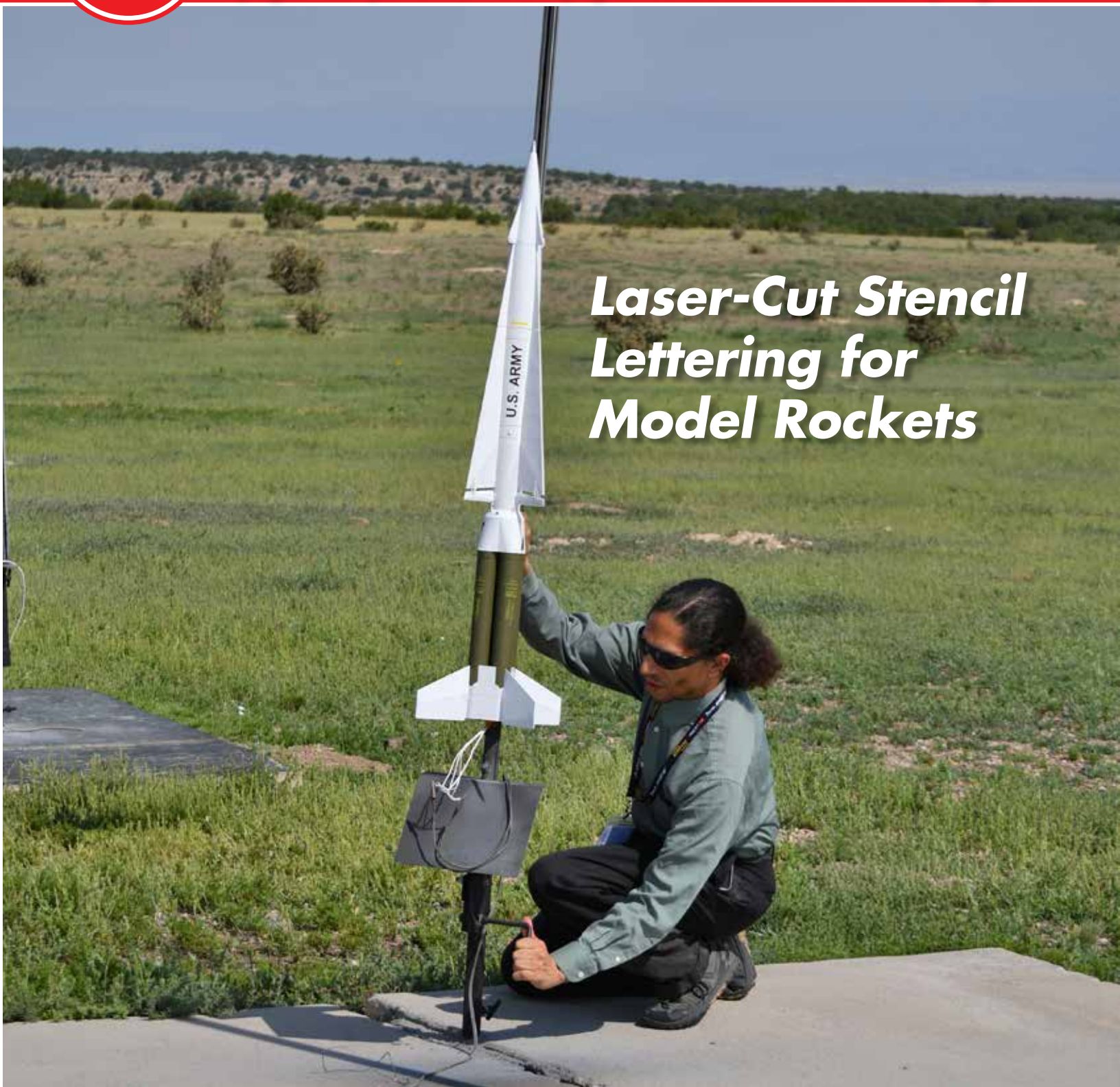
Issue 633 / August 27th, 2024

PEAK OF FLIGHT NEWSLETTER

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



Laser-Cut Stencil Lettering for Model Rockets

PEAK OF FLIGHT NEWSLETTER

Issue 633 / August 27th, 2024

COVER PHOTO

Apogee Nike Hercules

Martin Jay McKee prepares the prototype of the 1:10th scale Nike Hercules rockets for a launch. This is a two stage rocket with a cluster of four 29mm motors in the booster, to a single, electronically air-started 29mm diameter motor in the upper stage.

FEATURED ARTICLE

Laser-Cut Stencil Lettering for Model Rockets

by Martin Jay McKee

How do you make realistic stencil letters found on most military missiles. We'll make our own cut on a laser cutter.

Apogee Components, Inc.
4960 Northpark Dr.
Colorado Springs, CO 80918
1-719-535-9335
www.ApogeeRockets.com

About this Newsletter

You can subscribe to recieve this e-zine FREE at the Apogee Components website: www.ApogeeComponents.com, or by clicking the link here **Newsletter Sign-Up**

Editor-in-Chief: Tim Van Milligan
Managing Editor: Michelle Mason
Content Editor: Martin Jay McKee
Layout Design: Tim Van Milligan

Zephyr Jr. kit lights up the sky at NARAM-65 in Pueblo, Colorado.

