Australian Youth Rocketry Challenge

PO Box 84, Browns Plains QLD 4118

Australian Youth Rocketry Challenge

2017

Team Handbook
Secondary Schools

www.rocketcontest.org.au

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PO Box 84, Browns Plains QLD 4118

HANDBOOK

Section 1. INTRODUCTION

The Australian Youth Rocketry Challenge provides school students with a realistic experience in designing a flying aerospace vehicle that meets a specified set of mission and performance requirements. Students work together in teams the same way aerospace engineers do. It is not intended to be easy, but it is well within the capabilities of primary and secondary school students with a good background in science and math and some craftsmanship skills.

The purpose of the Challenge is to design and build a safe and stable model rocket flight vehicle that follows the basic principles of rocketry design and then successfully fly and recover the vehicle.

The following is the basic criteria for the challenge:

- Models must weigh no more than 1500grams at liftoff and must use commercially-made, AYRC safety-certified model rocket motors with no more than 62.5grams propellant weight each and a maximum combined propellant weight of no more than 125grams. Please see attached note regarding motors available for the 2017 challenge.
- Stability of flight and how accurate the flight path is.
- Aesthetics of the rocket and overall presentation.
- Winner is the team whose flight vehicle best meets the all the criteria in a safe and stable flight, and returns undamaged after one flight.

This year's challenge has three major flying events as follows:

- Victoria – Saturday 17/06/2017 (rain date – Sunday 18/06/2017)
- Western Australia – Saturday 24/06/2017 (rain date – Sunday 25/06/2017)
- Queensland (National Finals) - 22/07/2017 (rain date – Sunday 23/07/2017)

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

Teams should begin the Challenge by becoming familiar with the basics of model rocketry. Those who have no experience with how these models are built and flown should begin by reading G. Harry Stine's Handbook of Model Rocketry (available from Australian Rocketry and some bookstores) and by purchasing, building, and flying a basic model rocket kit, available from many model shops or the vendors listed in Section 7, "Resources".

If you live near one of the Australian Model Rocket Society Inc. (AMRS) affiliated clubs, or near experienced members of these clubs who have volunteered to be mentors, you are encouraged to consult with them. The clubs are listed at the AMRS web site, www.rocketry.org.au. These rocketeers can help teach you the basics of how to build and fly a payload-carrying rocket. Typically they can also help you in locating a test-flying launch sites.

Remember neither these "experts" nor any other adult can help you design, build or fly your actual entry. All of this work must be done by the student members on your team.

If model rocketry interests you and you want to be connected to the rest of the people in Australia who are part of the hobby's "expert team," you should visit Australian Rocketry's website for more information at www.ausrocketry.com.au. We also encourage you to join the Australian Rocketry forum at www.ausrocketry.com/forum. Good luck! Design carefully, fly safely, and we hope to see you at Victorian and Western Australian rounds in June and the final fly-off in Queensland in July 2017!

Section 2. 2017 EVENT RULES

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

2. **TEAMS**. The application for a secondary school team must come from a single school or a single Australian incorporated non-profit youth organisation (excluding the National Association of Rocketry, Tripoli Rocketry Association, or any other rocket club or organisation). Team members must be students who are currently enrolled in grades 1 through 12 in an Australian school or home school. Teams may have members from other schools or other organisations. Teams must be supervised by an adult approved by the principal of the school, or by an officially-appointed adult leader of the youth organisation. Minimum team size is two students and maximum is six students. Each student member must make a significant contribution to the designing, building, and/or launching of the team's entry. No part of any of these may be done by any adult, by a company (except by the sale of standard off-the-shelf components available to the general public) or by any person not a student on that team. No student may be on more than one team. The supervising teacher/adult may supervise more than one team. The Australian Youth Rocketry Challenge has a limited number of positions available.

3. **ROCKET REQUIREMENTS**. Rockets may be any size, but must not exceed 1500 grams gross weight at liftoff. They may not be commercially-made kits designed to carry egg payloads with the only modification being the addition of an altimeter compartment. They must be powered only by commercially-made model rocket motors that have 62.5 grams or less of propellant each and are listed on the AYRC Certified Engine List posted on the AYRC website and provided in the AYRC Handbook. They must have only one stage. Any number of motors may be used, but the motors used must not contain a combined total of more than 125 grams of propellant. Loose black powder and other pyrotechnic charges, separate from the certified rocket motors and their as-designed ejection charges, may not be used in rockets as its use requires an explosives license not available to minors. The portion of the rocket containing the egg and altimeter must return to the ground using only one parachute as its sole deployed recovery system. The rest of the rocket may be attached to the portion of the rocket containing the egg, altimeter, and this parachute, or may return separately with a different recovery device as long as it does so safely.

