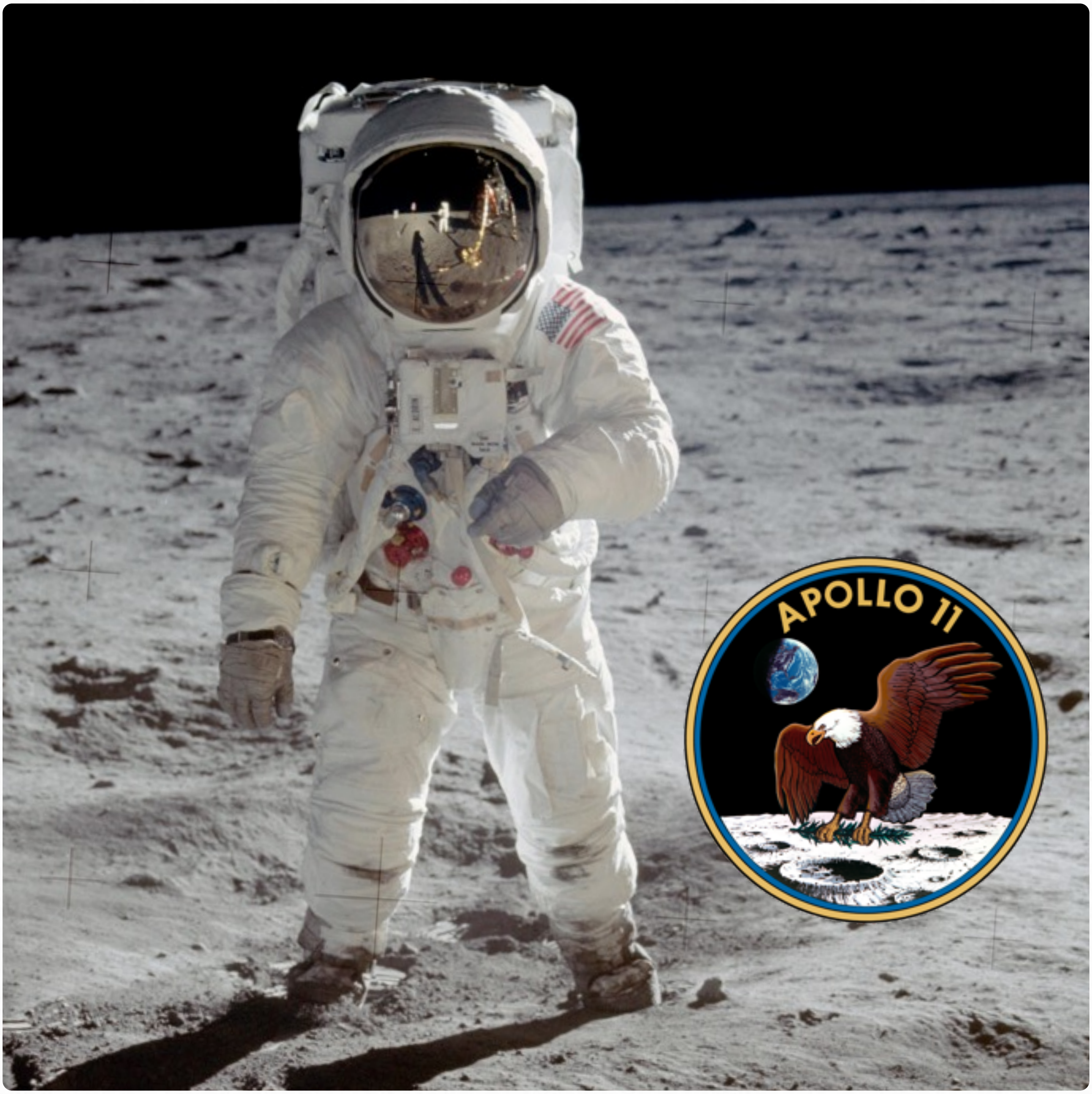
2019 Team Handbook

Team America Rocketry Challenge



Aerospace Industries Association - National Association of Rocketry

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

Over 5,000 students from across the nation compete in TARC each year. Teams design, build and fly a model rocket that reaches a specific altitude and duration determined by a set of rules developed each year. The contest is designed to encourage students to study math and science and pursue careers in aerospace.

The top 100 teams, based on local qualification flights, are invited to Washington, DC in May for the national Finals. Prizes include $100,000 in cash and scholarships split among the top ten finishers plus $5000 in prizes for special events, all sponsored by AIA member companies. In addition Raytheon Company sponsors a trip for the winning team to one of the major European air shows to compete in the International Rocketry Challenge.

The 2019 edition of the Team America Rocketry Challenge will celebrate the 50th anniversary of the successful mission of Apollo 11, the first journey to land humans on the surface of the Moon. The historical photographs contained within this handbook commemorate that achievement, and appear here courtesy of the National Aeronautics and Space Administration.

Cover photograph: Apollo 11 Lunar Module Pilot Edwin E. "Buzz" Aldrin stands on the surface of the Moon on July 20, 1969. Mission commander Neil Armstrong can be seen as a reflection in Aldrin's helmet visor.

1

Introduction

The Apollo 11 crew boards the transfer van for the short trip to the launch pad on July 16, 1969.

The Team America Rocketry Challenge (TARC) provides 6th 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. Over a period of several months, they experience the engineering process and compete through qualifying flights of their rockets with thousands of peers all across the country for the opportunity to participate in the culminating national fly-off event held in Northern Virginia on May 18, 2019. The purpose of the program is to inspire and excite students about learning and careers in science, technology, engineering and mathematics. The challenge 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.

2019 is the 50th anniversary year of Apollo 11, the first manned lunar landing, so the rules are designed to commemorate aspects of this great event.

The objective of the 2019 challenge is to design, build, and fly a safe and stable model rocket to an altitude of exactly 856 feet (Neil Armstrong set foot on the moon from Apollo 11 at 8:56 PM Houston time on July 20, 1969) while also achieving a total flight duration of between 43 and 46 seconds and returning a payload of three raw hen's eggs (Apollo carried three astronauts) undamaged in a section of the rocket (the “Apollo capsule”) that recovers separately from the section containing the rocket motors and fins, using two or more parachutes of nearly the same size (Apollo 11 recovered with three). The national winner is the team whose flight vehicle comes closest (in the sum of two flights) to exact altitude (856 feet on the first flight and either 25 feet higher or 25 feet lower on the second flight, depending on a coin toss at the Finals) and flight duration (the range of 43-46 seconds on the first flight and 1 second higher or lower, corresponding to the altitude choice made for the second flight) in a safe and stable flight, and returns the eggs from both flights undamaged at the National Finals in May, 2019. There are no requirements concerning rocket body tube diameter this year, except that there must be a portion that can enclose the egg payload, and these eggs may be up to 45 millimeters (1.77 inches) in diameter.

The ten top-ranking teams from the Finals receive scholarship prize money (ranging from $20,000 for first place to $5,000 for 10th) and their schools/sponsoring organizations receive a $1000 cash award to further their rocketry programs, with a combined award pool of $100,000. The U.S. 2019 champion will compete against teams from the United Kingdom, France, and Japan in the International Rocketry Challenge at the Paris International Air Show in France in June 2019.

The National Finals also include a variety of other optional contests and events throughout the day, each with cash prizes. Some of these are serious competitions, but others are just for fun.

The most important of these competitions is the presentation contest, where teams that enter are given ten minutes explain their rocket design process to a panel of judges drawn from the aerospace industry. This type of competition is a scored part of the International Rocketry Challenge, so teams with ambitions to win TARC and move on to Paris should consider practicing for the Paris event by entering this at the US Finals. At the U.S. National Finals it is not a part of the overall team score, but it offers a $1000 cash prize for the winner, and lesser cash prizes for 2nd and 3rd places.

Uniquely for the 2019 Finals, the rockets flown will be judged for resemblance to the Apollo 11 Saturn 5 in either profile (shape) or paint pattern, or both. This competition will not influence flight scoring, which is how the overall champions are selected, but there will be $1000 in prizes split among the top three finishers in this judging.

The most popular "fun" competition at the Finals is the rocket building competition, where up to 40 teams that sign up on the evening before are challenged to construct a rocket from a grab bag of parts. These rockets are judged for separate prizes that recognize craftsmanship and design creativity. In addition, there is a Finals award for most innovative technical approach to achieving exact mission performance. On the lighter side, each year we are impressed by the creativity and spirit of teams during the Finals. We have a best costume contest, where we've had teams dressed in everything from Hogwarts robes, to super hero outfits, to authentic ethnic attire from various regions. And we have a "Spirit" award for the team displaying the best team spirit and teamwork. All of these fun competitions have $500 cash prizes.

Starting in 2016 we also began running a competition for the best "engineering design notebook" maintained by a team during their process of designing, building, and flight testing their rocket. And we began a competition for the team that runs and documents the best outreach program, teaching others about rocketry and publicizing TARC to others who might be eligible to participate. Both of these competitions are open to all teams, not just those attending the Finals, and they have $500 cash prizes and the top finisher in the outreach competition gets an automatic invitation to the Finals regardless of qualification flight score, as long as they have two or more qualified, successful flights.

This Team Handbook provides the TARC 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 TARC by becoming familiar with the basics of model rocketry. Those who have no experience with how these models are built and flown should start by reading G. Harry Stine's Handbook of Model Rocketry (available from the National Association of Rocketry's Technical Services at http://www.nar.org/nar-products/), 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 180 National Association of Rocketry sections (chartered clubs) or the 400 experienced adult members of the National Association of Rocketry who have volunteered to be mentors, you are encouraged to consult with them. The sections are listed at the NAR web site, www.nar.org. The list of mentors is in the Team America section on the NAR web site and on the TARC website, www.rocketcontest.org . 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 site and will 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 is permitted to 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 Sport Rocketry, and a whole range of other benefits and resources.

Good luck! Design carefully, fly safely, and we hope to see you at the National Finals in May 2019.

2

2019 TARC Rules

NASA Mission Controllers review flight plans in the Mission Operations Control Room at NASA's Manned Spacecraft Center in Houston.

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

2. TEAMS. 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 of their local chapters or any other incorporated rocket organization). There is no limit to the number of teams that may be entered from any single school or organization, but no more than two teams containing students who attend the same school or who are members of the same organization, regardless of whether the teams are sponsored by that school or organization, can be invited to attend the Finals. Team members must be students who are currently enrolled in grades 6 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 activities for a rocket used in a qualification flight or at the Finals 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. TARC is open to the first 1000 teams that submit a completed application, including payment, postmarked between September 1 and December 1, 2018.

3. ROCKET REQUIREMENTS. Rockets must not exceed 650 grams gross weight at liftoff. The overall length of the rocket must be no less than 650 millimeters (25.6 inches) as measured from the lowest to the highest points of the airframe structure in launch configuration. The portion of the rocket containing the egg payload and the altimeter (the “Apollo Capsule”) must separate from the rest of the rocket in the air and must descend separately under at least two parachutes that are the same shape and are within 50 millimeters (2.0 inches) of the same diameter. The rest of the rocket must recover safely under any deployed recovery system. Rockets flown at the Finals will be required to have a paint or other decorative coating applied to any wood, paper, or fiber exterior surface of the rocket and will be assessed a 5-point flight score penalty on their first flight at the Finals if they do not. There will be a separate judged competition at the Finals (with a cash prize) to recognize the rocket that has the profile and/or paint scheme most closely resembling Apollo 11 on its Saturn 5. Results of this will not influence flight scores. Rockets may not be commercially-made kits designed to carry egg payloads with the only modification being the addition of an altimeter compartment. They must have only one stage. They must be powered only by commercially-made model rocket motors of “F” or lower power class that are listed on the TARC Certified Motor List posted on the TARC website and provided in the TARC Handbook. Any number of motors may be used, but the motors used must not contain a combined total of more than 80 Newton-seconds of total impulse based on the total impulse ratings in the TARC list. Motors must be retained in the rocket during flight and at ejection by a positive mechanical means (clip, hook, screw-on cap, etc.) and not retained simply by friction fit in the motor mounting tube. Rockets must not contain any pyrotechnic charges except those provided as part of the basic commercially-made rocket motor used for the flight, and these must be used only in the manner prescribed in the instructions for that motor.

4. **PAYLOAD.** Rockets must contain and completely enclose three raw hen's eggs of 55 to 61 grams weight and a diameter of 45 millimeters or less; and must return them from the flight in the Capsule without any cracks or other external damage. The eggs will be issued to the teams by event officials during the finals, but teams must provide their own eggs for their qualifying flights. The eggs and altimeter must be removed from the rocket at the end of a qualification or finals flight in the presence of a designated NAR official and presented to that official, who will inspect the eggs for damage after their removal and will read the altimeter score. All coatings, padding, or other materials used to protect the eggs must be removed by the team prior to this inspection. Any external damage to the eggs noted after their flight and removal from the rocket by the team is disqualifying.