Would you like to see your launch photo featured in the *Peak-of-Flight* newsletter? Submit your photo at apogeerockets.com.

PEAK OF FLIGHT NEWSLETTER

Laser-Cut Stencil Lettering for Model Rockets

by Martin Jay McKee

Issue 633 / August 27th, 2024 www.ApogeeRockets.com

Model rocketry, like most hobbies, has a tendency to grow past a small corner of your workshop and sometimes even take over the house. Tools are one of the main ways that this happens so perhaps this article is less helpful in overall minimalist living, but it does introduce a truly wonderful use for an already powerful tool. While homemade decals are a simple and effective option in many cases, there are some places that they are simply insufficient. One of those places is for lightly colored, highly detailed, designs over dark paint. A primary example of this situation is lettering. While it may not be advisable to go out and purchase a new laser engraver/laser cutter just to do stenciled lettering on rockets, the ability to do so is a valuable additional ability when a laser cutter already makes sense.

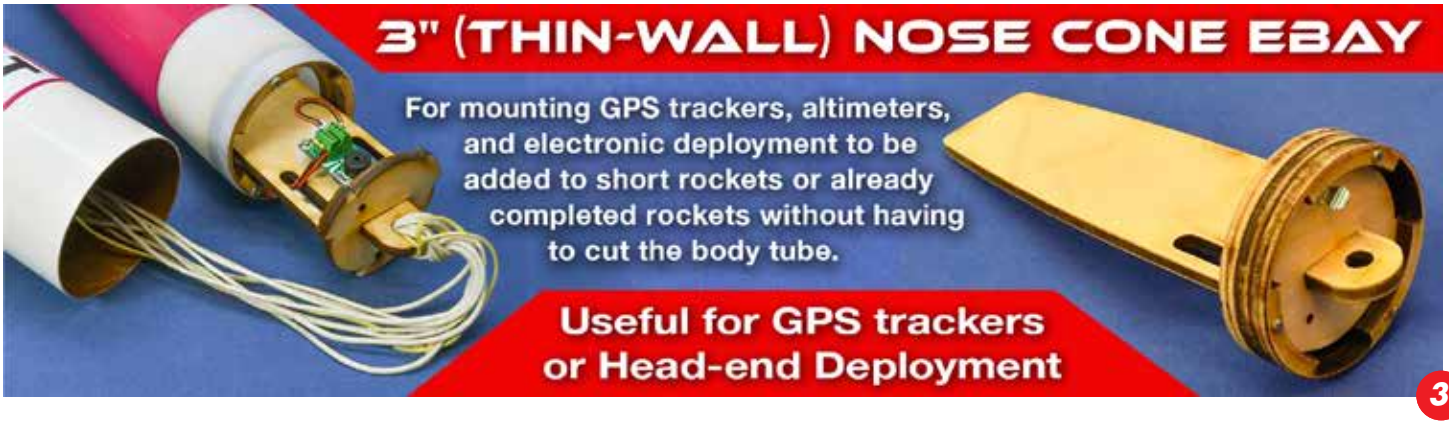
This article will begin by examining laser cutters and laser engravers and what to look out for if one is seeking to acquire such a tool. After that, we'll look into the sort of files that are necessary to create stencils, the process of creating a functional stencil, and finally the process of using a stencil to apply lettering. The project I'm working on in this article is the 1:10.25 scale Nike-Hercules that we are currently developing at Apogee Components (**https://www.apogeerockets.com/Model-Rocket-Kits/Skill-Level-5-Model-Rocket-Kits/Nike-Hercules**). The final kit will include professionally manufactured – white backed – waterslide decals for the lettering on the Nike boosters, but we had need of a demo model for the recent NARAM-65 in Pueblo, Colorado. So – having insufficient time to get the decals manufactured – we had to make due, and stenciled lettering was the perfect solution.

All (or some…) about Laser Cutters and Engravers:

If the only goal were to cut 1/4" plywood fins and centering rings, a full laser cutter (probably in the 60W-100W range) would be required. Such a beast of a machine is entirely superfluous for making stencils and, as it happens, for most uses in low and medium power rocketry (balsa, basswood, and thin plywood). In fact, a small laser engraver with a diode laser in the 2W - 5W range is wholly sufficient for stencils. Still, it would not make sense to buy a new (expensive) tool for simply cutting stencils; so, it makes sense to examine the many ways that such a tool could be used when considering purchase.

Fig 1: At around $300, the Wianlux K10 is about the least expensive laser engraver that is available yet still provides useful functionality. It provides a cutting area of 3"x3" and a peak laser power of 5W.

The most obvious capability that a laser cutter provides to a rocketry modeler is in cutting flat parts. These include fins and centering rings. Also included are things like paper transitions, general templates, alignment jigs, etc. If a rotary attachment is also added to the laser, it becomes possible to mark and cut tubes. Keeping in mind these capabilities, we should consider what machine features are important for the hobbyist.