4. **PAYLOAD**. Rockets must contain and completely enclose one raw hen's egg of 57 to 63 grams weight (no more than 45 millimeters in diameter), and must return this from the flight without any cracks or other external damage. Eggs will be issued to the teams by event officials during the fly-off, but teams must provide their own egg for their test flights. Rockets must be allowed to land at the end of flight without human intervention (catching) and will be disqualified if there is such intervention. The egg and altimeter must be removed from the rocket at the end of the flight in the presence of a designated AYRC official observer and presented to that official, who will inspect the egg for damage and will read the altimeter score. Any external damage to the egg is disqualifying.

5. **DURATION SCORING**. Scores shall be based on total flight duration of the portion of the rocket containing the egg and altimeter, measured from first motion at liftoff from the launch pad until the moment of landing or until the rocket can no longer be seen due to distance or to an obstacle. Times are to be measured independently by two people not on the team, one of whom will be an AYRC official, using separate electronic stopwatches that are accurate to 0.01 seconds. The official duration will be the average of the two times, rounded to the nearest 0.01 second. If one stopwatch malfunctions, the remaining single time will be used. The flight duration goal is a range of 48 to 50 seconds. Flights with duration in the range of 48 to 50 seconds get a perfect duration score of zero. Duration scores for flights with duration below 48 seconds will be computed by taking the absolute difference between 48 seconds and the measured average flight duration to the nearest 1/100 second and multiplying this by 3. Duration scores for flights with durations above 50 seconds will be computed by taking the absolute difference between 50 seconds and the measured average

flight duration to the nearest 1/100 second and multiplying this by 3. These duration scores are always a positive number or zero.

6. **ALTITUDE SCORING**. Rockets must contain one and only one electronic altimeter of the specific commercial type approved for use in the AYRC, being any of the following Jolly Logic units: AltimeterOne, AltimeterTwo or AltimeterThree; or Perfectflite units: Stratologger, MAWD, Alt15K/WD, APRA or PNUT. The altimeter must be inspected by an AYRC official both before and after the flight, and may not be modified in any manner. The altimeter must be confirmed by this official to have reset to zero before flight. The altitude of the portion of the rocket containing the egg, as recorded by this altimeter, will be the sole basis for judging the altitude score and this altimeter may be used for no other purpose. The altitude score will be the absolute difference between 850 feet and the altimeter-reported altitude in feet (always a positive number or zero).

7. **FLIGHTS**. All team members must be listed on the original entry form. Only team members on record at AYRC with valid parent consent forms are eligible to receive prizes. Only one flight is allowed per team at the fly-off. 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 AYRC official observer), a replacement flight may be made, with a replacement vehicle if necessary. Flights which are otherwise fully safe and qualified but which result in no altimeter reading or a reading of less than 50 feet will be counted as “no flight” due to false triggering of the altimeter and may be re-flown without penalty. This year’s challenge has three major flying events as follows:

- Victoria – Saturday 17/06/2017 (rain date – Sunday 18/06/2017)
- Western Australia – Saturday 24/06/2017 (rain date – Sunday 25/06/2017)
- Queensland (National Finals) - 22/07/2017 (rain date – Sunday 23/07/2017)

8. **SAFE RECOVERY**. Each part of the rocket must either contain a recovery device or be designed to glide, tumble unstably, or otherwise return to earth at a velocity that presents no hazard. Any entry which has a major part (including but not limited to an expended engine casing) land without a recovery system (lightweight gliding/tumbling tube sections are considered to be a system), or at a velocity that is judged by an event official to be hazardous, due to recovery system absence, insufficiency, or malfunction, will be disqualified.

