

Rocketry Toolkit



for Girl Scout Councils and Troops

Table of Contents

1. Introduction	<u>3</u>
What Is Rocketry?	<u>4</u>
Why Do Rocketry?	<u>4</u>
Why Girl Scouts and Rocketry?	<u>5</u>
Competitive and Noncompetitive Opportunities	<u>5</u>
2. Building Teams and Networks	<u>6</u>
Recruit Girls and Create Teams	<u>7</u>
Recruit Volunteers and Experts	<u>9</u>
Find Funding and Partners	<u>10</u>
3. Rocketry Basics	<u>11</u>
Get Started with Your Team	<u>12</u>
Supplies	<u>15</u>
Safety	<u>16</u>
4. Activities: The American Rocketry Challenge Logistics	<u>19</u>
The American Rocketry Challenge	<u>20</u>
Finding a Mentor	<u>20</u>
Qualification Flight Attempts and Official Observers	<u>21</u>
Going to the Finals	<u>22</u>
Recommended Activity Timeline for American Rocketry Challenge Teams	<u>22</u>
5. Activities: Noncompetitive Ways to Explore Rocketry	<u>26</u>
6. Resources	<u>31</u>
Acronyms and Glossary	<u>32</u>
Helpful Links for Rocketry Teams	<u>33</u>
American Rocketry Challenge Links	<u>33</u>
Resources Included in This Toolkit	<u>33</u>
Recruitment Flyer for Competitive Girl Scout Rocketry Teams	<u>34</u>
Recruitment Flyer for Noncompetitive Girl Scout Rocketry Teams	<u>35</u>
Rocketry Event Flyer for Councils	<u>36</u>
Recruitment Flyer for Adults	<u>37</u>
Customizable Letter for Funding and Partners	<u>38</u>
Sample Parent and Caregiver Letter	<u>39</u>
Sample Budget Worksheet for a Rocketry Team	<u>40</u>

1

Introduction

Introduction

What Is Rocketry?

Rocketry is the design and creation of rockets. They're often built by aerospace engineers.

Aerospace is the earth's atmosphere and the space beyond it. An **engineer** is someone who uses science and technology to build machines and solve problems. An **aerospace engineer** is someone who develops aircraft and spacecraft. They also build rockets for all kinds of uses, like space exploration, deploying satellites, and national defense. They're rocket scientists!

However, you don't have to be an aerospace engineer to build rockets! When non-professionals use model or sport rockets to experiment with different designs and rocket motors, it's called **sport rocketry**. Sport rocketry is a popular hobby and educational tool to teach aerospace engineering. The National Association of Rocketry (NAR) was founded in 1957 to provide a safe and inexpensive way for young people to learn the principles of rocket science and flight. It's since become a worldwide hobby; there are over 12 million flights per year around the globe, and it's practiced in 25,000 schools across the U.S.

Why Do Rocketry?

Rocketry provides a fun opportunity for Girl Scouts to develop important skills like teamwork, problem solving, and leadership. They work together to design, create, and launch rockets, solving problems along the way. Rocketry also provides an opportunity for hands-on experience with

rocket design and construction, the use of several **STEM** (science, technology, engineering, and math) skills, and the exploration of STEM careers. Sport rocketry has inspired many young people over the years to pursue careers in technology.

Do you have Daisy, Brownie, or Junior Girl Scouts?

Daisies and Brownies are not able to participate in sport rocketry, but they can participate in simple science experiments related to rocket science, like air-powered drinking-straw rockets, balloon rockets, stomp rockets, or water-powered bicycle-pump rockets. They may also observe model rocket launches at a safe distance.

Juniors can participate in noncompetitive sport rocketry activities, but neither they nor Daisies and Brownies are eligible to take part in The American Rocketry Challenge. The challenge requires participants to be in grades 6–12.

Why Girl Scouts and Rocketry?

Girl Scouts of the USA (GSUSA) is committed to providing Girl Scouts in grades K-12 with meaningful, real-life skill-building experiences in STEM. Sport rocketry provides an excellent path to explore STEM concepts and careers, building interest and confidence and paving the way for more women to enter the male-dominated field. The Aerospace Industries Association (AIA) and GSUSA are committed to supporting Girl Scout councils and troops that want to participate in sport rocketry.

The purpose of this toolkit is to provide guidance, encouragement, and resources for councils and troops both to participate in The American Rocketry Challenge (TARC) and to pursue sport rocketry experiences in general, regardless of whether they choose to take part in competitive events. This toolkit includes information and resources for organizing sport rocketry experiences and finding volunteers, materials, mentors, meeting locations, and funding to enable Girl Scouts to explore the world of rocketry.

Competitive and Noncompetitive Opportunities

While building and launching model rockets is fun and educational, some groups like to add the challenge of competition to the process. Here are two ways groups can participate in sport rocketry:

The American Rocketry Challenge

This is the biggest rocketry competition in the world, sponsored by AIA. It provides sixth graders through 12th-graders with real-life experience in designing a rocket that meets a specified set of requirements. According to AIA, it's often a group's first experience with rocketry, and even if the group has rocketry experience, they'll often recruit new members with no previous experience to take part. Rocketry mentors from the National Association of Rocketry are also available for teams with all levels of experience.

Registration for The American Rocketry Challenge is open from May to December each year. Go to rocketcontest.org for more details.

For more information, check out “[Activities: The American Rocketry Challenge Logistics](#),” beginning on page 19 of this toolkit.

Smaller Competitions and Noncompetitive Launch Opportunities

The National Association of Rocketry has local and regional clubs (called Sections) that may host competitions or noncompetitive sport launches. At a sport launch, the NAR Section will take care of providing the permits, field, launch equipment, range organization, and safety. There may be a small fee to cover event costs.

You can use the [NAR Club Locator](#) to find a Section near you, or check out [NAR's map and calendar of contest launches](#). Reach out to the hosting Section to let them know you are coming. Then, bring your rockets, motors, and flight supplies to join in on the fun!

There may also be other rocketry clubs, teams, or groups in your area. For more ideas, check out “[Activities: Noncompetitive Ways to Explore Rocketry](#),” beginning on page 26 of this toolkit. You can also check out the [Educational Resources](#) on NAR's website for videos, activities, and other materials.

2

Building Teams and Networks

Building Teams and Networks

Whether your rocketry team has just formed or has competed before, you'll want a strong team supported by a stable network. Team members will need to develop a rocketry base of knowledge and work together to build their rockets and solve problems. In each section below, you'll find ideas to build your team and network as well as additional information for teams participating in The American Rocketry Challenge.

Recruit Girls and Create Teams

Rocketry is a great way for Girl Scouts to explore STEM and problem solving while building their teamwork and leadership skills. Teams can be formed at the troop or council levels, with existing Girl Scouts and through the recruitment of new Girl Scouts.

One of the easiest ways to get girls at your council or in your troop interested in rocketry is to invite them to a virtual or in-person event! At your event or troop meeting, you may want to:

- **Do a mini rocketry activity**, like those in “[Activities: Noncompetitive Ways to Explore Rocketry](#)”(page 26), to introduce the science behind rocketry and flight. Or use a starter model rocket kit to build and launch a rocket.
- **Invite guest speakers**, such as other Girl Scouts who do rocketry, someone who does rocketry for fun (like a local rocketry club member), or someone who works in aerospace engineering. Remember, you can use the [NAR club locator](#) to find Sections in your area.
- **Explore the history of rocketry and its role in science and exploration**, sharing information (biographies, videos, etc.) about people who work with rockets and emphasizing the role of women in rocketry (from both the past and present).

To help invite troops and Girl Scouts to an event, check out the “[Rocketry Event Flyer for Councils](#)”. You can promote the event on your channels and ask members to invite friends who are nonmembers. And remember to communicate any outside events to volunteers and families! Then, during or after the event, follow up with attendees to form your rocketry team.

Note: As a reminder, while all Girl Scouts can learn about rocketry, Daisies and Brownies are not able to participate in sport rocketry. However, they can participate in simple science experiments related to rocket science and observe model rocket launches at a safe distance. Juniors can participate in sport rocketry, but they are not eligible to be a member of an official team competing in The American Rocketry Challenge.

Team Requirements for The American Rocketry Challenge

To compete in The American Rocketry Competition [TARC], you need to create an official team of three to 10 members in grades 6–12. Your team must be supervised by at least one adult from your troop or council.

You'll need to submit a [parent consent form](#) for each team member. Once your team has registered, you can use the [add/drop form](#) to drop members at any time and add members up until your team's first qualification flight attempt. These forms are available at rocketcontest.org/resources.

There is no limit to the number of teams that may enter from any one troop, but, at most, only the top two qualifying teams from a single troop would be invited to the finals.

Registration for The American Rocketry Challenge is open from May to December each year. Go to rocketcontest.org to register your team.

“I am a Girl Scout dad, and my daughter was an American Rocketry Challenge participant, so I volunteered. I am not a TARC-approved mentor, so I served as the troop TARC coach. I’m actually not in the aerospace field at all; I just thought it would be fun to try it and learn as the team did.”

Luigi Leblanc, The American Rocketry Challenge coach for Girl Scouts Nation’s Capital Troop 5064

Recruit Volunteers and Experts

Volunteers, families, partners, and others can support Girl Scout rocketry teams in many ways. Check out the ideas in this section to find volunteers and experts as well as additional information specific to The American Rocketry Challenge.

