UKSEDS COMPETITIONS

NATIONAL ROCKETRY CHAMPIONSHIP 2024-25

Technical Specification

NATIONAL ROCKETRY CHAMPIONSHIP

UKSEDS

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Roxel
Propulsion systems

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MRC Midland Rocketry Club

Full Flavour Behaviour

ROCKETS & THINGS

WIZARD ROCKETS

UNITED KINGDOM ROCKETRY ASSOCIATION

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NRC-TSN-001	Initial Release	5/10/2024

Table of Contents

1 Introduction

1.1 Scope

This document outlines technical requirements that are not competition year specific as they are generally based on the UK Rocketry Association safety code, UK laws or our experience on what does and does not work.

This document is meant to be the National Rocketry Championship's equivalent of a standards document like European Cooperation for Space Standardization (ECSS) standards that are used in industry.

2 Acronyms & Reference Documents

2.1 Acronyms

Acronym	Description

2.2 Reference Documents

2.2.1 Documents Referenced

No.	Document ID	Description
1		
2		

2.2.2 Useful Reference Documents

No.	Document ID	Description
1	ECSS-M-ST-10C Rev. 1	**Space project management** - Project planning and implementation
2	ECSS-S-ST-00-01C	**Glossary of Terms** - A list of commonly used terms in ECSS documents

2.3 Requirement Numbering Definition

The following describes the layout of the requirements within this document.

NRC MRD-<A>-<n> | Rev: <R>

<Title>

<text>

VV Method: *<v>*
Parent: *<p>*

Where:
<A>: Acronym for the section the requirement falls under.
<n>: Requirement number of 3 digits, starting from 001.
Note: <A> and <n> combine with the competition and document name acronyms to create the requirement ID.

<R>: Revision indicator, with “A” denoting the first version, “B” the second and so forth.
<Title>: Requirement title.
<text>: Requirement text.

<v>: the verification method(s) needed to demonstrate compliance to each requirement. The letters shall be only the following:
I: Inspection
D: Demonstration
A: Analysis
T: Test

<p>: Denotes if a requirement is derived from another requirement. Parent requirements shall be listed by the Requirement ID. If no Parent Requirement exists, the value shall be N/A.

3 Motors [MOR]

3.1 Mounting of the Motor in Rocket

NRC TSN-MOR-001 | Rev: A

The rocket motor/motor case shall be clamped axially at both ends.

The teams must provide a means of securely mounting the motor within the rocket. There are two types of motors that are available to be used within NRC's rules: single-use motors and reloads. Single-use motors do not require a case, reloads do. Therefore, you would clamp a single-use motor directly or you would clamp the case for a reload.

The mount must transmit the thrust loads from the motor to the structure of the rocket, provide axial alignment of the motor within the rocket and prevent it from slipping out during handling and all flight phases.

An example motor mount arrangement is shown in Figure 1.1. The motor can be clamped at the motor thrust ring to the base of the rocket. Please remember this configuration is just an example and will not work for everyone's purposes.

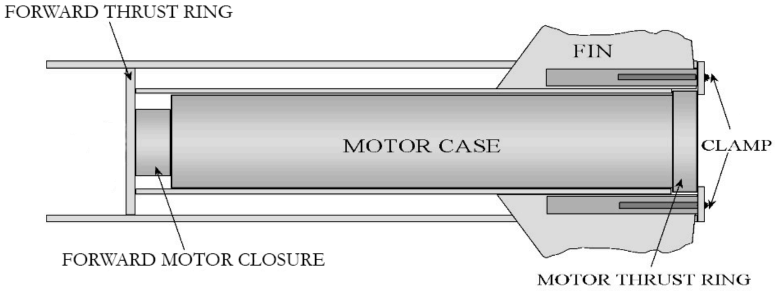

Figure 1.1

VV Method: D
Parent: N/A

3.2 Motor Mount Strength Requirements

NRC TSN-MOR-002 | Rev: A

The rocket motor mount shall be designed to withstand a force equivalent to twice the maximum motor thrust without permanent deformation.

