UKSEDS NATIONAL ROCKETRY CHAMPIONSHIP 2015
TECHNICAL GUIDELINES

UK STUDENTS FOR THE EXPLORATION AND DEVELOPMENT OF SPACE

The recommendations and instructions included in this brief are for the benefit of all participants and to aid the safety and success of all activities associated with the NRC.

CONTENTS

CHAPTER 1 – INTRODUCTION

This Handbook has been compiled with the aim of providing useful and often necessary information for all those participating in the UKSEDS National Rocket Championships (NRC).

For the construction and launch of medium to high power sounding rockets, a very wide subject matter must be covered. This Handbook contains technical guidelines recommended for a safe flight, together with concise explanations of the reasons behind them.

The UKSEDS NRC launches must be held at a launch site approved by the United Kingdom Rocketry Association (UKRA). As a result the safety requirements in this handbook are based on the UKRA safety code, with a few additional requirements that UKSEDS feel are necessary for the purpose of the competition.

UKRA is an organisation run by members of the British rocketry community. It is the recognised body for safe high-power rocket flying, and provides third-party insurance, and safe codes of practice. Team members may wish to join UKRA and pursue the UKRA certification scheme, so that they can take up high power rocketry as a hobby.

If a team requires further clarification and explanation of any of the information set out in this handbook, they should contact the UKSEDS NRC organisers (rocketry@ukseds.org).

Apart from the NRC requirements, many design suggestions are also included in this document. These are based on the collective experience gathered from many rocket projects over the years. These are not mandatory but are intended to be of use.

1.1 Project Report

To qualify their rockets for launch the NRC teams must submit a design report detailing the design and function of the vehicle, all components and payloads.

The build report should contain calculations, simulation data and tests carried out to prove that rockets are flight ready.

Not only will this reduce the risk of failure of the rocket, it will also be an important part of the judging criteria for the NRC.

1.2. Payloads

All Rockets participating in the NRC must have at least one payload.

Payloads can take many forms:

There are payloads that test the performance and behaviour of the rocket's systems. This may be an investigation of the structural loads during flight, aerodynamic pressure distribution around the body, guidance and navigation hardware function, novel recovery systems or novel avionics designs etc.

Payloads can also sound the atmosphere, gathering data on the outside environment through which the rocket passes. This can vary from environmental altitude lapse rates to gas composition monitoring with altitude.

Choice of a payload or payloads is left to the imagination and ingenuity of a team. The quality of the payloads flown will form an important part of the championship judging criteria.

UKSEDS reserves the right to disallow any payloads for ethical, legal or safety reasons.

CHAPTER 2 - INTERFACE OF THE ROCKET MOTOR

2.1 USE OF A AMMONIUM PERCHLORATE (HIGH POWERED) MOTOR

Due to safety and competition restrictions, only approved motors can be used in the NRC. UKSEDS will not allow self made motors or motors from unlicensed manufactures. As standard we approve Cesaroni technology Pro X for more information see http://www.pro38.com/products.php

Teams are limited to 2-grain 29mm Cesaroni reloads of G impulse. These are classified as mid-power motors and so do not require UKRA certification to purchase or fly. For teams wishing to obtain a UKRA level 1 certification it is suggested that you design your rocket with the ability to hold a 3 grain 29mm motor (for which H impulse reloads are available) for additional flights separate to the competition.

2.2 MOUNTING OF THE MOTOR IN ROCKET

The teams must provide a means of securely mounting the motor with the rocket. This 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 slipping out during handling and all flight phases.

An example motor mount arrangement is shown in figure 3.2.

