PEAK OF FLIGHT NEWSLETTER

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A HISTORY OF MOTOR ANALYSIS & THRUSTCURVE.ORG

EXPAND YOUR TOOLKIT WITH A MAKERSPACE



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www.ApogeeRockets.com
4960 Northpark Dr, Colorado Springs CO 80918
Ph# 719-535-9335

APOGEE COMPONENTS

PEAK OF FLIGHT

A History of Motor Analysis & Thrustcurve.org

By John Coker

History

I have been a user of RockSim for a long time, and getting data for all the motors I wanted to experiment with was always a problem. We would make our own data files from the little printed thrust curves that AeroTech includes in their instructions, but most manufacturers didn't provide even this information.



FIGURE 1: THRUST CURVE INCLUDED IN THE INSTRUCTIONS FROM AEROTECH.

Lots of great work has gone into RockSim (www.RockSim.com) and OpenRocket and they are invaluable tools for experimenting with rocket designs and ensuring a rocket will be stable. However, without reasonably accurate motor thrust curves, simulations aren't possible.

The natural source of good data was the certification organizations because when they test the motor, they collect thrust measurements from the test stand. Back in 1998, I was able to get a bunch of raw test stand data from TMT (Tripoli's motor testing organization) and wrote a program to convert them to the various formats then extant.

These files formed the core of the first iteration of thrustcurve.org (v1) and set the tone for what I thought it should be: high quality data files taken directly from the certification data test stands. Unfortunately, NAR's S&T was never willing to share their data so I was not able to realize that goal.

Subsequently, TRA stopped making data available and the site languished. There was still the original set of generated files, but it quickly became outdated as new motors were introduced and new motor manufacturers entered the market. As a stop-gap measure, I added a page to which people could contribute data from other sources (usually from the motor manufacturer).

I had thought repeatedly about changing the format of the site to being organized around the entire set of certified motors from all three organizations. (The Canadian Association of Rocketry, CAR, entered the certification business during that time as well.) Good intentions finally turned into action in 2006 when I started working on the first programmatic site (v2).

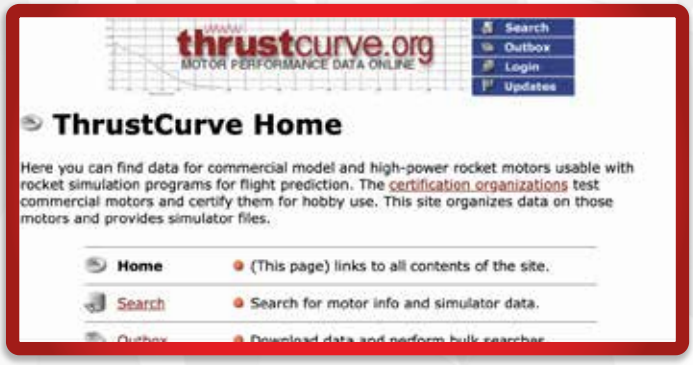


FIGURE 2: THRUST CURVE V2

The new model turned the original site inside out. Instead of being driven by motors for which I have data, the list of motors is all the ones that have been certified, mostly from the NAR combined list. Additional information is pulled from the web sites of the three certification organizations to fill in the details.

With the master motor list set up, motor data files can be contributed by anyone who has them. The data is no longer as "authoritative," but at least whatever is floating around can be available in one place.

By 2016, the site itself had become dated and was getting hard to maintain. I had been meaning to rework it to use a responsive layout, but instead I started rewriting it from scratch using modern web technologies and finally de-

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About this Newsletter

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Newsletter Staff

Writer: John Coker, Bobby Potter
Layout / Cover Artist: Matthew Martinez
Proofreader: Michelle Mason

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ployed it in late 2020. The current site is "v3": thrustcurve.org.