PEAK OF FLIGHT NEWSLETTER
Issue 633 / August 27th, 2024
www.ApogeeRockets.com

Laser-Cut Stencil Lettering for Model Rockets

by Martin Jay McKee

One of the banner specifications on most laser cutters and laser engravers is the peak power, in watts. A consumer grade CO2 laser cutter may range from 40W on the low end to 100W on the high end. These power levels are sufficient to cut up to 1/4” thick plywood (perhaps with a certain amount of patience on the 40W models!), and can do just about anything that any modeler might desire. There are, of course, materials that cannot be cut by consumer grade laser cutters (metals of any appreciable thickness are a prime example), and some that produce toxic chemicals when laser cut (such as PVC) so should never be cut, but a 40W-60W laser cutter is a highly flexible tool. As far as laser engravers are concerned, the typically available power range is roughly 2W - 10W. While these power levels do provide light cutting ability, they are primarily intended for marking the surface of materials - hence engraving. Even these low-power, diode-laser, models can be highly productive cutting paper, cardstock, thin plastic,

Fig 2: Over the years there have been dozens of K40 type lasers available and the K40+ from Omtech (list of $650), is another highly functional option. With a bed of 8"x12" and a maximum power of 40W, this is an exceptionally capable laser cutter with an attractive price.

and thin wood.

Another primary specification for laser devices is the bed size. This specifies the maximum area that the laser can cut or engrave in a single pass. While some devices are designed such that materials can pass through the enclosure so that multiple runs can be done on a single piece, the single pass bed size determines what can be cut with machine accuracy. For most low-power rocketry projects, a laser need only have a bed the size of a standard sheet of paper – roughly 8.5”x11” (or 22cm x 28cm). Bed dimensions of 12”, 18”, and 24” along the long axis are typical of

smaller laser cutters, while engravers are often under 8” in width. In any case, while the bed size is a major indicator for the cost of the machine, it is unlikely to be a critical value for most hobbyists as even a small laser is able to produce parts for medium and large rockets.

Unfortunately, many of the new breed of lower cost laser cutter/engravers are being built without enclosures. Given the extreme danger that high intensity laser light poses to eyes, I would not recommend any non-enclosed machine. It simply isn’t worth the risk. That knocks out all of the least expensive options. There remain, however, many reasonable options (such as a K40 style machine) starting at around $650 on Amazon. There are a few very small diode laser engravers (with enclosures) for under $300, but not having ever had the chance to use one myself, it’s unclear how attractive a deal that actually is. And, once the cost gets over $1000, the machine is likely to do everything that might be needed for just about any rocketry project within the constraints of the bed size.

Laser cutters, as a result of cutting by burning their way through materials, require ventilation. Some machines – the better machines – incorporate a ventilation connection while many of the lower cost machines simply vent to the outside of their enclosure (assuming they are even enclosed!) and directly into the room. In either case, it is important to place the laser cutter or laser engraver in a position that allows venting of the air to the outside. The fumes are not necessarily toxic, but they are generally unpleasant and will cause mild symptoms like itching eyes and dry skin with extended exposure. It is also possible to

