

2014 Team Handbook

# Team America Rocketry Challenge



Aerospace Industries Association - National Association of Rocketry

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# Team America Rocketry Challenge

## 2014 Team Handbook

Aerospace Industries Association - National Association of Rocketry

**The Team America Rocketry Challenge (TARC)** is the world's largest rocket contest, sponsored by the **Aerospace Industries Association (AIA)** and the **National Association of Rocketry (NAR)**. It was created in the fall of 2002 as a one-time celebration recognizing the Centennial of Flight, but the enthusiasm about the event was so great that AIA and NAR were asked to hold the contest annually.

Approximately 7,000 students from across the nation compete in TARC each year. Teams design, build and fly a model rocket that reaches a specific altitude and duration determined by a set of rules developed each year. The contest is designed to encourage students to study math and science and pursue careers in aerospace.

The top 100 teams, based on local qualification flights, are invited to Washington, DC in May for the national Finals. Prizes include \$60,000 in cash and scholarships split between the top 10 finishers. AIA member companies such as Lockheed Martin and Raytheon have sponsored additional prizes such as scholarship money and a trip to an international air show.

TARC is becoming bigger and better every year with the attendees and prizes growing annually. Register now to be a part of the excitement!

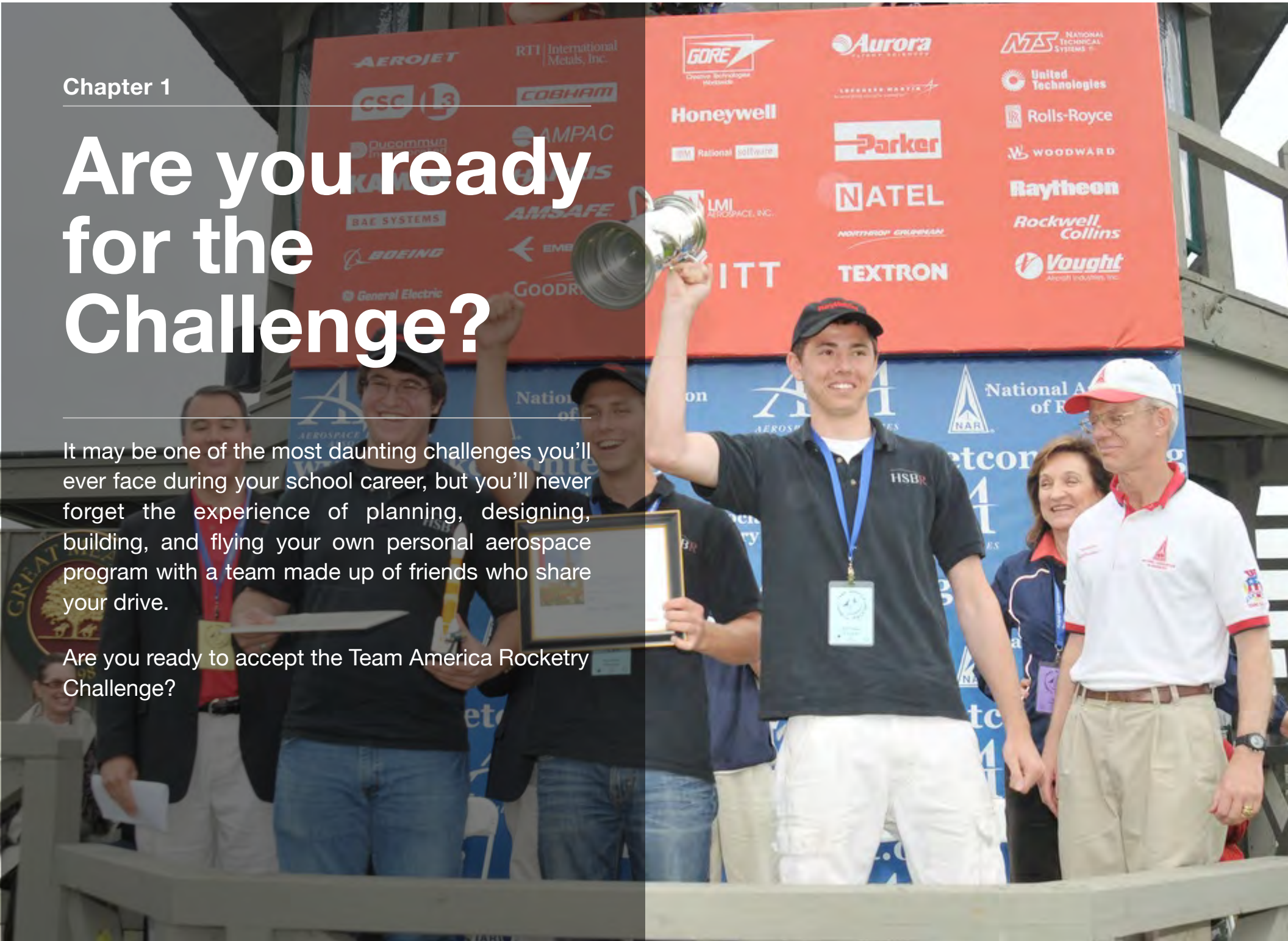


## Chapter 1

# Are you ready for the Challenge?

It may be one of the most daunting challenges you'll ever face during your school career, but you'll never forget the experience of planning, designing, building, and flying your own personal aerospace program with a team made up of friends who share your drive.

Are you ready to accept the Team America Rocketry Challenge?



# The Team America Rocketry Challenge

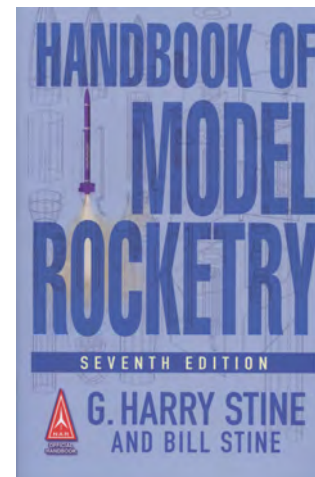
**The Team America Rocketry Challenge (TARC)** provides 7th through 12th grade students a realistic experience in designing a flying aerospace vehicle that meets a specified set of mission and performance requirements. Students work together in teams the same way aerospace engineers do. It is not intended to be easy, but it is well within the capabilities of students of these ages with a good background in science and math and some craftsmanship skills.

The purpose of the Challenge is to design, build, and fly a safe and stable model rocket to an altitude of exactly 825 feet while also achieving a total flight duration score of between 48 and 50 seconds and returning a payload of two raw hen's eggs undamaged using two identical-diameter parachutes for safe recovery. The winner is the team whose flight vehicle with egg payload comes closest (in the sum of two flights) to exactly 825 feet altitude and the range of 48-50 seconds flight duration score in a safe and stable flight, and returns both eggs undamaged at the National Finals



hosted in Northern Virginia on May 10, 2014.

This Team Handbook provides the Challenge rules plus some guidelines on how to approach the process of rocket design and flight. It also provides additional sources of information on general model rocket design, construction, and flying. It is not a "cookbook"; no design is provided as an example. The challenge and the learning for each team come from developing and testing your own completely original design.



Teams should begin the Challenge by becoming familiar with the basics of model rocketry. Those who have no experience with how these models are built and flown should begin by reading G. Harry Stine's Handbook of Model Rocketry (available from the [National Association of Rocketry's Technical Services](#)) and by purchasing, building, and flying a basic model rocket kit, such as the one offered by [Aerospace](#)

[Specialty Products](#) for TARC.

If you live near one of the 140 National Association of Rocketry sections (chartered clubs) or the 400 experienced adult members of the National Association of Rocketry who have volunteered to be mentors, you are encouraged to consult with them. The sections are listed at the [NAR web site](#). The [list of mentors](#) is in the Team America section on the NAR web site. These rocketeers can help teach you the basics of how to build and fly a payload-carrying rocket. Typically they can also help you in locating a test-flying launch sites and work with local officials if this is required. Many will allow you to do your practice or qualification flight at one of their already-organized launches ([launch dates and locations](#) also listed at the NAR web site). Remember neither these experts nor any other adult can help you design, build or fly your actual entry. All of this work must be done by the student members on your team.



If model rocketry interests you and you want to be connected to the rest of the people in the U.S. who are part of the hobby's "expert team," you should join the National Association of Rocketry. You can do this online at [www.nar.org](http://www.nar.org) or by filling out the membership application forwarded to each team. Membership brings you insurance coverage, the hobby's best magazine, the bi-monthly Sport Rocketry, and a whole range of other benefits and resources.

Good luck! Design carefully, fly safely, and we hope to see you at the Finals in May 2014.



# 2014 TARC Event Rules

At the heart of the Team America Rocketry Challenge is a precisely defined set of rules within which each team must operate. Here are the rules that you and your teammates must follow as you build your aerospace program.



# 2014 Team America Rocketry Challenge Rules

**1. SAFETY:** All rockets must be built and flown in accordance with the Model Rocket Safety Code of the National Association of Rocketry (NAR), any applicable local fire regulations, and Federal Aviation Regulations. Rockets flown at the fly-off must have previously flown successfully. They will be inspected before launch and observed during flight by an NAR official, whose judgment on their compliance with the Safety Code and with these rules will be final. Teams are encouraged to consult with designated NAR officials who are running this event well before the fly-off to resolve any questions about design, the Safety Code, or these rules.



**2. TEAMS:** No more than five teams may be entered by any sponsoring organization. The application for a team must come from a single school or a single U.S. incorporated non-profit youth or educational organization (excluding the National

Association of Rocketry, Tripoli Rocketry Association, or any other rocket club or organization). Team members must be students who are currently enrolled in grades 7 through 12 in a U.S. school or homeschool. Teams may have members from other schools or other organizations and may obtain financing from any source, not limited to their sponsoring organization. Teams must be supervised by an adult approved by the principal of the sponsoring school, or by an officially-appointed adult leader of their sponsoring organization. Minimum team size is three students and maximum is ten students. Each student member must make a significant contribution to the designing, building, and/or launching of the team's entry. No part of any of these may be done by any adult, by a company (except by the sale of standard off-the-shelf components available to the general public, but not kits or designs for the event), or by any person not a student on that team. No student may be on more than one team. The supervising teacher/adult may supervise more than one team.





The Challenge is open to the first 1000 teams that submit a completed application, including payment, postmarked between September 2 and December 1, 2013.

### 3. ROCKET REQUIREMENTS:

Rockets may be any dimension, but must not exceed 650 grams (23 ounces) gross weight at liftoff (Note: California state law has limitations on model rockets over 500 grams in that state). They may not be commercially-made kits designed to carry egg payloads with the only modification being the addition of an altimeter compartment. They must have only one stage. They must be powered only by commercially-made model rocket motors of “F” or lower power class that are listed on the [TARC Certified Engine List](#) posted on the TARC website and provided in the TARC Handbook. Any number of motors may be used, but the motors used must not contain a combined total of more than 80 Newton-seconds of total impulse based on the total impulse ratings in the TARC list. Rockets must not contain any pyrotechnic charges except those provided as part of the basic commercially-made rocket motor used for the flight, and these must be used in the manner prescribed in the instructions for that motor. The entire rocket must return to the ground safely with all



parts connected together using two separate and deployed parachutes of the same size as its sole recovery system. The outer edges of the canopies of the two parachutes shall not be separated from each other more than one inch at any point when one is laid on top of the other for pre-flight measurement by an NAR official. Both parachutes do not need to fully deploy and inflate in order for a flight to be qualified, but both must come out of the rocket body and neither can be deliberately packed in such a way that it cannot inflate.

