Team America Rocketry Challenge 2010
Team Handbook

Version 10.1
August 20, 2009
www.rocketcontest.org

TEAM AMERICA HANDBOOK

Section 1. <u>INTRODUCTION</u>

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 and build a safe and stable model rocket flight vehicle and use it to lift a fragile payload (one raw hen's egg) to an altitude of exactly 825 feet and also for a total flight duration score of between 40 and 45 seconds, then return this payload safely and undamaged.

- Models must weigh no more than 2.2 pounds (1000 grams) at liftoff and must use commercially-made, NAR safety-certified model rocket motors with no more than 62.5 grams propellant weight each and a maximum combined total impulse of 80.0 Newton-seconds and a maximum combined propellant weight of no more than 125 grams.
- Times will be determined by two observers on the ground with electronic stopwatches; time is measured from the moment of liftoff until the moment the egg lands.
- Altitudes will be determined by the official electronic altimeter for the event, the Adept A1-TA, which must be carried in the model rocket
- Winner is the team whose flight vehicle egg payload comes closest to exactly 825 feet altitude and within the range of 40-45 seconds flight duration score in a safe and stable flight, and returns the egg undamaged -- in a single attempt -- at a "fly-off" hosted in Northern Virginia on May 15, 2010.

The 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 <u>Handbook of Model Rocketry</u> (available for a reduced price from the National Association of Rocketry's Technical Services at www.nar.org/NARTS), 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 110 "sections" (chartered clubs) or the 375 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, www.nar.org. 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 or by filling out the membership application forwarded to each team. Membership brings you insurance coverage, the hobby's best magazine, the bi-monthly <u>Sport Rocketry</u>, and a whole range of other benefits and resources. Good luck! Design carefully, fly safely, and we hope to see you at the fly-off in May 2010.

Section 2. TARC 2010 EVENT RULES.

As of August 20, 2009

1. **SAFETY**. All rockets must be built and flown in accordance with the Model Rocket Safety Code of the National Association of Rocketry, 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 event 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, about the Safety Code, or about 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 Team America Rocketry Challenge is open to the first 750 teams that submit a completed application, including payment, postmarked between September 2 and November 30, 2009.

3. **ROCKET REQUIREMENTS**. Rockets may be any size, but must not exceed 1000 grams (2.2 pounds) gross weight at liftoff. 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 that have 62.5 grams or less of propellant each and 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 125 grams (4.4 ounces) of propellant and must not have more than 80.0 Newton-seconds of combined total impulse based on the propellant weights and total impulse values in the TARC list. Rockets must not contain any pyrotechnic or ejection 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 portion of the rocket containing the egg and altimeter must return to the ground using only one or more streamers as its deployed recovery system. The rest of the rocket may be attached to this portion, or may return separately as long as it does so safely. Each streamer that is used must be a separate single rectangular strip of thin flexible material such as paper or plastic that is at least five times as long as wide, and each must be attached to the rocket only by a single line that connects to one or more places on a single one of that streamer’s narrow sides.

4. **PAYLOAD**. Rockets must contain and completely enclose one raw hen's egg of 57 to 63 grams weight (no more than 45 millimeters in diameter), and must return this from the flight without any cracks or other external damage. Eggs will be issued to the teams by event officials during finals, but teams must provide their own egg 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 egg must be removed from the rocket at the end of the flight in the presence of a designated NAR official observer and presented to that official, who will inspect it for damage. Any external damage to the egg is disqualifying.

5. **DURATION SCORING**. Scores shall be based on total flight duration of the portion of the rocket containing the egg and altimeter, 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 40 to 45 seconds. Flights with duration in the range of 40 to 45 seconds get a perfect duration score of zero. Duration scores for flights with duration above 45 seconds will be computed by taking the difference between 45 seconds and the measured average flight duration to the nearest 1/100 second and multiplying this by 2. Duration scores for flights with durations between 35 and 40 seconds will be computed by taking the difference between 40 seconds and the measured average flight duration and multiplying this by 5. Flights with duration of less than 35 seconds are disqualified for unsafe recovery.

6. **ALTITUDE SCORING**. Rockets must contain one and only one electronic altimeter of the specific commercial type or types approved for use in the Team America event: Adept A1-TA or Perfectflite ALT15K. 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 to have reset to zero before flight. The altitude of the portion of the rocket containing the egg, 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 will be the absolute difference between 825 feet and the altimeter-reported altitude in feet (this difference is always a positive number or zero).

7. **FLIGHTS**. Team members cannot be changed after the first qualification flight. Only team members on record at AIA with valid parent consent forms are eligible to receive prizes. Only one flight is allowed per team at the final fly-off, except as specifically noted in these rules. In order to be eligible for the fly-off, a team is required to fly a qualifying flight 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 8, 2009 and Monday April 5, 2010. Each team may conduct a maximum of three qualification flights, and will be ranked based on the best of these three scores. No more than two of these qualification flights can be conducted after March 1, 2010. More than one qualification flight is not required if the team is satisfied with the results of their first flight. 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 or a reading of less than 50 feet will be counted as “no flight” due to false triggering of the altimeter 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 midnight EST on Monday, April 5, 2010. As soon as the qualifying score is processed, "Qualification Score Received" will appear under the team information on the "Registered Teams" page at www.rocketcontest.org. The top-scoring 100 teams will be notified no later than April 9, 2010, and invited to participate in the final fly-off to be held on May 15, 2010 (alternate fly-off date in case of inclement weather will be May 16, 2010).

8. **SAFE RECOVERY**. Each part of the rocket must either contain a recovery device or be designed to glide, tumble unstably, or otherwise return to earth at a velocity that presents no hazard. Any entry which has a major part (including but not limited to an expended engine casing) land without a recovery system (lightweight gliding/tumbling tube sections are considered to have a system), or 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 portion of the flight vehicle containing the egg and the altimeter is required by the deadline time established at the beginning of the day's flying. Entries whose egg and altimeter are not returned after flight may not be counted as a qualified flight. If this portion 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. Return of the other portions of the rocket is required only if there is a question from the NAR official concerning the safe operation of the vehicle (e.g. a question as to whether the vehicle ejected a part that landed in an unsafe manner). An entry which has any such portion that is not returned when its return is required for this safety inspection shall be disqualified.

