

Perth Advanced Rocketry Club Range Operations Manual

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1. **Definitions and Abbreviations**

The definitions given in this section are for practical guide purposes. In some cases strict accuracy has been compromised in favour of clarity and brevity.

1. **Scope and Audience**

This document covers the preparations and operations procedures for a Model Rocket or High Power Model Rocket Range. It does not cover competition procedures, or other similar matters.

This manual has been written for Western Australian conditions, and it is envisaged that it will serve as a guide for the writing of manuals designed for other states.

At the time of writing, laws governing the use of model rockets vary widely from state to state. Before utilizing this manual outside of Western Australia, you must confirm its suitability with the local authorities, and make such amendments as are required.

The target audience is Club officials and members intending to use or prepare a Range.

The terms Model Rocket Engine and Model Rocket Motor are used interchangeably throughout this document.

2. **General**

Certification

Qualification to use and fly model rockets of a given power and size. Certification levels are determined by the A.R.A. or equivalent organizations.

Static Stability

The measure of the degree to which an object is held in equilibrium, at rest, when acted on by outside forces. Typically measured by the relationship between the Centre of Pressure and the Centre of Mass measured in units of object diameter. Static stability is used in model rocketry for most stability calculations.

Centre of Mass

The point at which the object will balance.

Centre of Pressure

The point at which forces acting on the cross-section of the object balance.

Hold

A pause in a countdown.

Abort

A cancellation of a launch.

Apogee

A maximum height above the earth.

Newton-Second

A force of one Newton applied for one Second. (NS)

Motor Class or Power Class

A means of identifying the general power level of a model rocket engine. The basic model rocket engine is defined to be Class A - with a total maximum impulse of 2.5NS. Each higher class (B,C,D,etc) doubles the maximum power of the engine, whilst each lower class (1/2A,1/4A) halves it.

Impulse

The total energy provided by a motor, measured in Newton-Seconds.

Motor Type

A specific engine variety, specified in terms of Class, Average Thrust and Delay Time after burn-out.

Newton

The force required to accelerate 1kg by 1m/s/s. (N)

CASA

The Civil Aviation Safety Authority.

Airservices

Airservices Australia.

Waiver

A document detailing an exception to a regulation; usually referring to a permit to use airspace to a given altitude.

Ceiling

The maximum height permitted.

Visible Range

The maximum distance at which object can be seen by the naked eye.

AGL

Above Ground Level.

ASL

Above Sea Level.

Cloudbase

The minimum altitude occupied by clouds.

Controlled Airspace

Any airspace above 300' AGL

LWR

Lift to Weight ratio; the ratio between the initial thrust of a motor and the mass of the model.

Member

A current financial member of the Perth Advanced Rocketry Club, the Australian Rocketry Association, or organization affiliated with the Australian Rocketry Association.

3. **Equipment**

Launch Pad

A device designed to hold a rocket in an upright position prior to flight.

Launch Controller

An electronic device used to control the ignition of model rocket motor.

Model Rocket

A device propelled by a self-contained reaction device that is commercially prepared and recovers in a safe and controlled manner. Model rockets may use motors up to class D, and mass no more than 500g. Model rockets are non-metallic or contain minimal metallic parts in non-structural roles.

Large Model Rocket

A model rocket that masses up to 1500g, and uses any motor with a propellant mass less than 62.5g. To date, this limits the power class to G.

High Power Model Rocket

A model rocket, that masses over 1500g and uses motors with more than 62.5g of propellant. Upper power class is O.

Model Rocket Motor

A pre-built or pre-fabricated self-contained reaction device. Pre-fabricated types must be used as directed by the manufacturer, without modification.

Approved Model Rocket Engine

A model rocket motor that has been approved for use by a suitably qualified body. Example bodies are:

- Australian Rocketry Association
- National Association of Rocketry (U.S.A.)
- Tripolli Rocketry Association (U.S.A.)

Recovery Device

Any means of returning a model rocket to the ground in a safe and undamaged state.

Safety Interlock

A removeable device required for a launch controller to become active.

Igniter

An electrically operated device that ignites a model rocket engine.

Payload

An object carried by a model rocket that does not have a structural or aerodynamic purpose.

Airframe

The non-engine, non-payload portions of a model rocket.