9. **RETURNS.** Return of the portion of the flight vehicle containing the egg and the altimeter is required by the deadline time established at the beginning of the day's flying. Entries whose egg and altimeter are not returned after flight may not be counted as a qualified flight. If this portion cannot be returned after an otherwise safe and stable flight because it landed in a spot from which recovery would be hazardous (as determined by an NAR official), a replacement vehicle may be substituted for a replacement flight. Return of the other portions of the rocket is required only if there is a question from the AYRC official concerning the safe operation of the vehicle (e.g. a question as to whether the vehicle ejected a part that landed in an unsafe manner). An entry which has any such portion that is not returned when its return is required shall be disqualified.

10. **LAUNCH SYSTEMS**. Teams may use the electrical launch system and the launch pads (with 1 metre long, 3mm and 6mm rods or 1.7 metre 1010 rails) provided by the event officials at the fly-off, or may provide their own system. Systems provided by teams for their own use must be inspected for safety by an event official before use, and must provide at least 1 metre of rigid guidance, including use of a rod diameter of at least 3mm, if a rod is used. All launches will be controlled by the event Range Safety Officer and must occur from the ground.

11. **FREE FLIGHT.** Rockets may not use an externally-generated signal such as radio or computer control (except GPS navigation satellite signals) for any purpose, including flight termination 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. **JUDGING & PLACES.** Scores in the fly-off competition shall be based on total flight duration of the rocket, measured from first motion at liftoff from the launch pad until the moment of landing or until the rocket can no longer be seen due to distance or to an obstacle. The top three final places will be ranked on altitude score, which is the key criteria. In the event of a tie in altitude, three judges will also assess aspects of the rocket and

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flight including build quality, flight performance, recovery and how close the rocket is recovered to the launch pad. Australian Youth Rocketry Challenge reserves the right to make all last and final contest determinations. Judges decision is final and no correspondence will be entered into.

Section 3. ROCKET DESIGN

Designing a rocket that has good stability and flies correctly is not particularly hard to do, although designing one that meets a strict flight profile and does what you want it to do at exactly the right moments is a bit harder. Doing this will require either lots of trial-and-error (not recommended), or smart use of a rocket-design and flight-simulation computer program to get the design “roughly right” first. Modern aerospace engineers do lots of "flight tests" on a computer before they start building and flying hardware--it's quicker and cheaper!

How do you approach the process of designing a flight vehicle? Engineers start with what is a fixed, given quantity -- such as the size and shape of the rocket, payload (if any) and with what the mission performance requirements are. In this case the requirement is to carry a payload of a raw egg that launches correctly and flies straight with correct recovery deployment.

Remember that this event is about teamwork; engineers design in teams because complex projects that are due in short periods of time demand some kind of division of labour. There are many ways to divide the labour -- perhaps one person could become expert in computer flight-simulation programs, another in the craftsmanship techniques of model rocket building, a third in launch system design, and a fourth in charge of fundraising. All the members need to meet and communicate regularly, because what each one does affects how all the others approach their part of the job. You will need to elect or appoint a Program Manager to make sure everything fits together at the end so that your potentially complex system will work in flight test. And you need to start early!

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, and must not exceed 1500grams in weight. And the selection of the vehicle's rocket motors is another major variable. Since certified commercially made model rocket motors (those with 62.5grams and less of propellant each) must be used, you must pick which ones you plan to use from the "Approved Motor List" posted (and updated) at the AYRC website at www.rocketcontest.org.au and in Appendix 3. The list of certified motors is quite long, so there is a wide range of possibilities here as well.

There are other design variables to be considered including: what recovery system to use; how to predict or control flight duration in various weather conditions, especially to land close to the pad; how to secure and protect the delicate payload; what kind of electrical launching device to use; and how will the finishing touches affect the performance of the rocket.

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

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

1. **Accurate flight profile.** Remember that the rules prohibit the use of external man-in-loop controls like radio-control signals that you send to the rocket once it is in flight. This is based on the size and shape of the parachute or other recovery system you select. These factors can be initially simulated on a computer.
    a. With Free Flight (no control system), the flight vehicle can be fairly simple but you must develop strategy for the rocket’s recovery system size, shape, etc. before flight in response to the weather conditions at that time. Undertaking a number of practice flights will help you “calibrate” your adjustments.