**4. PAYLOAD:** Rockets must contain and completely enclose two raw hen's eggs of 57 to 63 grams weight and a diameter of 45 millimeters or less, and must return these from the flight without any cracks or other external damage. The eggs will be issued to the teams by event officials during finals, but teams must provide their own eggs for their qualifying flights. Rockets must be allowed to land at the end of flight without human intervention (catching) and will be disqualified if there is such intervention.

The eggs and altimeter must be removed from the rocket at the end of the flight in the presence of a designated NAR official and presented to that official, who will inspect the eggs



for damage and will read the altimeter score. All coatings, padding, or other materials used to protect the eggs must be removed by the team prior to this inspection. Any external damage to either of the eggs noted after flight is disqualifying.

**5. DURATION SCORING:** Scores for each flight shall be based on total flight duration of the rocket, measured from first motion at liftoff from the launch pad until the moment of landing or until the rocket can no longer be seen due to distance or to an obstacle. Times must be measured independently by two people not on the team, one of whom is the official NAR-member adult observer, using separate electronic stopwatches that are accurate to 0.01 seconds. The official duration will be the average of the two times, rounded to the nearest 0.01 second. If one stopwatch malfunctions, the remaining single time will be used. The flight duration goal is a range of 48 to 50 seconds. Flights with duration in the range of 48 to 50 seconds get a perfect duration score of zero. Duration scores for flights with duration below 48 seconds will be computed by taking the absolute difference between 48 seconds and the measured average flight duration to the nearest 1/100 second and multiplying this by 4. Duration scores for flights with durations above 50 seconds will be computed by taking the absolute difference between 50 seconds and the measured average flight duration to the nearest 1/100 second and multiplying this by 4. These duration scores are always a positive number or zero.

**6. ALTITUDE SCORING:** Rockets must contain one and only one electronic altimeter of the specific commercial types approved for use in the Team America event. These types are the Perfectflite APRA, or Pnut. The altimeter must be inspected by an NAR official both before and after the flight, and may not be modified in any manner. The altimeter must be confirmed by this official before flight to not have been triggered and to be ready for flight. The altitude of the rocket as recorded by this altimeter will be the sole basis for judging the altitude score and this altimeter may be used for no other purpose. The altitude score for each flight will be the absolute difference in feet between the 825 feet (251 meters) target altitude and the altimeter-reported actual flight altitude in feet (always a positive number or zero).



**7. FLIGHTS:** Team members cannot be changed after the first qualification flight. Only team members on record at Aerospace Industries Association (AIA) with valid parent consent forms are eligible to receive prizes. In order to be eligible for the national final fly-off event, a team is required to fly at least two qualifying flights observed in person by an adult (senior) member of the NAR (unrelated to any team members and not a paid employee of their school or member of their youth group) between September 2, 2013 and Monday March 31, 2014. Each team may conduct a maximum of three qualification flights, and will be ranked based on the sum of the best two of these three scores. More than two qualification flights are not required if the team is satisfied with the results of their first two flights. Teams that submit at least one qualification flight report by March 2, 2014 will be given a bonus deduction of 1 point from their final best-two flight score when the scores are ranked by AIA for Finals selection. A qualification flight attempt must be declared to the NAR observer before the rocket's motor(s) are ignited. Once an attempt is declared, the results of that flight must be recorded and submitted to the AIA, even if the flight is unsuccessful. A rocket that departs the launch pad



under rocket power is considered to have made a flight, even if all motors do not ignite. If a rocket experiences a rare "catastrophic" malfunction of a rocket motor (as determined by the NAR official observer), a replacement flight may be made, with a replacement vehicle if necessary. Flights which are otherwise fully safe and qualified but which result in no altimeter reading despite correct usage of the altimeter by the team, or that result in a reading of greater than zero but less than 50 feet despite a nominal flight will be counted as "no flight" and may be reflown without penalty. The results from qualification flight attempts must be faxed to and received at the offices of the AIA by 11:59 PM EST on Monday, March 31, 2014. Based on these qualification scores 100 teams will be selected on the basis of lowest combined scores for their best two flights, will be notified no later than 5 PM on Friday April 4, 2014, and will be invited to participate in the final fly-off to be held on May 10, 2014 (alternate date in case of inclement weather will be May 11, 2014).

**8. SAFE RECOVERY:** The rocket must return to earth at a velocity that presents no hazard. Any entry which has any structural part (including but not limited to an expended engine casing) separate and fall to earth not connected to the rest of the rocket, or that falls at a velocity that is judged by an event official to be hazardous due to recovery system absence, insufficiency, or malfunction, will be disqualified.

**9. RETURNS:** Return of the entire rocket is required by the deadline time established at the beginning of the day's flying. Entries which have parts (including but not limited to expended engine casings) not returned after flight shall be disqualified. If the rocket cannot be returned after an otherwise safe and stable



flight because it landed in a spot from which recovery would be hazardous (as determined by an NAR official), a replacement vehicle may be substituted for a replacement flight.

**10. LAUNCH SYSTEMS:** Teams may use the electrical launch system and the launch pads (with six-foot long, 1-inch rails or 1/4-inch diameter rods) provided by the event officials at the fly-

off, or may provide their own system. Systems provided by teams for their own use must be inspected for safety by an NAR official before use, and must provide at least 6 feet of rigid guidance, including use of a rod diameter of at least 1/4 inch, if a rod is used. All launches will be controlled by the event Range Safety Officer and must occur from the ground.

**11. FLIGHT CONTROL:** Rockets may not use an externally-generated signal such as radio or computer control (except GPS navigation satellite signals) for any purpose after liftoff. They may use autonomous onboard control systems to control any aspect of flight as long as these do not involve the use of pyrotechnic charges. Any onboard flight-control electronics must use only commercially-made altitude and/or timing devices that are available to all TARC participants.

**12. PLACES:** Places in the final fly-off of the competition will be determined on the basis of the sum of the altitude and duration scores. At the fly-offs, 24 teams will be invited to make a second flight at the last flight round of the day based on the results of their first flights. Prizes which are awarded



to the top places will be awarded only to those teams that make a second flight. In this final round, rockets which have issues which would otherwise rate a replacement flight under TARC rules #7 or



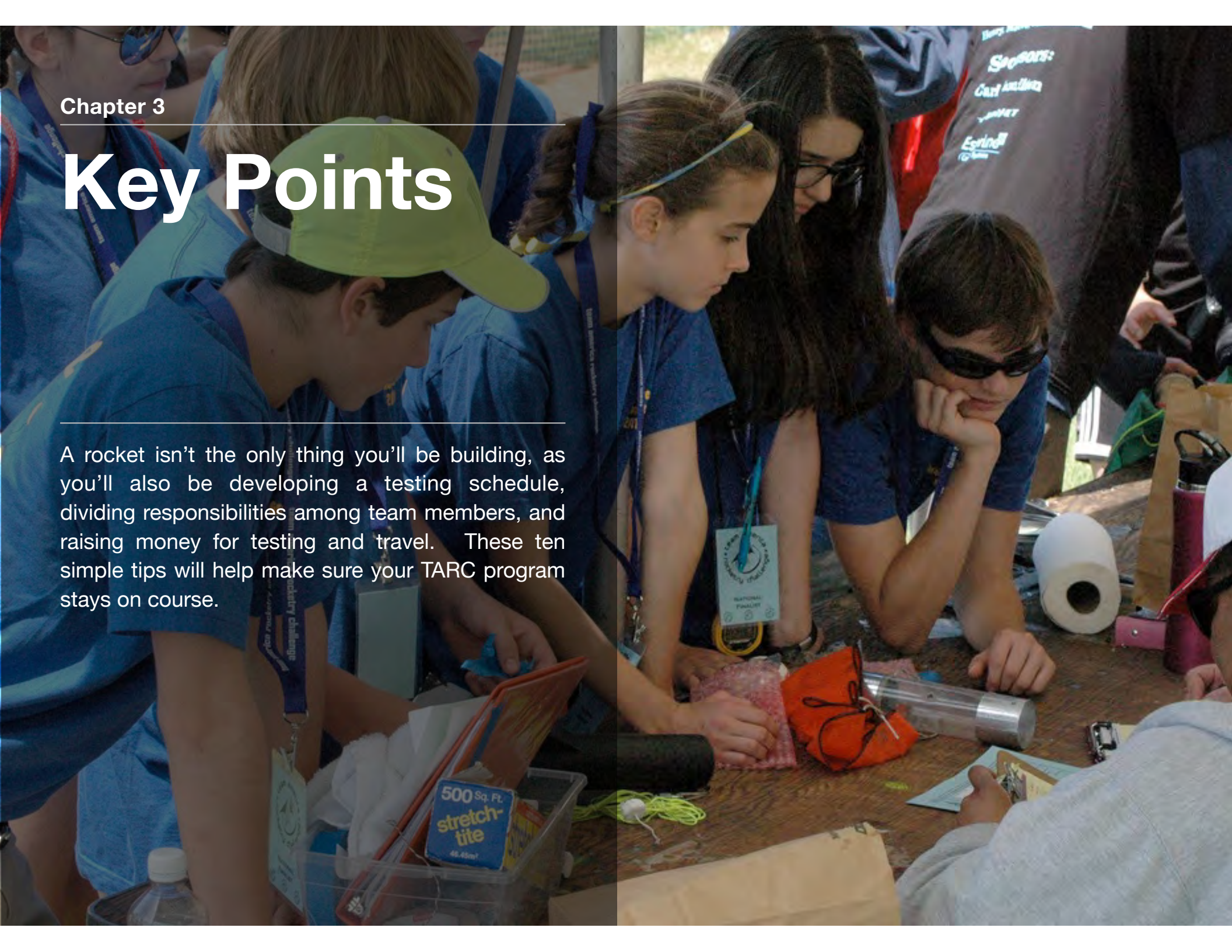
#9 will not receive a replacement flight. The top twenty final places will be ranked on the basis of the scores from the two qualified flights made at the fly-offs. Places twenty-one up to one hundred will be awarded to the remaining teams based on the scores from their first flight. Ties will result in pooling and even splitting of the prizes for the affected place(s) -- for example, a two-way tie for 4th place would result in

a merger and even division of the prizes for 4th and 5th places. If there is a tie for one of the top three places, the teams involved in the tie will be required to make a third flight to determine final places. Aerospace Industries Association reserves the right to make all last and final contest determinations.



# Key Points

A rocket isn't the only thing you'll be building, as you'll also be developing a testing schedule, dividing responsibilities among team members, and raising money for testing and travel. These ten simple tips will help make sure your TARC program stays on course.



# Key Points

After you read and understand the rules (**Section 2** in this Handbook), here are the ten key points about how to succeed in TARC 2014:

1. Do not make your TARC rocket the first rocket you build and fly; if you have never done model rocketry before, build and fly a simple rocket first.
2. Reach out to a NAR TARC mentor early for advice on how to build a rocket, where to get your rocketry supplies, and where to fly.



3. Develop a budget and a division of labor and schedule for your team's efforts, and raise the money needed to buy the parts and rocket motors it will take to be successful; plan on at least 10 practice flights.

4. Get your initial design done before Christmas; use one of the computer programs to see if it will be stable in

flight, and how high it is likely to go with which rocket motor, before you build it.



5. Do your first flight test by January, so that in case you have to do a major change in your design or your rocket crashes you have time to recover before the qualification flight deadline of March 31, 2014; and so that you have time to do lots of flight tests before this deadline.

6. Do lots of flight tests of your design 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.

7. Figure out who your official NAR flight observer will be for your qualification flights, and make sure that you know when they are available. Keep in mind that they are volunteers and may not be able to drop everything else they are doing on short notice to support you.

8. Earn the “early flier” qualification flight score bonus by flying your first qualification flight by March 2, 2014. Remember that up to three qualification flight attempts are permitted, and the best two scores count for computing the score for determining Finals eligibility.