Wadding

Flame-proof material used to protect a recovery device from a motor's ejection charge.

Boost Glider

A glider lifted in a ballistic manner by a rocket that detaches from the glider. The glider then transitions to an aerodynamic profile, and the booster recovers by other means.

Rocket Glider

A glider lifted in a ballistic manner by a rocket that is retained. The glider then transitions to an aerodynamic profile, and recovers intact.

2. Personnel

RSO

Range Safety Officer

LCO

Launch Control Officer (Sometimes also called Range Control Officer)

SCO

Safety Check Officer

FO

Fire Officer

Tracker

Person designated to track the flight of a model

Recovery Team

Person or persons designated to recover a model after landing

Flyer

Person responsible for the flight of a model

Spectator

Any person in the area not involved in a) the operation of the range b) the flying of the model

● Personnel Duties and Responsibilities

This section defines the duties and responsibilities of the range officers. For small meetings, some of these roles may be merged. The Safety Officer roles, however, are always separate from the other roles.

1. RSO

The RSO has to ensure that the range is operated safely and legally at all times. They are not there to make life hard for flyers, but rather to protect them from their own enthusiasm. If they must, they can ask flyers to leave, and close the range if things get out of hand. They can reject rockets as unsuitable for the range, dangerous, or not legal to fly. They must prevent flyers from launching outside of their certification. They CANNOT prevent a launch because of dislikes - they must validate all their decisions at all times. If a flyer wishes, they may discuss the RSO's decision, but it is the RSO that must make the final go/no-go choice. As a matter of protocol, another RSO may not accept another's rejection, in the event of the post being passed to another person (eg at a shift change). The RSO may also close the range if conditions become unsafe, or for any other reason. The RSO also has the power to assign duties to others on the range, and to relieve range officers of their duties if they are not performing them adequately.

2. LCO

The LCO's role is to ensure that the pad area is run safely, and quickly. They are to assist in speeding the turn-over of rockets on the pads, and are there to help flyers see as many *safe* launches as possible. The

LCO has control over which pads are in use, the launching order, what models are allocated to which pads, and announce each launch. They may also issue countdowns for flyers.

3. **FO**

An FO, if needed, watches the pad area for signs of fire resulting from a launch. He **MUST** watch the pad area at all times, and not watch flights at all. As for other safety positions, this should be rotated. An FO is not needed if launching from short green grass, sand, or other non-flammable surface.

4. **SCO**

An SCO is responsible for checking models that are to be presented to the LCO for launch. They must ensure that the model is sound and safe to fly, and that the fitted motor(s) and recovery device(s) are correct and appropriate. If an SCO is unsure of the safety of a model, he may choose to either reject it (giving the reasons, and how they may be addressed), or request a ruling from the RSO.

5. **Trackers**

Trackers are responsible for keeping the model in view during flight. They may also have additional duties, such as measuring altitude.

6. **Recovery Team**

A Recovery Team is responsible for retrieving a model once it has landed. This role is often filled by the flyer.

● **Site Preparation**

This section deals with the procedures to gain access to a site, arranging appropriate altitude clearances, and the physical set-up of a range.

1. **Access Permission**

Before any activities can be begun, written permission for the use of the selected site must be obtained from the owner or manager of the site. A suitable form is given in appendix A.

2. **Ceiling**

Every site has a ceiling; this ceiling is the minimum of:

- 300'AGL or the issued waiver
- Four (4) times the minimum dimension of the site
- The current cloud-base

3. **Altitude Waiver**

If flight operations are going to exceed 300'AGL, then an appropriate waiver or permission must be sought from the Civil Aviation Safety Authority.

Sites intended for regular or frequent use may be issued (on application to C.A.S.A.) with permanent permission for a given ceiling. If that altitude is intended to be exceeded, or the site is intended for occasional or infrequent use, then a specific waiver must be obtained. A suitable form for requesting a specific waiver is given in appendix B.

Specific waivers have a lead-time of 14 days.

4. **Fire Precautions**

No flight operations are permitted during a posted Total Fire Ban, or during a period of posted Very High or

Extreme Fire Danger in the site's region.

In areas where grass fires are a possibility, a non-flammable tarpaulin or blanket should be placed under each pad, and extend at least 1/10 of the minimum safe distance around the pad.

