Apogee Components

# PEAK OF FLIGHT

NEWSLETTER

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Using altimeter data to decipher why a flight didn't achieve its objective.

## TARC Suggestions Based On Watching the Finals

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ISSUE 209 MAY 20, 2008

# What is a Loadable Rocket Motor?

By Tim Van Milligan

There are three types of rocket motors that we currently sell here at Apogee Components. They are Single-Use, Loadable, and Reloadable. The purpose of this article is to give you some of the key differences between the three so you are better informed when you make your purchase from Apogee.

A single-use motor, as the name implies, is a rocket motor that can only be used once. After that, the case is rubbish and is disposed of.

*Fig. 1: A pre-assembled, single-use motor.*

On the other end of the spectrum is the "reloadable" rocket motor. These motors can be used over-and-over indefinitely. The advantage is that over time, they can really cut the price of a launch, because all you're paying for is the propellant inside the motor. You can refer back to Peak-of-Flight Newsletter #189 to find out at what point the reloadable motor makes economic sense.

A loadable motor has some characteristics of a single-use motor, and some characteristics of a reloadable motor.

*Fig. 2: A "reloadable" propellant kit. This propellant is assembled inside of a metal casing (sold separately).*

| | Single-Use | Loadable | Reloadable |
|---|---|---|---|
| Max. No. of Flights | 1 | 1 | Unlimited |
| Assembly Required? | No | Yes | Yes |
| Age Restriction | No | Yes | Yes |
| Case Needed? | No | No | Yes |
| Epoxy Required? | No | Yes | No |
| Cost of 1st Flight | Middle | Lowest | Highest |
| Reflight Cost | Highest | Middle | Lowest |

***Table 1: Some of the key differences of the three types of solid propellant motors sold by Apogee.***

## *What Exactly Is A "Loadable" Rocket Motor?*

A loadable motor is actually a single-use motor that you have to assemble like a reloadable motor.

The one disadvantage is that the loadable motor is not as cheap per flight as the reloadable motor. The reason is that each time you fly one, you're getting a brand new plastic casing, which does cost money. So the price isn't as cheap as the reloadable motor, but it is a little bit cheaper than the single-use motor.

The reason it is a little cheaper than the single-use motor is that you aren't paying Aerotech the cost associated with the labor-time needed to assemble it. You'll be providing the labor yourself, so there is a little cost savings. It isn't a lot. So, you may wonder what is the advantage of the loadable motor over the single-use motor?

## *Advantages of loadable motors*

The biggest advantage is availability and shipability of the "G" size motors. Everyone wants bigger motors, but there are Federal regulations that govern what can be shipped around the country. Because rocket propel-

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## What is a Loadable Rocket Motor?

***Fig. 3: A Loadable motor comes with the plastic case and requires assembly.***

lant is flammable (duh... of course it burns), it is classified as a hazardous material. That means it usually has to be shipped by special trucks that are authorized to transport these materials.

Companies such as UPS and FedEx are two companies that can transport hazardous materials, but they do it only for an extra expense. In other words, they charge a hazmat fee of $20 per box. If you're only ordering a couple of motors, this really adds to the cost of each rocket motor.

The good news is that the United States Postal Service has a very special exemption for model rocket motors that contain less than 30 grams of rocket propellant. Instead of paying a hazmat fee and shipping through FedEx or UPS, it is possible to ship rocket motors through the regular mail system with NO extra fees.

Loadable motors are designed so that they can take advantage of this shipping exemption. Since the motor is not assembled, it isn't really a rocket engine. It is just a collection of parts. One of those parts is rocket propellant. And since each slug of propellant is under the 30 gram weight limit, it can be shipped through the postal system without a hazmat fee.

In this respect, a loadable motor is a lot like the reloadable motors: shippable without a hazmat fee.

It is because of these regulations that dictate which products we carry. In other words, they determine what can be shipped inexpensively, and therefore what is "available." For example, Aerotech recently released a redesign the G80 single-use rocket motor. This is a very popular motor and everyone wants one. Unfortunately, it is single-use, meaning that it is already assembled. Because it contains

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## What is a Loadable Rocket Motor?

more than 30 grams of propellant, it cannot be shipped through the Postal System. On the other hand, we have a G77 motor (which is very close to the G80 in performance), but it is available as a loadable motor. We can ship the G77 easily, but not the G80. Therefore, we don't carry the G80.