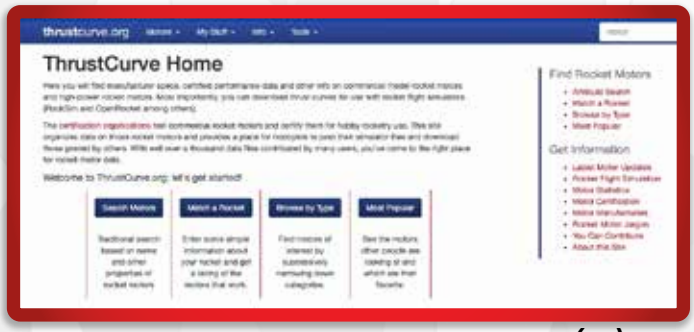


FIGURE 3: TODAY'S LAYOUT FOR THRUSTCURVE.ORG (V3)

Creating Data Files

There used to be several formats commonly used for motor thrust curve data, but now there are only two: "RASP" (.ENG) and "RockSim" (.RSE). The RASP format was introduced with the original simulator of the same name by Harry Stine and is the most widely supported by different programs.

The RockSim format, introduced by Apogee for RockSim, has the ability to store more information about the motor and is more extensible because it uses XML rather than a fixed text format.

When a source of data is available, either of these files can be generated from that source. This was the approach I took when I wrote a program to convert the TMT's "DAP" test stand data to the original set of data files.

However, most of the time we don't have high-quality data and are working from printed thrust curves, either in manufacturer's instructions or certification organization announcements. In order to make it easier and more accurate to transcribe printed thrust curves, I wrote TCTracer which imports an image and then allows you to "draw" the thrust curve on top of it, which it then captures as a file.

Tim Van Milligan made a great video demonstration of tracing the thrust curve from a Tripoli certification document.

High-Quality Data

Of course, tracing a printed thrust curve is never going to capture fine detail. Initially, I was focused on getting data from the source, particularly the actual test stand, but over time I realized that fine details don't make that much of a difference.

Motors can vary quite a bit from firing to firing and this is a classic case of false precision, especially given that very few (sometimes only one) firing is done during testing. Not to mention that years, sometimes a decade, have elapsed since the test firing and slight changes in motor production have doubtless happened in the interim.

A common question that comes up is "why didn't my rocket fly as high as it simmed?" My stock answer is the CD "fudge factor," but manufacturing variation, effects of weather, and accuracy of the simulator data also factor into this.

Long term, I would like to reduce the latter as much as possible. The main purpose of ThrustCurve.org, from the beginning, is high quality motor data. I'm exploring the possibility of getting data directly from the test stands and producing simulator files from that. Ideally we would get to a point where there was no need for manual production of data files and the data would be as fresh as the most recent motor test.

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Simulator Integration

Another area for improvement is the integration between the flight simulators and ThrustCurve.org. Finding motor data and downloading it and then getting the simulator to read it is still a clumsy manual process. I have streamlined it as much as possible by providing sets of data by manufacturer that you can download all at once, but getting it into the right folder and getting the simulator to read it is not always straightforward.

ThrustCurve.org provides an API that allows programs to query the database and download data automatically. RockSim has a way to do this when you run a simulation, but it's awkward to use and often overlooked. OpenRocket uses the API to freshen its own copy of the data before each release, but no way to automatically download new data.

I envisioned integration with the simulator programs would be deeper so that the data was downloaded seamlessly for the user when connected to the Internet. That hasn't happened yet, but I am still hopeful. This is definitely an area for improvement in the process.

Motor Discovery

One area where ThrustCurve.org has grown a lot is in motor discovery. There are a lot of motors out there and if you don't have a way to effectively browse them, you end up using the same motors over and over again.

Probably the most under-used feature of ThrustCurve.org is the Motor Browser. This lets you explore the space of motors in various ways. You make choices that narrow down the options until you find just the right motors.



FIGURE 4: THRUSTCURVE.ORG MOTOR BROWSER

For example, above I've started with "mid-power" and then selected "single-use". There are still 39 motors that match those criteria, but each link I click narrows down the results until there are few enough to show details in a table.

Whenever I need to find a motor for an application, I generally start here to view my options. For me, this is the easiest way to see what might work without limiting myself to the motors I already know well.

Better known is the Motor Guide, in which you enter a key information on your rocket and ThrustCurve.org will run a quick basic simulation on all the motors that fit your rocket.