10. **LAUNCH SYSTEMS**. Teams may use the electrical launch system and the launch pads (with six-foot long, 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 above. At the fly-offs, 20 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. Cash prizes, which are awarded to the top ten places, will be awarded only to those teams that make a second fully qualified 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 ten final places will be ranked on the basis of the scores from the two qualified flights made at the fly-offs. Places eleven 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 2nd place would result in a merger and even division of the prizes for 2nd and 3rd places. Aerospace Industries Association reserves the right to make all last and final contest determinations.

Section 3. ROCKET DESIGN

Because of the size of the payload (a large hen's egg must weigh between 57 to 63 grams and requires the rocket body 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 6 ounces. Because of the use of streamer recovery this year, there is a distinct advantage to using lightweight airframe construction; light weight will make achieving the flight duration of 40-45 seconds far easier. Heavy airframes could require awkwardly large streamers.

Designing a rocket that will reach an altitude of approximately 825 feet and stay up approximately 40-45 seconds is not particularly hard to do, although designing one that cushions and protects an egg is a bit harder and achieving this duration with a streamer is a new and somewhat harder challenge than in previous years. The Challenge is finding the exact combination of airframe design, rocket engines, and duration-control technique that will achieve exactly 825 feet and 40-45 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!

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 let’s say 42.5 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.

Remember that this event is 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!

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 1000 grams (2.2 pounds) in weight. And the selection of the vehicle's rocket motors is another major variable. Since certified commercially made model rocket motors (those with 62.5 grams and less of propellant each) must 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 at www.nar.org and in Appendix 3. The list of certified motors is quite long, so there is a wide range of possibilities here as well. Of course, you may not exceed a combined total of 80.0 N-sec of total impulse with the combination of motors that you choose to use. There are other design variables to be considered including: what type of streamer system to use; how to predict or control flight duration in various weather conditions; how to cushion and protect the fragile egg; and 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.

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) a Grade A large egg and cushion it against the shocks of rocket launch, recovery system deployment in flight, and impact with the ground at the end of flight.
   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 parachute snaps open.

2. **Accommodate the instrumentation**. The electronic altimeter specified for the event (which you must buy separately from Adept Electronics at a special TARC discount price) 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 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: Place the altimeter compartment well away from the egg compartment. Turbulent flow over the rocket's nose cone-body tube joint at the top of the rocket (where the egg is located) will introduce pressure fluctuations for a few inches down the body tube and this will make the altimeter readings unreliable if it is placed in these first few inches behind the egg compartment
   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, anyway). 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 how to design, assemble, attach, and fly a streamer recovery system. Plan to use a large streamer (at least 6 inches wide is a good starting point) and set the system up so that all parts of the rocket that are recovered by this streamer fall sideways, so their body area can add to the total drag of the descending rocket and thereby reduce its rate of descent. The lighter the airframe of your rocket, the easier it is going to be to find the streamer size, material, and system design that hits the target duration range.

4. **Learn to use a rocket-design computer 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 are two good rocket-design programs currently available on the market: SpaceCAD and RockSim. There is no single "right" design for this Challenge; there are many different combinations of motor types, rocket length and diameter, rocket weight, and recovery system size and shape that could lead to a flight altitude of 825 feet and flight duration of 40-45 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. Just because even the best simulation says your rocket will go a specific altitude does not mean that it will, exactly. Or it may crash because of a reliability problem such as how you attached the shock cord! 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 fly-off, whatever you fly has to work perfectly this first time. Add complexity (such as clustered rocket motors; staging is not allowed) 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 egg 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). 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 25 times the rocket's liftoff weight in units of pounds.

   And finally, plan on using a launch rod of at least 6 feet in length and 1/4 inch in diameter or 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.

   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.

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, 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. However, 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.

8. **Metal Parts.** You may only use non-metal parts for the nose, body, and fins of your rocket, those parts that are the main structure of the vehicle. Fiberglass is OK. You may use miscellaneous metal hardware items such as screws, snap links, engine hooks, electronic circuit boards, and (if you wish) commercial re-loadable metal rocket engine casings.

9. **Recovery**. Your rocket may be recovered in several separate sections if you wish. Each section or piece of the rocket must come down safely. The section that contains the egg and altimeter must return using only a streamer as its deployed recovery device. If this section is connected to the rest of the rocket, then the whole rocket must return using only the streamer. A heavy piece (nose cone, body section, rocket engine casing, etc.) that falls to earth in a stable, non-tumbling/non-gliding mode at high speed without a recovery system of some kind is not safe, and flights that have this happen will be disqualified for being unsafe. You cannot have a flight-control system that completely cuts away the streamer from your egg capsule at a predetermined time and causes it to free-fall to the ground with no recovery device from that point; this is not safe. Normally the only part that must be returned to the event officials after the flight is the part with the egg and altimeter.

Section 4. ROCKET CONSTRUCTION

Designing a rocket on a computer is important, but in the end you have to actually build it right for it to fly the way the computer says it will. There are two key resources available to you for learning the craftsmanship techniques for building a model rocket for TARC: One is the instructional video on rocket building available at the Aerospace Industries Association YouTube site at www.youtube.com/user/AerospaceIndustries . The other resource is the Handbook of Model Rocketry by G. Harry and Bill Stine, which can be purchased separately from www.nar.org/NARTS. Watch the video 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.

There are many aspects to constructing a rocket, and this section will not review everything that the video tells you. From observing hundreds of teams of new rocketeers over the first seven years of TARC, we have learned what common mistakes you need to avoid in this process.

1. 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 three "official" component vendors for TARC: Aerospace Specialty Products, Balsa Machining Service, 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.

2. Use the right tools. You will need a couple of X-Acto hobby knives with sharp new blades, a steel ruler or straight edge, and various grits of fine sandpaper to build most rocket designs. And you will need a well-lighted work area with a cutting surface. You should not need power tools.

3. Use the right materials in the right places. Body tubes and launch lugs should be commercially-made, smooth, and strong. Don't try using paper towel 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.

4. Use the right glues. Body parts should be held together with yellow carpenter's wood glue, not white 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 if you're worried about fins breaking off.

5. Use the right recovery technique. Leave some length of body tube to accommodate a wide streamer; you will need it. When flying make sure that you use plenty of non-flammable recovery wadding to protect the streamer from melting together due to the hot gases of the rocket motor ejection charge.