I hate the Government regulations as much as anyone. And I look forward to the day when the NAR/TRA lawsuit against the BATFE is resolved so that some of the regulations can be eliminated. It is affecting business here at Apogee Components. I'd love to be able to sell you those bigger motors without all the shipping, storage, and explosives hassles.

The one advantage that a loadable motor has over a reloadable motor is peace-of-mind. The metal case of a reloadable motor is expensive. You don't want to lose the rocket because it means you've also lost the metal case. With a loadable motor, you haven't got that extra expense sitting inside the motor. That is a little comforting if you've lost track of your rocket after a really high flight.

### *Loading Fun*

One of the fun things about loadable motors is that you get to assemble them. This can make you feel like a real rocket technician working on a big NASA rocket. In fact, because of the assembly aspect of the loadable and reloadable motors, the government requires that you be at least 18 years old to use them. I guess they don't want kids to be handling flammable substances.

This age restriction is another government regulation that we hate. Even if it did make sense, it adds extra confusion and time to the ordering process. Each time a customer orders a loadable or reloadable motor from us, we have to hold up the shipping of the motors until we can verify the person buying is actually 18 years old.

### *How Easy is it to Assemble A Loadable Motor?*

It is actually easier than putting together a reloadable motor. Since the plastic motor case has the nozzle built in, there are fewer parts that have to be assembled. It takes less than 5 minutes to put one together.

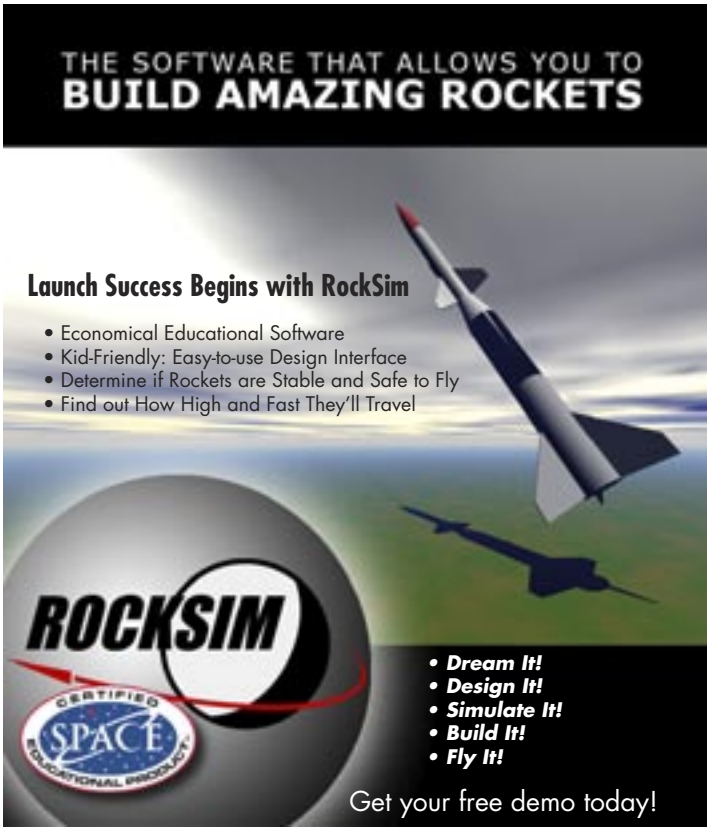
If you can read the instructions, you shouldn't have any problems. Once you get the motor home, you might as well go ahead and put the motor together. While they can be assembled on the launch field using 5-minute epoxy, I personally think it is easier to put them together prior to leaving the house. Things are less likely to fall in tall grass and get lost.

I recommend the React-A-Pack epoxy to glue in the forward bulkhead (the large red piece in the photo). It doesn't take much liquid epoxy to assemble the motor, which makes the small size of the React-A-Pack perfect for this task. A single pouch of React-a-Pack is enough for two loadable motors.

### *Why Can't Single-Use Be Reloaded?*

Since the casing is plastic, the insides of it get pretty charred. Some of the plastic is actually burned as the propellant is burned, so the case is getting thinner in some areas. That makes it weaker. If you tried to reload it with new propellant, the weak case would burst like a balloon, and the flight would come to an abrupt end.

The metal reload cases are much stronger and are designed for repeated firings. All you have to do is clean it out after firing, and it is ready to be reloaded.



## Learnings From The TARC Contest

### Consistency, Consistency, Consistency. That was the winning formula

By Tim Van Milligan

I just got back from the TARC finals in Virginia, and I thought I'd give you my impressions. I have some suggestions that will help your team do better next year.