Engage Volunteers

Volunteers can help plan activities, support logistics, or provide materials for meetings and events. Supporting rocketry teams allows volunteers to connect with their communities, amplify their own efforts, develop a relationship with GSUSA and their council, and build important skills in their Girl Scouts.

Volunteers might include troop leaders, new or existing community partners, or family members and caregivers. Volunteers can be experts or non-experts. They may have a background in engineering or physics, or just be willing to learn alongside the Girl Scouts. Volunteers with expertise in rocketry, The American Rocketry Challenge, or other rocketry competitions, like members of local clubs, or high school or university clubs, can help teams learn about the science concepts involved in rocketry and prepare for competition.

To recruit volunteers for your rocketry teams, you might:

- **Talk about the opportunity** on a webinar, meeting, or any other event for Girl Scout volunteers, partners, or families.
- **Share information** through your council's website, email blasts, blog, social media sites, and any other channels.
- **Send the “[Recruitment Flyer for Adults](#)”** throughout your network and to your service units.

To support volunteers, you may want to provide additional training or workshops. You can educate your volunteers on rocketry, share best practices, and provide them with resources. You might even bring in experts who can support the volunteers by sharing their knowledge and experience.

Engage Experts

Whether acting as a one-time volunteer or providing ongoing mentorship, experts can share their skills, knowledge, and passion with Girl Scouts in a way that works for them.

To find experts, search for more experienced teams within local clubs, universities, technical schools, or high schools. You can reach out to schools directly or you can look for National Association of Rocketry [NAR] Sections near you using the [NAR club locator](#). If you participate in local rocketry events, you may also meet more experienced teams that can provide guidance and support--the rocketry community is very welcoming!

To recruit experts, talk about the opportunity on a webinar, meeting, or any other event for Girl Scout volunteers, partners, or families (you never know who has useful expertise!). You might also share the “[Recruitment Flyer for Adults](#)” throughout your network and with your service units.

Collaborate with Other Girl Scouts

Girl Scouts is all about teamwork! Working within your troop and with other troops builds collaboration, teamwork, and leadership skills. By reaching out to your council or service unit, you may find nearby troops or other Girl Scouts who also are interested or involved in rocketry. And don't feel limited by geography—you can also find ways to connect with more distant troops and teams virtually.

Tip: Does your area have organizations such as a Women in Engineering or Society of Women Engineers chapter? Professional networks and organizations like these may be interested in supporting your team with funding or expertise.

Finding a Mentor for The American Rocketry Challenge

A rocketry expert who is a member of NAR and has been approved by The American Rocketry Challenge may serve as a mentor. Mentors can help their team find launch sites, provide guidance (both virtually and onsite during test launches), and validate the test flights required to qualify for the competition.

Check out the [map of mentors](#) for a list of approved mentors and their locations. Once you register a team, you will be able to access contact information for these mentors. You can also find more information in the [“Finding a Mentor”](#) section of this toolkit (page 20).

Find Funding and Partners

Teams need supplies to participate in sport rocketry. All teams will need to buy the materials to build and test their own rockets. Learning about rocketry also involves a lot of trial and error, so beginning teams may want to first purchase starter rocketry kits to learn the basics.

Supplies are not cheap, but don't let that deter you! Local businesses, schools, universities, and civic organizations may be willing to make donations or sponsor your team. They may want to make a general donation or support a particular aspect, like paying for your simulation software. They may also be willing to provide appropriate meeting space, volunteers, or expert advice.

To get started on finding funding, research supplies for the kind of sport rocketry your team plans to do. Use the [“Sample Budget Worksheet for a Rocketry Team”](#) on page 40 to help you understand your costs and figure out how much money you need to raise.

Then, research and reach out to potential funding sources and partners. For example, you may want to find local engineering, aerospace, and computer

companies—they may have a special interest in supporting your team! You might also find local businesses or groups that support STEM education. Use the [“Customizable Letter for Funding and Partners”](#) on page 39 to help your team find community support.

Here are some more tips to find support for your rocketry team:

- **Seek out in-kind donations.** Connect with local hobby and hardware stores and invite them to donate materials.
- **Create sponsorship opportunities.** Offer recognition for any partners or sponsors by adding their name or logo to your rocket decoration or on team T-shirts, posters, and other swag.
- **Apply for grants.** Whether or not your team plans to compete, your team may be able to apply for funding. NAR includes information on its educator page for specific grants and other sources. Some opportunities are restricted by age or for noncompetitive teams.

Budgeting for American Rocketry Challenge Teams

The American Rocketry Challenge estimates that most teams spend between \$500 and \$1,000 to learn about rocketry, design, build, and test their rocket, and then make their qualifying flights. This amount includes the event registration fee and the cost of the electronic altimeter that measures flight altitude, plus about a dozen expendable rocket motors.

First-time teams should also budget for starter rocketry kits and other design materials to help them learn the basics of rocketry, design, and construction. If a team makes it to the National Finals in May, they also have additional travel and materials costs.

Check out the [American Rocketry Challenge Handbook](#) for resources, including rocket building supplies and other fundraising ideas.

3

Rocketry Basics

Rocketry Basics

So, you've formed a rocketry team—what now? To successfully launch your team's rocketry experience, you'll need to lay some groundwork. Rocketry is very safe if you follow basic guidelines, but it takes planning and attention to detail. Learning how rockets work and how to build them as a team is a hands-on process requiring lots of materials—and lots of trial and error. In this section, you'll find detailed information about getting started, supplies, and safety.

Get Started with Your Team

Here are five easy steps to get your rocketry team started:

1. Decide on Your Goals: Competitive or Noncompetitive

How does your team want to explore rocketry? Do you want to build, test, and compare rockets on your own? Do you want to learn about rocketry with an eye toward competition?

Once you've formed a team, have a discussion with your team about what they want to learn and achieve. Competitions can provide structure and guidelines that are helpful to novices. They also give teams a common goal and deadline to work toward. However, you can have an equally engaging and educational experience without competing—your team can learn about, build, and test rockets on its own timeline.

For teams interested in competing in The American Rocketry Competition, check out the “[Activities: The American Rocketry Challenge Logistics](#)” section of this toolkit (page 20). For more ideas on engaging Girl Scouts in noncompetitive rocketry, take a look at the “[Activities: Noncompetitive Ways to Explore Rocketry](#)” (page 27).

2. Explore the Basics

There are many ways to get your team started with rocketry. You might start with simple flight and rocket activities (like those in “[Activities: Noncompetitive Ways to Explore Rocketry](#)” on page 27), read books and watch videos about rocketry, or observe more experienced rocketeers launch their rockets.

You might also start a discussion about the history, present status, and future of rocketry, looking more into what it has been used for—including space exploration, military uses, cloud seeding, fireworks, and satellite launches—and possible future uses. For example, will we go to Mars? Can rockets be used to address climate change? What about space tourism? Getting children and young adults to understand the physics and aeronautical concepts involved in rocketry can be a challenge, but support from an engineering-minded parent or volunteer can be very helpful. Many university, government, and other resources about rocketry are also available online. A quick internet search with keywords like “simple rocketry activities for students” will also provide you with lots of ideas and resources for all ages and levels of experience.

Another great resource for learning about rocketry is NAR, the oldest and largest sport rocketry organization in the world. NAR provides its members with resources, connections to sports

rocketry groups, and liability insurance for launches. You can find nearby launches to attend and fly at through your local NAR Section. Check out the [launch calendar](#) or contact your nearest NAR Section. You might also consider having an adult on your team [join](#) NAR.

3. Connect with Parents, Families, and Caregivers

Families and caregivers can be an invaluable resource to both support and amplify what Girl Scout rocketry teams do, continuing their Girl Scouts' learning and nurturing their love for STEM. To introduce rocketry to families, emphasize how participating is a safe, fun, and hands-on way to explore STEM. Share the "[Sample Parent and Caregiver Letter](#)" (page 39) and encourage them to get involved. You might even find that families have expertise or would like to volunteer!

For teams participating in The American Rocketry Challenge: Your team members' parents or guardians will need to sign a [consent form](#). Your council may also require additional parent or caregiver permission forms.

4. Secure a meeting space

Your team will need a meeting space with plenty of room to build rockets, so find someplace that is craft-, paint-, and glue-friendly.

You'll also need a computer and Wi-Fi to run computer-based rocket launch simulation programs. These help sport rocket designers test their rockets virtually and prepare for building a rocket with real materials.

5. Secure a launch site

Once you've built a rocket out of real materials, you'll need to launch several times to observe how well it works and to gather data to refine your design. An ideal launch site is a large, open area or field that is free of crowds and away from power lines, buildings, tall trees, and low-flying aircraft. The larger the launch area, the better your chance of recovering the rocket. Football fields, parks, and playgrounds often work well. Even if you're using starter rockets, make sure to launch them from a secure launch site. And always make sure to get permission and have the proper insurances in place.

Typically, new teams find it challenging to secure a launch site. One way to find one is to [reach out to your nearest NAR Section for assistance](#). Your team can work with a local NAR Section (if there is one) to fly with them on their launch site, or you can make your own deal with a local park or property owner, etc. Launch site owner insurance may be required, but NAR Sections already have this for their launch sites.

