Issue 623 / April 9th, 2024

PEAK OF FLIGHT NEWSLETTER

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

What Size Launch Field Do You Need?

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COVER PHOTO

Gyro Chaser

This is a highly efficient competition style rocket for the helicopter duration event using 18mm diameter motors. It has been optimized to fly higher into the sky due to both its lightweight components and low drag aerodynamic shape, and to descend slower to the ground because of its unique curved blades and free-spinning rotor hub. Be ready to chase this rocket a long way, because it was designed to hang in the air and make you the helicopter champion!

FEATURED ARTICLE

What size launch field do you need?

by Tim Van Milligan

The article discusses the factors involved in determining the minimum size of a launch site for model rockets to ensure safe recovery. It emphasizes the importance of considering variables such as rocket altitude, wind speed, and descent rate in calculating drift distance.

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About this Newsletter

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The Kronos rocket flying at the SCORE Launch in Pueblo, Colorado (July 2023)

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What Size Launch Field Do You Need?

by Tim Van Milligan

One of the most common questions in rocketry is how large of a launch site do you need when flying rockets? Obviously, you want to get your rocket back, and you don't want it to drift away into an area where it is not recoverable.

There are a lot of rules of thumb in this regard to picking a field. The short answer to the question though, is that the bigger the field, the better. A larger launch range, and if it is flat and devoid of trees, it will be better for recovery because the rocket will be easier to find, and you probably don't have to jump or climb over obstacles to retrieve it. But unless you live in the western part of the USA, where there are plenty of flat dry lake beds, you'll have to compromise with the space you have available.

The better question becomes, what is the "minimum size" launch field that you'll need for your rocket?

At this point, we need to go over some of the variables that will dictate how we'll decide the minimum dimensions of the launch site in order to easily recover our rocket.

The three variables that we'll have to look at in this situation for determining the minimum launch site dimensions are: 1) how high will the rocket fly, 2) how hard is the wind blowing on launch day, and 3) what is the rate of descent of the rocket as it comes down.

There is a simple formula for determining how far the rocket will drift with the wind. It is:

Altitude/descent rate x wind speed = Drift distance

When you divide the altitude by the descent rate, the result is the "time" the rocket takes to land from its peak altitude. Then you multiply this by the wind speed, because the assumption is the wind is going to push the rocket and the parachute along at the current wind speed.

So for example, say the rocket flies 100 feet into the sky, and pops out its parachute. The wind speed on that launch day is blowing at 4 mph. Let's say that the rate of descent of the parachute is 11.5 feet/second. That means the rocket will take 8.7 seconds to fall back to the ground (100/11.5 = 8.7).

During that 8.7 seconds, it is being pushed by the wind at a rate of 4 mph. When you do the conversion of mph to feet/second, it is being pushed at a speed of 5.87 ft/s. Multiplying the 8.7 seconds times the horizontal wind speed of 5.87 ft/s, means the rocket will drift 51.0 feet before it touches down to the ground.

So basically, we could say that for this particular rocket, flying on this particular day, it will need a minimum launch site of 51 feet (see figure 1).

	A	B	C	D	E	F
1	Altitude (ft)	Wind speed (MPH)	Wind speed (fps)	Descent Rate (fps)	Descent Time (s)	Drift Distance (ft)
2	100	1	1.47	11.5	8.70	12.8
3	100	2	2.93	11.5	8.70	25.5
4	100	3	4.40	11.5	8.70	38.3
5	100	4	5.87	11.5	8.70	51.0
6	100	5	7.33	11.5	8.70	63.8
7	100	6	8.80	11.5	8.70	76.5
8	100	7	10.27	11.5	8.70	89.3
9	100	8	11.73	11.5	8.70	102.0
10	100	9	13.20	11.5	8.70	114.8
11	100	10	14.67	11.5	8.70	127.5
12	100	11	16.13	11.5	8.70	140.3

Figure 1: A simple spreadsheet can be used to determine how far the rocket will drift based on its altitude and descent rate. At 100 foot altitude, and a 11.5 fps descent rate, the rocket will drift 51.0 feet downrange, in a 4 mph wind.

You can download a drift distance excel spreadsheet like Figure 1 from the Apogee website at: https://www.ApogeeRockets.com/Downloads/PDFs/Drift-Distance-Calculator.xlsx

Now you're probably wondering if that is a circular area, or a square area. What we found is the drift distance, so in a perfect world, it is simply a line.

What do we mean by a "perfect world?" That is what my teachers would always ask us in school. And it is a good question, because it requires us to think about the situation. For example, we are assuming that the wind is constant, and only is blowing in one direction. In the "real world," the wind is rarely constant, and it can come from slightly different directions.

So you could argue that the area of the launch site area probably should be a square or a rectangle.

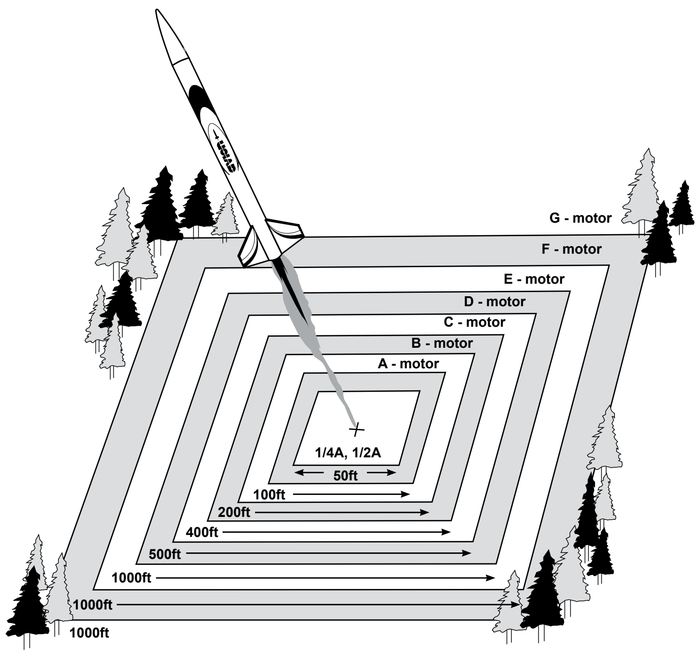

Figure 2 - The standard minimum launch site dimensions from the NAR

How High Will The Rocket Fly?

