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NEWSLETTER

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Cover Photo: The Apogee Saturn V kit flown on a G80 Rocket Engine.
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Flying The Apogee Saturn V Kit On High Power Motors.

By Tim Doll

At NARAM 52, Tim Van Milligan mentioned that he is often questioned regarding flying the Apogee Saturn V with high power motors (basically, any motor H or larger). Having flown my Apogee Saturn V numerous times 'high power' – literally to failure - I thought I'd relate my experiences, along with the relative strengths and weaknesses of the Apogee Saturn V when subjected to the extremes of high power flight.

The Apogee Saturn V was designed pretty much from the start as a 'mid power' rocket – intended to fly with a motor using less than 62.5 grams of propellant with a liftoff weight of less than 1500 grams (~3.3 lbs). While a conscious decision to keep from limiting the potential market to those with a high power certification, making a large Saturn V 'mid power' necessitated certain design compromises to keep the rocket weight within the mid power thrust and weight constraints. In essence, it constrained the motor mount to 29mm and limited the weight and hence strength of the rocket. A similar size Saturn V, designed with high power in mind, would have been stronger and hence heavier – making it unsuitable for mid power flight.

I've built three Apogee Saturn V's – the first was always intended to be a flier, the next two were flight capable but built as display models (one of which graces the Man-in-Space display at the Seattle Museum of Flight as shown in Photo 1). Lessons learned have meant each subsequent Saturn has come out a little better than the last, but all were built basically stock per the Apogee plans.

At the time when I built that first Saturn I hadn't seriously considered the prospect of flying it high power, and I didn't make any significant upgrades to handle the increased thrust other than to not install an engine block (so as not to limit the length of motor I could potentially use) . After one semi successful flight on the recommended G80-4T, and a couple very successful flights on G64-4W RMS motors (www.rocketreviews.com/reviews/all/apo_saturn.shtml#TD), I decided to use the Saturn V to attempt my Level 1 high power certification flight. My motor of choice was an H128W-S, and although there as a little bit of 'coning' on the way up (suggesting I didn't add quite enough nose ballast to compensate for the heavier motor), it was a good flight resulting in a successful Level 1 Certification.

Flying the Apogee Saturn V is a little magical – even on

Photo 1: Tim Van Milligan stands along side the Apogee Saturn V kit built by Tim Doll at the Seattle Museum of Flight.

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a G people tend to stop what they are doing to watch - and flying it High Power just magnifies that experience. After the successful certification flight the H128 motor became my normal motor (I added a little more nose ballast, and subsequent flights were arrow straight). I made a total of six high power flights with my Saturn V prior to NARAM 52 – five with an H128W, once with an H180 (a strange weathercock about 50 feet up and resultant high speed parachute deployment with the H180 resulted in some damage and spooked me enough that I've so far not tried it again).

Unfortunately, at NARAM 52 I discovered the limitations of a mid power Apogee Saturn V on high power, as it suffered multiple failures when flown on an H128W. The flight appeared picture perfect during boost. But when the parachutes opened it was a different story - the main parachute ripped the entire motor mount assembly out of the booster. Fortunately, without the mass of the motor or motor mount the booster sort of glided down and damage wasn't too serious. More surprising was damage to the upper 3rd stage portion – the third stage/service module transition had collapsed nearly an inch into the third stage. It's not clear when or why it happened as the upper stage recovery appeared nominal.

Photo 2: A destroyed motor mount after the 7th flight.

So, what does all this mean if you want to fly the Apogee Saturn V on high power? As I demonstrated, if built properly the basic rocket is strong enough to handle an occasional flight on a 29mm H motor – all you really need to do is add enough nose ballast to compensate for the heavier motor. But if you plan to regularly fly it High Power, you'll want to incorporate some upgrades.

Photo 3: Damage to the transition was unexpected.

First off, if you're going to fly this beautiful bird – mid power or high power - you need to expect some damage; it's going to get beat up. The fins are particularly fragile – I'm sure I've broken every fin at least once (they tend to snap off on touchdown where the fin transitions to the insertion 'tab'). The repair is straight forward with some CA, although fishing the broken tab out of the fin-fairing can be tricky (note to Tim VM – you might want to consider listing the Saturn V fins as spares on your website along with the

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wraps). As part of the post-NARAM refurb, I've created some new flight specific fins (details later). The fin-fairings are also fragile, they typically hit the ground first and if it lands on a rock or other hard surface the fairing will be damaged. In my opinion, if you plan to fly your Saturn, the 'option' of reinforcing the fairings with a thin layer of epoxy clay isn't an option – it's mandatory.