Section 5. 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 single flight attempt at the fly-off. First and foremost, of course, is safety: **read and follow the NAR Model Rocket Safety Code** (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 fly-off, an electrical launch system will be provided that can fire a single igniter of any type, and the launching devices provided will be 6-foot-long, 1/4-inch diameter launch rods. If your design requires something different (such as a rail or tower-type launcher), you must bring your own equipment and power source. In any case, you will need to have (or borrow) a system for pre-fly-off 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. You can also purchase or borrow a launcher.

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 with no more than 62.5 grams in any one motor 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 fly-offs is about 1500 feet by 2500 feet of treeless closely-mowed grassland. If the winds on the date of the fly-off are fairly light, recovery will be easy; in windy conditions (above 15 miles per hour), rockets that achieve a 45-second duration could drift out of the field. The site you use for pre-fly-off 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 7 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 (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, you have personal coverage of up to $1 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 fly-off. 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:

- Do the motors (or motor) 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 attached securely and straight?
- Is the recovery system (shock cords and anchors, streamer, etc.) sturdy enough to withstand the shock of opening with that rocket, and is it large enough to produce a safe landing speed?
- Does any separable part of the rocket have a recovery system or a design (e.g. gliding, tumbling) that will ensure it lands at safe, slow speed?
- Does the design prevent any expended motor casings or other massive objects from being separated in flight without a recovery system?
- If there is an electronic in-flight recovery control system, does it have a safety/arming technique (switch or safety plug) that positively ensures it is not capable of causing a non-pyrotechnic deployment event until the rocket has been installed on the launch pad? Hint: If your rocket is complicated, develop a pre-flight checklist and use it before every launch of you rocket. That’s what real engineers do!
- 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 expected) 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 note: 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 fly-off motors from the vendor for onsite delivery.

Section 6. <u>QUALIFYING AND PRACTICE FLIGHTS</u>.

Practice-fly early and often. The teams that qualified to attend previous fly-offs had an average of 15 practice flights with several crashes and/or lost rockets before they did the flight that got them to the fly-offs. None of them waited until the last week before the deadline to do their first test flight; teams that waited this long were universally unsuccessful. 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 an NAR-observed "qualification" flight and FAX (703-358-1133) the results of that flight to the AIA (using a copy of the form provided in this Handbook) no later than midnight EST Monday, April 5, 2010. 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 egg and timing stopwatches for all qualifying and practice flights; pre-measured egg and timers with watches will be provided by the NAR at the fly-offs.

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 15, 2010 (alternate fly-off date will be May 16, 2010, 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 9, 2010, by a representative of the AIA, and the list of those accepted will be posted at **www.rocketcontest.org**. Notification will be sent to you using the email addresses provided on your application.

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 is the total difference (in seconds and hundredths) by which the average timer-measured flight duration was outside the target range of 40.00 to 45.00 seconds (always a positive number) multiplied by TWO if the duration was above 45.00 seconds, or by FIVE if the duration was less than 40.00 seconds; <u>plus</u> the total difference (in feet) between the altimeter-reported altitude and 825 feet (always a positive number). Note that cracking of the egg carried by the rocket is <u>disqualifying</u>, as is a flight duration of less than 35.00 seconds.

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 web site, www.nar.org. 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 (some of these folks live in places remote from an NAR section).

Obtaining an observer and providing stopwatches **<u>is the responsibility of each team</u>. 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-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.

Finding a launch site is the responsibility of each team, but you do not have to fly at an NAR launch site. You simply need to locate an open field of suitable size (at least 1500 feet on a side), get permission from the landowner, and comply with any local laws regarding model rocketry. Model rocketry is recognized and regulated by the National Fire Protection Association's Code 1122, which local fire officials should be familiar with. There is a safety handout in Appendix 7 of this Handbook that you should read and can share with concerned landowners and public safety officials.

Teams may practice as much as they wish, but may only make THREE (3) official qualification flight attempts, and no more than TWO of these may be made after March 1, 2010. The form provided in this Handbook, or a copy, must be used to report the results of these flights. Be sure to get the signatures of the supervising teacher/adult of the team and the Senior NAR member who is the official observer. It is the responsibility of the team to fax your completed form for successful qualification flights to (703) 358-1133, no later than April 5, 2010. NAR observers who observe a qualification flight attempt that is not successful (i.e. crash or broken egg, or duration less than 35 seconds) are asked to fax the form on that flight directly to the AIA.

TEAM AMERICA ROCKETRY CHALLENGE 2010
QUALIFYING/SELECTION FLIGHT DEMONSTRATION

TEAM'S SCHOOL/ORGANIZATION: ____

AIA TEAM NUMBER: ______________ ADULT ADVISOR: ________________________________

DATE OF THIS FLIGHT: _____________ QUALIFICATION ATTEMPT # _______ OF NO MORE THAN 3

MINIMUM FLIGHT REQUIREMENTS (ALL MUST BE MET) PUT "YES" OR "NO"

Did this rocket weigh less than 1000 grams at takeoff, with egg and motors? __________

Did this rocket use only 80.0 N-sec or less of motors from the list of TARC approved motors? __________

Did the rocket contain one Grade A large, raw hen's egg and a TARC-approved altimeter? __________

Did this rocket make a safe flight and recovery under the TARC rules & NAR Safety Code? __________

Did the part of the rocket containing the egg land without any human intervention (catching)? ___________

Did the part of the rocket containing the egg use solely a streamer for recovery and stay up at least 35 sec? ___________

Did the egg carried by the rocket remain uncracked after the flight? ___________

SCORING

TIMER # 1 (NAR OBSERVER): _____ . _________
SEC HUNDREDTHS

TIMER # 2 (OTHER ADULT): _____ . _________
SEC HUNDREDTHS

AVERAGE TIME: _____ . ______
SEC HUNDREDTHS

ALTIMETER ALTITUDE: ____________ FEET

EXCESS ABOVE 45.00 SEC: ___ . ____

MULTIPLY EXCESS BY 2: ____ . ____

OR

SHORTFALL BELOW 40.00 SEC: ___ . ____

MULTIPLY SHORTFALL BY 5: ___ . ____

+

DIFFERENCE FROM 825 FEET: ___________
(NO NEGATIVES)

+

FINAL SCORE (SUM) ____ . ____
Put only "DQ" if any answers above are "no"

SUPERVISING TEACHER/ADULT CERTIFICATION

I certify that the student members of this team designed, built, and flew this rocket without my assistance and, to the best of my knowledge, without the assistance of any other adult or any person not on the team. I also certify that no more than two official qualification flight attempts were made by this team, and that the team information on file at AIA is current. I understand that team membership can no longer be changed and only team members on file at AIA with valid parent consent forms are eligible to receive prizes.