This variable is not the easiest for a newbie to rocketry to figure out. If they've never flown rockets before, they probably would have no idea how high the rocket will go. So hopefully the newbie modeler will look at the package that the kit comes in from the manufacturer, and see how high it will fly on various motors they might select.

That is the exact reason we create motor charts for all of our Apogee kits. We want to give the customer some

idea on how high their rocket will fly. But it really doesn't tell them how far the rocket will drift, and how much recovery area they'll need to easily get the rocket back after the flight.

If you're working with your own rocket designs, the situation is far more complex. Now the flier has to estimate how high they think the rocket will fly for themselves. If you've never done that before, our recommendation is that you use a computer program like RockSim (**https://www.apogeerockets.com/Rocket Software/Rocksim**). It will get you a very good estimate of how high the rocket will fly on any motor.

Wind Speed

This is the one variable that you don't know until you actually get out to the launch field. We obviously want a low speed wind, because then the rocket won't drift very far.

The safety code from the National Association of Rocketry puts an upper limit on the wind speed at 20 mph. But if you think about it, that is really howling. For me, I don't like to fly rockets in winds greater than 8 mph. When it gets to 10 mph, the rocket is drifting so far that the fun goes out of the launch. Not only is the rocket no longer flying straight up, but it is drifting faster than you can sprint after it. For example, say you're able to run a mile in 9 minutes, which means you're running 6.6 miles per hour, which is a really fast pace for most people. When the rocket is drifting away faster than you can run after it, you're losing ground and it just is a chore to recover it. And even after the rocket lands on the ground, the wind could easily push the rocket even further.

What I'm saying here is that you should have an upper limit on the wind speed that you're willing to even launch the rocket. Just because the NAR safety code gives you a little leeway in launching, it doesn't mean that it would be a smart thing to do. Be smart.

How fast is the rocket descending?

You're probably wondering where I picked 11.5 feet/second (3.5m/s) in the example situation I gave above. That is a good rule-of-thumb speed for a rocket that is coming down "slowly." We want rockets to land gently on the ground so that they aren't damaged. A fast speed would be approximately 14.8 feet/second (4.5m/s). This is the speed that a rocket would hit the ground if you just knocked it off your desk and it fell to the floor.

Ask yourself, would my rocket survive a fall to the floor if I knocked it off my desk? If so, then you can probably use a fairly small parachute so the descent speed is fast and the result is that it won't drift as far.

For example, say our rocket went 100 feet in the air, the wind was at 4mph, and the only difference was the descent speed of the rocket under parachute. For a slow descent speed of 11.5 ft/s, the rocket will drift 51 feet. But if it can survive a higher descent speed of 14.8 ft/s, the rocket will only drift 39.6 feet. That is a 25% difference in drift distance, which is not insignificant.

The descent speed is controlled by the size of the parachute that you use for your rocket. Basically, you start with the speed you want your rocket to land at, and then you size the parachute accordingly. I would suggest that you start with a slow descent speed of 11.5 ft/s (3.5m/s) if you are just starting out. Then you would pick the chute size that would give you that descent speed. I wrote an article called "*What Size Parachute Should I Use For My Model Rocket?*" - https://www.apogeerockets.com/Peak-of-Flight/Newsletter496 that gives you the size parachute you'll need for your rocket based on its weight, and a "slow" descent speed.

If you want to use software to calculate des cent speed, RockSim has a couple of buttons in the parachute editor screen that when clicked will tell you the diameter you'll need for speeds of slow, medium, or high descent velocity (see figure 3).

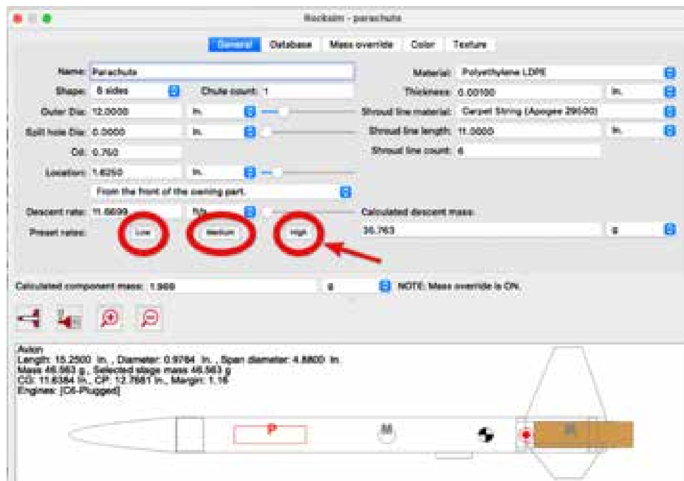

Figure 3: In RockSim, you can quickly size your parachute by clicking on the buttons for Low, Medium, or High, which correspond to the speed at which the rocket will fall.