2. **Learn to use a rocket-design computer program.** Such a program is the best way to work through the remaining steps of flight vehicle design on a basis other than trial-and-error. There are three good rocket-design programs currently available on the market: OpenRocket, SpaceCAD and Rocksim, all available online (Check the resources link on the AYRC website or section 7 of this handbook). There is no single "right" design for this Challenge; there are many different combinations of motor types, rocket length and diameter, rocket weight, and recovery system size and shape that could lead to a very successful flight. 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; the rocket motors you use may perform slightly differently from the notional data for them in the program due to normal manufacturing variations, etc. Just because even the best simulation says your rocket will go a specific altitude and then descend at a specific speed under parachute does not mean that it will, exactly. It may go to a lower altitude (usually simulations over-estimate the achieved altitude) and descend more quickly because a parachute shroud line got tangled during its deployment. Or it may crash because of a reliability problem such as how you attached the shock cord! That's why you still need to (and are required to) test-fly at the end of the design process.

3. **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 is what the customer wants. In this Challenge, since you only get one flight attempt at the fly-off, whatever you fly has to work well.

   Add complexity (such as clustered rocket motors, staging, etc.) only where you need to in order to meet performance requirements. It may turn out that you need to use one or more of these, but don't assume so from the start.

4. **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. Be conservative and design for a stability margin of at least two "calibers" (Center of Gravity ahead of Center of Pressure by at least two body tube diameters). Second, make sure that the motor(s) you pick provide enough thrust to give your size/weight rocket (including payload) a speed of 15 m/s or so by the time it reaches the end of its launcher, so that it does not "stagger" slowly into the air and tip over and fly non-vertically if there is any wind. Generally, you need a motor or combination of motors whose combined average thrust is at least five times the rocket liftoff weight. As a rule of thumb, make sure that the model's motors' combined average thrust (in units of Newton's, which is how these are marked on the engine casing) is at least 10 times the rocket's liftoff weight in kg. And finally, plan on using a launch rod of at least 1m in length and 3-5mm in diameter or a rail for flying heavier rockets -- they will need the length to achieve safe speed and the rigidity to avoid "rod whip" when the rocket is at the end of the launch rod on its way up.

5. **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, etc.) and may adapt some kinds of rocket kits for the event, or you can scratch-build components if you prefer. You can NOT use a commercially made housing for the egg payload though, this must be designed by yourself. There are many items available that can be used to house an egg, so brainstorming is great before committing to a design. Having a custom flight vehicle part fabricated by a composite or plastics company or custom wood machining company (even if it is to your design) does not constitute sale of a "standard off the-shelf product" and is not allowed. However, having a mandrel fabricated to your specifications that is used to wrap fiberglass on to make your rocket body would be OK. In this case, the company is making a tool; you are making the part that flies.

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

7. **Recovery**. Your rocket may be recovered in several separate sections if you wish. Each section or piece of the rocket must come down safely. A heavy piece (booster stage, nose cone, body section, rocket engine casing, etc.) that falls to earth in a stable, non-tumbling/non-gliding mode at high speed without a recovery system of some kind (parachute, streamer, etc.) is not safe, and flights that have this happen will be disqualified for being unsafe.

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Section 4. ROCKET CONSTRUCTION

Designing a rocket on a computer is important, but in the end you have to actually build it right for it to fly the way the computer says it will. The best resources available to you for learning the craftsmanship techniques for building a model rocket for Australian Youth Rocketry Challenge is the Handbook of Model Rocketry by G. Harry and Bill Stine, which can be purchased separately from Australian Rocketry and some bookstores. Read the applicable chapters of the book before you start trying to put together your rocket. Then build and fly a simple rocket kit before you build your Australian Youth Rocketry Challenge entry.

There are many aspects to constructing a rocket. From observing hundreds of new rocketeers over the last couple of decades, we have learned what common mistakes you need to avoid in this process.

1. Don't over-spend on parts. The basic components of a rocket, such as paper body tubes, balsa fins, and balsa or plastic nose cones are not going to cost you a lot if you design your rocket to use the inexpensive parts that are available from the specialist vendors in the Resources section.