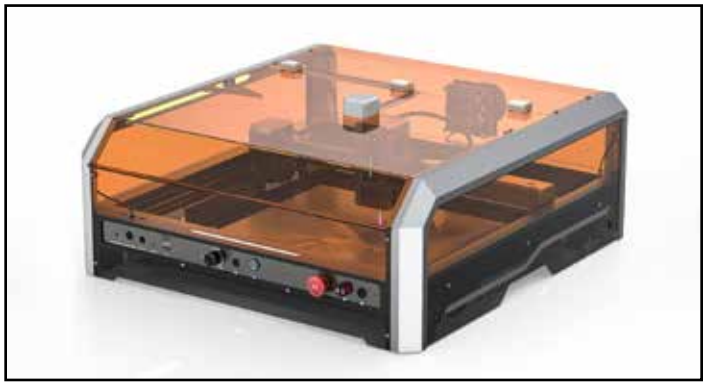
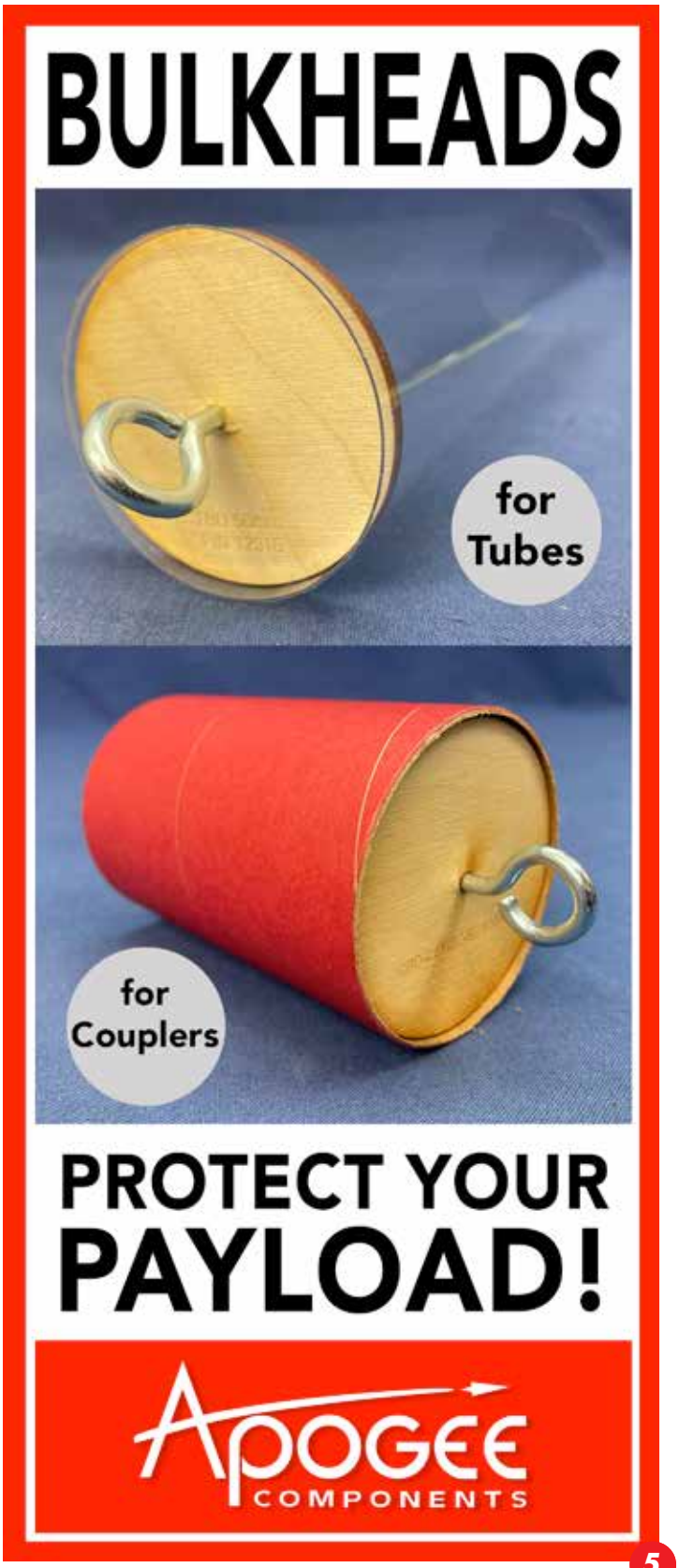


Fig 3: The Wainlux L8 laser engraver is the most expensive example included in the article, but provides a cutting area of 18"x18" and a power output of 20W. With a list price of $1100, it is an exciting option for shops with a requirement for larger parts.



simply use a laser cutter in an easily ventable space such as a garage and then simply open the space up and let it clear out before working further. There are many approaches to handling the ventilation requirement even if it is not built into the machine itself, but it is something to consider before buying any equipment.

Finally, just because one does not own a laser cutter, it does not mean that there is no way to take advantage of one. Many places have one or more maker spaces. These can be private entities but increasingly they are located in community spaces such as recreation centers and libraries. Moreover, as the cost of different machines continues to drop, it is becoming more and more common that friends (or club members) may have a laser cutter (or 3D printer, or vinyl cutter, or CNC router) at home that one can use. Therefore having purchased or otherwise located a suitable laser cutter, we can continue to actually designing, creating, and using stencils for the application of lettering.

The Required Materials:

There are only a handful of materials that are required to successfully create stenciled lettering. The most obvious of these materials is something to make the stencil itself out of. This can be a wide variety of things depending upon how large the stencil needs to be. One of the most widely available options is Mylar (PET) stencil sheet which is available in a wide variety of sizes and thicknesses. This is an inexpensive option that is durable in thicknesses

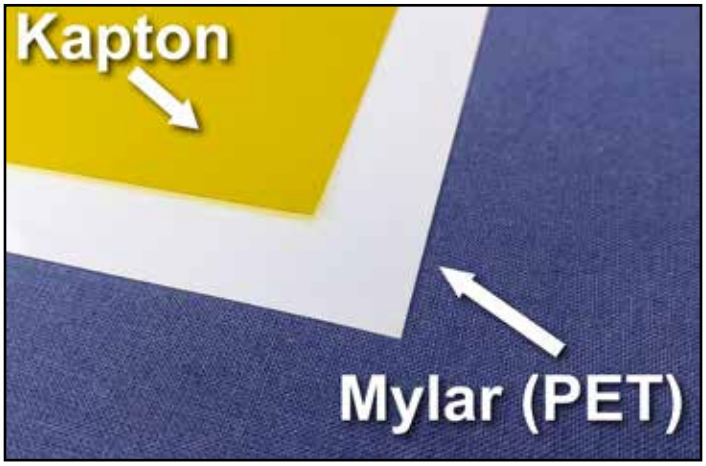


Fig 4: The thicker Mylar stencil material is often used for sewing and scrapbooking, but can be quite useful for larger rockets while the Kapton sheet is widely used to make solder paste stencils for assembly of printed circuit boards due its ability to reproduce fine details.

greater than 10 mil (0.010 in, .25 mm). For this particular project, I needed greater flexibility than the stencil sheet I had in stock (15 mil, I believe) so I went with a slightly more expensive, but all around much nicer option – Kapton sheet. Kapton is a high-temperature polymer, often used in the form of tape in electronics, that has high strength and high temperature resistance. It is also much more resistant to warping than Mylar, which is especially nice for small lettering. The Kapton sheets I chose are 6”x6” (150 mm x 150 mm) and 5 mil (0.13 mm) thick.