Other variables that will affect the size of your launch field

Up to this point, we've assumed that the rocket went straight up into the air, directly above the launch pad. But in the real world, that rarely happens. It almost never goes perfectly straight, even if you built everything perfectly straight (such as using a good fin alignment jig). The usual cause is that the wind is affecting the rocket.

A rocket that is stable (which is a good thing), tends to weathercock into the wind. So instead of going straight up, it will tend to turn gradually and fly upwind.

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This tendency to weathercock is actually a good thing when it comes to finding the minimum size launch field for two reasons. First, the rocket isn't going to fly as high into the sky. So it will start out at a lower altitude once the parachute is deployed. And second, since it is upwind of the launch pad, even if it does drift with the wind, it is going to land closer to the launch pad.

Similarly, you could also angle the rocket a little bit into the wind so that it will also arc over and not fly so high, and also fly upwind so it lands closer to the pad.

One word of caution here though when it comes to either angling the rocket, or allowing it to weathercock excessively into the wind. That is you should have a standard that says there could be too much of a good thing. I personally don't want the rocket traveling upwind a great distance because it could be a safety hazard. The "safest" direction for a rocket to fly is "up." When it goes up, you have more predictability on things that might occur.

You always have to assume that something bad might happen during the flight. One of those bad things might be the nose cone not coming off when the ejection charge fires. In that case the rocket is going to make a fast ballistic trajectory into the ground. If that happens while the rocket is going straight up, you have a pretty good idea where it will land (somewhere near the launch pad). You have time to warn people around the pad to look up and get out of the way of the rocket coming down.

But if that same situation happens when the rocket is going away from you by traveling upwind, you don't know what is further away from the pad, nor do you control the people in that area. When shouting upwind, your voice doesn't carry as far, and any people upwind may not hear your urgent cries to look up and move out of the way.

So I have a criteria of how much weathercocking or angling the launch pad is too much. I call this the weathercocking cone. It is an imaginary cone projecting upward from the launch pad. I want the rocket's apogee point (the highest point in the flight) to be inside of this imaginary cone. If the apogee point is outside of the cone, the rocket is going too far into the wind.

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To make it easy to see, I had this imaginary cone built into RockSim, RS-Pro (https://www.apogeerockets.com/Rocket_Software/RockSim_Pro), and the Launch Visualizer, so that you could tell if your rocket is going in a safer trajectory path.

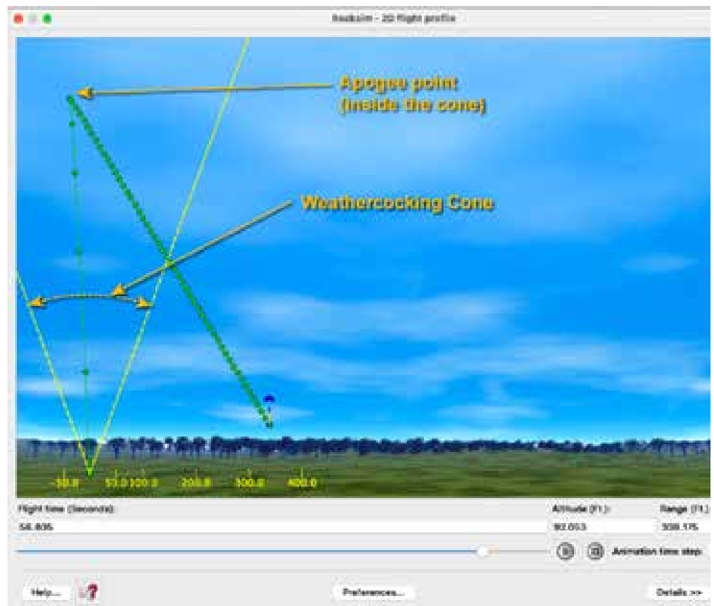

Figure 4 - You can display the weathercocking cone in RockSim when showing the 2D flight profile. The apogee point of the flight should always be within the weathercocking cone for the safest flight.

Can you predict how much your rocket will weathercock, or where it will go if you angle the rocket into the wind? You can if you use RockSim. It not only helps you estimate how high the rocket will fly, and what size parachute you'll need for a desired descent speed, but it will also help you see the effect of wind and angling the launch rod into the wind.

Are We Asking the Right Question?

What we're saying here, is that "you personally control" where the rocket will land, and that is a really powerful concept. The question we might ask instead is: 'where do we want the rocket to land?'

It is this new question that has been the driver for all sorts of technology advancement in model rocketry. It was the reason we have dual deployment for rockets that fly to extreme altitudes. Because the actual purpose of dual deployment is just one thing - to prevent the rocket from drifting so far that you can't easily recover it.

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In dual deployment, instead of letting the rocket drift for really long distances under a big parachute that is designed for a soft landing, we use two different size parachutes. One parachute is very small, so the rocket drops quickly, and doesn't have time to blow downrange very far. The other parachute is the big one, but it only opens up when the rocket is close to the ground, so the time it is open is reduced so again the drift distance is also reduced.

Furthermore, we here at Apogee Components developed the gliding parachute system (see figure 5), to take this concept to the extreme. You can use the system to put the rocket down exactly where you want it to land.

Figure 5 - Apogee's gliding parachute system allows you to control the flight of the rocket, so you can land it exactly where you wish.

We started this discussion asking what is the minimum size field that we need to fly a rocket in. And the question morphed into how to control the rocket to land where we want it to land.

However, there is actually a very good reason to have a minimum size launch range. And it isn't where we want the rocket to land, because as we've just shown, we can get it to land anywhere we want.