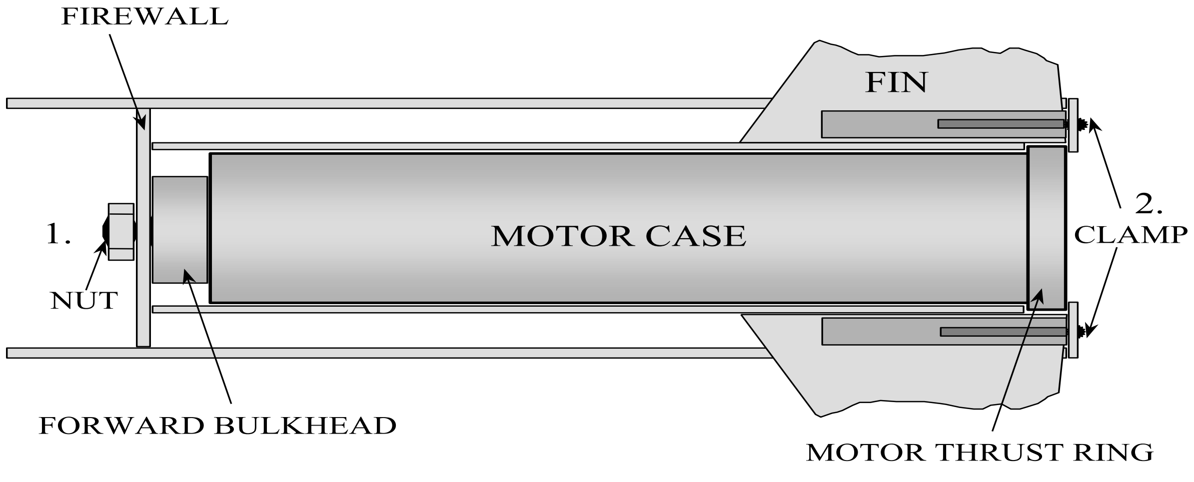

Figure 2.1

As suggested in the figure, the motor can either be *(1)* secured to a firewall by a bolt or *(2)* 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.

2.3 Motor Mount Strength Requirements

The motor mount must be designed to take all of the thrust loads, both axial and lateral via the motor thrust ring (referred to in figure 3.1). 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 thrust value cantilevered about the vehicle's centre of gravity after firing.

It is recommended to include any calculations and or tests in the build report.

CHAPTER 3 – PERFORMANCE MARGIN

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 must have a length to diameter ratio (L/D) which lies between 10 and 35
2. The normal force coefficient C_N must 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.

3.1 MINIMUM SPEED

When the rocket leaves the launch pad, it should have a minimum velocity of 20 m/s. This corresponds to an average acceleration of 50 m/s^2 over the first four metres of flight.

3.2 STATIC STABILITY MARGIN

The static stability margin (distance between the centre of mass and the centre of pressure) must be between 1.5 diameters and 2.5 diameters during all phases of flight before recovery (see figure 3.1).

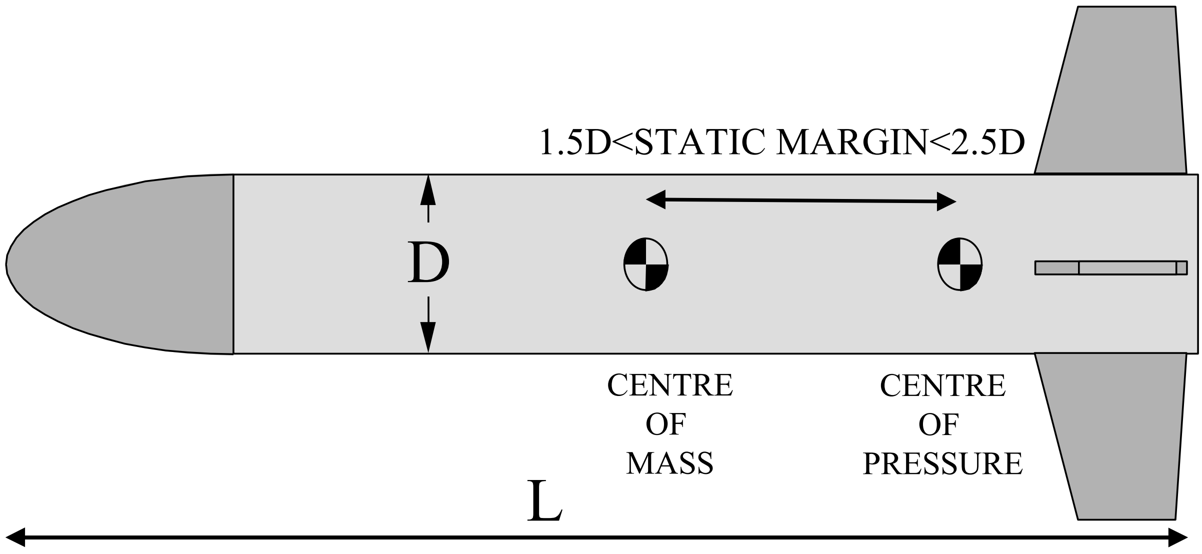

Figure 3.1

CHAPTER 4 - STRUCTURAL ACCEPTANCE REQUIREMENTS

In order 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.