5. Range Setup

The boundaries of the range should be clearly marked, and, if possible, the individual areas of the range also marked.

1. Range Head / Launch Pad Placement

The range head and launch pad area should be placed as near as is practical to the centre of the range area. If there is a prevailing breeze, this area maybe offset up to 1/4 of the site dimensions upwind of centre, so as to provide more recovery area. The only personnel permitted in this area are: RSO, LCO and Flyers. The only exception is when a person is given specific and explicit permission by the RSO.

1. Pad Separation

Launch pad are to be separated by the minimum safe distance for the rockets being launched from them, as given in the appropriate safety code. The exception to this is for launch racks, where a number of rockets are prepared simultaneously and launched sequentially. Such racks should be treated as one pad for safety purposes.

2. Pad Specifications

All launch pads are rated for models of certain sizes.

A launch pad must:

1. Be capable of supporting the largest model it is rated for.
2. Have a rigid guide for the model to travel along prior to gaining flight speed. A guide must be designed such that it prevents the model from leaving the guide until it has travelled the entire length of the guide.
3. Either be unable to be tilted past 30 degrees from vertical, or be clearly marked as to when that angle is exceeded.
4. Have a means of protecting the ground from the exhaust of the rocket.
5. Be stable when loaded.

2. Range Control Area

The Range Control area should be immediately North of the pad area, and is where the launch controllers are placed. This is also the area that the LCO operates from.

All controllers must be clearly linked to the appropriate pad.

Non-flying personnel may not enter this area without the permission of the LCO or RSO.

3. Preparation/Loading Area

The Preparation/Loading Area is North of the Range Control Area. This area is open to the public, and is where models are prepared for flight. SCO inspections are also carried out in this area.

4. Recovery Area

The Recovery area is all areas not otherwise specified. Most (and ideally all) recoveries, however, will take place in the area South of the Range Head. This area is also termed "Down-range".

5. Tracking Stations

If measured tracking is taking place (ie theodolite tracking for altitude determination) then the tracking stations should be placed as far North on the range as possible, and placed in opposite corners of the range to the East and West.

6. Spectators

The spectator area is to the North of the Preparation Area, and may include a parking area.

● Site Operations

This section relates the operation of an active range. Also refer to the RSO Range Checklist (appendix D).

It is acceptable practice for RSO, SCO, FO and LCO duties to be combined, and for the Flyer to assume the duties of tracking and recovery. Thus the minimum personnel for a range is two.

1. Acceptable Conditions

In addition to the conditions addressed in this section, a "safety first" attitude must be observed. Any unexpected conditions that could affect spectators, other air users, or the area surrounding the range should also be considered.

1. Wind Speed

During launching, the wind-speed must not exceed the maximum specified in the P.A.R.C. safety code applicable to the rocket being launched.

If possible, a simulation should be run to ensure that the rocket being launched will recover in the recovery area.

2. Cloud Cover/Ceiling

Cloud cover must not exceed 1/8 at any point in the flightpath.

Flights into airspace containing greater than 1/8 cloud cover are prohibited, as are any flights that will penetrate a cloud-mass. To ensure this, the ceiling will be the lower of the posted waived altitude or the cloudbase, less 10% of the altitude of the cloudbase.

3. Visibility Range

A visibility of 6NM at all levels in the site's airspace, up to its operating ceiling is required.

4. Recovery Area Obstructions

If the Recovery Area contains vehicles, animals or people not part of a Recovery Team, the range will be closed until the obstruction is cleared, or has left the area.

2. Pre-launch Rocket Safety Check

This check is performed in the Preparation Area by the SCO. The SCO may request a ruling from the RSO, if they are unsure of any point. In any event, the RSO's rulings are final.

Only current financial members may present models for checking an launch. A current financial member may present a third party's model, but assumes full responsibility for that launch. This does not confer permission for a third party to undertake the actual launch. See also 4.3.3

1. Proof of Current Membership

The first time a Flyer presents a model to be checked at any given session, they must present their membership card, or other proof, showing a valid financial membership.

2. **Structural Integrity**

The airframe and motor-mount will be constructed so as to be able to withstand the stresses of launch and recovery with the fitted motor and recovery device.