NAR offers two types of insurance:

1. **Personal liability insurance** covers members' liability for the consequences of their rocket flying.

It is included free with NAR membership but may not be necessary for minors because liability for their actions is the responsibility of their parents in most cases. If any of your team members are 18 or older, they should become NAR members to receive personal liability insurance.

2. **Site owner insurance** protects the landowner from property damage caused by a launch (e.g., fire), and from liability for the actions of the people whom they have permitted to fly rockets on the property.

It costs \$15 and is available only to chartered NAR Sections and to The American Rocketry Challenge teams with one adult NAR member and at least three youth members. (It is not necessary for all of the youth on the team to be NAR members.)

In many areas, teams have already found launch sites, and you can use social media to connect with them. Teams participating in The American Rocketry Challenge can also email AIA staff at rocketcontest@aia-aerospace.org to help make these connections.

Additionally, teams in areas experiencing drought should check their local fire safety conditions with their local fire department. For example, there have recently been multiple months of the year on the West Coast where model rockets may not be launched because of burn bans.

Check out the "[Safety](#)" section of this toolkit (page 16) for more information. Always follow both the GSUSA Safety Activity Checkpoints and NAR Safety Code when participating in sport rocketry.

How Big Should the Launch Site Be?

The size of your launch site depends on your rocket's motor size. Use this chart to figure out how big your launch site needs to be. American Rocketry Challenge rockets use E or F motor types:

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

Other tips to start a team for The American Rocketry Challenge:

Define roles and make a plan. Create a diverse team of Girl Scouts who are willing to participate and be responsible. Go over the contest rules in the [American Rocketry Challenge Handbook](#) to make sure everyone understands them. Then build a project plan, including a timeline with important deadlines and project management tasks, such as roles to understand who will do what.

Create a budget. You should overestimate your team's budget for the first year. This is because rockets for The American Rocketry Challenge typically cost \$30 or \$40 in parts and can be damaged or lost in trees after a few flights, and they use expendable motors that may be up to \$15 apiece. Check out the ["Find Funding and Partners"](#) section of this toolkit (page 10) and use the ["Sample Budget Worksheet for a Rocketry Team"](#) (page 40) to help you plan.

Review videos about rocketry. Find videos about rocketry online, or watch the ones recommended in the [American Rocketry Challenge Handbook](#).

Begin with starter kits. Because you can only use one motor per flight, the cost can really add up. So, begin with starter kits, which use smaller and cheaper motors because of their weight and size. Plus, this familiarizes your team with building a simple rocket. Make sure to find a kit that's targeted to the ages of your team members!

Practice with a program. Use your rocket simulation software to find a design that works to your specifications. It will save you time and money. Find more information in the ["Supplies"](#) section (page 15) of this toolkit.

Find your ideal mentor. Think about who might be a great mentor for your team. Take into consideration how far away your mentor is and whether you can meet with them virtually or in person. See the ["Finding a Mentor"](#) section (page 20) for more information.

Supplies

According to the [American Rocketry Challenge Handbook](#), a sport rocket “is a reusable, lightweight, non-metallic flight vehicle that is propelled vertically by an electrically-ignited, commercially-made, nationally-certified, and non-explosive solid fuel rocket motor. For safety reasons, no rocket hobbyist is ever required or allowed to mix or load chemicals or raw propellant; all sport rocket motors are bought pre-made. Sport rockets are always designed and built to be returned safely and gently to the ground with a recovery system such as a parachute. They are always designed to be recovered and flown many times, with the motor being replaced between flights.”

Girl Scout rocketry teams will need supplies to learn about, build, and test model rockets. A model rocket is a sport rocket that uses a solid propellant motor with a rating of “G” or lower (rockets using motors with a rating of “H” or higher are high-powered rockets that only adults are allowed to build and fly). This means teams will be creating rockets using premade and certified motors. They’ll be reusable and made of the team’s choice of nonmetal materials. They’ll also need to include a way for the rocket to safely return to earth, like a parachute. This section includes more information about the kinds of supplies needed for model rocketry and where you can find them.

What Supplies to Get

A book about model rocketry. You can find books about rocketry at your library or purchase them from a bookstore, hobby store, or NAR.

Starter rocket-building kits to learn about how rockets are constructed and the science behind how they work. You can find these at local hobby stores or online.

Rocket building materials, including: Nonmetal materials for the rocket body, such as wood or plastic for the fins and nose cone and cardboard, fiber, or paper for the body tube.

Materials to support and protect the payload, or rocket cargo (if you have one), such as bubble wrap and foam rubber.

Materials for the recovery system to return the rocket safely to the ground, like a parachute or streamers.

Tools, like hobby knives, pliers, scissors, rulers, sandpaper, masking tape, wood filler, and wood glue

Decorations for the outside of your rocket, like paint or other materials

An electronic altimeter to measure the height of your rocket’s flight

Rocket motors with igniters. Model rockets use premade, NAR safety-certified solid-fuel rocket motors with a power rating of “G” or lower. You’ll replace your motor after each flight, so if you’re competing, you’ll need enough for all your test flights and qualification flights. You may also want extra electrical igniters in case one of them burns out before lighting the rocket motor. The [NAR website](#) offers information about model rocket motors.

Items for your payload, if you want one or if one is required, such as competing in The American Rocketry Challenge.

Rocket simulation software. Building a rocket requires an exact combination of airframe design, rocket engines, and duration-control technique. Doing this requires either lots of trial-and-error or a rocket-design and flight-simulation computer program to get the design “roughly right” first. Modern aerospace engineers do lots of “flight tests” on a computer before they start building and flying hardware—it’s quicker and cheaper!

Registered American Rocketry Challenge teams may be able to find simulation software online at a special discount price; you can also do an online search for a free open-source option.

Important Note for American Rocketry Challenge Teams:

You must use a contest approved altimeter and motor. The American Rocketry Challenge rules specify which ones must be used for the current year's competition. Go to rocketcontest.org/resources for more information.

If you're competing in the rocketry challenge, you can also receive discounts on supplies like a rocketry book, motors, altimeters, rocket parts, and parachutes. Many of the component parts for rockets used in this competition are only available from online vendors. Check out the [list of official vendors](#) for more information.

Tips for Simulation Software:

From Luigi Leblanc, The American Rocketry Challenge coach for Girl Scouts Nation's Capital Troop 5064.

Buy two licenses for your rocket simulation software so that you can use it on two different devices. This will allow you to have a few members of the team become familiar with building simulations of the actual rockets.

It's helpful if the software is compatible with both macOS and Microsoft Windows.

Depending on where you get your parts, you may not find all the parts and model numbers in your software. To fix this, download the updated part file from the vendor and upload it into the application. Then you should be able to create the simulation with the parts your team is actually using.

Safety

Girl Scout rocketry teams should follow both the NAR Safety Code and GSUSA Safety Activity Checkpoints when participating in sport rocketry.

Summary of NAR's Safety Code and Guidelines

NAR's simple Model Rocket Safety Code procedures have helped keep participants safe by providing basic safety precautions and instructions from the manufacturers. All individuals, whether experienced or first-timers, must follow it. If you're launching rockets with your local NAR Section, your team will also be required to abide by everything in the NAR Safety Code. See the full NAR Model Rocket Safety Code in the [American Rocketry Challenge Handbook](#).

GSUSA Rocketry Safety Activity Checkpoints

GSUSA has incorporated the NAR Safety Code into its rocketry safety activity checkpoints. It also includes important Girl Scout values like inclusion, standard safety guidelines, COVID-19 guidelines, and Emergency Action Plans.

About Rocketry

Volunteers should use basic safety principles, including eye safety and safe distances when setting up simple rocketry experiments. For guidance, check with your council for the most recent version of the GSUSA Safety Activity Checkpoints. See the "Miscellaneous Activities" section of Safety Activity Checkpoints and always consult the safety standards at the start.

Note: Rockets over 1,500 grams or rockets powered by "H" class or larger motors are considered high-power rockets and flying them requires a certification from NAR that is available only to those 18 or older. Please contact your council for information and approval for high-power rocketry. Radio-controlled rocket gliders are not approved.

Include Girls with Disabilities. Talk to girls with disabilities and their caregivers. Ask about needs and accommodations. Connect with facilitators ahead of time to determine any access or safety steps that need to be arranged in advance.

Equity. In addition to physical and social-emotional disabilities, consider the history, culture, and past experiences of the girls in your troop that could affect a girl's ability to equally participate in an activity. Work with girls and families to understand how an activity is perceived. Ensure that all girls and their families feel comfortable that they have access to whatever is needed to fully participate, such as the proper equipment, prior experiences, and skills needed to enjoy the activity.

Standard Safety Guidelines. Refer to the “Standard Safety Guidelines” section at the beginning of Safety Activity Checkpoints. These standard safety guidelines apply to all Girl Scout gatherings and activities. When the adult-to-girl ratio, or other safety parameters, are stricter for a specific activity than in the Standard Safety Guidelines always follow the stricter parameters in the activity chapter.

COVID-19 Guidelines. Review the “Coronavirus Safety in Girl Scouts” section of Safety Activity Checkpoints and be certain to consult your council's specific COVID-19 guidance which can be accessed under the same section. When applicable, always call ahead to the vendor, property or facility involved to check for their COVID-19 safety requirements as you prepare to take girls for this activity.