Upgrading the engine mount is a necessity for regular high power flights. Although the stock cardboard centering rings are impressively strong, they are not up to the task of repeated high power flights. As a minimum, I'd upgrade the centering rings to 1/8" plywood (or thicker – I'm using 5/32" centering rings in my rebuild – also provisioning for four 24mm motors surrounding the 29mm core engine). Another option would be to upsize to a 38mm motor mount tube, greatly expanding the potential motor selection.

I remain puzzled by the collapse of the LEM transition into the third stage – it took considerable effort to remove the transition after the collapse (meaning it took considerable force to cause the collapse) and it's hard to understand how it could have experienced that sort of force during an otherwise nominal flight and recovery. At any rate to avoid a repeat, I took a surplus BT101 coupler, trimmed it to size, and glued it into the S-IVB stage to support the base of the LEM transition.

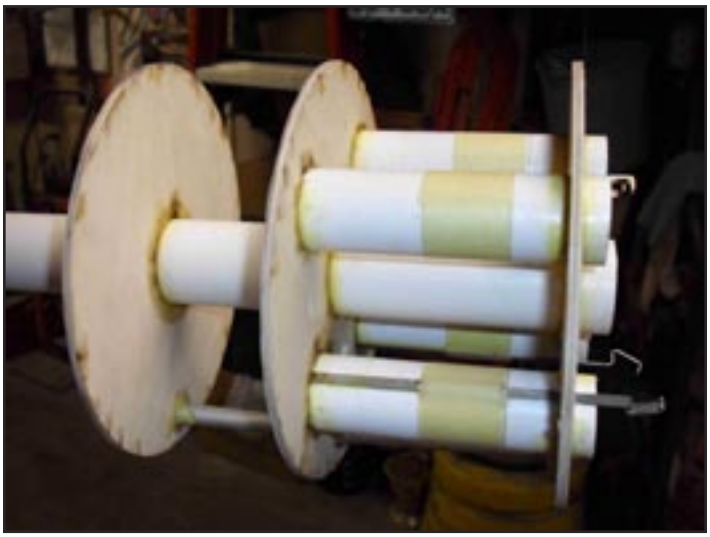

Photo 4: Plywood centering rings used in a 5-engine cluster version expected to fly this spring.

The Apollo escape tower is fragile and even mid-power it was pretty much 50-50 if it would survive a flight intact. I know many people simply leave the tower off for flight, but I pride myself on my scale models, and I just don't think it looks 'right' launched without the escape tower. I tried replacing the vertical escape tower struts with piano wire for additional strength, but that didn't really help. Ultimately I gave in, ending up with two Apollo capsules – a ballasted flyer missing the escape tower, and a display only capsule with the escape tower. However, while I was busy with the rebuild, our dog chewed up the 'flyer' capsule so I'm trying something different.

Photo 5 (left) shows 7 ounces of clay stuffed into the capsule. Photo 6 (right) the clay has been replaced by 9 ounces of lead shot and epoxy.

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On the new capsule I drilled a ¼" hole through the middle and installed a piece of clear acrylic rod between the capsule and the escape motor to reinforce the tower. I'm also using lead shot for the nose ballast – I ultimately ended up with seven ounces of clay for ballast which is about the maximum amount of clay that the capsule will hold – not enough for the planned five engine cluster capability. As a baseline I epoxied nine ounces of lead shot into the new capsule, and there is still plenty of room to add clay ballast if needed for the five engine cluster.

I added rail buttons, something I recommend even if you only fly mid-power. Not only does a rail eliminate the risk of rod whip, rails are typically available in longer lengths than ¼" rods and the extra length is desirable with this rocket. Be sure to allow adequate clearance between the rail and the fin fairings when locating the rail buttons.

