Issue 631 / July 30th, 2024

PEAK OF FLIGHT NEWSLETTER

Apogee Components, Inc. / ApogeeRockets.com / Colorado Springs, CO

Molding Helicopter Blades - Part 1

Also in this issue:
Tim's Messy Desk

NIKE SMOKE

-Pro Series II-

PEAK OF FLIGHT NEWSLETTER

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COVER PHOTO

Estes Nike Smoke

This is a 1:5.5 scale model of NASA's innovative atmospheric research rocket. At 41 inches long and 3 inches in diameter, this awesome replica features pre-molded plastic fins, a large conical nose cone, and launches on 29mm diameter motors. Easy to build and exciting to fly, it is perfect for space enthusiasts, rocket hobbyists, and speed seekers.

FEATURED ARTICLE

Molding Helicopter Blades - Part 1

by Tim Van Milligan

What does it take to make molded rotor blades for the competition rockets? And why would you even want to?

Tim's Messy Desk

What's Coming Next?

by Tim Van Milligan

In our blog, you'll find out what Tim has been up to, and what are some of the future projectes we're working on for later this year.

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About this Newsletter

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DynaStar Amarok rocket rips skyward.

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PEAK OF FLIGHT NEWSLETTER

Molding Helicopter Blades - Part 1

by Tim Van Milligan

Issue 631 / July 30th, 2024 www.ApogeeRockets.com

In this article, I'll share with you my philosophy and techniques on molding rotor blades for the competition rockets that my daughter has used in previous world championship events.

Why mold the blades, instead of sanding them like a balsa wood fin? Because you are better able to control the properties of the blade and get a consistency that you can't achieve any other way.

This will be a two part article, with the first part going over some of the history of our development and what problems we were attempting to solve. We'll also cover the process of building the special mold that will form the blades. In the second part of the article, we'll go through the assembly and build of the actual blades in a step-by-step manner so that you can duplicate it yourself and get similar results to what we were able to achieve.

I am very pleased at the way they came out, and I'm hoping that some other modeler will pick up the technique and carry out some future exploration to make them even better.

Figure 1: Molded Blades ready to mount in a helicopter model.

It has been a long journey of over 10 years of making small, minor improvements. But if you make enough of them, you can end up with some pretty remarkable achievements to where we are right now. And right now, my daughter Ashley is at the top of the leaderboard in every event that she is competing in, including one of our favorites, "Gyrocopter duration." That is truly a stunning achievement, which we believe is a result of having high quality rockets that perform consistently well. What I'll do in this article is share my secret methods, so that you can have the same level of achievement that we have attained.

So to begin, I'll start with some history of how we got to the point of molding helicopter blades.

The History of Our Competition Rotor Blades

As many readers know, I've been fascinated with helicopter recovery models since I saw my first one in the early 1980's. To me the challenge was to make them perform better, by having them fly higher into the sky and then increasing the amount of hang time in the air.

I've played around with just about every type of helicopter model I could find. But real progress on increasing their performance was when I discovered curved blades. In *Peak-of-Flight Newsletter #342* (July 2, 2013) {**https://www.apogeerockets.com/education/downloads/Newsletter342.pdf**}, I wrote about my first encounter with curved helicopter blades. They excited me, because they allowed three large blades to be inserted into a body tube. Putting the blades on the inside of the rocket reduces the drag, and allows the rocket to fly higher in the sky. It was a

key to competition success and flights that still get spectators to marvel at..

Once I learned how to make the basic curved blades, I turned my attention to the next challenge that I thought was important - which was "how do you attach the curved blades to the hub?" The result of that was an R&D report, which was turned into an article that appeared in *Peak-of-Flight Newsletter #375* (October 7, 2014 - **https://www.apogeerockets.com/education/downloads/Newsletter375.pdf**). The hub that I came up with is used in several kits, like these:

Rotary Revolution (**https://www.apogeerockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/Rotary-Revolution**)

GyroChaser (**https://www.apogeerockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/Gyro-Chaser**)

Mini-Copter (**https://www.apogeerockets.com/Rocket-Kits/Skill-Level-5-Model-Rocket-Kits/Mini-Copter**)

The hub and the hinge support arms are lightweight and strong, and performed marvelously. They turned out so useful, that other rocketry vendors are stealing and copying my basic hub design.

Once we figured out the way of attaching the blades to the hub, we returned to the blades to see what shape of a blade was most efficient and offered the slowest descent rate. My daughter Allison did an R&D report on that topic, which you can see in *Peak-of-Flight Newsletter #381* December 30, 2014 (**https://www.apogeerockets.com/education/downloads/Newsletter381.pdf**). We call that blade shape "Allison's optimized blade shape," and we're still using it for all our competition helicopter rockets that we make.

