Designing a model rocket with OpenRocket

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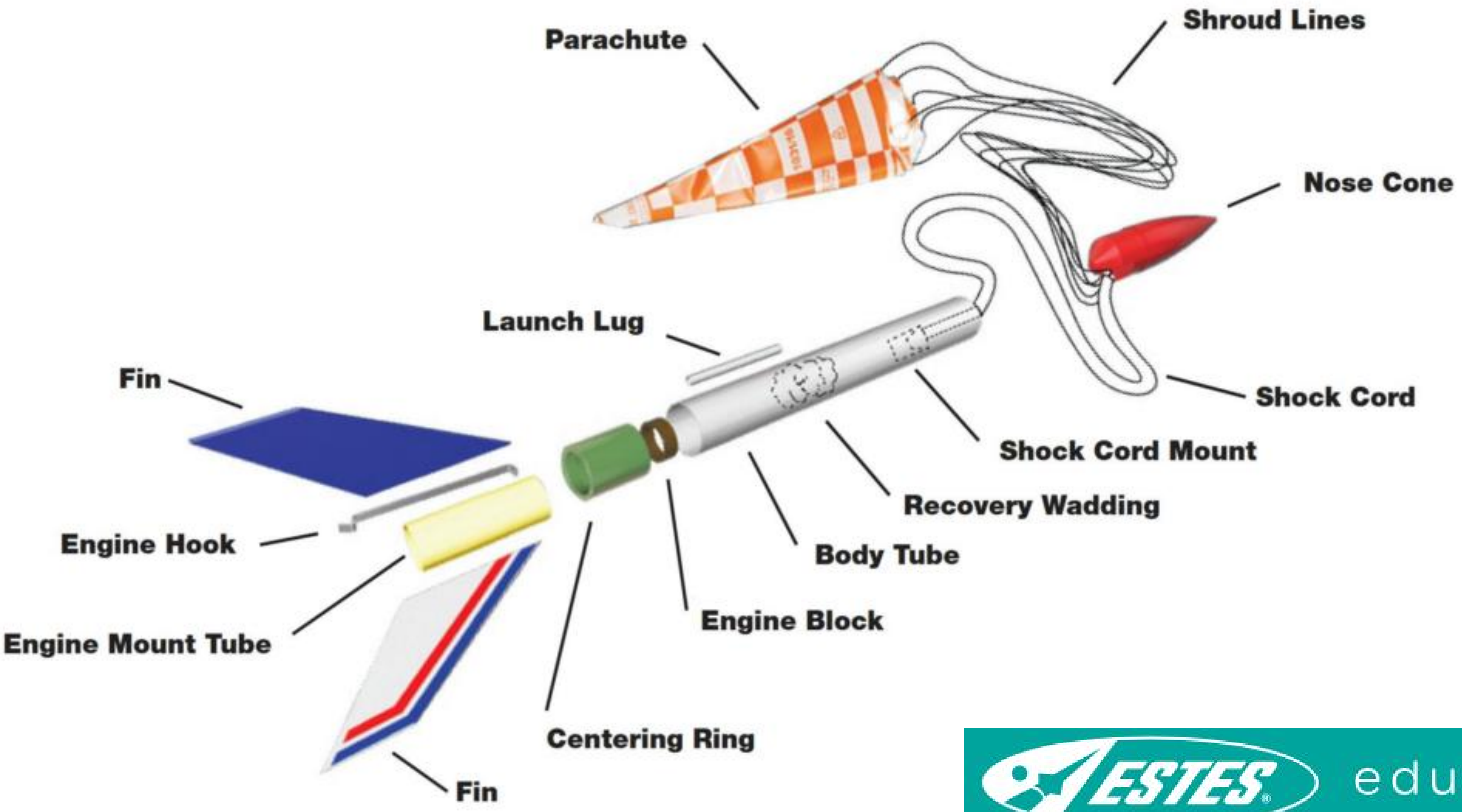
Rocket Design – The Basic Parts



ESTES education

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Rocket Design – The Basic Parts: Aerosurfaces

Nose Cone
The nose cone sits at the top of the rocket and helps it cut through the air smoothly. Its shape has a big impact on how high and fast the rocket will fly.

- Made from plastic or 3D printed
- Common shapes: ogive, parabola, hemisphere, cone, or combinations
- Parts include: tip, shoulder (fits into body tube), and lip (keeps it in place)

Body Tube (Airframe/Fuselage)
The body tube is the main structure of the rocket. It holds everything together and gives the rocket its shape.