5. DURATION SCORING. The duration score for each flight shall be based on total flight duration of the Capsule (portion of the rocket containing the eggs and altimeter), measured from first motion at liftoff from the launch pad until the moment that the first part of the Capsule touches the ground (or a tree) or until it 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, with .005 seconds being rounded up to the next highest 0.01 seconds. If one stopwatch malfunctions, the remaining single time will be used. The flight duration goal is a range of 43 to 46 seconds. Flights with duration in the range of 43 to 46 seconds get a perfect duration score of zero. Duration scores for flights with duration below 43 seconds will be computed by taking the absolute difference between 43 seconds and the measured average flight duration to the nearest 1/100 second and multiplying this by 4. Duration scores for flights with durations above 46 seconds will be computed by taking the absolute difference between 46 seconds and the measured average flight duration to the nearest 1/100 second and multiplying this by 4. These duration scores are always a positive number or zero. For those teams at the Finals that are invited to make a second flight based on their first-flight performance, the target duration for the second flight at that event will be 1 second less or 1 second more (determined by a coin toss at the student team preflight briefing at the Finals) and scoring for flights with durations above or below this revised range will be aligned to match the procedures for the 43-46 second range.

6. ALTITUDE SCORING. Rockets must contain one and only one electronic altimeter of the specific commercial types approved for use in the Team America event. These types are the Perfectflite APRA, Pnut, or Firefly. The altimeter must be inspected by an NAR official both before and after the flight, and may not be modified in any manner. The altimeter must be confirmed by this official before flight to not have been triggered and to be ready for flight. The peak altitude of the rocket as recorded by this altimeter and sounded or flashed out on its audible or visible light transmission post-flight will be the sole basis for judging the altitude score and this altimeter may be used for no other purpose. Other altimeters of other types may be used for flight control or other purposes. The altitude performance goal is 856 feet. (Note: Neil Armstrong set foot on the moon at 8:56 PM Houston time on July 20, 1969 on the Apollo 11 mission). The altitude score for every qualification flight and for the first flight at the Finals will be the absolute difference in feet between the 856 feet (261 meters) target altitude and the altimeter-reported actual flight altitude in feet (always a positive number or zero). For those teams at the Finals that are invited to make a second flight based on their first-flight performance, the target altitude for the second flight at that event will be either 831 feet or 881 feet, determined by a coin toss at the student team preflight briefing at the Finals.

7. FLIGHTS. Team members cannot be changed after the first qualification flight, with one exception as noted below for the Finals. Only team members on record at the Aerospace Industries Association (AIA) with valid parent consent forms are eligible to receive prizes. To be eligible for the national final fly-off event, a team is required to fly and submit the results from at least two qualifying flights observed in person by an adult (senior) member of the NAR (unrelated to any team members or to the team's adult supervisor and not a paid employee of their school or member of their youth group) between September 1, 2018 and Monday, April 8, 2019. Each team may conduct a maximum of three qualification flights, and will be ranked based on the sum of the best two qualified flights. More than two qualification flights are not required if the team is satisfied with the results of their first two flights. A qualification flight attempt must be declared to the NAR observer before the rocket's motor(s) are ignited. Once an attempt is declared, the results of that flight must be recorded and submitted to the AIA, even if the flight is unsuccessful. A rocket that departs the launch pad under rocket power is considered to have made a flight, even if all motors do not ignite. If a rocket experiences a rare "catastrophic" malfunction of a rocket motor (as determined by the NAR official observer), a replacement flight may be made, with a replacement vehicle if necessary. Flights which are otherwise fully safe and qualified but which result in no altimeter reading despite correct usage of the altimeter by the team, or that result in a reading of less than 50 feet despite a nominal flight will be counted as “no flight” and may be reflown without penalty. The results from qualification flight attempts must be faxed or scanned and e-mailed to and received at the offices of the AIA by 11:59 PM Eastern time on Monday, April 8, 2019. Based on these qualification scores

100 teams (with a limit of no more than the best two made up of students from any single school or organization) will be selected on the basis of lowest combined scores for their best two flights. If a school has more than two teams whose flight score is better than the cutoff score for Finals selection, they may adjust the membership of the two best teams invited to attend the Finals to include students from other teams with scores that met the Finals cutoff, up to a limit of ten students on any single team. Teams will be notified no later than 5 PM on Friday, April 12, 2019, and will be invited to participate in the final fly-off to be held on May 18, 2019 (alternate date in case of inclement weather will be May 19, 2019).

8. SAFE RECOVERY. Every portion of the rocket must return to earth safely and at a velocity that presents no hazard. An entry which has any heavy structural part or an expended motor casing separate from the rest and fall to earth without any form of recovery device will be disqualified. The rocket must be allowed to land at the end of flight without human intervention (catching) and the flight will be disqualified if there is such intervention.

9. RETURNS. Return of the portion of the rocket containing the eggs and altimeter is required by the deadline time on that same day that was established at the beginning of the day's flying. If the rocket cannot be returned after an otherwise safe and stable flight because it cannot be located or 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. Once the NAR official has declared that a rocket has landed in a place from which recovery would be hazardous, the results from that rocket's flight may not subsequently be used even if it is recovered.

10. LAUNCH SYSTEMS. Teams may use the electrical launch system and the launch pads (with six-foot long, 1-inch rails) provided by the event officials or may provide their own rail or tower system as long as it provides at least six feet of rigid guidance; launch rods will not be permitted to be used at the Finals. Launch systems used locally for qualification flights prior to the Finals must provide the rocket with at least six feet of rigid guidance, with a rail or with 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.

12. PLACES. Places in the final fly-off of the competition will be determined on the basis of the sum of the altitude and duration scores. At the fly-offs, at least 24 teams will be invited to make a second flight based on the results of their first flights. In these second flights, rockets which have issues which would otherwise rate a replacement flight under TARC rules #7 or #9 will not receive a replacement flight. Prizes awarded to the top places will be awarded only to those teams that make a second flight. The top final places will be ranked on the basis of the scores from the two qualified flights made at the fly-offs. Remaining places will be awarded based on the scores from the first flight. Ties will result in pooling and even splitting of the prizes for the affected place(s) -- for example, a two-way tie for 4th place would result in a merger and even division of the prizes for 4th and 5th places. If there is a tie for one of the top three places, the teams involved in the tie will be required to make a third flight to determine final places. Aerospace Industries Association reserves the right to make all last and final contest determinations.

3

Key Points

Apollo 11 crew members Neil Armstrong and Buzz Aldrin train on board a Lunar Module simulator.

After you read and understand the rules, please consider these ten key pointers about how to succeed in TARC 2019:

1. Do not make your official competition rocket the first rocket you build and fly; if you have never done model rocketry before, build and fly a simple rocket first.

2. Reach out to a NAR TARC mentor early for advice on how to build a rocket, where to get your rocketry supplies, and where to fly.

3. Develop a budget and a division of labor and schedule for your team's efforts, and raise the money needed to buy the parts and rocket motors it will take to be successful; plan on at least 10 practice flights plus your 3 official qualification flights. A typical budget is between $500 and $1000, including entry fee and one altimeter, plus the parts for two rockets and the rocket motors for 13 flights, but not launch equipment or travel to the Finals.

4. Get your initial design done before Christmas; use one of the computer programs to see if it will be stable in flight, and how high it is likely to go with which rocket motor, before you build it.

5. Do your first flight test by sometime in January, so that in case you have to do a major change in your design or your rocket crashes you have time to recover before the qualification flight deadline of April 8, 2019; and so that you have time to do lots of flight tests before this deadline.

6. Conduct lots of flight tests of your design (try to do at least ten) and take data on each test (rocket weight, motor type, altitude and duration; wind and temperature conditions; launch angle) so that you can make the right adjustments to exactly hit the target flight performance.

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

8. Remember that up to three qualification flight attempts are permitted, and the best two scores count for computing the score for determining Finals eligibility. These flights must be declared to an NAR observer before launch, and there are no "do-overs" for flights that do not have good scores; every official flight must be reported.

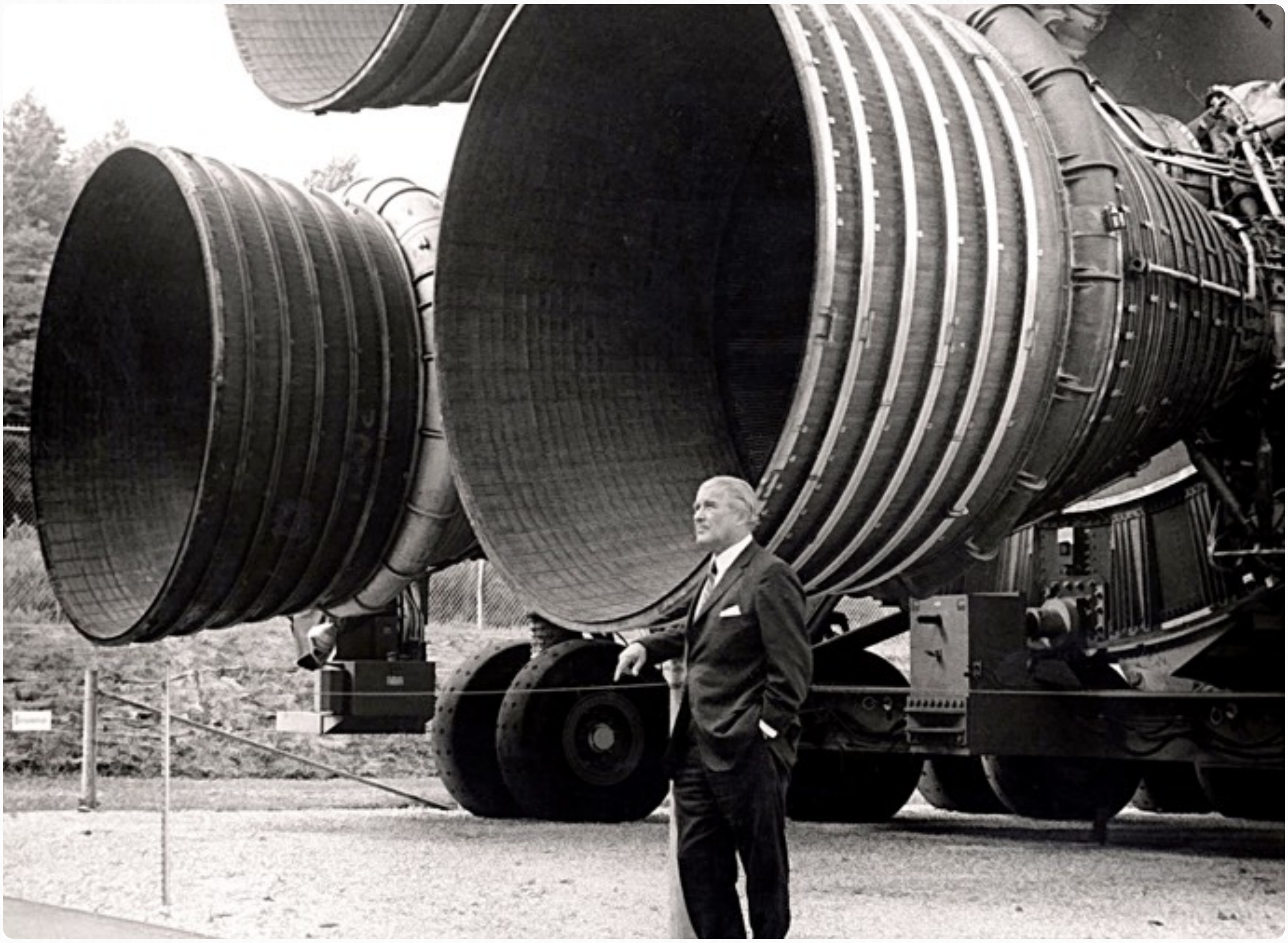
9. Complete your qualification flights and submit the scores by the deadline of April 8; do not wait until the last weekend to fly and just hope that the weather will be perfect and an NAR observer will be available!

10. If you have a very good combined two-flight score from your qualification flights, develop your plan for how you will fund your travel to the National Finals, in

case you are one of the 100 top teams that are announced on April 12, 2019.

4

Rocket Design



Werner Von Braun, Director of NASA's Marshall Space Flight Center, poses at the aft end of a Saturn V rocket.