In 2015, Chris Flannigan, who has written some *Peak-of-Flight* articles for Apogee, mentioned to me that a blade with less curvature was more efficient than the highly curved blades that we use in the Rotary Revolution kit. In fact, he did an R&D report titled *Blade Aerodynamics of Helo Duration* (NARAM 57, 2015) that you can download from the NAR's website if you are a current member.

Based on this, my youngest daughter Ashley did a R&D report on the topic of blade curvature. You can read it in *Peak-of-Flight Newsletter #397* (**https://www.apogeerockets.com/education/downloads/Newsletter397.pdf**)

We did find that a flatter blade did indeed fall slower, but it had a couple of drawbacks. First, it didn't spin up as quickly as a highly curved blade. So you lost a lot of altitude waiting for the rocket to start rotating.

Another drawback was that it was less stiff than a highly curved blade. A flexible blade isn't necessarily a bad thing,

Figure 2: Curvature comparison of my new blades (left) with the old blades used on the Rotary Revolution.

as you get some natural dihedral as the blade tips flex upwards once they are deployed and the rocket starts to descend. This is stabilizing, and keeps the rocket oriented with the hub towards the sky.

However, the slightly curved blades are more susceptible to warping due to humidity in the air. You never know which way the thin blades are going to warp, and we found out that some sets of blades wouldn't spin up at all, because they warped to the point where they didn't have the negative angle-of-attack that is needed to cause rotation.

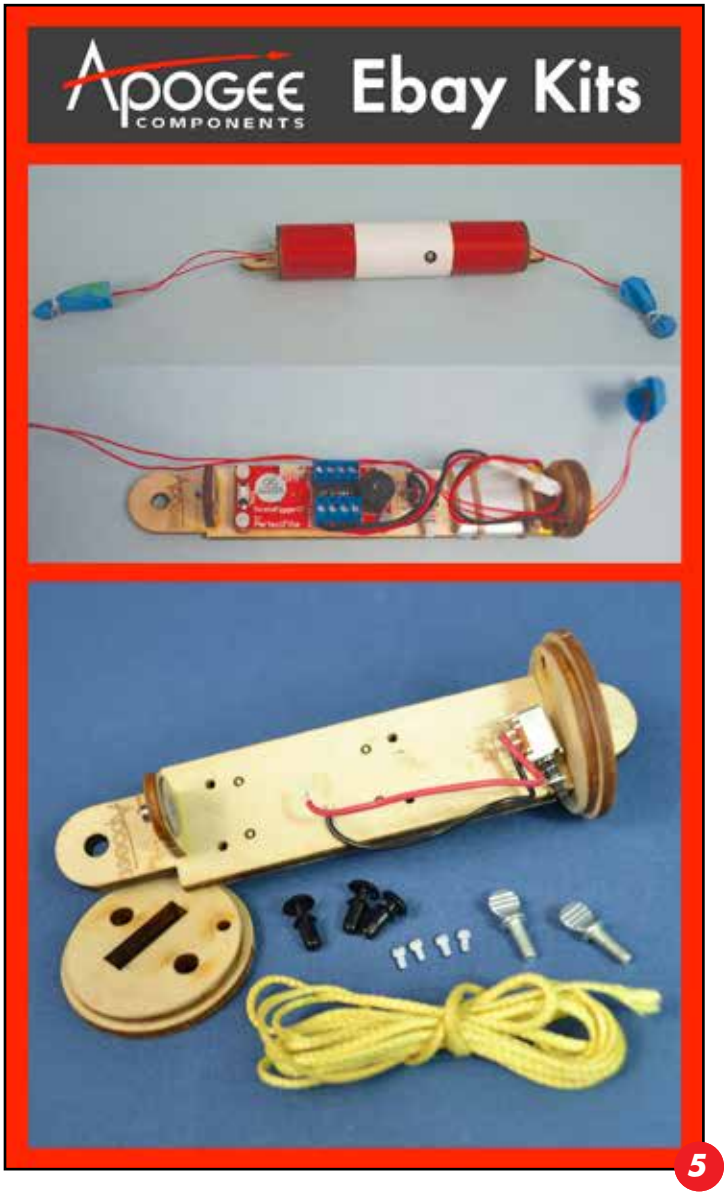
To try to counteract this and improve the spin up of the rotor blades, we gave the blades a 5° twist. This was the topic of Allison's R&D article in *Peak-of-Flight Newsletter #398* (**https://www.apogeerockets.com/education/downloads/Newsletter398.pdf**). This twist indeed helped the blades to spin up faster, which helped increase the duration time of our competition helicopters.

At the time, we were using 1/16" thick balsa wood for the rotor blades on our competition helicopters. They were doing OK, but the rockets weren't boosting as high as we liked, because they were heavy. In an effort to reduce the weight, we reduced the thickness of the wood by half, dropping down to 1/32" thick balsa.

