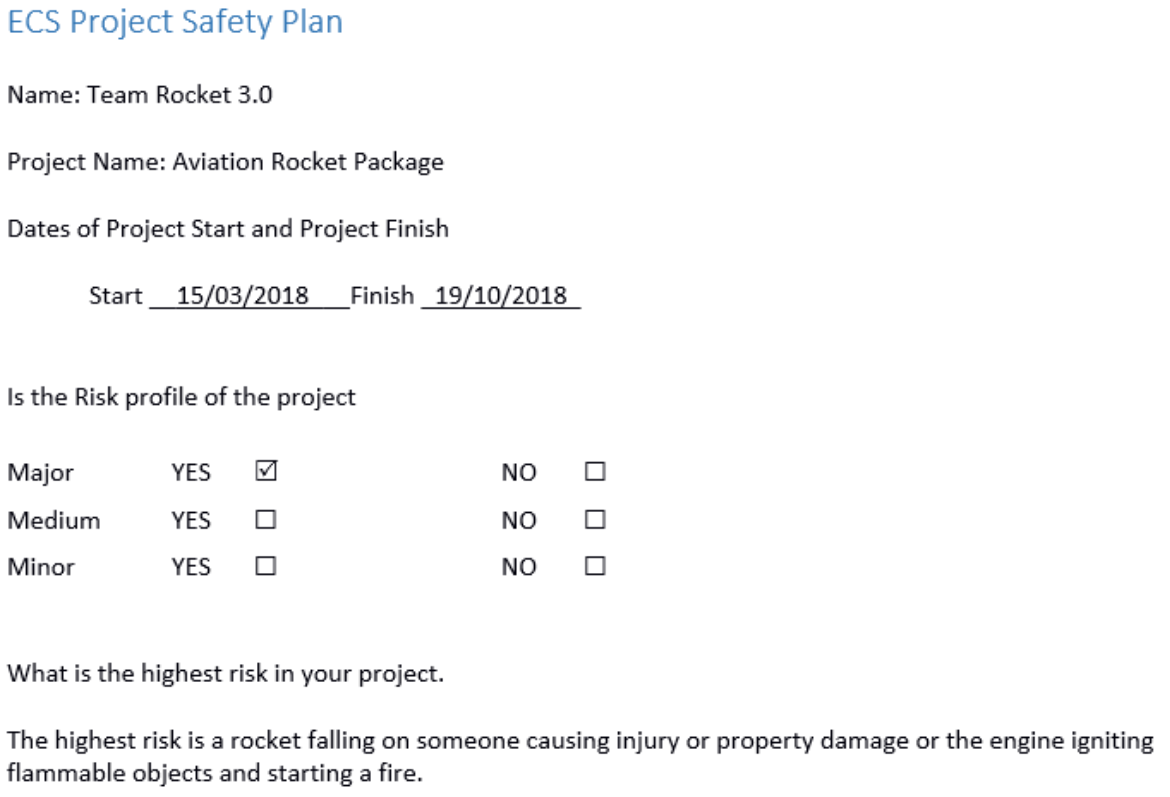
Safety Plan

Note: This Safety Plan is valid for the first milestone of the project. This plan is complemented by a Launch Document that will be created for each launch. This plan should not change until completion of the first milestone.



ECS Project Safety Plan

Name: Team Rocket 3.0

Project Name: Aviation Rocket Package

Dates of Project Start and Project Finish

Start 15/03/2018 Finish 19/10/2018

Is the Risk profile of the project

Major	YES	☑	NO	☐
Medium	YES	☐	NO	☐
Minor	YES	☐	NO	☐

What is the highest risk in your project.

The highest risk is a rocket falling on someone causing injury or property damage or the engine igniting flammable objects and starting a fire.

Figure 1: safety form cover.

Contents

1. The Rocket

The rocket to be launched has a maximum weight of 79 grams and a maximum length of 9 centimetres. It will use a Quest C6-5 motor which has 10.8 grams of black powder propellant containing Potassium Nitrate, Sulphur and Charcoal and 8.8 Newton-seconds of impulse. The motor will not be modified in any way or used in any way except those recommended by the manufacturer of this motor. OpenRocket, a free, open-source rocket simulator was used to run tests to estimate the apogee and landing radius under varying wind speeds. The rocket will be able to reach an estimated maximum height of 45 metres (150 feet) based on simulations of flight under ideal conditions (i.e. 0 km/h winds); facilitating to a straight, undiverted, upward trajectory. The maximum landing radius based on simulations of the worst case launching conditions (e.g. high winds) is approximately 47 metres.