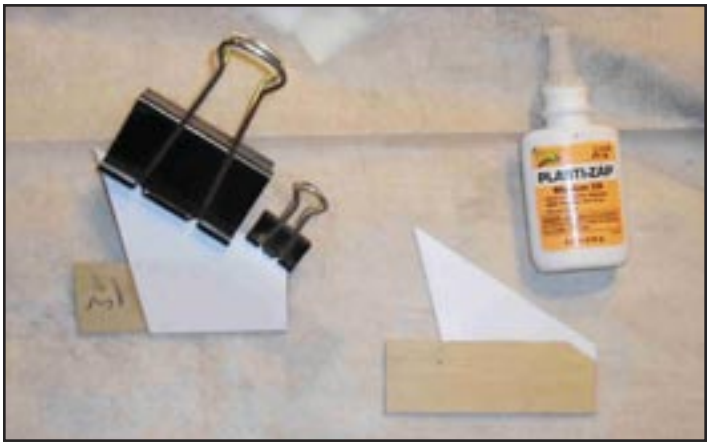


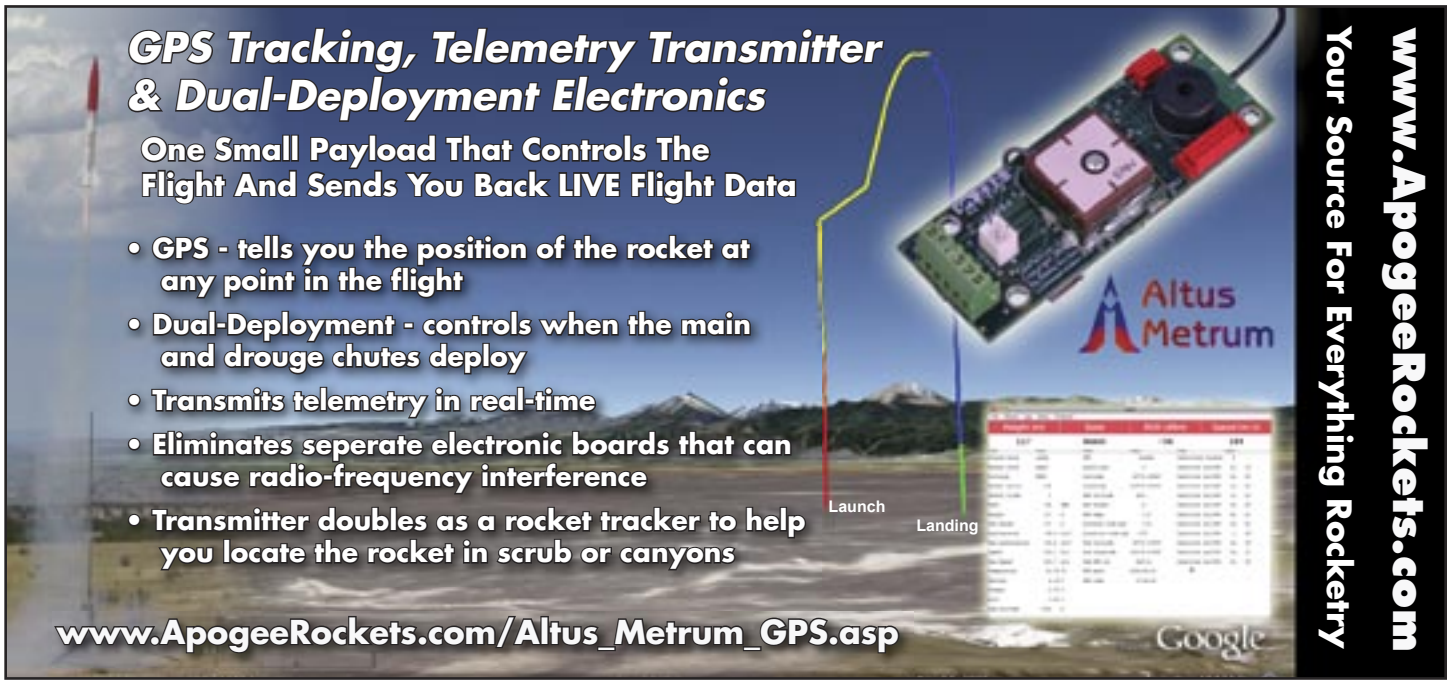
Photo 7: The resin fins were replaced by a built-up fin for extra durability for the actual launches.

I decided it wasn't practical to strengthen the stock resin fins, so I created new 'flight only' fins out of basswood and sheet styrene plastic. I used a piece of 1/16" basswood 15/16" wide for the fin tab, extending the full length of the fin. I then cut fins out of .030" styrene sheet and laminated them to the fin tabs with "Plastic-Zap" CA, gluing the leading edges together. A little green putty to fill the gaps, some touch-up sanding, and the flight fins were ready to paint. I made the flight fins a little oversized, extending them ~3/8" in both height and width. Although visually the increase is not readily apparent, it nearly doubled the effective fin area to provide an extra margin of stability.

Winter in the Northwest means it'll be April before I have the opportunity to fly my rebuilt Saturn V. One down side of high power rocketry is it pretty much eliminates 'spur of the moment' launches, and the extra weight I added during the rebuild pushed the flight ready weight over the 1500 gram limit for Class 1 rockets. However I have high confidence that the improvements I incorporated during the rebuild will make my Apogee Saturn V an even better flyer on H and even I motors, I can't wait to try it out!