Figure 3: The blade was tilted on the pvc pipe during the curvature process in order to give it a negative pitch angle by 5° in order to induce a quicker spin-up upon deployment.

This thin wood is OK for highly curved blades, like on the Rotary Revolution kit, but not as good for our slightly curved blades. Because they were thinner, the humidity in the air really warped them a lot which caused rotation problems. We had to prevent them from warping.

First, we tried painting the blades to keep the moisture out. But it was heavy, and really didn't add any strength to the blades. Our next solution was to add fiberglass cloth to the surface of the blades. This did help with the warping of the



wood, but fiberglass is heavier than paint.

We then switch to carbon-fiber tow, which is attached to the blades using epoxy. This really stiffened them up. Our initial technique of spreading out the tow and attaching it to the blades can be found in *Peak-of-Flight Newsletter #478* (**https://www.apogeerockets.com/Peak-of-Flight/Newsletter478**).

Carbon-fiber is so incredibly strong, that we were pleased to discover that we could drastically reduce the amount we used on the rotor blades to save even more mass. A little bit goes a long way. This allowed the rocket to ascend higher into the sky, and increased the descent time because it was lighter than before. Our technique for applying the carbon-fiber tow to the blades changed because the amount we added was less. You can read those techniques in *Peak-of-Flight Newsletter #577* (**https://www.apogeerockets.com/Peak-of-Flight/Newsletter577**).

While this was going on, around 2016 I also revisited the hub that was used on our competition models. While the laser-cut plywood hub works great, I wanted to reduce the mass to as low as possible. So I contracted a 3D printer company to make me a prototype hub out of plastic, and I've since made a silicone rubber mold of that piece so I could duplicate it. I'm currently making them out of epoxy, but I'm thinking that modern 3D print technology has gotten to the point that I can print them instead of molding them.

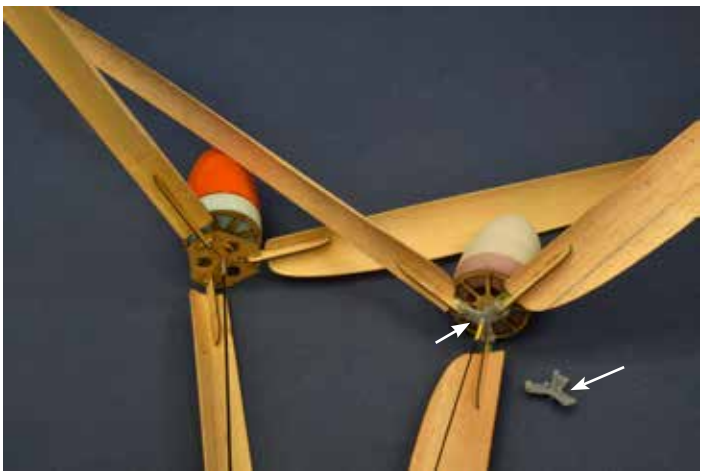


Figure 4: Rotary Revolution hub (left) can be simplified with a 3D printed hub (right)

What Could Be Improved on the Blades?

My blades at this point were structurally sound. They worked great, but they had two small flaws.

First, they weren't smooth on the outer surface. The reason is that adding bundles of carbon-fiber tow to the surface leaves speed bumps on the skin. They are relatively small, but it bugged me that they weren't as smooth compared to just sanded balsa blades. And unfortunately, they can't be sanded once they are attached, because the fibers are so fine. If you sanded the surface, they would easily come off the surface and you'd lose the added strength they add.

The second issue is that the carbon-fiber covered blades are totally black color. This is not my preferred color, because once the rocket lands on the ground, the blades blend into the shadows on the ground making the rocket hard to locate.

I could paint the blades, which would also allow the surface to be smoothed out. But paint adds weight, and I wasn't willing to do that just to make the rocket easier to find on the ground.

What was going on in parallel during all this time, was my

work on making lightweight composite tubes for the rocket bodies. I was trying to perfect the traditional approach of making competition fiberglass/epoxy tubes using an aluminum mandrel (see **https://www.apogeerockets.com/education/downloads/Newsletter434.pdf**). The main driver was to get a glass smooth surface on the outside of the rocket.

The conclusion of that process was the realization that in order to get a smooth surface on the outside of the rocket, I'd have to have a two-part female mold, instead of a male mandrel mold.

It was in 2020 that I switched from using a mandrel to a two-part female mold, and forming the tubes in an entirely different method.

The culmination of that project is that I feel that I've just about perfected the ultimate body tube for competition rockets made from carbon-fiber and epoxy. The tubes for the helicopter rockets now weigh under 3 grams, and the surface is glass smooth.