SIGNATURE: ______________________________ PRINT NAME: ______________________________

ADULT N.A.R. MEMBER OBSERVER CERTIFICATION

I certify that I am a Senior NAR member who personally observed this flight, and the above initials and scores are mine, based on my observations. I certify that I am not related to any team members or affiliated with their school or non-profit organization, and that this flight was conducted in compliance with the rules of the Team America competition.

SIGNATURE: ______________________________ PRINT NAME: ______________________________

NAR NUMBER: ___________ STREET ADDRESS: ____

CITY, STATE: ________________________ PHONE: ______________ EMAIL: ________________________

******FAX TO 703-358-1133 NO LATER THAN MIDNIGHT (EST) APRIL 5, 2010******
Team sends in form if flight successful, NAR observer sends in form for unsuccessful flights.

Section 7. 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 at www.rocketcontest.org. 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:

www.nar.org	The web site of the National Association of Rocketry, 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 110 or more "sections", or local clubs, for advice and general assistance. You can join NAR online as well, to get insurance plus NAR's glossy magazine "Sport Rocketry". NAR Technical Services (NARTS) at www.nar.org/NARTS has many technical resources on the hobby for sale, including the official reference handbook for TARC, the Handbook of Model Rocketry by G. Harry Stine (available at a special price of $20 postpaid for registered TARC teams).
www.rocketryplanet.com	This is a popular commercial web site useful to get to other online resources.
www.SpaceCAD.com	SpaceCAD is an approved simulation software for TARC, and information regarding its successful use and other useful rocket design information can be found here.
www.apogeerockets.com/rocksim.asp	RockSIM is an approved simulation software for TARC, and information regarding its successful use and other useful rocket design information can be found here.

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. BMS, ASP, and SEMROC have agreed to offer a discount to teams that are registered for TARC:

www.balsamachining.com	Balsa Machining Service (BMS), 11995 Hillcrest Drive, Lemont, IL 60439. A manufacturer/vendor of body tubes, balsa nose cones, model rocket motors, and other components for model rockets.
www.asp-rocketry.com	Aerospace Specialty Products (ASP), PO Box 1408, Gibsonton, FL 33534. A manufacturer/vendor of body tubes, plastic nose cones, streamers, plastic egg-carrying capsules for rockets, and a special TARC learner's kit.
www.semroc.com	SEMROC Astronautics, Box 1271, Knightdale, NC 27545. A manufacturer and vendor of body tubes, nose cones, and other component parts.
www.heavenlyhobbies.com	Heavenly Hobbies. An online vendor of component parts and recovery devices, and a kit manufacturer
www.hangar11.com	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.) There is a list of NAR-approved mentors on the NAR website for your convenience. 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 group at http://groups.yahoo.com/group/NARTARC.

APPENDIX 1.

RECOMMENDED SCHEDULE OF ACTIVITIES FOR TARC 2010 TEAMS

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 TARC electronic forum (Yahoo group http://groups.yahoo.com/group/NARTARC/)

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 at www.nar.org)
- Watch the instructional video "How to Build and Fly a Model Rocket" that is provided on YouTube at www.youtube.com/user/AerospaceIndustries
- Download the Team Handbook & Rules and the Frequently Asked Questions from www.rocketcontest.org, and have all team members read both
- Begin research on rocket parts supply sources (starting with the three "official parts suppliers" listed in the TARC Handbook)
- Order one of the two available flight-simulation and rocket-design computer programs, SpaceCAD or RockSIM, at the TARC Team discount price directly from the vendor.

WEEK 3

- Purchase an inexpensive one-stage rocket kit to familiarize 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 at www.nar.org or contact the nearest NAR club or "section" listed at this same website)
- Develop a plan to raise required funds for purchase of rocket supplies (and hopefully for later travel to the flyoffs), covering at least 2-3 rockets and motors for at least 10 test and qualification flights

WEEK 4

- Obtain a comprehensive book on model rocketry, such as G. Harry Stine's "Handbook of Model Rocketry" (available at a TARC Team discount from NAR Technical Services www.nar.org/NARTS), 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 Adept A1-TA official altimeter from Adept at the special TARC price of $29.

WEEK 6

- Using the computer program and the knowledge gained from reading and from building 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 flight(s), 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 April 5 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 15 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 April 5 you must:

- Make your final official qualification flight attempt in front of an NAR Senior member observer
- Submit (fax) your qualification flight report to AIA

April 9

- If notified of selection to attend the flyoffs, 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 "tune" rocket design to target altitude
- If you plan to travel to the flyoff by airline, order rocket motors for flyoff to be shipped to TARC receiving point or delivered on-site by flyoff vendor (Hangar11 Hobbies)

NO LATER THAN May 1

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

APPENDIX 2

NATIONAL ASSOCIATION OF ROCKETRY
MODEL ROCKET SAFETY CODE

Revision of February 2001

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.
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. If my model rocket weighs more than one pound (453 grams) at liftoff or has more than four ounces (113 grams) of propellant, I will check and comply with Federal Aviation Administration regulations before flying.
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 attached 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 (N-sec)	Equivalent Motor Type	Minimum Site Dimensions (ft.)
0.00--1.25	1/4A, 1/2A	50
1.26--2.50	A	100
2.51--5.00	B	200
5.01--10.00	C	400
10.01--20.00	D	500
20.01--40.00	E	1,000
40.01--80.00	F	1,000
80.01--160.00	G	1,000
160.01--320.00	Two Gs	1,500

APPENDIX 3.

NATIONAL ASSOCIATION OF ROCKETRY CERTIFIED MODEL ROCKET MOTORS APPROVED FOR USE IN TEAM AMERICA 2010

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 2010 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.

Download "Motor Data Sheets" from the NAR web site if you desire additional information. 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.