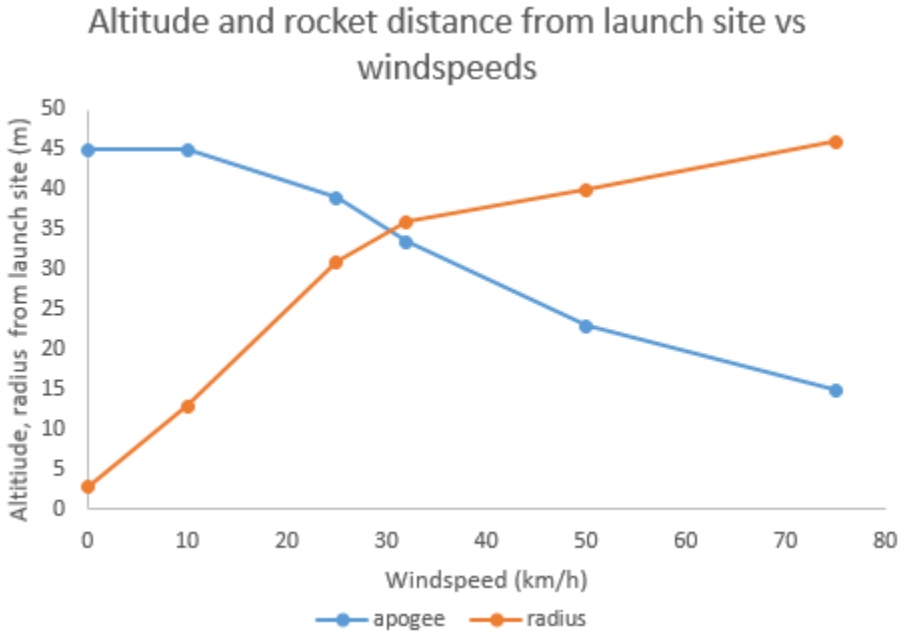


Figure 2: Rocket simulation analysis of maximum apogee and ground hit distance.

In accordance with the NZ Model Rocketry Safety Code, the rocket exterior contains no metal parts, and the ignition system includes two safety interlocks. As per CAA regulations Part 101.3 (Appendix B), a rocket is defined as being a pilotless vehicle propelled by a system that contains every ingredient needed to form its own jet other than – a rocket propelled by a model rocket motor of size A-D which achieves no more than 20 Newton-seconds of total impulse. Our rocket is estimated to have 8.8 Newton-seconds of impulse using a C-class motor and is therefore not

classified as a rocket under the CAA guidelines. However, the team will ensure the rocket follows the guidelines regardless. In addition, as a recovery charge is not needed for this flight, it will be deactivated, this will greatly reduce the potential damage risk from fire or debris, as a non-deactivated charge could ignite after the rocket has already landed. The rocket is designed to tumble after burnout, preventing a dangerous ballistic fall.

In keeping with the New Zealand Rocketry Asociation safety code, the minimum dimensions for the launch exclusion zone is 120 metres for a C-class motor (Appendix E). This measurement is defined as being the diameter of a circular launch site or the shortest edge of a rectangular lauch site.

2. Launch Details

Details specific to a launch will be found in the launch documents.

2.1 Travel Plan

The heat needed to ignite the motor is approximately 288°C (550°F), thus the rocket will be kept far from any source of heat greater than 50°C during transportation to minimise the risk that the motor ignites (see Appendix A). Multiple persons of contact will be present during transportation; should an issue occur, such as getting lost or injured. The mobile phone(s) can thus be used to resolve the issue appropriately (see section 2.5 Communications). In accordance with the Land Transport Rule: Dangerous Goods 2005, the rocket motor is classified as Class 1 dangerous goods under division 1.4S.

A designated member of the university staff, who are well informed of the excursion, will be contacted upon return to confirm that all participants have safely returned from the launch. If the staff member has not been contacted to confirm this by one hour after the planned arrival time to Kelburn Campus, emergency action should be taken. This member of staff and their contact details are laid out in the launch documents.

2.2 Environment

As required by CAA regulations Part 101.157 and Part 101.159 (see Appendix C), the launch will take place during daylight hours and will be cancelled under the following weather conditions:

- Cloud cover which obscures more than half of the visible sky.
- Conditions which limit horizontal visibility to less than 8km.
- Heavy precipitation.
- High wind speed (speeds exceeding 32 km/h). N.B. previous launch teams required lower wind speeds as one of their launch conditions (14 km/h), this was due to the previous airframe having a much more aerodynamic shape than the current iteration.