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 856 feet and stay up for 43-46 seconds, and then have each of two separating parts of the rocket make a safe return to earth at the end. No matter what your design, it must incorporate this payload and achieve the performance requirement.

The challenge is finding the exact combination of airframe design, rocket engines, and duration-control technique with two or more parachutes that will achieve exactly 856 feet and 43-46 seconds (for the egg/altimeter section). Doing this will require either lots of trial-and-error, or smart use of a rocket-design and flight-simulation computer program to get the design “roughly right” first. Modern aerospace engineers do lots of "flight tests" on a computer before they start building and flying hardware--it's quicker and cheaper!

What, then, are the variables in your 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, must be at least 650 millimeters in overall length, must not exceed 650 grams (23 ounces) in weight, and must comply with the specific requirements in the 2019 rules (eggs plus altimeter must be in a separate section of the rocket that recovers separately using two or more parachutes of the same size). And the selection of the vehicle's rocket motors is another major variable. Since any certified commercially made model rocket motor or combination of motors with an aggregate total of 80 Newton-seconds or less of total impulse may be used, you must pick which ones you plan to use from the "Team America Approved Motor List" posted (and updated) at the National Association of Rocketry website at www.nar.org and in Appendix 3 of this Handbook. Because of the size of the payload (three large hen's eggs, each of which must weigh between 55 to 61 grams) the minimum length requirement of 650 millimeters, rockets entered in this challenge will be fairly large. The minimum liftoff weight is probably at least 12 ounces and the rocket will probably need at least a 45 to 60 N-sec F motor to achieve the altitude goal.

There are other design variables to be considered including:

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

What all of this means is that, like all engineers, you must engage in an iterative design process. You start with a very rough design, evaluate its performance against the requirements, and change the design progressively until your analysis shows that you have a design that is likely to meet them. Then you build, test, evaluate the success or failure of the test, and adjust the design as required until your analysis and tests show that the performance requirement is approximately met. Initial tests are best done as virtual flights on a computer, with the time-consuming construction and relatively expensive flight testing of an actual rocket saved for the second step.

Remember that this program is also about teamwork; engineers design in teams because complex projects that are due in short periods of time demand some kind of division of labor. There are many ways to divide the labor -- perhaps one person could become expert in computer flight-simulation programs, another in the craftsmanship techniques of model rocket building, a third in launch system design, and a fourth in charge of fund raising. 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/Team Captain to make sure everything fits together at the end so that your complex system will work in flight test. And you need to start early!

Here is a path that you may wish to follow to take you through the design process.

1. Accommodate the payload. Determine what size compartment is required to contain the altimeter and three Grade A large eggs and to cushion the eggs 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 eggs from impact with the walls of the payload compartment or metal hardware including the altimeter in every direction including the sides.

Hint: Put a solid disc of some type between each of the eggs in addition to soft padding, so that the eggs do not slap against each other during the shock of ejection and parachute opening.

2. Accommodate the instrumentation. One of the electronic altimeters specified for the event must be used in your rocket, and will be the sole basis for measuring the rocket's achieved maximum altitude. You may install other additional altimeter-based systems if you wish to control duration or other features, but only an official altimeter type can be used for the official record of achieved altitude and this altimeter cannot be used for anything else. 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.

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). But make it easy to remove, because you will have to remove the altimeter both before and after flight for inspection by event officials. Secure the battery in place (on the APRA) and secure the shorting plug that powers up the altimeter so that neither can shake loose in flight.

3. Decide on a recovery system design approach. Your payload capsule (containing eggs and altimeter) must recover separately from the rest of your rocket, and must use two or more nearly-identical (diameters equal with 2 inches) parachutes to do this. It is the part that is timed for score. The rest of the rocket may use a separate parachute or streamer to recover safely. For your capsule, determine how to trade off among parachute-design features (canopy diameter and shape, number and length of shroud lines, size of center spill hole, etc.) in order to achieve the specified duration of 43 to 46 seconds. Keeping the multiple parachutes on it from tangling with each other and/or tangling with the booster recovery system will be part of the challenge!

4. Learn to use a rocket-design computer program. There are three good rocket-design programs currently available: the commercial RockSim and SpaceCAD programs and the “freeware” Open Rocket program. Such a program is the best way to work through the remaining steps of flight vehicle design on a basis other than trial-and-error. There is no single correct design for this challenge; there are many different combinations of motor types, rocket length and diameter, rocket weight, and recovery system configuration that could lead to a flight altitude of 856 feet and flight duration of 43-46 seconds. A computer program will let you work through the rough possibilities fairly quickly and discard approaches that simply will not work or designs that are not aerodynamically stable. No simulation, however, is exactly accurate. Its estimate of the aerodynamic drag forces on your rocket may be off due to your construction techniques and it may therefore overestimate how high your real rocket will go; the rocket motors you use may perform slightly differently from the notional data for them in the program due to normal manufacturing variations, etc. That's why you still need to (and are required to) test-fly at the end of the design process.

5. Simplicity. The more complex you make your rocket design, the more things it has that can go wrong and the more it will cost both to develop and test. In the real world of engineering, low cost, rapid delivery, and high reliability are what the customer wants. In this Challenge, since your eligibility for the top ten prizes is based on the results of your flight attempts at the fly-off, whatever you fly has to work perfectly the first time. Add complexity (such as clustered rocket motors) only where you need to in order to meet performance requirements. It may turn out that you need to use something complex, but don't assume so from the start.

6. Basic design safety. First and foremost, your rocket must be "stable." Read the Handbook of Model Rocketry chapter on stability if you do not know what this means, and use a computer program to calculate stability if in doubt. Because your rocket will be nose-heavy as a result of the egg and altimeter and its overall length (minimum of 650 millimeters), you should not need extremely large fins -- be conservative and design for a stability margin of at least two "calibers" (Center of Gravity ahead of Center of Pressure by at least two body tube diameters) with the eggs and with loaded rocket motors. Second, make sure that the motor(s) you pick provide enough thrust to give your rocket a speed of 40 ft/sec 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.

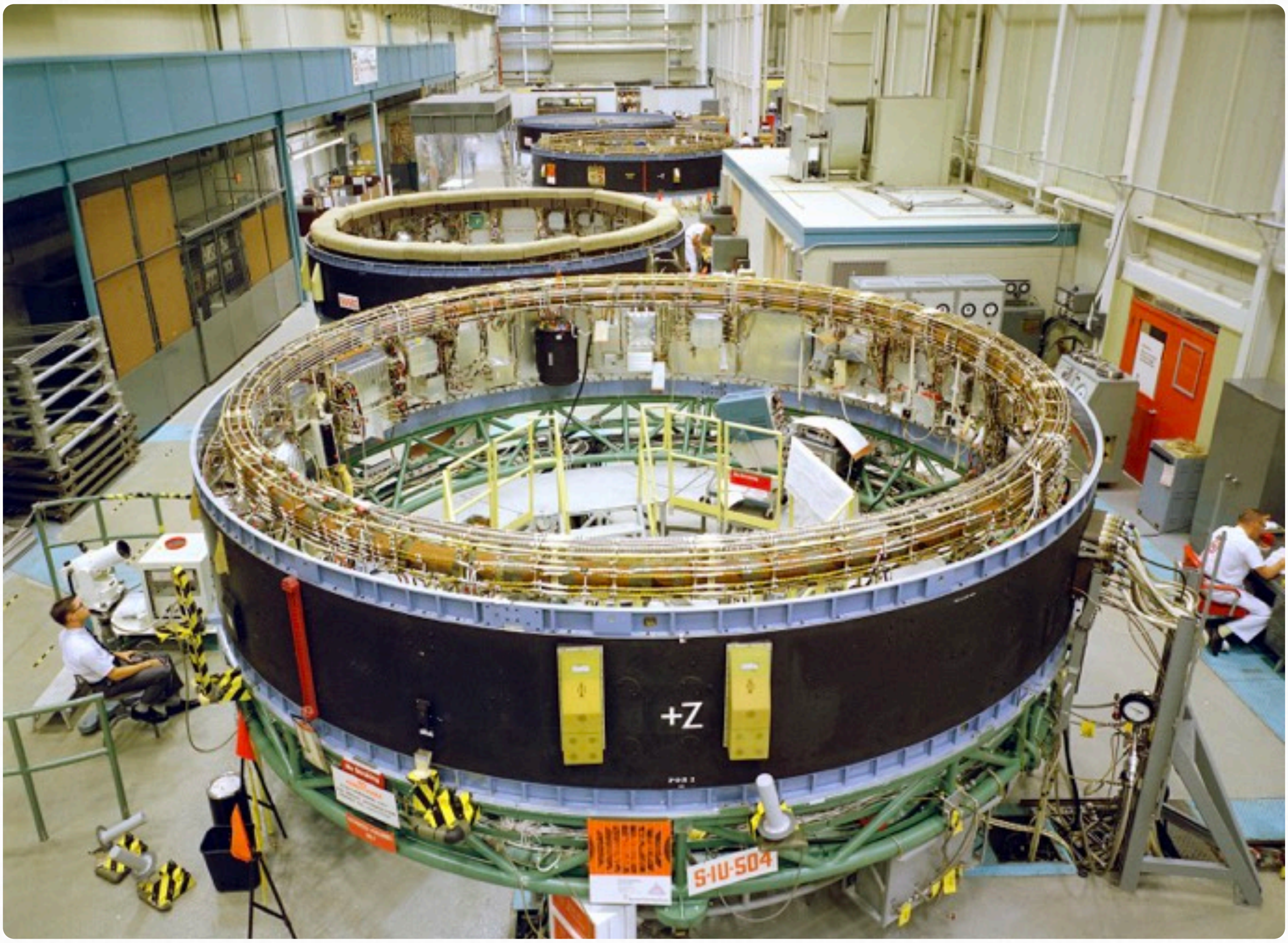
Finally, plan on using a launch rod of at least 6 feet in length and 1/4 inch in diameter or (much better) a rail for flying these heavy rockets -- they will need the length to achieve safe speed and the rigidity to avoid "rod whip" when the heavy rocket is at the end of the launch rod on its way up. While launch rods can be used for local test and qualification flights, all teams must fly from 1-inch rails at the Finals; use of launch rods will not be permitted there.

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 allow ed to fly if they do not. These systems may not use pyrotechnic charges of any type (no Pyrodex or black powder) to trigger deployment, but may use standard igniters to burn through or deploy something.

7. Commercial vs Custom Parts. The flight vehicle must be made by the student team members. You may use commercially-available "off the shelf" component parts (body tubes, nose cones, egg capsules, parachutes, etc.) and may adapt some kinds of rocket kits for the event, or you can scratch-build components if you prefer. Commercial kits or published designs that are made specifically for TARC are not allowed. Having a custom flight vehicle part fabricated by a composite or plastics company or custom wood machining company (even if it is to your design) does not constitute sale of a "standard off the-shelf product" and is not allowed. Using a 3-dimensional printer to make parts is OK as long as the team does all the programming and runs the printer. Having a mandrel fabricated to your specifications that is used to wrap fiberglass on to make your rocket body is OK. In this case, the company is making a tool; you are making the part that flies.

5

Rocket Construction



Instrumentation Unit (IU) components for the Saturn V rocket are assembled at an IBM facility in Huntsville, AL.

Designing a rocket on a computer is important, but in the end you have to actually build it and fly it. There are four key resources available to you for learning the craftsmanship techniques for building a model rocket for TARC. Review the online material and read the applicable chapters of the book before you start trying to put together your rocket. Then build and fly a simple rocket kit (such as the TARC practice kit from Aerospace Specialty Products) before you build your entry.

1. Nine web pages of basic tutorial material on how to build a model rocket on the NAR website at http://www.nar.org/educational-resources/model-rocket-building-techniques/

2. Free online how-to resources from Apogee Components (a 2019 TARC partner vendor) on building model rockets at https://www.apogeerockets.com/New-to-Model-Rocketry#WhatIsARocket

3. A 45-minute instructional video for rocketeers of all ages on all the steps and techniques involved in building and flying a basic model rocket. This instructional video has been divided into six short segments of 4 to 9 minutes duration and posted online by the Aerospace Industries Association on their YouTube site. The six segments are:

- Part 1: How Model Rockets Work www.youtube.com/watch?v=gYh1pWHoQXE

- Part 2: Components of a Rocket www.youtube.com/watch?v=7kAkitKKKlA

- Part 3: Construction www.youtube.com/watch?v=sxQ7vGgXx5Y

- Part 4: Finishing the Rocket's Fins www.youtube.com/watch?v=xS021hCT3LU

- Part 5: Assembling the Rocket www.youtube.com/watch?v=E4GLuSSyBWo

- Part 6: Painting the Completed Rocket www.youtube.com/watch?v=NQFx1qe6zww

4. The NAR's official handbook, the Handbook of Model Rocketry by G. Harry and Bill Stine, which TARC teams can purchase at a discount price of $20 from http://www.nar.org/nar-products/

Below are some common mistakes we have observed in the last sixteen years.