If you're interested in learning the techniques, I've created a Udemy Academy course that will walk you through the process. It is at: **https://www.udemy.com/course/make-ultra-lightweight-carbon-fiber-tubes-for-model-rockets/?referralCode=5CAB535D852E3B3529A1**.

What I realized from the process of making tubes, is that if I wanted smooth blades, I'd have to mold them in a two-part mold too.

This would involve a massive commitment, because once you make a mold, you can't change anything about the blades shape. And it would be time consuming to make up the molds, plus the expense of the materials required.

But I made the commitment, and I started working on it early 2023. The basic techniques for making molds can be found in Apogee Technical Publication #12 (**https://www.apogeerockets.com/Rocket_Books_Videos/Pamphlets_Reports/Tech_Pub_12**).

The process starts with making a finished pattern of how you want the blade to be. In my case, it is a very thin balsa sheet that has been curved around a 4-inch diameter pvc pipe. The surface finish had to be perfectly smooth, so I painted up the balsa wood after curving it to give it the correct camber and shape. The balsa wood blade was so thin and fragile, that I actually snapped and ruined several pieces while trying to sand the surface smooth. But finally I got a good pattern that I could use for making the Silicone RTV rubber mold. The final blade that became my "pattern" that I wanted to replicate is shown in Figure 3 on page 5.

Figure 5: The blade was positioned on the PVC pipe, and then a Silicone RTV mold was made from that. There are two sides to the surface of the blade, so a second silicone rubber mold was made (middle).

The blade was then tacked down to the PVC pipe using a spray adhesive. After that, I build up a box around the blade, into which I could pour the liquid silicone RTV rubber. Normally, building up a box around the part is easy, because normally the part is flat. But this blade had a curvature to it. So I actually had to build the box to attach to the PVC tube.

I wish I had taken photos of the process of making the molds, but I didn't.

Once the rubber has cured and hardened, everything is removed from the pvc pipe. The blade has to stay in the rubber, so that a second box can be built around the rubber. You do this, so that you can get a mold of the underside of the curved blade. So essentially, we're making a rubber mold of the first rubber part. This is shown in Figure 5.

The goal is to make a hard resin mold, that matches the rubber molds shown in Figure 5. The rubber is too soft to adequately press the carbon fiber into the surface of the balsa wood blade. I tried it… but it didn't work. The mold needs to be harder than the surface of the balsa wood.

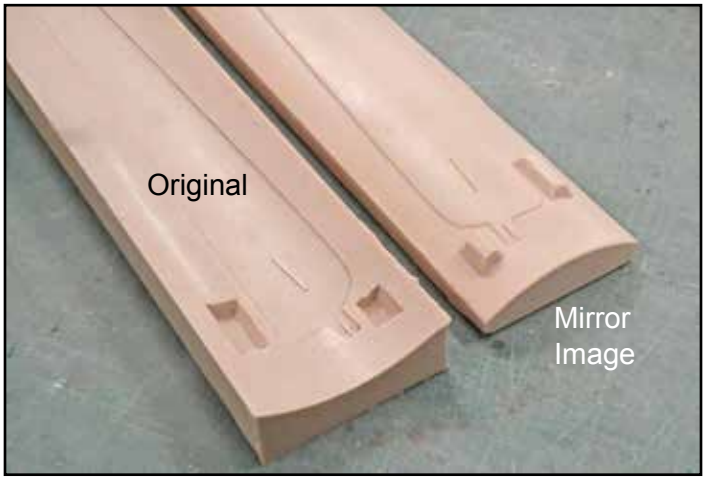


Figure 6: Each of the rubber molds had to be "reversed". So a total of four batches of silicone were made to this point.

So to make a hard resin mold, we actually have to reverse each side of the mold shown in figure 5. For example, in the left-hand side, we see the blade "depressed" into the surface of the rubber. We want it to be "raised" off the surface. If you get it like that, then that you can pour resin over the mold to make a "hard" mold that can be used to form balsa helicopter blades.

Figure 6 shows the mold from Figure 5 on the left side, and it's mirror image that we need to form the hard resin mold.

All told, I had to make four separate rubber parts just to get ready to make the first hard resing mold. Figure 7 shows one side of the hard resin mold, along with the rubber mold that was used to create it. I added a little bit of dye coloring to the resin to give it a blue color. But the color doesn't mean anything really.

I actually made three hard molds of the blades, so that I could make three helicopter blades at once which would give me enough for a single 3-blade helicopter model.