9. Complete your qualification flights and submit the scores by the deadline of March 31; do not wait until the last weekend to fly and just hope that the weather will be perfect and an NAR observer will be available!



10. If you have a very good combined two-flight score from your qualification flights, develop your plan for how you will fund your travel to the TARC Finals, in case you are one of the 100 top teams that are announced on April 4, 2014.





## Chapter 4

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# Rocket Design

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Great results always start with a great plan. By focusing your early efforts on planning, design, and simulation, your team will arrive at a workable design more quickly and with less expense.

*"If at first you  
don't succeed,  
call it version  
1.0."*



# Rocket Design

**How do you approach the process of designing a flight vehicle?** Engineers start with what is a fixed, given quantity -- such as the size and shape of the egg payload and its cushioning and the altimeter -- and with what the mission performance requirements are. In this case the requirement is to go to 825 feet and stay up for 48-50 seconds, and then make a safe return to earth at the end. No matter what your design, it must incorporate this payload and achieve the performance requirement.

The Challenge is finding the exact combination of airframe design, rocket engines, and duration-control technique with two identical-diameter parachutes that will achieve exactly 825 feet and 48-50 seconds.

Doing this will require either lots of trial-and-error (not recommended), or smart use of 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!

What, then, are the variables in yours aerospace system's design? Well, the size and shape of the rocket certainly has a wide range of possibilities, subject to the overall limitations that the rocket must be safe and

stable, and must not exceed 650 grams (about 23 ounces) in weight. And the selection of the vehicle's rocket motors is another major variable. Since any certified commercially made model rocket motors with 80 Newton-seconds or less of total impulse may be used, you must pick which ones you plan to use from the "Team America Approved Motor List" posted (and

updated) at the National Association of Rocketry [website](#) and in [Appendix 3](#) of this Handbook. Because of the size of the payload (a large hen's egg must weigh between 57 to 63 grams and requires the rocket to have a body tube that can accommodate an egg diameter of up to 45 millimeters) rockets entered in this Challenge will be fairly large. The minimum liftoff weight is probably about 10 ounces and the rocket will need at least a low-range F motor of two E motors to achieve the altitude goal.

There are other design variables to be considered including:

- how to predict or control flight duration in various weather conditions
- how to cushion and protect the fragile egg
- what kind of electrical launching device to use.

What all of this means is that, like all engineers, you must engage in an iterative design process. You start with a very rough design, evaluate its performance against the requirements, and change the design progressively until your analysis shows that you have a design that is likely to meet them. Then you build, test, evaluate

the success or failure of the test, and adjust the design as required until your analysis and tests show that the performance requirement is approximately met. Initial tests are best done as

virtual flights on a computer, with the time-consuming construction and relatively expensive flight testing of an actual rocket saved for the second step.

Remember that this event is also about teamwork; engineers design in teams because complex projects that are due in short periods of time demand some kind of division of labor. There are many ways to divide the labor -- perhaps one person could become expert in computer flight-simulation programs, another in the craftsmanship techniques of model rocket building, a third in launch system design, and a fourth in charge of fundraising. All the members need to meet and communicate regularly, because what each one does affects how all the others approach their part of the job. You will need to elect or

appoint a Program Manager to make sure everything fits together at the end so that your complex system will work in flight test.

***And you need to start early!***



Here is a path that you may wish to follow to take you through the design process, along with some additional explanation of the design implications of rocketry terminology used in the [event rules](#) and in the [NAR Safety Code](#).

**1. Accommodate the payload.** Determine what size compartment is required to contain the altimeter and (separately) two Grade A large eggs and cushion them against the shocks of rocket launch, recovery system deployment in flight, and impact

with the ground at the end of flight. The rules require that the payload compartment must have a body diameter of no less than 60 millimeters.

*Hint: Make sure you cushion the egg from impact with the walls of the payload compartment or metal hardware in every direction including the sides when the rocket's recovery device snaps open.*

**2. Accommodate the instrumentation.** One of the electronic

altimeters specified for the event must be used in your rocket, and will be the sole basis for measuring the rocket's achieved maximum altitude. You may install other additional altimeter-based systems if you wish, to control duration or other features, but only the official altimeter types can be used for the official record of achieved altitude. It is very important that the compartment in which the altimeter is placed be properly positioned on the rocket and vented with holes as described in [Appendix 5](#), so that the air pressure inside it is always at equilibrium with the outside air pressure.

The instrument measures altitude on the basis of the air pressure changes it senses during flight.

*Hint: Place the altimeter in a compartment that is totally sealed on the bottom against intrusion by high-pressure gases from the rocket motor's ejection charge. These gases will make the altitude reading inaccurate.*

*Hint: Secure the altimeter in place mechanically in its compartment, don't let it "rattle" around or rely on foam padding to hold it in place (such padding might interfere with proper pressure equalization of the compartment). But make it easy to remove, because you will have to remove the altimeter both before and after flight for inspection by event officials.*



**3. Decide on a recovery system design approach.** Read the [Appendix 4](#) information on parachute recovery systems. Determine how to trade off among those parachute-design features that can be varied within the TARC rules, and how to manage the weight of the flight vehicle (or the egg/altimeter capsule) in order to achieve the specified duration of 48 to 50 seconds. The entire rocket must return with all parts connected together using two parachutes of identical diameter (plus or

minus one inch) as its sole deployed recovery device.



**4. Learn to use a rocket-design computer program.** There are three good rocket-design programs currently available: the commercial [RockSim](#) and [SpaceCAD](#) programs and the “freeware” [OpenRocket](#) program. Such a program is the best way to work through the remaining steps

of flight vehicle design on a basis other than trial-and-error. There is no single correct design for this Challenge; there are many different combinations of motor types, rocket length and diameter, rocket weight, and parachute configuration that could lead to a flight altitude of 825 feet and flight duration of 48-50 seconds. A computer program will let you work through the rough possibilities fairly quickly and discard approaches that simply will

not work or designs that are not aerodynamically stable. No simulation, however, is exactly accurate. Its estimate of the aerodynamic drag forces on your rocket may be off due to your construction techniques and it may therefore overestimate how high your real rocket will go; the rocket motors you use may perform slightly differently from the notional data for them in the program due to normal manufacturing variations, etc. That's why you still need to (and are required to) test-fly at the end of the design process.

**5. Simplicity.** The more complex you make your rocket design, the more things it has that can go wrong and the more it will cost

both to develop and test. In the real world of engineering, low cost, rapid delivery, and high reliability are what the customer wants. In this Challenge, since your eligibility for the top ten prizes is based on the results of your flight attempts at the Finals, whatever you fly has to work perfectly the first time. Add complexity (such as clustered rocket motors) only where you need to in order to meet performance requirements. It



may turn out that you need to use something complex, but don't assume so from the start.

**6. Basic design safety.** First and foremost, your rocket must be "stable". Read the *Handbook of Model Rocketry* chapter on stability if you do not know what this means, and use a computer program to calculate stability if in doubt. Because your rocket will be nose-heavy as a result of the eggs and altimeter, you should not need extremely large fins -- be conservative and design for a stability margin of at least two "calibers" (Center of Gravity ahead of Center of Pressure by at least two body tube diameters) with the eggs and with loaded rocket motors. Second, make sure that the motor(s) you pick provide enough thrust to give your size/



weight rocket a speed of 40 ft/sec or so by the time it reaches the end of its launcher, so that it does not "stagger" slowly into the air and tip over and fly non-vertically if there is any wind. Generally, you need a motor or combination of motors whose combined average thrust is at least five times the rocket liftoff weight. As a rule of thumb, make sure that the model's

motors' combined average thrust (in units of Newtons, which is how these are marked on the engine casing) is at least 1.5 times the rocket's liftoff weight in units of ounces.

Finally, plan on using a launch rod of at least 6 feet in length and 1/4-inch in diameter or (better yet) a rail for flying these heavy rockets -- they will need the length to achieve safe speed and the rigidity to avoid "rod whip" when the heavy rocket is at the end of the launch rod on its way up. Both 1/4-inch rods and 1-inch rails will be available for your use at the Finals. Electronic recovery system deployment systems, if you choose to use them, must be SAFE. If they are designed to sense acceleration or deceleration of the rocket as the basis for starting an ejection sequence, then there is a great risk that they can trigger on the ground or in your hands if you drop or jog the rocket while carrying it. Such systems must have a power switch, plug, or other electrical disconnect mechanism that permits you to maintain them in a completely "safe" configuration until placed on the launching pad, and will not be allowed to fly if they do not. These systems may not use pyrotechnic charges of any type (no Pyrodex or black powder) to trigger deployment, but may use standard igniters to burn through or deploy something.





## 7. Commercial vs Custom

**Parts.** The flight vehicle must be made by the student team members. You may use commercially-available "off the shelf" component parts (body tubes, nose cones, egg capsules, parachutes, etc.) and may adapt some kinds of rocket kits for the event, or you can scratch-build components if you prefer. If a company should release a kit or design specifically for the TARC event

you would not be allowed to

use such a kit or design. Having a custom flight vehicle part fabricated by a composite or plastics company or custom wood machining company (even if it is to your design) does not constitute sale of a "standard off-the-shelf product" and is not allowed. Using a 3-dimensional printer to make parts is OK as long as the team does all the programming and runs the printer. Having a mandrel fabricated to your specifications that is used to wrap fiberglass on to make your rocket body would be OK. In this case, the company is making a tool; you are making the part that flies.



# Rocket Construction

Once you and your teammates have agreed on a design for your rocket you'll need to turn that vision into reality. Like every step of your TARC journey, planning is the key.





## Chapter 5

# Rocket Construction

**Designing a rocket on a computer is important, but in the end you have to actually build it and fly it.** There are four key resources available to you for learning the craftsmanship techniques for building a model rocket for TARC. Review the online material and read the applicable chapters of the book

before you start trying to put together your rocket. Then build and fly a simple rocket kit (such as the **TARC practice kit** from Aerospace Specialty Products) before you build your TARC entry.



1. Nine web pages of basic tutorial material on how to build a model rocket may be found on the **NAR website**.

2. Free online how-to rocket building resources may be found on the **Apogee Components** website.

3. View the 45-minute instructional video for rocketeers of all ages on all the steps and techniques involved in building and flying a basic model rocket.

This instructional video has been divided into six short segments of 4 to 9 minutes duration and posted online by the Aerospace Industries Association on their **YouTube** site. The six segments are:



- **Part 1: How Model Rockets Work**
- **Part 2: Components of a Rocket**
- **Part 3: Construction**
- **Part 4: Finishing the Rocket's Fins**
- **Part 5: Assembling the Rocket**
- **Part 6: Painting the Completed Rocket**

4. The NAR's official handbook, the Handbook of Model Rocketry by G. Harry and Bill Stine, which TARC teams can purchase at a discount price of \$20 from the [NAR website](#).

5. There are many aspects to constructing a rocket, and this section will not review everything that these resources tell you. Below are some common mistakes we have observed in the last eleven years.

**Don't over-spend on parts.** The basic components of a rocket, such as paper body tubes, balsa fins, and balsa or plastic nose cones are not going to cost you a lot if you design your rocket to use the inexpensive parts that are available from the five "official" component vendors for TARC: [Aerospace Specialty Products](#), [Balsa Machining Service](#), [Heavenly Hobbies](#), [Estes](#), and [SEMROC](#). See their addresses in the "[Resources](#)" chapter of this Handbook. Get advice from an experienced NAR mentor concerning where to get parts and what kinds to get, to avoid overspending on materials that are overpriced or will not be needed.



