Gary Santarelli and his level 3 rocket.

LEVEL III
HIGH POWER ROCKETRY

by Gary Santarelli

Introduction

Like most of you reading this article, I started flying Estes rockets as a child. As I grew older in high school and college I quit flying rockets. It was not until I was married and had our first child that I returned to rocketry. When our son was old enough, it was time to get back into rockets and buy him his first kit. We started flying Estes kits again. One day a friend asked if I wanted to go with him to watch a local rocket club fly rockets. When we arrived at the launch site I could not believe my eyes. There were rockets as tall as I am. I had never seen a high power rocket before. But I knew that it was time to get into high power. When I started flying rockets, a D motor was considered big.

I joined the Dallas Area Rocket Society (DARS) and started to attend the meetings each month. I have never met a more helpful, friendly, and knowledgeable group. I asked many questions about high power rocketry. It was recommended that I build and fly a medium rocket on E, F, and G motors; I picked the Aerotech Arcas. The first time I flew the Arcas on a G motor I could not believe the power. I started thinking about the power of level 1 and level 2 motors

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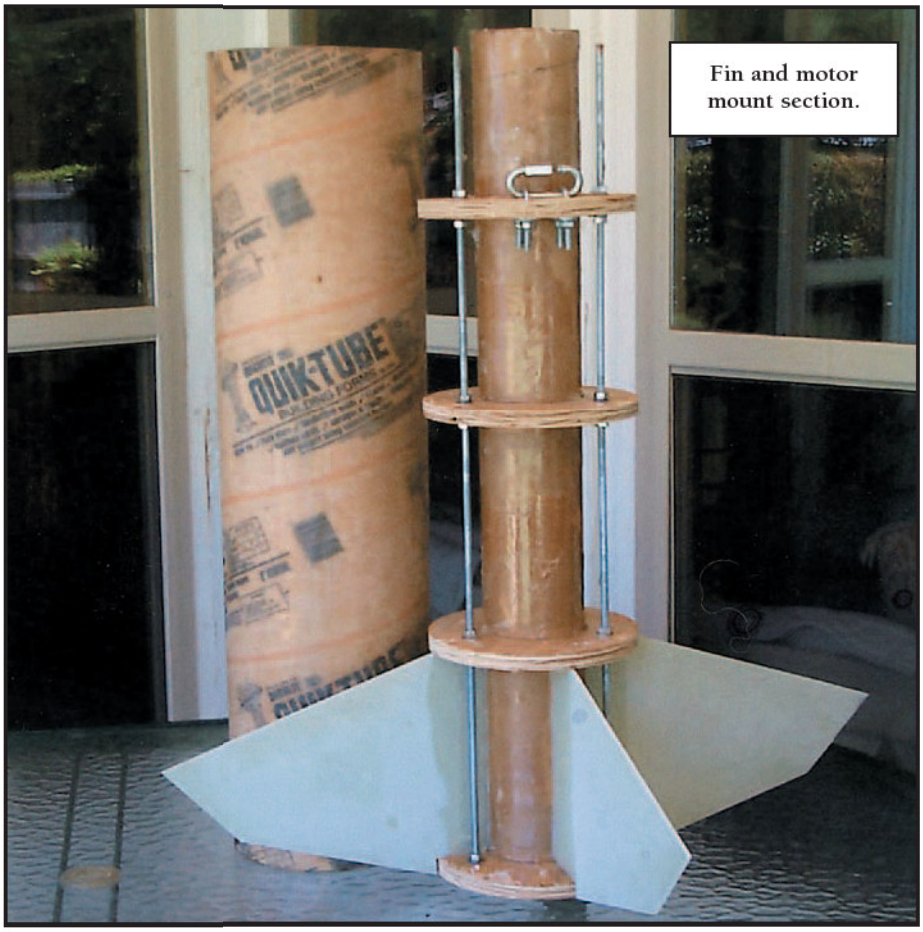
Getting into High Power Rocketry

For my level 1 project, I picked the two-stage PML Quantum Leap. I wanted to get my level 1 by flying just the upper stage. Later on I would add the bottom stage and fly it as a two-stage rocket. After receiving my level one certification, I added the PML CPR2000 and the Transolve P5 to the upper stage and the Transolve ST2 timer in the bottom stage. The Transolve products have worked every time.

After flying the PML Quantum Leap



Fin and motor mount section.

The completed fin assembly.

and the 4-inch PML AIM-120 AMRAAM on level 1 motors, it was time for the level 2 attempt. I added the PML CPR2000 with the Transolve P5 to the PML 4-inch AMRAAM kit and certified to level 2 on a J275. The PML 4-inch AMRAAM flies great on a J275.