Conclusion of Part 1:

My long-standing fascination with helicopter recovery models has put me on a quest to improve their performance. This began in the early 1980s and led to innovative discoveries like curved blades, that allowed rockets to fly higher by reducing drag. Attaching these blades to the hub in novel ways was another milestone that improved performance. Additional studies and R&D reports led to further optimized blade shapes and adjustments to blade curvature for better efficiency. Issues like blade warping due to humidity were addressed by using materials like carbon-fiber tow and epoxy to seal the surface. The process of making lightweight,

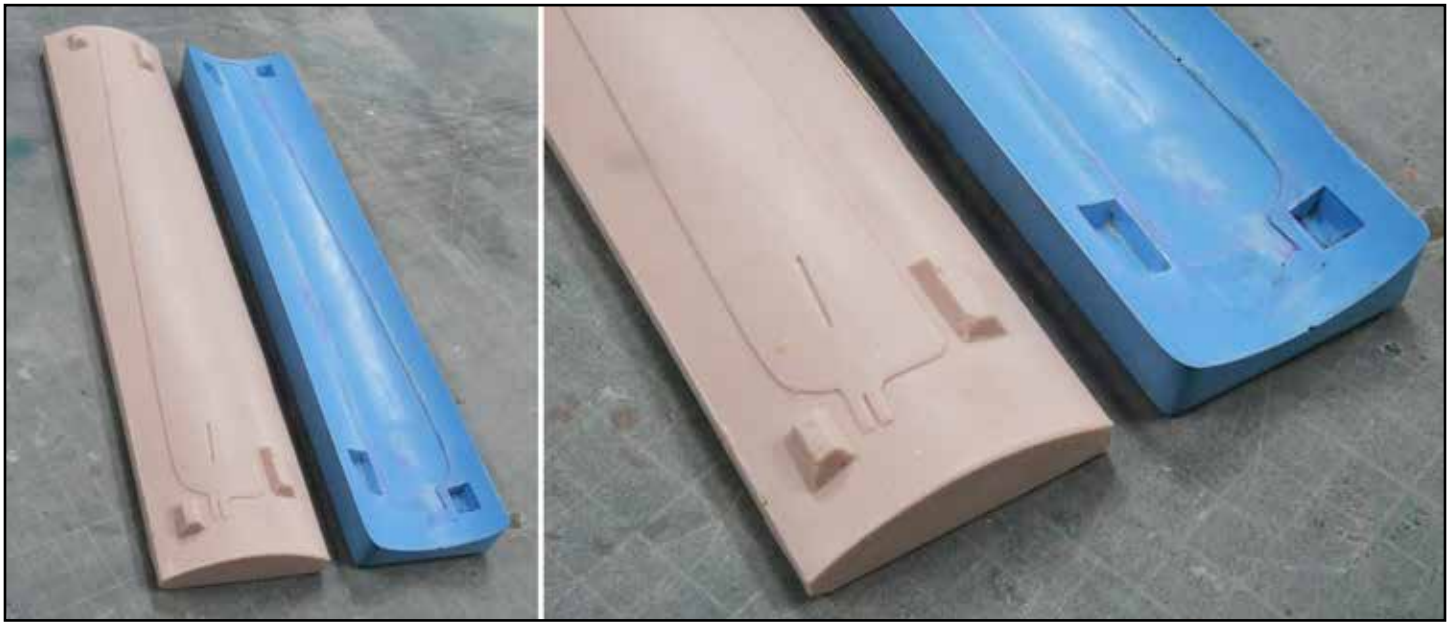


Figure 7 - Using the reversed rubber mold, a hard resin mold was created. This would be the final mold needed to press the fibers into the surface of the balsa wood blade.

smooth-surfaced composite tubes for rocket bodies was the final inspiration that led me to try molding the blades for the next generation helicopter models.

This article concluded with the process of how the molds for the blades were made using silicone RTV rubber and resin casting.

In the second part of this article, we will discuss the actual step-by-step process of molding the helicopter blades, and some of the challenges you might face during the assembly process. And we'll also apply this technique to molding other parts, such as the fins on your rockets. So be sure to stay subscribed to this newsletter to be the first to read part 2.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. He is an avid rocketry competitor and is Level 3 high power certified. He is often asked what is the biggest rocket he's ever launched. His answer is that before he started writing articles and books about rocketry, he worked on the Delta II rocket that launched satellites into orbit. He has a B.S. in Aeronautical Engineering from Embry-Riddle Aeronautical University in Daytona Beach, Florida, and has worked toward an M.S. in Space Technology from the Florida Institute of Technology in Melbourne, Florida. Currently, he is the owner of Apogee Components (http://www.apogeerockets.com) and also the author of the books: Model Rocket Design and Construction, 69 Simple Science Fair Projects with Model Rockets: Aeronautics and publisher of the "Peak-of-Flight" newsletter, a FREE ezine newsletter about model rockets. You can email him by using the contact form at https://www.apogeerockets.com/Contact.