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 four "official" component vendors: Aerospace Specialty Products, Balsa Machining Service, eRockets, or Estes. 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 materials in the right places. Body tubes and launch lugs should be commercially-made, smooth, and strong. Don't try using gift-wrap rolls or other "economy" parts for the main structural member of your rocket, or soda straws for launch lugs. Use balsa wood (or aircraft plywood or basswood) from a hobby store for your fins, probably at least 1/8 inch thickness (for balsa), and make sure that the wood grain lines start on the fin-body glue joint and go outward from it. Be careful about rocket airframe weight management, with this year's payload of 3 eggs you cannot make your rocket too big and heavy without exceeding the liftoff mass limit of 650 grams.

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

6

Rocket Flying

Apollo 4 lifts off for the first test flight of the Saturn V rocket on November 9, 1967, from NASA's Kennedy Space Center in Florida.

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

There is a detailed Powerpoint briefing on how to do flight testing and how to understand and control for all the variables that may affect flight results in the "files" section of the NAR_TARC Yahoo group at https://groups.yahoo.com/neo/groups/NARTARC but here is a summary of its key points:

- Flight testing needs to be systematic – take data, understand what it tells you, and use it to make purposeful adjustments

- Record everything about each flight in a consistent format – rocket weight, flight characteristics, launch device angle, weather; not just altitude and duration

- Use a data-logging altimeter and evaluate the trace after each flight

- Use computer simulations adjusted with the rocket's actual weight and drag coefficient to determine how much weight change will be required to change the altitude the number of feet needed to hit the altitude target

- Adjust your rocket to hit the altitude target, then adjust the recovery device to hit the duration target – then do your qualification flights early in the day

- Figure out based on your data how to adjust your rocket's launch angle for different wind speeds to get a vertical flight and its weight for different temperature conditions to get the right altitude

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 with 12VDC and 18 amps of current through one set of clips, and the launching devices provided will be 6-foot-long, 1-inch rails. Use of launch rods is OK for local practice flying and qualification flights, but rods will not be available or permitted at the Finals. If your design requires something different (such as a tower-type launcher or cluster-motor "clip whip"), you must bring your own equipment and power source. In any case, you will need to have (or borrow) a system for pre-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.

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

3. Launch Site. The launch site for the TARC national fly-off is about 1500 feet by 2500 feet of treeless closely-mowed grassland. If the winds at the Finals are light, recovery will be easy; in windy conditions (above 15 miles/hour), rockets that achieve a 46-sec duration may 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:

o "It's dangerous". Not true -- the NAR handout at Appendix 10 summarizes why this is so,and should be used (along with the NAR Safety Code at Appendix 2) to persuade site owners of this. The accident rate for model rocket flying is nearly zero with exactly zero fatalities caused by the rockets, and it is hundreds of times safer than any of the organized athletic events that use similar open fields!

o "I'm afraid of the liability (lawsuit) consequences if anything happens". If you are a member of the NAR, or if you are a member of a TARC team flying at a launch organized and run by an NAR “section” (club) you have personal coverage of up to $5 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 9 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. See the NAR website at http://www.nar.org/team-america/ for more information. 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 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 eggs installed?

* Are the motor(s) used listed on the TARC 2019 Approved Engine List, and are they clearly not modified in any manner by the user?

* Are the fins and launch lugs or rail buttons attached securely and straight?

* Is the recovery system (shock cords and anchors, parachute material, etc.) sturdy enough to withstand the shock of opening with that rocket?

* Does the design have a positive mechanical means (hook, screw cap, etc.) to prevent any expended motor casings from being ejected in flight?

* 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 ig-

nition is planned); and does the launcher have sufficient length (6 feet is minimum) and stiffness to guide the rocket securely until it reaches safe speed? As a change to previous years, use of launch rods will no longer be permitted at the Finals.

Important note! It is against the law to travel by airliner with rocket motors in your luggage. We will provide information on how to advance-order fly-off motors for on-site delivery.

7

Qualifying and Practice Flights

Apollo 11 crew members Neil Armstrong and Buzz Aldrin train for lunar surface operations in preparation for the first lunar landing.

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

Each team that enters this competition must conduct two NAR-observed "qualification" flights, fill out the attached score form for each one, and return it to AIA. The preferred method for submission of successful qualification flights is via the registration portal at portal.rocketcontest.org. Submitting through the portal will give you instant notification that your score was received. You may also fax the form to 703-358-1133 or email it to QualificationFlights@aia-aerospace.org no later than 11:59 PM EST Monday, April 8, 2019. NAR observers who observe a qualification flight attempt that is not successful (i.e. crash or broken egg) are asked to fax or e-mail the form on that flight directly to the AIA. Plan ahead for weather (rain or wind that "scrubs" a launch day, problems with the rocket's flight, etc.) and do not wait until the last minute to try and fly this flight. Teams must provide their own eggs and timing stopwatches for all qualifying and practice flights; pre-measured eggs and timers with watches will be provided by the NAR at the fly-offs.

Selection of the top 100 teams will be made on the basis of the lowest (best) 100 scores reported on the qualification flight forms. Score for any single flight is the total difference (in seconds and hundredths) by which the average timer-measured flight duration was outside the target range of 43.00 to 46.00 seconds (always a positive number) multiplied by FOUR; plus the total difference (in feet) between the altimeter-reported altitude and 856 feet (always a positive number). The final score for determining Finals eligibility is the sum of the two best (of up to three permitted) scores submitted by a team. Note that any cracking of either of the eggs carried by the rocket is disqualifying.

The top 100 qualifying teams (but with a limit of no more than three from any single school or other sponsoring organization), based on their reported scores, will be invited to attend the competitive "fly-off" event that will be held on May 18, 2019 (alternate fly-off date will be May 19, 2019, 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 12, 2019 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 during the registration process.

An official qualifying flight must be declared before the motors are ignited and 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:

1. 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.

2. 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.

3. Contact someone on the list of volunteer mentors posted on the NAR web site. Many mentors live in places remote from an NAR section.

Obtaining an observer and providing stopwatches is the responsibility of each team. PLAN AHEAD, to find an observer for your qualification flight(s). DO NOT WAIT until late March to try to find someone on a day's notice to observe your flight, and do not expect them to drive a long distance to do so. Upon request, we will send you a roster of every senior NAR member in your state to help you find a nearby qualification observer. Contact us at rocketcontest@aia-aerospace.org if you need this assistance. Not every NAR member is aware of the Team America Rocketry Challenge program, 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.

8

Guidelines for NAR Official Flight Observers

The TARC program and the NAR count on the local NAR flight observers to be impartial and honest in the way that they score official TARC qualification flights, and to understand and enforce the rules and requirements consistently. Here are some guidelines for this duty:

1. **Be an NAR member.** You must be a current dues-paid adult (age 21 or older)

member of the NAR as of the day of a flight in order to observe a flight. Membership in other organizations does not count. This is your responsibility to get right; the team trusts you and has no way to know your status. Joining or renewing online the morning of the flight, before the flight, is OK. We check observer membership status in the NAR database for every score report.

2. **Be impartial.** You cannot be related to any member of the team or employed by the organization that sponsored the team. If you are their mentor (which is permissible, but only if there is no other choice) you must not bend any rules for "your" team.

3. **Report all flights**. Teams only get three official qualification flight attempts. Any attempt must be reported to AIA except as noted in #3 below: by the team if successful, by the NAR observer if a DQ. No do-overs due to disappointing performance, weather issues, etc.

4. **All flights count.** Qualification flights must be declared before motor ignition, and must be counted and reported to AIA if the motor ignites, with the following exceptions:

1. Flights that stick on the launch pad and fire the motor without lifting off do not count.

2. Flights that experience a catastrophic motor failure do not count. Such failures are explosions that blow out either end closure or rupture the casing. Inaccurate delay times, "chuffing" ignition start-ups due to igniter mis-installation, or failures of reloadable motors due to user mis-assembly are not catastrophic failures and flights that experience these still count as official attempts.

3. Flights that land in a place too dangerous for recovery or that drift away and are not recovered on the day of flight do not count, and cannot subsequently be counted even if found, once this basis for non-counting has been claimed by the team or declared (for safety reasons) by the NAR observer.

5. Time accurately. Two people must time the flight, using digital stopwatches accurate to 0.01 seconds, and one of these timers must be the official NAR observer. Timing is from first motion on the pad until the moment the first part of the rocket touches the ground (or tree or building!) or is lost from direct visibility due to distance, terrain, trees, etc. If one timer's

stopwatch malfunctions, use the single remaining time.

6. Report the apogee altitude based on the altimeter's external signal (beeps or flashes) only. Apogee altitudes interpreted off a digital download to a computer post-flight can be used for flight analysis, but the official altitude score must only be what the altimeter beeps or flashes.

7. Disqualify if you have to. If a rocket drops off a part in flight, goes unstable, streamlines in dangerously on recovery, or cracks an egg then the flight must be disqualified. The NAR observer takes custody of the score report for such flights and must send it in to AIA.

9

Resources

Margaret Hamilton, Director of the Software Engineering Division of the MIT Instrumentation Laboratory, stands next to the code she and her team developed for the Apollo Guidance Computer.

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 rocketry skills needed to succeed in TARC or in getting the supplies necessary to participate, including:

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 180 sections or local clubs, for advice and general assistance. You can join NAR online, to get insurance plus NAR's magazine "Sport Rocketry". NAR Technical Services (NARTS) has many technical resources on the hobby, including the official reference handbook for TARC, the Handbook of Model Rocketry by G. Harry Stine.

http://tarc.spacecad.com/ SpaceCAD is an approved simulation software for TARC, and information regarding its use and other rocket design information can be found here.

http://www.apogeerockets.com/Rocket_Software/RockSim_Educational_TARC RockSIM is an approved simulation software for TARC and is the most sophisticated of these software systems; information on its use and other rocket information can be found here.

http://openrocket.sourceforge.net/ "Open Rocket" free downloadable rocket design/simulation software.

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

www.balsamachining.com Balsa Machining Service (BMS), 3900 South Winchester Ave, Pahrump, NV 89048, 800-537-6232. A manufacturer/vendor of body tubes, balsa nose cones, model rocket motors, and other components for model rockets.

http://www.asp-rocketry.com/ Aerospace Specialty Products (ASP), PO Box 1408, Gibsonton, FL 33534. A manufacturer/vendor of body tubes, plastic nose cones, parachutes, transition sections, and a special TARC learner's kit.

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

www.wildmanrocketry.com Wildman Rocketry. Free "Wildman Club" membership for registered TARC teams, providing discount on motor and parts.

http://cart.amwprox.com/ Animal Motor Works. Registered team discounts for rocket motors.

www.estesrockets.com/rockets/tarc Estes Industries, the largest model rocket manufacturer, offers a special parts assortment for TARC, and a discount on D and E motors

http://www.dinochutes.com/ Dino Chutes, a provider of parachutes suitable for TARC

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 Team Activities

Members of the NASA leadership team brief Vice President Lyndon B. Johnson (left) and President John F. Kennedy (center) on plans for the Apollo program.

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

WEEK 1

* Ensure all team data (names, e-mail, etc.) on file with AIA is correct

* Join the TARC Yahoo group http://groups.yahoo.com/group/NARTARC

WEEK 2

* Assign team responsibilities (such as project manager, airframe, propulsion & ignition, launch system, fund raising 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 pro-

vided on YouTube at www.youtube.com/watch?v=gYh1pWHoQXE

* 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 "official suppliers" listed in the TARC Handbook)

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

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, see www.asp-rocketry.com/team-america-rocketry-challenge.cfm

* 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 covering at least 2 rockets and motors for at least 10 test and qualification flights and potentially for travel to the flyoffs.

WEEK 4

* Obtain a comprehensive book on model rocketry, such as G. Harry Stine's "Handbook of Model Rocketry" (available at http://www.nar.org/nar-products/), 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 Perfectflite official altimeter from Perfectflite with your discount code.

WEEK 6

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

WEEK 7

* Using the computer program, conduct flight simulations of your design with various rocket motors on the 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 (preferably with a one-inch rail) to be used with your TARC entry, if you do not have a local rocket club's system available for your use

WEEK 9

* Begin construction of your initial design for your TARC entry

* Locate a NAR Senior (adult) member who can serve as your official observer for your qualification flights, if you do not already have an NAR Mentor who will do this.