Abbreviation	**Full Manufacturer Name**
Aerotech	Aerotech
Apogee	Apogee
Cesaroni	Cesaroni Technology Incorporated
Estes	Estes Industries
Quest	Quest Aerospace Education
Rdrunner	Roadrunner Rocketry

Note: (R) following the listed casing dimensions denotes that the motor is a reloadable motor system certified only with the manufacturer-supplied casing, closures, nozzle, and propellant. Reloadable motors (and "G" power class motors of any kind) are not available for sale to persons under age 18, per U.S. Consumer Products Safety Commission regulations. 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.

NATIONAL ASSOCIATION OF ROCKETRY CERTIFIED MODEL ROCKET MOTORS APPROVED FOR USE IN TEAM AMERICA 2010

As of August 20, 2009

Designation		Mfgr.	Casing Size (mm)	Propellant Mass (grams)	Total Impulse (N-sec.)
1/4A3-3T		Estes	13 x 45	0.8	0.62
1/2A3-2T,4T		Estes	13 x 45	2.0	1.25
1/2A6-2		Estes	18 x 70	2.6	1.25
A3-4T		Estes	13 x 45	3.3	2.50
A6-4		Quest	18 x 70	3.0	2.30
A8-3,5		Estes	18 x 70	3.3	2.50
A10-3T,PT		Estes	13 x 45	3.8	2.50
B4-2,4		Estes	18 x 70	6.0	5.00
B6-0		Estes	18 x 70	5.6	4.90
B6-2,4,6		Estes	18 x 70	5.6	5.00
B6-0,2,4		Quest	18 x 70	6.5	5.00
C6-0,3,5,7		Estes	18 x 70	10.8	9.0
C6-0		Quest	18 x 70	11.0	8.8
C6-3,5		Quest	18 x 70	12.0	8.76
C11-3,5		Estes	24 x 70	12.0	9.0
D5-P		Quest	20 x 88	25.0	19.6
D9W-4,7	R	Aerotech	24 x 70	10.5	20.0
D10-3,5,7		Apogee	18 x 70	9.8	18.3
D10-3,5,7		Aerotech	18 x 70	9.8	18.3
D11-P		Estes	24 x 70	24.5	18.0
D12-0,3,5,7		Estes	24 x 70	21.1	17.0
D13W-4,7,10	R	Aerotech	18 x 70	9.8	20.0
D15T-4,6/7	R	Aerotech	24 x 70	8.9	20.0
D21T-4,7		Aerotech	18 x 70	9.6	20.0
D24T-4,7	R	Aerotech	18 x 70	8.8	18.5
E6-4,6,8,P		Apogee	24 x 70	22.0	37.8
E9-4,6,8,P		Estes	24 x 90	35.8	28.5
E10-6,10		Ellis	24 x 102	28.3	35.8
E11J-3	R	Aerotech	24 x 70	25.0	31.7
E12-6,10		Ellis	24 x 102	28.3	35.8
E15W-4,7,P		Aerotech	24 x 70	20.1	40.0
E16W-4,7	R	Aerotech	29 x 124	19.0	40.0
E18W-4,8	R	Aerotech	24 x 70	20.7	39.0
E23T-5,8	R	Aerotech	29 x 124	17.4	37.0
E25R-4,7,P		Rdrunner	29 x 76	20.6	38.7
E28T-4/5,7/8	R	Aerotech	24 x 70	18.4	40.0
E30T-4,7		Aerotech	29 x 70	19.3	40.0
F10-4,6,8		Apogee	29 x 93	40.0	74.3
F12J-2/3,5	R	Aerotech	24 x 70	30.0	45.0
F20W-4,7		Aerotech	29 x 73	30.0	64.0
F20-6,10		Ellis	24 x 140	31.2	67.9
F22J-4/5,7	R	Aerotech	29 x 124	46.3	65.0
F23FJ-4,7	R	Aerotech	29 x 73	32.0	56.0
F23FJ-4,8		Aerotech	29 x 83	30.0	41.2
F23-6,10		Ellis	24 x 140	31.2	67.9
F24W-4,7	R	Aerotech	24 x 70	19.0	50.0
F25W-4,6,9		Aerotech	29 x 98	35.6	80.0

F26FJ-6,9		Aerotech	29 x 98	43.1	62.2
F27R-4,8		Aerotech	29 x 83	28.4	49.6
F32T-4,6,8		Aerotech	24 x 90	25.8	56.9
F35-6,10		Rdrunner	29 x 112	40.1	76.5
F35W-5,8,11	R	Aerotech	24 x 95	30.0	57.1
F36SS-11A	R	Cesaroni	29 x 98	29.5	41.2
F36BS-14A	R	Cesaroni	29 x 98	25.6	51.5
F37W-S,M,L	R	Aerotech	29 x 99	28.2	50.0
F39T-3,6	R	Aerotech	24 x 70	22.7	50.0
F40W-4,7,10	R	Aerotech	29 x 124	40.0	80.0
F42T-4,8		Aerotech	29 x 83	27.0	52.9
F45R-5,8,P		Rdrunner	29 x 112	30.0	62.3
F50T-4,6,9		Aerotech	29 x 98	37.9	80.0
F52T-5/6,8,11	R	Aerotech	29 x 124	36.6	78.0
F59WT-12A	R	Cesaroni	29 x 98	26.1	57.0
F60R-4,7,10		Rdrunner	29 x 112	38.1	75.9
F62T-S,M,L	R	Aerotech	29 x 89	30.5	51.0

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

APPENDIX 4.
DESIGN TIPS FOR STREAMERS

All rocket recovery devices are designed to produce aerodynamic drag to slow the descent of the rocket once they are deployed. The drag that a falling object experiences 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 2010, if your rocket goes up 825 feet and takes 7 seconds after liftoff to reach this altitude and deploy its streamer, and you want the total flight duration to be 42.5 seconds, then the descent terminal velocity that you want is 825 / (42.5 – 7) = 23 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 bigger in diameter; with a streamer, it is not that simple.