Fins:

4.1 FIN ALIGNMENT

The geometric alignment of each fin must be within 2° of the projected longitudinal axis of symmetry of the rocket (see fig 4.1)

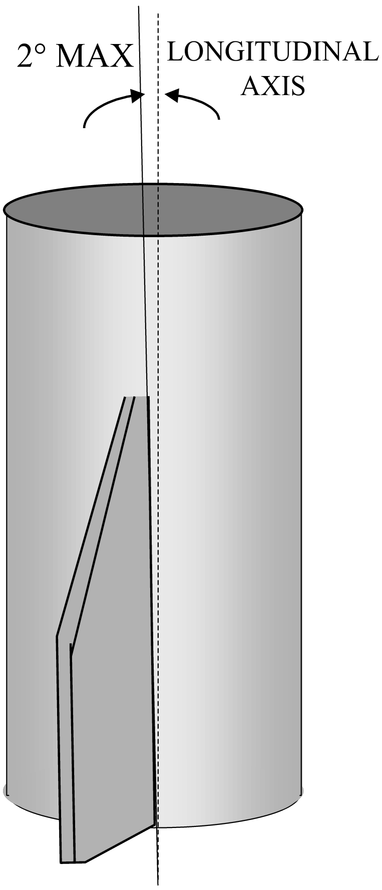

Figure 4.1

4.2 FIN LONGITUDINAL LOADING

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 (fig 4.2)

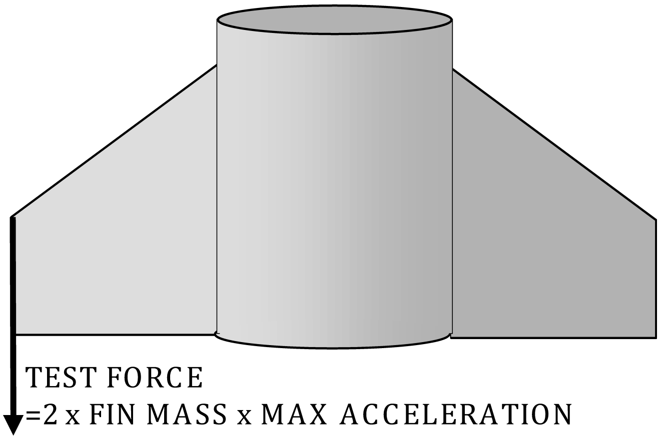

Figure 4.2

4.3 FIN LATERAL LOADING

Each fin must withstand a transverse load equal to the rocket's launch mass when suspended from the fin tip. When subjected to this load, the maximum lateral deflection measured at the tip must be less than 10° in either direction.