WEEK 10

* Develop a pre-flight checklist for your 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 rocket and rerun 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 8 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 1 you should (but are not required to):

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

By March 1:

* Your application for the TARC Outreach Program must be received by this date to receive consideration.

NO LATER THAN April 8 you must:

* Make your final official qualification flight attempt (of up to three permitted) in front of an NAR Senior member observer

* Submit your qualification flight reports to AIA using the Online Portal, or by email

April 12

* Engineering notebooks submissions must be postmarked or emailed to rocketcontest@aia-aerospace.org no later than this date to receive consideration.

* If notified of selection to attend the fly-offs, make reservations at one of the hotels identified by the organizers and conduct fund-raising to cover travel and lodging

* Continue test-flying to fine tune rocket design to target altitude

* If you plan to travel to the flyoff by airline, order rocket motors for flyoff to be shipped to the Finals receiving point at Aurora Flight Sciences or delivered on-site by Finals vendor

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: NAR Model Rocket Safety Code

Apollo 1 crew members practice emergency egress procedures at a recreational swimming pool near Houston's Manned Spacecraft Center.

National Association of Rcoketry - Model Rocket Safety Code

Revision of August 2012

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

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

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

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

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

6. Launcher. I will launch my rocket from a launch rod, tower, or rail that is pointed to within 30 degrees of the vertical to ensure that the rocket flies nearly straight up, and I will use a blast deflector to prevent the motor's exhaust from hitting the ground. To prevent accidental eye injury, I will place launchers so that the end of the launch rod is above eye level or will cap the end of the rod when it is not in use.

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

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

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

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

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: Rocket Motors Approved for TARC 2019

F-1 engine components were assembled by Aerojet-Rocketdyne in Canoga Park, CA.

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 2019 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 TARC; this expansion and any revised list will be communicated to all those teams enrolled in the TARC.

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.

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 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.

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

Motors with “sparky” propellant or with an average thrust higher than 80 N are officially classified as “high power motors” even if their total impulse is in the F power class or below, and such motors are not listed or approved for use in TARC. Motors that are no longer in production are also not listed and may not be used.

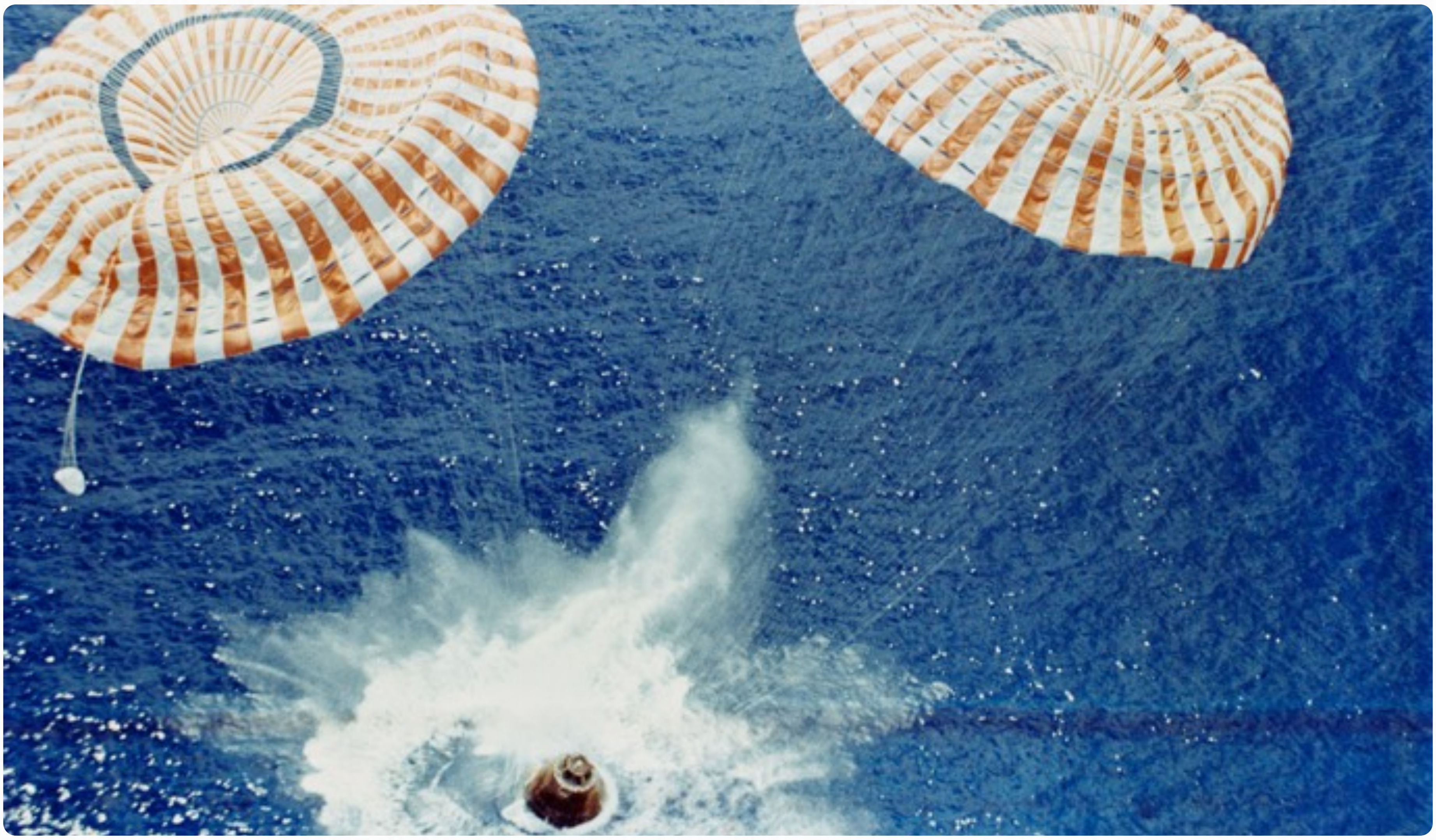
Designation	Manufacturer	Casing Size (mm)	Propellant Mass (grams)	Total Impulse (N-sec.)
1/4A3-3T	Estes	13 x 45	0.8	0.62
1/2A3-2T, 4T	Estes	13 x 45	2.0	1.25
1/2A6-2	Estes	18 x 70	2.6	1.25
A3-4T	Estes	13 x 45	3.3	2.50
A6-4	Quest	18 x 70	3.5	2.50
A8-0, 3, 5	Estes	18 x 70	3.3	2.50
A10-0T	Estes	13 x 45	3.6	1.88
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	Estes	18 x 70	6.5	5.00
C6-0, 3, 5, 7	Estes	18 x 70	10.8	9.00
C6-0	Quest	18 x 70	11.0	8.80
C6-3, 5	Quest	18 x 70	12.0	8.76
C11-0, 3, 5, 7	Estes	24 x 70	12.0	9.00
C12-4, 6, 8	Quest	18 x 70	10.4	9.80
D5-P	Quest	20 x 88	25.0	19.6
D8-0, 3, 5	Quest	24 x 70	22.0	18.6
D9W-4, 7 (R)	Aerotech	24 x 70	10.1	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, 7 (R)	Aerotech	24 x 70	8.9	20.0
D16-4, 6, 8	Quest	18 x 79	12.9	12.4
D21T-4, 7	Aerotech	18 x 70	9.6	20.0
D24T-4, 7, 10 (R)	Aerotech	18 x 70	8.8	18.5

Designation	Manufacturer	Casing Size (mm)	Propellant Mass (grams)	Total Impulse (N-sec.)
E6-4, 6, 8, P	Apogee	24 x 70	22.0	37.8
E9-4, 6, 8, P	Estes	24 x 95	35.8	28.5
E11J-3 (R)	Aerotech	24 x 70	25.0	31.7
E12-0, 4, 6, 8	Estes	24 x 95	35.9	27.2
E15W-4, 7	Aerotech	24 x 65	16.2	35.0
E16-0, 4, 6, 8	Estes	29 x 114	40.0	33.4
E16W-4, 7 (R)	Aerotech	29 x 124	19.0	40.0
E18W-4, 8 (R)	Aerotech	24 x 70	24.7	39.0
E20-4, 7, 10	Aerotech	24 x 65	16.2	35.0
E22SS-13A (R)	Cesaroni	24 x 69	13.4	24.2
E23T-5, 8 (R)	Aerotech	29 x 124	17.4	37.0
E28T-4, 7 (R)	Aerotech	24 x 70	18.4	40.0
E30T-4, 7	Aerotech	24 x 70	17.8	33.6
E30-4, 7	Estes	24 x 70	17.8	33.6
E31WT-15A	Cesaroni	24 x 69	11.2	26.1
E75VM-17A	Cesaroni	24 x 69	10.4	24.8
F10-4, 6, 8	Apogee	29 x 93	40.0	74.3
F12-3, 5 (R)	Aerotech	24 x 70	30.0	45.0
F15-0, 4, 6, 8	Estes	29 X 114	60.0	49.6
F20W-4, 7	Aerotech	29 X 73	30.0	51.8
F21W-4, 6, 8	Aerotech	24 x 98	30.0	55.0
F22J-5, 7 (R)	Aerotech	29 x 124	46.3	65.0
F23FJ-4, 7	Aerotech	29 x 83	30.0	41.2
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, 90	Aerotech	29 x 98	43.1	62.2
F26FJ-6	Estes	29 x 98	43.1	62.2
F27R-4, 8	Aerotech	29 x 83	28.4	49.6
F29-12A (R)	Cesaroni	29 x 83	30.9	54.8

Designation	Manufacturer	Casing Size (mm)	Propellant Mass (grams)	Total Impulse (N-sec.)
F30FJ-4, 6, 8	Aerotech	24 x 90	31.2	47.0
F30WH/LB-6A (R)	Cesaroni	24 x 133	40.0	73.1
F31CL-12A (R)	Cesaroni	29 x 98	25.7	55.5
F32T-4, 6, 8	Aerotech	24 x 90	25.8	56.9
F32WH-12A (R)	Cesaroni	29 x 98	29.9	52.8
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-11A (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
F44W-4, 8	Aerotech	24 x 70	19.7	41.5
F50T-4, 6, 9	Aerotech	29 x 98	37.9	80.0
F50T-4, 6	Estes	29 x 98	37.9	80.0
F51BS-13A (R)	Cesaroni	24 x 101	22.0	49.9
F51CL-12A (R)	Cesaroni	24 x 133	33.0	75.0
F51NT-10 (R)	Aerotech	24 x 70	26.5	55.1
F52T-5, 8, 11 (R)	Aerotech	29 x 124	36.6	78.0
F59WT-12A (R)	Cesaroni	29 x 98	26.1	57.0
F62T-S, M, L (R)	Aerotech	29 x 89	30.5	51.0
F62FJ-10 (R)	Aerotech	24 x 95	32.2	47.6
F63R-10 (R)	Aerotech	24 x 95	27.6	49.5
F67W-4, 6, 9	Aerotech	29 x 89	30.0	61.1
F70WT-14A (R)	Cesaroni	24 x 101	22.5	52.9
F79SS_13A (R)	Cesaroni	24 X 133	40.1	67.8

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.

Appendix 4: Tips for Parachutes



The Apollo 15 Command Module splashes down in the Pacific Ocean after successful completion of the mission on August 7, 1971.

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

For 2019, if your rocket goes up 856 feet and takes 7 seconds after liftoff to reach this altitude and deploy its parachute, and you want the total flight duration to be 44 seconds, then the descent terminal velocity that you want is 856 / (44 – 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. The factors other than size that affect how a parachute performs (how much drag it has) include:

- Weight of the rocket hanging under the parachute
- Shape
- Length of shroud lines
- Number of shroud lines
- Type of material (fabric vs plastic)
- Size of “spill hole” in the center of the parachute
- Interaction with other parachutes where two or more are being used

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

Some of the vendors who make rocket parachutes are listed below. Remember that under the 2019 rules you cannot get a commercial parachute (or any other part of your rocket) custom-made to your specifications, you have to buy and use a standard-stock item available to all.

