If the rocket balances level with the pivot point of the teeter-totter arrangement at or forward of the CG point you marked, you're good to go! If not, you'll have to add nose weight until it does.

Up to two body diameters is usually even better, but don't go much over two diameters or the rocket will be overstable. By the way, this is what's meant by "one-caliber" or "two-caliber" stability. It comes from wartime artillery terminology, where the diameter of a gun is called the "caliber", so "one-caliber" = one diameter, and so on. Don't forget that if you use, say, a small H motor and set the CG, that if you then decide to use a big J motor, the J weighs more and you may have to add nose weight again to compensate. That's why it's usually recommended to set the CG/CP relationship with the largest motor you intend to use in the rocket.

If you don't have the biggest motor you intend to fly on hand, or if you haven't reached a certification level where you can buy one, check out the weight of the propellant you intend to use and the reload casing from the manufacturer. Many times that information is available on the manufacturer's web site. Simulate the weight of the casing and propellant in the motor mount tube. Use one or more rolls of coins, a baggie with dirt in it, whatever you can come up with that's similar to the weight of the motor and casing.

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PML HARDWARE FAQ

Launch Lugs

- All our round/tubular launch lugs under ¾" are thin-wall brass tubing, like a brass soda straw. ¾" lugs are thin-walled copper tubing.
- The round lug sizes refer to the size rod they fit. For example, if a kit has a 3/8" launch lug, that means it loosely fits a 3/8" launch rod.
- Customers sometimes ask: "Is it OK to put the launch lug in the corner of a fin root and the main body? The instructions say to put it in-between two fins, but it would produce less drag near a fin root and would be stronger also." This can be done if you're careful, but by putting the lug at the fin root, you limit the size of the fillet. If you make the fillet too big, the epoxy will block the ends of the lug. Also, it just makes it harder to sand that area of the rocket while painting.
- Our Linear Rail Lugs can be screwed or glued, or both. Any epoxy will work but JB Weld is strongest. Some customers ask about screws interfering with the piston. Usually there is dead space in the booster area so we glue and screw there. If the screws might interfere with the piston travel or other functional item, we simply epoxy it in place.

Motor Retention

Thrust Ring

High-power kits don't use a thrust ring in the front of the motor mount like Estes-class rockets do, because high-power motors can vary greatly in length. Therefore, if you glued in a thrust ring you'd be stuck flying only that length of motor.

If you use a reloadable motor for high-power flights, the lower closure has an OD larger than the OD of the motor mount tube, so that provides the thrust ring by transmitting the force against the bottom of the motor mount tube. If you're using a single-use motor, as opposed to a reloadable, you'll need to wrap masking tape around and around the base of the motor, until you've built up maybe 1/16-3/32" thickness of tape to act as a thrust ring against the OD of the motor mount tubing. That's typically how it's done, and works just fine.

Motor "Ejection Clip"

Regarding retaining the motor from ejection, you have a few options. In high power rockets, there is no "engine clip" like you may be used to with model-rocket-sized products. Many people use masking tape around the motor casing for a tight friction fit to the inside of the motor tube. You need it to be tight enough that the motor will hold against ejection charges, but not so tight you won't be able to get it out after the flight; it just takes a little practice.

A more solid retention option is to use one of our PMR or HAMR motor retainers described below. They work great and are really easy to use.

HAMR Motor Retention System

PML has developed our own line of high quality, threaded motor retainers! The HAMR (Highly Adaptable Motor Retainers) system has been designed specifically for use with our rocket kits or any scratch-built rocket using PML motor tubes. These lightweight, tool-free, threaded retainers are precision CNC turned from 6061 aluminum and anodized.

These retainers fit virtually all popular motor brands and types including Aerotech RMS ™, CTI Pro XX ™, Animal Motor Works ™, Hypertech ™, Kosdon ™, Sky Ripper ™, Loki ™, and others.

The HAMR system can be adapted to existing rockets if the motor tube extends at least 3/8” beyond the aft centering ring. The HAMR can also be used with boattail and tailcone rockets.

PML offers both a HAMR system for standalone/single-diameter motor mounts, and a HAMR system for PML’s popular Kwik-Switch 54/28/29mm motor mount system.

General notes for retro-fitting the HAMR system onto existing rockets and other important information

1) The motor tube must protrude 3/8" beyond the aft ring for the sleeve to fit. If the rocket is already built and the motor tube is flush with the ring, difficult but possible surgery is required for a retro-fit. You will have to Dremel out the aft ring, Dremel back the fin tabs about 1/4", then insert a new ring to the proper depth to expose 3/8" of the motor tube. This is beyond what most people would want to do. In this case, the best solution is the original Public Missiles Ltd. PMR.

If the motor tube protrudes more than 3/8”, the motor tube can be cut back to fit. Depending on how much tube needs to be removed, you can use a hack saw, X-Acto razor saw, or a coarse sanding block.

2) For years we have only sold the PMR for motor retention. Hence all of our kit instructions state that the motor tube should be flush with the aft centering ring. But as stated in note #1 above, the motor tube MUST protrude beyond the aft centering ring by 3/8”. You can confidently ignore the kit instructions and make the required adjustment to facilitate the HAMR system. There will be no adverse effects to the rocket, it’s assembly, or it’s flight characteristics. However, it is always prudent to check the CP/CG relationship on any rocket before flight.

3) It is actually a very simple matter to retro-fit a rocket that uses a boattail or tailcone. Simply scribe a line around the boattail or tailcone 3/8" from the base and cut this section off with a Dremel cut-off wheel leaving the motor tube intact and exposed. Of course,

you can perform the cut with a hacksaw blade or X-Acto razor saw just as easily. This method works with kits where the motor tube is wedged into the narrow end of the boattail without the use of a centering ring (IE. Bull Puppy, Pit Bull 256). It will not work with the Bull Dog or Pit Bull 600 since these have a centering ring at the base. See note #1 above for details.

4) JB Weld, Loctite Weld, or similar must be used to secure the sleeve to the motor tube. These epoxies have a high temp rating, are not brittle, and bond very well with phenolic and aluminum. Common hobby epoxy may soften from the heat of the motor and fail. Do NOT use standard hobby epoxy or even the epoxy PML sells for general kit construction. The high temperatures generated by the motor can cause these epoxies to fail.

The motor retainer sleeve should be inspected after every flight to make sure the impact from landing did not loosen the retainer sleeve.

5) For the KS washers to work with older KS kits already in the field, both adapter tubes must be cut 1/8" to 3/16" by the user. In the past, we made the adapter tubes a bit long to aid in insertion and removal of the adapters within the mother tube. This is not really necessary and now the adapter tubes are too long to work with the HAMR-KS adapters. The tubes can be easily cut by the user with a hack saw, Dremel, miter saw, X-Acto saw, etc. whether they are assembled or not. Beginning in mid-February 2007, we have changed the length of the KS adapter tubes to accommodate the use of these retainers. This includes all KS kits that were in stock at that time. Keep in mind that dealers may have older kits on their shelves for an extended period of time. If all of the tubes in the Kwik-Switch set (Mother tube and both adapter tubes) are the same length, then you have the new version. This change will not affect the use of the original PMR KS version.

6) The bonding surface of the sleeve must be sanded with 80 grit sandpaper to thoroughly scuff the anodized surface. The anodizing does NOT have to be removed (that's almost impossible anyway), just scuffed.

7) The motor tube must be sanded with 80 grit as well. The retainer sleeve should fit loosely on the motor tube. IE. It should just fall off when tipped. This will assure that the JB Weld (or similar) is not just pushed out of the way when mounting the sleeve on the tube. The sleeve's bonding surface and the tube should be coated with the epoxy and then the sleeve should be pushed onto the tube with a slow twisting motion. Any epoxy squeeze-out can be removed when the epoxy gels but before it cures.

8) After....and only after....the adapter sleeve is epoxied to the rocket, the threads can be lubed with a tiny bit of grease for smoother threading of the 2 pieces and to prevent future galling (however unlikely). The grease should not be applied before assembly since even the slightest bit accidentally smeared on the bonding surface will weaken the epoxy bond.