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

3. Use the right materials in the right places. Body tubes and launch lugs should be commercially-made, smooth, and strong. Don't try using paper towel rolls or other "economy" parts for the main structural member of your rocket, or plastic straws for launch lugs. Use balsa wood (or aircraft plywood or basswood) from the specialist vendors for your fins, probably at least 3mm thickness (for balsa), and make sure that the wood grain lines start on the fin-body glue joint. Put at least a 3 times your rocket length piece of 3mm or 6mm wide sewing elastic or other suitable material in your recovery system as a "shock cord" between the nosecone, parachute and the main body of the rocket, to absorb the opening shock of the recovery system.

4. Use the right glues. Body parts should be held together with 2 part epoxy, preferably not white glue. You can use cyanoacrylate "super" glues for repairs, but do not use them for structural construction. You can reinforce fin-body joints with a "fillet" of hobby epoxy if you're worried about fins breaking off. A piece of tissue paper covered in white glue over balsa wood will make balsa fins quite strong.

5. Use the right recovery system. A standard plastic model rocket parachute with 6-8 shroud lines held on using tape discs at the edges of the canopy are usually only suitable for light rockets as heavy rockets, the plastic can split, or the shroud lines will come off. There is many suitable parachutes to return your rocket and egg payload on the specialist vendors websites. Alternatively, use thin nylon parachutes, or thicker plastics, to make the parachute (garbage bin liner bag plastic works). For plastic chutes, run the shroud lines over the top of the chute canopy – do not just attach them at the edges. Make sure that you fold the chute carefully (see the Handbook of Model Rocketry on this) and use plenty of non-flammable recovery wadding to protect it from melting together due to the hot gases of the rocket motor ejection charge.

Section 5. ROCKET FLYING

Once your flight vehicle (rocket) is designed and built, it's time for flight test. This section provides some suggestions for organizing and conducting these tests, and for preparing for your flight attempts at all rounds and the final the fly-off. First and foremost, of course, is safety:
Read and follow the Model Rocketry Safety Code (Appendix 2).

1. Launching system. Consider the launching system to be an integral part of the flight vehicle system design, not an afterthought. Of course, the system has to be electrical and incorporate the standoff distance, safety interlock switch, and other requirements of the Safety Code, and it must be on the ground (no balloons!). But it also has to be able to provide the right amount of electrical current and voltage to fire your rocket motor(s) igniter(s), and it must provide rigid guidance to the rocket until it has accelerated to a speed where its fins can properly stabilize it (generally about 15m/s). At the fly-off, an electrical launch system will be provided that can fire a single igniter of any type, and the launching devices provided will be 1 metre long, 3mm and 6mm rods or 1.7 metre 1010 rails. If your design requires something different (such as a rail or tower-type launcher), you must bring your own equipment and power source. In any case, you will need to have (or borrow) a system for pre-fly-off test-flying. If you do not use a commercially-made "off the shelf" system, you may want to have one team member assigned the job of designing and building the launcher.

2. Of course, you must follow the AMRS Safety Code and not fly when aircraft are nearby or might be endangered or frightened by your flight! As rules of the air may vary depending on your location, we recommend to contact a member of the AYRC to discuss your location and responsibilities.

   The issue of a NOTAM does not remove the responsibility to avoid other air users.

3. Launch Site. The launch sites for the rounds have closely-mowed grassland with a few trees, powerlines and a low traffic density road. If the winds on the date of any round are fairly light, recovery will be easy; in windy conditions (above 10 km per hour), rockets could drift a fair distance. The site you use for flight testing may or may not be large, but note the minimum site dimensions in the Model Rocketry 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 organisation 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. The general main concern expressed by landowners concerning rocket flying:
   1. "It's dangerous". Not true -- the AYRC handout at Appendix 4 summarizes why this is so, and should be used (along with the Model Rocketry Safety Code at Appendix 2) to persuade site owners of this. The accident rate for model rocket flying is nearly zero and it is hundreds of times safer than any of the organised athletic events that use similar open fields!

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 any round or the final fly-off. Any discrepancies noted must be corrected before flight is allowed. **AT ALL ROUNDS, 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:
   a. 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?
   b. Is the rocket stable (CG at least one calibre ahead of CP) with motor(s) and any payload/s installed?
   c. Are the motor(s) used listed on the AYRC Approved Engine List, and are they clearly not modified in any manner by the user?
   d. Are the fins and launch lugs attached securely and straight?
   e. Is the recovery system (shock cords and anchors, parachute, etc.) sturdy enough to withstand the shock of opening with that rocket, and is it large enough to produce a safe landing speed?
   f. Does every separable part of the rocket have a recovery system or a design (e.g. gliding, tumbling) that will ensure it lands at safe, slow speed?