Dino Chutes, http://www.dinochutes.com/

Aerospace Specialty Products, www.asp-rocketry.com

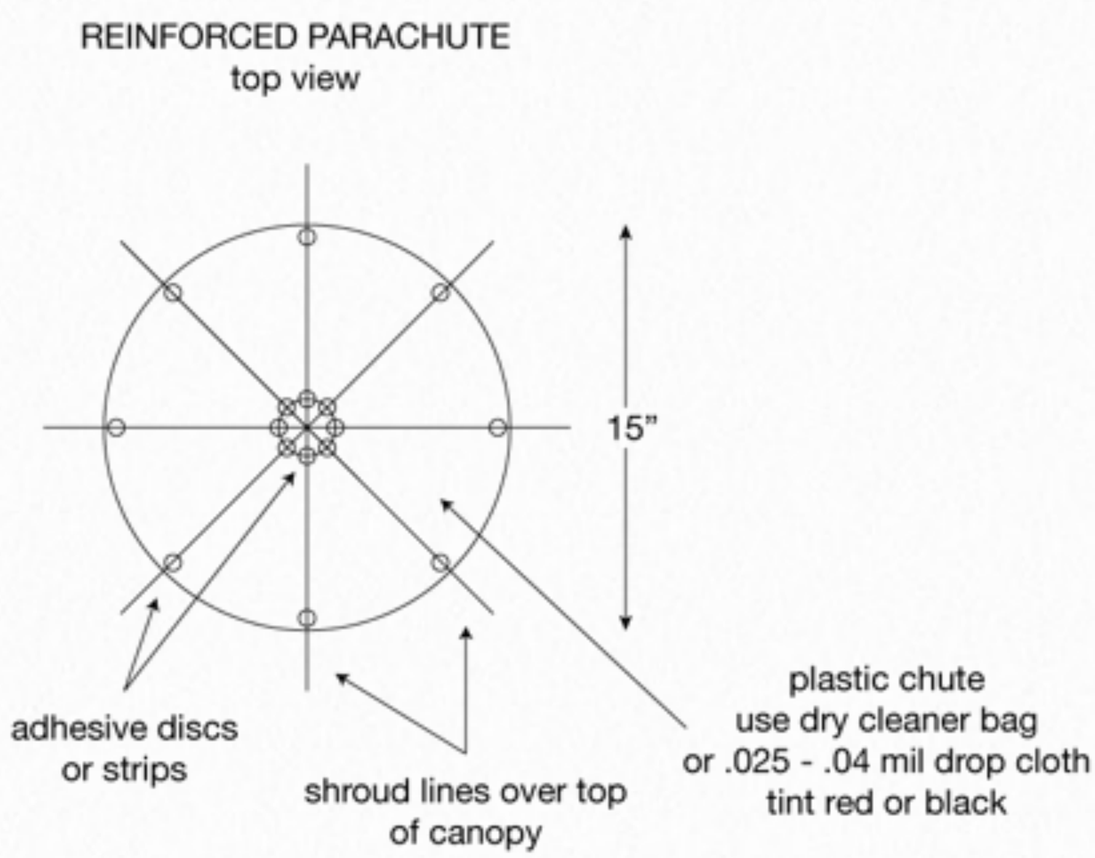
Sunward Aerospace, www.sunward1.com/content/tarc-competition-parachute (also sold via Apogee Components, www.apogeerockets.com)

Rocket Chutes, www.rocketchutes.com

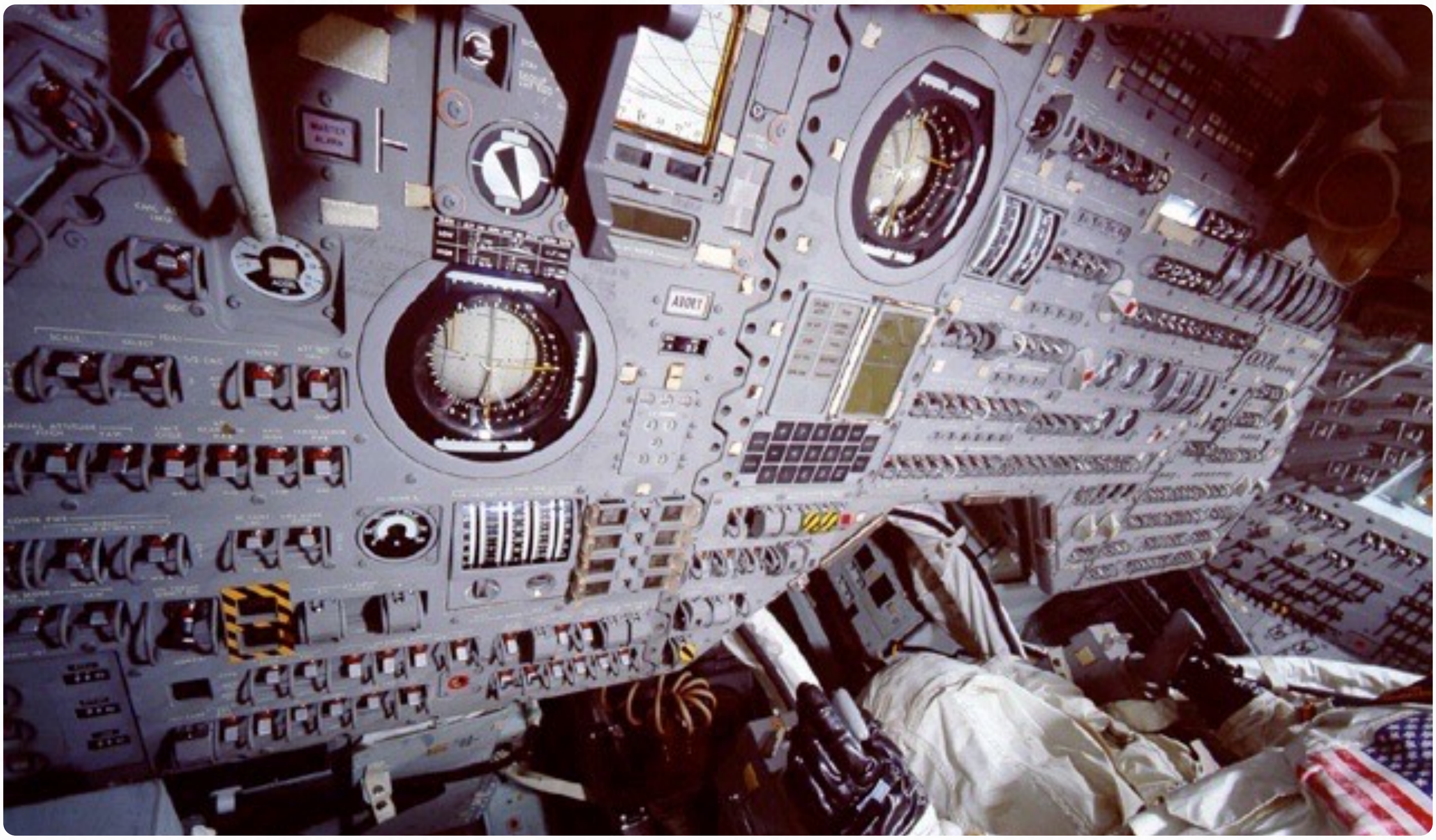
Top Flight Recovery, http://topflightrecoveryllc.homestead.com/ (sold via Balsa Machining Service, www.balsamachining.com)

Making your own parachute is a bit more work than buying one. Model rocket parachutes can either be sewn from nylon fabric or cut out of thin flexible plastic film. Since these parachutes will be absorbing a significant opening shock from the weight of your rocket, if a plastic film is used it needs to be sturdy enough not to tear easily. Black garbage bags (3 mil thickness) are a great material; dry cleaner bags are too thin. And the shroud lines need to be strong (40 plus pounds of breaking strength, nylon or Kevlar) attached very securely, not just by discs of tape on the edges of the canopy. Typically model rocket competition fliers use a reinforcing technique called "over the top shroud lines" where the shroud lines are run across the center of the parachute and held in position with adhesive discs or squares of Band-Aid tape so that these lines, and not the plastic of the canopy material, take the full shock of the parachute's opening.

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



Appendix 5: Perfectflite Maximum Altitude Altimeter



Instrument panel of an Apollo Command Module.

Description: The altimeters approved for use in TARC 2019 (the Perfectflite APRA, Pnut, and Firefly models) are "maximum altitude altimeters" that precisely measure the air pressure at the altitude where your rocket is located every 0.05 seconds and convert this to an above-ground altitude value. The altimeter senses the liftoff of the rocket from the sudden air pressure drop that results from its altitude change, then senses the maximum altitude that the rocket subsequently reaches, and "freezes" and beeps/flashes out this maximum altitude thereafter using a piezoelectric buzzer (or flashing light in the case of the Firefly), until the battery is removed to turn it off. It will not work on flights that achieve less than 160 feet altitude above ground level.   It is accurate to better than 1 percent of the measured altitude, which is far better accuracy than any other altitude-measurement technique readily available to hobby rocketeers.

Using the Altimeter: Read and follow the detailed manufacturer usage instructions provided with the altimeter. Always handle them by the edges when testing or installing to avoid touching any of the circuitry. Never store the device bare in a clear plastic bag; use a small cardboard box, or wrap the altimeter in a paper towel inside a plastic bag. Do not use tape on the altimeter, and use care to keep it clean and dry. Protect it from the fumes and residue created by rocket motors and their ejection charges by installing it in a compartment of your rocket that is totally sealed from motors and charges. Make sure that it cannot "rattle around" in this compartment and get damaged in flight. If the altimeter has a battery holder always mount the altimeter with the spring end of the battery holder facing upward toward the nose end of the rocket. This will avoid compression of the spring and battery disconnection during a very high acceleration liftoff.

The altitude achieved by the rocket (and the altitude read by the altimeter) depends on launch site altitude and air temperature. If you live at an altitude much different from the Team America launch site (600 feet above sea level), or fly when the temperature much different from the temperature on "fly-off" day in May, your rocket will go to a different altitude (and the altimeter will read a different altitude) than it will at the fly-off. You need to compensate for this. The flight-simulation programs (such as RockSim) have user inputs for ambient air temperature which will accurately adjust predicted altitude for its effect on aerodynamic drag on the rocket (rockets go higher in the thinner air of hotter days).

In addition, the computation algorithm inside the altimeter that converts measured air pressure changes during flight into flight altitude is based on the assumption that ambient temperature at the ground is 58 degrees F. If the temperature is different from one flight to the next, the altimeter-calculated altitude will change even if the flights go to precisely the same geometric altitude. This effect is almost exactly one percent per five degrees F – with colder air temperatures leading to higher calculated altitudes (the opposite effect of temperature on aerodynamic drag). No manual post-flight adjustment for temperature is permitted in calculating or recording official altitude scores, so if you want to hit the same altimeter-reported altitude on flights flown at different temperatures you will have to make appropriate allowance in rocket weight for both this altimeter calculation effect and the aerodynamic drag effect.

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

It is better to use multiple (preferably four) static ports (vent holes) instead of just one. Never use two. Very strong wind blowing directly on a single static port could affect the altimeter. Multiple ports evenly spaced around the rocket tube may help cancel the effects of strong wind on the ground, the effects of transitioning through wind shears during flight, the pressure effects of a non-stable liftoff, or the pressure effects that occur due to flipping and spinning after deployment. Ports must be the same size and evenly spaced in line around the tube. For most TARC rockets the best configuration is four 0.02" holes (and no bigger than 1/32") spaced at 90 degree intervals around the circumference of the body tube. Using a larger hole will increase wind noise on the data. It will also increase the likelihood and magnitude of spikes in the data when the rocket separates, which can affect the apogee reading. Since the goal of the contest is consistency, clean data is essential. In order to get the cleanest data, the sampling holes should NOT be oversized, and ejection should be slightly after apogee so any turbulence-induced noise on the data will not spike up over the true apogee height.

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

After power is applied to the altimeter you have approximately 25 seconds to install it and close the rocket before it begins looking for a pressure change to signify launch. If you are handling the altimeter after the 25 second period has elapsed, you could trigger it prematurely. When the altimeter is putting out the periodic “launch ready” chirp/flash it is sensitive to handling, wind gusts, and light in the sensor hole. The altimeter should be safely inside the rocket with the altimeter compartment closed before this occurs.

If the altimeter remains silent post-flight, there are a number of possibilities. First is a weak battery. Battery voltage must be at least 11 volts (for the APRA) or 3.7 volts (for the Pnut). Second is dirty battery contacts or battery holder contacts (on the APRA). If the altimeter starts beeping again when the battery is rotated a turn or two in the battery holder of an APRA it would indicate that the contacts were dirty. Clean with an eraser and blow out debris. Third is that the battery lost contact briefly during flight (again just for the APRA; shock at motor ignition or ejection are the most likely times, especially if the altimeter is free-floating in a compartment and can slam around, which is a bad practice). The altimeter should be padded to protect it from shock, the battery holder should be inspected for cracks from previous crashes which could loosen the battery retention force, and the altimeter should be installed with the spring end of the battery holder facing "up" so the spring is not compressed during acceleration.