After flying these rockets on different H, I, and J motors, it was time to think about the larger level 2 K and L motors. With the help of PML, I purchased their Ultimate Endeavor kit and modified it by adding the CPR2000 kit to it. I added my P5 and a P6 altimeter as backup deployment electronics to the rocket. The plan was to fly this rocket on a K550 and then a L850, giving me experience with K and L power. So far, the rocket has flown twice on K550 power. It worked great, and the P5 and P6 altimeters performed without problems.

Level III Project

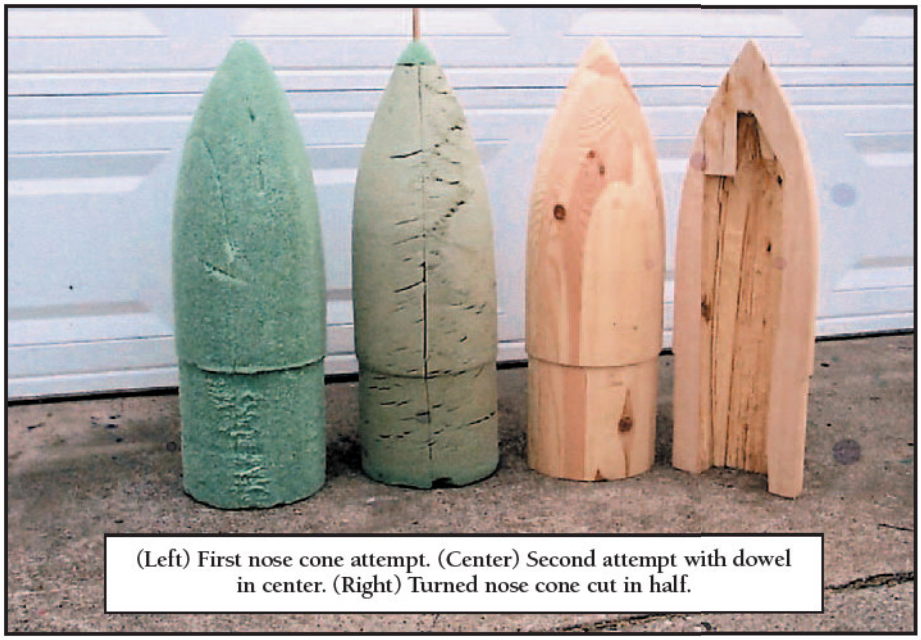
It was time to think about the level 3 rocket itself. I looked at all my past *High Power Rocketry* and *Sport Rocketry* magazines to get ideas on building a level 3 rocket. After looking at many pictures of rockets and missiles, I decided on the STANDARD SM1 Missile. The real SM1 missile is 15 feet long. At 15 feet, my wife would divorce me. I picked a scale that would put the rocket at 8.5 inches diameter and 10 feet tall. At 10 feet, I am still married.

The only problem with using the STANDARD missile is the possible effect of the long side fins on the rocket's stability. One of the level 3 committee members was afraid that under windy conditions the long side fins would want to turn the rocket. It was recommended that I increase the size of the bottom fins by 10% and decrease the width of the side fins by 10%.

I decided to add two-stage parachute deployment and use the same Transolve P5 and P6 that I used in the Ultimate Endeavor.

My local Home Depot store carries the 8.5-inch diameter concrete form tubes that I used for the airframe. I ordered the 75mm/98mm motor mount from PML. This way I could test fly the rocket on a 75mm L motor and then fly the rocket on both 75mm and 98mm M motors. I cut out the four centering rings myself out of 3/4" plywood. Home Depot carries a 4" drill bit that is perfect for drilling the center 98mm hole. I also fiberglassed the four center rings to the 98mm motor mount tube. I used three 5/16" all-tread rods to connect the centering rings.

The airframe is covered with two layers of 6-oz. fiberglass cloth with one finish layer of epoxy. I used the West System 20-minute epoxy. If you are building a large rocket that uses a large amount of epoxy, buy the West System pumps, they will save you a lot of time. One lesson I learned was that a rocket this size uses a lot of epoxy. I started by purchasing the smaller 1-quart cans of epoxy. I learned quickly that the small cans do not



(Left) First nose cone attempt. (Center) Second attempt with dowel in center. (Right) Turned nose cone cut in half.

go far. For a rocket this size, start with the gallon size cans.

The bottom fins were custom ordered from PML. I had PML make the fins out of 0.125" G10 fiberglass. I used through-the-tube construction to mount the fins to the engine mount. I then fiberglassed the fins to the engine mount and the body tube.