In addition to a stencil material, completing the stenciled lettering requires: masking tape, some large flat sheets of rigid material, an airbrush or rattle-can spray paint, and potentially, some sort of clear coat. The characteristics of the masking tape are fairly inconsequential - basically anything will be fine. The sheets of rigid material must be small enough to fit in the laser cutter and must be fairly thin, but otherwise, anything is fine. More important are the paints used for applying the lettering. The two best options are applying the paint with an airbrush and using spray paint. For especially small lettering (as is being applied here) the added control of an airbrush is extremely valuable. One of the main problems with spray paint is that it is difficult to control the amount of paint being applied. As I tested the lettering, I actually ran tests using standard spray paint and they ended up looking pretty good. Nevertheless, as I had access to both an airbrush and an appropriate color of paint for the lettering, I took advantage of them.

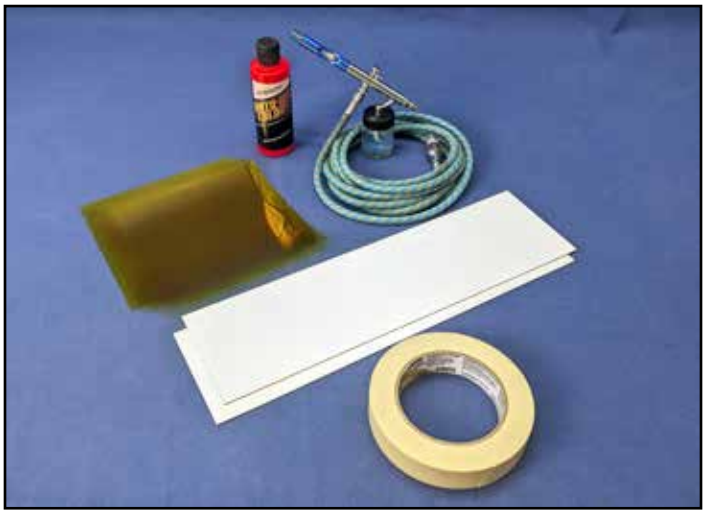


Fig 5: All together, not many materials are actually required to complete the stencil and application of lettering.

Finally, of course, applying lettering to a rocket requires the rocket itself, and it needs to have the primer and base coat of paint applied and thoroughly dry. The rocket being used in this article is the booster portion of a Nike-Hercules missile. This provided interesting problems during application as the four tubes in close proximity made dealing with overspray and holding the stencil in place more difficult. Still, it provided an excellent example of the efficacy of this process.

Designing Stencils for Laser Cutting:

Graphic design isn't for everyone, but lettering doesn't actually need to be difficult. There are many different programs available that can complete the job. At Apogee, we typically use Adobe Illustrator for this sort of work. At home, I often use Inkscape. There are many other options, and the software used is generally unimportant. What is most important, is that it works for the user. The whole goal is to get the lettering design into a form that the laser cutter can process.

Laser cutter software uses standard graphic file formats as input and they then produce the commands to send to the laser. Generally these input files will be in a vector format such as svg, pdf, dxf, etc. File formats are beyond the scope of this article but *Peak-of-Flight Newsletter 619* (**https://www.apogeerockets.com/education/downloads/Newsletter619.pdf**) provides a good introduction to these as well as the various software used to create them. Beyond simply providing the graphics in an accepted format, however, there are a couple of important challenges to keep in mind while creating files. Chief among these are providing sufficient tabs for retaining internal shapes and – for small lettering especially – kerf compensation.

It's pretty obvious that the shapes in the middle of some letters (B, D, R, etc.) cannot simply float in mid air. The shape must be supported by tabs. On military rockets that originally used stenciled lettering this is not a problem. Indeed, the absence of tabs can be even more of an issue as they add quite a bit to the "military" look of the lettering. If the lettering is supposed to be replicating hand painted or otherwise non-stenciled graphics however, the size of the tabs should be minimized. There is a danger though, in minimizing the size of the tabs too much that the internal shapes could be easily dislodged – ruining the lettering entirely. Tab size is something that should be experimented with to find a reliable and visually appealing recipe. It should be noted that tab size interacts in non-obvious

