AURC

Australian Universities Rocket Competition

RULES, STANDARDS & GUIDELINES

2020

THE AUSTRALIAN UNIVERSITIES ROCKET COMPETITION

AYAA

Revision History

Revision	Description	Date
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Operations/Projects Manager	Updated Sections 2.3, 2.5, 2.6 and changed Appendix B to reflect the most current CASA documentation	26/03/2018
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1 INTRODUCTION

The Australian Universities Rocket Competition (AURC) is the first Australian competition of its kind. Beginning in 2018, the AURC (hosted by the AYAA) was designed with the core purpose of providing undergraduate engineers and scientists with the skills required for Australia's growing aerospace industry. The AURC serves to provide passionate students with a practical competition targeted at reinforcing interest and experience in the sector.

Industry-standard space projects require a mix of engineers and scientists from different backgrounds to achieve boldly and innovatively. This is why the AURC promotes multidisciplinary activity in the development of such rocketry projects. It is therefore encouraged that, across all elements of a projects design, AURC teams consider core industry principles such as collaboration.

This event continues the AYAA's legacy of promoting education, awareness and involvement in the aerospace industry to young Australians. The AURC is a step forward in strengthening the Australian space sector and fundamentally serves as *the* means of providing experience to undergraduate and postgraduate university students of all disciplines.

1.1 Background

Australia is no stranger to space; the nation's involvement can be dated back as far as the 1940's when the Woomera Rocket Range was established in South Australia. This site eventually became a landmark in the West as the world's second largest launch and tracking facility. Paul Scully-Power, the first Australian to enter space as an Oceanographer in 1985, and Andy Thomas the first Professional Australian Astronaut acting as payload commander in 1996 are a few famous names in Australia's space adventures.

The students that compete in the AURC will have an extensive opportunity to strengthen their skills in a team environment and in solving industry-pertinent problems. All this under the same constraints of time, budget and standards (regulations) that students would experience in their future careers. Such ideas or industry-preparedness and student participation are core to the AYAA principles, and this will be the second AURC hosted by the AYAA for precisely this reason.

1.2 Purpose and Scope

This document outlines the important standards, rules and guidelines regarding what is and is not acceptable regarding participation in the AURC. If there are any further questions that are not answered by either this document or subsequent resources, do not hesitate to contact an AURC representative whose details can be found on the AURC website.

General guidance for student teams entered in the AURC can be found on the Australian Model Rocketry Society (AMRS) webpage (https://rocketry.org.au/). The AMRS is Australia's premier representative body for rocketry, which advocates for its various member groups and exists to serve the broader rocketry community. Organisers of the AURC highly recommend joining a local AMRS club for mentorship in rocket building. Departures from this guidance may negatively impact a student team's rocket design and launch performance.

1.3 Documentation/Resources

The following document includes standards, guidelines, schedules, or required standard forms. It is the team's own responsibility to ensure they are in the possession of the latest version of the below mentioned resources. The documents listed in Table 1 are either applicable to the extent specified in this document or contain reference information useful in the application of this document. Further clarification can always be sought through the FAQ page, by direct communication with the AURC Committee or by contacting the AURC at aurc@ayaa.com.au

Document	Location
AURC Rules, Standards & Guidelines	AURC Website (https://aurc.ayaa.com.au/competitors-information-2020)
AURC Registration Form	AURC Website (https://aurc.ayaa.com.au/competitors-information-2020)
AURC University Declarations	AURC Website (https://aurc.ayaa.com.au/competitors-information-2020)
AURC Competition Deliverables	AURC Website (https://aurc.ayaa.com.au/competitors-information-2020)
AURC Payload Challenges	AURC Website (https://aurc.ayaa.com.au/competitors-information-2020)
AURC Industry Support	AURC Website (https://aurc.ayaa.com.au/support)
AURC Submission Portal	TBA
AURC Templates	TBA
AURC Leaderboard	AURC Website (https://aurc.ayaa.com.au/competitors-information-2020)
Civil Aviation Safety Regulations 1998: Part 101 – Unmanned Aircraft & Rockets	(https://www.legislation.gov.au/Details/F2017C00742/Html/Volume_3#_Toc493165511)
Australian Rocketry Forum	(https://forum.ausrocketry.com/)
AMRS Safety Information	(https://rocketry.org.au/safety-information/)