Perfectflite Electronics

www.perfectflite.com

P.O Box 29, Andover, NH 03216

(603) 735-5994

Appendix 6: Outreach Program

Apollo 11 crew members Michael Collins, Buzz Aldrin, and Neil Armstrong participate in a celebratory parade following the successful completion of their mission.

The best advocates for TARC are the students that participate in the program! To keep TARC going and growing we need your help to spread the word, so we are offering a prize for the team that is the biggest advocate through this “Outreach Program. Here is how it works:

There is a 101st spot at the National Finals for a team that did not make the Finals score cutoff, but did the best job at spreading the word about TARC to their peers and community. In order to qualify for this bonus spot, the team must:

1) Submit at least two valid qualification flight score reports by the April 8, 2019 deadline. DQs do not count.

2) Submit an outreach application that is received no later than March 29, 2019.

There are more details about the competition on the website at http://rocketcontest.org/about-the-contest/team-outreach-program/

The 101st team selection will be announced on April 12, 2019 in connection with the announcement of the 100 teams that made the Finals by their flight scores. We will also award a special prize at the National Finals to the team with the best overall outreach program. Teams in the top 100 are eligible for this award too, so submit an application, even if you expect to make it to the Finals based on your qualifying scores!

Outreach Program:

- Mission: Spread the word about TARC, about the National Association of Rocketry, and about how awesome science, technology, engineering, and math can be. Use mass contact, recruitment, education, and anything else you can come up to promote the program.

- Scoring: Team outreach efforts will be evaluated holistically by a panel of judges drawn from our educational partners and sponsors. Teams will be evaluated in four areas, with each area equally weighted.

- Quality: How substantively did you engage with your audience? Getting ten people to show up to a rocket-building demonstration would be worth more than tweeting to ten followers

- Reach: How many people did your outreach efforts contact? How many times did you reach them?

- Impact: What happened as a result of your outreach efforts? Did you convince a new team to join TARC, did you interest elementary school students in rocketry, did your School Superintendent come to watch your qualification flight?

- Creativity: What new and novel ways did you spread the word? Have fun with your outreach!

- How to apply: Fill out the application form posted on the website. Send us the application form, along with whatever documentation you collected over the course of the year. Where necessary, include a brief description of how an event met each of the four judging criteria.

You can submit your application to us either by email (rocketcontest@aia-aerospace.org) or by mailing it to:

Jeremy Davis

Aerospace Industries Association

1000 Wilson Blvd., Suite 1700

Arlington, Virginia 22209 USA

There is no specific form or required length for your application. We just want to get a sense of your outreach efforts. In the past we have had teams submit videos, press clippings, newsletter articles, and more. Make sure to submit your application no later than March 29, 2019.

- Prizes: The team with the best Outreach Program score that submitted a valid qualifying score (sorry DQs do not count) but did not make the top 100 teams by flight score will earn a spot to compete in the National Finals—and will be eligible to compete for prize money just like all the other teams. We will also be awarding a cash prize at the National Finals to the team with the best overall outreach program—teams in the top 100 are eligible for this award too.

Education and Outreach Resources:

Here are some other suggested ways to do outreach:

- Mass communication

- Twitter: Make sure you use the ##TARC2019 so we can track you!

- Facebook: Like our page so we know to follow you!

- Instagram: Follow us @RocketContest and tag your posts with #TARC2019!

- Brochures: Make sure you include the TARC website and information about the program and local launches!

- Recruitment

- Get a new team to join, it could be from your school or elsewhere in your community

- Recruit new NAR members. These could even be your teammates!

- Education

- Develop a lesson plan or presentation. Execute your lesson plan for a classroom of students or deliver your presentation. It might be to a community group, your school board, or at a school assembly.

If you decide to make a presentation or lesson plan and need some ideas outside of your TARC experience try some of the resources listed below from the NAR's web-

site's "Teacher and Youth Group Leader Resources" page
http://www.nar.org/educational-resources/
or from the online version of the NAR's educator resource CD at
www.2020vertical.com/nar_edu_cd_dev

- NASA's "Adventures in Rocket Science Educators' Guide" at https://www.nasa.gov/pdf/265386main_Adventures_In_Rocket_Science.pdf which has a range of educational programs and low-cost hands-on activities for young students.

- A whole STEM curriculum for teachers based around using TARC

These rocket manufacturers also have good online resources suitable for use in presentations:

- Estes Industries
http://www2.estesrockets.com/cgi-bin/wedu001P.pgm?p=videos

- Apogee Components
https://www.apogeerockets.com/Teach-with-Model-Rockets?m=quickside

NASA Glenn Research Center has an online directory of rocket education resources at
http://exploration.grc.nasa.gov/education/rocket/shortr.html

The NAR also has resources for you to use in recruiting new NAR members:
http://www.nar.org/join-nar/

Appendix 7: Engineering Notebook

Apollo Mission Controllers were supported by teams of "back room" staffers who advised them on critical decisions made during each mission.

Engineering notebooks are used by aerospace engineers, research institutions, government laboratories, and many other organizations. A good engineering notebook details the entirety of an engineering project, from the initial concept designs to the fully operational system. It documents every step in the concept development, design, construction, and flight testing process. In some cases in professional industry the settlement of an intellectual property dispute may even come down to the records contained in an engineering notebook!

We recommend (but do not require) that every team keep an engineering notebook. In order to provide an incentive and recognition for doing so, we established a competition for the best engineering notebook in 2016 and due to its success are continuing this competition in 2019. The team of 8th graders that won the 2016 flying competition grand prize also won the Engineering Notebook Competition. This was not a coincidence; the detailed documentation and analysis of every step of their process that this team put into the notebook gave them the data and the knowledge to drive their rocket design exactly onto the flight performance targets. Their notebook and another high-quality one are posted as examples on the website page (referenced below) that describes the Engineering Notebook Competition.

A good engineering notebook should allow a person familiar with TARC and rocketry to follow your design process from beginning to end and successfully reproduce a copy of your rocket at any stage in your design cycle. The notebook should be a running record of your design-build-fly process, compiled as you go through the process rather than retrospectively. All entries should be recorded as they occur. Group meetings, discussions, ideas, questions, and notes should be included. The notebook should contain preliminary rocket plans, flight data, evaluation of the flight data, modifications to rocket plans, and the reasoning behind project decisions. Even if your team chooses not submit a notebook for the Engineering Notebook Competition (and it is an optional event that does not directly affect your flight score), we still recommend you keep a notebook. It will help your team order your thoughts and be deliberate about your design and flight-testing processes. It is hard to even make it to the Finals, much less win it, if you do not do some form of record-keeping and analysis that is this systematic.

The detailed rules for the Engineering Notebook Competition are posted on the website at http://rocketcontest.org/about-the-contest/engineering-notebook-competition/. There are specific requirements in these rules for notebook format and structure, so while having a notebook of any kind is good and helpful, if you intend to enter this competition you need to set your notebook up from the beginning in the particular way required by these rules.

Appendix 8: Fund Raising

Apollo astronauts Frank Borman, James A. McDivitt, Donald K. Slayton, Walter M. Schirra Jr., and Alan B. Shepard participate in a Congressional hearing.

Participation in TARC generally requires a team to raise between $500 and $1000, not counting the costs for travel to the National Finals. We want to provide you with some ideas to help you get going in your efforts to raise funds for TARC supplies and other related expenses. Below are some things that other teams have done successfully in the past.

- Host an event and charge admission. Carwashes, concerts, pasta dinner, pancake breakfast, bake sale, garage sale, rocket demonstration, etc. Be creative!

- Participate in organized fund raising activities - school sports concession stands, restaurant fundraiser nights, Krispy Kreme donuts, entertainment books, raffle tickets, candy or gift wrapping, calendars, flowers or wreaths.

- Contact local businesses for donation of parts and materials for the construction of your rocket designs - places such as hobby shops, hardware stores, home supply/construction, etc. Teams in the past have gotten things such as carpeting remnants, foam padding and a multitude of other supplies donated simply by asking. Often local stores may offer you a discount, so be sure to ask about that as well.

- Sell decal logo spots on your rockets. This is a great way to fund your team's participation in the Team America Rocketry Challenge and an easy way for you to give your sponsors something tangible in return for their financial support. Be sure to remind your sponsors that their logos may get national as well as local media coverage if you qualify for the finals or even win the contest!

- Ask people and groups directly to support your team financially. Think about the organizations, businesses or people in your community that are supportive of education and technology. These are good places to start. You may need to do a little research and brainstorm with your teacher supervisor and family members to come up with some good leads. Log into the TARC portal to find a sample fund raising packet.

- Create a team press release and submit it to your local area media (you can find a sample press release in the Team Tool Kit). This is a great way to alert people in your community to your activities and get them interested in what your team is doing!

If you have a unique fundraiser, let us know! Tweet at us (@rocketcontest), post it to our Facebook page, or email it to us at rocketcontest@aia-aerospace.org.

Appendix 9: NAR Rocket-Flying Insurance FAQ

Astronauts Buzz Aldrin, Neill Armstrong, and Michael Collins answer questions for the press prior to the launch of Apollo 11.

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 $5,000,000 per occurrence and $5,000,000 aggregate per annum.

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

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

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

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

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

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

9. Does the NAR insurance cover property damage? If my rocket damages a

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

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

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

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

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

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

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

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

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

18. How do I convince the landowner that this is real insurance backed by a reputable provider, so that he'll let me launch? What benefits can I show him? The NAR Section or a TARC team can deliver an insurance certificate listing the landowner as an additional insured regarding NAR activities on their site. This certificate will provide the site owner with policy facts such as limits, effective dates, and the insurance company providing the coverage. We recommend keeping one copy on file with your records, and providing another copy to your landowner. Your landowner can then contact our insurance agency directly with any questions.

19. A rocket launched is responsible for seriously injuring a human being. The loss of income and medical damages comes to several millions. The NAR covers up to $5 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 a team member who belongs to the NAR is flying, does the team's supervising teacher/adult need to be present? There is no requirement for an adult to be present at a launch. However, we strongly encourage a responsible adult to attend all flying events. In all cases, we strongly recommend that a Range Safety Officer be appointed and on duty at all times.

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

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

Appendix 10: Painting and Finishing Tips

Saturn V components stand ready for final assembly at NASA's Michoud Assembly Facility near New Orleans, LA.

If your team is among the 101 who earn the right to fly at the Finals in May, you'll want to apply a spiffy paint job inspired by the Saturn V vehicle that was used for Apollo 11. A careful reading of the 2019 TARC rule book will reveal this intriguing twist: *your rocket must be painted, or your team will be assessed a 5-point penalty!*

This paint job can take any form you wish. In years past TARC rockets have sported paint schemes as varied as school and sponsor logos, hand-painted artwork, and even simple one-color schemes.

However, we'll be celebrating the 50th anniversary of the Apollo 11 mission, so you'll probably want to have your model resemble the massive Saturn V rocket that flew from Launch Pad 39A on the morning of

July 20, 1969. There's even an opportunity to win a bit of money, as we will be holding an optional contest that will award a cash prize to the model that most closely resembles the Apollo 11 Saturn V, in either outline or finish.

Painting your model to look like the Saturn V may seem like a daunting task, but you can achieve great results by following a simple five-step process.

Prime and sand. Once your model is assembled, spray it with an overall primer coat, either white or grey. Just about any spray primer found at your local hardware store should work, but we've achieved great results using the Rustoleum Light Grey Automotive Primer.

In a wind-free, well-ventilated area, spray the model with several light coats of the primer. Do not try to cover the model with a single heavy coat, as the primer may run and drip. That's not good!

Allow the primer to dry for a couple of days, especially if you live in a humid area. Once the primer has dried (or "cured") sand it lightly with 220-grit sandpaper, followed by 400-grit sandpaper. Wipe the excess sanding dust from the model using a damp rag.

Apply a white base coat. While the paint scheme of the Saturn V vehicle may seem complex, it's actually pretty simple, with everything built on an overall white base coat. Use a quality white spray paint, such as Rustoleum White Gloss Protective Enamel. As we did with the primer, apply the white coat in several light coats rather than one heavy layer. Allow the white base coat to dry for a couple of days before proceeding.

Mask and paint the black roll pattern. Throughout this handbook we've included several photos of the Saturn V launch vehicle. Notable in these pictures is the distinctive "roll pattern" of black blocks painted onto the surface of the rocket. These were used to improve visibility of the launch vehicle in flight, and to make the position of the rocket readily discernible in photographs and film. To help guide you in creating and applying the appropriate markings to your rocket, we've included two drawings of the Saturn V vehicle researched by aerospace historian and NAR member Peter Alway.

It's easy to create your own roll pattern. Just decide where you would like the alternating black and white pattern to appear on your model, then apply masking tape to your model so that the black areas can be painted while protecting the areas you wish to remain white.