PMR Motor Retention System

- Regular (non-KS) motor retainers use the lower centering ring as the anchoring point for the threaded inserts. For Kwik-Switch motor retainers, they do not mount to the KwikSwitch adapters, but actually span across to the CR that holds the KS Mother tube to the airframe. Both KS retainers (one for 29/38mm and one for 54mm) have the same bolt hole pattern, just the ID is different. The reason we had to do this is that the Medusa nozzle on the 54mm motors is larger in OD than a 29mm motor casing; two different retainers with different ID's were required.
- The PMR-29/38-KS and the PMR-54 stainless steel retainers have the same "hole pattern" dimensions. This means they can be interchanged on the same rocket. However, they will NOT interchange with the hole pattern for a PMR-29/38. Said another way, if you have a rocket that can use a 54mm and a 38 or 29mm, EVEN IF IT DOES NOT USE A KWIK-SWITCH SYSTEM, you must buy the PMR-54 and PMR-29/38-KS. The "non-KS" PMR-29/38 and the PMR-54 do not have the same hole pattern; the PMR-29/38-KS and PMR-54 do.
- PMR-29/38 should not be used on CR-2.1-1.5 (1.5=38mm) and CR-2.5-2.1 (2.1=54mm) as there is not enough wood for ample insert anchoring. PMR-29/38KS and PMR-54 should not be used in a Quasar kit or with any CR-2.5-2.1 application.
  - CR-2.1-1.5 kit examples: Callisto 38mm, Io 38mm, Phantom/X-Calibur, Phobos 38mm, Explorer 38mm, Black Brant VB 38mm
  - CR-2.5-2.1 kit examples: Quasar, Small Endeavour, Tempest, Thunder 'n' Lightning
- Since the threaded inserts for the KS-compatible retainers require a 3/16" hole drilled in the aft centering ring, no retainer is available for a 2.5" diameter rocket using a 54mm motor mount. The PMR retainers cannot be used with boattailed or minimum diameter rockets (with the exception of our Bulldog kit, which has enough exposed centering ring area at the boattail). For ideas on other motor retention options for kits which cannot use a PMR system go to Rocketry Online at www.rocketryonline.com, click on InfoCentral, then on Construction, then on Motor Retention.
- PMR motor retainers **should NOT** be used on Loki motors. The retainer will very slightly block the exit of the motor causing overheating of the retainer and/or motor casing and potential failure of the retainer, motor casing, or both. For retainers to use with Loki motors goto http://www.lokiresearch.com/retainer.asp.
- Extra PMR inserts are available separately so you can equip all your rockets for the motor retention system without having to buy a complete retainer system for every rocket.
- We recommend installing the PMR after the rocket is built. This gives the best support for the ID of the centering ring when drilling for the inserts.
- The PMR-54 will work with many hybrid motors; it does not work with a Hypertek J grain, the hole ID on the PMR is about 1/8" too small.
- The PMR system will work with Cesaroni Pro38 motors.
- The PMR-29/38KS and PMR-54 use 8-32 screws. The PMR-29/38 uses 4-40.

Other Motor Retention Solutions

See the Motor Mounts FAQ for details on other potential positive motor retention solutions for PML kits.

PML HYBRID-READY FAQ

Hybrid Ready

What makes a kit “hybrid ready”? A long motor tube, an electronic deployment system and/or compartment, and a venting hole. The customer must drill the venting hole as motors differ as to where the hole should be located.

Hybrid Motor Mounts

Hybrid motors require very long motor mounts. Call us for specific assistance in obtaining a hybrid motor mount for a scratch-build project. We offer kits that are already designed specifically for hybrid motors; see the Hybrid Ready section of the webstore.

Our 54mm kits can take Hypertek’s "Standard J" and their "New Hammerhead J". Our 38mm kits are intended for Sky Ripper Hybrids and, with the use of a 29mm adapter, RATT Works hybrids.

Some customers ask why the Ion kit has a shorter (28”) MMT than our other 38mm kits. Simple…to keep the price, size and weight down for using smaller H and I hybrids and/or smaller composite motors.

PMR Motor Retention System

The PMR-54, -38, and -29/38 will work with hybrid motors.

ERM System

The Electronic Recovery Module (ERM) system is based on our CPR3000 system, and is designed specifically for hybrid rockets. ERM is designed for the PML AccuFire timer or PML Co-Pilot altimeter, though others may work. All of our hybrid-ready rockets (except Aurora, Tempest, and Nimbus) use the ERM System.

Here’s what you get with the ERM system:

- Complete altimeter/timer bay assembly.
- Complete Threaded Airframe Coupler assembly made from 6061 aluminum with a blue anodized finish.
- All mounting hardware for the PML Co-Pilot or Transolve P6 altimeter. (Mounts for Transolve P5 or P4 and Adept ALTS-25 altimeters sold separately).
- A complete ejection system including charge canister for e-matches and holder. (Charge cylinders for flash bulbs sold separately.)
- Rear deployment piston system.
- External safety switch and lead wires.

See the Hybrids page of our website for graphics of ERM and additional details.

ERM-Complete vs. ERM-Retrofit Systems
The ERM Complete includes the recovery airframe and the pre-cut nosecone. All you will need with this is the MMT/fin section to make a rocket.

The ERM Retrofit does not include the recovery airframe nor the nosecone. This is good for retrofitting an existing kit.

ESH-54 Timer Housing

An ESH54 is a timer housing made from a 54mm coupler tube, a couple of bulkplates, a removable G-10 plate (that you mount the timer to) and an LES holder. The tank of a Hybrid motor is approximately the same diameter as the ID of the coupler tube. This allows the ESH to slip over the tank (must be friction fitted) by a distance of about 1/2" to 1" and butt against the lower bulkplate. The upper bulkplate (cap) has the LES holder attached to the topside and is removable for accessing the timer. This "cap" is actually two bulkplates glued together in a fashion similar to the one on an Intellicone. The G-10 plate (with timer installed) is held centered within the tube via two opposing (wooden) runners and can be slid out when the upper bulkplate (cap) is removed.

CPR3000 and Hybrids

Using CPR3000 with a hybrid-based rocket is usually impractical, due to the excessive length that needs to be added to the rocket. CPR3000 requires nearly 3 feet to be added to a hybrid-based rocket, effectively putting it “out of bounds” for use with hybrid rockets. Our ERM system is a much better solution.

PML AccuFire and Hybrids

The AccuFire Staging Timer is NOT affected by hybrid motor harmonics; it’s completely safe to use with hybrids.

PML IGNITERS FAQ

Igniter manufacturers will specify the electrical usability (ohms and volts) range for their devices; contact the igniter manufacturer for their specifications.

Igniters

PML offers an igniter-making kit: Magnelite igniter kits, which allow you to make your own igniters, ranging from A size BP motors all the way up to M and larger motors, depending upon the igniter wiring size purchased.

See the Igniters page in our webstore for more information.

Ematches vs. Igniters

The difference between e-matches and igniters is that ematches are intended to ignite an easy-to-burn substance quickly, such as the BP used in rocket ejection charges. However, an igniter is intended and constructed to produce a large, hot ball of flame for an extended period (say, 0.5-0.75 seconds) to ignite a rocket motor. Ematches typically will not ignite motors unaided, as they do not produce a hot enough flame for long enough, whereas igniters certainly could ignite BP. Another significant difference between them, which is critically important for onboard rocket electronic use, is their current requirements. Igniters typically require much more current than an e-match; the current requirements are usually more than altimeters can provide. Therefore, for onboard altimeters, which need to ignite deployment charges, ematches are needed. For staging timers, which need to ignite motors, igniters are needed. Be sure to always check to be sure an e-match or igniter will work with your onboard electronic device.

PML MOTOR MOUNTS FAQ

Kwik-Switch

- PML is the only company with the Kwik-Switch quick-interchangeable motor mount.
- The Kwik-Switch 2000 increases the ease of use and positive retention features of the original Kwik-Switch system.
- The standard Kwik-Switch has 13.75" of "usable length", meaning motor cases less than 13.75" will fit the KS. See the Motor Recommendations Chart on the Specs Page of our website for casing lengths of various motors.
- The Kwik-Switch 2000, whether as a stand-alone part for scratchbuilds or used in kits, comes with the 54mm main motor tube, and 38mm and 29mm adapters included.
- The Kwik-Switch 2000 ships with the 29mm adapter threaded piece screwed into the mother tube mating half. This is done for shipping purposes. Some customers have thought the 29mm piece was missing because they didn't notice it already screwed in.

EXTENDED Kwik-Switch

The 54mm/1706 reload casing (K185W, K550W, K1100T) will not fit the standard KS2000 system. For $5.00, you can upgrade to an extended KS2k system that will fit. The standard extended KS is 17", which is long enough for a 54mm/1706 (K185W, K550W, K1100T) case. Also, you do not need an extra (third) centering ring with the extended KS for the center of the longer adapter tubes.

If you have already purchased a kit and wish to upgrade to the extended KS, you must return your original, unbuilt KS2000 components with the $5.00. Keep in mind that you may also need to have a longer airframe to compensate for the additional length of the KS-EXT, depending upon the kit. That would also be additional cost and/or we'd need to ship you some coupler and airframe extension pieces at additional cost to upgrade your "standard length" kit.

Some of our rocket kits require strengthening from their stock configuration to fly certain larger motors that would require an Extended KS. These rockets MUST use phenolic airframe reinforced with fiberglass cloth and have the fins upgraded to a thicker G-10 material. There may be other considerations as well; it depends upon the specific application. See the *Kit Strengthening* section of the Airframes FAQ for information on when and how to strengthen.

Extended Kwik-Switch and J570

The super long 38mm casing (J570; 19.2") does not fit the Extended KS. We do NOT recommend a "super-extended" (even longer) KS to be used with the J570. We do not believe the urethane KS mother tube and adapter tube mounts should be used with the high thrust profile of the J570 motor.

For super-long casing mounts (such as the J570) or custom motor mounts, we recommend our **ADPTR 54/38HD** shown on the Motor Mounts page of our webstore.

This adapter is similar to ADPTR-54/38 on our Motor Mounts page, with additional larger-OD centering rings on the bottom of the adapter. This allows the thrust of the motor in the adapter to be transferred directly to the 54mm mother tube instead of through the urethane adapter interface. This will stand up to J570 and other "high-thrust" 38mm motor thrust profiles (assuming of course that the motor mounts were built and installed per instructions).

GIANT Kwik-Switch

PML also carries a "Giant KS" motor mount. This mount uses a 98mm mother tube and can be equipped with both a 75mm and 54mm adapter tube. This Giant KS is based on the original Kwik-Switch locking tab design. It comes standard with a 54mm adapter; the 75mm adapter can be purchased separately.