VV Method: T
Parent: N/A

NRC TSN-MOR-003 | Rev: A

The rocket motor mount shall be designed to withstand a lateral force in any direction equal to a thrust misalignment of 5° at the maximum motor thrust cantilevered about the vehicle's centre of gravity.

The motor mount must be designed to take all the thrust loads, both axial and lateral via the motor thrust ring (referred to in Figure 1.1). It must be designed to withstand and transmit into the body tube a force equivalent to twice the maximum motor thrust without permanent deformation. The mount must withstand a lateral force in any direction equal to a thrust misalignment of 5° at the maximum motor thrust cantilevered about the vehicle's centre of gravity.

VV Method: T
Parent: N/A

4 Stability Margin [SMN]

4.1 Motor Mount Strength Requirements

All rockets participating in the NRC must comply with certain stability criteria. Normally, stability will be verified using slender body theory.

For slender body theory to apply, the following four constraints are set on the vehicle:

1. Rockets shall have a length to diameter ratio (L/D) which lies between 10 and 35
2. The normal force coefficient CN should be greater than 15 and less than 30.
3. The vehicle is flying at subsonic speeds.
4. The fins are of thin cross-section.

If the basic criteria given above cannot be met, further documentation must be presented to the RSO to demonstrate that the rocket is both statically and dynamically stable.

4.2 Minimum Speed

NRC TSN-SMN-001 | Rev: A

The rocket shall have a minimum velocity of 20 m/s when leaving the launch rail.

At Midlands Rocketry Club we usually fly with 2m rails.

VV Method: A

Parent: N/A

4.3 Static Stability Margin

NRC TSN-SMN-003 | Rev: A

The rocket shall have a stability margin between 1.5 diameters and 2.5 diameters during all phases of flight before apogee.

The static stability margin is the distance between the centre of mass and the centre of pressure (see Figure 2.1).

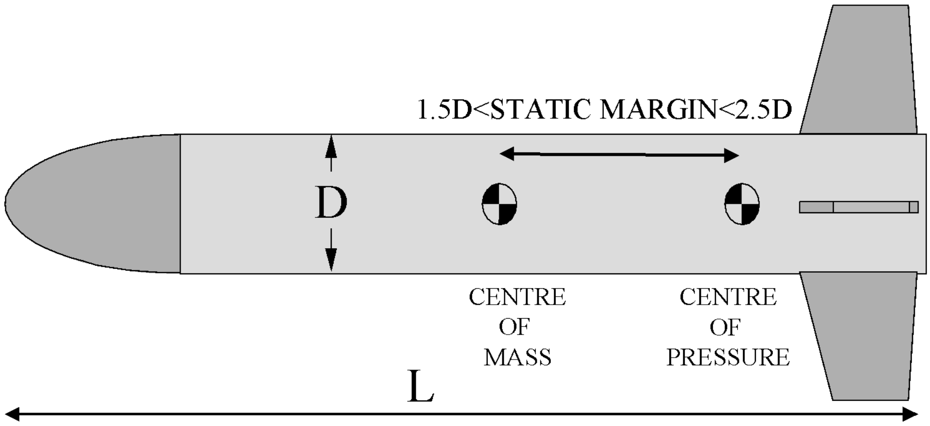

Figure 2.1

VV Method: A
Parent: N/A

5 Structural Acceptance Requirements [SAR]

For a rocket to be accepted for launch it must pass certain pre-launch criteria, which include structural tests. Passing these tests will not guarantee that a rocket will have a flawless flight but will ensure that there is a minimum chance of failure and the rocket will be safe to fly.

5.1 Fin Alignment

NRC TSN-SAR-001 | Rev: A

The geometric alignment of each fin shall be within 2° of the projected longitudinal axes of symmetry of the rocket.