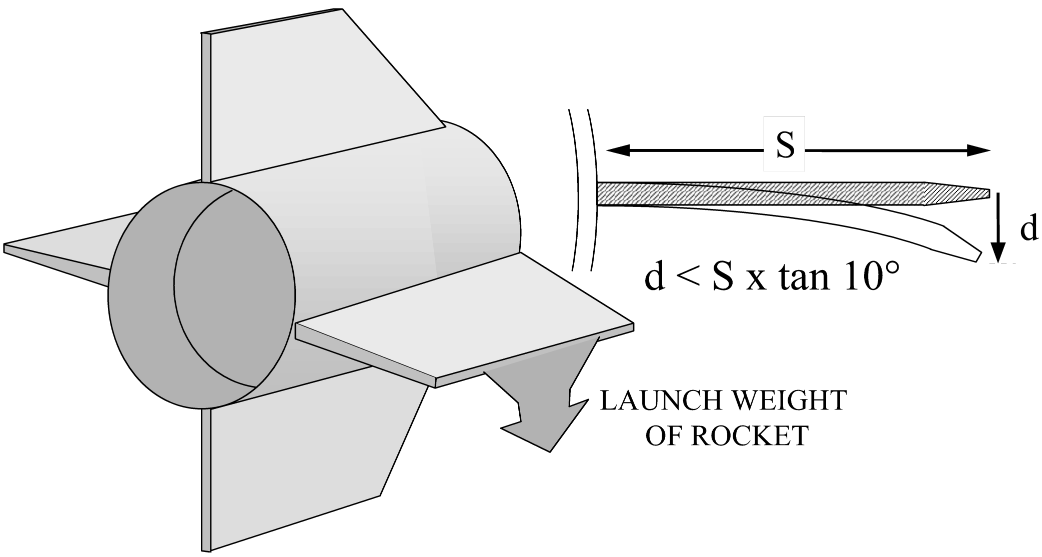

Figure 4.3

4.4 FUSELAGE STIFFNESS

When a fully assembled and loaded rocket is suspended from its centre of mass it must produce a lateral deflection in any direction of less than 0.01 radian = 10mm deflection per metre length

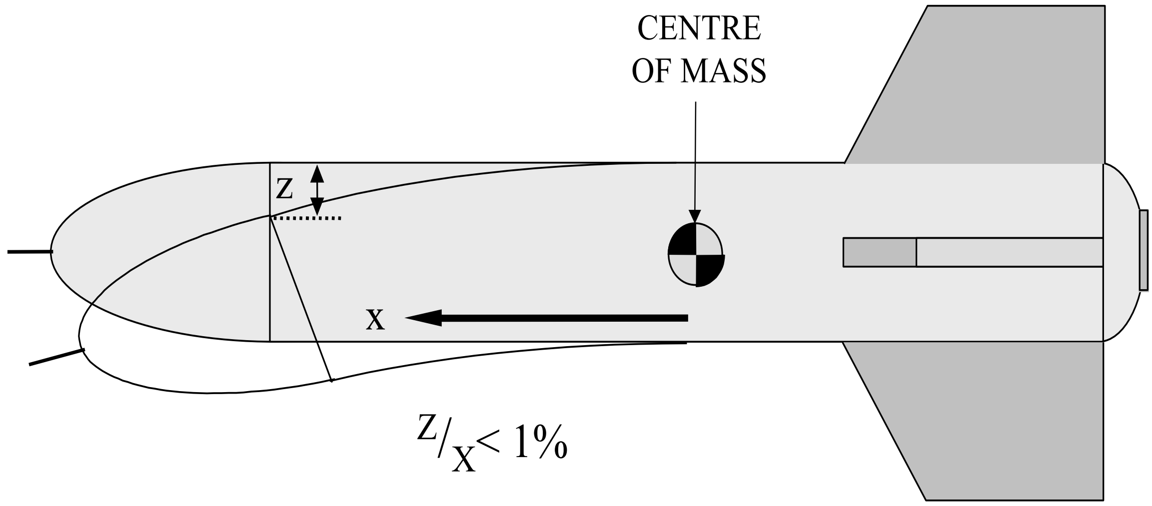

Figure 4.4

When a rocket is coupled together from a number of tubes, the method of joining the tubes is left to the application and discretion of the designer. However, it is recommended that the mating length between the coupler and each tube should be a minimum of 1 diameter when using plastics or composites and a minimum of 1/2 a diameter when using metals (see figure 4.5). This is advised in order to maintain satisfactory levels of stiffness along the length of the rocket.