The following resources will be used to together to confirm weather conditions prior to departure to the launch:

- Accuweather. This site shows expected hourly expected wind speeds, as well as expected wind gust speeds.
- Wind Finder. This site uses live data from weather stations in order to show live wind speed and direction.
- Metservice. Metservice provides three hourly measurements from each weather station.

Both Accuweather and Wind Finder use prediction models for the Kelburn area, Metservice takes measurement data from a Kelburn weather station and records the data every three hours. By comparing the measured data from Metservice and the predictions from Accuweater and Wind Finder a more accurate estimation of current wind speed will be found.

After arrival at the launch site and necessary preparations have been made for launch, weather conditions will be checked again prior to beginning the launch countdown. Furthermore, the rocket will not be launched into the clouds, as per CAA regulations Part 101.157 (b).

To ensure no harm is caused to any members of the general public who may be using the park at the time of the launch, each member will be notified of the launch and any safety precautions they will need to take for the duration for the launch. If they indicate prior to the launch that they will not comply with these precautions, or the number

of people present in the park is greater than ten, the launch will be postponed until the members leave the park (if possible), or simply cancelled (if not possible).

Throughout the duration of the launch itself, three members of the team will be stationed around the launch site at the maximum landing radius. They will ensure that any nearby users of the park are kept aware of the launch and remain outside the safe radius of 5m from the launch point.

2.3 Equipment

The equipment to be taken on the launch is summarised in the table below.

Equipment	Owner
Rocket and ignition switch	Andre
Fire extinguisher	School of Engineering and Computer Science, VUW
First aid kit	School of Engineering and Computer Science, VUW
Safety goggles x11	School of Engineering and Computer Science, VUW
Hi-Vis vests	School of Engineering and Computer Science, VUW
Ammo bag	School of Engineering and Computer Science, VUW
Glad wrap (for burns)	Participants
Launch rail and pad	School of Engineering and Computer Science, VUW
Laptop computers	Participants
Digital camera	School of Engineering and Computer Science, VUW
Mobile phones	School of Engineering and Computer Science, VUW

A checklist based on this list will be used to ensure all equipment is packed before departure to and from the site.

2.4 Supervision

The launch will be supervised by Andre Geldenhuis. Andre is a very experienced expert in model rocketry and is a member of the NZ Model Rocketry Association. Andre will be responsible for launching the rocket and deactivating any recovery charges which are deemed unnecessary for the first airframe. Additionally, all motors will be transported to and from the launch site only by Andre, who is experienced in this procedure. The rocket will be launched from the launch rail and pad provided by Andre, the rocket will be launched only by Andre.

2.5 Launch

In regards to NOTAMs, as per CAA regulations Part 101.161, Airways NZ (Air Traffic Control) does not need to be notified of any launch attempts, as the rocket does not meet any of the requirements for issuing a NOTAM. Furthermore, nearby hills and buildings have been identified as being higher than the maximum apogee of the rocket, negating any possibility of aircraft in the vicinity.

Upon arrival at the site, a safety inspection will be conducted to identify any hazards in the area and mitigate risks pertaining to those hazards. At this point, any hazards relating to members of the general public present in the park will be assessed as has been described above. In particular, any dry vegetation of flammable materials in a 3 metre radius around the launcher that might be ignited by the motor's exhaust, following the NZ Rocketry Association safety code Section 2-14.2. The launch exhaust is expected to cause a small burn scar on the ground; if deemed necessary, a blast deflector will be used to prevent the motor's exhaust from hitting the ground; this minimizes the risk of fire or damage to the ground.

A countdown will be used to provide plenty of notice to all participants and ensure they are prepared for the launch. This countdown can be stopped upon request from any of the participants at any time to ensure the launch does not commence until all are prepared for it. Should the rocket motor fail to ignite, the safety interlocks will be put back in place and all participants will wait at least one minute before approaching the rocket. Launch trajectory will be directed as vertically as possible. This serves to minimize the landing distance from the the launch point. All

participants will wear protective eye goggles or glasses during the launch and when handling the rocket. The rocket will be launched only by Andre Geldenhuis.

2.6 Unforeseen Events

2.6.1 Members of the Public

- If a member of the public confronts a team member for any reason, the team member is to ask them to talk to Andre Geldenhuis.
- If a member of the public has a complaint, they should be asked to contact James Quilty with contact details that the team member should have on hand.
- If a member of the public poses a safety threat, the launch shall be suspended until the situation can be resolved by Andre Geldenhuis.