3. **Approved Motor**

The motor being used must be:

- An approved model rocket motor
- Provide a LWR greater than 4
- Have a delay that will ensure safe recovery

4. **Stability**

The model will exhibit at least 2 calibers of static stability, or be of an otherwise proven design.

Design test flights may be carried out if the range has been opened for the express purpose of design testing.

Formal proof of design stability (using the Barrowman centre of pressure calculations) is an acceptable substitute for previous flights.

5. **Recovery**

The fitted recovery device must be properly attached and packed, and be designed to recover the model safely. Any protective wadding must be of an approved type.

6. **Estimated Apogee**

The estimated apogee must not exceed the site ceiling.

7. **Special Types and Requirements**

Special types of model may require additional considerations. These include R/C gliders, Boost-Gliders, staged models, clustered engines, and specialized payloads. Examples of these are given in the SCO Checklist (appendix F).

3. **Range Operation**

This section is summarized in appendix E, the LCO checklist. Any model presented for launch must have passed the pre-flight check.

1. **Launch Pad Loading**

During the loading process, the Flyer, who must be present during the loading, must retain the safety interlock for the pad being loaded.

Only personnel required to load the model onto the launch pad are permitted to approach the pad during the loading operation, unless specifically approved by the RSO. Approval must be given in each and every instance.

The rocket must be loaded onto a pad that has specifications that at least match the model's requirements.

After loading onto the pad, any other pre-flight preparations are made (eg removing protective hoods from lenses, arming recovery systems).

After all other pre-flight preparations are made, the model's ignitors are connected to the launch controller.

After the ignitors are connected, all personnel must leave the pad area.

2. Pre-launch Checks

The safety interlock is inserted into the launch controller, continuity is confirmed through the ignitors, and the pad is announced as armed. If continuity is not established, then the safety interlock is removed, and the loading personnel may be permitted to approach the pad to correct the problem at the LCO's discretion. The LCO may choose to abort the launch and require the model to be removed for diagnosis and correction.

1. Tower Notification Not Required The LCO checks the surrounding airspace and the recovery area, and, if clear, gives the go-ahead for launch.
2. Tower Notification Required The LCO contacts the appropriate ATC, as advised by CASA, and informs them of the launch location, the waiver reference, and intended altitude. If a series of launches will be following, an estimated end time must also be provided. If the ATC gives clearance, then the LCO proceeds as per 4.3.2.1. If clearance is not given, then either a hold is placed until it is given, or the launch is aborted.

3. Countdown and Launch

The Flyer must be a current financial member of the club. With specific and explicit permission from the RSO, a flyer may designate a third party to perform the actual act of launching. Under such circumstances the third party must be under direct supervision by the flyer at all times.

The LCO, or by the LCO's choice the Flyer, will issue a five second count down, as follows: "Five, Four, Three, Two, One, Start"

During the Countdown, the LCO will maintain a lookout for hazards, and may call a hold at any point.

At the call of "Start", the launch controller will be activated by the flyer.

If the engine(s) fail to ignite after two (2) seconds, the flyer may request a re-count, or safe the controller.

After safing, the LCO may permit (after no less than 60 seconds) the flyer to attempt to correct the ignition problem at the pad, or order an abort.

4. Tracking

The model will be tracked, as far as is practical, through its flight, to the point of landing, by at least one person.

Tracking may be interrupted by the LOS being blocked, or by the model traveling too fast to track, or by being too small to track at its apogee. If at all possible, the track should be regained as soon as is possible.

Failure to successfully track may result in the model being unrecoverable.

5. Recovery

Once the model lands, its position should be noted by the recovery team, who then approach the model, safe any payload, and return it to the flyer.

6. Holds and Aborts

Holds may be called by any person spotting a hazard during a countdown. After a hold, the LCO determines the nature of the hazard, and either restarts the countdown (from the start) calls an abort, or requests clarification from the RSO.

Aborts may be called by the RSO, the LCO or the flyer. After an abort the controller is safed, and the model removed from the pad. Once the cause of the abort has been resolved, the model may be

● Site Closure

These procedures are to be followed after the range has been closed, and will not be re-opened that day.

1. Tower Notification

If flights have required local Air Traffic Controllers to be notified, they are to be informed that the ranged is now closed and will not be re-opened that day.

