PEAK OF FLIGHT NEWSLETTER

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THE NAR+3 METHOD OF CHECKING SAFETY

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PEAK OF FLIGHT

Is it Safe to Fly?

By Jim Bassham

HOW CAN YOU KNOW THAT SOMETHING THIS WEIRD WILL BE SAFE TO FLY?

Rockets are wonderful tools for teaching science and math. With readily available software such as Apogee Component's RockSim, and volumes written on the science of rocketry, such as Tim Van Milligan's *Model Rocket Design and Construction* https://www.apogeerockets.com/Rocket_Books_Videos/Books/Model_Rocket_Design_And_Construction, world-class computer-aided design tools and advanced rocketry concepts are readily available to teachers and educators to use in teaching advanced math and science concepts through model rocketry.

But sometimes that level of sophistication is not appropriate or possible in the time allowed. When working with a group of kids, whose eyes will glaze over when you start talking math, it may not be advisable to get too far into the science of rocketry and too far away from the fun.

Or you may volunteer to check rockets at a group launch, where in-depth discussions of the theory of center-of-pressure verses center-of-gravity may not be practical when someone just wants to get their rocket in the air.

In these cases, how can we make a quick determination if a rocket is safe to fly?

When working with new rocketeers and in group build sessions everyone likes to push the boundaries and come up with something new. Fins can be put on backwards, or there may be ten of them of different shapes. With all that creativity, how do you know if that newly minted rocket will be safe to launch?

There are also times when you might have volunteered to do safety inspections at a club launch and someone brings their scratch-built, pride-and-joy to the check-in and you aren't sure it will go up instead of sideways. Wouldn't it be useful if there were a set of simple guidelines to help you decide if the rocket is safe to launch? This article will explain the "NAR +3" "rules-of-thumb" that I use when deciding if an unknown, unproven design has a reasonable chance to fly safely.

An important place to start is the NAR (National Association of Rocketry) safety code. These eleven basic rules are included with every rocket kit sold in the US. These rule sheets often get tossed aside when constructing a rocket kit, but are very important to review for two reasons. First, they form the foundation of the incredibly safe record that model rocketry has enjoyed over the last 60 years of the NAR's existence and second, violating these rules can void your insurance coverage that the NAR provides clubs and NAR member's flights.

The safety code was first created in the founding days of the NAR and its focus is on safety. There are four key components of the code: construction, motors, recovery and launch systems:

Rules 1 and 10 focus on construction:

Rule 1: "I will use only lightweight, non-metal parts for the nose, body and fins of my rocket."

Any rocket that fails to deploy a recovery system can become a lawn dart. This is why it is extremely important that model rockets not be made of metal. Any rocket with metal nosecone, fins or pipe for a body tube is immediately disqualified from flying. Even sharp "antennas" made from round toothpicks must have their tips dulled and are not rec-

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ommended. If you would not want the rocket dropped from a couple feet nose-down onto your open palm, you don't really want it falling uncontrolled from the sky.

Rule 10: "I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket"

Any rocket presented for flight must have a recovery system and the rocketeer must be able to explain how it is supposed to come down safely. "I glued the nosecone on because I didn't want it to come off" and "I don't know how it comes down" are not adequate recovery systems. On the other hand, most small rockets ("C" impulse or smaller) will recover just fine without a parachute as long as they have a shock cord and a motor hook or tape to prevent the motor kicking. The primary reason a rocket will fall uncontrollably is because its recovery system failed. That usually happens because the rocket ejected the motor instead of the nosecone. This is why it is so important that you inspect how solidly the motor is mounted verses the nosecone. The nosecone should come off with just a gentle tug; the motor, however, should not budge. If you inspect a rocket for flight and it is easier for the motor to come out than the nosecone to come off, there is an immediate problem.

The second part of the NAR code deals with motors:

Rule 2: "Motors: I will use only certified, commercially-made model rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer."

When the NAR was founded, garage accidents from amateur rocketeers building their own motors had given model rocketry a bad reputation. The NAR was founded to make rocketry safe and stop these types of accidents from happening and has been remarkably effective at doing so. One of the primary ways it has done this is through the motor certification program. The NAR tests hundreds of motors, from every manufacturer, every year. Additionally, through the MESS (Malfunctioning Engine Statistical Survey) the NAR keeps track of motor malfunctions in the field. The NAR publishes a list of certified motors and all NAR sanctioned launches only allow motors from this list to be used.