2.6.2 Faulty Components

If an electronic component is found to be faulty on the launch site, the motor will be removed and the team will attempt a fix.

If it is found that the motor is faulty, e.g. a miss fire or a significantly decreased burn time, after waiting one minute, Andre Geldenhuis will be the only one to approach the rocket and provide an all-clear for the other members to approach, if and only if it is deemed safe to do so.

3. Appendices

Appendix A: Risks and Mitigations

Category	Hazard	Risk	Impact	Controls/Mitigations
Rocket	Falling rocket	Rocket falls onto one or more people causing injury	20 - Extreme	All participants will remain 5 metres from the launch site for the entirety of the flight. All passers-by will be warned of the launch and if the park is too busy (more than 10 people) the launch will be delayed until the number of people has decreased or the launch will be cancelled.
	Rocket engine ignites prematurely	Engine exhaust hits participants causing burns, injuries or property damage	15 - Very High	The rocket will be kept away from any heat sources to reduce the chance of premature ignition. Two safety interlocks will also be used to reduce the chance of premature ignition
		Participants caught off guard and are unable to follow safety procedures	6 – Medium	A countdown will be used to ensure all participants are prepared for the launch
	Engine fails to ignite then ignites unexpectedly at a later time	Engine exhaust hits participants causing burns, injuries or property damage	8 – Medium	If the engine fails to ignite the ignition system will be disabled and all participants will wait one minute before approaching the rocket.
	Chassis falls apart while in air	Parts of chassis fall on people or property causing damage	9 - Medium	The frame of the rocket will be made from a single 3D printed piece minimising the chance that it falls apart. All components will be securely attached to the frame to prevent them from falling off mid flight
Environment	Rocket engine lands in flammable area	Fire that spreads beyond control	12 - High	The chosen site is a wide open field with very little flammable material within range of the rocket. The fire risk for the area will be checked before the launch and the launch will be cancelled if the risk is too high. A fire extinguisher will be present for all launches and participants will have working phones in case emergency services need to be contacted.
	Aircraft flight nearby	Aircraft flight disturbed	5 - Medium	By using a C engine with a maximum height of about 60 metres the rocket will be well under the minimum flying height for aircraft.
	High wind	The rocket could land on people or property causing damage	12 - High	The wind levels will be measured before any launches and the launch will be cancelled if the wind is too high for a safe launch.
People	Ejected light, heat and particles from engine	Heat, light and small particles could hit participants causing injury	9 - Medium	All participants will stand 5 metres away from the rocket at launch which is the recommended safe distance advised by the NZ Model Rocketry Association when using D motors or lower.

Appendix B: CAA of NZ Regulations Part 101 amendment 2, page 7, Definition of Rocket

Model aircraft means a pilotless aircraft with a gross mass of between 100 g to 25 kg and includes—

(1) control line model aircraft:

(2) free flight model aircraft:

(3) radio controlled model aircraft:

Model Rocketry Safety Code means the code of that name that is approved by the New Zealand Rocketry Association:

Moored balloon means a pilotless balloon that is moored to the surface of the earth, or to an object on the surface of the earth, and has a maximum diameter of more than 1.5 m or a gas capacity of more than 3 m^3:

Parasail means an aerodyne, having the general form of an open, circular parachute carrying a person or persons towed behind a vehicle or motorboat to sustain flight:

Radio controlled model aircraft means a model aircraft that is primarily controlled by radio signals from a remote transmitter being operated by a person:

Rocket means a pilotless vehicle propelled by a system that contains every ingredient needed to form its own jet other than—

(1) an aerial firework; or

(2) a rocket propelled by a model rocket motor of size A-D which achieves no more than 20 Newton-seconds of total impulse:

Shielded operation means an operation within 100 m of a structure and below the top of the structure.

Appendix C: CAA od NZ Part 101 Operating Rules, page 21, 101.157 and 101.159 highlighted

(c) A person shall not operate a rocket between 4 and 8 km of an aerodrome boundary above 400 feet AGL.

101.157 Meteorological limitations

(a) A person shall not operate a rocket at any altitude where—

(1) there are clouds or obscuring phenomena of more than four-eighths coverage; and

(2) the horizontal visibility is less than 8 km.

(b) A person shall not operate a rocket into cloud.

101.159 Night operations

Except for a large model rocket, a person shall not operate a rocket at night.