Emergency Action Plan (EAP). Review and document your EAP before taking girls out for this activity (see pages 8–12 of Safety Activity Checkpoints). Think through scenarios of what can go wrong such as an accident, physical injury to a girl or adult, a missing girl, or sudden illness.

Verify instructor knowledge and experience. Make sure that the facilitator has experience with model rocketry and that they understand common safety protocols. Consider partnering with your local rocketry club or science teacher who may have experience with model rockets.

Assess maturity level. Participants must be old enough to understand safety procedures and handle equipment so as not to endanger themselves and others.

Launch site. Launch rockets outdoors in an open area. Choose a large open area or field that is free of crowds and away from power lines, buildings, tall trees, and low-flying aircraft. The larger the launch area, the better the chance of recovering the rocket. Football fields, parks, and playgrounds often work well. According to the National Association of Rocketry, launch site size depends on the size of the rocket and should be at least as large as outlined in the table on page 13. Set up safety zones for launch and for observation (at least 15 feet away for D motors or smaller and 30 feet away for larger rockets.) See the [**“How Big Should the Launch Site Be?”**](#) table on page 14.

Prepare for emergencies. Follow your Emergency Action Plan (EAP) and always have a first aid kit available. Know ahead of time where the nearest emergency room is located. For this activity, have a specific preparedness plan in case of grass fires.

Get permission and local ordinances. You should always check with your local city government for any special regulations that may apply to your area. Generally, you can fly most model rockets in a clear area the size of a football or soccer field. Follow FAA guidance. For example, if you live near a U.S. border, take care not to cross over into the territory of a foreign country. Within the U.S. be careful not to cross into a sovereign nation or territory; and never launch rockets near airports, low-flying aircraft or military bases. Seek permission from the site and consider if permission is needed from any neighboring properties should rockets need to be recovered.

Weather conditions. Check for safe weather conditions. Be prepared to postpone the launch, if needed. Wind speeds should not be greater than 20 miles per hour. There should be no lightning storms forecasted in the area. Ensure that there is no dry grass close to the launch pad and that the launch site does not present risk of grass fires. Areas experiencing droughts may have bans on outdoor fires and rocket launches.

Materials. Ensure that equipment and materials are in good working condition. Use materials that are lightweight and non-metal parts for the nose, body, and fins of the rocket. Rockets should not weigh over 1,500 grams — these require a High-Power Rocketry Certification.

Motors. Use only certified commercially made model rocket motors. Do not tamper with the motors or use them for any purposes except those recommended by the manufacturer.

Ignition system. Launch rockets with an electrical launch system and electrical motor igniters. Launch system should have a safety interlock in series with the launch switch. Use a launch switch that returns to the “off” position when the rocket is released. Fuse-lit ignition is prohibited.

Launch safety. Use a countdown before launch and ensure that observers are paying attention and at a safe distance. Safety zones may need to be adjusted based on wind conditions. Use a launch rod, tower, or rail that is pointed to within 30 degrees of the vertical to ensure that the rocket flies nearly straight up. Make sure the rod is above eye-level or capped off when not in use. Use a blast deflector to prevent the motor’s exhaust from hitting the ground. Consult the National Association of Rocketry for guidance on simultaneous launches.

Flight safety. Do not launch rockets at targets, into clouds or near airplanes. Do not put any flammable or explosive payload on or in the rocket.

Misfires. If the rocket does not launch, have a plan to safely disconnect the battery and wait at least 60 seconds before allowing anyone to approach the rocket.

Recovery. Use a flame-resistant or fireproof recovery system such as a streamer or parachute on the rocket so that it returns safely and undamaged. Rockets may be used again if they aren’t damaged. Do not attempt to recover a rocket from power lines, tall trees, or other dangerous places.

Dress appropriately for the activity. Dress for the weather. Launch sites often lack shade. In hot weather make proper arrangements for shade, ensure that participants have sunscreen, and make water available.

4

Activities:
The American Rocketry
Challenge Logistics

Activities: The American Rocketry Challenge Logistics

This section describes what The American Rocketry Challenge is all about. It includes activity information, timelines, and information on how to find a mentor and observer.

Important note: Registration for the competition is open from May to December every year, and qualification flight reports are due the following April. You'll want to begin planning and learning about rocketry by the fall. Go to rocketcontest.org for more details

The American Rocketry Challenge

This competition provides 6th through 12th graders with real life experience in designing a rocket that meets a specified set of requirements. It aims to inspire and excite youth about learning and careers in STEM. Throughout the challenge, teams work together in the same way aerospace engineers do. Along with thousands of peers all across the country, they'll experience the engineering process and compete for the opportunity to participate in the National Finals.

Teams participating in The American Rocketry Challenge can compete for more than \$100,000 in prizes. Prizes are given to the top 10 teams, as well as to winners of the [Marketing Competition](#), [Presentation Competition](#), and other on-site competitions. See the [Prizes and Awards](#) page on the contest website for more details.

Go to rocketcontest.org for information about how to compete in The American Rocketry Challenge, including contest rules, key competition dates and deadlines, and frequently asked questions.

Finding a Mentor

Rocketry experts who have been approved by The American Rocketry Challenge are called mentors. Teams aren't required to have a mentor, but their experience and expertise make them valuable

resources. A mentor can help your team find launch sites and provide guidance, both virtually and onsite during test launches.

Check out The American Rocketry Challenge's [map of mentors](#) for a list of approved mentors. You may find that there are no mentors nearby, but don't worry—they can support your team virtually! When you register your team, you'll also receive access to a list of contest-approved mentors and their email addresses. You may also engage with your local Section of NAR during your test flights (such as by attending a nearby launch or using their launch site) or come to meet more experienced

teams naturally. The American Rocketry Challenge also publishes a full teams list each January and can help facilitate connections.

Because official mentors for The American Rocketry Challenge are also members of NAR, your mentor can also serve as your official observer and validate the test flights required as qualifiers to compete. The next section of this toolkit has more information.

Qualification Flight Attempts and Official Observers

Once you've finalized your rocket design and tested it, you'll need to complete qualification flights to submit to the competition. For each qualification flight, you'll measure the length of time the rocket was in the air and how high it went, and any other requirements, such as confirm that your payload returned safely to the ground and your rocket stayed together.

You must submit your qualification flight reports to AIA either using their online portal or via email (see rocketcontest.org for details). If you have a very good combined two-flight score from your qualification flights, you could be one of the 100 top teams invited to the National Finals.

Up to three qualification flight attempts are permitted, and AIA will determine your team's eligibility by adding your best two scores. There are no "do-overs" for flights that do not have good scores; every official flight must be reported.

Obtaining an observer and a second impartial timer, and providing stopwatches, is your team's responsibility. An official observer (an adult member of NAR) must be on-site to time and verify the data. A second timer is also required. The observer must be impartial, meaning not related to any member of your team and not a paid employee of Girl Scouts. As a member of NAR, your official mentor for The American Rocketry Challenge can also serve as your observer.

Your flights must be declared to an NAR observer before launch. Plan ahead to find an official NAR observer and a timer for your qualification flight(s). Let them know well in advance when your flights will take place. Keep in mind that they are volunteers and may not be able to support your team with short notice.

If you do not already know of a qualified local adult NAR member who can be your observer, here are three ways to find someone:

1. Fly your rocket at a launch organized by a nearby NAR Section. You can also use these launches as a place to practice-fly before your official qualification flights. Check out NAR's "[Launch Windows Calendar](#)" and confirm the time and place of the launch with the contact person.
2. Reach out to your nearby [NAR Section or chartered club](#) to see if they have launches not listed on their website.
3. Identify someone from [the list of mentors on the American Rocketry Challenge website](#). Contact them to see if they can be your observer. Many mentors live in places remote from an NAR Section. Contact information for these mentors is accessible only to registered teams.

When seeking out NAR members to be your observer, you may have to explain The American Rocketry Challenge program because not every NAR member is aware of it or signed up as an approved mentor.

Tip: Don't wait until the last weekend possible for your qualification attempts! You never know what the weather will be or if an NAR observer will be available.

If there is no NAR member available within a reasonable distance (this will be the case in a number of places), you can have an impartial adult (not related to any team member and not a paid employee of Girl Scouts) become an NAR member to be an observer. Though it's preferable to have experienced rocketeers perform observer duties (they can usually understand the rules better and offer advice and tips at the same time), experience is not required.

NAR membership can be obtained online and goes into effect the day it's ordered. Observers who don't yet have a membership card and number may record their membership number as "PENDING" on the qualification flight form.

Having trouble finding an observer?

Email The American Rocketry Challenge at rocketcontest@aia-aerospace.org to request a roster of senior NAR members in your state and for help finding an observer.

Going to the Finals

If your team makes it to the National Finals, you'll need to fine-tune your rocket design so that it can reach both of the designated altitudes for the current year's competition. All your practice flights need to take place before the finals event. The winning team at finals is the one that comes closest to the target heights and durations in the sum of two flights.

You'll also need to make travel and hotel arrangements. Note that model rocket motors are not allowed on airplanes, so have them shipped directly to the event venue no later than May 1. See [The American Rocketry Challenge Handbook](#) for more information.