**Use the right materials in the right places.** Body tubes and launch lugs should be commercially-made, smooth, and strong. Don't try using gift-wrap rolls or other "economy" parts for the main structural member of your rocket, or soda straws for launch lugs. Use balsa wood (or aircraft plywood or basswood) from a

hobby store for your fins, probably at least 1/8 inch thickness (for balsa), and make sure that the wood grain lines start on the fin-body glue joint and go outward from it. Put at least a 24-inch long piece of 1/4 inch wide sewing elastic in your recovery system as a "shock cord" between the egg section and the main body of the rocket, to absorb the opening shock of the recovery system.

**Use the right glues.** Body parts should be held together with yellow carpenter's wood glue or epoxy, not white glue or hot-melt glue. You can use cyanoacrylate "super" glues for repairs, but do not use them for structural construction. You can reinforce fin-body joints with a "fillet" of hobby epoxy, or glue the fins into slots cut into the body tube if you're worried about fins breaking off.

## Chapter 6

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# Rocket Flying

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Before you qualify for a spot at the TARC Finals, you'll need to learn the basic skills required to be a "rocket scientist." Here are the essentials needed to get you and your teammates out to the launch pad quickly and safely.



# Rocket Flying

Once your flight vehicle (rocket) is designed and built, it's time for flight test. This section provides some suggestions for organizing and conducting these tests, and for preparing for your flight at the TARC Finals. First and foremost, of course, is safety: read and follow the NAR Model Rocket Safety Code located in [Appendix 2](#).

**1. Launching system.** Consider the launching system to be an integral part of the flight vehicle system design, not an afterthought. Of course, the system has to be electrical and incorporate the standoff distance, safety interlock switch, and other requirements of the Safety Code, and it must be on the ground (no balloons!). But it also has to be able to provide the right amount of electrical current and voltage to fire your rocket motor(s) igniter(s), and it must provide rigid guidance to the rocket until it has accelerated to a speed where its fins can properly stabilize it (generally about 40 ft/sec). At the TARC Finals, an electrical launch system will be provided that can fire a single igniter of any type with 12VDC and

18 amps of current through one set of clips, and the launching devices provided will be 6-foot-long, 1/4-inch diameter launch rods or 1-inch rails (your choice). If your design requires something different (such as a tower-type launcher or cluster-motor "clip whip"), you must bring your own equipment and power source. In any case, you will need to have (or borrow) a system for pre-Finals test-flying. You may want to have one team member assigned the job of designing and building the launcher, particularly if you do not use a commercially-made "off the shelf" system.



**2. Federal Aviation Administration (FAA).** Model rockets that weigh 3.3 pounds (1500 grams) or less and have less than 4.4 ounces (125 grams) of propellant are exempt from flight regulation by the FAA; it does not take FAA notification or clearance to fly them anywhere in the U.S. This is explicitly stated in [Federal Aviation Regulations \(FAR\) Chapter 101.1](#). Of course, you must follow the NAR Safety Code and not fly when

aircraft are nearby or might be endangered or alarmed by your flight!

**3. Launch Site.** The **launch site** for the Challenge Finals is about 1500 feet by 2500 feet of treeless closely-mowed grassland. If the winds on the date of the Finals are fairly light, recovery will be easy; in windy conditions (above 15 miles per hour), rockets that achieve a 48-second duration could drift out of the field. The site you use for pre-Finals flight testing may or may not be large, but note the minimum site dimensions in the NAR Model Rocket Safety Code, which depend on the size of the motor(s) in your rocket. The first and most important thing you must have at a launch site is permission from the owner! If your school or organization has a suitable site and supports this event, your problem is easily solved. Otherwise, you must work with local park authorities, private landowners, etc. for permission to use a suitable site. There are generally two concerns expressed by landowners concerning rocket flying:

- *"It's dangerous"*. Not true -- the NAR handout at **Appendix 8** summarizes why this is so, and should be used (along with the NAR Safety Code at **Appendix 2**) to persuade site owners of



this. The accident rate for model rocket flying is nearly zero with exactly zero fatalities caused by the rockets, and it is hundreds of times safer than any of the organized athletic events that use similar open fields!

- *"I'm afraid of the liability (lawsuit) consequences if anything happens"*. If you are a member of the NAR, or if you are a member of a TARC team flying at a launch organized and run by an NAR "section" (club) you have personal coverage of up to \$2 million against the consequences of an accident that occurs while you are flying, as long as you are following the NAR Safety Code. See **Appendix 6** for more information on this insurance coverage. If your organization, school, school district, or other landowner of your rocket launch site requires liability insurance, your team can obtain "site owner insurance" coverage for this potential liability by having your supervising teacher/adult and at least three student members of the team members join the NAR and then having the supervising teacher/adult order "site



owner insurance" from NAR Headquarters. This insurance is not available to provide personal coverage for school officials or organization

officials, only for the legal owner of launch sites. This additional coverage costs \$15 per site insured and requires filling out either an online form or a mail-in form, both available at the [Team America section of the NAR website](#).

**4. Launch Safety.** Your rocket and your launch system (if any) will be inspected for flight safety by an event official before they may be used in the Finals. Any discrepancies noted there must be corrected before flight is allowed. **AT THE FINALS, YOUR ROCKET MUST HAVE PREVIOUSLY BEEN SUCCESSFULLY TEST-FLOWN.** You must also be prepared to show and explain any complex rocket features affecting flight such as electronic timer systems, etc. The pre-flight safety check will also look for the following types of things:

- Does the motor (or motors) have sufficient thrust (average thrust to liftoff weight ratio 5 or greater) to give the rocket a safe liftoff velocity from its launcher?
- Is the rocket stable (CG at least one caliber ahead of CP) with motor(s) and egg installed?
- Are the motor(s) used listed on the [TARC Approved Engine List](#), and are they clearly not modified in any manner by the user?
- Are the fins and launch lugs or rail buttons attached securely and straight?

- Is the recovery system (shock cords and anchors, parachute material, etc.) sturdy enough to withstand the shock of opening with that rocket?
- Does the design prevent any expended motor casings or other massive objects from being separated in flight without a recovery system?
- Does the launch system (if the team provides its own) comply with Safety Code requirements for interlocks and standoff distance; can it deliver enough current to ignite multiple motors at once (if cluster ignition is planned); and does the launcher have sufficient length (6 feet is minimum) and stiffness (if a launch rod is used, it must be 1/4-inch) to guide the rocket securely until it reaches safe speed?

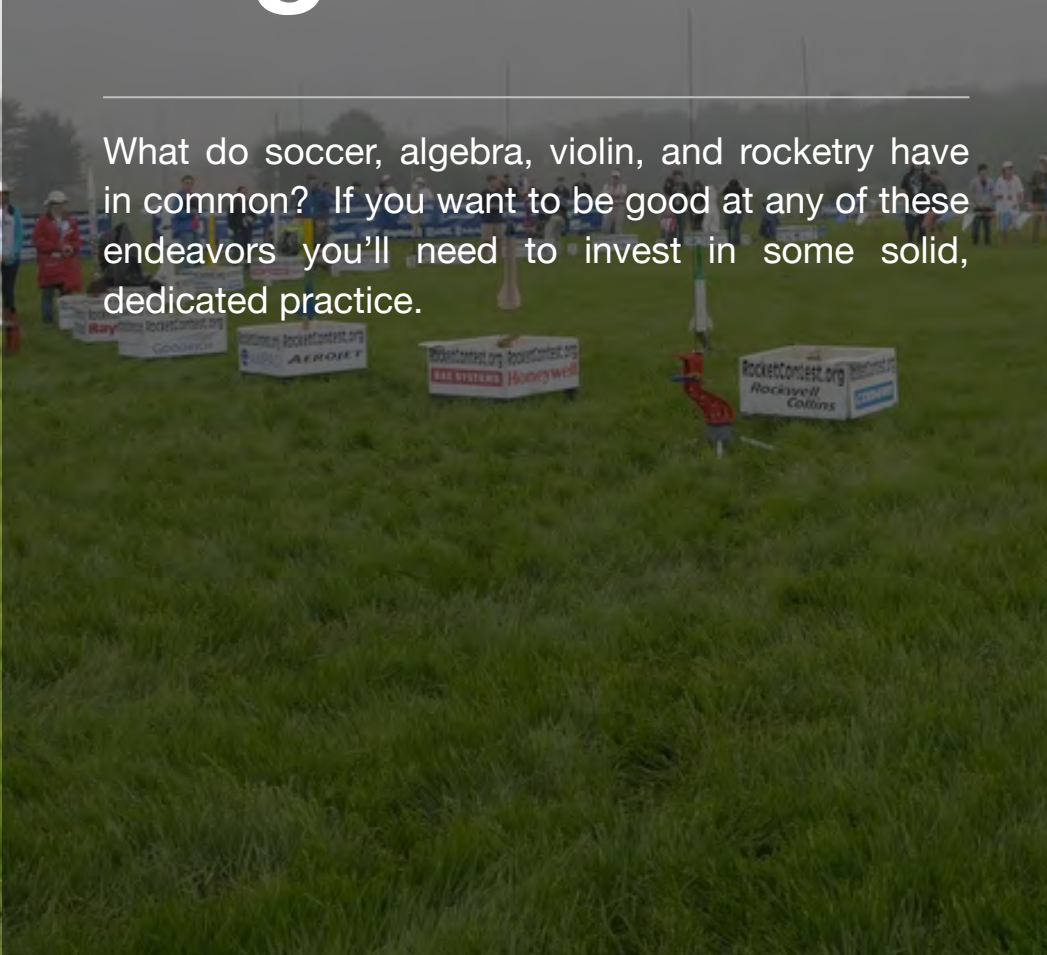


**Important!** It is against the law to travel by airliner with rocket motors in your luggage. We will have a motor vendor ([Hangar11 Hobbies](#)) available on site at the finals for teams who fly in, and will provide information on how to advance-order Finals motors from the vendor for onsite delivery.

## Chapter 7

# Qualifying and Practice Flights

What do soccer, algebra, violin, and rocketry have in common? If you want to be good at any of these endeavors you'll need to invest in some solid, dedicated practice.



# Qualifying and Practice Flights

**Practice-fly early and often.** Only by test-flying can you master the skills of recovery system deployment, egg cushioning, and overall flight reliability and repeatability needed for success.

Each team that enters this competition must conduct two NAR-observed "qualification" flights, fill out the **score form** for each one, and return it to AIA by fax the form to 703-358-1133 or email it to [anne.ward@aia-aerospace.org](mailto:anne.ward@aia-aerospace.org) no later than midnight EST Monday, March 31, 2014. NAR observers who observe a qualification flight attempt that is not successful (i.e. crash or



broken egg) are asked to fax the form on that flight directly to the AIA. Plan ahead for weather (rain or wind that "scrubs" a launch day, problems with the rocket's flight, etc.) and do not wait

until the last minute to try and fly this flight. Teams must provide their own eggs and timing stopwatches for all qualifying and practice flights; pre-measured eggs and timers with watches will be provided by the NAR at the fly-offs.

Selection of the top 100 teams will be made on the basis of the lowest (best) 100 scores reported on the qualification flight forms. Score for any single flight is the total difference (in seconds and hundredths) by which the average timer-measured flight duration was outside the target range of 48.00 to 50.00 seconds (always a positive number) multiplied by FOUR; plus the total difference (in feet) between the altimeter-reported altitude and 825 feet (always a positive number). The final score for determining Finals eligibility is the sum of the two best (of up to three permitted) scores submitted by a team, minus one "bonus point" if any of the qualification flight attempts were made on or before March 2, 2014. Note that cracking of either egg carried by the rocket is disqualifying.