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g. Does the design prevent any expended motor casings or other massive objects from being separated in flight without a recovery system?
h. If there is an electronic in-flight recovery control system, does it have a safety/arming technique (switch or safety plug) that positively ensures it is not capable of causing a pyrotechnic event until the rocket has been installed on the launch pad? Hint: If your rocket is complicated, develop a pre-flight checklist and use it before every launch of you rocket. That's what real engineers do!
i. Does the launch system (if the team provides its own) comply with Safety Code requirements for interlocks and standoff distance; can it deliver enough current to ignite multiple motors at once (if cluster ignition is planned); and does the launcher have sufficient length (min 1 metre is expected) and stiffness (if a launch rod is used, it must be thick enough) to guide the rocket securely until it reaches safe speed?

Important note: Model rocket motors up to G impulse can be transported by road. It is against the law to travel by airliner with rocket motors in your luggage. It is also illegal to send rocket motors via Australia Post, no matter what size.

We will have a motor vendor available on site at the finals for teams who fly in, and will provide information on how to advance-order fly-off motors from the vendor for onsite delivery.

Section 6. PRACTICE FLIGHTS.

Practice-fly early and often. The top ranking teams have an average of 8 practice flights with several crashes and/or lost rockets before they optimised their rockets ready for the fly-offs. None of them waited until the last week before the deadline to do their first test flight; teams that waited this long were universally unsuccessful. Only by test-flying can you master the skills of recovery system deployment, and overall flight reliability and repeatability needed for success.

Finding a launch site is the responsibility of each team, but you do not necessarily have to fly at a rocketry club launch site. You simply need to locate an open field of suitable size, get permission from the landowner, and comply with any local laws regarding model rocketry. As a rule of thumb, most areas you cannot fly above 400feet (121metres) without permission, however this is not the case in all areas. We recommend to contact a member of the AYRC to discuss your location and responsibilities. There is a safety handout in Appendix 4 of this Handbook that you should read and can share with concerned landowners and public safety officials.

For more information on where you can fly, please visit: http://ausrocketry.com.au/launching-model-rockets

Section 7. RESOURCES

This Team Handbook is the most important resource you need to participate in this Challenge. In addition, many answers to questions on contest specifics may be found in the Frequently Asked Questions section at www.rocketcontest.org.au and the Australian Rocketry forum: www.ausrocketry.com/forum. There are many resources that may be useful in learning the basic model rocketry skills needed to succeed in this Challenge or in getting the supplies necessary to participate. These include:

Australian Model Rocket Society Inc. (AMRS), Australia's governing body for model rocketry - www.rocketry.org.au

Australian Rocketry's "School of Rocketry" - www.rocketschool.com.au

How Stuff Works - www.howstuffworks.com/rocket.htm

Software

OpenRocket. **OpenRocket** is a free, fully featured model rocket simulator that allows you to design and simulate your rockets before actually building and flying them. This can be downloaded directly from: http://openrocket.sourceforge.net/

SpaceCAD. SpaceCAD is approved simulation software for Australian Youth Rocketry Challenge, and information regarding its successful use and other useful rocket design information can be found here. www.SpaceCAD.com

Rocksim. RockSIM is approved simulation software for Australian Youth Rocketry Challenge, and information regarding its successful use and other useful rocket design information can be found here. www.apogeerockets.com

Books

There are many good books on model rocketry. Particularly noteworthy is:
"The Handbook of Model Rocketry" by G Harry Stine. This is the classic book about model rocketry.

Australian Specialist Rocketry Vendors

"Australian Rocketry": www.ausrocketry.com.au

Australian Rocketry's "School of Rocketry": www.rocketschool.com.au

Information

"Australian Rocketry Forum": www.ausrocketry.com/forum
This is also the official forum for the Australian Youth Rocketry Challenge.
"Essence Model Rocketry Reviews": www.rocketreviews.com
"Rocketry Online": www.rocketryonline.com

Rocket clubs involved in AYRC 2017

Queensland Rocketry Society Inc. – www.qldrocketry.com

Western Australian Rocket Society Inc. – www.wars.org.au

Melbourne Amateur Rocket Society Inc. – www.rocket.org.au

APPENDIX 1

RECOMMENDED SCHEDULE OF ACTIVITIES FOR Australian Youth Rocketry Challenge 2017 TEAMS

Week 1-7 below is a guideline to progress and milestones that teams should aim for when entering the AYRC.