"Streamers" as used in rocketry are rectangular strips of a very flexible material that are rolled up inside the rocket body for boost and unroll when deployed for recovery. Rockets may use one or more of these as a recovery device. For TARC 2010 the pertinent rules requirements are as follows: "*The portion of the rocket containing the egg and altimeter must return to the ground using only one or more streamers as its deployed recovery system. The rest of the rocket may be attached to this portion, or may return separately as long as it does so safely. Each streamer that is used must be a separate single rectangular strip of thin flexible material such as paper or plastic that is at least five times as long as wide, and each must be attached to the rocket only by a single line that connects to one or more places on a single one of that streamer's narrow sides.*"

Although the largest contributor to the total drag of a descending rocket is its recovery device (parachute, streamer, etc.), at the higher descent rates typical for streamer recovery the rocket body and fins contribute useful drag as well, particularly if the body falls in a sideways orientation. A lightweight body with fins that falls sideways while attached to its streamer can reduce the rocket's terminal velocity significantly compared to performance if the rocket just hangs straight down below the streamer. Simple calculations of streamer performance usually assume that the rocket attached to the streamer is a dragless point mass, but may not actually be correct unless you are using the streamer only for a small, heavy egg capsule.

Steamers create drag by a combination of the drag from airflow across their surface area, and the drag from any aerodynamic activity that they can be made to perform by their shape, such as flapping, whipping, etc. The larger the surface area (size) of a streamer, the more drag it will have. But <u>size</u> alone is not the whole story in getting the streamer to have lots of drag. A streamer that descends straight behind a rocket with no aerodynamic activity has only modest drag so the terminal (recovery) velocity it provides a heavy rocket is fairly fast. An otherwise-identical streamer that performs vigorous aerodynamic activity will make a rocket fall much slower. This aerodynamic activity can be induced by the way that the streamer is <u>attached</u> or <u>folded</u>, but the ability to do this depends on the type of <u>material</u> used to make the streamer. So there are four important factors in streamer design: size; material; folding technique; and how it is attached.

<u>SIZE</u>

Larger streamers produce more drag than smaller streamers, if all else is equal, because they have a larger surface area. Beyond this, however, a single large streamer has been found to produce more than twice as much drag as two smaller streamers that have the same combined surface area. And wide shorter streamers have been found to produce more drag than thin longer ones that have the same surface area. In fact, extensive testing by rocket hobby researchers over the years has shown that streamer lengths much beyond about 10 times the streamer width normally add little to performance. The extra length adds weight of streamer material (increasing terminal velocity) without a significant compensating increase in drag.

MATERIAL

Since a streamer creates drag by skin friction with the passing air, you would expect that materials with a rough surface finish, such as crepe paper, would be good for use as streamers. And since terminal velocity on descent is reduced by reducing weight you'd expect that the lightest-weight streamer material would be the best. All else being equal, and if the streamer simply descended as a flat, motionless sheet, these would be true. However, the majority of a streamer's effective drag actually comes from aerodynamic flapping. Achieving this flapping requires the use of streamer materials that are stiff enough to hold curls and creases and to maintain some shape despite the flapping. Crepe paper and very thin, light, or soft and flexible plastic films cannot do this.

The optimum streamer material is lightweight but stiff, capable of holding curls and creases but not susceptible to ripping in the face of aerodynamic forces. Rocket fliers who compete in streamer duration contests are always on the hunt for such a "perfect" streamer material; they call it "unobtanium." They have not found it yet, but along the way they have found a number of things that work pretty well. These include the following, but there is plenty of room still for discovery and innovation to add to this list by finding the plastic film that no one has found yet. Note that any streamer used in TARC (like in NAR competition) must all be made of a single type of material.

- Mylar – a thin polyester plastic film (usually with a silver metallization layer) used as a sun shield for windows or as "sun film" in hydroponics greenhouses, as electrostatic discharge packaging film, etc. It comes in a variety of thicknesses, but only the types that are "1 mil" (0.001 inches) to 2 mils in thickness are stiff enough to be useful for high-performance streamers. Sometimes you can buy Mylar with this kind of thickness as party streamers.
- Micafilm – a model airplane wing-covering material made by Coverite and sold through model aircraft hobby vendors. Streamer creases have to be folded in, not ironed or baked in, as this is an iron-on wing covering with adhesives that are activated by heat. This is a tough material that is very resistant to tearing.
- Tracing paper – vellum paper sold in rolls by graphics and art suppliers for use in drafting/tracing. The heaviest grades have good stiffness to take and hold creases, but can be a bit vulnerable to tearing when used as a streamer.

FOLDING

A flat streamer attached to a rocket by a single line at the midpoint of one narrow end will normally demonstrate minimal aerodynamic flapping activity during recovery; it will fall smoothly and fast. In order for the streamer to whip around and create the aerodynamic flapping that increase its effective drag, it needs some kind of creasing or folding that makes it behave as something other than a flat surface. In order to hold these creases and folds at the drop rates of 20 – 25 feet/second that TARC rockets will experience, the streamer material needs to have a certain amount of stiffness.

There are many different theories among rocket streamer duration competition fliers as to what the best way is to crease or fold a streamer, and there has been a certain amount of research done. This research has shown conclusively that one form of creasing, called the "accordion fold", does work. This technique involves putting sharp folds across the width of the narrow axis of the streamer in back-and-forth "Z" shaped pleats similar to those seen in an accordion. The width of these pleats should be anywhere from 0.5 to 1.0 inches, and they should extend for at least the last 75 percent of the streamer length, up to as much as 100 percent. The pleats can either be folded in using a metal ruler to provide a sharp mechanical creasing, or (for Mylar or other plastic films only) they can be ironed in using a very low-temperature iron that does not melt the streamer material. When this kind of streamer flies, properly made pleats will retain their shape and break of the flat surface of the streamer to improve its drag. Various forms of additional diagonal folds can be added to a pleated streamer to improve its tendency to whip around. There is a lot of room here for experimentation and optimization.

A second popular technique, useful only with mylar/plastic streamers that can be heated, is called the “scorpion roll”. This technique requires that the steamer be rolled around a ¼ to ½-inch diameter rod, and then slipped off the rod. The rolled streamer is then clamped completely flat between two pieces of wood and heated in an oven to a very low temperature (generally no more than 140 degrees F) for an hour or so. When it is flown, the streamer wants to curl back up on itself against the airflow like the tail of a scorpion, once again breaking up the flat surface and improving drag.