The top 100 qualifying teams, based on their reported scores, will be invited to attend the competitive "fly-off" event that will be held on May 10, 2014 (alternate fly-off date will be May 11, 2014,



in case of bad weather) at the Great Meadow Outdoor Center, The Plains, Virginia. All teams who submit a qualification flight form will be notified of their status by April 4, 2014 by a representative of the AIA, and the list of those accepted will be posted on the [TARC website](#). Notification will be sent to you using the email addresses provided during the registration process.



The official qualifying flight must be observed by a Senior (adult) member of the National Association of Rocketry, who must be impartial, i.e. not related to any member of the team, and not a paid employee of the school or member of the non-profit organization sponsoring the team. This NAR observer is one of your two required flight timers. In addition, a second impartial person not on the team (who does not have to be a member of the NAR, or an adult) must be the second flight timer. There are three ways to obtain an NAR observer, if you do not already know of a qualified local NAR Senior member who is ready to do this for you:

- **Attend an organized launch run by an NAR section, and fly your rocket at that launch.** You can also use these launches as a place to practice-fly before you do your official qualification

flight. These launches are listed in the "[Launch Windows](#)" Calendar on the NAR website. Always call a launch's point of contact before attending to confirm the time and place of the launch.

- **Contact the nearest section or chartered club of the NAR to see if they have launches not listed on the web site.** Check the NAR site for a [list of these sections](#) and contact information.
- **Contact someone on the [list of volunteer mentors](#) posted on the NAR web site or in [Appendix 9](#) of this Handbook.** Many mentors live in places remote from an NAR section.

Obtaining an observer and providing stopwatches is the responsibility of each team. PLAN AHEAD to find an observer for

your qualification flight(s). DO NOT WAIT until late March to try to find someone on a day's notice to observe your flight, and do not expect them to drive a long



distance to do so. Upon request, we will send you a roster of every senior NAR member in your state to help you find a nearby qualification observer. Contact us at [rocketcontest@aia-](mailto:rocketcontest@aia-)

[aerospace.org](http://aerospace.org) if you need this assistance. Not every NAR member is aware of the Team America event, so you may have to explain it a bit first when you call one who is not already signed up as a mentor!

If there is no NAR member available within reasonable distance (and this will be true in a number of areas of the US), it is OK to have an impartial adult, i.e. someone who is not related to any member of the team and not a paid employee of the team's sponsoring school or the team's sponsoring non-profit organization, become a NAR member in order to be an observer. NAR membership can be ordered online and is effective the day it is ordered. Observers who joined too recently to yet have a membership card and number may record their membership number as "PENDING" on the qualification flight form, and we will check with NAR Headquarters to get the membership number.

Experienced rocketeers are certainly preferred to do the observer duties because they can usually understand the rules better and offer advice and tips at the same time -- but experience is not absolutely required. We do not pre-approve observers, but we will check the form they sign to verify that the



observer who signs is a current NAR senior (adult) member.



*President Barack Obama greets TARC Team members Gwynelle Condino, Ana Karen Nieto and Janet Nieto from Presidio (TX) High School.*

## Chapter 8

# Vendors and Web Resources

Whether this is your first time as a TARC competitor or you have several Finals behind you, you and your teammates will need rocketry supplies. Here are several sources that are all familiar with the TARC program and are committed to helping TARC competitors.



# Vendors and Web Resources

This Team Handbook is the most important resource you need to participate in this Challenge. In addition, many answers to questions on contest specifics may be found in the **Frequently Asked Questions** section on the TARC website. There are many resources that may be useful in learning the basic model rocketry skills needed to succeed in this Challenge or in getting the supplies necessary to participate. These include:



The **National Association of Rocketry** is the nation's oldest and largest non-profit model rocket consumer and safety organization. From this you can link to one of the NAR's 125 sections or local clubs, for advice and general assistance. You can join NAR online, to get insurance plus NAR's magazine "Sport Rocketry". **NAR Technical Services (NARTS)** has many technical resources on the hobby, including the official reference

handbook for TARC, the *Handbook of Model Rocketry* by G. Harry and Bill Stine.

Each TARC team will want to build their design and test program around one of the approved simulation programs. These include Space CAD and Rocksim.

- **SpaceCAD** is an approved simulation software for TARC, and information regarding its use and other rocket design information can be found here.
- **RockSIM** is an approved simulation software for TARC; information regarding its use and other rocket design information can be found on the Apogee Rockets website.
- **OpenRocket** is a free, full-feature rocket simulator.

The following are vendor-supporters of the NAR and TARC who have the types of rocket supplies and components needed for most TARC designs, at reasonable prices with good customer service.

**Balsa Machining Service (BMS)**, 3900 S. Winchester Ave., Pahrump, NV 89048. A manufacturer/vendor of body tubes, balsa nose cones, model rocket motors, and other components for model rockets.

**Aerospace Specialty Products (ASP)**, PO Box 1408, Gibsonton, FL 33534. A manufacturer/vendor of body tubes, plastic nose cones, parachutes, plastic egg-carrying capsules for rockets, and a special TARC learner's kit.

**SEMROC Astronautics**, Box 1271, Knightdale, NC 27545. A manufacturer and vendor of body tubes, nose cones, and other component parts.

**Heavenly Hobbies**. An online vendor of component parts and recovery devices, and a kit manufacturer.

**Fade to Black Rocket Works**. Manufacturer of high-end rocket launch pads such as those used (with rails or 1/4-inch rods) at the TARC Finals.

**Commonwealth Rocketry**. An online vendor of component parts and motors.

**Estes Industries**, the largest model rocket manufacturer, offers a special parts assortment for TARC, and a discount on the D and E motors that might be useful in TARC designs.

**Hangar11 Hobbies, Inc.**, 29 Capital Drive, Washingtonville, NY 10992. (845) 304-1303. The official on-site vendor for the TARC finals.

The NAR has developed a nationwide list of experienced rocketeer mentors who are willing to be a resource to teams. A

mentor is an adult rocketry expert advisor who helps a team learn basic rocketry skills and shows them where to get rocket supplies and launch sites. They can do this in person, by phone or e-mail. Teams are not required to have mentors, and mentors are not required to be NAR-approved (i.e. you can get local help from non-NAR rocket experts.) **Appendix 9** of this Handbook contains information on contacting a NAR mentor. You may contact any mentor on the list, regardless of the state you or they live in, or you may seek online advice through the very active NAR TARC Yahoo! online discussion group at <http://groups.yahoo.com/group/NARTARC>



Chapter 9

# Appendices



# Recommended Schedule of Team Activities

Week 1-11 below refers to the elapsed time since team entry forms and payment were received and accepted by AIA.

## WEEK 1

- Ensure all team data (names, e-mail, etc.) on file with AIA is correct.
- Join the [TARC Yahoo group](#).

## WEEK 2

- Assign team responsibilities (such as project manager, airframe, propulsion & ignition, launch system, fundraising etc.).
- Get a mentor (see the list of available [NAR mentors](#) or in [Appendix 9](#)).
- Watch the instructional video “[How to Build and Fly a Model Rocket](#)” that is provided on the AIA’s YouTube page. (Note that there are six separate segments.)

- Download the Team Handbook & Rules (this document) and the [Frequently Asked Questions](#) from the TARC website and have all team members read both.

- Begin research on rocket parts supply sources (starting with the “[official suppliers](#)” listed in the TARC Handbook).

- Order one of the flight-simulation and rocket-design computer programs ([RockSIM](#) or [SpaceCAD](#)), at the TARC Team discount price directly from the vendor after you have registered as a TARC team, or try out the less-sophisticated downloadable freeware program [OpenRocket](#).

## WEEK 3

- Purchase an inexpensive one-stage rocket kit to familiarize your team with rocket building & flying, and build it. A good basic kit specifically for TARC teams is available from [Aerospace Specialty Products](#).

- Locate a place to fly rockets (or a nearby NAR launch to attend and fly at, see the "[Launch Windows](#)" calendar on the NAR website or contact the [nearest NAR club or section](#)).

- Develop a plan to raise required funds for purchase of rocket supplies covering at least 2-3 rockets and motors for at least 10 test and qualification flights and potentially for travel to the Finals.

#### **WEEK 4**

- Obtain a comprehensive book on model rocketry, such as G. Harry and Bill Stine's *Handbook of Model Rocketry* (available through the [NAR Technical Services](#) webstore), and have all team members read it.

- Load the rocket design and flight simulation computer program that you purchased, and have team members learn to use it.

- If you require "site owner" insurance for the place where you will be flying, have the teacher and at least three team members join the NAR, and order NAR site owner insurance.

#### **WEEK 5**

- Fly a basic one-stage model rocket.

- Order your official TARC altimeter from [Perfectflite](#).

#### **WEEK 6**

- Using the computer program and the knowledge gained from reading and from building and flying basic rockets, develop a first design for TARC entry.

#### **WEEK 7**

- Using the computer program, conduct flight simulations of your design with various rocket motors on the [TARC approved motor list](#), to determine the best motor(s) to use.

- Locate sources for the materials needed to build the TARC design (starting with the [official vendors](#) in the TARC Handbook) and purchase required parts and rocket motors.

#### **WEEK 8**

- Design and build (or purchase) the electrical launch system and the launch pad (rod or rail) to be used with your TARC entry, if you do not have a local rocket club's system available for your use.



## **WEEK 9**

- Begin construction of your initial design for your TARC entry.
- Locate a NAR Senior (adult) member who can serve as your official observer for your qualification flights, if you do not already have an NAR Mentor who will do this.

## **WEEK 10**

- Develop a pre-flight checklist for your TARC flight and assign responsibility for each of the duties to a member of the flight team.
- Test your launch system by test-firing igniters without installing them in rocket motors.

## **WEEK 11**

- Weigh your completed TARC rocket and re-run computer flight simulations with actual rocket weights.

## **By February 1 you should (but are not required to):**

- Test-fly your initial TARC design (without altimeter), making sure that you leave time to redesign, rebuild, and re-fly by March 31 if this initial flight/design is not successful!
- If your first flight is fully successful, test-fly again with stopwatch timing and the altimeter installed. Repeat test flights until you hit the design targets.
- If your first flight is not successful, do post-flight failure analysis and re-design.

## **By March 2 you should (but are not required to):**

- Make your first official qualification flight attempt in front of an NAR Senior member observer.

## **NO LATER THAN March 31 you must:**

- Make your final official qualification flight attempt in front of an NAR Senior member observer.
- Submit your qualification flight report to AIA by fax or email.

## April 4

- If notified of selection to attend the Finals, make reservations at one of the TARC motels identified by the organizers and conduct fund-raising to cover travel and lodging.
- Continue test-flying to fine tune rocket design to target altitude.
- If you plan to travel to the Finals by airline, order rocket motors for the Finals to be shipped to TARC receiving point or delivered on-site by the official Finals vendor, Hangar11 Hobbies.

## NO LATER THAN May 1

- Complete and test-fly the actual rocket to be used in the Finals. This Finals rocket must have been test-flown before arrival at the Finals, as there is no opportunity for test-flying at the Finals site.



*2010 Team America Rocketry Challenge winners Penn Manor (PA) High School with NASA Administrator Charles Bolden.*

# NAR Model Rocket Safety Code

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

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

**3. Ignition System.** I will launch my rockets with an electrical launch system and electrical motor igniters. My launch system will have a safety interlock in series with the launch switch, and will use a launch switch that returns to the "off" position when released.

**4. Misfires.** If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher's safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

**5. Launch Safety.** I will use a countdown before launch, and will ensure that everyone is paying attention and is a safe distance of

at least 15 feet away when I launch rockets with D motors or smaller, and 30 feet when I launch larger rockets. If I am uncertain about the safety or stability of an untested rocket, I will check the stability before flight and will fly it only after warning spectators and clearing them away to a safe distance. When conducting a simultaneous launch of more than ten rockets I will observe a safe distance of 1.5 times the maximum expected altitude of any launched rocket.