1.4 Australian Universities Rocket Competition Overview

Student teams competing in the AURC must design, build, and launch a single-staged rocket with a commercial-off-the-shelf (COTS) solid rocket motor. This rocket must carry a 2 kg payload to a target height of either 10,000 ft or 30,000 ft above-ground-level (AGL). Student teams will need to submit several progress updates and a project technical report throughout the duration of the competition to the AURC organising committee. Teams are strongly encouraged to work with local AMRS rocketry clubs for mentoring and safety input.

The AYAA reserves the right to change the category in which a project is initially entered based on the design presented. Teams are permitted to switch categories as necessary prior to submitting their final Project Technical Report.

1.5 Revisions

AYAA withholds the right to revise the **AURC Rules, Standards & Guidelines**. Minor revisions which do not impact the design goals of the teams competing may be made throughout the year. Major revisions which affect the design goals of competing teams will only be made during the transition between competition years. It is the responsibility of the participating team to ensure that they are correctly using the most recently revised document, available on the AURC website (https://aurc.ayaa.com.au/competitors-information-2020). Student teams will be made aware of revisions (both minor and major) through email to the people listed on the registration submission.

1.6 Project Deliverables

An outline of deliverables can be found in the **AURC Competition Deliverables** document. Failure to meet the deadlines for these deliverables will result in a penalty and potential disqualification, thus it is imperative that all deliverables are met. As per the **AURC Competition Deliverables** document, should a report be submitted late, a 5% per day reduction in your mark for this piece of assessment will apply. In addition, the AURC reserves the right to disqualify teams who consistently do not meet project deliverables or provide unsatisfactory documentation.

All deliverables, unless otherwise noted, must be submitted to the AURC via the AURC website. Each time a deliverable is due, a submission portal will be made available on the AURC website. Progress updates will be scored on engineering professionalism, punctuation, grammar, spelling, technicality and adherences to safety codes. Specific criteria and mandatory content for each progress update will be released in advance of the deadline.

2 TEAM COMPOSITION AND ELIGIBILITY

Teams are encouraged to diversify their educational background when selecting or recruiting new team members. The AURC is designed to be as multidisciplinary as possible, by encouraging students from all programs to take part in the project and work alongside each other. Real world complex projects, like launching rockets with a scientific payload, require efficient teamwork by people from different educational backgrounds and experiences. Every team entered into the AURC is required to abide by the rules and guidelines outlined in the following section.

2.1 Student Team Members

AURC teams shall consist of members who are current undergraduate or graduate students (including master's or PhD students) during the current academic year from one or more academic institutions (e.g. "joint teams" are eligible). Teams may be of any size as long as the majority of students involved in rocket construction are current undergraduates. Students who graduate throughout the course of a competition (e.g. are enrolled at the time of registration but have graduated by the time of competition) remain eligible to compete in the AURC. Students are free to participate in multiple teams, as long as each team is led by a different individual.

2.2 One Project per Team

Only one rocket per team may be submitted for the AURC and can only participate in a single category (it is permissible to change categories as desired prior to the submission of the Final Report). This restriction is to ensure the fairness of the competition such that no team can launch multiple rockets and/or participate in a variety of categories.

Note that multiple teams within one overarching organisation are allowed to compete, subsequently leading to multiple rockets representing a singular university.

2.3 AMRS Group Membership

Information regarding AMRS Group Memberships will be updated in due course.

2.4 Participation Waiver

Each attendee at the AURC launch event must sign the **AURC Participation Waiver.** Importantly, by signing this waiver each individual team member and/or participant acknowledges that the AURC (and AYAA) are not liable for any errors, omissions, acts, failures, or harm caused to or by any individual. This waiver will become available on the website in due course.