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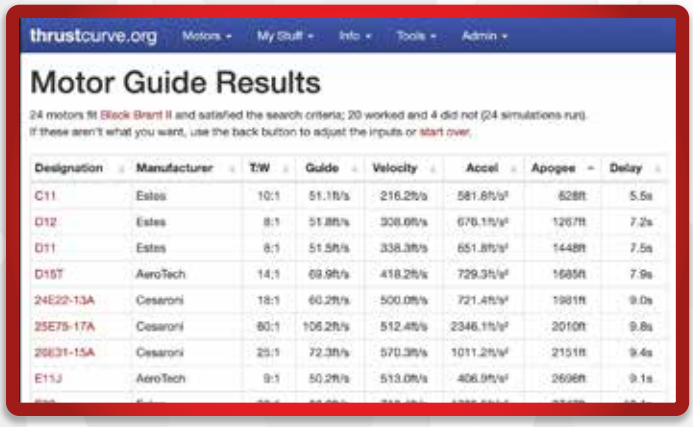


FIGURE 5: SIMULATIONS RUN ON THRUSTCURVE.ORG FOR THE BLACK BRANT II.

For example, above are the results for my Black Brant II model rocket, showing me which motors would work. Of course, this simulation is much simpler than that done by RockSim and OpenRocket, but gives you an idea of your options.

This is another area I'd like to see deeper integration with the simulator programs. I imagine the simulators could use the API to get this simulation output and then allow the user to run a better simulation for motors of interest.

Current Status

The current site has been successful at collecting data and distributing it for nearly two decades now. There are over a thousand motor entries (including many no longer in production) and nearly two thousand data files.

The goals of the site have expanded from just being a repository of data to being a way to find rocket motors you may not have known about. If you haven't explored the site recently, be sure to try out some of of them:

•The Motor Browser allows you to explore motors in various ways to narrow ones you may be interested in. This is usually where I start when looking for motors when designing a rocket.

•The Motor Guide allows you to enter some basic information on your rocket and it will run a quick simulation against every motor that physically fits and tell you which ones might work.

•Popular Motors lists the motors most frequently browsed by others, giving you an idea of what's hot. A lot of the classic motors are perennial favorites, but the newest releases usually get a spike as they are interesting.

•Recent Updates lists the newest motors entered or with updated information as well as the newest data files contributed.

•The Simulator File Outbox can also be used to download sets of files by manufacturer.

The good news is that the new version of the site is based on the latest technologies so is much easier to maintain and improve. The project is open source and if you're interested, you can find it on GitHub.

Lots of things have been suggested by users. If you see something isn't working right or you'd like to see a new feature, post a message on TRF or shoot me an email.

Contributing Data

Of course, this site only works if we have the motor data, and given the current state of the hobby that means

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largely we have to create that data. If you can't find a data file you need, it's easy to create one. And if you contribute it to ThrustCurve.org then it'll help others.

Thanks to the many people who have made and contributed data files in the past, most motors have one or more data files. As of this writing, only 5 of 777 current production motors are missing data!

Thank you to everyone who has contributed data or suggested features for ThrustCurve.org. I think this is more evidence of how engaged and cooperative the people in the rocketry hobby are.

JohnCoker
john@jcsw.com





About The Author



John Coker has enjoyed many hobbies over the years, but has found a home in rocketry. He frequents the Rocketry Forum, and enjoys the people in the community that rocketry provides. In addition to Thrustcurve.org, he has a personal website (jcrocket.com) where you can keep up with all of his builds and the launches he attends. There you can find the wealth of his knowledge on display in the form of how-to articles and step-by-step video content he has created for the community.



Expand Your Toolkit with a Makerspace

By Bobby Potter

Makerspaces

Often people have an idea for a rocket or system for rocketry that requires tools or equipment outside of their budget. This is a problem as old as time, and becomes a limiting factor on those who want to explore their capabilities with the kind of tooling that rocketry manufacturers or businesses in the space industry have at their disposal.

These tools have just become more powerful as time has gone on, and have created a real divide between what a hobbyist can do in their basement and what a company can do in their workshops. Even here at Apogee we have access to equipment like laser-cutters, vinyl printers, 3D printers, vacuum-formers, and a whole suite of woodworking equipment; not to mention expensive CAD, graphics and design software. We need them for all sorts of manufacturing processes, but as an amateur hobbyist, acquiring all this equipment and software would require a sizable budget. A single capable 3D printer like the one we have here at Apogee runs in the thousands of dollars, and things like our free Falcon 9 and Crew Dragon plan would have been impossible without it. In fact, for that free plan we used Fusion 360 CAD Software, the Adobe Creative Suite, a 3D printer, a laser-cutter, and a vinyl decal printer. This is hardly equipment found in an everyday hobbyist workshop.