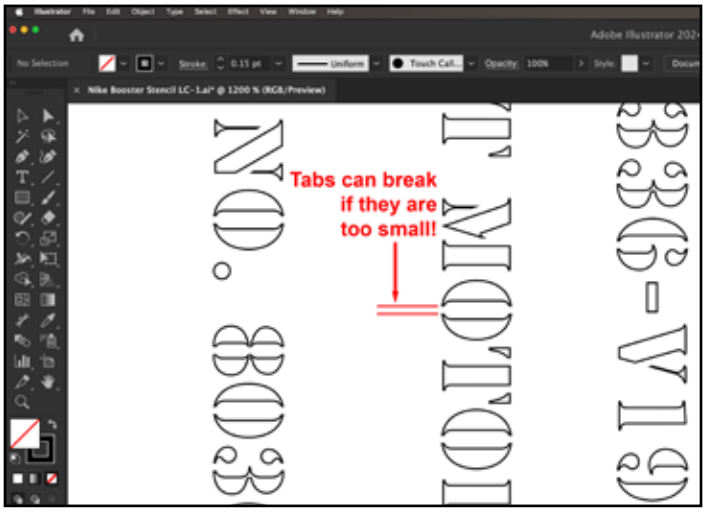


Fig 6: Different materials will support tabs of different widths and testing is needed to determine the minimum tab width that will hold together.

ways with the other challenge mentioned above, kerf compensation.

The kerf is the width of a cut line. A table saw may have a kerf of 1/16". A laser cutter is much smaller, maybe no

more than 5 mil (0.005”, 0.125 mm) when the laser is correctly focused. However, with lettering that is only 1/4” (6 mm) tall, the kerf ends up being a significant portion of the whole size and the actual cut file should be adjusted to take the kerf into account. Not doing so can lead to lettering that is heavier (more bold) than it should be, but it can also result in any tabs (which are much smaller than the letters themselves) being cut away entirely. Some laser cutting software does have kerf compensation built in, or at

Fig 7: The magenta line represents the kerf corrected cut path that will result in a correctly shaped stencil. While the difference is small in absolute size (on the order of 0.005"), it is clear that it is significant at the scale of the lettering.

least configurable; but, not all of the software does. Once again, it is important to run tests before committing to a final design.

Having completed a vector design with sufficient tabs and proper kerf compensation, the next step is to actually cut the final stencils.

Cutting the Stencils:

There are a number of things that can go wrong when cutting stencils, but there are two primary issues that should be kept in mind first: using proper power to minimize curling around the cuts, and ensuring that the stencil material remains flat on the cutting bed to maximize sharpness. The power setting is something that should be identified through testing before the final stencils are to be cut. This can be done fairly simply by cutting a small shape, such as a square, out of the stencil material and adjusting the cut settings until the shape just falls out of the sheet. If the power is too high, the kerf (the width of the cut line) will

be larger and can easily distort the shape of letters - even leading to internal letter shapes falling out because the support tabs are cut through. Moreover, some materials will accumulate blobs of melted material if the cutting power is too high. On the other hand, power that is too low will result in the material only being engraved, rather than cut, and sometimes will also result in the buildup of soot on the surface. After running several tests, I came to an optimal

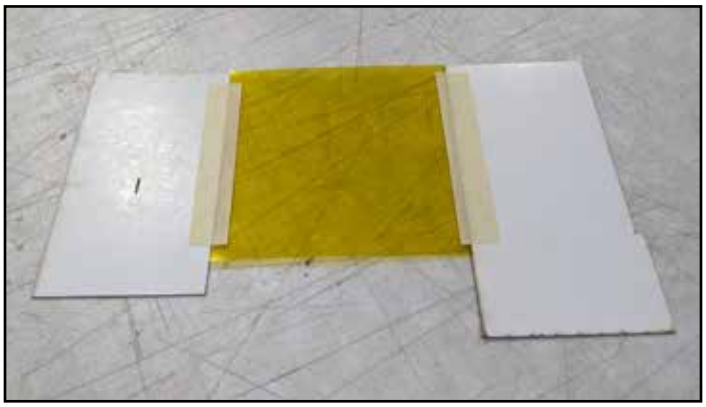


Fig 8: Heavy cardstock taped onto the back of the Kapton material to facilitate holding the stencil flat as it is cut.

configuration of doing two passes (to minimize heat build-up and edge curling) at a fairly low power setting. This led to a reasonably clean final surface, a nice sharp edge with no blobs, and zero warping.

Part of the difficulty of cutting stencils however (especially on a laser cutter with air-assist such as our Epilog laser) is that the thin, flexible, stencil material has a tendency to bow up in the middle. The result of this is that the focus point of the laser is not constant and this leads to different