2.5 Academic Advisors

The work surrounding the design of the launch vehicle for the AURC is to be completed by students. As such, to ensure that no team has an unfair advantage, all advisors will be required to sign a waiver and return it to the AURC to serve as a document of record stating their involvement with their respective team. Teams that have academics actively assisting in the developments of their payload and or project will be at risk of having severe penalties imposed, including disqualification from assessed pieces up to the competition overall.

It is the responsibility of all teams to ensure that their advisors are fully aware of the level of support they are allowed to provide to students and for waiver forms to be submitted. If teams are uncertain of the level of support they can request from their advisor, please contact the AURC, we are happy to clarify where requested and will evaluate the request on a case by case basis. To ensure this requirement is met; please complete the **AURC University Declaration** forms.

2.6 Disqualification

Teams can be disqualified from the competition if any of the following criteria are met:

- If a team fails to comply with the **AURC Rules, Standards & Guidelines** document.
- If a team is found guilty of cheating or plagiarism.
- Consistent failure to meet deadlines or required quality standards (refer to the **AURC 2020 Competition Schedule**); and
- The breaching of any critical safety protocols.

Note that all teams that are disqualified from the competition are ineligible for any refunds.

2.7 Withdrawal from the AURC

Teams may withdraw from the AURC at any time by sending a formal email to the AURC organising committee with their Team ID in the subject title. Withdrawal may forfeit the competition entry deposit, as stipulated in the competition schedule.

3 HIGH-POWERED ROCKETRY COMPLIANCE

Launch vehicles entered in the AURC are considered rockets of high-power type (HPR) and will be treated as such in compliance with the Civil Aviation Safety Authority (CASA) regulations and all other federal, state, and local laws, rules and regulations. Please refer to the link below for the most recent CASA description of high-powered rocketry. It is the responsibility of a given team to remain informed.

CASA Regulations at the effective date: https://www.legislation.gov.au/Series/F1998B00220
During testing, teams must launch from a CASA approved area (see CASR 101.425) in order to operate high power rockets regardless of the intended altitude. It is best to speak with your local club to discuss what size motors you can fly at their relevant launch sites.

3.1 Tracking systems

Launch vehicles and deployable payload(s) shall carry a radio beacon or similar transmitter aboard each independently recoverable assembly. This is to aid in locating them after launch. Live telemetry implementation is highly encouraged; however, all tracking systems must abide by the Australian Communications and Media Authority (ACMA) Australian Radiofrequency Spectrum Plan.

If a member of your team has an appropriate radio license for additional frequencies, you may use those frequencies with that member's callsign. Using a radiofrequency illegally can result in a federal offence.

Local AMRS clubs can provide guidance on which products to use and where to purchase them. Purchasing equipment from overseas is allowable, however care must be taken to ensure the radio frequency used by the overseas products abide by the ACMA's requirements. The AYAA is not liable for any federal offences that teams may receive during testing.

3.2 Official Altitude Logging

Teams must use an AURC approved altimeter to record the official apogee reached. The AURC will provide a list of approved altimeters at a later date. This list will be available in the document titled **AURC Approved Components.** In addition, you may want to consider GPS for altitudes for the 30,000' flights. Note that all legal GPS units will lose tracking above Mach 1.5. Thus, it is important to verify a lock can be re-enabled after the rocket has slowed down sufficiently. If a deployable payload is used, it is required that the altimeter is integrated into the launch vehicle. Officials will review each altimeter before launch and extract altitude data upon successful recovery of the rocket.

3.3 Electrical Design

For the purposes of this section, 'safety critical' electronics refers to any components that interface with deployment events (such as e-matches) and related flight computers. Any computers or electronics that are purely for data logging or telemetry are not considered safety critical.

- All safety critical components must be dual redundant.
    - For an event (such as a drogue parachute) not to deploy, two or more separate electrical failures must occur. In general, this means you should utilise at least two flight computers, two batteries, and two isolated circuits per deployment event. This way, one failure (such as a crimp disconnecting, a flight computer malfunctioning, or a wire connected incorrectly) cannot cause a catastrophic failure by itself.
    - There is no requirement for redundant components to be dissimilar, however using different brands or form factors further reduces risk due to manufacturing errors or environmental factors.
- All safety critical wiring must abide by the design and manufacturing guidelines listed in Appendix C - Safety Critical Wiring Guidelines.