ATTACHING

There are two key elements to attaching a streamer to a rocket: how and where you attach the single line to one of the narrow edges of the streamer; and how and where you attach the other end of this line to the rocket. This line needs to be fairly long (at least three feet) and should be wrapped loosely around the rolled streamer so the streamer takes a second or two to unroll after deployment. This slows the velocity seen by the streamer when it first unrolls, reducing its tendency to tear.

The leading edge of a streamer (the edge to which the line is attached) must maintain its straight shape in order for the streamer to function well. If you are using a wide streamer, this generally requires stiffening the leading edge somehow. You can do this by putting a piece of wide stiff packing tape across this edge, or by putting an extremely thin (1/64 inch or less) piece of steel wire (“music wire” or “piano wire”) across this edge under a tape strip.

The attachment method and location for the single line is also important. It must be very securely attached, since it will absorb significant stress when the streamer deploys. If you are using a thin steel wire on the leading edge, tie the line to it before you secure it to the streamer. If you are using a tape strip for stiffness, then put a hole through it for the line and use a reinforcing eye around this hole. A line that is simply taped to the flat surface of the streamer will usually not hold. Most fliers find that if the single line is attached away from the midpoint of the narrow end of the streamer, anywhere from ¼ of the way from one edge to all the way at one edge, the streamer has a significantly greater tendency to whip around. An additional option is to secure the line to the narrow end of the streamer using more than one attachment point, such as a “yoke” that attaches to both ends of the streamer then is attached to the single line at a point offset from its center.

Finally, how and where the streamer line is attached to the rocket determines the orientation that the rocket body will fall in during recovery. If you attach the streamer to an anchor inside the body tube or on one end of the egg capsule, these heavy objects will fall end-on beneath the streamer and present minimal surface area to the airflow past them. If the streamer is attached to a point at (center of gravity or balance point) of the capsule or rocket, then these objects will fall sideways and present maximum surface to the airflow, increasing recovery drag and reducing terminal velocity. If you want to place your anchor point at the recovery CG, remember to determine this point with the rocket in post-burnout configuration, i.e. with an empty expended rocket motor casing. Experiment with this; it may turn out that the rocket hangs purely horizontal when this anchor point is slightly closer to the fins than the CG.

One technique often used by rocket competition fliers is to attach a strong line to the root of one fin (or to the screw eye on the end of the payload compartment) and run this line along the body and into the body tube where the shock cord and recovery device are stored during boost. You can tape or glue the line at the point along the body where the burnout CG is located. When the recovery system deploys the rocket then hangs sideways from this line at its CG balance point.

APPENDIX 5.

ADEPT MAXIMUM ALTITUDE ALTIMETER

Adept Rocketry
www.adeptrocketry.com
P.O. Box 1138
Summerville, SC 29484-1138
(843) 851-1853

DESCRIPTION

The altimeters approved for use in TARC 2010 (the Adept A1-TA and, for returning teams only, any Perfectflite ALT15K/WD Rev 2 altimeters still left from last year) are "maximum altitude altimeters" that precisely measure the air pressure at the altitude where your rocket is located every 0.1 second and convert this to an above-ground altitude value. The altimeter is energized by inserting the battery. It 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 50 feet altitude or greater than 15,000 feet altitude (far outside the 825-foot TARC 2010 target range) 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.

APPROVED ALTIMETERS

Only two altimeters are approved for use in TARC 2010 official altitude scoring: the Adept A1-TA and the Perfectflite ALT15K/WD Rev 2. These are about 2.5 inches long, fit in an 18mm-diameter body tube like Estes BT-20, weigh 13-14 grams with battery, and use a 12 volt "N" size lighter battery. Only these TARC-approved altimeters may be used as the basis for official event scores in either local qualification flights or in the final fly-offs. Only the Adept A1-TA is available at the special TARC price ($30) for registered TARC teams.

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.

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.

The A1-TA uses a custom absolute pressure device to precisely measure and report altitude values. It uses an 18-bit logarithmic analog-to-digital converter to precisely (4 inch resolution) measure the nonlinear pressure versus altitude relationship over the altitude range. Once powered up, the A1-TA constantly measures the ground-level altitude and waits for an increasing change upward. It then captures the maximum altitude obtained (above ground zero), and begins to report the maximum altitude value. The value is "beeped" out as a series of counts that can be heard easily, even when the unit is still inside the rocket. The rocketeer knows the maximum altitude as soon as he/she picks it up, or just gets close to it.

TESTING AND USING THE A1-TA

NOTE 1: The precision amplifier circuitry on the altimeter may be sensitive to noise and static when being held. Following power up the A1-TA reports the previous flight's maximum altitude from permanent memory. The altitude is reported twice, and then there is a 10-second silent period to allow time to get your hands off the unit before it starts taking readings. The A1-TA is a super precision instrument. Use care to keep the device clean and dry.

NOTE 2: This device must be installed in a “clean area.” *Electronic Instrumentation is not compatible with the fumes and residue created by rocket motors and deployment charges.* **Install the A1-TA in an area that is totally sealed from motors and charges.**

To turn the unit on, install a 12-volt alkaline lighter battery (GP-23A, Eveready Energizer No. A23, Radio Shack, 23-144, etc.) in the battery holder. The spring end of the battery holder connects to the negative end of the battery. Remove the battery to turn off the device. When the battery is first installed, there will be a long beep to indicate that power is on. Then the A1-TA will report the previous flight's maximum altitude twice. Then after an additional 10 seconds, the unit will beep every 1.6 seconds to indicate that it is working and looking for an increasing altitude. The start up beeps and pause after power up gives the user time to slip the unit inside the rocket tube before it starts looking for liftoff. Also, it is best to wait at least three minutes after power up before launching. This assures that the precision circuitry has ample time to stabilize and adjust to local conditions.

An increase in altitude tells the unit it has liftoff. The A1-TA constantly measures the ground-level altitude and waits for movement upward. It then precisely captures the maximum altitude obtained above ground zero and begins reporting the maximum altitude.

After a flight, an A1-TA Altimeter will be beeping out the maximum altitude in this manner: (1,323 feet) Beep ..... Beep Beep Beep ..... Beep Beep ..... Beep Beep Beep. A zero is indicated with a long Beep: (1,310 feet) Beep ..... Beep Beep Beep ..... Beep ..... Beeeeeep. After each sequence there is a pause before it repeats. The A1-TA beeps out the altitude to the nearest foot. This system works for three, four, or five digits depending on the value.