WEEK 1

- Ensure all team data (names, e-mail, etc.) is filled out and sent to AYRC.
- Get a mentor (Contact AYRC or your local club and organise a guest speaker to come to your school)
- Sign up to the official forum for the AYRC: www.ausrocketry.com/forum
- Obtain a copy of "October Sky". (These are available from www.ausrocketry.com.au)

  ** We **strongly** recommend watching the movie 'October Sky' during the next seven weeks.*

WEEK 2

- Assign team responsibilities (such as project manager, airframe, propulsion & ignition, launch system, fundraising etc.)
- Have the team read this document "Team Handbook" and Frequently Asked Questions from the Australian Youth Rocketry Challenge website – www.rocketcontest.org.au
- Begin research on rocket parts supply sources (starting with the suppliers listed in the Australian Youth Rocketry Challenge Handbook)
- Obtain a comprehensive book on model rocketry, such as G. Harry Stine's "Handbook of Model Rocketry" from Australian Rocketry or bookshop. Have all team members read it.
- Obtain either OpenRocket, SpaceCAD or RockSim design and flight simulation computer programs and have team members learn to use it.
- Purchase inexpensive one-stage rocket kit and motors to familiarize team with rocket building & flying. Compare the various components to that in the Handbook of Model Rocketry or information on the Australian Rocketry Forum.

WEEK 3

- Purchase other equipment such as launch controller and launch rod (if using commercial items).
- Locate a place to fly rockets or contact your local club about flying at a regular launch. Participating rocketry clubs are listed on www.rocketcontest.org.au.
- Develop a plan to raise required funds for purchase of rocket supplies covering a few rockets and motors for 6-10 test flights. We recommend 2 - 3 rockets in case one does not perform correctly. (Yes some rockets do crash)

WEEK 4

- Read the instructions of your rocket thoroughly and then read the instructions of your rocket thoroughly (This is not a typo).
- Once you are comfortable with how the components go together, build your rocket. (Don't rush the build, all great rockets take a little bit of time and patience.)
- Weigh your rocket and record this somewhere easily accessible (Log Books are perfect for this and are available through Australian Rocketry).

WEEK 5

- Develop a pre-flight checklist for your Australian Youth Rocketry Challenge flight and assign responsibility for each of the duties to a member of the flight team.
- Fly your rocket and assess its performance.

WEEK 6

- Using OpenRocket, SpaceCAD or RockSim and the knowledge gained from reading and building your rocket(s), develop other designs and experiment with changing the characteristics of the different components to see how they affect your rocket.
- After using the simulation software, assess your rocket and make sure you are happy with the build.
- Continue to fly your rocket until you are comfortable with all of your pre-flight checks and processes.

WEEK 7

- Create a checklist of everything required for the challenge.
- Pack your rocket/s and anything else that you will need. Don't leave anything behind.

LAUNCH DAY

- Further instructions will be given prior to any of the rounds or the final fly-off as to how the day will operate and when teams will be required to fly.

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APPENDIX 2

MODEL ROCKETRY SAFETY CODE

PLEASE VISIT http://www.rocketcontest.org.au/ for the latest version of the safety code.

AMRS Model Rocket Safety Code
Revision of February 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.
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 table below and in safe weather conditions with wind speeds no greater than 30 km 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.

LAUNCH SITE DIMENSIONS

Installed Total Impulse (N-sec)	Equivalent Motor Type	Minimum Site Dimensions (m)	Minimum Site Dimensions (ft.)
0.00--1.25	1/4A, 1/2A	15	50
1.26--2.50	A	30	100
2.51--5.00	B	60	200
5.01--10.00	C	120	400
10.01--20.00	D	150	500
20.01--40.00	E	300	1,000
40.01--80.00	F	300	1,000
80.01--160.00	G	300	1,000
160.01--320.00	Two Gs	450	1,500

10. **Recovery System.** I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.
11. **Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places.