The real reason to have a minimum size field is for safety. As alluded to previously, we have to assume that something bad might happen during the launch, and the rocket could take a wayward trajectory on a course away from us.

In this case, another question we could ask is: "how far can our rocket travel if we don't have any control over the path it takes?"

In this situation, ballistic flights might be the determining factor of launch range size. As we talked about above, if the nose cone stays on throughout the entire flight, what is the maximum distance that we can get it to fly? This maximum ballistic flight distance is now the minimum size of our rocket range.

As before, we can use software to estimate this for us. But this time, the variables have increased. The shape of the rocket (how aerodynamic it is), the tube size, its mass, and launch conditions like air density, launch angle, wind speed and motor used will all affect how far downrange we can get our rockets to fly. It is no longer a problem with just one simple answer.

You really need to know the rocket you're using, and then run the simulations to figure out the maximum distance that the rocket can fly. For something like this, I would switch from RockSim, to RS-Pro so that we could run hundreds of simulations quickly to find what is called the “splash pattern.” That is one of the main advantages of RS-Pro, in that you can vary a lot of the variables and let it chug through hundreds, if not thousands of launch simulations to find the maximum range the ballistic rocket might take.

For an example, let’s take a popular kit like the Apogee Avion, and launch it on an Estes C6 motor. The hard part is coming up with some sort of criteria that would define an unsafe launch. We mentioned before that if the nose cone stayed on, the rocket would fly a ballistic arc as its trajectory. First, let’s see what the maximum range we could get in this situation. So for our first simulation, let’s set the launch angle at 45 degrees, and point it to the East (see figure 6).

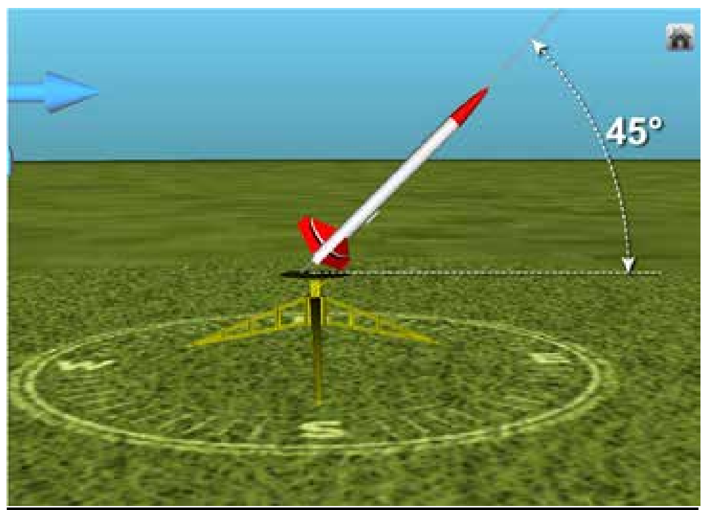

Figure 6 - Setting the launch angle to get maximum range from the launch.

Let’s also say that there is a 5mph wind from out of the west (270° direction), so it is tailwind pushing the rocket faster. We’ll run 500 simulations, and with an elevation error of 10 degrees. What this means is that the launch angle could be anywhere from 35° from vertical, all the way to 55° from vertical. When RS-Pro runs the 100 simulations, it will randomly vary the launch angle, with most of the runs between these two values. It will

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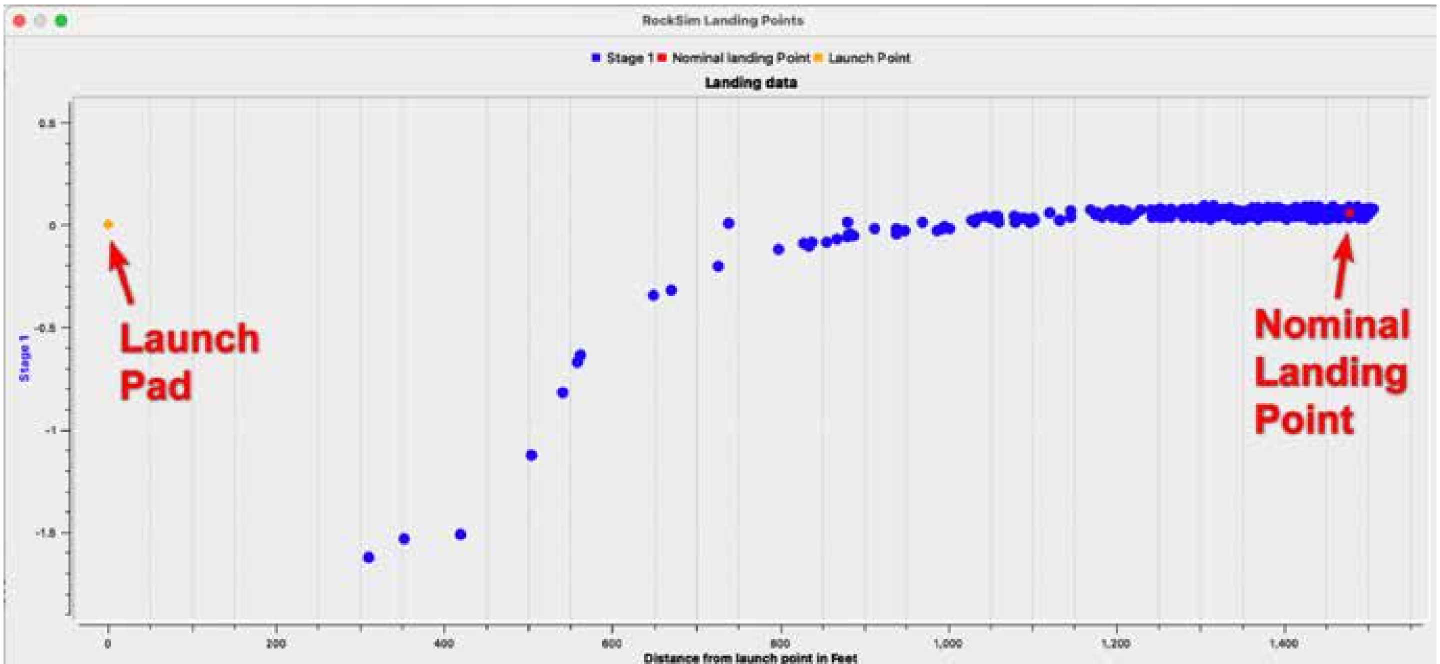