Team America Rocket Challenge (TARC) is now an annual event put on by the NAR and Aerospace Industry Association. It is a contest for middle and high school students to design and build a rocket with a specific mission in mind. The goal this year was to build a rocket to launch and recover two eggs. To make it difficult, the rocket had to fly to exactly 750 feet and touch down on earth again in 45 seconds. The team closest to the altitude and duration aloft earned the title as grand champion.

This year it was even harder. To make sure that "luck" played no part in the contest, a second flight was required for the top 18 teams after the first round of flying. To be in the top 10 teams, you had to be consistent in both flights. That was very true this time. Of the 18 teams that flew, all of them had successful flights. There were no DQ's in that second round. I think I counted 12 DQ's in the first round of 100 teams.

I can't recall seeing any lawn dart flights this year. Of the 12 DQ's, it was usually a partially deployed parachute that caused the rocket to come down a little faster than

***The winning TARC team measuring out the precise amount of ballast weight to get to the 750 feet target.***

anticipated, and one of the two eggs got cracked. Based on this, I was impressed by the preparation and flying skills of the students.

Where I think there could be major improvement is in the quality of construction. I really only saw about two or three models that I considered OK quality. I saw them

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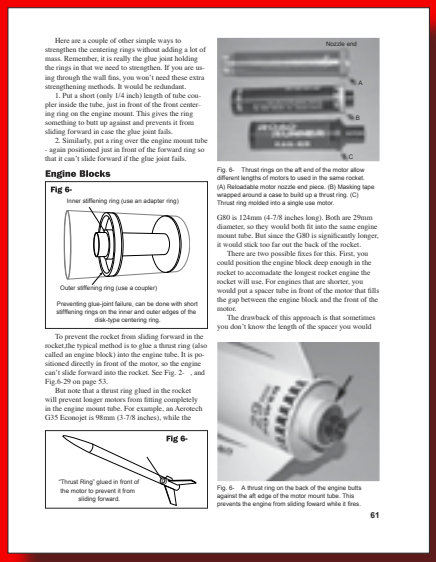
# Model Rocket Design And Construction



Here are a couple of other simple ways to strengthen the centering rings without adding a lot of mass. Remember, it is really the glue joint holding the rings in that we need to strengthen. If you are using through the wall fins, you won't need these extra strengthening methods. It would be redundant.

1. Put a short (only 1/4 inch) length of tube coupler inside the tube, just in front of the front centering ring on the engine mount. This gives the ring something to butt up against and prevents it from sliding forward in case the glue joint fails.

2. Similarly, put a ring over the engine mount tube - again positioned just in front of the forward ring so that it can't slide forward if the glue joint fails.

**Engine Blocks**

**Fig 6-**
Inner stiffening ring (use an adapter ring)
Outer stiffening ring (use a coupler)
Preventing glue-joint failure, can be done with short stiffening rings on the inner and outer edges of the disk-type centering ring.

To prevent the rocket from sliding forward in the rocket,the typical method is to glue a thrust ring (also called an engine block) into the engine tube. It is positioned directly in front of the motor, so the engine can't slide forward into the rocket. See Fig. 2- , and Fig.6-29 on page 53.

But note that a thrust ring glued in the rocket will prevent longer motors from fitting completely in the engine mount tube. For example, an Aerotech G35 Ecosojet is 98mm (3-7/8 inches), while the

**Fig 6-**
"Thrust Ring" glued in front of the motor to prevent it from sliding forward.

Nozzle end
A
B
C
Fig. 6- Thrust rings on the aft end of the motor allow different lengths of motors to used in the same rocket. (A) Reloadable motor nozzle end piece. (B) Masking tape wrapped around a case to build up a thrust ring. (C) Thrust ring molded into a single use motor.

G80 is 124mm (4-7/8 inches long). Both are 29mm diameter, so they would both fit into the same engine mount tube. But since the G80 is significantly longer, it would stick too far out the back of the rocket.

There are two possible fixes for this. First, you could position the engine block deep enough in the rocket to accomodate the longest rocket engine the rocket will use. For engines that are shorter, you would put a spacer tube in front of the motor that fills the gap between the engine block and the front of the motor.

The drawback of this approach is that sometimes you don't know the length of the spacer you would

Fig. 6- A thrust ring on the back of the engine butts against the aft edge of the motor mount tube. This prevents the engine from sliding foward while it fires.