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FIGURE 6: A STUDENT WORKING AT A UNIVERSITY MAKERSPACE.

However, over the last decade makerspaces have emerged and we now live in a world where access to these pieces of machinery has opened up to everyone for a relatively small cost.

What is a Makerspace? Why Consider Joining?

A makerspace is a community operated facility where people with common interests and a do-it-yourself attitude can congregate to learn, build and create. It's a space where you can find knowledge and make things happen.

Often makerspaces, specifically at public libraries or

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Expand Your Toolkit with a Makerspace

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high schools, are free and open to the public. They are an effort to bring more individuals into the STEM fold, and are intended to give everyone access to these technologies.

Other makerspaces, like the "Pike's Peak Makerspace" we have here in Colorado Springs, are not-for-profit institutions that allow access for monthly or annual memberships. That makerspace in particular costs about $600 annually, or $50 per month, but offers a wide range of high quality equipment. This includes several 3D printers, access to powerful computers with CAD software, and a large variety of metal and woodworking equipment. If you spent that membership on the equipment itself, it would take decades for you to acquire everything you would have access to.

You can almost certainly find a makerspace quite close to home. These are growing wildly in popularity and are scattered all over the planet. If you want to find one near you, check out this map: https://www.nationofmakers.us/find-a-makerspace.

Common Technologies found at Makerspaces

A makerspace can have a lot of different machines, and they definitely vary from one place to another, but usually you will find at least a few of these key pieces of equipment.

CNC Router & Mills

CNC stands for "Computer Numeric Controlled". This is essentially a computer controlled wood cutting and carving machine. This has a lot of potential uses in model rocketry, like the precision airfoiled fins found in Peak-of-Flight #530. (https://www.apogeerockets.com/education/downloads/Newsletter530.pdf)



FIGURE 7: THE CNC ROUTER USED IN PEAK-OF-FLIGHT #530 (https://www.apogeerockets.com/education/downloads/Newsletter530.pdf)

CNC Mills are similar in concept, except instead of a flat piece of wood being carved, it works more like a sculptor slowly removing material from a larger block in an effort to make detailed components. This is a great option for making balsa nose cones. Additionally, these machines can be used for metal.

A 3D Printer

3D printing has become all the rage in advanced manufacturing nowadays. Universities and organizations in the space industry rely on these everyday for the manufacturing of the many components that go into their designs. Rocketeers can use 3D printers to make everything from fin cans and nose cones to printing an entire rocket. Outside

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CHECK OUT THE APOGEE YouTube PAGE
CLICK OR SUBSCRIBE HERE FOR OUR HELPFUL
AND INFORMATIVE HOW-TO VIDEOS
ON MODEL ROCKETRY
APOGEE COMPONENTS

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of rocketry, there are just as many uses. 3D printers have become one the most capable and versatile tools, and they are found in nearly every industry.

Laser-Engraver and Cutter

Want to engrave a design into your next metal or woodworking project? Most makerspaces will have access to an engraver, and usually have the graphics design software available to turn your idea into reality. The laser cutting feature allows you to cut out custom fins, centering rings and bulkheads easily.

Welders



FIGURE 8: CONNECTING METAL PIECES THROUGH THE USE OF A WELDER.

Connecting metal components with any real strength typically requires a welder. Fortunately, these are usually available at makerspaces, though often will require you to take an additional safety course before use. But that is a small price to pay for a new skill and access to low-cost welding equipment. This could be exceptionally useful for university level rocketry applications.

General Woodworking Equipment

Band saws, table saws, routers, power sanders, and a large variety of other woodworking equipment are generally available at makerspaces.

Conclusion

If you are lacking some of the tools and machinery to bring your designs to life, a makerspace might provide you with the low or no-cost solution you have been looking for. Check with your local library to see what they have available, and for those looking to get into the more advanced tooling, check out the not-for-profit makerspaces in your area. You can find a makerspace near you at https://www.nationofmakers.us/find-a-makerspace.