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

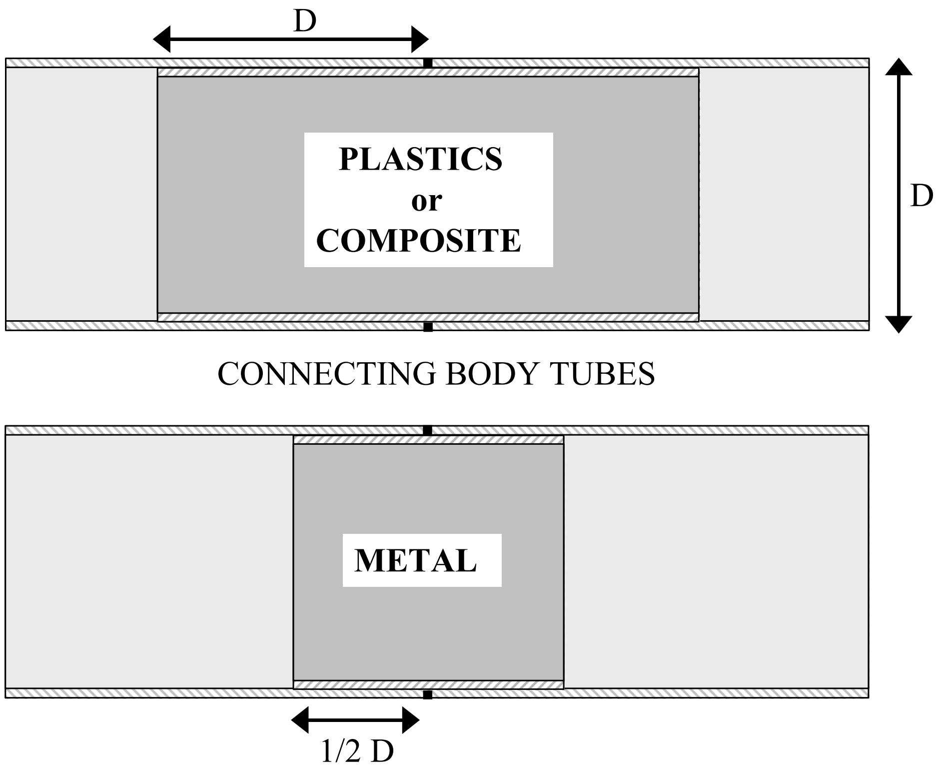

Figure 4.5

4.5 Static Strength Requirements

All calculations in the build report must prove that all structural parts can withstand twice the inertial and aerodynamic loads on them during all phases of flight without failure.

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

CHAPTER 5 - ELECTRICAL SYSTEM LAYOUT

There are going to be a number of electrical subsystems onboard a rocket such as payloads, a telemetry system and a flight sequencer to control the recovery system.

5.1 INTERNAL POWER SUPPLY

The rocket must be capable of being switched on and left to run autonomously using its internal power source for up to 15 minutes on the launch pad

This should be budgeted for in addition to the energy used during the predicted total flight time.

5.2 ELECTRICAL CONSIDERATIONS

It is strongly recommended that single strand wire not be used as electrical cable for primary systems since it is considered too fragile. Multi-strand wire is considered to be tougher and more reliable under handling and flight conditions.

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.

CHAPTER 6 - RECOVERY REQUIREMENTS

6.1 USE OF 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.

6.2 LANDING SPEEDS

The recovery system must reduce the rocket's vertical landing speed to less than 15 m/s. This speed must be demonstrated by documented calculation in the build report.

6.3 MAXIMUM POST-APOGEE RANGE

After apogee, the rocket must not drift more than one kilometre before landing in all wind speeds up to and including 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.

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 4seconds.

Flight Sequencer

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

The simplest and most reliable way of achieving this 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.

6.4 Isolation of Recovery Circuit

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

It is important that special attention is paid to the design of the recovery system sequencing circuit. This is one of the most safety critical components. Good design will produce a safe and reliable system.

The sequencing circuit consists of three main parts: the ***launch detector***, the ***timer*** and the ***actuator***. A lot of systems available already have these built in but teams are encouraged to use these. An example is the perfectflite miniTimer 4 see http://www.perfectflite.com/timers.html. However teams can develop their own systems.

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.

The Timer

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. This is set into a timer that activates the recovery system.

However, if a team wants to employ other techniques for directly sensing apogee a back up timer should still be used.

6.5 Detection of Apogee

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.

6.6 Flight Sequencer Disarming Mechanism

The flight sequencer 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.

6.7 Validation of Flight Sequencer

Teams must demonstrate the reliability and reproducibility of their flight sequencer and recovery system at the pre-launch checks. If the system contains any expendable components (such as pyrotechnics), a sufficient quantity must be brought to demonstrate the proper functioning of the system.

6.8 Integrity of Circuit under Force

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. The recovery system design must be well researched and documented in the project report.

6.9 Transmission of Recovery Shock Loads

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

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