PEAK OF FLIGHT NEWSLETTER

Issue 629 / July 2nd, 2024

www.ApogeeRockets.com

Tim's Messy Desk

by Tim Van Milligan

I've been enjoying my summer because my two daughters still want to hang out on occasion. I took a week off during July 4th, and visited my daughter Allison in Florida. She is getting ready to move out of the state, and wanted me to come over and hang out at the beach and get some help with packing for her move.

We had some really enjoyable days at the beach, just swimming in the Atlantic ocean and chill'in in the ocean. But one activity she wanted me to participate in, was 5K foot race along the beach. I hadn't participated in a race since I was in the 7th grade in the late 1970's.

While the race started at 8 a.m., it was already scorching hot (see Figure 1). I felt pretty good, considering that I don't really run outdoors here in Colorado. I usually run on an elliptical machine so that it isn't so hard on my joints.

But with the heat, plus the high humidity of Florida and the pounding of the hard sand at the beach, I injured my left foot pretty badly. I barely crossed the finish line, and after that I couldn't put any weight on the foot at all. But I finished the race, and actually took 1st place in my age division, and 24th place overall out of over 450 runners.

Would I do it again? The pleasure of running with both my daughters made it worth it, as we now have another great story to enjoy in the future.

As I write this, I'm working with my other daughter, Ashley, to get ready for NARAM at the end of July. Building rockets together is so much fun. That is the real joy of rocketry - the time you share with the people you love. And I've seen her devotion to the hobby start to really devel-

Figure 1: Tim at the half-way point in the race on the beach.

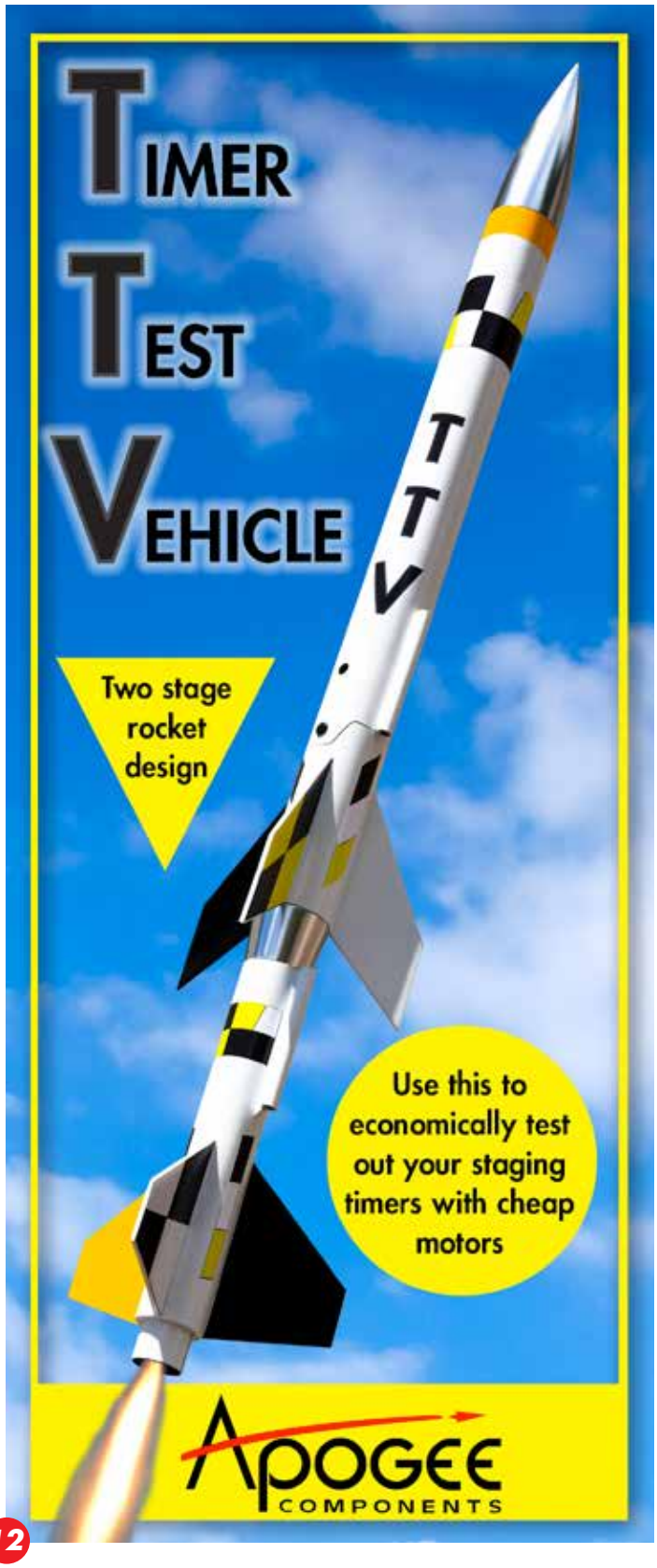
Figure 2: Ashley Van Milligan prepping her rocket at the July 20th launch in Pueblo, Colorado

op, which gives me a warm feeling in my heart. At this NARAM, we're going to work together as a team instead of competing as individuals. She is also trying out for the FAI team, in order to be able to compete for the USA in Serbia next summer. Those FAI models take a little longer to construct, because there is a lot of prep work involved. Nearly everything is "molded", including the fins. The main article in Peak-of-Flight Newsletter 631 is about the process of molding balsa wood parts. The advantage is they are stronger, flatter, smoother, and have a shiny metallic appearance that helps to make the rocket sparkle and so tracking is a bit easier. It also adds some consistency to the process, so that all the fins are more uniform when compared to each other.