Recommended Activity Timeline for the American Rocketry Challenge

Fall and Winter: Get Started

- **Form your team.** You'll need at least three members, enrolled in sixth through 12th grade (entry is based on grade level, not age), and one adult supervisor. See [The American Rocketry Challenge Handbook](#) for details.
- **Begin to think about volunteers and mentors.** See the "[Recruit Volunteers and Experts](#)" section of this toolkit (page 9) for details.
- **Find a meeting space.** See the "[Secure a meeting space](#)" section (page 13) for guidelines.
- **Learn the basics of rocket science.** Obtain a comprehensive book on model rocketry and have all team members read it. Watch instructional videos about rocketry. Search online or see [The American Rocketry Challenge Handbook](#) for recommendations.
- **Determine your launch site.** Find a nearby NAR launch to attend and fly at, contact your nearest NAR club, or find and get permission for your own launch site. See the "[Secure a launch site](#)" section of this Toolkit (page 13) or search NAR [Launch Window Calendar](#) and [NAR club locator](#).

- **Build and launch starter rockets.** Don't make your official competition rocket the first rocket you build and fly; if you've never done model rocketry before, build and fly a simple rocket first, like an inexpensive one-stage rocket kit. Refer to the [American Rocketry Challenge Handbook](#) for recommendations.
- **Create a fundraising plan.** Develop a plan to buy enough supplies for at least two rockets, igniters and motors for at least 10 test and qualification flights, and potentially money to pay for travel to the fly-offs. Use the "[Sample Budget Worksheet for a Rocketry Team](#)" (page 40) to estimate your costs. See the "[Find Funding and Partners](#)" (page 10) and "[Supplies](#)" (page 15) sections of this toolkit for guidance.

By December: Register and Submit Team Forms and Payment for The American Rocketry Challenge

- Go to rocketcontest.org for instructions, including the registration deadline for the current year's competition.

January: Onboard Your Team

- **Check your info on file with AIA.** Once your entry forms and payment are received and accepted by AIA, make sure all of your team's data (names, emails, etc.) on file with AIA is correct.
- **Learn about The American Rocketry Challenge.** Review [The American Rocketry Challenge Handbook](#) and the [Frequently Asked Questions](#) for the challenge with your team. Be sure to read and understand the [competition rules](#). Review the extensive instructional materials provided on the "[Resources](#)" page of the event website.
- **OPTIONAL: Decide if your team will participate in the Marketing or Presentation competitions.** For the [Marketing Competition](#), teams must create a video to generate excitement about their team, The American Rocketry Challenge, STEM, and aerospace and space exploration. Videos are judged on strength of the message, creativity, and editing and technical skills. The [Presentation Competition](#) is a chance for teams to explain their rocket design, how they conducted and utilized test flight information, and the lessons they learned in both rocketry and teamwork. Because the presentation is based on flight data, only teams that have completed at least three test flights, successful or not, are eligible to enter. If your team chooses to submit entries, brainstorm what you'd like to include and make a game plan to gather documentation and photos or videos of your rocket-building process.
- **Organize your team.** Assign team responsibilities, such as project manager, airframe, propulsion and ignition, launch system, computer simulation, Marketing and/or Presentation competitions, and fundraising.
- **OPTIONAL: Check out the contest's social media pages.** Find general updates about the contest (specifically info for mentors and teachers), connect with other teams for advice, or ask questions to find experts and resources. Links to social media pages can be found on rocketcontest.org.
- **Create your supply list.** Use the "[Supplies](#)" section on page 15 of this toolkit to understand the materials your team will need. Then research rocket parts supply sources online or in your local area. Begin to develop your budget using the "[Sample Budget Worksheet for a Rocketry Team](#)" (page 40).
- **Find a rocket-design program.** Order a flight-simulation and rocket-design computer program or try out a downloadable freeware program. For more information about software, see the "[Supplies](#)" section (page 15). For software recommendations (as an American Rocketry Challenge team, you may be able to receive a discount directly from the vendor), check out [The American Rocketry Challenge Handbook](#).
- **Start designing simple rockets based on what you've learned from using kits.** Test your designs using your flight-simulation software. In the "Rocket Design" section of [The American Rocketry Challenge Handbook](#) to guide you.
- **Find a mentor.** Use the "[Finding a Mentor](#)" section (page 20) of this toolkit to find out more about competition mentors and connect your team with one for the competition.

February: Develop Your Rocket Design for the Competition

- **Develop a first design for your competition entry.** Use tips from the “Rocket Design” section of [The American Rocketry Challenge Handbook](#) and your flight-simulation program to help design your rocket. Your team may want to sketch out ideas based on their experience with building starter sets, observing others’ rockets, or reviewing your materials list.
- **Practice with your flight-simulation program.** Have your team learn how to use the rocket design and flight simulation computer program or freeware program.
- **Check your insurance.** If your launch site requires site owner insurance, have an adult volunteer and at least three team members join NAR, and order NAR site owner insurance for \$15. Find more information and [frequently asked questions about insurance](#) on the NAR website.
- **Purchase your altimeter.** Order an approved altimeter. See [The American Rocketry Challenge Handbook](#) for more information about altimeters.
- **OPTIONAL:** Gather documentation and photos or videos about your process if your team is going to submit entries to the Marketing and/or Presentation competitions.
- **Find an observer.** Locate an NAR Senior (adult) member who can serve as your official observer for your qualification flights if you do not already have a mentor who will do this. See the [“Qualification Flight Attempts and Official Observers”](#) section (page 21) of this toolkit for more information.
- **Build your initial design.** Begin construction of your initial design for your competition entry, using the “Rocket Construction” section of [The American Rocketry Challenge Handbook](#).
- **Weigh your rocket** and run computer flight simulations with actual rocket weights.
- **Build and test your launch system and pad.** If you do not have a local rocket club’s system available to use, design and build (or purchase) the electrical launch system and the launch pad (preferably with a one-inch rail) for your competition entry. Then test your launch system by test-firing igniters without installing them in rocket motors. Most rocket motors come in packs of three, with four igniters. You may want to purchase a few extra igniters to practice lighting them.
- **Prepare to launch.** Develop a preflight checklist for your flight and assign responsibility for each of the duties to a member of the flight team. Preflight checklists cover all of the steps of preparing a rocket for flight and the procedures for each step. These include packing the recovery device and inserting it and the rocket motor into the rocket, setting up the altimeter for flight, and inserting the payload and its protective materials.

March: Build and Test Your Design

- **Test motors for your rocket.** Using the computer or freeware program, conduct flight simulations to see if your rocket will be stable in flight and how high it is likely to go using various rocket motors on the approved motor list. Then use what you learn to determine the best motor(s) for your design.
- **Purchase materials.** Locate sources and purchase required parts and motors for your rocket. Refer to the [“Supplies”](#) section (page 15) of this toolkit for more information; [the vendor list](#) on the American Rocketry Challenge website for official vendors; and your research on rocket parts supply sources online or in your area.
- **Test-fly your initial design.** Leave time for flight tests and to make major changes before the qualification flight deadline. Test your design (without altimeter), leaving enough time to redesign, rebuild, and re-fly if this initial flight/design is not successful. If your first flight is fully successful, test-fly it again with stopwatch timing and the altimeter installed. Then repeat test flights until you hit the design targets. If your first flight is not successful, do post-flight failure analysis and redesign.

Tip: Conduct lots of flight tests of your design (try to do at least 10) and take data on each test (rocket weight, motor type, altitude and duration; wind and temperature conditions; launch angle) so that you can make the right adjustments to exactly hit the target flight performance. See the presentation on “[Flight Testing in the American Rocketry Challenge](#)” on the event website for more tips.

- **Make your first official qualification flight attempt.** When you’re ready, make your first official flight in front of an NAR Senior member observer. See the “[Qualification Flight Attempts and Official Observers](#)” section on page 21 of this toolkit for more information.
- **OPTIONAL:** Create your Marketing and/or Presentation Competition entries.

April Contest Deadline: Submit Your Qualification Flights

- **Weigh your completed rocket** and re-run computer flight simulations with actual rocket weights.
- **Complete your official qualification flight attempts by the deadline for the current year’s competition (see [rocketcontest.org](#) for details).** Remember that up to three qualification flight attempts are permitted (they must be declared to an NAR observer before launch), and the best two scores count for determining finals eligibility.
- **Submit your qualification flight reports to AIA** as instructed on the contest website.

After April: If Your Team Qualifies for the National Finals...

- **Plan your trip.** Make hotel reservations and raise funds to cover travel and lodging for the National Finals. Finalists will receive a list of hotels that will house participant (go to [rocketcontest.org](#) for full event details). See the “[Find Funding and Partners](#)” section on page 10 of this toolkit for fundraising ideas.
- **Prepare for the altitudes at the finals.** Continue test-flying to fine-tune your rocket design to the target altitudes for the current year’s competition.
- **Ship your motors.** If you plan to travel to the finals by air, order your rocket motors for fly-off to be shipped to the receiving point at Aurora Flight Sciences or delivered on-site by a vendor.
- **Complete and test-fly the actual rocket for the Final Fly-Off.** Your rocket must have been test-flown before arrival at the fly-off. There is no opportunity for test-flying at the fly-off site.
- **Compete in the National Finals.** Go to [rocketcontest.org](#) to see the finals date and schedule for the current year.