One of the downsides of the internet age in which we live is that a million bad ideas are just a mouse-click away. Videos and instructions on sugar-motor rockets, making rocket propellant and "reloading" spent black powder motors are readily available. In many ways the "bad days" of amateur rocketry that the NAR thought it had left behind have come back worse than ever. Rocketry is an extremely safe hobby when done properly, but all the dangers that worried the early founders of the NAR are still just an internet search away. You should never let anyone fly a rocket with a motor they made, or modified in any way. It simply is too big a risk to everyone involved.

The third part of the NAR code involves launch systems: Rules 3, 4, 5, 6, 8 and 9 all deal with launch systems. In summary, it is important that you use an electrical launch system (No fuses), the rocket is launched on a rod or rail, pointed up, that there are no aircraft or low clouds in the area and you have an adequately open area to fly in. Rockets should never be aimed at anything and you must be aware of anything in the air that they would pose a hazard to. Building your own launch system or launch pad are advanced concepts that are better left to experienced rocketeers and clubs. When starting out, it is best to stick to commercially

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available launch pads and ignition systems and always follow the instructions.

Rule 7 of the safety code deals with the weight and propellant limits of model rockets. Any rocket over 53 ounces in weight or carrying more than 4.4 ounces of propellant is considered a high-power rocket and requires special FAA waivers and NAR certification to fly - definitely not something to be messing with for your first rocket. Range safety checks of high powered rockets requires that you hold at least level 2 certification yourself, so they are not something you will likely encounter except at club launches.

The last rule of the safety code is about recovering a rocket from dangerous areas such as power lines or tall trees. If your rocket lands on a power line, you should never attempt to recover it yourself. The risk of electrocution is simply too

great. You should also be careful about trying to recover a rocket from tall trees. Rockets tend have a habit of landing at the edges of trees, out of reach of the ground and on far too thin of branches to climb.

So, following the NAR safety code is an absolute must. You cannot really have a safe launch without it. But following the safety code doesn't really tell you if the rocket will actually fly. A rocket can follow the NAR safety code to the letter, yet still spin out of control. Or worse, the rocket may take off horizontally like a cruise missile and be dangerous. These types of safety problems are caused by rockets that are unstable. Is there a way to have a reasonable idea if a rocket will be stable when you fly it? I propose three simple guidelines to check an unknown rocket for stability that you can do "on the fly" - so to speak.

The first thing to consider is the construction of the rocket. I used to think this was unnecessary until I saw some rockets at a club launch. If the fins are cut from notepaper, put on with a glue-stick and there is no shock cord, then, of course, the rocket is not safe to fly.

THIS ROCKET USES FINS OF DIFFERENT SHAPES AND SIZES TO MAKE THE ROCKET LOOK LIKE A SUPERSONIC AIRPLANE.

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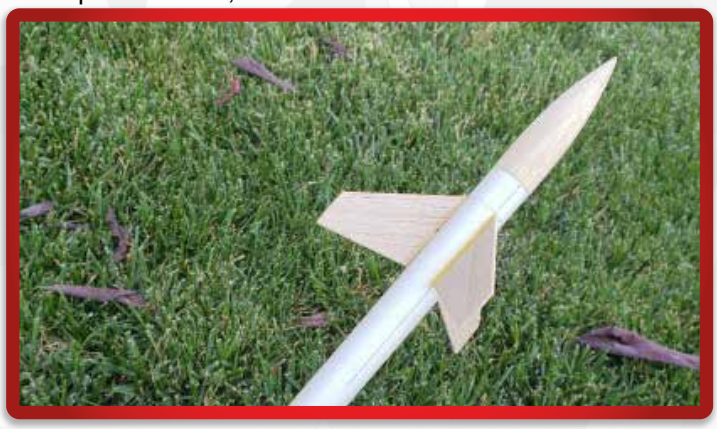
The fins must be stiff, attached with glue (not a glue stick or hot glue that can soften from the heat of the motor) and not wiggle or come off when given a gentle tug. Think of when you were a kid and you stuck you hand out the window of a car into the airstream. Remember how much force just air could exert on your hand? A rocket's fins must be able to hold on in that same force and not fly off. A rocket that sheds parts upon launch could go anywhere, and we don't want that.

The second thing to consider is the rocket's overall design. One place to start is to understand the things that don't matter about a rocket's design.

Nose cones don't have to be "pointy." In fact, nosecones can be almost any shape. Round, square, even concave nose cones will work. In fact, seeing how different nose cone shapes effect the performance of a rocket is a great science fair project and Apogee Components sells a kit just for this purpose (the Avion Nose Cone Science Fair Kit) https://www.apogeerockets.com/Rocket-Kits/Skill-Level-1-Model-Rocket-Kits/Avion-Nose-Cone-Science-Fair-Kit-24mm. Just looking at that kit will show you that the shape of the nose cone may affect performance, but will not make a rocket unsafe.