101.161 Pre-launch notice

Except for a large model rocket, a person shall not launch a rocket unless they provide the following information to the New Zealand NOTAM office at least 24 hours prior to launch:

(1) their name, address, and telephone number or, where there are multiple participants at a single event, the name, address, and telephone number of the person whose duties include co-ordination of the launch data estimates required by paragraphs (2), (3), and (4) of this rule and co-ordinating the launch event:

(2) the estimated number of rockets to be operated:

(3) the estimated size and the estimated weight of each rocket:

(4) the estimated highest altitude or flight level to which each rocket will be operated:

(5) the location of the operation:

(6) the date, time, and duration of the operation:

(7) any other relevant information requested by the person to whom notification is given.

Appendix D: CAA od NZ Part 101 Operating Rules, pages 20, 21, 101.155 highlighted

101.155 Aerodromes

(a) Except as provided in paragraph (b), a person shall not operate a rocket on or within 4 km of an aerodrome boundary.

(b) A person may operate a rocket within 4 km of an aerodrome boundary providing—

(1) the rocket does not fly above 400 feet AGL; and

(2) at uncontrolled aerodromes, it is operated in accordance with an agreement with the aerodrome operator; and

(3) at controlled aerodromes, it is operated in accordance with an authorisation from ATC; and

(4) it is not operated on or over any active aircraft movement area of an aerodrome; and

(5) it is not operated on or over any active runway strip area.

(c) A person shall not operate a rocket between 4 and 8 km of an aerodrome boundary above 400 feet AGL.

Appendix E: NZ Rocketry Association launch site dimensions for motor classes A-G

MotorType	Installed Total Impulse (Newton-Seconds)	Minimum Site Dimensions (metres)
Micromaxx		15
½A	0.00 - 1.25	15
A	1.26 - 2.50	30
B	2.51 - 5.00	60
C	5.01 - 10.00	120
D	10.01 -20.00	150
E	20.01 - 40.00	300
F	40.01 - 80.00	300
G	80.01 - 160.00	300
2 G's	160.01 - 320.00	450

Appendix F: NZ Rocketry Association launch site dimensions for motor classes H-O

INSTALLED TOTAL IMPULSE(N-SEC)	EQUIVALENT MOTOR TYPE	MINIMUMSITE DIMENSIONS (M)	EQUIV, KMS
160.01 - 320.00	H	457	0.5
320.01 - 640.00	I	914	0.9
640.01 - 1280.00	J	1609	1.6
1280.01 -2560.00	K	1609	1.6
2560.01 - 5120.00	L	3219	3.2
5120.01 -10240.00	M	4828	4.8
10,240.01 - 20480.00	N	6437	6.4
20,480.01 -40960.00	O	8047	8

Appendix G: NZ Rocketry Association Safety Code

1. MATERIALS

I will use only lightweight, non-metal parts for the nose, body and fins of my rocket.

2. Motors

I will use only certified, commercially-made model rocket motors and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer.

3. IGNITION SYSTEM

I will launch my rockets with an electrical launch system and electrical motor igniters. My launch system will have a safety interlock in series with the launch switch, and will use a launch switch that returns to the 'off' position when released.

4. MISFIRES

If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher's safety interlock or disconnect it's battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

5. LAUNCH SAFETY

I will use a countdown before launch, and will ensure that everyone is paying attention and is a safe distance of 5 metres away when I launch rockets with D motors or smaller, and 10 metres away when I launch larger rockets. If I am uncertain about the safety or stability of an untested rocket, I will check the stability before flight and will fly it only after warning spectators and clearing them away to a safe distance.

6. LAUNCHER

I will launch my rocket form a launch rod, tower, or rail that is pointed to within 30 degrees of the vertical to ensure that the rocket flies nearly straight up, and I will use a blast deflector to prevent the motor's exhaust from hitting the ground. To prevent accidental eye injury, I will place launchers so that the end of the launch rod is above eye level or will cap the end of the rod when it is not in use.

7. SIZE

My model rocket will not weigh more than 1,500 grammes at liftoff and will not contain more than 125 grammes of propellant nor produce more than 320 N-secs of total impulse.

8. FLIGHT SAFETY

I will not launch my rocket at targets, into clouds, or near aeroplanes, and will not put any flammable or explosive payload in my rocket.

9. LAUNCH SITE

I will launch my rocket outdoors, in an open area at least as large as shown in the table below, and in safe weather conditions with wind speeds no greater than 32 kilometres per hour. I will ensure that there is no dry grass close to the launch pad, and that the launch site does not present risk of grass fires.

10. RECOVERY SYSTEM

I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery wadding in my rocket.

11. RECOVERY SAFETY

I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places. I promise to read and follow the Model Rocket Safety Code.

Bibliography

B1: Fire Risks Maps
B2: Airspace Maps