For the long side fins I needed something other then fiberglass. Fiberglass would have been too heavy; each side fin is almost 6 feet long. I went to a local surplus store and found a hard laminate called LP-509. I did not know what this was but it was light and strong. I looked it up on the Internet and found it under high-pressure laminates. The thing I liked was that it 'can withstand severe shock and bending stress' and has 'high impact and tensile strength' plus it was only $30. I had to use 50 grit sandpaper to sand the finish off of it. I cut the fins out on my table saw and glued them on with 30-minute epoxy. I added two layers of 6-oz fiberglass cloth to each side of the fins. The cloth ran 2 inches on each side of the fin and 2 inches over onto the body tube.

Nose Cone

Now for the nose cone. How do you build a 26" x 8.75" nose cone? My first attempt was made out of green floral Styrofoam. I sanded the whole thing with a file. This first attempt looked fine but I could not be sure that the tip of the cone was in the center of the whole cone. I needed a way to turn the nose cone.

My second attempt was again with the same green floral Styrofoam. This time I imbedded a 3/8" dowel rod in the center of the Styrofoam. I made a rig to hold this second nose cone so I could turn it using my 3/8" drill to spin the rig. This worked fine, but I was not sure how to add several pounds of weight to it. I really wanted to make a nose cone out of wood so I could turn it on a wood lathe. The prob-

On pad with Dave (level 3 adviser) reading check list prior to launch.

lem is that I do not have a wood lathe.

Things changed one night when a friend that I had not seen for some time came over my house. I showed Mike my rockets and told him my nose cone problem. Mike told me that he had a wood lathe and would be glad to help. Thanks, Mike Sohner, for giving up a full Saturday turning this nose cone. I went up to Home Depot and purchased 30 feet of number 2 pine. I cut the pine into 30" pieces. In order to get the 8.75" diameter, I had to glue 12 of these pieces together. The next morning I unclamped the pieces and weighed the block of wood. I had created a block of wood weighing 47 pounds! Now what was I to do? The whole rocket should weigh less than 47 pounds!

I cut as much as I could from the block, and it still weighed almost 40 pounds. After Mike and I finished turning the cone it was down to 22 pounds. Based on my RockSim calculations, I figured that I needed to get this down to about 15 pounds. In order to get more weight out of the center, I cut the cone in half long ways and then used my skill saw to cut wood out of the center of the cone. Finally, I had a 14-pound nose cone accurately turned. I had to glue a 1/8" piece of balsa wood in between the two halves to compensate for the width of the saw blade cut from cutting the nose in half.

The safety and arming switches for the on-board electronics.

Electronics and Shear Pins

My P5 and P6 have flown many times before using up to 2 grams of black powder for ejection charges. Both altimeters use flashbulbs to ignite the black powder. For this project I calculated that I would need 10 grams of powder in each charge. The P5 and P6 can hold up to 3 grams of powder each, so I had to modify each of them to hold the necessary 10 grams.

Next, I needed to verify that 10 grams of powder would shear the four #2 nylon screws that I was using as shear pins. I could not use the real rocket for the ejection test so I made a mockup of the center section of the rocket to simulate the ejection charge. I loaded my mockup and 10 grams of powder into our van. I parked near our Home Depot and set up the mockup 100 feet from the van. I could not believe the sound that 10 grams of powder makes. I picked up everything quickly before the police came to see what the noise was. Looking at the mockup at my house, I saw that the four shear pins did not shear; instead, all four screws were bent. My L3 adviser told that I could not just drill the screw holes, I needed to drill and tap the holes. Here I go again up to Home Depot with my mockup and black powder. This time the screws were sheared clean at the head of the #2 nylon screws. With this test done, I could move on.