** AMRS Model Rocket Safety Code is based on the NAR Safety Code and modified for Australian conditions.*

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APPENDIX 3

ROCKET MOTORS APPROVED FOR USE IN THE AUSTRALIAN YOUTH ROCKETRY CHALLENGE 2017

The commercially-made model rocket motors listed below have been subjected to rigorous safety and reliability testing and are the only ones approved for sale in Australia 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 2017 event regardless of any subsequent announced changes to the AYRC's overall official engine certification list. This list may be expanded if new motors are certified during the period of the Challenge; this expansion and any revised list will be communicated to all those teams enrolled in the Challenge.

Download "Motor Data Sheets" from the manufacturer's 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 data points for use in altitude simulation computer programs.

Abbreviation	Full Manufacturer Name
SCR	Southern Cross Rocketry
CTI	Cesaroni Technology Incorporated
Aerotech	Aerotech Consumer Aerospace
Estes	Estes Industries

ROCKET MOTORS APPROVED FOR USE IN THE AUSTRALIAN YOUTH ROCKETRY CHALLENGE 2017

* Currently any available Southern Cross Rocketry, Estes and Quest Black Powder motors are approved.
* CTI and Aerotech APCP motors are also approved as long as the propellant mass is less than 62.5grams.

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APPENDIX 4

MODEL ROCKETRY: THE WORLDS SAFE, EDUCATIONAL AEROSPACE HOBBY

WHAT IS MODEL ROCKETRY?
Model 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 5 million flights per year, used in some 30,000 schools worldwide. Its safety record is extraordinarily good, especially compared to most other outdoor activities, and its safe and inexpensive products are available in some model shops and dedicated vendors in the US, Europe, the UK and most importantly Australia. Model rocketry has inspired at least two generations of young people to pursue careers in technology.

WHAT IS A MODEL ROCKET?
A model rocket is a reusable, lightweight, non-metallic flight vehicle that is propelled vertically by an electrically-ignited, commercially-made, certified, and non-explosive solid fuel rocket motor. Beside very important safety reasons, it is illegal for any rocket hobbyist to mix, load chemicals or manufacture raw propellant; all model rocket motors are bought pre-made, including reusable casing type systems. Model 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.

Model rockets come in two size classes: LOW & MID POWER rockets, which are less than 1500grams in weight, have less than 62.5 gram (125 gram under some conditions) of propellant, and 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 certified individuals.

ARE THESE ROCKETS LEGAL?
Model rockets may be legally flown provided that the entire flight starts and finishes land for which the landowner has given permission. Flights may be made in uncontrolled airspace, which is away from airfields. The guiding principle is that model rockets must not cause a hazard to other air users. This is amplified in CASA’ CASR part 101.

Flights should not be made in mountainous areas or on estuaries, as the rockets could be confused with emergency flares causing an inadvertent call-out of the rescue services.

IS THIS HOBBY SAFE? ABSOLUTELY!!
The hobby operates under the simple and easy-to-follow Model Rocket and High-Power Rocket Safety Codes, which have been fine-tuned by professional engineers and public safety officials to maximize user and spectator safety. The foundations of these Safety Codes are that model 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 model rocket motors are subjected to extensive safety and reliability certification testing to strict international standards.

There has been well over 500 million flights since the hobby was founded. With internationally recognised safety codes, model rocketry’s record shows that it is safer than the majority of other model or outdoor physical activities.

ARE THESE ROCKETS FIREWORKS? NO!!
Most Australian guidelines recognise model rockets as different from fireworks. Fireworks are used by professional operators only. They 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 safety testing of a reusable model rocket, and none of the model rocket’s educational value.

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Fireworks are fuse-lit, an inherently dangerous ignition method that is specifically forbidden in the hobby of model rocketry. Model 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?

There are varying rocketry groups throughout the world and in Australia the governing body for rocketry is the Australian Model Rocket Society (AMRS). The best source of information is through your local club which has plenty of members with many years of experience. Visit the AMRS to find a club near you www.rocketry.org.au. The next best source is the largest rocketry forum in Australia, which we encourage everyone to join and discuss everything relating to your project. www.ausrocketry.com/forum

You can download copies of the Australian Youth Rocketry Challenge handbook at www.rocketcontest.org.au