Figure 7 - Landing point plot of the Apogee Avion launched at 45° angle, with a 5mph tailwind. Each blue dot represents a simulation where the launch angle was varied slightly from 45°.

actually go greater than this range, but most of the flights will be between the 35° to 55° launch angle.

When you do this, you get a plot that looks something like shown in Figure 7.

What we see from this splash-down pattern, is that most of the launches are going to land between 1,200 to 1,500 feet from the launch pad.

If you look at the image, you see some rockets that seemed to stray a little bit off the normal path. But if you look at the vertical scale, the actual distance off is less than two feet. So I wouldn't worry about that so much. The big point is that the rocket can land a really long way away.

If you're still not convinced, you can also use RS-Pro to generate a google earth plot of the same set of simulations overlaid on an actual launch site. In Figure 8, before I used the launch site of the Colorado Springs Rocket Society (COSROCS) to display the landing zone. You can see that the landing points make almost a straight line away from the landing point.

Figure 8 - The same landing point plot, but this time overlaid on a Google aerial photo.

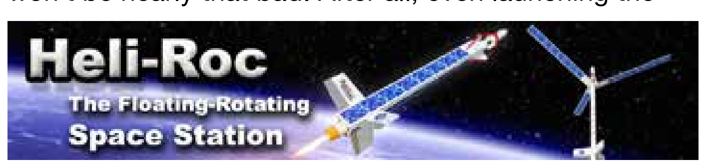
Now the National Association of Rocketry has a chart that shows the minimum launch site dimensions based on the rocket motor used (http://www.nar.org/safety-information/model-rocket-safety-code/), which is shown in chart 1, and in Figure 2. In this case, for a C motor, the NAR recommends a minimum size launch area of 400 feet.

When I saw this big difference between what RockSim-Pro is calculating and what the NAR says for the minimum launch site dimensions, I got to scratching my head trying to figure out why they recommend a smaller launch area.

Installed Total Impulse (N-sec)	Equivalent Motor Type	Minimum Site Dimensions (ft)
0.00 - 1.25	1/4A, 1/2A	50
1.26 - 2.50	A	100
2.51 - 5.00	B	200
5.01 - 10.00	C	400
10.01 - 20.00	D	500
20.01 - 40.00	E	1,000
40.01 - 80.00	F	1,000
80.01 - 160.00	G	1,000
160.01 - 320.00	Two Gs	1,500

I'm not sure what criteria the NAR used for determining minimum launch site dimensions, but I'm guessing they weren't looking at the worst case situation. After all, things will rarely ever get to the point of being "the worst case". In our simulations, we were trying to get the rocket to go as far as possible by preventing the nose cone from coming off during the flight so that the trajectory would be ballistic.

For most people, the worst case situation probably won't be nearly that bad. After all, even launching the



rocket at a 45° launch angle violates the NAR safety code. And most people want the nose cone to come off and the parachute to deploy properly so they get it back.

I sense that for a typical rocketeer, the worst case would be if the model went unstable during launch. That was in the back of my mind when I selected a launch angle of 45°, which would be like the rocket taking off and then heading out at an odd angle. I've seen that happen, but that is not an unstable rocket. And unstable rocket doesn't follow a ballistic trajectory. It is going to skywrite all over the place in random directions.

Fortunately, we can somewhat simulate this in either the Launch Visualizer (www.RockSim.com) or in RS-Pro, and see where the rocket might land. The Launch Visualizer even has a pre-made "unstable" rocket included in the demo designs that you can play with for free. Figure 9 shows what the random trajectory would look like on a C6 motor.

Figure 9 - The trajectory of an unstable rocket. Note that the distance to touchdown (shown top-left corner) shows it only made about 153 feet.

To set this up in RS-Pro, I'll take the standard Apoge Avion kit (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-1-Model-Rocket-Kits/Avion) and slide the fins forward so the CP is ahead of the CG. Then we'll launch it straight up in a 5 mph wind. The problem with simulating unstable rockets is that the software can't account for every type of wind force acting on the