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## TARC Rocketry Suggestions

again a second time when they came back for the final round of flying. I've been stressing this again and again since the first TARC contest in 2002: ***quality construction pays off!***

Let me say that again, in case you didn't understand it the first time. To get to the finals and to do well, you need to build "GREAT" rockets. Average rockets can get you to the front door, but it seems that only really good construction techniques will get you into the final round and finish in the top 10.

Why is this? Like all rocket contests, it takes consistency to win. Rockets with good construction techniques and good paint finishes are going to be more consistent when they are launched.

### *Do you really think you can win with just one rocket?*

The chances of making it through the qualification flights at home and the final round in Virginia with just a single rocket are very slim. As anyone that has been in rocketry for a while knows, a rocket always suffers some sort of minor damage on each flight. For example, scuffed paint, an *Estes-dent*, or a chipped fin. After several flights, that little damage starts to add up. The end result is that the rocket's performance becomes degraded. In TARC this is magnified because the competition you'll face is much better. Sooner or later the rocket will have to be replaced with a newer one.

***Globby fillets were a sure sign that the rocket wouldn't make the finals.***

If the new rocket is not built to the same level of quality as the previous one, then it will take more flights to dial in the variables to get a consistent flight that meets the objective of the contest. During these test flights it is likely that the rocket is going to get some minor damage, and so the cycle starts all over again.

The conclusion of this is that all the models should be

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## TARC Rocketry Suggestions

built to the same level of quality; and it must be "high" quality. If there are globs of glue running down the side of one rocket, and not down the other model, then the two rockets are going to fly differently. You need to eliminate the variability by building high quality rockets to begin with.

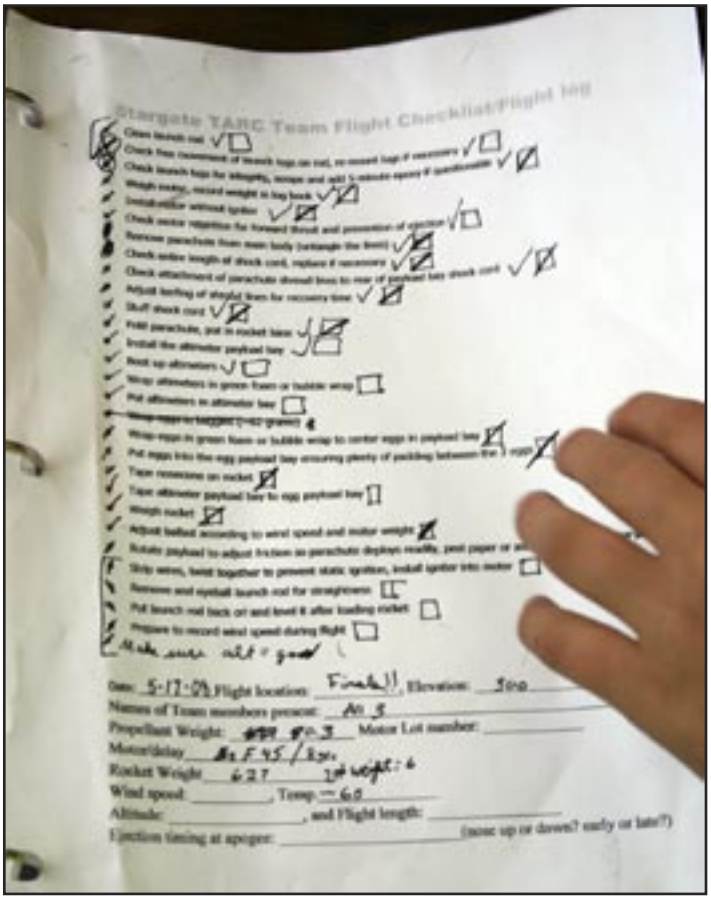
### *What does it take to build a good rocket?*

First off, you have to fill and seal the wood grain on the fins. I was pleasantly surprised by the number of rockets where the fins were sealed, but the quality wasn't the greatest.

What was far worse was the application of the glue fillets. Most rockets just had big old globs of epoxy. Besides looking terrible, they didn't reduce the drag on the models, they increased it!

While I sound like I'm coming down hard on the students, I'm not. I'd like the team mentors to do more teaching about quality construction skills and techniques. The students are mostly first-time flyers. The mentors should know better after flying for many years. We must all raise the level of quality of our construction techniques.