75/54 Kwik-Switch

PML carries a 75/54mm Kwik-Switch motor mount based on the original Kwik-Switch locking tab design similar to the Giant KS discussed above. The KS-75/54 system comes standard with the 54mm adapter, though it can also be purchased separately.

Friction-Fit Adapters

Friction fit adapters are available for those who do not want the KS system, or for kits that are not equipped with the KS system. Available adapters are: ADPTR-38/29; ADPTR-54/38; ADPTR-54/29.

PML recommends you purchase the 38mm mount option for all kits that can be purchased standard with a choice of 38mm or 29mm motor mount, and also purchase an adapter for 29mm (ADPTR-38/29). This allows maximum flexibility in motor selection, since if you build with 29mm that's all you can use. If you build with 38mm you can always install the 29mm adapter if you want to step down to smaller motors, but can also fly 38mm as well.

Some people have asked why the PML 29-to-38mm adapter (ADPTR-38/29) costs more than the one from LOC, and why is ours worth the extra money? Our adapter is built up of various tubing sizes so it ends up like a double-thickness tube. LOC's is a standard 29mm tube with centering rings to adapt out to the 38mm tube. Ours are worth the extra money for two reasons:

1. It's easier to friction-fit ours because you have the entire tube area to work with instead of just the two thin contact spots of the centering rings.
2. If you happen to have the misfortune of a motor blowing up, the super-thick tubing of our adapter will tend to contain and absorb the explosion, usually leaving the rocket without damage.

Hybrid Motor Mounts

Hybrid motors require very long motor mounts. Call us for specific assistance in obtaining a hybrid motor mount for a scratch-build project. We do offer kits that are already designed specifically for 54mm hybrid motors; see the Hybrid Ready section of the webstore.

Currently our Hybrid-Ready rockets are only 54mm. We sell the Tempest and Aurora as Hybrid-Ready, which can both take the "Standard J" and the "New Hammerhead J".

Motor Retainers

Thrust Ring

High-power kits don't use a thrust ring in the front of the motor mount like Estes-class rockets do, because high-power motors can vary greatly in length. Therefore, if you glued in a thrust ring you'd be stuck flying only that length of motor.

If you use a reloadable motor for high-power flights, the lower closure has an OD larger than the OD of the motor mount tube, so that provides the thrust ring by transmitting the force against the bottom of the motor mount tube. If you're using a single-use motor, as opposed to a reloadable, you'll need to wrap masking tape around and around the base of the motor, until you've built up maybe 1/16-3/32" thickness of tape to act as a thrust ring against the OD of the motor mount tubing. That's typically how it's done, and works just fine.

Motor "Ejection Clip"

Regarding retaining the motor from ejection, you have a few options. In high power rockets, there is no "engine clip" like you may be used to with model-rocket-sized products. Many people use masking tape around the motor casing for a tight friction fit to the inside of the motor tube. You need it to be tight enough that the motor will hold against ejection charges, but not so tight you won't be able to get it out after the flight; it just takes a little practice.

A more solid retention option is to use one of our PMR motor retainers described below. They work great and are really easy to use.

PMR Motor Retention System

- Regular (non-KS) motor retainers use the lower centering ring as the anchoring point for the threaded inserts. For Kwik-Switch motor retainers, they do not mount to the KwikSwitch adapters, but actually span across to the CR that holds the KS Mother tube to the airframe. Both KS retainers (one for 29/38mm and one for 54mm) have the same bolt hole pattern, just the ID is different. The reason is that the Medusa nozzle on the 54mm motors is larger in OD than a 29mm motor casing; two different retainers with different ID's were required.
- The PMR-29/38-KS and the PMR-54 stainless steel retainers have the same "hole pattern" dimensions. This means they can be interchanged on the same rocket. However, they will NOT interchange with the hole pattern for a PMR-29/38. Said another way, if you have a rocket that can use a 54mm and a 38 or 29mm, EVEN IF IT DOES NOT USE A KWIK-SWITCH SYSTEM, you must buy the PMR-54 and PMR-29/38-KS. The "non-KS" PMR-29/38 and the PMR-54 do not have the same hole pattern; the PMR-29/38-KS and PMR-54 do.

- PMR-29/38 should not be used on CR-2.1-1.5 (1.5=38mm) and CR-2.5-2.1 (2.1=54mm) as there is not enough wood for ample insert anchoring. PMR-29/38KS and PMR-54 should not be used in a Quasar kit or with any CR-2.5-2.1 application.
  - CR-2.1-1.5 kits: Callisto 38mm, Io 38mm, Phantom/X-Calibur, Phobos 38mm
  - CR-2.5-2.1 kits: Black Brant VB 38mm, Explorer 38mm, Quasar, Small Endeavour, Tempest, Thunder 'n' Lightning
- Since the threaded inserts for the KS-compatible retainers require a 3/16" hole drilled in the aft centering ring, no retainer is available for a 2.5" diameter rocket using a 54mm motor mount. The PMR retainers cannot be used with boattailed or minimum diameter rockets (with the exception of our Bulldog kit, which has enough exposed centering ring area at the boattail). For ideas on other motor retention options for kits which cannot use a PMR system go to Rocketry Online at www.rocketryonline.com, click on InfoCentral, then on Construction, then on Motor Retention.
- Extra PMR inserts are available separately so you can equip all your rockets for the motor retention system without having to buy a complete retainer system for every rocket. Install inserts in all your rockets and you can use the PMRs in whichever rocket you're flying.
- We recommend installing the PMR after the rocket is built. This gives the best support for the ID of the centering ring when drilling for the inserts.
- The PMR-54 will work with many hybrid motors; it does not work with a Hypertek J grain, the hole ID on the PMR is about 1/8" too small.
- The PMR system will work with Cesaroni Pro38 motors.
- The PMR-29/38KS and PMR-54 use 8-32 screws. The PMR-29/38 uses 4-40.

Other Motor Retention Solutions

Many of the following are emails from PML customers with solutions they have come up with for retaining motors in PML rockets. PML has not tried these solutions themselves, and does not endorse them as viable, safe, and effective solutions. They are presented here simply as "thought-starters" for you in coming up with your own solutions to motor retention concerns you may have. PML cannot/will not be able to comment on using any of the information below with your rocket.

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Mini-BBX and Terrier Booster

If possible I'd like to find an alternative to friction fitting the upper stage engine. I know this subject has been discussed before on RMR.

I haven't, but will do, what Daniel Flury from Switzerland has done:
http://www.shuttle-endeavour.de/webimg/bbx_tailcone.jpg
The blue circle shows where the 29 mm engine is protruding from the tailcone, the red shows to U-shaped lengths of 1 mm steel that are glued into small holes drilled into the "lip" of the tailcone, between the engine and the 38 mm tube (shown with brown dots). The steel Us can be bent outwards (see arrows) to allow changing the motor.

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Bullpuppy

I've started working on the Bullpuppy and I wanted to let you know that your assistance was invaluable. I decided to go with the Aeropack retainer. Fortunately, Aeropack is

based right here in San Diego so I was able to get the retainer directly from them. In fact, Bob Mosley (the owner) met me personally to deliver it. Bob had a great suggestion, which I have used and I thought I would pass on to you.

The outer diameter of the retainer is slightly larger than the boat tail. I shortened the boattail by 3/8" so that the diameters matched - very clean look. The motor tube extends the shortened boat tail by 3/8" to allow attachment of the ring so the motor is actually in the same position as the stock kit. The outer diameter of the Aeropack ring was a nice snug fit in the shortened boat tail.
+++

Bullpuppy/Little Lunar Express/Lunar Express

I've made a minor modification to my full-size Lunar Express that may work for you as well. (I've also done it to my Bullpuppy...it works for any boattail kit). I'll try to describe it to you, but bear with me! I've attached a crude JPG drawing that'll help make sense of what I'll describe. What I did was to take about a 3" long piece of 3/4" dowel (you may want to go smaller for the Little Lunar Express), and cut it lengthwise from "corner to corner". Imagine taking a piece of flat wood 3" long by 3/4" wide and drawing a line lengthwise from the lower left to the upper right corners, then cutting along that line. It's the same idea with the dowel. Then, tape a piece of sandpaper to the boattail of the rocket at the bottom end. Now take the dowel you cut and, moving the dowel up and down along the centerline of the rocket, sand the flat area from the cut until it conforms to the shape of the boattail. Now sand the boattail area well where the retainer will go, and epoxy it in place. You might even want to drill a few holes through the boattail under the retainer before installing it to allow epoxy to seep in and "rivet" the retainer to the boattail. The most important thing is to ensure you get a very good bond of the retainer to the boattail, since epoxy doesn't bond as well to the plastic as it does to other materials. In my full-size LE I also slotted the front of the retainer to fit over the fin, but you can also put it between fins. Whatever looks good to you.