- All energetics must require two separate events to be armed.
    - For example, an e-match which is controlled by a flight computer may have a separate battery for the flight computer and the e-match. This way, an accidental arming of one component doesn't immediately ignite events, potentially injuring people.

- All energetics arming features shall be externally accessible.
    - This way, the rocket should only be armed when vertical and ready to launch on the pad.
    - Wireless arming systems (such as the use of WiFi or Bluetooth switches) are acceptable.

- All energetics arming features shall be normally open.
    - If a failure occurs in the arming feature, such as a switch falling apart during rocket assembly, the circuit will become open. A closed circuit in the case of an arming failure increases the risk of a surprise deployment.

4 SAFETY GUIDELINES

Safety is a core principle of experimental rocketry. Rocketry involves handling energetic materials such as black powder, solid rocket propellent and in some cases high pressure fluids. As such, it is expected that all teams uphold consistent and sufficient safety standards throughout the competition and at any other launch events. All AURC launch event specific safety guidelines for the AURC will be outlined in the **Launch site Safe Operating Procedures** document.

Note that the first progress report of the competition is to include an assessment of a team's safety procedures. It is recommended that all teams have checklists and procedures. Checklists allow your team to work more efficiently and they can help maintain a minimum level of safety while working on a rocket.

Checklists and procedures allow your team to work step by step and ensure that nothing in your preparations is missed. Having this organised well in advance of the competition can serve in identifying any equipment, tools and PPE that will be required on the day.

Appendix A: Payload Specifications

A.1 Payload Mass and Physical Dimensions

The minimum capacity for the payload shall be no less than two kilograms (2 kg). The definition of a payload is being defined as: *"replaceable with a dead weight of the same mass, with no change to the launch vehicle trajectory in reaching the target apogee, or its successful recovery."* The weight of the avionics package is not included in the payload.

This payload will be assumed present when calculating the launch vehicle's stability. In other words, launch vehicles entered in the AURC need not be stable *without* the required payload mass on-board.
On competition day, the payload will be weighed and a tolerance of 10% will be accepted. Thus, an acceptable payload weight on the competition scales will be at least 1,800 grams due to the potential calibration errors between the participant scales and the competitions. Note, the payload weight can exceed 2,000 grams as this is a minimum requirement and not a target.

In addition, for participants competing in the 10,000 ft. category, the payload must conform to the CubeSat standard and must be of a form factor greater than equal to 1U (i.e 1U, 1.5U, 2U, 3U and 3U+). Teams may deviate from each form factor's respective maximum weight as permitted In Clauses 3.2.10.1, 3.2.11.1, 3.2.12.1, 3.2.13.1 of the CubeSat standard. For participants competing In the 30,000 ft. category, these dimensional constraints for the payload do not apply.

The payload is required to be fully enclosed in the rocket before launch and must always be either secured inside the rocket or autonomously stable outside with the capability of returning home. If the payload will operate autonomously to the rocket and return home, evidence of the payload's capability to do this must be provided prior to the launch day. Further detail regarding payload scoring will be outlined In the **AURC 2020 Competition Deliverables** document.

For teams competing in multiple payload challenges, the challenges may be separated Into Independent payload modules so long as the total weight of the modules complies with the minimum weight requirement. Additionally, for teams competing in the 10,000 ft. category with multiple payload challenges in separate modules, each module must conform to the above CubeSat dimensional constraint.

A.2 Payload Functionality

The payload is required to be functional. Payloads are used as a scientific experiment or technology demonstration and will be evaluated for awards by sponsors as part of a payload challenge. Payloads are judged based upon the criteria specific to the challenge a team enters. Further details regarding the challenges will be made available in due course.

A.3 Payload Location and Interface

Whilst the location and integration mechanism of each team's payload is subject to a team's design, competition officials will be required to weigh the payload independent of the launch vehicle structure and associated flight systems. Thus, it is necessary that a payload is removable from the launch vehicle.