I've also been mentoring via Zoom another young woman that is trying out for the FAI team in the Junior division. I've been on the mentor list for years, and this is the first person that actually requested my help. To be frank, other people think she is getting an unfair advantage by having me as a mentor. She's already making rockets that are performing well beyond others in her age division.

The point is, that I've been giving out advice to rocketeers for decades. That is exactly what we do here at Apogee Components. Our motto is *"your success is our mission."* What that means is that once you create a rocketry goal, we will be behind you to help you succeed. Whether it be to win a contest, or get your level-1 high power certification.

So when someone actually comes to me for help with their



rocketry project, of course I'm going to give advice to help them succeed. And succeed she did.

I would have helped other people that wanted help in this event too. But they wanted to do things on their own. That is totally fine, and I do encourage people to experiment and try new things.

After NARAM ends, we will get more focused on our new products that we've been planning for release later this year. We talked about what new rockets we'll be working on during our NARCON presentation in February, so this isn't some kind of corporate secret. This is a status update to keep you informed about what is coming. Keep this in mind as you start to plan out your future rocketry purchases.

The next rocket in the development line is a high-power two stage rocket. There aren't too many of them out in the market, and we think that there are rocketeers that want to try something more challenging, but with the higher quality that comes from an Apogee Components kit.

This new rocket will be called the Invicta, and will be based on our 3" diameter nose cone. It will be a big rocket, with 29mm diameter motors in both the lower and upper stages. It will operate very similarly to the TTV rocket (**https://www.apogeerockets.com/Model-Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/TTV**) from 2023. We came out with the TTV so that modelers like you that wanted to do

Figure 3: The 2-stage Invicta rocket on a test flight.

staging could have a low-cost option available before you step up to a high-power model like the Invicta model that we're working on. Just like the TTV, the Invicta will require a staging timer in order to ignite the upper stage motor.

You just don't see many high power two stage rockets, and we'd like to change that because they are so much fun to witness. And the upper stage can be flown alone as a single stage rocket, so you'll get double the amount of fun.

The model after the Invicta will be another challenging, yet very spectacular rocket. This is a scale model of the Nike Hercules missile (Figure 4). It has been one of my favorites scale models, but we haven't done it before because it is very complex and has some parts that are difficult to manufacture.

For example, it is a 2-stage rocket, which already means it will require a staging timer in the upper stage. Plus the lower stage is a cluster of four rocket motors.

Going from a cluster of four motors in the booster to a single motor in the upper stage requires a very special transition section. We originally thought we could 3D print it, but the cost per piece would have been prohibitive, and we were worried about the strength of the part because wanted to make this a big rocket that would draw attention.

So I bit the bullet, and had a metal injection mold manufac-

Figure 4: The Nike Hercules missile thunders skyward on a cluster of four 29mm diameter motors.

Figure 5: All the new plastic parts of the Nike Hercules missile are here, including the complex injection-molded transition (right) and the blow molded baoattail (center). The large nose cone is the same one as used on the Invicta (see Figure 3).

tured to produce the transition. We're committed to producing this kit, and it **IS** coming out later this year.

A couple of weeks ago, the first samples of the transition came in, and they are spectacular (see Figure 5). Not only are they much stronger than a 3D printed part, but the surface finish is glass smooth. You won't need to do anything to make this part ready to paint. It already is.

In addition to the injection molded transition, I also invested in a special blow-molded boattail that is used on the second stage of the model. Like the transition, this boattail is totally dedicated to just one kit. We normally like to make parts generic so that they can be used on several rockets in order to amortize the tooling cost over several kits.

One such example is the 3-inch diameter, 5-to-1 ogive nose cone that is also used on the Nike-Hercules. We have been planning to make this rocket since last year, so we purchased the mold ahead of time. And the nose cone is already being used in several kits. For example, the Invicta rocket uses it, as well as the Catalyst (**https://www.apogeerockets.com/Model-Rocket-Kits/Skill-Level-3-Model-Rocket-Kits/Catalyst)** and the Kronos (**https://www.apogeerockets.com/Model-Rocket-Kits/Skill-Level-3-Model-Rocket-Kits/Kronos)** rockets.