The geometric alignment of each fin shall be within 2° of the projected longitudinal axes of symmetry of the rocket (see Figure 3.1)

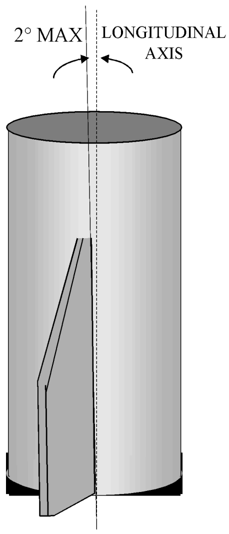

Figure 3.1

VV Method: I
Parent: N/A

5.2 Fin Longitudinal Loading

NRC TSN-SAR-002 | Rev: A

Each fin must be able to support a suspended load from its tip equal to twice the fin mass times the rocket's maximum axial acceleration occurring during any flight phase.

Please see Figure 3.2 for more details.

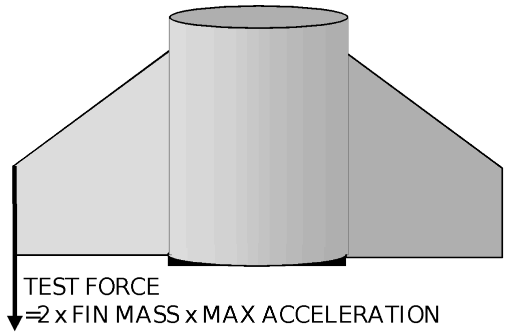

Figure 3.2

VV Method: T
Parent: N/A

5.3 Fin Lateral Loading

NRC TSN-SAR-003 | Rev: A

Each fin shall withstand a transverse load equal to the rocket's launch mass when suspended from the fin tip with a maximum lateral deflection of less than 10° in either direction.

See Figure 3.3 for more information.

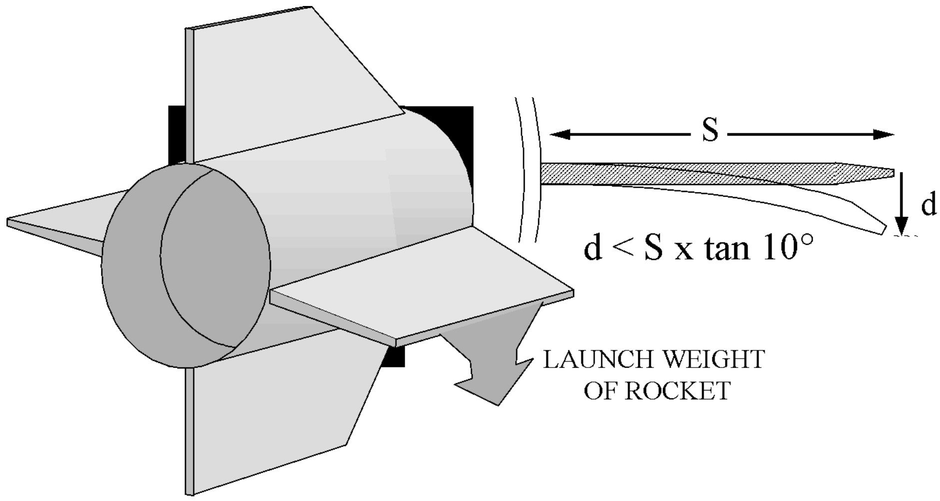

Figure 3.3

VV Method: T
Parent: N/A

5.4 Fuselage Stiffness

NRC TSN-SAR-004 | Rev: A

The launch-ready rocket shall deflect less than 10mm per metre length in any lateral direction when suspended from its centre of mass.

See Figure 3.4 for more information.

VV Method: T
Parent: N/A

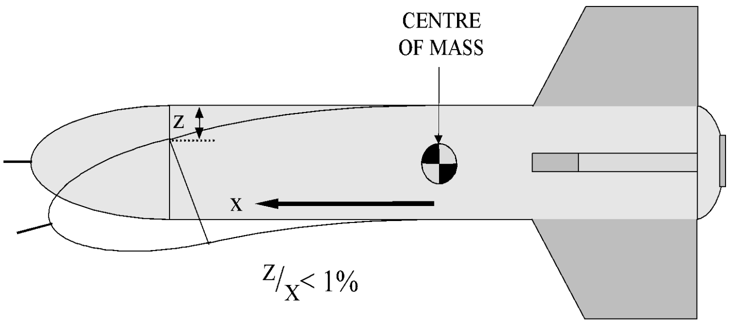

Figure 3.4

NRC TSN-SAR-005 | Rev: A

The mating length between a coupler and body tube shall be a minimum of 1 body tube diameter.