To simulate rocket liftoff and to see (hear) the unit do its thing, you will need to place the altimeter inside a bottle or other make-shift vacuum chamber, then slowly pull a vacuum on the bottle. You need only hold the vacuum for a few seconds, then release slowly. Several such devices are available from various sources that serve the purpose well. It is easy to simulate rocket flights to altitudes of several thousand feet. Slowly pull the vacuum, and then slowly release the vacuum. As the vacuum (altitude) increases, the A1-TA will start beeping at the faster rate of once every 0.8 second to indicate that it has detected liftoff. When it reaches maximum altitude, there will be two quick beeps. Then when the Altimeter starts its descent (vacuum is being released), it starts beeping out the maximum altitude attained above ground.

SPECIFICATIONS

- Altitude Capability: 50 feet to 15,000 feet Above Ground Level (AGL).
- Resolution of Measurement: 4 inches; system uses a logarithmic 18-bit A-to-D converter. Internal measurements and calculations are performed at the resolution of 4 inches. The A1-TA reports altitude to the nearest one foot.
- Altitude Sampling Rate: 10.0 samples per second.
- Launch Detection: due to the super fine resolution of the A1-TA, it is capable of measuring launch velocity and acceleration. To detect a slow launch, it watches the velocity for a period of 3 seconds. Launch detection is at 50 feet for a slow launch with acceleration over one G. An additional launch detect threshold of 150 feet is used for immediate detection of high speed launches. Problems with wind gusts are completely avoided with Adept Rocketry's Wind Burst Glitch Removal™ system.
- Nonvolatile Memory: remembers and reports the altitude of the most recent flight, no matter how long the device has been powered down.
- Calibration Accuracy Over Full Range: better than 0.3 % + 4 feet. Calibration is optimized to the range 500 to 1,200 feet AGL.
- Piezo Beeper reports altitude and operational status. The Beeper uses a push-pull driver for increased volume level, loud enough to serve as a location beacon for a lost rocket.
- Battery Life: 10 hours minimum.
- Advanced on-board Voltage Regulator that is totally immune to reverse voltage (battery in backwards).
- Custom altitude sensor that is immune to light, including direct sunlight.
- Conformal Coating of components to avoid problems with carbon contamination and humidity.
- Measures .55" wide by .62" thick by 2.9" long.
- Fits inside a tube with a minimum ID of .69 inch (17.5 mm), a loose fit in an Estes BT-20 body tube.
- Weight: 6.2 grams. Weight with battery installed is 14.2 grams (0.50 ounce).
- Accessory required: one 12-volt alkaline lighter battery (2 included).
- Warranty is for the lifetime of the altimeter up to 5 years, as long as it remains clean, unmodified, and undamaged.

This device is intended to be installed lengthwise in a small rocket tube. It fits inside an 18 mm or BT-20 tube. When it is to be used in a larger diameter body tube, it may be mounted in any orientation. It may be mounted inside a BT-20 tube that is connected to bulkheads or other structural elements. Also, it may be wrapped with or rolled up in foam rubber or paper towels before being slipped into a larger diameter tube. This has the advantage of additional protection against crash damage, and contamination. The Altimeter will still be able to "breathe" through the porous materials. The Altimeter will still work normally.

When installing lengthwise, always mount the Altimeter with the spring end of the battery holder facing upward toward the nose end of the rocket.

An Altimeter must be mounted in a "sealed" chamber with a vent or vents 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. Some rocketeers use multiple static ports (vent holes) instead of just one. 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. If you wish to use multiple ports, then use three or four. **Never use two.** Ports must be the same size and evenly spaced in line around the tube.

The general guideline for choosing port size is to use one 1/8 inch diameter vent hole (or equivalent area, if multiple holes are used) per 25 cubic inches of volume in the altimeter chamber. For instance, an altimeter chamber two inches in diameter and four inches long (12 cubic inches) needs one 3/32 inch vent hole or three or four 1/16 inch vent holes. Try to keep hole sizes within -50% or +100% of the general guideline. Do not make the holes too small, and **especially do not make them too large**. Obviously, a vent or vents in a BT-20 (18 mm) body tube will be quite small.

Vent holes should be a minimum of four body diameters below the junction of the nosecone with the rocket body. This is necessary with high performance (high speed) rockets. The tremendous pressure on the nosecone leeches down the rocket body as much as four diameters before it dissipates. With lower speed rockets, the "minimum of four body diameters" rule may be reduced to one or two.

APPENDIX 6.

QUESTIONS AND ANSWERS ABOUT INSURANCE NATIONAL ASSOCIATION OF ROCKETRY

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 $1,000,000 per occurrence and $2,000,000 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? After my personal insurance has been exhausted?

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 $1 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-members attending our launch. Are they covered by NAR insurance when they fly with us?

No. Non-members are not covered by NAR insurance. To obtain coverage, they must join and become members of the NAR. However, your Section or Team's coverage and your individual NAR members' coverage remains, and they are covered by the policy.

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, field trips, 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 (including mine) 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 owned property is also covered. Any existing member insurance (in this case, auto insurance) would be primary. Fire damage coverage is limited to $100,000 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. 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. They must also be NAR members.

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 Team 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.

16. **Any difference between individual and Team insurance as far as what stuff it can cover?**

    No. Policy limits and coverage are the same for individuals, Sections, and site owners.

17. OK, what about the site owner insurance we get after we've covered our 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 NAR TARC team. This coverage can only be obtained by chartered NAR sections, and by registered TARC teams that have the adult supervisor and at least three of the student team members signed up as members of the NAR.

18. How do I convince the landowner that this is real insurance backed by a reputable provider, so that he'll let me launch on his land? What benefits can I show him?

The NAR Section 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 strongly recommend keeping one copy on file with your Section records, and providing another copy to your landowner. Your landowner can then contact our insurance agency directly with any additional 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 $1 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 insured Team 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 at the J. A. Price Agency: (952) 944-8790, Ext. 127. Please understand that Bob is there to address and help with your insurance issues only. Questions about Safety Codes, By-Laws, Section activities, other NAR services and other sport rocketry issues should be directed to the NAR at (800) 262-4872 or nar-hq@nar.org.

National Association of Rocketry

SPORT ROCKETRY: AMERICA'S SAFE, EDUCATIONAL AEROSPACE HOBBY

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