2. Equipment Recovery

All ground equipment is to be safed, checked for damage by the RSO, and packed. If equipment belongs to specific persons, it is to be returned, and club equipment passed to the responsible officer.

3. Waste Disposal

After all equipment has been packed, the site is to be searched for launch debris (eg used wadding, ignitors, etc) and other rubbish.

Particular attention is to be paid to the pad areas, where there may be numerous small items remaining.

4. Security

After all other personnel have left, the site is to be secured by the RSO and the LCO, jointly. The level of security required is to be determined by the site owners/managers.

APPENDICES

. Site Permission Form

Site Approval for the Launch of Model Rockets

I, _____, being the owner/occupier of the property listed below, or the owner's/occupier's delegated authority, give permission for model rockets to be launched to an altitude of _____ feet AGL, on ____/____/____ from the hours of ____:____ to ____:____.

This permission is subject to the following restrictions:

A/ Site Fees (indicate those that apply):

- Each person launching will be required to pay a fee of \$____.____ per day.
- The club/group launching will be required to pay a fee of \$____.____ per day.
- No fee will be levied.

B/ Altitude Waiver

Should the permission extend to altitudes in excess of 300 feet AGL, a valid waiver from the Civil Aviation Safety Authority must be held, and the conditions of that waiver followed.

C/ Fire Hazards

No launch shall be permitted in a total fire ban.

() Fire extinguishers required.

If required they must be of an appropriate approved type.

D/ Other Conditions

Signed,

_____ (Name)

_____ (Position)

Property Details:

B. Altitude Waiver Request Form

Ph: (h) (08) _____
 (w) (08) _____
FAX: (08) _____

Flying Operations Inspector
CASA
Perth District Office
PO Box 1082
Cloverdale
6985
Ph : 131757
FAX: 08 9366 2891

TO LAUNCH ROCKETS

Dear _____,

I/we are seeking permission under CAR 295 to launch model rockets over 100 metres. I/we have listed the relevant details:

- (1) A weight restriction of 1000/_____ grams will apply.
- (2) The maximum height above ground level of flights will be _____ feet.
- (3) The estimated safety buffer above maximum height of flights will be _____ feet.
- (4) The maximum horizontal distance of flights will be _____ metres.
- (5) The location is _____.
Please refer to the attached map for the exact location of the operation. We have/do not have written permission of the landowner/occupier to conduct this launch.
- (6) Dates of flying are _____. The duration of these operations will be from ____hrs to ____hrs local time. I/we may be contacted during these times on _____.
- (7) The event will be overseen by _____ as Range Safety Officer, under the codes of the Australian Rocketry Association and according to the Range Operations Manual of the Perth Advanced Rocketry Club.

Sincerely,

Perth Advanced Rocketry Club member#____-__.

C. Ideal Site Layout Diagrams

Range Layout
Diagram

Rangehead
Layout

Range Situation

1. Is range large enough for ceiling?
2. Is pad area clear?
3. Is spectator area at appropriate distance behind firing line?
4. Are prep areas, firing line, spectator line all clearly marked?

Range Closure Conditions

1. Is cloud below waiver ceiling? (Reduced ceiling is an option.)
2. Is wind above maximum safe speed?
3. Limited visibility?
4. Airspace occupied?
5. ANY OTHER CONDITION THAT THE RSO FEELS WARRANTS THE CLOSING OF THE RANGE.

RSO POWERS

1. A rocket may be rejected for any reason.
2. A flyer may be asked to leave the range for any reason.
3. A countdown may be halted for any reason.
4. A range may be closed for any reason.
5. Any flyer attempting to bypass the RSO or any other officer of the range **will** be ejected for compromising range safety.

An RSO **MUST** justify their rejection, closure or ejection from the field.

D. RSO Range Checklist

E. LCO Checklist

Setup

1. Ensure all pads/controllers are at at least minimum safe distance.
2. Number each pad and controller clearly.
3. If possible, separate

Pads Empty

1. Are all controllers clear?
2. Call for flyers.
3. Check each flyer has cleared the SCO
4. Allocate 1 flyer per pad.
5. Mark flyer, motor, and model on flight sheet.