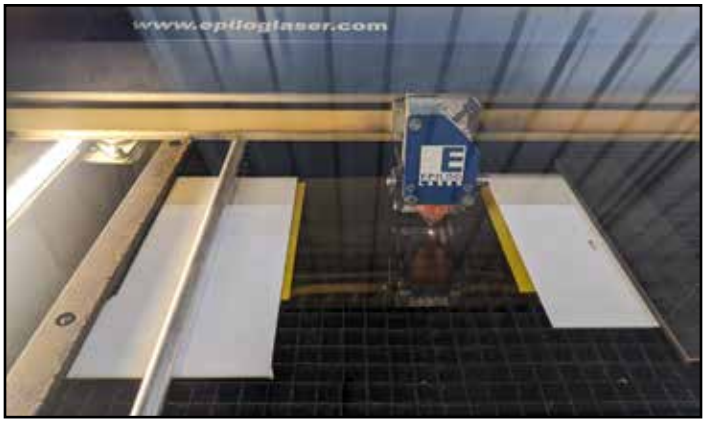


Fig 9: Since it resulted in the best cut quality, the Nike-Hercules stencils were cut in two passes where the first pass did not cut all the way through.

beam widths at different places on the stencil. If this is limited, it may not be a problem. The 5 mil Kapton that I was using, however, is thin enough that I was getting far more ripple in the material (and therefore the lettering) than I could accept. To deal with that, I taped the material to some pieces of heavy cardstock and then used those to hold the Kapton in place and flat against the cutting grid.

Once the power is determined and the material is restrained, all that needs to be done is to open the stencil file in the laser cutter software, configure the cut settings, and run the cut. Since every laser is going to follow a different procedure, we won't cover the actual cutting process here. With luck, the laser you choose will have a variety of

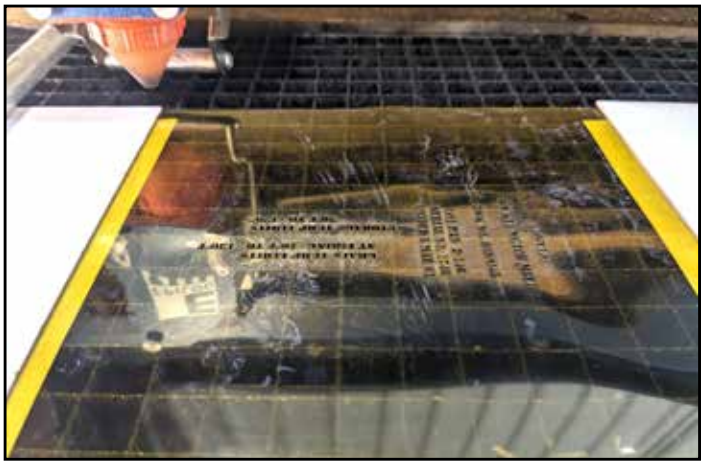


Fig 10: The fully cut stencil shows nicely cleared letters and only a minimum of residue on the surface of the stencil.

excellent tutorials available describing its use (many do). Sometimes, however, it's necessary to do a bit of digging because – for some reason – CNC (computer-numerical control) software of all sorts is still fairly rough and lacks polish.

Applying Lettering with Stencils:

As with any application of paint, applying stenciled lettering requires masking of any areas in a close proximity to avoid overspray. I did the basic masking on the Hercules booster with masking tape and then used the stencil material itself to cover the remainder of the booster I was painting. This is sufficient because I was using an airbrush and quick drying paint. As such, overspray was limited and the possibility of smudging almost nonexistent. The secondary advantage – beyond minimizing the amount of masking required – was that I was able to spray all four booster

Fig 11: Masked and ready for application of paint, the Nike booster was easy to handle with one hand, but larger (or much smaller) rockets may need additional support.

tubes in sequence while with a rattle can I would have been required to do one at a time due to needing to mask the entirety of the stage rather than just small portions of it.

The stencil should ideally be taped into position so as to minimize the possibility of leakage under the edges of the stencil during spraying. However, unlike masking tape, there is no chemical barrier so it is very easy to get paint where it is not wanted. Again due to the cluster of four tubes, I was unable to tape the stencil into place and simply held it with my left hand while I worked the airbrush with my right. While far from ideal, the results were certainly more than acceptable.

The application of paint needs to be as close to perpendicular to the surface as possible in order to minimize paint being blown under the edge of the stencil. Any paint that is blown under the stencil will result in a soft edge rather than the sharp (clean) edge that is generally desired. Since the paint is being sprayed onto a round tube the perpendicularity constraint requires that either the tube be rotated or the paint source be moved as the paint is applied. Since I was holding both items, I did a little of both and managed to get a fairly uniform coat of paint (though, there was just a bit of thin paint in spots due to me erring on light coats). The other important aspect with applying paint is to apply the minimum required and, if a light coat does not produce an opaque enough result, to allow time for coats to dry in between applications. Since I was using an acrylic airbrush paint that dries extremely quickly, I was able to do two quick coats while still holding the stencil in place. This is,

Fig 12: The paint was applied in two coats with a short drying time between them and the results were plenty opaque, despite the light color of the lettering paint.

however, another good reason to tape the stencil in place as repositioning the stencil between coats is extremely difficult. Do not, however, apply a thick coat of paint as the paint will wick its way under the stencil and ruin the application. A slightly soft line from the stencil lifting doesn't usually ruin the effect of stenciled lettering (especially on a