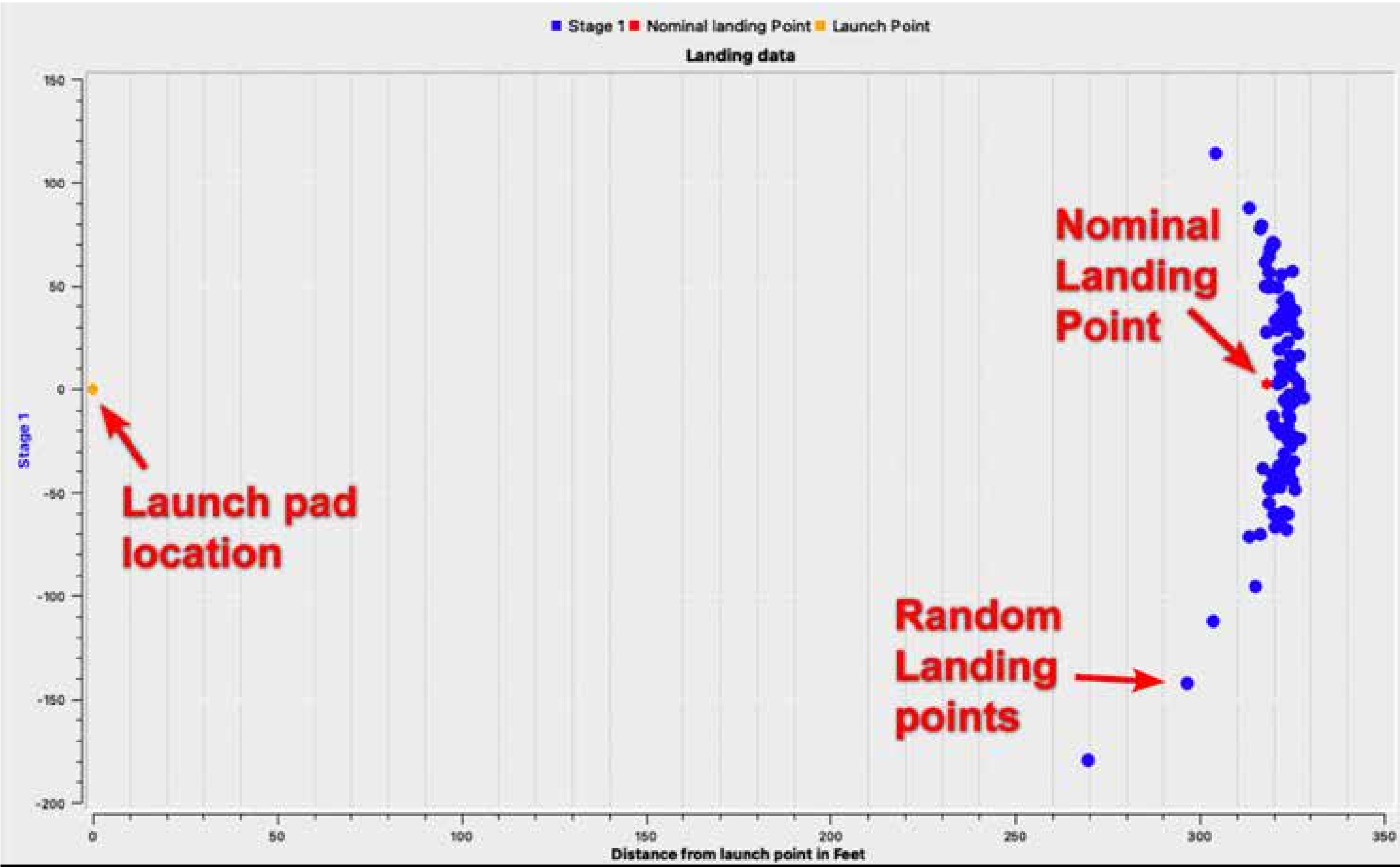


Figure 10 - A plot of 100 simulations of a rocket that went unstable, and that was launched straight up with a C6 motor, and came down without ejecting the parachute.

rocket, so there isn't as much randomness in a simulation as you'd want. What this means is that in RS-Pro the unstable rocket will have the same trajectory every time you launch it. In real life, we know that every time you launch an unstable rocket, it will take a completely different random trajectory.

In order to make each simulation a bit more random, for a run of 100 simulations, I added an uncertainty error of 10 degrees for the wind angle. So instead of the wind blowing at 5mph from directly out of the west, it can vary from the northwest to the southwest. That will give us different trajectories on each launch. Doing that, and plotting out the results as a splash pattern, gives us what is shown in Figure 10.

In this situation, the distance the rocket gets from the pad is under 350 feet. This is well within the NAR's recommendation of 400 feet for the minimum launch site dimension.

However, I really wish I knew what criteria other experienced rocketeers are using in order to figure out the minimum launch site dimension. I can see that it is possible for the NAR's recommendations to work, but a bigger launch site is always better. My personal opinion is that the minimum site dimensions are a bit too small, and when I fly rockets, I look for a bigger field.

Conclusion

In this article, we basically came to the conclusion that it is possible to get your rocket to land in any desired location that you want. So the minimum launch site is not really related to how easy it will be to retrieve your rocket. What really matters is "safety." The question we need to ask is how far away your rocket might go if something in the flight goes radically wrong? If the rocket completely goes unstable, then the NAR recommendations for minimum launch site dimensions are probably OK. But if you look at the maximum distance a stable rocket might reach, then you'd really want a much larger site. A quick look at the numbers from RockSim seem to indicate that a distance of twice the nominal altitude of a rocket launched straight up is probably at the maximum amount of space you'd need.

There is probably some happy medium or compromise that makes a bit more sense, because it is always going to be really hard to find wide open spaces that are twice as long as the expected altitude. One suggestion I've heard of in the past is the site should be about the same dimension as the expected altitude of the rocket if it is launched straight up. That might not be a bad rule of thumb for a newbie that is just getting into rocketry.

But you're not a newbie, and that makes a big difference. You've flown rockets before, and you know what to expect, and how to assure that your rockets will perform how you want them to. In my mind (just an opinion), the minimum size field is really about rockets that you don't know if they will fly straight. So just make sure your rockets will fly straight. If you can predict how they will go up, you can certainly plan for where you want them to land.