Now that it's mounted, drill a hole for a woodscrew **parallel to the centerline of the rocket**. Drill it small enough that the woodscrew will "cut threads" into the dowel when you install it, but large enough that it won't split the wood. Be careful to go deep enough but also not so deep you come through the side of the dowel. Now get a washer from your local hardware that'll capture the edge of the motor when it's installed on the woodscrew, and you're done. You may need to get what's called a "fender washer". They're just like a regular flatwasher but with a much larger OD for the size of the center hole. With careful installation of the woodscrew each flight to make sure you don't strip the threads, this will work very well for you. If you spend a little time shaping the retainer as well, you can make it blend in and look like it belongs there rather than just an add-on piece. If you use a harder material for the retainer than wood, you can actually thread the hole and use a threaded machine screw instead of the wood screw. I've done 'em both, and they both work.

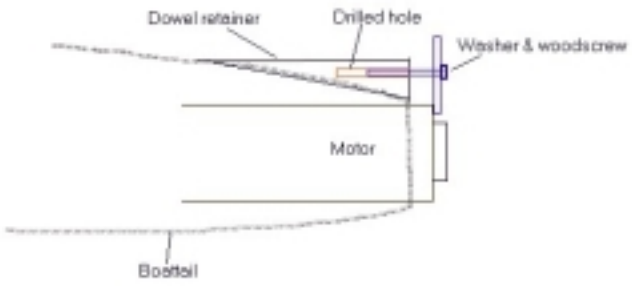

Figure 1 - Boattailed Kit Motor Retainer

+++

Bullpuppy

On my Bullpuppy, and all my minimum diameter rockets, I thread the inside of a piece of brass tube. In this case choose tubing to fit a 6-32 screw. Then I drill a hole in the tail cone parallel to the axis of the rocket. Be sure it is located far enough from the aft closure of the motor to allow the screw to just clear it. I epoxy the brass tube in the tail cone and to the motor tube. With a little filling you can blend this into the tail cone and it is almost invisible on the finished rocket. I use 6-32 all thread rod for the actual retainer. I cut a piece long enough to engage most of the treads in the brass tube plus about 1/2 inch. I then bend it 90 degrees about 1/2 inch from the end. Thread the rod in the tube and turn it down until it firmly holds the motor in. It works. It is cheap and easy. It takes up very little room. It is a low CD approach.

++++++++++

Bullpuppy

Attached is a photo of a big external motor clip one customer made; looks like aluminum stock to me. With this one you'd have to work with some retaining nuts, etc. on the inside of the boattail before assembly, but it may be an idea you'd like.

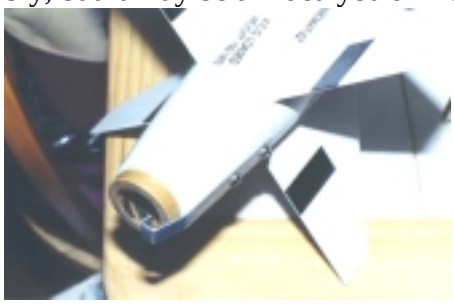

Figure 2 - Bullpuppy Aluminum Retainer Clip

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Thunder ‘n’ Lightning

I think maybe I found a solution to retaining the motor in the booster for "Thunder & Lightning". I acquired an Aeropack motor retainer. I took a "spare" piece of pml 38 mm motor mount tube and rubber cemented a strip of 220 grit emery paper (The same width as needed) around one end. I then inserted the other end into the aft end of the tail cone and rotated to remove material from the inside of the aft end. (The forward extension of the tube keeps the assembly square and by rotating the "relief" is constant. when the Paper loads up pull it out and clean it with a brush. when the strip is all inside the cone, pull it out, clean it and glue on another strip. (Try not to get glue on the working side of

the emery paper). I'm holding a PML tailcone that has an Aeropack motor retainer that looks like it belongs there.
+++

Sudden Rush

I believe it was Darrell Mobley (Darrell, can you confirm?) that epoxied a short piece of 54mm airframe inside the boattail, then screwed the boattail onto the airframe, "sandwiching" the rear closure of the reload between the 54mm MMT and the short piece of 54 in the boattail.
+++

BBX/Sudden Rush

I incorporated positive retention into my PML Black Brandt X. The BBX is a 4" kit while the Sudden Rush is 3", but I believe you can find a variation on what I did that will work.

I can't remember whether it was part of the kit or if I had to add it, but you need a centering ring that will go immediately in front of the boat tail. Drill two holes 180 degrees apart for retaining screws. On the BBX, I inserted long screws (use washers to keep from crushing the plywood ring) and threaded 3 hex joiners (these are used to join threaded rod and can be obtained from Home Depot) onto each of them. 3 happens to be the number that equals the length of the BBX boat tail. The tip of the screw should be about half way into the final joiner so you have room to screw in the retaining screw when finished.

Resting the boat tail's aft end on the table of my drill press, I drilled two holes 180 degrees apart that match the locations of the screws. This allows the boat tail to be slipped over the studs we have created on the centering ring. Make sure the MMT holes in the ring and boat tail line up! When it comes time to install the boat tail, apply epoxy as directed and also apply epoxy to the base of the studs and to all the joints so the assembly can't come unscrewed. Slip the boat tail over the studs and install the complete assembly into the rocket.

I made my own retainer from aluminum sheet and it looks a lot like PML's retainer except that it only has 2 tabs. Socket head screws hold it onto the studs, which are recessed slightly into the boat tail. For the Sudden Rush, you may have to modify this approach by allowing the screw threads to project through the boat tail and anchor the retainer ring with nuts. Not as pretty, but effective. Another approach might be to install blind nuts into the aft centering ring and use really long screws to hold the retainer ring in place.
+++

Sudden Rush & Slimline Motor Retainer

If anyone else ever asks, the slimline tail cone does create problems with the Sudden Rush kit.

Details:
The Slimline Tail Cone is shorter than the PML tail cone. In addition, the design of the retainer has the end of the motor tube about 3/8 inch inside the tail cone. The combination of a shorter cone, and the motor tube being inside the cone, pushed the

motor tube's top centering ring close to 1.5 inches further up the body. The result is that the 5 inch coupler that is used to form the top of the fin section can only be inserted about 3/4 inch into the top of the fin section before it hits the top centering ring. I doubt that a 3/4 shoulder is a good idea that close to the business end of the rocket.

Solution:
Since the SlimLine retainer was not cheap, I'm determined to use it. I plan to sand the top centering ring on the motor tube until it fits INSIDE the 5 inch coupler. I'll attach the strap to the motor tube per the instructions. I'll then dry fit everything. With everything dry fit in place, I'll glue the motor tube into the coupler. I'll them assemble the rest of the bulkhead per the instructions. I'll now have a bulkhead, with the top of the motor tube glued inside. I'll then prep the outside of the coupler and the inside top of the body, apply the epoxy, and slide the whole assembly into place, dry fitting the tail cone to ensure that it is all in the right place. Once all that sets, I'll pull the tail cone and install the fins per instructions. Make sense? I figure this will have a plywood to phenolic bond for the top centering ring, and a 2.5 inch wide phenolic coupler to quantium tube bond for the coupler/bulkhead. That combo should be strong as steel.
+++

Modification of PMR-29/38 motor retainer for CR-2.1-1.5 kits (PML Io):

As described in the PML Hardware FAQ, there is not enough wood in the aft centering ring of the CR-2.1-1.5 kits (e.g., the Io with a 38 mm motor mount) to hold the brass inserts that come with the PMR-29/38 motor retainer. A solution is to purchase some 4-40 nuts from a hardware store and epoxy them to the back of the aft centering ring before gluing the centering ring in place.

1. Center the motor retainer on the centering ring and mark the position of the screw holes on the centering ring.
2. Drill a small pilot hole (5/64” drill bit). Hold the centering ring securely, GO SLOW and BE CAREFUL – if you rush this step or the next one, you could split the centering ring.
3. Carefully enlarge the hole to the proper diameter for the bolt to pass through (7/64” drill bit).
4. Line up a 4-40 nut with the hole in the centering ring. You probably will find the nut is slightly wider than the centering ring. In this case, grind or file off part of the outside edge of the nut until it’s the same width as the centering ring (a Dremel tool works fine).
5. Scuff up both sides and edges of the nut with 100-150 grit sandpaper (to help epoxy adhere to it).
6. For each of the 3 holes in the centering ring, insert a 4-40 bolt through the hole and attach the nut on the other side of the centering ring (don’t use the bolts that came with the retainer, since you might ruin them during the following steps). Use a small amount of epoxy to tack the nut in place on the back of the centering ring (the bolt is used to center the nut and pull the nut back against the centering ring while the epoxy sets). While the epoxy sets, carefully back off the bolt a turn or two (while holding the nut secure) to free up any epoxy that may have found its way into the hole in the centering ring, or between the nut and bolt.

7. After the epoxy has set, build up a “shoulder” of additional epoxy around the nut to firmly anchor it to the centering ring. Make sure some the epoxy actually goes up and over the edge of the nut. It will be difficult not to get epoxy between the nut and bolt at this stage, but if you occasionally turn the bolt a turn or two while the epoxy cures, you’ll break any bond that forms. Make sure you turn the bolt in the direction that won’t pull additional epoxy down into the threads of the nut.
8. After the epoxy has cured, remove the bolt. It may be helpful to use a fresh bolt and run it back and forth a couple of times through the nut to remove any epoxy that found its way into the threads.
9. Attach the centering ring to the aft airframe/motor mount per the kit instructions. Make sure the side of the centering ring with the nuts faces INTO the airframe, and that the holes are NOT in line with the fins.

PML NOSECONES FAQ

All PML nosecones (except as noted below) are 4.2:1 length/diameter ratio, with a true ogive shape. Sizes indicate the size tubing they fit, i.e. the ID of the tubing they fit.