The ShamRocket Rocket Plan



ShamRocket

Download the ***RockSim*** design file for the ShamRocket at: https://www.apogeerockets.com/Peak-of-Flight-Rocket-Plans

ShamRocket Parts List

20068 - (1) PNC-33 Nose Cone

10131 - (1) 33mm Body Tube (12 inches long)

10141 - (2) 14.6mm Body Tube (8 inches long)

12007 - (1) Motor Mount Kit 18mm/BT-55

30325 - (1) Kevlar Cord 100# X 8 feet

29091 - (1) 15” Printed Nylon Parachute

13052 - (2) 1/8” Launch Lug

Recommended Motors

B6-4, C6-5, C12-4, D16-6

The concept of the ShamRocket was a team effort here at Apogee. I asked our graphic designer, Matthew Martinez to come up with a tube fin design. He drew inspiration from Steve Riegel’s Sagittarius design from Peak-of-Flight Newsletter #516 (https://www.apogeerockets.com/education/downloads/Newsletter516.pdf) where the rings intersected each other. He wanted the tube fins to intersect with the main core tube of the rocket. I was trying to figure out a way to simplify this, and what I came up with was a tube fin that was split open, and the edges pried apart, then glued to the core tube. It was nice, and with two edges glued to the core, the tube fins are twice as stiff as compared to a tube that is simply glued onto the surface of another.

The hard part of the design was creating the template that is needed to cut the angled ends of the tube fins. That part I had to contemplate for a few weeks. In the end, I had to do it the old-fashioned way of “pattern development.” This is shown in Peak-of-Flight newsletter #121 (https://www.apogeerockets.com/education/downloads/Newsletter121.pdf).

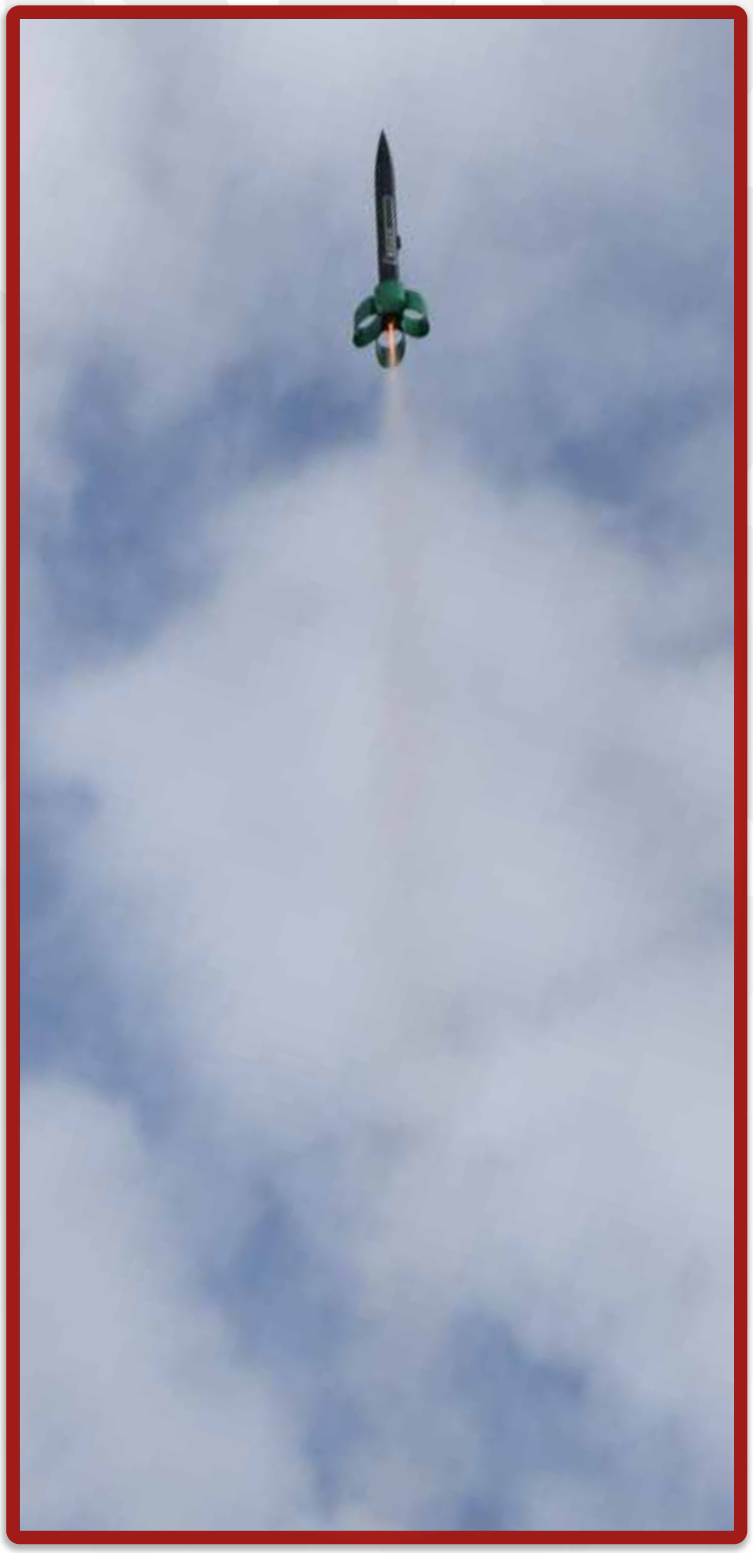
Once we built the rocket, Matthew said to me that the end view looked like a four-leaf clover. From that, we looked for names that centered around the term “shamrock.” Of course, when we saw the word “Rock” at the end, we had no choice but to expand it to “rocket.” That’s what we rocketeers do. And that is how the name became ShamRocket. ~Tim