5

Activities:
Noncompetitive Ways
to Explore Rocketry

Activities: Noncompetitive Ways to Explore Rocketry

This section includes simple, hands-on activities to explore basic flight and rocketry concepts. **Local NAR Sections** also hold numerous non-contest sport launches each year, where teams and individuals can fly rockets. For Girl Scouts interested in rocketry, they can also check out the Space Science badge and the Think Like an Engineer Journey for their level.

Words to Know

Force: The strength or energy that creates movement (push and pull are examples)

Gravity: The force that pulls objects toward each other and toward the earth

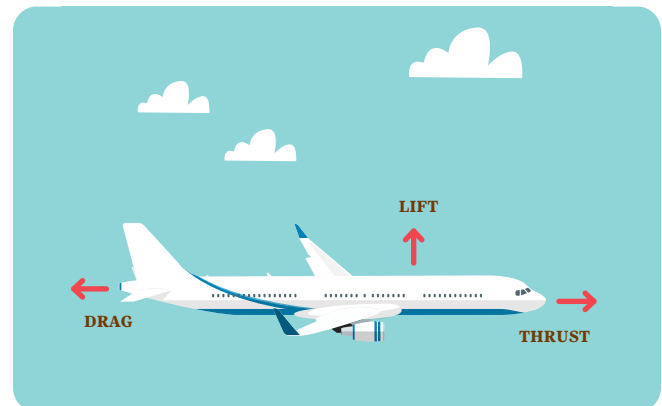
Thrust: The force that moves an object forward

Drag: The force (air molecules) that acts against something in flight

Lift: The force that pushes back up on the wings during flight

Balanced forces: These exist when forces are equal on an object—when forces are balanced the object does not move

Unbalanced forces: These exist when forces are unequal on an object—the object moves in the direction of the greater force.



Activity: Learn About Flight with Paper Airplanes

Purpose: Fold and throw basic paper airplanes to explore the different forces involved in flight.

Materials:

- Paper of different sizes and weights
- **Optional:** Markers, stickers, and other materials to decorate



Activity Instructions:

Invite everyone to fold a paper airplane, experimenting with papers of different weights and sizes. Then, have them line up to throw their planes and watch them fly.

After, ask questions to explore each concept such, such as:

- **What makes the planes move?** (Answer: Force—they pushed the planes when they threw them.)
- **What is the force that makes it move forward?** (Answer: Thrust.)

- **What is the force that lets it stay in the air?** (Answer: Lift—air pushes up under the wings.)
- **What is the force that pulls the plane down?** (Answer: Gravity.)
- **Why did your plane slow down?** (Answer: Drag.)
- **Were forces balanced or unbalanced when your plane flew?** (Answer: Unbalanced.)

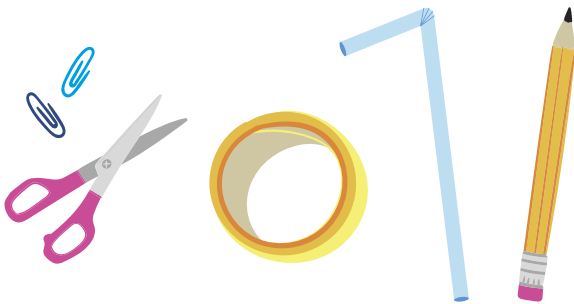
Lastly, explain to the group that for something to fly, lift must be greater than weight, and there must be thrust that can overcome drag.

Activity: Build a Rubber Band-Powered Plane

Purpose: Make a paper airplane with a rubber band to increase its thrust.

Materials:

- **Prepare ahead:** Create a sample plane.
- Dowels, BBQ skewers, straws, craft sticks, etc.
- Paper clips
- Large rubber bands
- Paper of different sizes and weights
- Tape (masking or duct) or glue
- Scissors
- Scrap paper for drawing designs
- Pencils



Activity Instructions:

First, fly your sample plane and explain how it works! Point out to everyone how the rubber band works similar to a slingshot, thrusting the plane through the air when stretched.

Next, share the materials you have available for everyone to create their own. Have them draw designs before starting to build. Encourage everyone to use their imaginations to design their planes to do what they want them to do—fly far, stay in the air a long time, or do tricks.

Help everyone to build their planes and practice flying them. Then take the planes outside and test what they can do. Fly each one multiple times and record their results, including:

- How far it goes
- How long it stays airborne
- How many flips it does

After, have everyone analyze the data from their test flight. Ask questions like:

- **What pushes the plane forward through the air? Why does the plane slow down?** (Answer: The rubber band creates “thrust,” moving the plane through the air. It also has to push air molecules out of the way, slowing down and creating “drag.”)
- **What pulls the plane back down to the ground?** (Answer: Gravity pulls it back down. However, air is in the way—the wings deflect the air, which pushes back up on the wings. This force is called “lift.”)

- **When forces on an object are balanced, like a box being pushed equally by two Girl Scouts on opposite sides, what happens?** What if forces are unbalanced, like two Girl Scouts pushing on one side of the box or trying to walk on a windy day? (Answer: If forces are balanced, neither force moves the object. If they're unbalanced, the object moves in the direction of the greater force.)

Lastly, brainstorm ways to improve the planes. Ask questions like, "How could you change the design to create more thrust? How could the shape of the nose or wings change how the plane flies?"

For more fun, try making other kinds of paper airplanes with thrust. Compare the effectiveness of different designs.

Activity: Make a Stomp Rocket

Purpose: Build a model rocket powered by compressed air.

Materials:

- **Prepare ahead:** Create a sample stomp rocket.
- Paper
- Pencils
- **For each Stomp Rocket, you will need:**
 - 2 pieces of construction paper or card stock
 - Tape
 - Scissors
 - 2-liter soda bottle
 - 1-inch-wide bicycle inner tube, cut to create a hose (at least 3 feet long), or piece of garden hose about 2 feet long
 - 1-inch-wide PVC pipe (at least a foot long)—not needed if using garden hose
 - Pen or pencil



Activity Instructions:

First, fly your sample stomp rocket and explain how it works! Point out to everyone how it's launched using compressed air.

Next, share the materials you have available for everyone to create their own. Have them draw designs before starting to build. Encourage everyone to use their imaginations to design their rockets to do what they want them to do—fly high, stay in the air a long time, or do something else.

Then, walk them through these steps to build and launch their stomp rockets:

1. **Build your rocket body.** Roll a piece of paper lengthwise around the outside of the PVC pipe or piece of garden hose, creating a tube that fits around it but can slide off. Use tape to secure the tube.
2. **Make a nose cone.** Do this by either cutting one end of the rocket body to a point and sealing it with tape (it must be fairly airtight to fly well) or rolling a triangular piece of paper into a cone and taping it securely to the rocket body, trimming extra paper from the edges as needed.
3. **Add fins to the base of your rocket body.** Fins will help your rocket fly straight. Tape triangles of paper or cardstock to the rocket base. Try different triangle sizes and shapes to see which ones work best.

4. **Build your launcher.** Place one end of your bicycle tube or garden hose over the opening of the empty 2-liter bottle and secure it with tape. If using the bicycle tube, tape the other end of the tube to one end of the PVC pipe. Make sure these connections are airtight so all the air from your bottle will go into your rocket when you stomp.
5. **Launch your rocket.** Place your paper rocket just over the open end of the garden hose or the PVC pipe, pointing the hose or PVC pipe in the direction you want your rocket to go. Then stomp on the plastic bottle and watch how the air pushed out of the bottle creates thrust, pushing the rocket into the air.

Have everyone launch their rockets multiple times and note the results. Ask, “How far did your rocket go? Did it fly straight? Did your rocket “fly” or “glide” like a plane once it stopped climbing?” As needed, help everyone to replace their bottles and repair or reinforce their rockets during testing.

After, have everyone analyze the data from their test flight. Ask questions like:

- **What pushes the rocket up or forward through the air? Why does it slow down?**

(Answer: The compressed air creates “thrust,” moving the rocket up and through the air. It also has to push air molecules out of the way, slowing down and creating “drag.”)

- **How does the cone help with drag?** (Answer: The cone pushes the air out of the way, making it easier for the rocket to fly.)
- **What pulls the rocket back down to the ground?** (Answer: Gravity pulls it back down. However, air is in the way—the fins deflect the air, which pushes back up on the fins. This force is called “lift.”)
- **When forces on an object are balanced, like a box being pushed equally by two Girl Scouts on opposite sides, what happens?** What if forces are unbalanced, like two Girl Scouts pushing on one side of the box or trying to walk on a windy day? (Answer: If forces are balanced, neither force moves the object. If they’re unbalanced, the object moves in the direction of the greater force.)

Lastly, brainstorm ways to improve the rockets. Ask questions like, “How could you change the design to create more thrust? How could the shape of the nose or fins change how the plane flies?”

Activity: Build Your Own Rockets

Once you’re ready to build your own full-sized motor-powered model rockets, begin with a starter kit or build your own from scratch. Do an internet search using keywords like “DIY or homemade model rocket” for ideas, or see the “Rocket Design” and “Rocket Construction” sections of [The American Rocketry Challenge Handbook](#).

As you build, try a variety of materials and designs. Experiment with different kinds of motors. Keep detailed notes about your design process and flight data so you can make improvements. Using flight-simulation software can improve your design process and save you time, materials, and money.



6

Resources

Resources

In this section, you'll find a list of resources mentioned in the toolkit, some sample flyers and letters, and a budget builder to help your team get started in rocketry.