Mentors—start by concentrating on the fins! Teach them how to seal the wood, and how to apply epoxy fillets. I would suggest you ditch the liquid epoxy and use the Fix-It epoxy (http://www.apogeerockets.com/epoxy-clay.asp). It is easily shaped, so that you get much better looking fillets.




***A page from the Stargate TARC Team's checklist and flight log. This team from Colorado finished in fifth place. Notice they had to add a second column of check boxes because of the additional flight.***

## Much More Than 3 Fins and a Nose Cone

(Odd-Roc Picture Contest Until 7/13/08 at EMRR)

**What is an Odd-Roc: 1) Slang term for a strange-looking rocket. Odd-rocs are often made in the shape of other, non-rocketry-related items. [from EMRR Rocket Glossary];**

**2) Anything clearly *not* originally intended to fly. Odd shapes, odd conversions. The antithesis of 3FNC [from Apogee Newsletter 43];**

**3) Are strange looking things that often shouldn't fly. (And sometime don't!) [ Dick's Rocket Dungeon]**

(LEFT) Dick Stafford with his award winning "Sweat-Stained Clifton Tracking Station Hat of Death"

(RIGHT) Chuck Straka's NCAA (Descon8); (FAR RIGHT) Jeff Lane's Los Alamos Chicken (current entry)

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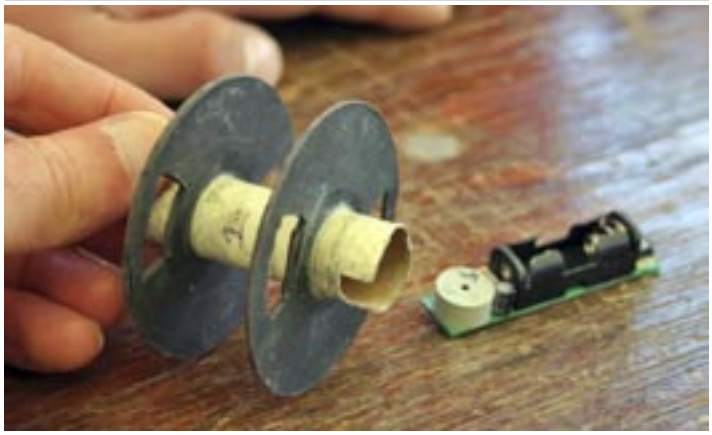
## TARC Rocketry Suggestions



***I liked this example of an altimeter holder. It shows there was some great engineering going on.***

If your team doesn't have a knowledgeable mentor, then please check out Apogee Components' web site. I have a FREE quicktime movie you can download that will show you how to build a quality rocket the first time. It can be found at: http://www.apogeerockets.com/getting_started.asp

What would I personally like to see in the future? I'd like to raise the quality of the rockets by suggesting some type of weight penalty on the rocket. It would give another thing for the students to worry about. Real aerospace engineering is always concerned about weight anyway, so they would be getting a dose of realism that they otherwise might not be exposed to.

Additional Suggestions:

I've written a number of articles on how to do well, and they are full of good ideas. Here are some tips that are on my mind as I'm sitting here writing this article:

1. Use pre-flight checklists. This will help you when your nerves are all flustered during the heat of battle, and help you ensure consistency when you get to the finals in Virginia. I was really impressed by the checklist I saw one team using (they finished in 5th place overall).

2. Take at least three rockets with you to the finals. You may suffer an engine cato that destroys the rocket and have to use your back-up model. One team had a cato and they had to shorten their rocket for the reflight. They didn't make the final 18 teams because the rocket was completely different from the rocket that got them there. Had they had a back-up model of the same level of quality, it would have been easy to swap out rockets. And why two back-up models? Another team had two engine catos!

3. You don't know what the wind is going to be like at the finals. Assume is it going to be 19mph with a light drizzle rain. Concentrate on getting a straight flight in these conditions. What would you do in this case? Here are my suggestions: try using tube fins, use high thrust rocket motors, spin the rocket using spin tabs, and use a long launch "rail". Stay away from clusters!

4. You have to have RockSim on the field with you. Everyone uses lap tops, so take one with you. Use it to dial in with the exact wind conditions and temperature. From this ballast the rocket to get your prefect altitude. Don't adjust the drag as that is too iffy.

***This rocket reacted very well to the gusty winds at launch. You can see by the shape of the smoke trail that it is starting to straighten out very quickly.***