Our goal for this year has been to put out some high-quality kits that require a bit of challenge in both building and in the flying aspects. What do you think of this? Are you look-

ing for a challenge, or do you just want simple rockets? Please let me know. And I'd appreciate it if you could tell your rocketry friends about what we're working on. Also tell them to subscribe to our newsletter so that they can keep up to date on what we're working on next. They will thank you for that, I'm positive of that.

Our other project that we'll be working on in the coming months, is to start switching over some resin-cast components in many of our kits to having them 3D printed. We've had a 3D printer in our building for prototyping parts since 2014. That was very early in the history of SLA printers. But they were slow, finicky and expensive.

We've recently upgraded to a much more reliable printer, and the new resins are very nice. They can now match the smoothness, durability and strength of cast resin parts. So because the technology is to the point where 3D printing is now economical, we've decided to phase out some of the cast resin parts. We'll be phasing them in on a kit-by-kit basis, starting with those kits that don't require us to make changes to the assembly instructions. That really is the limiting factor as to how fast we can switch out the parts to new 3D printed components

In the future, we'll have the capability to do some really exciting new kits with 3D printed parts. So stay tuned to our newsletter to find out what is coming next.

Figure 6: The 3D print technology has progressed sufficiently to where we are going to use it for production parts like the ones shown here.

SUBMITTING ARTICLES TO APOGEE

We are always looking for quality articles to publish in the *Peak-of-Flight* newsletter. Please submit the "idea" first before you write your article. It will need to be approved first.

When you have an idea for an article you'd like to submit, please use our contact form at **https://www.apogeerockets.com/Contact**. After review, we will be able to tell you if your article idea will be appropriate for our publication.

Always include your name, address, and contact information with all submissions. Including best contact information allows us to conduct correspondence faster. If you have questions about the current disposition of a submission, contact the editor via email or phone.

CONTENT WE ARE LOOKING FOR

We prefer articles that have at least one photo or diagram for every 500 words of text. Total article length should be between 2000-4000 words and no shorter than 1750 words. Articles of a "how-to" nature are preferred (though other types of articles will be considered) and can be on any rocketry topic: design, construction, manufacture, decoration, contest organization, etc. Both model rocket and high-power rocket articles are accepted.

CONTENT WE ARE NOT LOOKING FOR

We don't publish articles like "launch reports." They are nice to read, but if you don't learn anything new from them, then they can get boring pretty quick... Example: "Bob flew a nice blue rocket on a H120 motor for his certification flight." As mentioned above, we're looking for articles that have an educational component to them, which is why we like "how-to" articles.

You can see what articles and topics we've published before at: **https://www.apogeerockets.com/Peak-of-Flight?pof_list=archives&m=education**. You might use this list to give you an idea or two for your topic.

Here are some of the more common articles that we reject all the time, because we've published on these topics before:

- How to get a L1 Cert
- How to get an L2 or L3 Cert
- Building cheap rockets
- How to 3D print parts
- Building Low Cost Launch Equipment (pads and controllers)
- Getting Back Into Rocketry After a Long Hiatus
- How to Build a Rocket Kit
- How to Build a Computer (too technical)

ARTICLE & IMAGES SUBMISSION

Articles may be submitted by emailing them to the editor. Article text can be provided in any standard word processor format (MS Word, Libre Office, etc.) or as plain-text. Graphics, meanwhile, should be provided in either a vector format (Adobe Illustrator, SVG, etc.) or a raster format (such as jpg or png) with a width of at least 600 pixels for single column images or a width of 1200 pixels for two-column images. If possible, it is generally preferable for images to be simple enough to be readable in a two-column layout, but special layouts can use the whole page width if required.

Send the images separately via email as well as showing where they go by placing them in the word processor document.

ACCEPTANCE

Submitted articles will be evaluated against a rubric (available here on our website). All articles will be evaluated and the results will be sent to the author. In the evaluation process, our goal is to ensure the quality of the content in *Peak-of-Flight*, but we want to publish your article! Resubmission of articles that do not meet the required standard are heavily encouraged.

ORIGINALITY

All articles submitted to Peak-of-Flight must not have been run in another publication before inclusion in the *Peak-of-Flight* newsletter, but it may be based on another work such as a prior article, R&D report, project report, etc. After we have published and paid for an article, you are free to submit them to other publications.

RATES

Apogee Components offers **$300** for a quality-written article over 2,000 words in length. Payment is pro-rated for shorter articles.

WHERE WILL IT APPEAR?

These articles will mainly be published in our free newsletter, *Peak-of-Flight*. Occasionally some of the higher-quality articles could potentially appear in one of Tim Van Milligan's books that he publishes from time to time.

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Your Success Is Our Mission!

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