- 1.1 & 1.5" diameter are solid urethane; both are conical shape.
- 2.15, 2.56, 3, 3.9 are plastic.
- 6, 7.5, 11.4 are fiberglass
- 11.4 is 3.5:1 L/D ratio. We also offer a Harpoon-missile-style 11.4" fiberglass nosecone.

- PML does not make custom nose cones.
- Some customers have asked about conical nose cones in larger than 1.1" (29mm) or 1.5" (38mm) diameter. A suggestion would be going to a craft store and buying a Styrofoam cone used in craft projects and fiberglassing over it. That might work out for you. Or, if you know a woodworker with a lathe, have them turn you one. Some rockets can benefit from some nose weight, so the weight of the wood would be good.
- We cannot tell you with certainty whether our tubing is compatible with that of another manufacturer. This also includes whether our couplers, nosecones, pistons, CPR parts, etc. will fit another manufacturer's tubing. With the variation in tubing from one manufacturer to another, we simply cannot tell you with certainty if our components will match well with non-PML tubing.

Nosecone Fits and Airframe Tubing

After cutting airframe tubing, it may be necessary to deburr the edges inside and out using 150 grit or finer sandpaper. This is especially true with QT, as the cutting process may "squeeze" the cut end ever so slightly, making it tight for inserting a nosecone or for inserting the piston. Deburring or chamfering the inside edge of a QT will eliminate those problems.

Plastic Nosecones (PNCs)

- HDPE (high-density polyethylene).
- Thicker wall than competitors; less flex, which reduces paint chipping/flakeoff.
- Double shock cord/chute eyelets, which make them much stronger. You may need to clear out flashing from manufacturing in the nosecone eyelets to pull the shock cord through; use an X-Acto knife. If you must open up the eyelet to allow the shock cord to pass through easier, do it toward the body of the nosecone, not toward the edges of the eyelet (that will weaken the eyelet). An easy way to pull through a shock cord strap is to put one corner through the eyelet and pull the strap through using pliers.
- Ridges on shoulder that can be easily sanded to achieve perfect fit; shoulder also provides better sealing, like piston rings in an engine.
- Polyethylene is notorious for being difficult for adhesives to adhere to. First of all, wash the OD in very hot, soapy water (and the ID for plastic boattails) and rinse. This will help remove any mold release compound from manufacturing. Secondly, sand all surfaces to be bonded with 120 grit sandpaper; sand exceptionally vigorously inside

boattails made of our plastic nosecones, since appearance doesn't matter here...getting a good bite on the epoxy does. Our Two-Part Expanding Foam (sold on the Adhesives page of the webstore) is perfect for this application.
- Urethane automotive topcoats over paint can increase resistance to paint chipping.
- Fill imperfections in plastic nose cones with Squadron Green or White putty, automotive spot putty, etc.
- Neither acetone nor MEK causes any problem on our plastic NCs (used in moderation and for short-term contact with the plastic, of course).
- If you need to add noseweight for CG/CP adjustments, we recommend sand held in place by our Two-Part Expanding Foam (sold on the Adhesives Page of the webstore).

Custom PNC

- "Custom PNC" means changes to standard PML PNCs; we do not make custom cones.
- **See our website at www.publicmissiles.com for current pricing on all custom work. The prices below are shown only to give you a general idea of the pricing range for such work.**
- Convert to boattail by cutting tip add $4.00. Customer must provide motor tubing size (if base diameter is to be same as the motor tube) or base diameter.
- $4.00 charge includes cutting shoulder. Customer must provide shoulder length.
- Slotting for 3" & 4" only: add $3.50 per slot.

Intellicones

The PML Intellicone is intended to be used above a payload section to mount electronic equipment. The Intellicone is not intended to have a shock cord attached to it; the shock cord attaches to the payload section, to which the Intellicone is screwed, removably-riveted, or some other attachment scheme. The cable is used to retain the payload section into the Intellicone. Put the two ends of the cable into the cone, put in the payload tube with the cables going into the notches in the hole in the cone, then pull on the cable to wedge the payload tube into the Intellicone. See the Nosecones page of the webstore for a "click here" graphic showing more detail.

Fiberglass Nosecones (FNCs)

- White epoxy surface coat.
- 6": two layers of fiberglass cloth; one layer 10oz., one 6oz.
- 7.5 and 11.4": one layer 18oz., one 6oz.
- Molded in one piece, not two halves that are then joined. One piece is much stronger.
- All fiberglass cones use a U-bolt into a ½" thick ply bulkplate for 'chute and shock strap attachment due to the size and weight of the cones.
- Scuff fiberglass cones with fine sandpaper to paint.
- Fill imperfections in fiberglass cones w/Bondo, automotive spot putty, etc.
- When using epoxy in a fiberglass cone to retain nose weight, do just a little at a time, allowing the epoxy to cool between batches. This will prevent the resin used in manufacture of the cone from breaking down due to the heat of the setting epoxy.

When you put a lot of quick set epoxy into the tip of the cone the heat generated during curing can exceed 200 degrees F. The resin the cone is made of begins to deteriorate at 170 degrees. Better yet, use a slow-setting (24-hour) epoxy, or our Two-Part Expanding Foam (sold on the Adhesives page of the webstore.

Custom FNC

- "Custom FNC" means changes to standard PML FNCs; we do not make custom cones.
- If more strength is required, an additional layer of 16 oz. fiberglass can be added to our FNC-6.0, 7.5, and 11.4 during fabrication for an additional charge of 30% of the standard price of the FNC. (Example: FNC-6.0 is $84.95; 30% x $84.95 = $25.49; an "extra strength" FNC-6.0 would be $84.95 + $25.49 = $110.44. This is only an example. Always check the webstore for current FNC pricing).
- **See our website at www.publicmissiles.com for current pricing on all custom work. The prices below are shown only to give you a rough idea of the pricing range for such work.**
- Convert to boattail by cutting tip: add $6.00 for 6". Add $10.00 for 7.5" and 11.4".
- Slotting for 6" only, add $6.00 per slot.
- Slotting for 7.5" and 11.4" is done and charged on a "per order" basis, meaning the charges are not standard. They will be quoted when the slotting job is specified.

Boattails

Boattails are long, ogive shaped components that are attached to the tail end of the rocket and serve to reduce drag (and can add a "retro look" to the rocket). PML boattails are made by modifying our existing line of nosecones. 2.1" through 3.9" boattails are made of plastic while our 6.0" and 7.5" boattails are fiberglass. Centering rings are included.

In most cases the tip of the nosecone is cut off at the point that will allow the motor mount tube to fit through the opening. In the larger 6.0 and 7.5" boattails, various motor mount sizes can be used with the appropriate centering ring placed in the opening at the base of the boattail. Unlike tailcones, the fins of the rocket are usually mounted through the boattail and to the motor mount tube.

PML boattails vary in the following areas:
-- Number of slots (3, 4 or 6)
-- Slot width
-- Length of slots.
The above details are described for each boattail on the Nosecones page of the PML website. Also, slotting charges are not included in the pricing of the boattail since it varies (3, 4 or 6).

Tailcones

- All tailcones (except Mini-BBX) are 1.75" exposed length with 3/16" to ¼" shoulder. See the Nosecones page of the website for Mini-BBX tailcone details.

PML RECOVERY COMPONENTS FAQ

Parachutes

Construction/Design

- PML chutes are made by a real parachute company, are not just “hobby parachutes”.
- All are multi-panel chutes, not a flat disc with shroud lines.
- All are a 15-degree conical design.
- All sizes use 1.9 ounce rip-stop nylon coated with urethane for zero porosity. Actual weight of the fabric is 2.6 ounces/sq. yard.
- The lines used on 36” and smaller chutes are braided polyester with a breaking strength of 180 pounds minimum.
- The lines used on 48” and larger chutes are flat braided nylon with a breaking strength of 300 pounds minimum.
- 60” chutes and above have heavier lines and every seam and edge is reinforced with high strength webbing.

Spill Holes

- The spill hole provides straighter descent and reduces swinging or rotation of rocket under the chute while on descent; the swinging occurs with non-spillhole chutes due to the chute trying to dump air. See the Recovery page of the webstore for approximate spill hole sizes; they vary slightly from chute to chute within a size.
- If a rocket experiences rotation or swinging under a PML spill hole chute, this is because the shroud lines are not completely equal lengths to the tie-off point.
- Our 18” chute has a relatively large spill hole as it is intended for drogue applications. This chute is not a good choice as a replacement for a plastic 18” chute from other manufacturers due to the large spill hole.

Sizing

- Chutes come in the following sizes: 18, 24, 30, 36, 48, 54, 60, 72, 84, 96, and 120”. We also offer a drogue X-form chute and a 4”x144” streamer you can cut to length.
- Our diameter ratings for our chutes are measured as follows: From shroud line attach point, along panel seam, across spill hole, down opposing panel seam to shroud line attach point.
- Parachute Sizing Upgrades -- PML chutes are sized for Midwestern and Eastern flying, as opposed to the open areas and hard landing surfaces of many Western sites. We size our chutes for minimal drift for smaller landing sites, while still allowing a safe descent rate into the grassy areas prevalent in the Midwest and East. However, if you're flying in Western areas where drift is not as much a concern and where landing areas are harder (such as desert playa), or if you 're flying from high-elevation launch sites with lower-density air, we can upsize the chute in your kit. Nearly all of our kits have an Upgrade Chute option listed right next to the kit itself in the webstore.