IF SOMEONE SHOWS YOU A DESIGN LIKE THIS IN A BUILD SESSION, TRY GETTING THEM TO FLIP IT AROUND.

THAT DESIGN WILL FLY, EVEN WITH THE REVERSE SWEPT FINS.

Something else that doesn't matter is that all the fins be the same shape or even size. A good rule of thumb is that no fin should be more than about 25% smaller than the others, but many cool designs use fins of different shapes to make "airplane" or "spaceship" looking rockets. What often surprises people is that fin shape isn't really that important. Rockets can be built with almost any fin shape you can imagine. They can be swept forward, backward, be circular, diamond shaped, almost anything, as long as they are solidly attached.

So what does matter with fins?

The fins must be at the back (engine end) of the rocket. It seems that everyone thinks at some point that it would be cool to put the fins at the front of the rocket. This simply is a no-go. No rocket will fly with the fins at the front and you should never attempt to launch one.

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The one exception is that a rocket can have small fins near the front that are decorative. These small fins should be as far back from the nose as possible and should never be more than a tenth of the area of the main fins or stick out much more than a body-tube diameter from the body.

There must be at least 3 fins spaced roughly equally around the rocket. Think of this like the legs of a stool. A stool will not stand with only one or two legs, the minimum is three. The same is true for a rocket; the minimum number of fins is three, spaced roughly equal around the rocket. More than three fins are even better. You can't really have too many fins, but you can have too few.

The fins must be large enough to control the rocket. A rocket with no fins will not fly. The same is true of rockets whose fins are too small.

THE ROCKET IN THIS PICTURE, DESPITE BEING WELL-MADE, HAS FINS THAT ARE SIMPLY TOO SMALL AND IT IS UNSTABLE.

To be safe, the rocket's fins should stick out from the body tube at least one and one half times the body tube diameter. They should also be at least that long from front to back.

So if a rocket is well constructed of safe materials and has enough fins at the right end of the rocket will it be stable? Not necessarily. There is one last check that needs to be made to really be sure the rocket will be safe and that is balance.

One concept that is hard to understand for most beginning rocketeers is that a rocket must be heavier in the front than in the back to fly correctly. Most people think a rocket must be heavier on the "bottom" because gravity will act on the rocket like a pendulum and hold the heavy end down.

Though it is very counter-intuitive, the exact opposite is true. A rocket must weigh more in the front end (ahead of the fins) than in the back, or it will tumble across the sky. An easy way to test this is to balance the rocket on your finger or a ruler with the motor and parachute in it. If it balances ahead of the fins you are good.

DESPITE ALL THE DECORATIVE PARTS AND HAVING 9 FINS, THE STARSHIP VEGA STILL BALANCES FORWARD OF THE FINS ON A RULER. THE FORWARD FINS ARE LESS THAN A TENTH OF THE MAIN FIN AREA AND BARELY STICK OUT MORE THAN 1 BODY TUBE DIAMETER.

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So, in summary, how can you know if a rocket is safe to fly? Follow the NAR +3 rules:
NAR: Are we following all the parts of the safety code?

1. Is the rocket well constructed of safe materials?
2. Does it have at least 3 fins at the motor end and are they adequately sized and equally spaced around the rocket?
3. Does the rocket balance in front of the fins?

If the NAR +3 rules are met, you can have a reasonable expectation that the rocket will be safe to fly.

One last note:
What can you do if a rocket won't balance in front of the fins?
There are two ways to fix this "on the fly." The first is to add more nose weight in the form of clay or washers to the back of the nosecone. The second way is to make the rocket longer. A simple way to do that is to add a payload section to the front of the rocket. If you happen to have another rocket with a payload section of the same diameter, simply detach the rocket's nosecone and attach the payload section. This will both lengthen the rocket and add weight to the nose and usually solves the problem.
Happy flying!

DESPITE HOW ODD THE SHAPE OF THIS ROCKET IS, IT BALANCES IN FRONT OF THE FINS.

EVEN THE MOST EXOTIC ROCKETS CAN FLY SUCCESSFULLY IF THEY FOLLOW THE NAR +3 RULES.

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About the Author

Jim Bassham has been flying rockets since Gene Cernan was walking on the moon. He has written several articles for Sport Rocketry Magazine and is the author of the upcoming book "Everything I Know About Rockets I learned From Der Red Max" coming from ARA Press in 2020. This is his second article for Peak of Flight.

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