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The ShamRocket Rocket Plan

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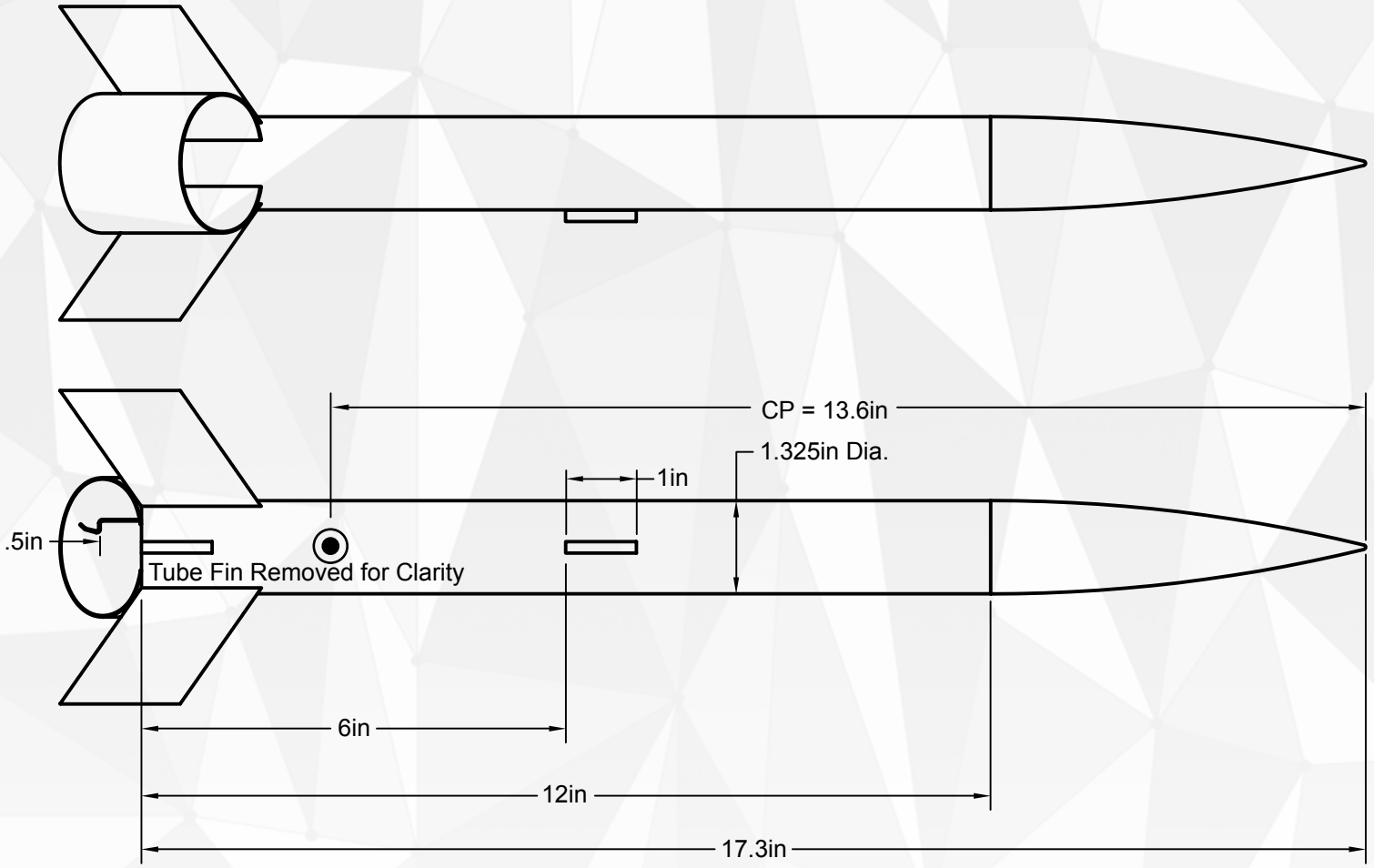