Going forward, here is my advice:

1. Do everything you can to improve the reliability of your rocket. Are you confident it will fly straight and stable?

2. A stable rocket that flies ***upward*** is the safest, because it makes it easier to predict where it will go.

3. Build "quality" rockets. Use fin jigs to make sure your rocket flies as straight as possible. Then use strong fin fillets to make sure the fins will stay on throughout the trajectory of the flight.

4. Test the fit of your parachute in the tube and the amount of friction holding the nose on. You want to be confident that the nose will come off and the parachute comes out when the ejection charge goes off.

5. When setting up the launch angle, if you are unsure, use the weathercocking cone in RockSim as a guide for preventing the rocket from being angled too far.

6. Have a maximum wind speed criteria for your rockets. You don't have to fly if you feel the winds are going to carry your rocket too far. Be smart.

7. If you can, run your RockSim simulations and look at the flight animation to see how your rocket will fly. The more you know about your rocket's flight characteristics, the better you can plan.

8. If you really want to see where your rocket will land, and if that landing area is devoid of trees and other obstacles, use the Launch Visualizer at www.RockSim.com or RS-Pro. I personally find it to be an indispensable tool for planning my flights.

In reality, there is really nothing new here. Basically, we're just saying to follow the NAR's model rocket safety code. It is proven to work well when you apply it to your flights.

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.

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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.

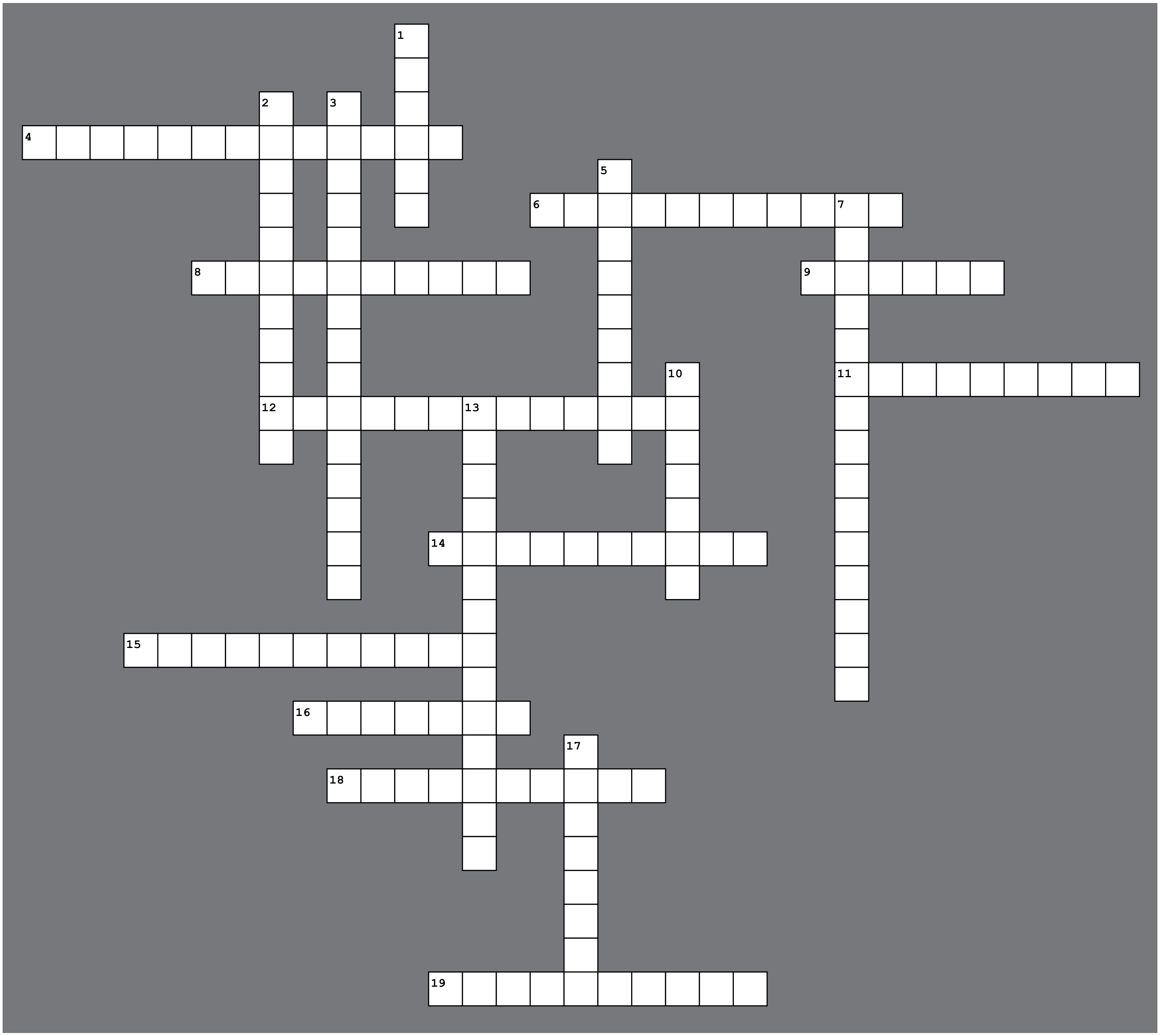
RATES

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.