A.5 Restricted Payload Materials

Due to CASA regulations, there is a restriction on the type of materials that can and cannot be used with a payload. It is necessary that the payload will never carry live animals (with the exception of insects) or any material that is intended to be flammable, explosive or harmful. In addition, radioactive materials must be permitted by a competition official and signed off. If approved, materials must be fully encapsulated and must be restricted to 1 μSv or less of activity.

Appendix B: High Power Rocket Safety Code

1. **Certification.** I will only fly high power rockets or possess high power rocket motors that are within the scope of my user certification and required licensing.
2. **Materials.** I will use only lightweight materials such as paper, wood, rubber, plastic, fiberglass, or when necessary ductile metal, for the construction of my rocket.
3. **Motors.** I will use only certified, commercially made rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer. I will not allow smoking, open flames, nor heat sources within 8 metres feet of these motors.
4. **Ignition System.** I will launch my rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after my rocket is at the launch pad or in a designated prepping area. My launch system will have a safety interlock that is in series with the launch switch that is not installed until my rocket is ready for launch, and will use a launch switch that returns to the "off" position when released. The function of onboard energetics and firing circuits will be inhibited except when my rocket is in the launching position.
5. **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.
6. **Launch Safety.** I will use a 5-second countdown before launch. I will ensure that a means is available to warn participants and spectators in the event of a problem. I will ensure that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table, shown in Table 1. When arming onboard energetics and firing circuits I will ensure that no person is at the pad except safety personnel and those required for arming and disarming operations. I will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable. When conducting a simultaneous launch of more than one high power rocket I will observe the additional requirements of AMRS Safe Launch Practices.
7. **Launcher.** I will launch my rocket from a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and that is pointed to within 20 degrees of vertical. If the wind speed exceeds 8 km (5 miles) per hour. I will use a launcher length that permits the rocket to attain a safe velocity before separation from the launcher. I will use a blast deflector to prevent the motor's exhaust from hitting the ground.

I will ensure that dry grass is cleared around each launch pad in accordance with the accompanying Minimum Distance table, and will increase this distance by a factor of 1.5 and clear that area of all combustible material if the rocket motor being launched uses titanium sponge in the propellant.

8. **Size.** My rocket will not contain any combination of motors that total more than 40,960 N-sec (9208 pound-seconds) of total impulse. My rocket will not weigh more at liftoff than one-third of the certified average thrust of the high-power rocket motor(s) intended to be ignited at launch.

9. **Flight Safety.** I will not launch my rocket at targets, into clouds, near airplanes, nor on trajectories that take it directly over the heads of spectators or beyond the boundaries of the launch site, and will not put any flammable or explosive payload in my rocket. I will not launch my rockets if wind speeds exceed 32 km (20 miles) per hour. I will comply with the Civil Aviation Safety Authority airspace regulations when flying, and will ensure that my rocket will not exceed any applicable altitude limit in effect at that launch site.

10. **Launch Site.** I will launch my rocket outdoors, in an open area where trees, power lines, occupied buildings, and persons not involved in the launch do not present a hazard, and that is at least as large on its smallest dimension as one-half of the maximum altitude to which rockets are allowed to be flown at that site.

11. **Launcher Location.** My launcher will be 450 metre (1500 feet) from any occupied building or from any public highway on which traffic flow exceeds 10 vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.

12. **Recovery System.** I will use a recovery system such as a parachute in my rocket so that all parts of my rocket return safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

13. **Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places, fly it under conditions where it is likely to recover in spectator areas or outside the launch site, nor attempt to catch it as it approaches the ground.