About the Author:

Tim Doll lives in Everett, Washington.



Apogee Saturn V On Five F10 Motors?

By Tim Van Milligan

Can the Apogee Saturn V kit be flown on a cluster of five F10 motors? That was a question that Brian Schneider wanted to know when he contacted me about four years ago. My answer was "probably." There isn't any real reason why it can't, it only needs some modification to the aft end of the model where the motors go.

Brian wanted to build the Saturn V with his father, Dan Schnieder, who used to work on the Apollo program (see Peak of Flight Newsletter 216 at: www.ApogeeRockets.com/education/dowloads/Newsletter216.pdf). The cluster of five F10 motors has the advantage of giving a total burn time of nearly 8 seconds. If you're looking for that slow, realistic lift-off that just seems to go on forever, the F10 is about as good as it gets. The only downside is that it is so efficient that it doesn't make a lot of tracking smoke during the burn.

Figure 1: The cluster of 5 29mm diameter motors, with Aeropack engine retainers.

Brian was intrigued, and sent me a lot of questions during his build phase.

The most pressing problem that has to be solved with a cluster of 5 motors, is it will really move the CG really far rearward. That is not good, since it makes the model unstable. You would either have to add a lot of nose weight, or make the fins bigger.

Brian's solution, as you can see in the accompaning photographs, used several techniques; including using larger fins. In addition to that, he tried to keep the motor mount as light as possible. You can see he kept the motor mount tubes of the outer motors fairly short. Then he cut holes in the rings to further reduce the weight of the rings.

These "lightening" holes as they are called, also serve a secondary purpose too. They allow the ejection charge gases of the outer motors to vent out the rear of the rocket. Basically, they blow forward like a typical rocket, but since the tube is plugged by a bulkhead, they have to turn around

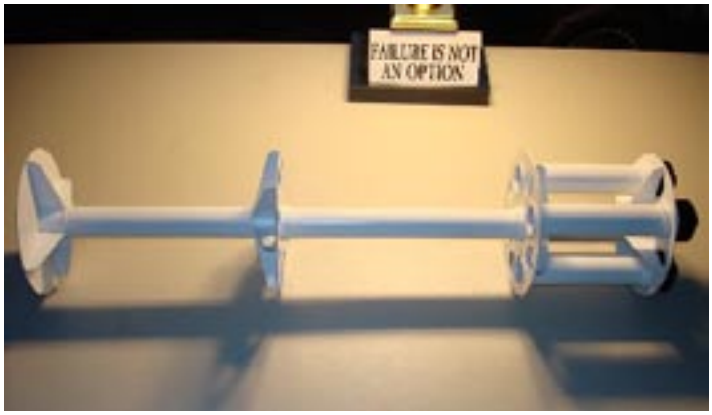


Figure 2: The central motor kicks out the parachute, and the perimeter motors vent the ejection gases out the base of the rocket.

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and escape out of the rocket through the bottom end.

Like Tim Doll did in the previous article, Brian also had to add a bunch of nose weight to the rocket to move the CG far enough forward.

Figure 3: The aft end of the rocket with the five motors hooked up and ready for launch.

But, the basic construction of the rocket was fairly typical of the Apogee Saturn V model.

One extra modification that Brian used was to add Aeropack engine retainers to each of the five motor mount tubes. Because the outer motors we're going to use turn-around and vent rearward out the aft rings, there would be more force on them than if they simply pushed off the nose cone on the front end. So strong engine retention is a must in this situation.

Brian and his dad finally launched the 5-engine cluster two times last October. He said that the first launch had a mis-fire on one of the outboard motors, so it only went up on four motors. The launch video showed the flight was stable, although it did do a little bit of coning on the way up (like a big barrel roll). That typically means that it needs larger fins and more nose weight to get it to go a bit straighter.

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But the second flight, according to Brian was spectactular, as everything worked perfectly.

The videos of the flight are on YouTube at:

http://www.youtube.com/watch?v=Rg9tF_VwaFo

http://www.youtube.com/watch?v=mxHB3mSNHRI

Figure 4 (Left): The five needle-like flames of the F10 motors are clearly visible as the Saturn V takes to the sky.

Figure 5 (above): Brian holds up the bottom portion of the rocket after the successful launch. Figure 6 (left): The intense radiant heat of the five recessed motors charred the base of the tube after the two launches.