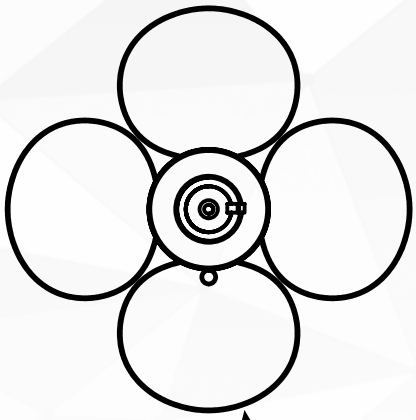


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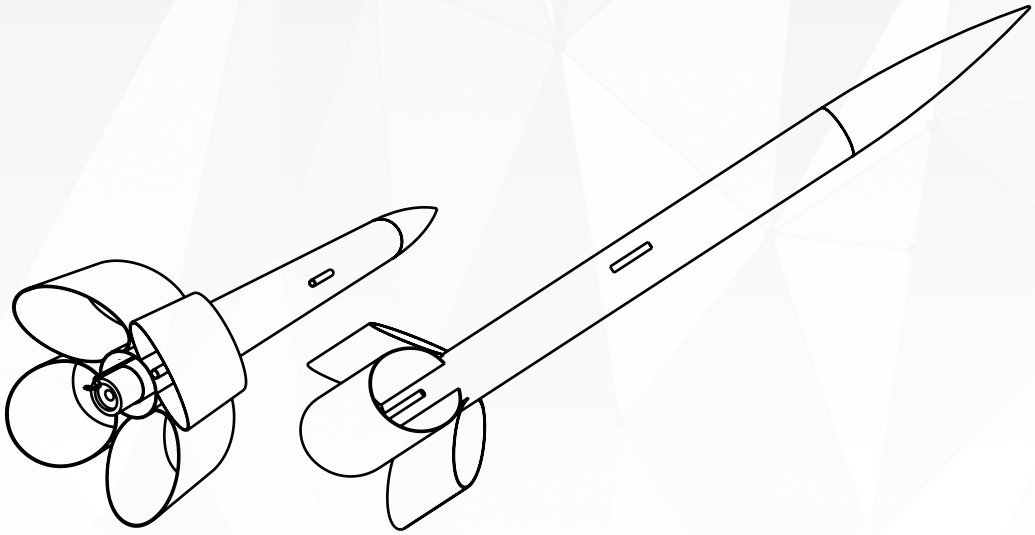
The ShamRocket Rocket Plan

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AT-41.6 (BT-60 size) Tube
See Cutting Pattern Template