Installed Total Impulse (Newton-Seconds)	Equivalent High Power Motor Type	Minimum Diameter of Cleared Area (m / ft.)	Minimum Personnel Distance (m / ft.)	Minimum Personnel Distance (Complex Rocket) (m / ft.)
160.01 -- 320.00	H	15 / 50	30 / 100	61 / 200
320.01 -- 640.00	I	15 / 50	30 / 100	61 / 200
640.01 -- 1,280.00	J	15 / 50	30 / 100	61 / 200
1,280.01 -- 2,560.00	K	23 / 75	61 / 200	91 / 300
2,560.01 -- 5,120.00	L	30 / 100	91 / 300	152 / 500
5,120.01 -- 10,240.00	M	38 / 125	152 / 500	305 / 1000
10,240.01 -- 20,480.00	N	38 / 125	305 / 1000	457 / 1500
20,480.01 -- 40,960.00	O	38 / 125	457 / 1500	610 / 2000

Table 2: Minimum Distance Table --

Appendix C: Safety Critical Wiring Guidelines

This appendix is based upon Spaceport America Cup's 2019 Rules and Requirements.

C.1 Introduction

With the aim of supporting recovery reliability and overall safety, this white paper sets out guidelines for all safety critical wiring. This is defined as wiring associated with drogue (or other drag device) deployment, main parachute deployment, and any air-start rocket motors. The wiring techniques described here are optimised for inspectability and ease of field repair. All non-critical wiring is outside the scope of this white paper

C.2 Wiring Guidelines

1. All wire should be stranded, insulated, 22 AWG or larger. Strands should be copper, plated with either silver or tin (entire wire, not just the ends).
    - 1.1. When an off-the-shelf component includes flying leads, those leads may be used unmodified. For example, an E-match may contain solid wire, a battery connector may integrate 26 AWG wire, etc.
    - 1.2. Stranded wire of sizes smaller than 22 AWG may be used only when needed by an off-the-shelf component. For example, if the terminal block on an altimeter is sized to accept 24 AWG wires then that is the size of wire that should be used for that portion of the circuit.
    - 1.3. Wire strands should never be removed in order to allow a wire to fit into a smaller hole or terminal. Use smaller wire for this purpose.
2. Wire should be stripped only with a wire stripping tool of the correct gauge. Any severed strands should be cause for rejection.
    - 2.1. The best wire stripping is achieved with thermal strippers and Teflon/Tefzel wire, however these are not absolutely necessary. PVC-insulated wire is acceptable and may be stripped with thermal strippers
    - 2.2. Personnel using a new stripper for the first time should practice on a piece of scrap wire the same gauge and type will be used. Strip a short length and then strip more insulation from the same wire. If you can now see scratches or nicks in the wire strands from the first strip, something is wrong with either tool or technique.
    - 2.3. Pocket knives and teeth are right out!
3. Each end of a wire should be terminated in one of the following approved methods, with exceptions in Paragraphs 4 and 5 below:
    - 3.1. Crimped into a crimp terminal (preferred). This includes crimp terminals on multi-conductor connectors such as 9-pin D-sub connectors (see table below).
    - 3.2. Screwed into a binding screw terminal (acceptable).
4. Wires should be terminated into a terminal block, only if a piece of off-the-shelf equipment (i.e. an altimeter) has built-in terminal blocks and so there is no other choice. Two-piece terminal blocks must be positively secured together – friction fit is insufficient.
5. Wires should be terminated by soldering, only if a piece of off-the-shelf equipment (i.e. an arming key switch) has built-in solder terminals and so there is no other choice.
    - 5.1. There's nothing wrong with solder, of course. The issue is that the reliability of a solder joint cannot be established by visual inspection alone. There are a number of process

parameters (temperature profile, solder alloy, flux, gold removal, etc.) that must be well controlled to give reliable results and these cannot be inspected post-fact.