CROSSWORD



DOWN 1. Drogue 2. Aeronautics 3. Recovery Wadding 5. Launchpad 7. Exhaust Velocity 10. Neptune 13. CenteringRings 17. Body Tube

ACROSS 4. Kinetic Energy 6. Black Powder 8. Trajectory 9. Thrust 11. Shock Cord 12. Cyanoacrylate 14. Redundancy 15. First Motion 16. Misfire 18. Engine Hook 19. Propellant

QUESTIONS

ACROSS

4. An object's energy of motion; for example, the force of a falling body

6. A mixture of saltpeter (potassium nitrate), sulfur, and charcoal, used in explosives and as an early propellant for rockets.

8. The flight path of a projectile, missile, rocket or satellite.

9. The reaction force that pushes a rocket in one direction as propellant is pushed in the opposite direction.

11. This part of the model rocket is what holds everything together once they separate at ejection.

12. aka Super Glue

14. The duplication of certain critical components in a space vehicle.

15. The instant at which a model begins to move upward under the thrust provided by a model rocket motor.

16. Failure of a model to make an official flight when its launch is attempted. Failure to launch caused by a malfunction of a meet-provided launch system must not be considered a misfire.

18. A form of motor retainer.

19. The material that is used to create a pressurised gas that creates thrust when released. For a chemical rocket, the propellant is the fuel and oxidiser.

DOWN

1. A small parachute used to slow and stabilize a spacecraft returning to the atmosphere, usually preceding deployment of a main landing parachute.

2. The science of building and operating vehicles for flight.

3. flame-resistant material that protects the parachute (or other recovery system components) from the hot blast of the motor ejection charge.

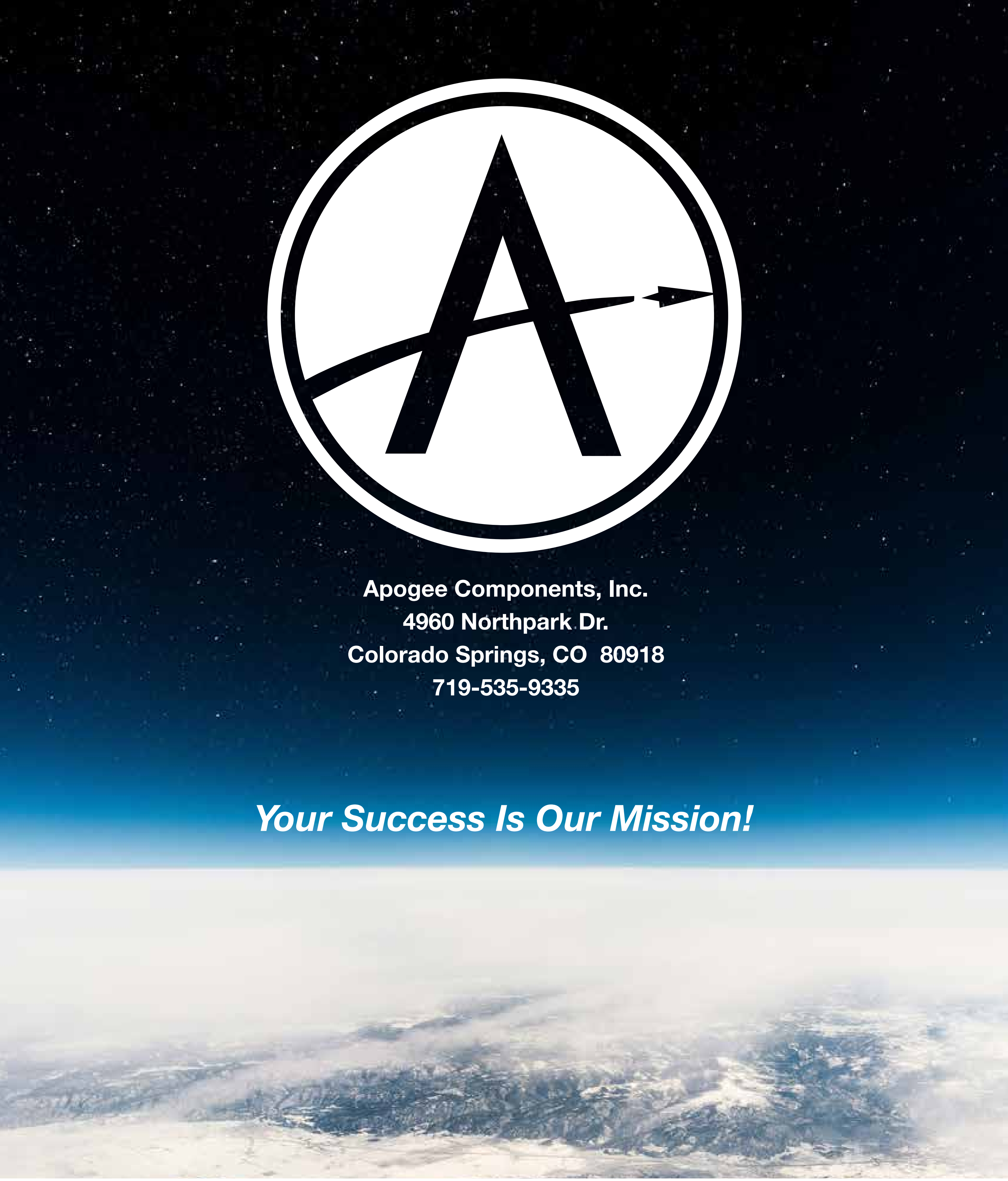
5. The load-bearing base from which a rocket or spacecraft positioned on its launcher is fired.

7. The velocity of the exhaust leaving the nozzle of a rocket.

10. Eighth planet from the Sun, a gas giant or Jovian planet.

13. These parts center the engine tube in the center of the model rocket body tube.

17. The airframe of the model rocket



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Your Success Is Our Mission!

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