When a rocket is coupled together from several tubes, the method of joining the tubes is left to the application and discretion of the designer. However, it is required that the mating length between the coupler and each tube should be a minimum of 1 diameter when using plastics or composites (see Figure 3.5). This is advised to maintain satisfactory levels of stiffness along the length of the rocket.

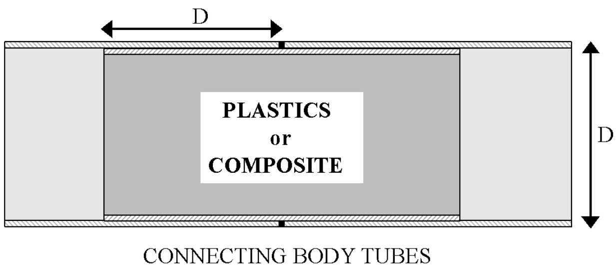

Figure 3.5

For sliding connections, the minimum mating length between the coupler and tube should always be 1 diameter. Additionally, the fit between parts must stop any noticeable rotation at the joint.

VV Method: D
Parent: N/A

5.5 Static Strength Requirements

NRC TSN-SAR-006 | Rev: A

All structural parts shall withstand twice their expected maximum inertial and aerodynamic loads without failure.

If participants wish to re-use their vehicles, all parts must withstand 1.5 X applied loads without permanent deformation (yield).

VV Method: T
Parent: N/A

5.6 Launch Lug

NRC TSN-SAR-007 | Rev: A

All rockets shall be equipped with a minimum of 2 rail buttons.

At Midlands Rocketry Club we usually fly on 2m rails which are compatible with 6mm launch buttons. We recommend using delrin rail buttons and an example can be found here. A recommended layout of the launch buttons can be found in Figure 3.6.

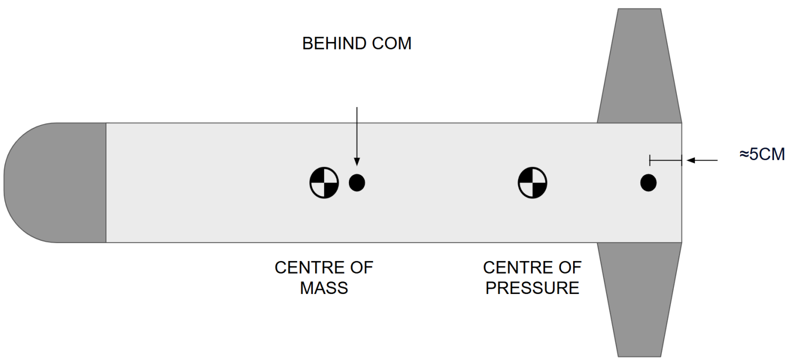

Figure 3.6

VV Method: D
Parent: N/A

5.7 Finite Element Analysis

NRC TSN-SAR-008 | Rev: A

Finite Element Analysis shall not be used to produce evidence for any structural requirements.

Whilst we would encourage teams to learn FEA for NRC and welcome its use in competition reports and documentation as supplementary evidence, for safety reasons, we cannot accept FEA evidence for verifying any structural requirements. Historically we have seen teams making incorrect assumptions (for example, the homogenous material properties for additive manufacturing methods ie. 3d printing) which have led to issues at the flight readiness review where they find their design does not pass real-world structural tests. FEA would be best used to trade off material or design choices before real-world testing occurs.

VV Method: D
Parent: N/A

6 Electrical Systems [ESS]

You may have several electrical subsystems onboard a rocket such as payloads, a telemetry system and an altimeter.