6. 6. All crimp operations should be performed with the correct tooling, using crimp terminals sized for the appropriate wire gauge. Where multiple wires are crimped into a single terminal, calculate the effective gauge (for example, two 22 AWG are effectively 19 AWG).
   - 6.1. Crimp tooling should not be improvised from pliers, vices, or other incorrect tools. Crimp features of multitools (Leatherman, Gerber, etc) should not be used.
7. Terminals with insulated plastic sleeves (usually colour-coded to indicate barrel size) should not be crimped.
   - 7.1. If a terminal is supplied with an insulated plastic sleeve, it should be removed prior to use. It may be necessary to adjust the crimp tooling to get a tighter squeeze.
   - 7.2. The crimp quality of insulated terminals is difficult to inspect. There is normally no need for insulation when terminals are mounted properly in barrier blocks. If insulation is needed, add clear heat-shrink tubing.
8. When a bare wire is held down by a binding screw terminal the wire should make a 180 degree hook, and strands must be visible exiting the screw head. Only one wire should be permitted per screw. The wire bend should be clockwise, so that it will tighten as the screw is torqued.
9. When ring or spade terminals are held down by binding screw terminals, a maximum of two terminals are allowed per screw.
10. A maximum of three wires should be crimped into a single terminal barrel. Butt-splice terminals are considered to have separate barrels in each end.
11. If two or more wires must be joined, one of the following approved methods should be used: Note: for the purposes of this white paper, “barrier blocks” have screw terminals between insulating barriers, and often have metal jumpers between screws to allow electrical connections of screws across the block. The screws are usually larger than those in terminal blocks and are easily visible for inspection. The screws are designed to allow the connection of bare wires (turned in a clockwise “J” shape) or ring terminals.
    - 11.1. Crimp a ring terminal onto each wire, and then screw them into a barrier block. Add approved barrier block jumper pieces if many wires must be joined.
    - 11.2. Screw bare wires under binding head screws in a barrier block. Add approved barrier block jumper pieces if many wires must be joined.
    - 11.3. Crimp the wires into an un-insulated butt-splice terminal, and then insulate with clear heat-shrink tubing.
    - 11.4. Any wire-twisting splice method (including wire nuts) is explicitly forbidden. Forget everything you know about household wiring. Houses don't see launch vibration!
12. All insulating tubing (usually heat-shrink) should be transparent.
    - 12.1. This allows inspection of the underlying hardware. It's a good habit to get into.
13. No tape, glue or RTV should be used to insulate or bundle any element of the wire harness.
    - 13.1. If you have followed these guidelines properly there should be no exposed metal in need of insulation.
    - 13.2. Tape (especially PVC electrical tape) is messy and uninspectable
14. The following rules apply to connectors:
    - 14.1. They should use crimp contacts, as soldering has been forbidden.
    - 14.2. They should use a positive locking mechanism to keep the two halves mated under vibration and tension. Friction fit alone is not acceptable.

14.3. Plastic connector latches should not be used (such as found on automotive applications), but circular connectors with plastic coupling nuts are acceptable.

15. 15. Individual wires should be bundled together to make a harness (factory multi-conductor wiring in a common outer jacket is also acceptable). The safety critical harness should be kept separate from the payload harness (if any). Bundling should be accomplished by:

 15.1. A light twist (for mechanical reasons only, no EMC mitigation is intended).

 15.2. Short (1 cm) lengths of clear heat-shrink tubing or zip-ties every 5 cm.

 15.3. Wire mesh sleeving, provided it allows for inspection of the wiring inside.

16. The harness should be supported by plastic P-clamps. It should not be permitted to touch any sharp edges or screw thread.

17. All items that are connected by the harness (barrier blocks, sensors, batteries, actuators, switches, etc) should be rigidly fixed to the rocket structure so that they cannot move. Rigid fixing implies attachment with threaded fasteners or a solid glue bond. Cable ties and/or tape are not acceptable examples of rigid fixing.

18. No wire should be tight. All wire must have some slack, demonstrated by a curve at its termination.

19. Batteries should be connected appropriately:

 19.1. 9V transistor batteries should be secured in clips, and connected using proper snap terminals.

 19.2. Gel-cell batteries should be secured with clamps, and connected using "faston" crimp terminals.

 19.3. Cylindrical batteries (AAA, AA, C, D, etc) should be mounted into commercial holders. The holders should be rigidly secured to the structure, and the batteries should then be strapped into the holders.

C.3 Circuit Board Guidelines

All heavy components should be staked. All IC sockets and press-fit contacts should be positively restrained so that they cannot de-mate under vibration. Provided they are done right, wire-wrap, through-hole solder, and surface-mount solder are all acceptable fabrication methods. Solderless breadboard (aka plug-in breadboard) should not be used.