**6. Launcher.** I will launch my rocket from 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, and I will use a blast deflector to prevent the motor's exhaust from hitting the ground. To prevent accidental eye injury, I will place launchers so that the end of the launch rod is above eye level or will cap the end of the rod when it is not in use.

**7. Size.** My model rocket will not weigh more than 1,500 grams (53 ounces) at liftoff and will not contain more than 125 grams (4.4 ounces) of propellant or 320 N-sec (71.9 pound-seconds) of total impulse.

**8. Flight Safety.** I will not launch my rocket at targets, into clouds, or near airplanes, and will not put any flammable or explosive payload in my rocket.

**9. Launch Site.** I will launch my rocket outdoors, in an open area at least as large as shown in the accompanying table, and in safe weather conditions with wind speeds no greater than 20 miles per hour. I will ensure that there is no dry grass close to the launch pad, and that the launch site does not present risk of grass fires.

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

**11. Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places.



## LAUNCH SITE DIMENSIONS

Installed Total Impulse	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

# List of TARC-Approved Model Rocket Motors

The commercially-made model rocket motors listed below have been subjected to rigorous safety and reliability testing conducted by the NAR Standards & Testing (S&T) Committee and are the only ones approved for sale in the U.S. or for use in this Challenge. All motors listed here are in current production. Every motor listed here will continue to be approved for use in the Team America 2014 event regardless of any subsequent announced changes to the NAR's overall official engine certification list. This list may be expanded if new motors are certified during the period of the Challenge; this expansion and any revised list will be communicated to all those teams enrolled in the Challenge.

You may download the "[Motor Data Sheets](#)" from the NAR web site if you desire additional information on any specific motor. Each data sheet contains a thrust curve together with values from a test firing, including measured average thrust and total impulse, plus 32 data points for use in altitude simulation computer programs.

Note: (R) following the motor designation denotes that the motor is a reloadable motor system certified only with the

manufacturer-supplied casing, closures, nozzle, and propellant. Reloadable motors are not available for sale to persons under age 18, per U.S. Consumer Products Safety Commission regulations and there are special restrictions on their use in California. Also, the metal casings that reloadable motors use are quite expensive. But if the performance of these types of model rocket motor happens to be exactly what you need for your design, your supervising teacher/adult advisor can purchase them and supervise your use of them.

Manufacturers of E and F motors often use letter codes right after the motor average thrust value on the label (e.g. the "FJ" in an F23FJ motor type) which designate the type of that manufacturer's propellant used in the motor. This code, or the absence of a code, does not affect status of certification for TARC use.

Designation	Manufacturer	Casing Size (mm)	Propellant Mass (grams)	Total Impulse (N-sec.)
1/4A3-4T	Estes	13x45	0.8	0.62
1/2A3-2T, -4T	Estes	13x45	2.0	1.25
1/2A6-2	Estes	18x70	2.6	1.25
A3-2T, -4T	Quest	13x55	3.6	1.71
A3-4T	Estes	13x45	3.3	2.50
A6-4	Quest	18x70	3.0	2.30
A8-3	Quest	18x70	3.6	1.86
A8-0, -3, -5	Estes	18x70	3.3	2.50
A10-0T	Estes	13x45	3.6	1.88
A10-0T, PT	Estes	13x45	3.8	2.50
B4-2, -4	Estes	18x70	6.0	5.00
B4-4	Quest	18x70	10.4	3.84
B6-0	Estes	18x70	5.6	4.90
B6-2, -4, -6	Estes	18x70	5.6	5.00
B6-0, -2, -4	Quest	18x70	6.5	5.00
C6-0, -3, -5, -7	Estes	18x70	10.8	9.00
C6-0	Quest	18x70	11.0	8.80

Designation	Manufacturer	Casing Size (mm)	Propellant Mass (grams)	Total Impulse (N-sec.)
C6-3, -5	Quest	18x70	12.0	8.76
C11-0, -3, -5, -7	Estes	24x70	12.0	9.00
D5-P	Quest	20x88	25.0	19.60
D5-4, -6	Quest	20x96	24.0	17.60
D9W-4, -7 (R)	Aerotech	24x70	10.5	20.00
D10-3, -5, -7	Apogee	18x70	9.8	18.30
D10-3, -5, -7	Aerotech	18x70	9.8	18.30
D11-P	Estes	24x70	24.5	18.00
D12-0, -3, -5, -7	Estes	24x70	21.1	17.00
D13W-4, -7, -10 (R)	Aerotech	18x70	9.8	20.00
D15T-4, -6/7 (R)	Aerotech	24x70	8.9	20.00
D21T-4, -7	Aerotech	18x70	9.6	20.00
D24T-4, -7 (R)	Aerotech	18x70	8.8	18.50
E6-4, -6, -8, P	Apogee	24x70	22.0	37.80

Designation	Manufacturer	Casing Size (mm)	Propellant Mass (grams)	Total Impulse (N-sec.)
E9-4, -6, -8, P	Estes	24x90	35.8	28.50
E11J-3 (R)	Aerotech	24x70	25.0	31.70
E12-0, -4, -6, -8	Estes	24x95	35.9	27.20
E15W-4, -7, P	Aerotech	24x65	20.1	35.00
E16W-4, -7 (R)	Aerotech	29x124	19.0	40.00
E18W-4, -8 (R)	Aerotech	24x70	20.7	39.00
E20-4, -7, -10	Aerotech	24x65	16.2	35.0
E22SS-13A (R)	Cesaroni	24x69	13.4	24.2
E23T-5, -8 (R)	Aerotech	29x124	17.4	37.00
E25R-4, -7, P	Rdrunner	29x76	20.6	38.70
E28T-4/5, -7/8 (R)	Aerotech	24x70	18.4	40.00
E30T-4, -7	Aerotech	24x70	17.8	33.60
E30-4, -7	Estes	24x70	17.8	33.60
E31WT-15A	Cesaroni	24x69	11.2	26.1
E75VM-17A (R)	Cesaroni	24x69	10.4	24.80
F10-4, -6, -8	Apogee	29.93	40.0	74.30

Designation	Manufacturer	Casing Size (mm)	Propellant Mass (grams)	Total Impulse (N-sec.)
F12J-2/3, -5 (R)	Aerotech	29x93	30.0	45.00
F20W-4, -7	Aerotech	29x73	30.0	64.00
F22J-4/5, -7 (R)	Aerotech	29x124	46.3	65.00
F23FJ-4, -7 (R)	Aerotech	29x73	32.0	56.00
F23FJ-4, -7/8	Aerotech	29x83	30.0	41.20
F24W-4, -7 (R)	Aerotech	24x70	19.0	50.00
F25W-4, -6, -9	Aerotech	29x98	35.6	80.00
F26FJ-6, -9	Aerotech	29x98	43.1	62.20
F26FJ-6	Estes	29x98	43.1	62.20
F27R-4, -8	Aerotech	29x83	28.4	49.60
F29-12A (R)	Cesaroni	29x98	30.9	54.80
F30-4, -6, -8	Aerotech	24x90	31.2	47.00
F30WH/LB-6A (R)	Cesaroni	24x133	40.0	73.10
F32T-4, -6, -8	Aerotech	24x90	25.8	56.90
F35-6, -10	Rdrunner	29x112	40.1	76.50



Designation	Manufacturer	Casing Size (mm)	Propellant Mass (grams)	Total Impulse (N-sec.)
F35W-5, -8, -11 (R)	Aerotech	24x95	30.0	57.10
F35SS-11A (R)	Cesaroni	29x98	29.5	41.20
F36BS-14A (R)	Cesaroni	29x98	25.6	51.50
F37W-S, -M, -L (R)	Aerotech	29x99	28.2	50.00
F39T-3, -6 (R)	Aerotech	24X70	22.7	50.00
F40W-4, -7, -10 (R)	Aerotech	29X124	40.0	80.00
F42T-4, -8	Aerotech	29X83	27.0	52.90
F45R-5, -8, P	Roadrunner	29x112	30.0	62.30
F50T-4, -6, -9	Aerotech	29x98	37.9	80.00
F50T-6, -9	Estes	29x98	37.9	80.00
F51CL-12A (R)	Cesaroni	24x133	33.0	75.00
F52T-5/6, -8, -11 (R)	Aerotech	29x124	36.6	78.00
F59WT-12A (R)	Cesaroni	29x98	26.1	57.00
F60R-4, -7, -10	Rdrunner	29x112	38.1	75.90

Designation	Manufacturer	Casing Size (mm)	Propellant Mass (grams)	Total Impulse (N-sec.)
F62T-S, -M, -L (R)	Aerotech	29x89	30.5	51.00
F79SS-13A (R)	Cesaroni	24x133	40.1	67.80

**Additional notes:**

- The manufacturer-reported total impulse and propellant mass of motors often differs from the values reported above, which are based on testing by the NAR Standards & Testing Committee. The values above are the ones that will be used in TARC.
- Where two delays are listed with a slash for a motor, both delay times are approved for use
- • Motors marked as “reloadable (R)” are no longer classified by the California State Fire Marshal as “model rocket motors” in that state and may be flown only under the supervision of a California-licensed pyrotechnics operator. Most NAR clubs have such licensed operators at their launches in that state.

# Tips for Parachutes

All rocket recovery devices are designed to produce aerodynamic drag to slow the descent of the rocket once they are deployed. The drag on a falling object increases as the square of its velocity. When a descending rocket stabilizes at terminal velocity, the drag forces on all the connected parts of the descending rocket at that velocity exactly offset its weight and its acceleration becomes zero. No matter how far it falls after this, the rocket's descent velocity will not further increase. The heavier a rocket, the higher this terminal velocity will be. The larger and more “draggy” a rocket is in its recovery configuration, the lower this terminal velocity will be.

For TARC 2014, if your rocket goes up 825 feet and takes 7 seconds after liftoff to reach this altitude and deploy its parachute, and you want the total flight duration to be 49 seconds, then the descent terminal velocity that you want is  $825 / (49 - 7) = 20$  feet/second. The heavier the rocket, the more drag it will need on recovery to achieve a velocity this small. Higher recovery drag is easy to achieve with a parachute, just make it (actually, both of them, since two identical-diameter parachutes are required) bigger in diameter. The factors other

than size that affect how a parachute performs (how much drag it has) include:

- Weight of the rocket hanging under the parachute
- Shape
- Length of shroud lines
- Number of shroud lines
- Type of material (fabric vs plastic)
- Size of “spill hole” in the center of the parachute

There are two ways that teams can get 15-inch parachutes: make buy a premade chute of the appropriate size from one of the many parachute vendors servicing the rocketry hobby; or make a parachute yourself from scratch. The former is easier, the latter is cheaper. We will discuss both.

Some of the vendors who make rocket parachutes are listed below. Remember that under the TARC rules you cannot get a commercial parachute (or any other part of your rocket) custom-

made to your specifications, you have to buy and use a standard-stock item available to all. Also remember that you are responsible for your parachute's compliance with the TARC requirements, so be sure to measure carefully what a vendor may send you to make sure that both parachutes are actually the same in canopy diameter.