- Upgrade pricing will vary depending upon the base and upgrade chute. There is a fairly large “jump” in upgrade pricing to move from a 54” to 60” chute. This is because the 60” and up PML ‘chutes are a totally different construction. Lines are heavier and every seam and edge is reinforced with high strength webbing.
- RockSim, a popular rocket design and flight simulation program, has a parachute descent calculator as one of it’s features. The parachute descent calculator function routinely “over-recommends” what size PML chute is necessary; said another way, RockSim will report that the chute we ship with a kit is far too small (rocket descends too fast, according to RockSim). Apogee admits that the descent rate calculation in RockSim 4.0 uses a fixed Cd, which may lead to incorrect chute sizing calculations. Here's their reply when we asked them about it:
  "This is one of the things we expect to change in a future version of RockSim. We want to allow the user to change the Cd for the particular parachute. Right now, it is fixed, and it may be too high or too low (depending on the parachute)."
- People sometimes ask us for a “chute size calculator”. We don't really have any hard and fast rules on chute sizing. We do it by "gut feel" and experience. We suggest you look at the Kit Specs sheet on our website and find a rocket of comparable size and weight to what you're working with, and select a chute of similar size to what we ship with that kit. We also have a Parachute Size vs. Weight chart on the Recovery page of our webstore that can help. Sometimes we will upsize a chute one notch from what a similar kit might ship with because the kit in question has something special about it that might need to descend slower. For example, if a kit that would normally ship with a 30" chute has some protrusions, particularly big fins, or fins that extend well below the airframe, we might ship it with a 36" instead to help it descend and land a little softer.

Folding/Packing/Flying

- We have a guide to properly folding/packing PML chutes on the Recovery Page of our website.
- We no longer recommend use of the Gradual Deployment feature on our larger chutes. Successful operation of the system is too dependent on specific flight conditions and exact setup of the system. We have not sold/shipped parachutes equipped with Gradual Deployment for a number of years, but some customers may still have some Gradual Deployment chutes.

Piston systems

Design/Operation

- Very efficient design; captures 95+% of ejection gases.
- A PML first, and exclusive to PML for years.
- Esssentially guarantees the chute will eject from rocket and will not be damaged from the ejection charge. Ejection gases can’t leak past the chute and eject the nosecone but not the chute, as can happen in non-piston rockets, especially the larger-diameter ones.

- The operation of the piston system is quite simple. The piston sits in the airframe "over" the motor and "under" the parachute. It is attached to the motor mount via a nylon blend strap, which is epoxied to both the motor mount and the piston itself. When the ejection charge goes off, the pressurization between the motor and the piston bottom pushes the piston upward, which separates the rocket and pushes the chute out. That's all there is to it. No special prep needed, nothing to do...just push in the piston, load the chute, and you're done.
- We use metal D-rings with a butt-welded joint for shock cord attachment to the piston on all kits up to and including 4”. On 6” and larger kits, we use Kwik-Links.

Fitting the Piston

- After cutting airframe tubing, it may be necessary to deburr the edges inside and out using 150 grit or finer sandpaper. This is especially true with QT, as the cutting process may “squeeze” the cut end ever so slightly, making it tight for inserting a nosecone or for inserting the piston. Deburring or chamfering the inside edge of a QT will eliminate those problems.
- Phenolic pistons should slide easily in or out with just a little push or pull from you. Sand until you achieve this fit, and chamfer (round) the edge of the upper and lower portion of the piston. We also recommend that you keep some sandpaper in your range box to adjust the fit at the field if necessary. The first few times you fly you may need to "tune" the fit for differing temperature and humidity; once you've gotten it dialed in you should be good for the life of the rocket. Sometimes it just takes a bit of tweaking the first couple of times out.
- The first time you fly a QT rocket in cold weather, take it with the piston OUT to the launch site with you, and set it outside while you're doing other things. Once the rocket's come to ambient temperature, try to fit the piston; it'll probably be too tight. Sand it until it has the nice slip-fit you'd expect. Voila...you're done. Your QT rocket is now ready to go now and forever. Basically once you sand the piston for cold flying conditions it'll fit well then, and also will be fine in warmer weather, as it's nearly impossible to sand a piston so much it's too loose. Think of it sort of like setting CG/CP...when you build the rocket, you add as much weight as the heaviest motor you'll fly to the tail, then adjust the noseweight once until it's right. It's something you do one time to make sure you're set for the future. Same thing with the piston.
- A little baby powder on the ID of the body tube and OD of the piston helps lubricate the piston assembly. Only do this when the rocket is completely finished! The baby powder may prevent glues and paints from adhering.

Piston Systems and Black Powder Ejection Charges

Piston systems require less black powder (BP) than non-piston systems. This is very important, as ***most recovery system damage we see to our kits can be traced back to too much BP*** and a too-strong ejection charge. The following shows how much BP to use with our piston systems, for a piston travel of under 30 inches.

- 1.5-2.0” diameter: 0.3-0.5g BP
- 2.5-3.0” dia.: 0.6-0.8g BP
- 4.0” dia.: 0.8-1.2g BP

- 6.0” dia.: 1.4-1.7g BP
- 7.5” dia.: 1.7-2.0g BP

The measuring cup provided in our LES Kit measures out 1 gram. If you don’t have the measuring cup from the LES kit, the cup provided in the kit measures out about ¼ teaspoon of 4f (FFFFg) black powder. We also offer the cup separately (CPR-1GM) on our CPR Systems page.

The following will give you an idea of how much ejection charge BP is commonly supplied with various size motors:

- G: 0.7g
- H: 1.4g
- I: 2.0g
- J, K: 2.1g

The values below are intended as a guide for determining the proper amount of ejection powder used with various diameter CPR-MAX rockets using a piston ejection system and a 24” fore or aft recovery airframe.

6.0” dia. — 1.0 to 1.3 grams
7.5” dia. — 1.2 to 1.5 grams

Using too much BP for the ejection charge causes damage like that described by this customer in an email to us:

> “I discovered damage to the piston tube on the piston ejection assembly. About a 1-inch square portion on the end opposite the bulkplate was broken off. Is this a common failure? Is there anything I can do to prevent it from happening again? I showed it to someone else at the launch and they indicated the same thing had happened to them.”

This damage to the piston is the classic indicator of too much BP used for the ejection charge. What's happening is the piston is ejecting with so much force that it's coming to the end of the piston strap at tremendous velocity, then snapping back against the top of the airframe and, voila, chunked piston skirt. In phenolic airframe, this is usually manifested by a cracked or chunked top of the airframe, too. QT can sometimes crack from this problem. Look carefully at the top of your airframe and you may find a small indentation or other witness mark of where the piston hit. Follow the directions on how much BP to use on the sheet that was packed in your piston kit baggie, or as shown above.

Post-Flight

There are debates as to whether the piston and airframe need to be regularly cleaned of black power residue. All of us at PML occasionally run a damp cloth in the airframe and around the OD of the piston (just like wiping off dirt) and let them dry. If necessary wrap the cloth around a stick to reach inside.

Piston strapping

Piston retaining strapping: 10mm tubular = approx. 500 lb., 3000 lb. (3/4”), and 6000 lb. (2”). The piston strapping comes with a PML piston kit if you buy the piston kit separately.

Piston Strapping Selection Criteria

- 10mm tubular for 1.5" rockets like the Cirrus.
- 0.75" for 2.1" through 3.9" rockets; strap 5’ long for these diameters
- 2.0" for 6.0" and larger rockets; strap is 6’ long for 6.0” and 7.5”

Piston Strap Heat Resistance/Nomex Protectors

We sometimes get questions about whether the piston strapping needs to be protected from ejection heat. First, the strap is a nylon blend, not pure nylon, so it's relatively resistant to the short-term heat of an ejection charge. Regarding strap protection, PML has sold more than 20,000 kits over the past 10 years. That's probably 100,000 flights assuming only 5 flights per kit (which is probably substantially too low, but for the sake of argument that's what we'll use). We've only had two piston straps returned because of burn-through damage. That's a 0.00002% failure of piston straps due to heat damage. Clearly, customer experience has shown there’s no need to add piston strap protection; it only adds unnecessary weight and cost.

Also, to be perfectly honest, most people will lose their rocket to either drifting away on a very windy day, a motor cato, super-late ejection, or some other problem long before degradation of the piston strap becomes a concern.

Shock cords

Tubular Nylon Shock Cords

- We offer three sizes of tubular nylon shock cords: 3/8”, 9/16” and ¾” (actually, the 3/8” isn’t tubular, but it is/should be used just as you would TN)
- Strength Ratings: 3/8” 1000#; 9/16” 2100#, ¾” 3100#
- You may need to clear out flashing from manufacturing in the nosecone eyelets to pull the shock cord through; use an X-Acto knife. If you must open up the eyelet to allow the shock cord to pass through easier, do it toward the body of the nosecone, not toward the edges of the eyelet (that will weaken the eyelet). An easy way to pull through a shock cord strap is to put one corner through the eyelet and pull the strap through using pliers.
- We have a guide to properly tying tubular nylon available on the Recovery Page of our webstore.
- Regarding why we have you attach the ‘chute to the shock cord and not to the nosecone, if you attached to the cone and the cone came off the shock cord, the whole rocket would plummet. If the chute is attached to the shock cord and the cone comes loose, only the nose cone falls. The reason it's one-third of the way up is that if it were exactly halfway, the nosecone would bang into the rocket on descent, since they

were both equidistant from the chute. With it at 1/3 and 2/3, respectively, they are separated on descent.