6.1 Internal Power Supply

NRC TSN-ESS-001 | Rev: A

The rocket shall be capable of being switched on and left to run using its internal power source for a minimum of 15 minutes on the launch pad.

Ideally, you should have a way to arm the rocket externally so that it can be armed on the launch pad. If this is not possible with your design then you will need to power it for much longer (up to an hour) on the competition day before it is placed on the pad. This should be budgeted for in addition to the energy used during the predicted total flight time.

VV Method: A
Parent: N/A

NRC TSN-ESS-002 | Rev: A

The rocket shall be capable of being armed within 5 minutes at the launch site.

Many delays on competition days are caused by teams having to fully disassemble their rockets to arm them or switch on a payload. It is highly advised that they can be armed externally, this can be done with pull pins or screw switches for example.

VV Method: D
Parent: N/A

6.2 Electrical Considerations

NRC TSN-ESS-003 | Rev: A

The rocket shall not contain single-core wire.

Single-core wire shall not be used for electrical cable for primary systems since it is considered too fragile. Multi-core wire is tougher and more reliable under handling and flight conditions so this shall be used instead.

During assembly, testing and flight, electronic circuits and wiring are subjected to a high level of abuse. This requires that construction should be rugged, tidy and of a high standard of workmanship as possible.

Care should be taken when using electromechanical components (such as relays, switches, and connectors) to ensure that they are capable of withstanding high acceleration and vibration loads. Care should be taken to ensure that the switch is placed in the correct orientation. This is critical as they can only withstand high G loads along certain axes, always refer to the manufacturer's data sheets.

The circuit must be structurally and electrically robust so that no parts of the circuit can change state or function due to any mechanical loads from transportation, manipulation on the launch pad or in flight.

Recovery system deployment shock loads are a very important design case and can exceed the thrust loads.

VV Method: D
Parent: N/A

6.3 Radio Frequencies

NRC TSN-ESS-004 | Rev: A

Teams shall conform with Ofcom's IR 2030 radio frequency regulations.

A copy of Ofcom's IR 2030 can be found here. All teams must ensure that they comply with these regulations when using radios.

Generally, teams are caught out with 915MHz which you will find is not permitted for airborne use. Depending on the specifics of the system, 868MHz and 433MHz are the most popular choices but please make sure to check the latest IR 2030 document.

VV Method: D
Parent: N/A

7 Recovery Requirements [RRS]

7.1 Use of Recovery System

NRC TSN-RRS-001 | Rev: A

The rocket shall have a recovery system.

All rockets must have a system to recover them in a safe and controlled manner. This usually takes the form of a parachute that is activated when the rocket reaches apogee.

VV Method: D
Parent: N/A

7.2 Landing Speeds

NRC TSN-RRS-002 | Rev: A

The recovery system shall reduce the rocket's vertical landing speed to less than 15 m/s.

This can be shown through OpenRocket simulations if you use a parachute based recovery system. If you are using an alternative recovery system then you shall need to demonstrate this through hand calculations and possibly real-world tests.

VV Method: A
Parent: N/A

7.3 Maximum Post-Apogee Range

NRC TSN-RRS-003 | Rev: A

After apogee, the rocket shall not drift more than one kilometre before landing at wind speeds of 15m/s.

The prospective launch site is quite windy, but all rockets must still land within the landowner's boundaries. It is advisable to make the recovery device highly visible to assist tracking.

VV Method: A
Parent: N/A

7.4 Motor Ejection Charge

Certain motors have an adjustable ejection charge which can be used to trigger the recovery system. This is a relatively passive approach, as the recovery system will deploy at a fixed time after burnout no matter what stage of flight the rocket it in. So premature and late deployment is common using this method.

Some delays are only adjustable to certain time intervals from a maximum so you have a limited amount of options for delay times e.g. 13 seconds, 10 seconds, 8 seconds, 6 seconds and 4 seconds.