Acronyms and Glossary

AIA – Aerospace Industries Association

GSUSA – Girl Scouts of the United States of America

NAR – National Association of Rocketry

STEM – Science, Technology, Engineering, and Math

TARC – The American Rocketry Challenge
Aerospace – the earth's atmosphere and the space beyond it

Aerospace engineer – someone who develops aircraft and spacecraft, sometimes called a rocket scientist

Altimeter – a device that measures how high a rocket flies

American Rocketry Challenge mentor – a rocketry expert who has been approved by The American Rocketry Challenge; they can provide experience and expertise to an American Rocketry Challenge team, both virtually and on-site during test launches, including on how to find launch sites. If they're a Senior member of NAR, they can also serve as your team's official observer and validate the qualification test flights required to compete in The American Rocketry Challenge.

American Rocketry Challenge observer – an impartial (not related to any member of the team, and not a paid employee of the school or member of the nonprofit organization sponsoring the team) adult member of NAR who times and certifies the results of qualification test flights for American Rocketry Challenge teams.

Engineer – someone who builds machines and systems to solve problems

Fly-off – any competitive model rocketry event where teams or individuals launch their rockets to see which one can come closest to specific flight goals like height, duration, and/or payload delivery

Model rocket – a kind of non-metal sport rocket that uses a premade solid propellant motor with a power rating of "G" or lower; rockets using electric motors with a rating of "H" or higher are high-powered rockets and can only be built and launched by adults.

NAR Section – a rocketry club, team, or group that is part of the National Association of Rocketry

Payload – the cargo inside your rocket, like raw eggs, a camera, or rocks

Rocket simulation software – computer software that simulates model rocket flights based on information about the materials used to build it

Sport launch – a noncompetitive rocket launch event

Sport rocket – a reusable, lightweight, non-metallic flight vehicle that uses a premade electrically ignited motor

Resources Included in This Toolkit

Recruitment Flyer for Competitive Girl Scout Rocketry Teams (page 34) – use this flyer to recruit Girl Scouts for a competitive team

Recruitment Flyer for Noncompetitive Girl Scout Rocketry Teams (page 35) – use this flyer to recruit Girl Scouts for a noncompetitive team

Rocketry Event Flyer for Councils (page 36) – use this flyer to invite troops in your council to a rocketry event

Recruitment Flyer for Adults (page 37) – use this flyer to recruit adult volunteers and experts to support your team

Customizable Letter for Funding and Partners (page 38) – use this letter to reach out to community members to support your rocketry team

Sample Parent and Caregiver Letter (page 39) – use this letter to introduce rocketry to parents, guardians, and caregivers

Sample Budget Worksheet for a Rocketry Team (page 40) – use this customizable budget to help your team plan

Helpful Links for Rocketry Teams

NAR Club locator – helps you locate NAR Sections near you

NAR Resources for Teachers and Youth Group Directors – provides educational resources to use with kids

NAR Launch Window Calendar – lists scheduled sport launches for NAR Sections

NAR Insurance Questions – explains personal liability and site owner insurance provided by NAR

NAR Rocket Motor Information – explains rocket motor codes

American Rocketry Challenge Links

Rules for the current year's challenge

Approved American Rocketry Challenge vendors for starter rocket kits, motors, and altimeters – lists vendors selling rocket starter kits and approved motors and altimeters

American Rocketry Challenge Handbook – comprehensive handbook for teams, including rules; information on rocket design, construction, and flight, qualification flights and official observers; and resources including information about approved motors and altimeters, safety, fundraising, insurance, and recommended timeline.

Map and list of approved American Rocketry Challenge mentors – use this to locate mentors near you

The Process of Designing a Rocket for the American Rocketry Challenge – a step-by-step guide to designing a rocket for the challenge

Marketing Competition information

Presentation Competition information

American Rocketry Challenge email address – submit your team's qualifying flight data and ask questions at rocketcontest@aia-aerospace.org

American Rocketry Challenge FAQ – answers to frequently competition questions

Recruitment Flyer for Competitive Girl Scout Rocketry Teams

(Click on the image below to download the customizable flyer)



Come fly with us
and explore rocketry!

Are you interested in science, technology, engineering and, math (STEM)? Would you like to build and fly rockets?

Girl Scout Troop [Troop#] is forming a sport rocketry team and we want YOU!

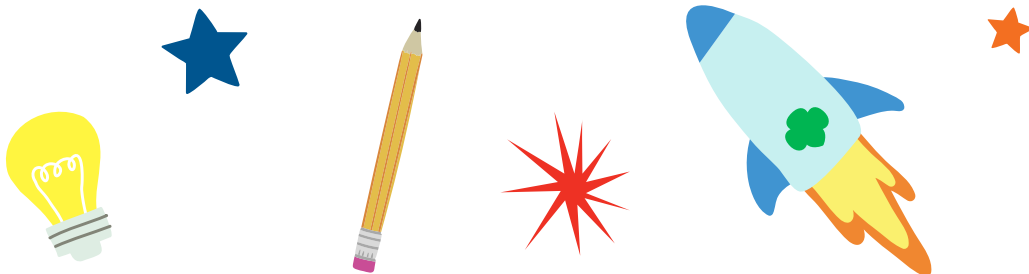
Rocketry is a fun way to learn about the physics of flight, aerospace engineering, computer flight simulation, and model rocket design. You can build your problem-solving, teamwork, and leadership skills, too!

We'll work together to learn about rocketry and then design, build, test, and enter our rocket in The [American Rocketry Challenge](#), an annual national rocketry competition. If you are in grades 6-12, you can be part of our team.

Contact Girl Scout Troop [Troop #] for more information:

Phone: [Phone #]

Email: [Email Address]



Recruitment Flyer for Noncompetitive Girl Scout Rocketry Teams

(Click on the image below to download the customizable flyer)



Come fly with us
and explore rocketry!

Are you interested in science, technology, engineering and, math (STEM)? Would you like to build and fly rockets?

Girl Scout Troop [Troop#] is forming a sport rocketry team and we want YOU!

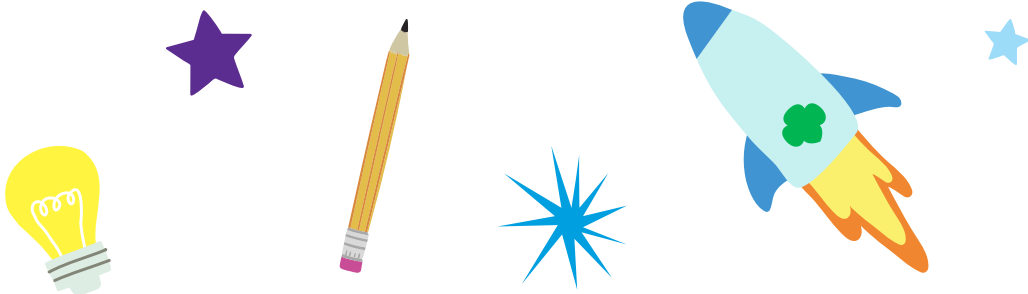
Rocketry is a fun way to learn about the physics of flight, aerospace engineering, computer flight simulation, and model rocket design.

We'll work together to learn about rocketry and then design, build, test, and enter our rocket. We'll build our problem-solving, teamwork, and leadership skills, too!

Contact Girl Scout Troop [Troop #] for more information:

Phone: [Phone #]

Email: [Email Address]



Rocketry Event Flyer for Councils

(Click on the image below to download the customizable flyer)



Come fly with us
and explore rocketry!

Are you interested in science, technology, engineering and, math (STEM)? Would you like to build and fly rockets?

Rocketry is a fun way to learn about the physics of flight, aerospace engineering, computer flight simulation, and model rocket design. You can build your problem-solving, teamwork, and leadership skills, too!

We'll work together to learn about rocketry and then design, build, test, and test a rocket. If you want, you'll even be able to join our rocketry team.

Join [GS COUNCIL NAME] to begin your rocketry adventure and explore your STEM future! RSVP for more information.

When? [DATE and TIME]

Where? [Event Location]

Cost: [FREE/PRICE]

Join us!

[Registration link or information]



Recruitment Rocketry Event Flyer for Adults

(Click on the image below to download the customizable flyer)



Help us reach for the stars!

Girl Scout Troop [Troop #] is forming a rocketry team.

Sport rocketry is a great way to learn, hands-on, about science, technology, engineering, and, math (STEM), as well as build as problem-solving, teamwork, and leadership skills. Women are underrepresented in STEM careers, including aerospace engineering. Sport rocketry is a fun way for our troop to build important background knowledge and explore possible career paths.

Do you have a background in STEM or computers, experience with sport rocketry, or an interest in learning about these topics? Volunteer with us!

We need volunteers to:

- help us learn how to design, build, and launch model rockets
- understand the physics and math concepts involved in sport rocketry
- use rocket flight simulation software
- raise funds to purchase supplies we'll need
- reach out to community partners to support our rocketry adventure
- help us participate in sport launches and competitions like The American Rocketry Challenge

Contact Troop [Troop #] to join our science team!

Phone: [Phone #]

Email: [Email Address]

Customizable Letter for Funding and Partners

(Use this email to invite a community partner, like a business, school, or organization, to support your rocket science team.)



Subject: Girl Scout Rocketry Team

Dear [appropriate TITLE or NAME of community or business leader]:

I hope you and [NAME of the business, school, or community group] community are staying safe and well.