Shock Cord Selection Criteria

We use the following as general guidelines for kits. For scratchbuilders: more and wider shock cord may be better if it fits. We recommend using our ½" Tubular Nylon for kits up to 4" diameter, with ¾" Tubular Nylon for larger than 4".

- 2.1" dia. rockets w/o payload (nosecone only at other end of shock cord): 3 yrds. ½" TN.
- 2.1" and all 2.5" dia. rockets w/ payload (payload section and nosecone at other end of shock cord): 4.5 yrds. ½" TN.
- 2.5" dia. rockets w/ payload (payload section and nosecone at other end of shock cord) and 54mm motor mount (more weight and higher velocity; harder to predict exact ejection time): 4.5 yrds. ½" TN.
- Most 3.0" dia. rockets 4.5 yrds. ½" TN. Heavy or with large payload, section 7.5 yrds ½" TN.
- Economy 3.9" dia. rockets 7.5 yrds. ½" TN. Heavy or with large payload, section 7.5 yrds ½" TN.
- 6.0" and 7.5" dia. rockets w/o payload (nosecone only at other end of shock cord): 7.5 yrds. ¾" TN.
- 6.0" and 7.5" dia. rockets w/ payload (payload section and nosecone at other end of shock cord): We usually have each section come down with it's own chute and use 7.5 yrds. ¾" TN for the booster and 4.5 yrds. ¾" for the payload.

PML ROCKSIM FAQ

We offer RockSim files for every PML rocket, and RockSim data on every PML component on the RockSim Page of our website. PML was the first high-power manufacturer to provide this to our customers, and is still the manufacturer that provides the most simulation data and information to their customers.

What You Need To Know About Simulations

We use RockSim as our tool because it's one that's readily available and that many modelers have. Real-life conditions in flight like temperature, launch site altitude, humidity, launch lug drag on the rod, winds (a biggie) and variation in actual motor performance from the "perfect motor" RockSim uses (another biggie) are going to affect the real flight, sometimes substantially. Motor performance can vary up to 15% from manufacturer's specs and still achieve certification. Also, the user's ignition technique and/or device can make a big difference as well. A motor chuffing a bit on the pad can make a big difference in an actual flight performance vs. the simulation which of course ignites perfectly every time. Also note that an altimeter you may use to evaluate the accuracy of the simulation prediction can be off by 10%-15% as well.

RockSim (or any simulator) is just that, a simulation, so *use it as a guide, not a gospel*. We've provided the information to assist our customers in motor and delay selection, but everyone needs to understand that it is indeed only a simulation. However, since we do use RockSim for all our simulations, and also include the files we use on our website, the individual modeler can download the files and run their own simulations for the flight conditions they usually experience. As noted on the front page of our Motor Recommendations Chart:

"Data was produced from RockSim simulation software with 500' elevation launch site, 70% humidity, 75 deg. F, 0 mph wind, 0 deg launch rod angle.”

These are clearly relatively "perfect" conditions to allow repeatability in producing our charts. Sure, 0 mph wind might be unrealistic for most people's flying conditions, but what is "realistic"? 5 mph? 10? Depending on the launch sites you personally fly at, anything from 2 to 20 mph might be a typical wind condition. So, the only "fair" way for us to produce the chart is to set it at known conditions, clearly state what those conditions were, and leave it to the user's experience (or THEIR copy of RockSim) to make adjustments to the data we provide as they deem prudent.

Motor Recommendations Chart

The numbers on the Motor Recommendations Chart, (available on the Specs Page of the website) are from simulations run using RockSim software. All these simulations are run on “bone-stock” kits, so if you add nose weight or make other modifications you will need to adjust the file accordingly to match your situation. We recommend you weigh

your kit when you're done building and painting and enter that weight into RockSim to get the most accurate simulation results.

Keep in mind that these predictions were made with the "flight day" in the simulator set essentially "perfect" as mentioned above, and the real world isn't. Your actual flight will likely be different than the simulated one.

Days with absolutely no wind are quite rare, so be sure to compensate for flight conditions on the day you actually fly. For example, if it is a windy day and you've added some launch rod angle, the rocket's altitude will be lower, the speed of the rocket at apogee will be higher (since it will be going at an angle instead of straight up) and you may also need a slightly shorter delay. Conversely, if you're flying in a high-altitude area (Denver, for example), the air is thinner and therefore produces slightly less drag on the rocket. In that case you may want to choose a slightly longer delay. The essential thing to remember is that these are just simulations. Launch conditions as mentioned above can and WILL cause differences in actual flights. PML recommendations for motors, delays, and altitude predictions are to be used only as a guideline to provide you a starting point for making your decision as to what motor and delay to fly for the launch conditions at the time of flight.

RockSim 5.0 and Higher

People sometimes ask if we intend to offer PML RKT files and component data for RockSim 5.0 or higher. We worked with Apogee before they released version 5.0, so updated PML data files are ALREADY in 5.0 and above. We updated our component data files on the PML website at the same time 5.0 was released, so if you download our component data you'll have the latest as well.

Regarding updating our Motor Recommendations Chart simulations with 5.0 or higher, the differences between 4.0 and 5.0 or higher files for generalized altitude and delay predictions with various motors are not significant enough for us to rework all the files for 5.0 or higher. Also, the files we have provided for 4.0 still work with 5.0 or higher, though the reverse isn't true. 5.0 or higher use a different file format that will not open with 4.0.

Real-life flying conditions will cause variations greater than the difference between the two versions. For example, motor thrust variation of up to 15% is allowed by both the NAR and Tripoli motor testing organizations for a motor of a certain classification, and the difference between the 4.0 and 5.0 or higher simulations isn't nearly 15%. The difference between simulations could very easily be "washed away" by real-world conditions. It's simply not worth the time involved to do it because the real world is going to be different from the simulation anyway. Version 4.0 or 5.0 or 6.0 or "whatever-point-oh", the data will just be a guide for you to go by, not absolute data that you should expect to match with your flight.

Quantum Tubing and RockSim

Many people ask about why Quantum Tubing is not in the PML RockSim database... here's the answer. The manufacturer says the QT density is 1.05 g/cc. However, when you add QT to the materials database using that figure and construct tubes from it (basically just pull up one of our phenolic tubes, change to "custom", then change the material) you'll find that the weights in RockSim don't match our measured weights of the tubes. We've tried "fiddling with" the 1.05 number, but then once one tube is right, say the 2.1 at 10.7 oz, another tube is off by enough that the "fiddling" of the density in the RockSim materials database is no good. What we suggest you do is just build the kit in RockSim from phenolic, then add a mass object right at the CG point for the difference in weight. (The weights of the tubes are shown in our webstore). Here's a quick reference of tubing weight differences, all for 36" pieces of tubing:

Airframe Size	PT Weight	QT Weight	Difference
2.1	8.7 oz.	10.7 oz.	2.0 oz.
2.5	10.3 oz.	11.3 oz.	1.3 oz.
3.0	12.1 oz.	15.2 oz	3.1 oz.
3.9	15.3 oz	18.0 oz	2.7 oz.

Also, keep in mind that RockSim 4.0 doesn't take into account the weight of fin tabs through the airframe wall, epoxy, paint, etc. There's also no way to easily add piston strapping or shock cord. We took care of these difficulties in the RockSim RKT files we provide by adding a mass object to bring the RockSim weight of the kit up to our measured weight of the actual kit. The minor weight difference you're going to get between RockSim and QT is going to be different from what the real rocket weighs when you build it anyway, since build techniques (amount of epoxy), painting, etc. will vary from builder to builder.

What we suggest is to use RockSim as a design tool to figure fin sizes needed, etc., then build the real rocket. Weigh the completed rocket, add a mass object at the CG to make the RockSim rocket weigh what the real one does, THEN do your simulations. That way your simulator rocket weighs exactly what your real one does, so you don’t have to worry about build differences and slight component weight differences in the RockSim component database. Also, there's going to be enough difference in RockSim's "idealized/perfect" motor thrust and how your real motor burns, wind and temperature, humidity, etc., that the little bit of difference between QT and phenolic isn't going to matter much. You shouldn't worry about dialing in RockSim to the n-th degree, because it's just a simulation...a real life flight is going to be different no matter how perfect your input into RockSim is.

CPR Systems and RockSim

See the Close Proximity Recovery (CPR) Systems FAQ for information on CPR component weights for use in RockSim. We recommend creating a Mass Object or Objects with the weight of the CPR components involved.

Parachute Sizing and RockSim Descent Rate Calculator

RockSim has a parachute descent calculator as one of it's features. The parachute descent calculator function routinely "over-recommends" what size PML chute is necessary in 4.0. Said another way, RockSim 4.0 will report that the chute we ship with a kit is far too small; the rocket descends too fast, according to RockSim. Apogee admits that the descent rate calculation in RockSim 4.0 uses a fixed Cd, which may lead to incorrect chute sizing calculations. Here's their reply when we asked them about it:

> "This is one of the things we expect to change in a future version of RockSim. We want to allow the user to change the Cd for the particular parachute. Right now, it is fixed, and it may be too high or too low (depending on the parachute)."