Be wary of the delays on your selected motor and check that it is long enough to suit your time to apogee based on your OpenRocket simulations.

7.5 Flight Computer

NRC TSN-RRS-004 | Rev: A

If a flight computer is used for recovery it shall be a COTS or UKRA qualified system.

The purpose of the flight computer is to activate the recovery system when the rocket reaches apogee.

An alternative method to using the motor's ejection charge is to use an electronic timer. This timer is activated on launch and is pre-programmed to wait for a set time interval before firing the recovery system. Some devices can be trigger via acceleration, velocity or altitude. COTS means commercial-off-the-shelf. Essentially, this requirement says that you cannot make your own flight computer and use it to trigger the recovery system, you must use a commercially available one. You may, however, make your own flight computer and fly it as a payload, as long as it is not connected to the recovery system.

There is an exception to this requirement which is a SRAD (student researched and developed) or homemade flight computer that has been flight-qualified to UKRA's standards. If teams wish to develop their own recovery circuit, as per the UKRA safety code section 2, this will be classed as an experimental rocket and so UKRA section 8 applies. This means that the **"homebrew" recovery electronics must be**

flown as a backup to a COTS recovery system until they have been qualified as per section 8 of the UKRA Safety Code.

The UKRA Safety Code can be found here.

VV Method: D
Parent: N/A

7.6 Isolation of Recovery Circuit

NRC TSN-RRS-005 | Rev: A

Any electronic recovery circuits should be electrically isolated from other electronic systems.

It is recommended that all of the recovery sequencing circuitry be electrically isolated (including the battery) from any other electrical circuit used in the rocket.

VV Method: D
Parent: N/A

7.7 The Launch Detector

Detection of the actual launch can be done in a variety of ways: pulling out of a connector fixed to the launch pad, use of an optical sensor, use of a threshold accelerometer to initiate the time or any other system a team wishes to develop although these are not required.

7.8 Parachute Deployment

The best point to open the recovery device is at the instant the rocket reaches apogee. This is when the speed of the rocket is at it's lowest and the opening shock loads on the rocket are the smallest. Normally, calculations are made using computer simulations to find the time from lift-off to apogee.

Recovery systems are usually triggered with the ejection charge that is built into the rocket motor but sometimes other approaches are used such as separate black power charges with a COTS flight computer.

7.9 Detection of Apogee

NRC TSN-RRS-006 | Rev: A

Tilt switches shall not be used.

Detectors relying on the physical orientation of the rocket relative to the gravity vector to detect apogee (e.g. tilt switches) are inaccurate and should not be used.

VV Method: D
Parent: N/A

7.10 Flight Computer Disarming Mechanism

NRC TSN-RRS-007 | Rev: A

Any flight computers used to trigger recovery systems shall have an externally accessible disarming mechanism.

The flight computer (if used) must have a safe and secure disarming mechanism, which prevents inadvertent activation of the recovery system during handling and loading (this is especially important where pyrotechnic actuators are used).

The system must be kept in the disarmed (safe) condition until the rocket is safely loaded into the launch pad. At the designated point during countdown, the rocket can then be armed.

VV Method: D
Parent: N/A

7.11 Transmission of Recovery Shock Loads

NRC TSN-RRS-008 | Rev: A

Recovery loads shall be transmitted via eye bolts through bulkheads with a nut on the other side.

The main recovery shock loads must not be transmitted in shear through screw threads into the rocket body as shown in Figure 5.1.

It is recommended that these loads be transmitted through links and hook-eye anchor points.