### Aerospace Specialty Products

Sunward Aerospace (also sold via Apogee Components)

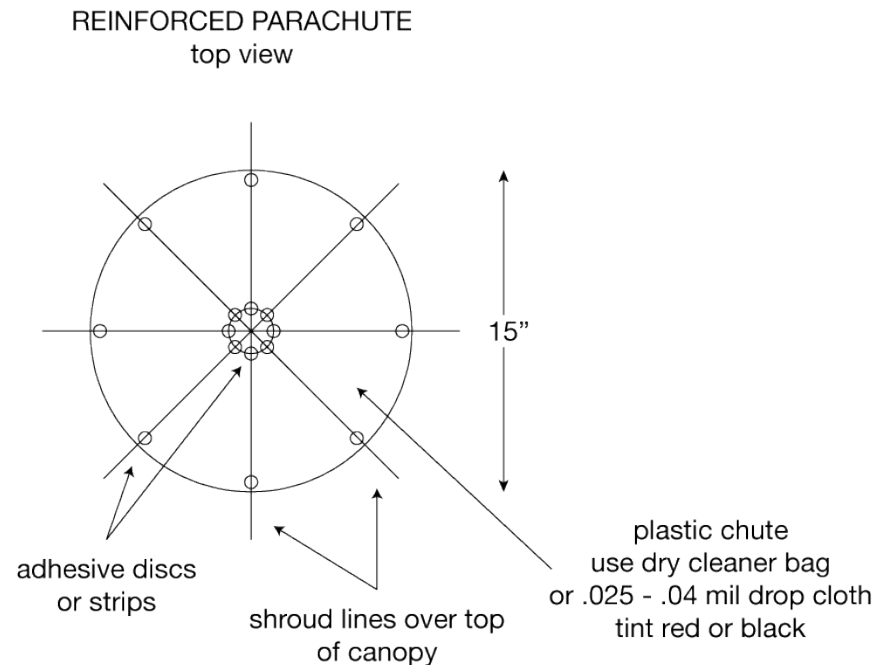
### Rocket Chutes

Top Flight Recovery (sold via Balsa Machining Service)

Making your own parachute is a bit more work than buying one. Model rocket parachutes can either be sewn from nylon fabric or cut out of thin flexible plastic film. Since these parachutes will be absorbing a significant opening shock from the weight of a TARC rocket, if a plastic film is used it needs to be sturdy enough not to tear easily. Black garbage bags are a great material; dry cleaner bags are too thin. And the shroud lines need to be strong (40+ pounds of breaking strength, nylon or Kevlar) attached very securely, not just by discs of tape on the edges of the canopy. Typically model rocket competition fliers use a reinforcing technique called "over-the-top shroud lines" where the shroud lines are run across the center of the parachute and held in position with adhesive discs or squares of Band-Aid tape so that

these lines, and not the plastic of the canopy material, take the full shock of the parachute's opening.

See the diagram below for an example of how this is done.



# PerfectFlite Maximum Altitude Altimeter

TARC APRA and Pnut altimeters are available from *Perfectflite Electronics*, P.O. Box 29, Andover, NH 03216 (603) 735-5994

**Description:** The altimeters approved for use in TARC 2014 (the Perfectflite APRA or Pnut models) are "maximum altitude altimeters" that precisely measure the air pressure at the altitude where your rocket is located every 0.05 seconds and convert this to an above-ground altitude value. The altimeter senses the liftoff of the rocket from the sudden air pressure drop that results from its altitude change, then senses the maximum altitude that the rocket subsequently reaches, and "freezes" and beeps out this maximum altitude thereafter using a piezoelectric buzzer, until the battery is removed to turn it off. It will not work on flights that achieve less than 160 feet altitude above ground level. It is accurate to better than 1 percent of the measured altitude, which is far better accuracy than any other altitude-measurement technique readily available to hobby rocketeers.

**Using the altimeter:** Read and follow the detailed manufacturer usage instructions provided with the altimeter. Always handle them by the edges when testing or installing to avoid touching any of the circuitry. Never store the device bare in a clear plastic

bag; use a small cardboard box, or wrap the altimeter in a paper towel inside a plastic bag. Do not use tape on the altimeter, and use care to keep it clean and dry. Protect it from the fumes and residue created by rocket motors and their ejection charges by installing it in a compartment of your rocket that is totally sealed from motors and charges. Make sure that it cannot "rattle around" in this compartment and get damaged in flight. If the altimeter has a battery holder always mount the altimeter with the spring end of the battery holder facing upward toward the nose end of the rocket. This will avoid compression of the spring and battery disconnection during a very high acceleration liftoff.

The altitude achieved by the rocket (and the altitude read by the altimeter) depends on launch site altitude and air temperature. If you live at an altitude much different from the Team America launch site (600 feet above sea level), or fly when the temperature much different from the temperature on "fly-off" day in May, your rocket will go to a different altitude (and the altimeter will read a different altitude) than it will at the fly-off. You need to compensate for this in your planning.

An altimeter must be mounted in a "sealed" chamber which must have a vent hole or holes to the outside. A sealed bulkhead below the altimeter chamber is necessary to avoid the vacuum caused by the aft end of a rocket during flight. A sealed bulkhead above the altimeter chamber is necessary to avoid any pressure fluctuations that may be created at the nose end of the rocket. If the front of the payload section slip fits to another section such as a nosecone, then the fit must be as free as possible from turbulence. A breathing hole or vent (also known as a static port) to the outside of the rocket must be in an area where there are no obstacles above it that can cause turbulent air flow over the vent hole. Do not allow screws, ornamental objects, or anything that protrudes out from the rocket body to be in line with and forward of a vent hole. Vents must be neat and burr free and on an outside surface that is smooth and vertical where airflow is smooth without turbulence.

It is better to use multiple (preferably four) static ports (vent holes) instead of just one. Never use two. Very strong wind blowing directly on a single static port could affect the altimeter. Multiple ports evenly spaced around the rocket tube may help cancel the effects of strong wind on the ground, the effects of transitioning through wind shears during flight, the pressure effects of a non-stable liftoff, or the pressure effects that occur due to flipping and spinning after deployment. Ports must be the same size and evenly spaced in line around the tube. For most TARC rockets the best configuration is four 0.02" holes (and no bigger than

1/32") spaced at 90 degree intervals around the circumference of the body tube. Using a larger hole will increase wind noise on the data. It will also increase the likelihood and magnitude of spikes in the data when the rocket separates, which can affect the apogee reading. Since the goal of the contest is consistency, clean data is essential. In order to get the cleanest data, the sampling holes should NOT be oversized, and ejection should be slightly after apogee so any turbulence-induced noise on the data will not spike up over the true apogee height.

If the altimeter is reporting an altitude of some very small value (a number less than 160, the launch detect trigger altitude) post-flight, this is a result of it getting a brief (approximately 0.1 second) vacuum spike due to a wind gust over the vent hole or other causes. The altimeter would see the altitude going from 0 to over 80 to 160 in 0.1 second (more than 800 feet per second, obviously not a valid reading around apogee) so the spike itself would be excluded from the beeped out apogee reading. Any small number that the altimeter does beep out (4, 8, 12...) would just be the result of background or wind-induced noise.

After power is applied to the altimeter you have approximately 25 seconds to install it and close the rocket before it begins looking for a pressure change to signify launch. If you are handling the altimeter after the 25 second period has elapsed, you could trigger it prematurely. When the altimeter is sounding the periodic "launch ready" chirp it is very sensitive to handling, wind gusts,

and light in the sensor hole. The altimeter should be safely inside the rocket with the altimeter compartment closed before this occurs.

Direct exposure to sunlight can trigger the altimeter pressure sensor and cause it to incorrectly "sense" maximum altitude and beep out a false value before liftoff. Be sure to shade the altimeter from the time you zero it before flight until it is safely inside the altimeter compartment in your rocket. If direct sunlight shines in the sensor hole, you will get such a spike, though you can exclude this possibility if the altimeter is already shielded inside the rocket and emitting the periodic "ready" chirp.

If the altimeter remains silent post-flight, there are a number of possibilities. First is a weak battery. Battery voltage must be at least 11 volts (for the APRA) or 3.7 volts (for the Pnut). Second is dirty battery contacts or battery holder contacts (on the APRA). If the altimeter starts beeping again when the battery is rotated a turn or two in the battery holder it would indicate that the contacts were dirty. Clean with an eraser and blow out debris. Third is that the battery lost contact briefly during flight (shock at motor ignition or ejection are the most likely times, especially if the altimeter is free-floating in a compartment and can slam around, which is a bad practice). The altimeter should be padded to protect it from shock, the battery holder should be inspected for cracks from previous crashes which could loosen the battery

retention force, and the altimeter should be installed with the spring end of the battery holder facing "up" so the spring is not compressed during acceleration. While it shouldn't be necessary, a wrap of tape around the battery holder can prevent deformation, especially if the holder is cracked.

If the altimeter is still beeping the launch ready chirp on landing, this is almost without question a case of the altimeter losing power during flight. It detected launch, started recording the flight, and then lost power momentarily during flight (again, shock from boost, ejection, etc breaking battery contact). It would then start over from scratch, waiting thirty seconds and beep awaiting launch. But since the rocket would be on its way down by then, another launch detect would never get triggered, so it would still be beeping readiness on the ground.



# NAR Rocket-Flying Insurance FAQ

**1. What activities does NAR individual insurance cover?** NAR insurance is general liability coverage included as part of NAR membership benefits. Individual insurance covers the insured NAR member for accident losses solely arising out of NAR sport rocketry activities, including both model and high power rockets. It protects the owner of the model in the event his rocket causes damage or injury to the person or property of another.

**2. What are the coverage limits of the insurance?** The NAR policy limit is \$2,000,000 per occurrence and \$3,000,000 aggregate per annum.

**3. What are the deductibles for the insurance?** The NAR policy has a \$5,000 deductible per Bodily Injury & Property Damage Claim. Members are personally responsible for payment of the first \$1,000 of the deductible. If a member is responsible for more than one claim in any NAR policy period, they will be responsible for the entire amount of the NAR deductible. In the event of a claim filing, failure to pay the deductible may be cause for the loss of membership benefits.

**4. When do NAR insurance benefits kick in on a claim?** NAR individual insurance is primary coverage, meaning it applies before other applicable coverage you might have (such as a homeowners' policy).

**5. If my rocket hurts someone at a club launch (with or without my own stupidity contributing to the accident) does the NAR insurance cover it completely?** NAR insurance will cover individual members up to the existing limits in the policy (up to \$2 million annually). However, "stupidity" in disregarding any part of the NAR Safety Codes is never covered. Your insurance is void if you violate the NAR Safety Codes.

**6. If I get hurt at an NAR sponsored activity, does the NAR insurance cover medical expenses?** Yes. The NAR policy has a medical payments provision for accidents during NAR operations. The applicable limit for this coverage is \$5,000. This would also apply if a fellow club member were to be injured. Other medical insurance coverage you possess must be exhausted first.

**7. My Team has non-NAR-members attending our launch. Are they covered by NAR insurance when they fly with us?** Only if they are at a launch sponsored by a "section" or club of NAR. At NAR section launches, all registered members of a TARC team are covered. Otherwise flights by non-members are not covered by NAR insurance. To obtain coverage, they must join and become members of NAR.

**8. Does this cover rocket-related injuries only? What if I trip over a hole on the launch field and break a leg?** Coverage applies to losses arising out of NAR sport rocketry activities. "Activity" would include meetings, launches, etc. An injury on the premises of such an activity would be part of the activity.

**9. Does the NAR insurance cover property damage?** If my rocket damages a car is this covered? Are we covered if a rocket hits a house and causes damage? Property damage to "third parties" is covered. Coverage for property damage to the member's own property is also covered. Any existing member insurance (in this case, auto insurance) would be primary. Fire damage coverage is limited to \$1,000,000 per occurrence.

**10. Are we covered if a rocket hits someone who is not part of the launch?** Yes. The individual NAR member has coverage over and above any existing personal liability coverage (e.g., homeowner's policy). The NAR, and the applicable NAR Section, are also covered. Flights by non-NAR members are not covered.

**11. Can NAR offer a rider to allow the individual rocketeer to purchase extra coverage above the policy limits?** Currently the NAR's insurance provider has no provisions for additional coverage.