Pre-launch

1. Pad area clear?
2. Recovery area clear?

Loaded Pads

1. Call flyer name, model and motor.
2. Check airspace for other users.
3. Call "clear to launch!". If misfire, call "Hold !".
4. Repeat for each pad.

If any misfired pads remain at end of sequence, allow re-try, then remove from pad to diagnose.

In the case of drag-race launches, announce all all fliers and pads as a group.

F. SCO Checklist

General: 1 / Is flyer a valid member? 2 / Is the motor approved? 3 / Does the flyer have the appropriate

certification for the motor in use? 4 / Motor properly retained? 5 / Is the delay correct? 6 / Is the LWR>4 (ie enough thrust to lift the model safely)? 7 / Is the model aerodynamically stable? 8 / Is the model structurally fit to fly with the fitted motor? 9 / Are the ignitors suitable for the motor? 10/ Is the recovery device securely fitted, and correctly packed? 11/ Is the nosecone/payload bay correctly fitted (too loose too snug)? 12/ Are any launch lugs strong enough, and securely fitted? 13/ Is the proposed altitude in excess of the ceiling? Radio Control Only 1/ Flyer has Frequency Control Pin? 2/ Legal frequency? 3/ Can system be disarmed until ready to launch? Ejection Controlling Altimeter Only 1/ Can the system be disarmed until ready to launch? 2/ Properly wired? 3/ Can the altimeter be activated with the ejection leads isolated? 4/ Power supply fresh and secure? 5/ Proper indicators from altimeter module? 6/ Compartment properly vented? 7/ Compartment isolated from ejection charges? 8/ (dual deployment systems only) Main system secure enough not to deploy on drogue deployment or apogee? Multistage Only 1/ Each stage combination stable? 2/ Each stage has appropriate recovery system? 3/ If separating by drag, do the stages separate easily? 4/ Is the upper stage delay appropriate?

G. Flight Recording Sheet

DATE:		FIELD:		LCO:				
Time	Flyer Name	Mem#	Model	Mass	Engine	SCO	Est Alt	Rec?

H. Minimum Site Dimensions Table

Installed Total Impulse (NS)	Equivalent Motor Type	Minimum Diameter (Metres)
0.00-1.25	1/4A-1/2A	15
1.26-2.50	A	30
2.51-5.00	B	60
5.01-10.00	C	120
10.01-20.00	D	150
20.01-40.00	E	300
40.01-80.00	F	300
80.01-160.00	G	300

160.01-320.00	H	460
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I. Minimum Safe Distances Table

Installed Total Impulse (NS)	Equivalent Motor Type	Minimum Distance(Metres)
0.00-1.25	1/4A-1/2A	5
1.26-2.50	A	5
2.51-5.00	B	5
5.01-10.00	C	5
10.01-20.00	D	5
20.01-40.00	E	9
40.01-80.00	F	9
80.01-160.00	G	9
160.01-320.00	H(As 2xG ONLY)	9

REFERENCES, FURTHER READING, AND SOFTWARE

Handbook of Model Rocketry, 6th Ed; Stine, G. Harry; John Wiley & Sons; ISBN 0-471-59361-3.

Australian Rocketry Association "Blue Book"; Australian Rocketry Association. (PO Box 777 Marlestone S.A. 5033)

Newsgroup posting to rec.models.rockets, 17th May 1997, by "rocketweb@aol.com" (Douglas Caskey) based on work by John Ritz.

Perth Advanced Rocketry Club Safety Codes.

The [rec.models.rockets newsgroup](#).

The rec.models.rockets FAQ. Available from the rec.models.rockets archive at <http://sunsite.unc.edu/pub/archive/rec.models.rockets/RMRFAQ/>.

The 2d (Alt + Time) simulation program RASP, by Kent Hoult, et al. Available from the rec.models.rockets archive at <http://sunsite.unc.edu/pub/archive/rec.models.rockets/RASP/>.

The 3d (Alt, Drift + Time) simulation program RSIM, by Kenneth S. Hutchinson. Available from the rec.models.rockets archive at <http://sunsite.unc.edu/pub/archive/rec.models.rockets/PROGRAMS4/rsim13.zip>.

The stability calculation program VCP, available from Impulse Aerospace at <http://www.impulseaero.com/Software/VCP/index.html>.