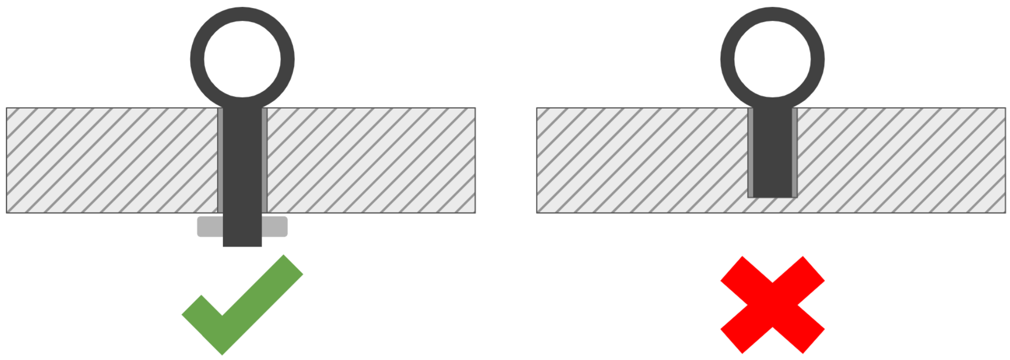

Figure 5.1

VV Method: D
Parent: N/A

7.12 Shock Cord

NRC TSN-RRS-007 | Rev: A

Recovery systems that use shock cords shall have a minimum length of 2m.

A lot of energy is released when the ejection charge goes off. It needs to be enough to separate the airframe and so if the shock cord is very short then there may not be sufficient length to dissipate this energy leading to the shock cord snapping.

VV Method: D
Parent: N/A

NRC TSN-RRS-008 | Rev: A

Any shock cords shall be made of kevlar.

From experience, this is the best material to use for shock chords and is relatively inexpensive compared to alternatives.

VV Method: D
Parent: NRC TSN-RRS-007

8 Alternative Recovery [ARY]

8.1 Alternative Recovery Definition

NRC TSN-ARY-001 | Rev: A

All rockets must conform to CAA UAS laws.

VV Method: D
Parent: N/A

NRC TSN-ARY-002 | Rev: A

All rockets must conform with the UKRA Safety Code.

The UKRA Safety Code can be found here.

VV Method: D
Parent: N/A

UKSEDS define alternative recovery methods as **any** method used to slow a rocket down that does not use a conventional parachute.

The Civil Aviation Authority (CAA) and United Kingdom Rocketry Association (UKRA) have very strict laws and rules governing what can and cannot be done with rockets. To help teams adhere to them, the organisers have added the below sections as guidance.

Disclaimer: Please always refer to the CAA and UKRA's websites for up-to-date guidance and information. If you find any discrepancies between this document and their websites, please follow the CAA and UKRA's guidance and let the organisers know at: rocketry@ukseds.org

8.2 Alternative Deployment Methods

For any deployment that occurs **above** the CAA's drone limit of 120m/400ft either:

1. The ejection charge within the motor
2. A COTS (Commercial Off-The-Shelf) flight computer

must be used to trigger any deployment.

For the deployment of any Unmanned Aircraft Systems (UAS) from a rocket, this **must** occur **below** the CAA's drone limit of 120m (400ft). The maximum distance a UAS should be flown from its operator is 500 metres or not beyond the visible line of sight if less than 500 metres.

More information about the CAA's drone laws can be found here.

However, for safety reasons, the deployment of the rocket's first stage recovery system must be triggered within 150m of apogee and the final stage (or the first stage if single stage) must deploy no lower than an altitude of 200m.

Any alternative recovery system designs proposed by a team in their reports will be submitted to the UKRA Safety and Technical Committee for approval before launch.

8.3 Active Stabilisation and Recovery

NRC TSN-ARY-003 | Rev: A

Active stabilisation shall only be used on ascent.

As per the UKRA's safety code, active stabilisation can only be flown on ascent This means that section 8 of their safety code **must** be followed.

Active recovery **must** only be used to guide the rocket back to the launch site on the descent. It will also be classed as an experimental rocket and so section 8 **must** also be followed.

The UKRA's safety code can be found here.

VV Method: D
Parent: N/A

8.4 Altitude and Deployment Limits for UKRA Clubs

A list of active UKRA clubs can be found here.

Please note that no person or team can break the max altitude of any site. This is set by the CAA and cannot be altered.

If your team is going to go above the dual deployment limit of any club, you must use a dual deployment system. For more information on dual deployment, please refer to Apogee Rocket's guide here.