I'm reaching out today because we would love to partner with you as our Girl Scout troop has decided to form a rocketry team. The Girl Scouts are committed to providing hands-on learning experiences for our members and have increased our focus on science, technology, engineering, and math (STEM) experiences to enable Girl Scouts to learn about these concepts and career opportunities.

Model rocketry is a great way to learn, hands-on, about STEM, as well as build problem-solving, teamwork, and leadership skills. Our troop will learn about the basics of model rocketry and flight by building starter rocket kits and launching those rockets. Then, we'll design our own rockets and build, test, and improve them, the same way aeronautical engineers do. We'll be using the [safety code of the National Rocketry Association](#), the country's oldest sport rocketry organization, to help us build our rocketry experience safely.

[Add optional paragraph about The American Rocketry Challenge participation here: To put our knowledge of rocketry to the test, we'll compete in The American Rocketry Challenge, the world's largest rocket contest.]

To have a successful rocketry experience, we need help. There are a number of ways [NAME of the business, school, or community group] might participate, including:

- Sharing your knowledge or expertise to help us learn how to design, build, and launch model rockets or to understand the physics and math concepts involved in sport rocketry
- Helping us use rocket flight simulation software
- Providing space for us to build or test our model rockets
- Donating supplies or funds we'll need to build and test our rockets
- Publicizing our rocketry team in the community partners to help us build support for our rocketry adventure

By participating, [NAME of the business, school, or community group] will be helping our troop work as a team to learn about STEM concepts and careers.

I would like to meet with you or the appropriate person at [NAME of the business, school, or community group] to share information and seek your input on how we might work together to support our rocketry team. I have good availability on [2-3 DAYS OF WEEK/DATE OPTIONS]. Please let me know what might work for you.

Thank you for your consideration and support.

Sincerely,

[YOUR NAME]

Sample Parent and Caregiver Letter

(Use this email to invite a community partner, like a business, school, or organization, to support your rocket science team.)



Subject: Girl Scout Rocketry Team Dear Caregivers and Families of Girl Scouts,

Will you help us reach for the stars? We want to learn about rocketry by building and launching our own rockets.

Model rocketry is an ideal way for your Girl Scout to learn, hands-on, about science, technology, engineering and math (STEM), problem-solving, teamwork, and leadership. They'll learn about physics and aerodynamic design and use math to calculate how high their rockets will soar. Women and girls are underrepresented in STEM careers, including aerospace engineering. Rocketry is a way for your Girl Scout to explore and experience aspects of STEM that might turn out to be her passion.

Our troop will learn about the basics of model rocketry and flight by building starter rocket kits and launching those rockets. Then, we'll design our own rockets and build, test, and improve them, the same way aeronautical engineers do!

[Paragraph for Troops participating in The American Rocketry Challenge: We'll enter our rocket in The American Rocketry Challenge, an annual national rocketry competition.]

We'll be using the [safety code of the National Rocketry Association](#), the country's oldest sport rocketry organization, to help us build our rocketry experience safely.

Here are some ways families can support our rocketry experience:

- **Support your Girl Scout.** Support her as she participates individually and/or with her Girl Scout community. Sign and return the required parent, guardian, or caregiver permission forms so your Girl Scout can participate.
- **Volunteer for troop rocketry activities.** If you have a background or interest in STEM, share your expertise, curiosity, and enthusiasm!
- **Share connections you have that can support your Girl Scout's troop and/or council.** Do you know model rocketeers or engineers? What about folks who own hobby or hardware stores? Do you know of a large outdoor space where the troop might be able to test their rockets?
- **Help our troop raise money.** We'll need to buy materials to build our rockets and starter rocketry kits to learn the basics of rocket building and flight.

Want to learn more about our troop's rocket science adventure? Join us for [insert details about an informational discussion or meeting with an introductory model rocket activity here.]

Thank you for your support,

[YOUR NAME]

Sample Budget Worksheet for a Rocketry Team

This sample budget is meant to be used by a team competing in The American Rocketry Challenge. As your team plans, keep in mind that a typical budget for the Challenge is between \$500 and \$1,000. This includes an entry fee and one altimeter, plus the parts for two contest rockets and the rocket motors for flights of those rockets. It also includes one beginner rocket plus two motors for each team member if they have no prior rocketry experience but does not include launch equipment or travel to the local launches or the National Finals. The table below is based on a team of 10 beginners that makes a total of 10 test flights and three qualification flights for the Challenge.

Tools

Item	Quantity	Source	Cost Per	Total Cost
Craft knife (X-acto type)	1	Craft store	\$2	\$2
Metal 12-inch ruler	1	Craft store	\$2	\$2
Sandpaper (220 grit)	1 pack	Craft/hardware store	\$3	\$3
Wood filler	1	Hardware store	\$3	\$3
Spray paint (2 colors)	2	Craft/hardware store	\$5	\$10
Masking tape (¾ or 1 inch)	1 roll	Craft store	\$2	\$2
Yellow wood glue	1	Craft/hardware store	\$4	\$4
Rocket Flight Simulation Software	at least 1 license	Online store	\$20	\$20
NAR membership for adult	1	NAR	\$70	\$70
NAR membership for youth team members (optional)	3	NAR	\$30	\$90
Laptop or tablet to run software	1	Parent/school	0	
Subtotal:				\$206

Supplies

Item	Quantity	Source	Cost Per	Total Cost
Starter rocket kits	1 per student	Online store	\$6.50	\$65
Altimeter approved for The American Rocketry Challenge	1	Online store	\$55	\$55
Model rocket motors for starter kits	2 per student	Online store	\$3	\$60
Model rocket motors approved for The American Rocketry Challenge (F power class)	13	Online store	\$20	\$260
Large rocket body tubes	4	Online store	\$5	\$20
Large nose cones	2	Online store	\$10	\$20
Motor mount for large body tube	2	Online store	\$7	\$14
Fins/fin material	2 fin sets	Online store	\$8	\$16
Launch rail buttons	2 sets	Online store	\$4	\$8
Rocket body connectors	2	Online store	\$12	\$24
Nylon parachutes	2	Online store	\$8	\$16
Parachute protectors (Nomex cloth)	2	Online store	\$8	\$16
¼-inch sewing elastic (shock cord)	1	Craft store	\$1	\$1
Shipping costs for online orders				\$30
			Subtotal:	\$605

Team Expenses

Item	Quantity	Source	Cost Per	Total Cost
Entry fee	1		\$125	\$125
Fees to participate in test launches	4	Local NAR club	\$5/day (varies)	\$20
Transportation to test launches			varies	
Transportation to National Finals Fly-Off			varies	
Food and lodging for National Finals Fly-Off			varies	
			Subtotal:	\$145

Launch & Safety Items

Item	Quantity	Source	Cost Per	Total Cost
Launch equipment for starter rockets	1		\$30	\$30
First-aid kit(s)	1	Pharmacy/online	\$20	\$20
			Subtotal:	\$50

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Girl Scout Troop [Troop#] is forming a sport rocketry team and we want YOU!

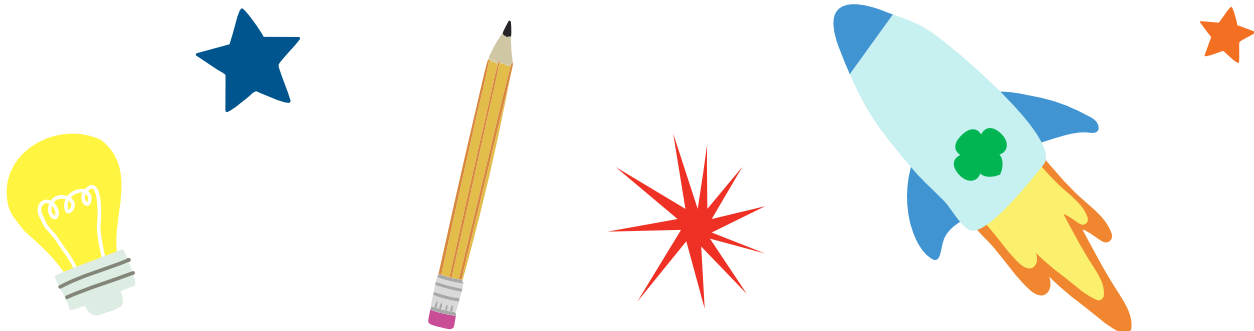
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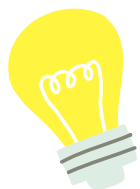
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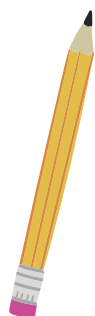
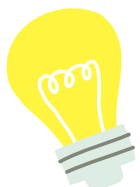
When? [DATE and TIME]

Where? [Event Location]

Cost: [FREE/PRICE]

Join us!

[Registration link or information]





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- help us participate in sport launches and competitions like The American Rocketry Challenge

Contact Troop [Troop #] to join our science team!

Phone: [Phone #]

Email: [Email Address]

Subject: Girl Scout Rocketry Team

Dear [appropriate TITLE or NAME of community or business leader]:

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Thank you for your consideration and support.

Sincerely,

[YOUR NAME]

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Want to learn more about our troop's rocket science adventure? Join us for [insert details about an informational discussion or meeting with an introductory model rocket activity here.]

Thank you for your support,

[YOUR NAME]