It is important to use quality masking tape for this step. We use 3M blue painter's tape, which can conveniently be found at the hardware store very near the spray paint! Butcher paper or aluminum foil can be used along with the tape to protect large areas of your model.

Once your masking is complete, spray the black areas with quality paint. (Again, we like the Rustoleum products.) Importantly, fog the first coat on very lightly! This will help prevent the black paint from migrating under the masking tape. Following your first 'fogged" layer, continue applying the spray paint in light layers. Once you are satisfied with the coverage, carefully remove the masking tape and other covering materials.

Paint the silver details. In examining the photos of real Saturn V vehicles, you'll note that there are notable silver details. In particular, the fins of the rocket are silver, along with portions of the "skirts" to which the fins are attached. Also, the Service Module is silver, just to the aft of the Command Module in which the astronauts were housed. Since your model will likely differ from the outline of a real Saturn V vehicle you can exercise a bit of artistic license in adding some silver details.

The same procedures we used for masking and painting the black areas can be repeated here, using a quality silver spray paint.

Add flags and lettering. The real Saturn V rockets had simple red "UNITED STATES" and "USA" markings on the first and second stages, along with American flags on the first stage. You can approach these markings in a variety of ways, ranging from the simple to the elaborate.

Perhaps the simplest approach would be to simply "freehand" the markings onto your model with red paint and a brush, or with a red paint marker. Small American flag stickers could be purchased to replicate those markings.

A more refined way to do this would be to create digital artwork in Adobe Illustrator, Microsoft Word, or some other composition tool. This artwork could then be printed onto white or clear sticker paper and applied to the model.

A truly professional technique would be to use that digital file to create cut vinyl markings. This can be done using a Cricut vinyl cutter, which a team member or school may own. Alternately, a sign shop may be able to assist with this step. Regardless of the approach taken, your team will have a great looking rocket!

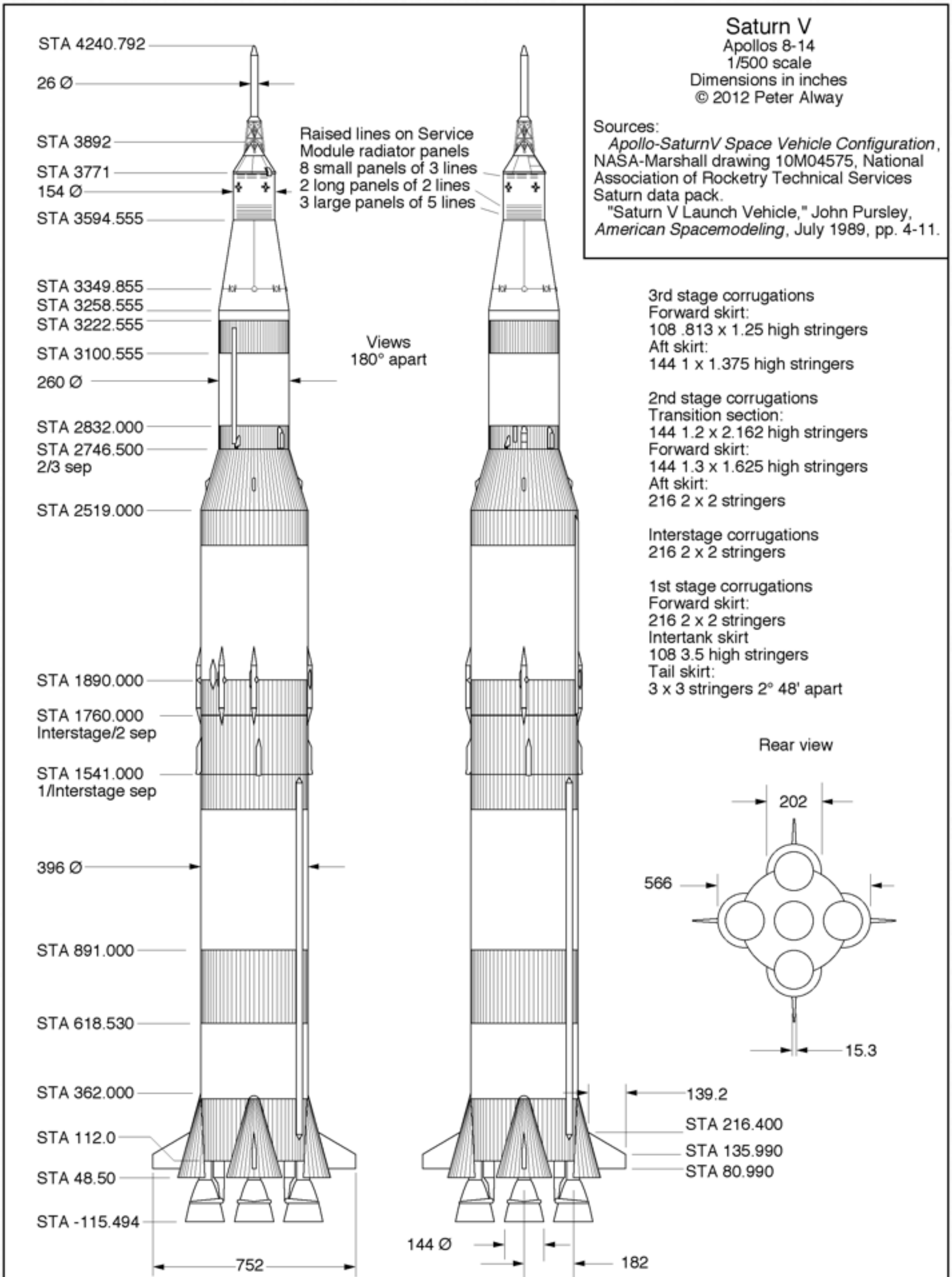
Go visit a real Saturn V if you can! There's no better way to gather ideas for building and painting your own Apollo-inspired rocket than to stand in the shadow of one the these massive vehicles. Here's where the complete remaining Saturn V rockets can be seen:

Houston, TX, on display at NASA's Johnson Space Center.

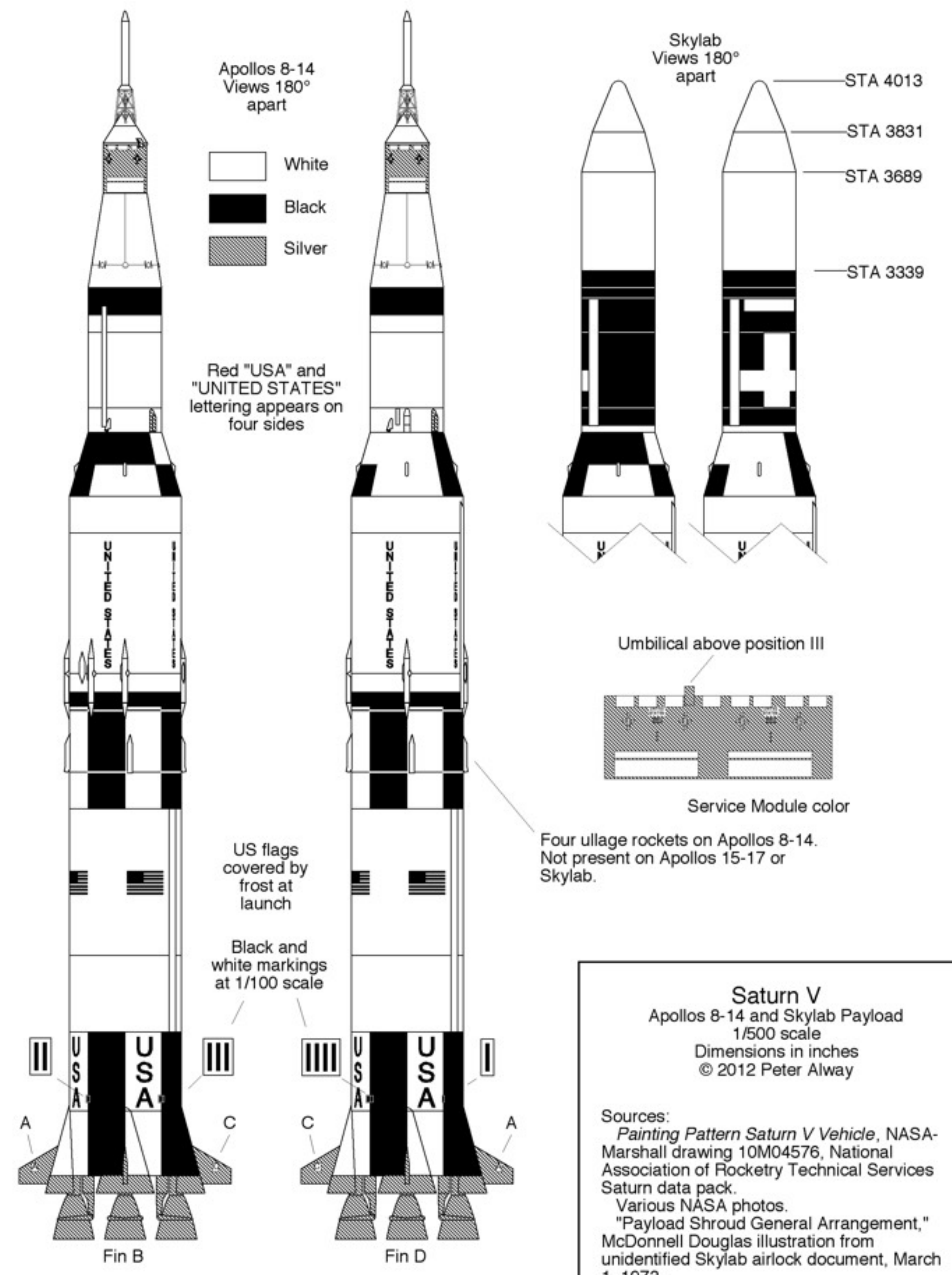
Huntsville, AL, on display at the US Space and Rocket Center. The USSRC also has a full-scale model of the Saturn V on display.

Cape Canaveral, FL, on display at NASA's Kennedy Space Center.

The Saturn V rocket used to launch Apollo 13 to the moon on Launch Pad 39B at the Kennedy Space Center.



Saturn V
Apollos 8-14
1/500 scale
Dimensions in inches
© 2012 Peter Alway
Sources:
Apollo-SaturnV Space Vehicle Configuration, NASA-Marshall drawing 10M04575, National Association of Rocketry Technical Services Saturn data pack.
"Saturn V Launch Vehicle," John Pursley, *American Spacemodeling*, July 1989, pp. 4-11.
STA 4240.792
26 Ø
STA 3892
STA 3771
154 Ø
STA 3594.555
STA 3349.855
STA 3258.555
STA 3222.555
STA 3100.555
260 Ø
STA 2832.000
STA 2746.500
2/3 sep
STA 2519.000
STA 1890.000
STA 1760.000
Interstage/2 sep
STA 1541.000
1/Interstage sep
396 Ø
STA 891.000
STA 618.530
STA 362.000
STA 112.0
STA 48.50
STA -115.494
752
Raised lines on Service Module radiator panels
8 small panels of 3 lines
2 long panels of 2 lines
3 large panels of 5 lines
Views 180° apart
3rd stage corrugations
Forward skirt:
108 .813 x 1.25 high stringers
Aft skirt:
144 1 x 1.375 high stringers
2nd stage corrugations
Transition section:
144 1.2 x 2.162 high stringers
Forward skirt:
144 1.3 x 1.625 high stringers
Aft skirt:
216 2 x 2 stringers
Interstage corrugations
216 2 x 2 stringers
1st stage corrugations
Forward skirt:
216 2 x 2 stringers
Intertank skirt
108 3.5 high stringers
Tail skirt:
3 x 3 stringers 2° 48' apart
Rear view
202
566
15.3
139.2
STA 216.400
STA 135.990
STA 80.990
144 Ø
182



Saturn V

Apollos 8-14 and Skylab Payload
1/500 scale
Dimensions in inches

Sources:

Painting Pattern Saturn V Vehicle, NASA-Marshall drawing 10M04576, National Association of Rocketry Technical Services Saturn data pack.

Various NASA photos.

"Payload Shroud General Arrangement," McDonnell Douglas illustration from unidentified Skylab airlock document, March 1, 1973.

Appendix 11: Sport Rocketry: America's Safe, Educational Aerospace Hobby

NASA Mission Controllers celebrate following the successful completion of an Apollo mission.

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, nonmetallic 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? Over 500 million model rockets have been launched since the hobby's founding and our simple Safety Code procedures have almost totally eliminated accidents and injuries. 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

Team America Rocketry Challenge

2019 Team Handbook

Aerospace Industries Association - National Association of Rocketry

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