PML has been designing and flying high-power rocket kits for nearly 12 years as of this writing. We have a pretty good handle on how to size chutes for our kits, and tens of thousands of customer flights have proven that out, so we recommend ignoring the chute descent rate calculator feature of RockSim.

Custom Work and RockSim Files

We welcome customers forwarding us RockSim files of their projects, as it sometimes helps us understand what you're after. However, YOU STILL MUST PROVIDE US A DETAILED PARTS LIST OF WHAT YOU NEED, INCLUDING CUT LENGTHS, DIAMETERS, ETC. YOU MUST PROVIDE US WITH THE SAME LEVEL OF DETAIL AS IF YOU HAD NOT INCLUDED THE ROCKSIM FILE. We will not "decipher" the RockSim file to determine exactly which parts it contains. Look at the RockSim file as a way to help us ***understand*** your parts list, not a way to ***produce*** your parts list and measurement data.

PML SPECS PAGE FAQ

Specification Sheets

PML provides various specification sheets on our website for customer convenience. Public Missiles' specifications documents are made available to you in the Adobe Acrobat Portable Document Format (*.pdf). We make them available to you in this format so the document can be viewed or printed, either online or offline, using your monitor and your own printer. If needed, the PDF viewer is available through a link on our site as well. On rare occasions customers report they cannot view a PDF file while on the website; this seems to usually be from unusual user computer configurations. We would like to remind you that you can always right-click on a file and save it to your local hard drive and open it from there.

Kit Specifications

The purpose of this chart is to show you various specifications customers are often interested in, such as length, weight, diameter, fin thickness, Center of Pressure, launch lug size, stock parachute size, and other information.

Motor Recommendations, Predicted Altitude and Ejection Delay Chart

The purpose of the Motor Recommendations Chart is to give you an example of possible altitudes that can be attained with various rocket/motor combinations. All motors shown except hybrids are made by Aerotech. Motors of different total or average impulse or motors from other manufacturers may work as well. Consult your favorite motor manufacturer or dealer. Match motor to rocket for approximate altitude and ejection delay time. Optimum delay time is printed after the estimated altitude. The numbers on the chart are from simulations run using RockSim 4.0 software. All these simulations are run on “bone-stock” kits, so if you add nose weight or make other modifications you will need to adjust accordingly. Be sure to read the information on the first page of the chart thoroughly! It explains the chart in detail as well as giving you helpful tips on kits, motors and delays.

Keep in mind that these predictions were made with the “flight day” set as no wind, no launch rod angle, and with the launch site at 500’ above sea level, 70° F, and 75% humidity. Days with absolutely no wind are quite rare, so be sure to compensate for flight conditions on the day you actually fly. For example, if it is a windy day and you’ve added some launch rod angle, the rocket’s altitude will be lower, and you may also need a slightly shorter delay. Conversely, if you’re flying in a high-altitude area (Denver, for example), the air is thinner and therefore produces slightly less drag on the rocket. In that case you may want to choose a slightly longer delay. The essential thing to remember is that these are just simulations. Launch conditions such as wind, temperature, and variations in motor impulse due to manufacturing variations in the motor can and WILL cause differences in actual flights. PML recommendations for motors, delays, and altitude predictions are to be used only as a guideline to provide you a starting point for making

your decision as to what motor and delay to fly for the launch conditions at the time of flight.

Information is also shown in the chart regarding motor/kit combinations that should be strengthened or otherwise require special treatment. This is explained in the chart, and additional information can be found in the Kit Strengthening section of the Airframes FAQ.

Data Sheets

The Data Sheets are available for nearly every kit PML makes, and are available by clicking on a link under the description of the kit in the webstore. These sheets show a photo of the kit, list the kit's features and specs, and have a mini Motor Recommendations Chart on them, all on a single "printer-friendly" page. (Of course we recommend you always look at the full Motor Recommendations Chart on the Specs Page of the website for the latest information).

PML STAGING FAQ

Interstage Couplers

Interstage Couplers are used to house staging timers and to connect the upper and lower stages together. The Interstage 3000, the latest version from PML, is used in our two-stage rocket kits, but is now available for scratchbuilders designing their own staged rockets. Using an IS3000 system from PML is a quick, simple solution to an often-difficult design problem. Interstage 3000 kits are ready to ship in 2.1, 2.5, 3.0 and 3.9" diameters.

To use an IS-3000 system, the booster needs 3" (regardless of diameter) at the top, just like a regular rocket would for a payload coupler or nosecone shoulder. The sustainer (upper stage) also requires 3" clear at the bottom. The Staging page of the website has a PDF file that illustrates design requirements for the upper stage if you are designing a scratchbuilt two-stage rocket. There is also a PDF file that shows design requirements for the Terrier IS3000 system.

IS3000 Specifications

Weight

The weights given below are without the timer. See the Electronics Page on the PML website for timer weight information.

- IS-3000-2.1 = 5.5 oz.
- IS-3000-2.5 = 6.8 oz.
- IS-3000-3.0 = 7.0 oz.
- IS-3000-3.9 = 9.3 oz.
- IS-3000-Terrier = 7.5 oz. (The urethane transition piece weighs 1.3oz. with the rest of the system weighing 6.2 oz.)

Length

The timer enclosure tube, which comprises the entire length of the IS-3000, is 5” for all systems except the IS-3000-TERR Terrier system, in which it is 8” long.

Fitting ST-2 Timer to IS3000

The PML AccuFire is the recommended staging timer for the IS3000 system; the two were designed together to complement each other. The Transolve ST-2b will also fit directly. The ST-2 can be used if the customer drills holes in three of the corners of the board. However, using an ST-2 can be potentially unsafe as it only has one set of two screw terminals, requiring the customer to install a switch in series with the electric match to safe the system from firing on the ground. Everything else uses off-board power and will not fit the IS3000 system.

Two-Stage Rocket Booster Delay Timing

Shortly after the release of our Terrier Booster for our Mini-BBX kit, a customer wrote with the following question: *"What motor delay times do you recommend for the Mini-BBX Terrier booster? Short medium or long? Does it matter which upper stage motor?"*

ANSWER:
I think what you're asking is more correctly not what delay time is necessary for the booster (but we'll talk about that, too), but when the upper stage motor should be ignited. Well, as in lots of rocketry, it really depends. The general rule or situation you need to look for is: if at booster motor burnout the rocket is not moving quickly, i.e. doesn't have a lot of kinetic energy to keep it coasting, you want to get the upper stage motor lit NOW. If it has a lot of velocity and can coast for a second or two, you can set your sustainer stage ignition to be a little later. The idea is that you don't want the rocket slowing down to the point where the fins aren't providing good guidance for it before the upper stage gets lit and gets everything under power again. When considering when to ignite the sustainer motor, also don't forget that the motor may require a bit of time to come up to pressure and really begin a thrusting burn. You have to figure that into it too, which depends upon the upper stage motor you've selected. Also take into consideration the composition of the second-stage motor and account for that in the timing as well. For example, a Blue Thunder motor will ignite and come up to pressure far quicker than will a Blackjack. It also depends on what you're trying to achieve: the absolute maximum altitude of a certain kit? A successful two-stage flight but staying under a certain waiver? Etc. It all depends on what you're trying to do. Honestly your best bet would be to simulate a number of different delay scenarios to see which one provides the flight profile you're looking for (but always keeping in mind a generous safety factor of timing to account for problems like a slow-pressurizing motor, etc.). Sometimes an immediate ignition of the second-stage motor is best, but other times that can actually decrease the ultimate altitude due to pushing the flight profile into a higher-drag situation. "It depends" is the honest answer.

You really need a simulation program to help determine what you want/need to do depending upon what motor combos you're using since of course the power level of the booster motor, and the weight of the entire rocket, which of course depends upon what motors are installed, play a big factor in it. We'd suggest RockSim, available at http://www.apogeerockets.com/index.asp since we already have the data files for the MiniBBX/Terrier available for RockSim on our RockSim Data page in our website.

Now, regarding actual booster motor ejection times, that of course depends somewhat on the above now that you understand that, but there's more to it than just igniting the sustainer stage and immediately ejecting the booster recovery system. The booster itself will coast fairly well on it's own after separation, so you need to figure that out, too. A good way to approximate what delay time you should use for the booster is to calculate the coast time to apogee for the entire rocket as though there were no upper stage motor. Basically use the entire two-stage rocket in your sim, but install only a booster motor and no sustainer motor, run your simulation, and look for when the rocket reaches apogee. That time is a pretty good estimate of what delay to select for the booster motor, because

the booster itself will coast about that long after separation. Let's do a hypothetical example: let's say you're going to use an I284W as your booster motor. Load your simulation with an I284 in the booster, and no motor in the sustainer stage. Run the sim, and see when it says the rocket will reach apogee. Let's say it's about 10 seconds. So, you'll want to use about a 10-second delay in your booster motor for your real two-stage flight, since the booster will tend to coast about that long. If you use anything too terribly much shorter than that you run the risk of stripping the chute off the booster section. It doesn't seem to make sense that the booster would coast that long without a nice aerodynamic nosecone on it, but it will.

Two-stage rockets are a complex thing, and do definitely require special considerations, experience, and lots of "what if" thinking and simulation.