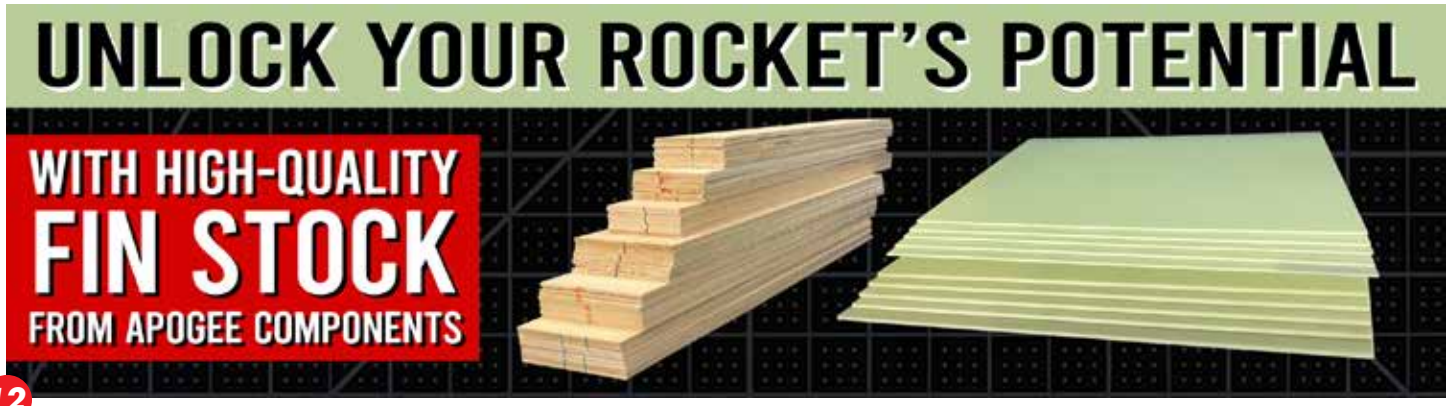


Fig 13: A closeup of the results shortly after painting shows that the results are excellent given the easy of creation. There are some soft edges here and there, and some variation in the opacity of the letters, but the overall result is extremely scale, and surprisingly readable given the small size.

scale rocket where the lettering on the full-scale craft was often applied in a hurried manner), but paint wicking under the stencil is a guaranteed way to necessitate sanding and repainting the whole rocket.

As a painted detail, it is less important to top coat the finished lettering than if it were something more fragile such as water-slide decals. That does not prevent the use of a top coat, however. If a clear coat is desired, it is important to allow the base color and lettering to dry fully. Then, choosing a clear coat that is compatible with both the base color and the lettering paint is critical (be sure to test on something other than the final project!). It is also important to be as gentle in the application of a clear coat as possible. An overly thick coat, in fact, is nothing but trouble. Thick coats have the tendency to run or even cause wrinkling or orange peel in the already applied paint. That said, no top coat was applied on the Nike-Hercules boosters because it was desirable to see the contrast between the

Fig 14: Despite being a small detail in the overall design, the stenciled lettering adds quite a bit of interest and scale detail to the finished rocket - detail that would have been difficult to achieve any other way in a home shop.

matte olive drab and the gloss yellow.

The Final Word:

Perhaps the most important thing about any functional tool box is that it be nearly bottomless, that is, containing a tool for every task. It is not every day that painted lettering is required on a rocket, but when it is, the flexibility of creating stencils with a laser cutter is hard to beat. With the pervasiveness of maker spaces and the ever decreasing cost of the machines, it is becoming much easier to secure access to a laser cutter for many rocketry applications, including the creation of stencils.

This article outlined the important requirements of a laser cutter to be used in a stencil application then continued through outlining the required materials. Luckily, lettering requires little more than some material to produce the stencil (we demonstrated with a thin Kapton sheet) and a controllable source of paint (in our case, an airbrush). We discussed a few of the important considerations during stencil design and cutting, then finished by demonstrating how the stencils are used to apply the final lettering.

Given access to a laser cutter and some basic knowledge of designing graphics on a computer, just about anyone will be able to create unique and beautiful, custom lettering for their rocket. And, of course, the techniques really go far beyond lettering and open up a wide variety of painting techniques with stencils (one of my favorites is adding fish scales!).

One of my favorite things about building rockets is how many new things it allows me to learn – new construction methods, new tools, new science, and history. This process of creating stencils to apply lettering is one drop in a large ocean of opportunities to make our rockets more interesting and more beautiful, and I hope it gives you further ideas for the future, whether you add a laser cutter to your workshop or not.

About The Author:

Martin has been designing and building rockets for as long as he can remember. After originally toying with the idea of pursuing a career in Aerospace Engineering, he did a double major in Computer Science and Fine Art then spent a decade working in K-12 math and science education. He joined Apogee Components as the Product Designer in 2022.

PEAK OF FLIGHT NEWSLETTER

Article Submission Guidelines

Issue 633 / August 27th, 2024

www.ApogeeRockets.com

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.

Apogee Components, Inc.
4960 Northpark Dr.
Colorado Springs, CO 80918
719-535-9335

Your Success Is Our Mission!

www.ApogeeRockets.com