**12. Does my insurance expiration date match my membership expiration date?** All NAR members are additional insureds on the NAR policy as long as they have paid their membership dues and are entered on the NAR membership list.

**13. Does my insurance (as a teacher Senior member) cover my students too?** Only if they are also members of the NAR. If your students are not members, then your NAR member insurance does not cover them when they fly rockets.

**14. Will the NAR insurance cover claims related to use of non-certified motors?** No. NAR insurance is null and void if the accident involves a Safety Code violation. Use of uncertified motors is prohibited by the NAR Safety Codes.

**15. Who is protected under NAR Section (club) insurance?** This insurance protects the group, corporately, against liability claims during activities sponsored by the group. If the group is sued as a result of a rocket accident, insurance would pay for the expenses resulting from the lawsuit, plus damages awarded. Individual members may still be held liable for their own actions. TARC teams may if they wish fill out the NAR section charter



application and become chartered NAR sections as long as they have the required number of NAR members on the team.

**16. Any difference between individual and Section (club) insurance as far as what stuff it can cover?** No. Policy limits and coverage are the same for individuals, Sections, and site owners.

**17. What about the site owner insurance we can get as a Team? What does it cover?** The optional additional coverage (available for \$15 from NAR HQ) for the site owner is to defend him from third-party liability claims brought against him as the owner of the property, due to covered activities of the Section or of TARC team members who belong to the NAR. This coverage can only be obtained by chartered NAR sections, or by registered TARC teams whose adult supervisor and at least three of the student team members are members of the NAR. The form for ordering this coverage is on the NAR website at <http://www.nar.org/pdf/TAInsForm.pdf>

**18. How do I convince the landowner that this is real insurance backed by a reputable provider, so that he'll let me launch? What benefits can I show him?** The NAR Section or a TARC team can deliver an insurance certificate listing the landowner as an additional insured regarding NAR activities on their site. This certificate will provide the site owner with policy facts such as limits, effective dates, and the insurance company

providing the coverage. We recommend keeping one copy on file with your records, and providing another copy to your landowner. Your landowner can then contact our insurance agency directly with any questions.

**19. A rocket launched is responsible for seriously injuring a human being. The loss of income and medical damages comes to several millions. The NAR covers up to \$2 million. The landowner's personal policy does not fully cover the difference. What happens to the owner?** The landowner is the least likely party to be found negligent and legally liable for injuries from a rocket. If, however, a court found the owner legally liable for the loss, and his NAR insurance and all other insurance he has becomes exhausted, he would be personally liable for the balance.

**20. When an team member who belongs to the NAR is flying, does the team's supervising teacher/adult need to be present?** There is no requirement for an adult to be present at a launch. However, we strongly encourage a responsible adult to attend all flying events. In all cases, we strongly recommend that a Range Safety Officer be appointed and on duty at all times.

**21. Is there anything my TARC team can do to minimize the risk of paying a judgment?** Yes! Follow the Safety Codes. Use only certified motors at your launches. Make sure there is a designated and safety-conscious Range Safety Officer (RSO)

supervising your launches at all times. If in doubt, err on the side of safety.

**22. Can I contact someone if I have questions about insurance?** NAR members (only) may call or email [bob.blomster@japrice.com](mailto:bob.blomster@japrice.com) at the J. A. Price Agency: (952) 944-8790, Ext. 127. Bob is there to address and help with your NAR insurance issues only.



*TARC 2013 was won by the Georgetown 4H team from Georgetown, TX. Team members Mark Janecka, Matt Janecka, and Daniel Kelton went on to represent the United States at the International Rocketry Challenge held at the Paris Air Show. After winning that contest against the champions from the French and UK versions of TARC, the team met French President François Hollande.*

# Past TARC Champions

Contest Year	Teams Entering	States Represented	Teams Qualifying	States in Finals	Altitude Target	Egg Count	Duration Target	Other Requirements	TARC Champion
2003	873	50	275		1,500 ft.	2	N/A	2 stages	Boonsboro HS, Boonsboro, MD
2004	619	50	201		1,250 ft.	2	N/A	2 stages	Penn Manor HS, Millersville, PA
2005	712	49	268		N/A	1 or 2	60 sec.	1 or 2 stages, bonus for 2 eggs and/or 2 stages	Dakota Co. 4-H Federation, Farmington, MN
2006	678	47	390		800 ft.	1	45 sec.		Statesville Christian School, Statesville, NC
2007	690	48	313		850 ft.	1	45 sec.		Newark Memorial HS, Newark, CA
2008	643	43	340	32	750 ft.	2	45 sec.		Enloe HS Team 2, Raleigh, NC
2009	653	43	382	30	750 ft.	1	45 sec.	Egg must lay horizontally	Madison West HS Team 3, Madison, WI
2010	666	45			825 ft.	1	45 sec.	Streamer recovery	Penn Manor HS Team 1, Millersville, PA
2011	604	48	338	34	750 ft.	1	40-45 sec.	Portion of rocket containing egg must utilize 15" parachute	Rockwall-Heath HS Team i, Rockwall, TX
2012	678	48	409	29	800 ft.	2	43-47 sec.	Rocket limited to 650g maximum lift-off weight; total motor impulse limited to 80ns	Madison West HS Team 1, Madison, WI
2013	735	44	470	29	750 ft.	1	48-50 sec.	Portion of rocket containing egg must utilize 15" parachute; rocket limited to 650g maximum lift-off weight; total motor impulse limited to 80ns; egg must lay horizontally; minimum airframe diameter of 60mm	Georgetown 4H, Georgetown, TX

# Sport Rocketry: America's Safe, Educational Aerospace Hobby

A photograph of three young men at an outdoor event. The man in the center is holding a white model rocket with a grid pattern. The man on the left has his right arm raised in a celebratory gesture. The man on the right is smiling broadly. They are standing in front of a blurred background of trees and a tent.

**WHAT IS SPORT ROCKETRY?** Sport rocketry is aerospace engineering in miniature. This popular hobby and educational tool was founded in 1957 to provide a safe and inexpensive way for young people to learn the principles of rocket flight. It has grown since then to a worldwide hobby with over 12 million flights per year, used in 25,000 schools around the U.S.. Its safety record is extraordinarily good, especially compared to most other outdoor activities. It is recognized and permitted under Federal and all 50 states' laws and regulations, and its safe and inexpensive products are available in toy and hobby stores nationwide. Sport rocketry has inspired two generations of America's young people to pursue careers in technology.

**WHAT IS A SPORT ROCKET?** 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. Sport rockets come in two size classes: MODEL rockets, which are under 3.3 pounds in weight, have less than 4.4 ounces of propellant, and are generally available to consumers of all ages; and HIGH-POWER rockets, which are larger, use motors larger than "G" power, and are available only to adults.

**ARE THESE ROCKETS LEGAL?** Model rockets are legal under the laws and regulations of all 50 states and the Federal government, although some local jurisdictions may have ordinances restricting their use. Model rockets are regulated by the National Fire Protection Association (NFPA) Code 1122, which is adopted as law in most states. They are specifically exempted from Federal Aviation Administration (FAA) air traffic control by Part 101.1 of Federal Aviation Regulations (14 CFR 101.1) and may be flown anywhere without FAA clearance. They are permitted for sale to children by the Consumer Product Safety Commission under their regulations (16 CFR 1500.85 (a) (8)). They are permitted for shipping (with appropriate packaging

and labeling) by the Department of Transportation and U.S. Postal Service. They are not subject to regulation or user licensing by the Bureau of Alcohol, Tobacco, Firearms & Explosives (BATFE). They are endorsed and used by the Boy Scouts, 4-H Clubs, the Civil Air Patrol, and NASA. High power rockets are regulated under NFPA Code 1127. Because of their size and power they are not available to people younger than age 18. Their flights are subject to FAA air traffic regulations, and purchase of the larger motors for these rockets generally requires user certification by a national rocketry organization, plus BATFE licensing in some cases. Despite these greater legal restrictions, high power rockets are also very popular. They also have an outstanding safety record.

**IS THIS HOBBY SAFE?** In well over 500 million flights since the founding of the hobby, there has never been a death caused by the flight of a sport rocket. Injuries are rare and generally minor. They are almost always the result of failure to follow the basic safety precautions and instructions provided by the manufacturers. Sport rocketry's record shows that it is safer than almost any sport or other outdoor physical activity. The hobby operates under the simple and easy-to-follow Model Rocket and High-Power Rocket Safety Codes of the National Association of Rocketry, which have been fine-tuned by professional engineers and public safety officials over the past 50 years to maximize user and spectator safety. The foundations of these Safety Codes are that sport rockets must be electrically ignited from a safe distance

with advance warning to all those nearby, must have recovery systems, must be flown vertically in a suitably-sized field with no aircraft in the vicinity, and must never be aimed at a target or used to carry a pyrotechnic payload. All sport rocket motors are subjected to extensive safety and reliability certification testing to strict NFPA standards by the National Association of Rocketry or other national organizations before they are allowed to be sold in the U.S..

**AREN'T THESE ROCKETS FIREWORKS?** All Federal and state legal codes recognize sport rockets as different from fireworks. Fireworks are single-use recreational products designed solely to produce noise, smoke, or visual effect. They have few of the designed-in safety features or pre-consumer national safety testing of a reusable sport rocket, and none of the sport rocket's educational value. Fireworks are fuse-lit, an inherently dangerous ignition method that is specifically forbidden in the hobby of sport rocketry. Sport rockets are prohibited from carrying any form of pyrotechnic payload; their purpose is to demonstrate flight principles or carry educational payloads, not blow up, make noise, or emit a shower of sparks.

**WHO ARE THE EXPERTS?** The oldest and largest organization of sport rocketeers in the U.S. is the National Association of Rocketry (NAR). This non-profit organization represents the hobby to public safety officials and federal agencies, and plays a key role in maintaining the safety of the hobby through rocket engine

certification testing and safety code development. The NAR also publishes Sport Rocketry magazine, runs national sport rocketry events and competitions, and offers liability insurance coverage for sport rocketeers and launch site owners. You may reach the NAR at: National Association of Rocketry, Post Office Box 407, Marion, IA 52302

<http://www.nar.org>

You may purchase copies of the NFPA Codes 1122 or 1127 regulating sport rocketry from: National Fire Protection Association 1 Batterymarch Park Quincy, MA 02269-9101

<http://www.nfpa.org>

A printable PDF version of this section may be found on the [NAR website](#).



# Team America Mentor Volunteers

The role of the "mentor" is to provide advice to a Team America team that needs local expertise in how to build and fly complex model rockets, or that needs advice on launch sites, rocketry vendors, or other general aspects of the hobby. Mentors may provide advice by phone, e-mail, or (at their discretion) in person. They are purely volunteers doing on their own time and expense; they are not expected to travel long distances to a launch, or to drop everything they are doing in order to provide advice or observe TARC qualification flights on short notice at the last minute before the March qualification flight deadline.

Teams are not required to have mentors. It is not necessary for mentors to provide advice in person; any mentor may be contacted by any team using phone or e-mail, regardless of state.

In accordance with the rules of the Team America event, neither mentors nor any other adult may participate in the actual design or construction of a rocket used in the competition. They may (if they wish) serve as the official "NAR Senior Member Observer" of Team America qualification flights.

Many of the mentors (but not all) are members of local NAR clubs (sections) with launch facilities, and may be able to assist with locating a means or place for a Team America team to fly. If you need a mentor and none is listed below in your area, consult the [list of NAR sections](#) on the NAR website and contact the nearest section; they will very likely be able to find someone to help.

A [list of NAR members](#) who may be available to serve as a mentor to your Team America Rocketry Challenge team may be found on the NAR website.



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# Team America Rocketry Challenge

## 2014 Team Handbook

Aerospace Industries Association - National Association of Rocketry



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