Parachute

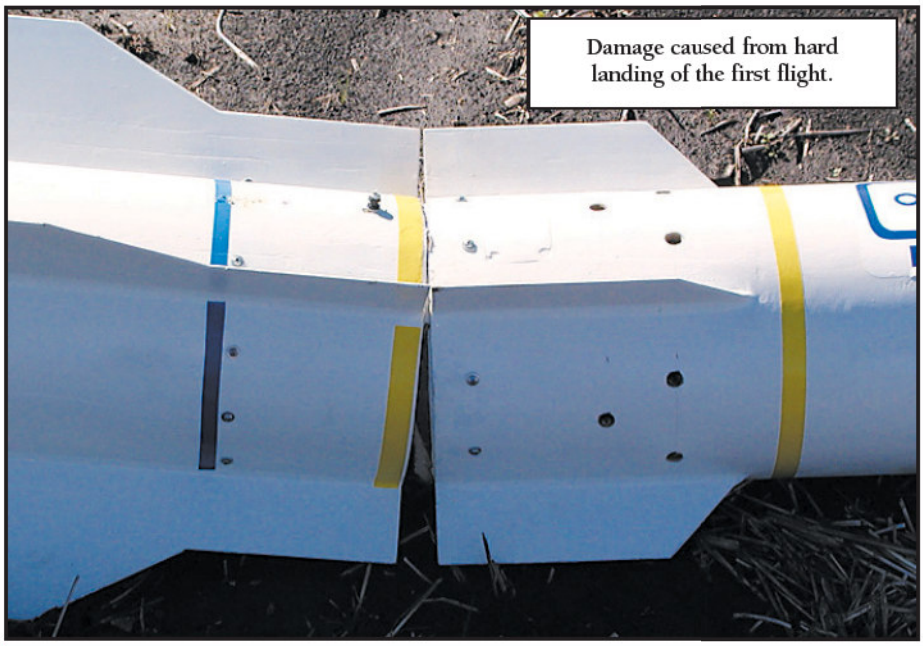
I decided to use one parachute on this rocket. If I had to do it over again, I would have the rocket separate into two parts, each with its own parachute. I went with the Standard R18C parachute from Rocketman. To help pull the R18C from the deployment bag, I used a 30" parachute attached to the end of the deployment bag.

Motor Selection

At this point in the construction of the rocket, I started to get scared. This rocket was growing fast! Did I really want to try for level 3? I considered just staying at level 2 and flying the rocket on L motors.

But RockSim calculated that an L850 was not powerful enough for this 63-pound rocket. Even a full L1120W would only lift it to 2100 feet. From 2100 feet, I could use just the main parachute instead of two-stage deployment using a drogue and a main parachute.

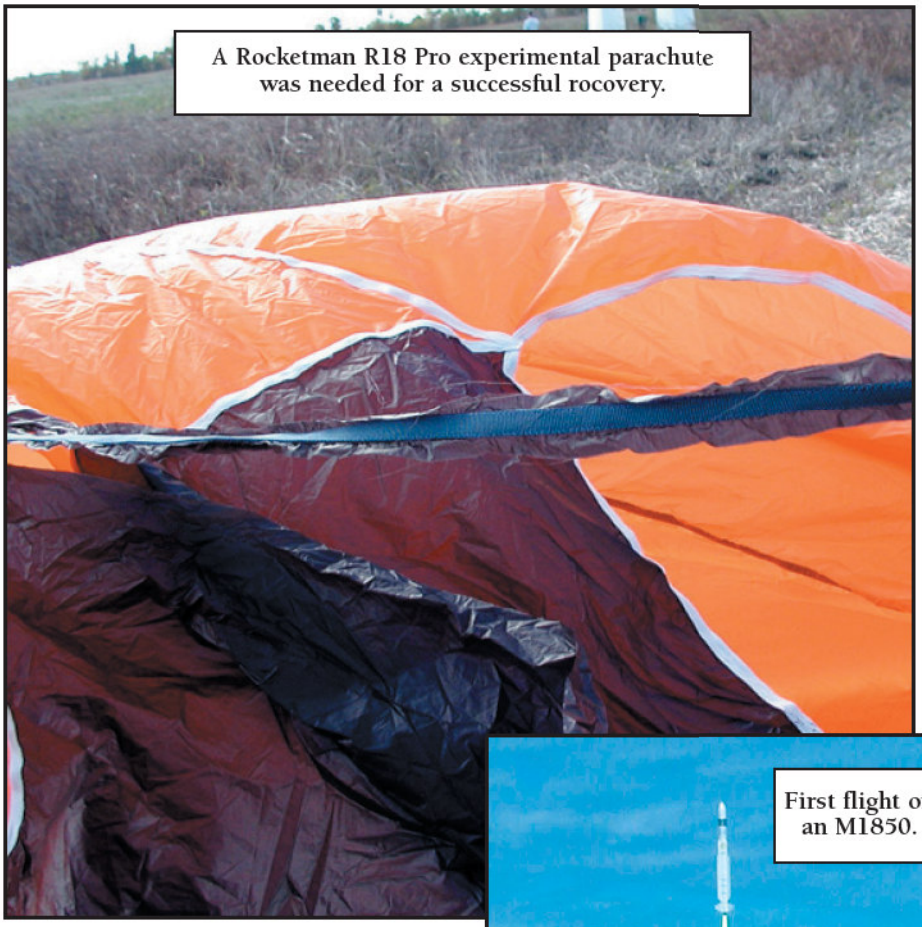
It was recommended that I forget the L1120 flight and go straight to the level 3 flight with a 75mm baby M motor. With an M1315 motor, the rocket could hit over 3700 feet—and the M1315 is just one motor size above the L1120. The problem with the Aerotech M1315 was I could not find one. Because of the fire at Aerotech and because Aerotech was so very slow to start manufacturing motors again, I had to switch to an Animal Works M1850.