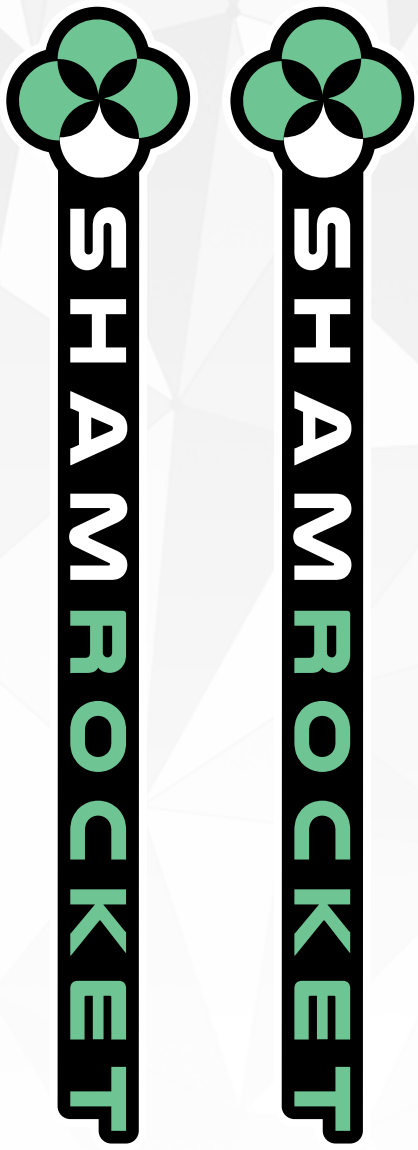
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The ShamRocket Rocket Plan

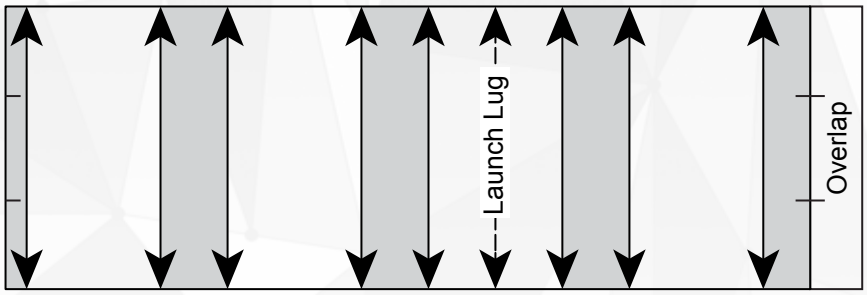
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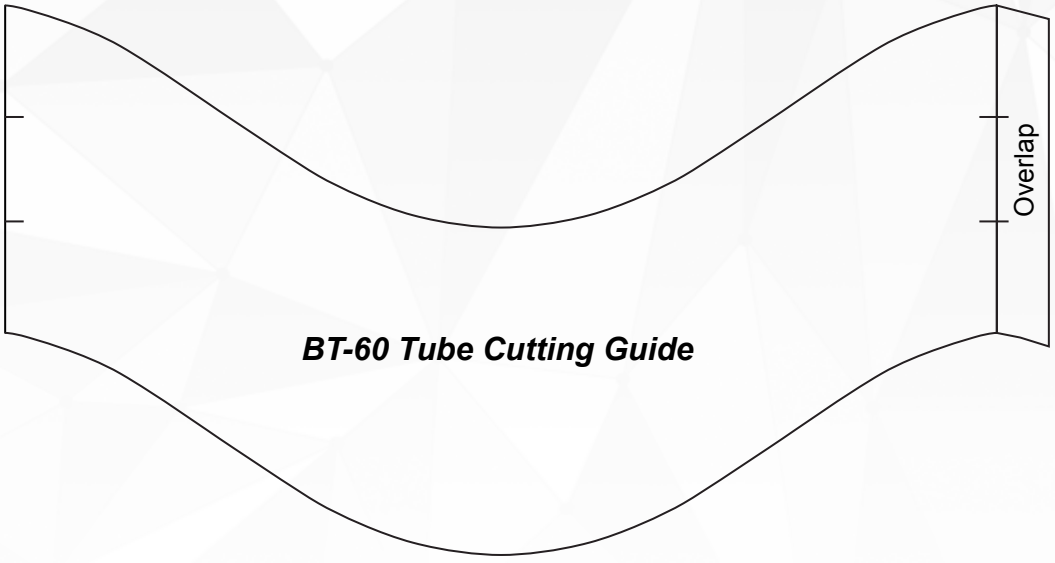


Decals Sheet



BT-55 Tube Marking Guide





BT-60 Tube Cutting Guide