Damage caused from hard landing of the first flight.

Launch #1

After almost two years of designing and building this rocket, launch day was here. On Saturday, September 7, 2002, I arrived at the launch site at 8:00 AM only



A Rocketman R18 Pro experimental parachute was needed for a successful rocovery.

to see we had 20 mph winds. The winds were too strong for me. At 4:00 PM, the winds stopped. We carried the rocket out to the pad. After the official picture of me with the rocket on the pad, things were ready to go. About the same time we took the picture, one of the club members came running out to the pad yelling, "Turn off the rocket and get it off the pad now!" We turned around only to see a wall of rain coming at us. You never saw a rocket come off a pad so fast. The wind stopped all right, but this was the calm before the storm. We put the rocket back into my van with about one minute before it started to rain.

The next day was even worse. It rained so hard that we had four vehicles stuck in the mud. Some of our club launch equipment was under water. Because of rain, the October launch was cancelled. The rocket would need to sit until November.

First flight on an M1850.

Launch #2

On Saturday, November 9, 2002, I again arrived at the launch site early hoping to launch this rocket. Again, the winds were 20 mph winds. No launch today—try again tomorrow.

On Sunday, the winds were fine, and it was finally time to launch the rocket. I loaded the black powder charges and the M motor. Finally the rocket was on the pad and ready. After the countdown the M motor came to life. My first thought was, "This is a scratch built 63-pound rocket...will it stay together? Is my CG and CP correct?" My next thought was, "What about the spear pins? Will they hold after the motor burns out?"

The flight was almost a success. The rocket held together and flew

straight, and the parachute deployed at apogee about 3,000 feet. The only problem was that the parachute canopy ripped completely free from one of its four suspension lines. We guessed that I lost about 40% of the parachute's effectiveness. The rocket landed hard but was in good condition. I am very lucky that the rocket survived this hard landing. Even though I could not do anything about the parachute failure, I did not get the level 3 certification. Everyone at the launch site agreed this was a normal deployment at apogee; the parachute should have survived the opening.

I felt that this 63-pound rocket was pushing the Standard parachute to its limit. I returned the R18 Standard parachute and replaced it with the R18 Pro experimental. Many thanks to Rocketman for working with me on this. Our next launch window was scheduled for February 2003. My plan was to replace the parachute, make a some other changes to the rocket, and try again. Because of rain, the February 2003 launch was cancelled. The rocket needed to sit until March.

Launch #3

On March 15, 2003, I tried again. I arrived at the launch site only to see more rain and clouds. About 11:00 AM, the rain stopped and so did the wind. We setup the high power pad and I finished the prep on the rocket. The clouds were at 6000 ft. and the wind speed was zero. The Animal Works M1850 motor came to life after the 10 second countdown. The parachute held together this time.

With the calm winds, the rocket landed only 150 feet from us. The winds were too calm; the rocket came straight down almost hitting cars and the city of McGregor, Texas, fire engine that was on site. The rocket missed the fire engine by 4 feet. The altimeter beeped out 4,000 ft. The rocket had slight damage to one of the side fins, but the rocket could fly again. After about ten minutes of inspections and my heart not beating, the L3 advisor announced that he was giving me the level 3. This L3 project took two years to complete.

Lessons learned

- The entire L3 project is a lesson in rocketry.
- Buy the 1-gallon containers of epoxy. I started buying the smaller cans, but the small cans do not go far. Buy the pumps also; you cannot mix this amount of epoxy by hand.
- Do not build a rocket with large side fins like my rocket. With the side fins, you can only fly this rocket on a very calm day.
- A rocket this size requires a large heavy-duty pad. Be sure you have access to a large pad.
- A rocket this size is hard to move by yourself. It takes four people to mount this rocket on the launch pad.
- A L3 project needs to be built strong, but I think I overdid it. This rocket is probably 10 pounds heavier than it needs to be.
- A L3 project this size should separate into two parts with two separate parachutes. I am going to rework this rocket to separate into two parts.

Many thanks go to everyone at Dallas Area Rocket Society (DARS). A lot of members had input on the building and launching of this rocket. A special thank you goes to Dave Schaefer, my level 3 committee member.