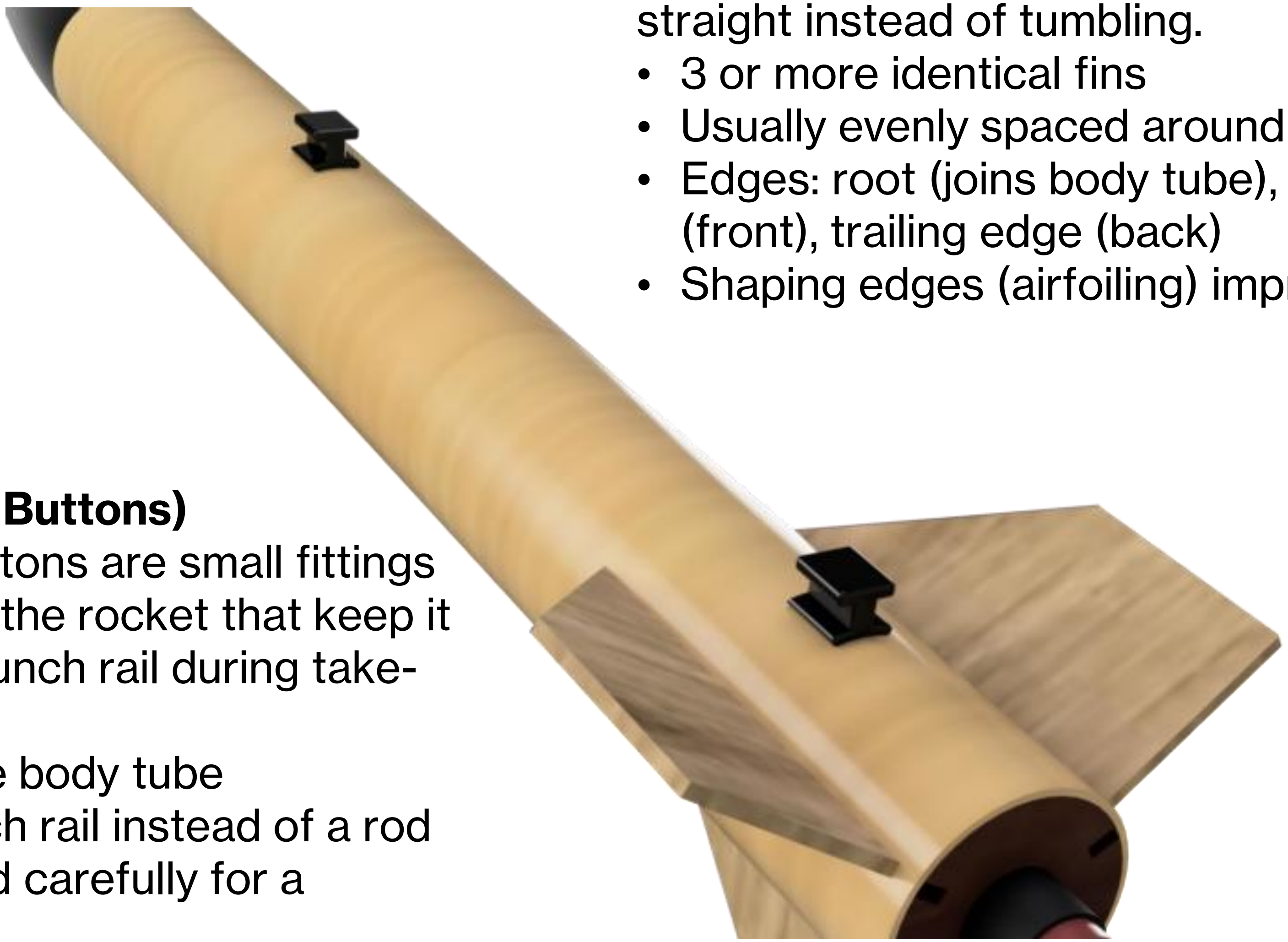
- Long, round tube, usually cardboard or heavy paper
- Connects the nose cone, fins, and rail guides
- Houses the motor and recovery system inside

Rocket Design – The Basic Parts: Aerosurfaces

Fins

Fins keep the rocket stable in flight, making sure it flies straight instead of tumbling.

- 3 or more identical fins
- Usually evenly spaced around the rocket
- Edges: root (joins body tube), tip (outer end), leading edge (front), trailing edge (back)
- Shaping edges (airfoiling) improves performance



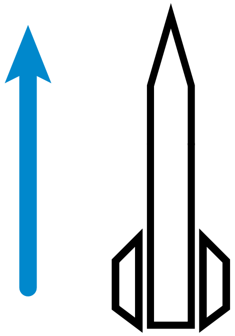
Rail Guides (Rail Buttons)

Rail guides or buttons are small fittings on the outside of the rocket that keep it straight on the launch rail during take-off.

- Attached to the body tube
- Fit onto a launch rail instead of a rod
- Must be aligned carefully for a smooth launch

Rocket Design – OpenRocket

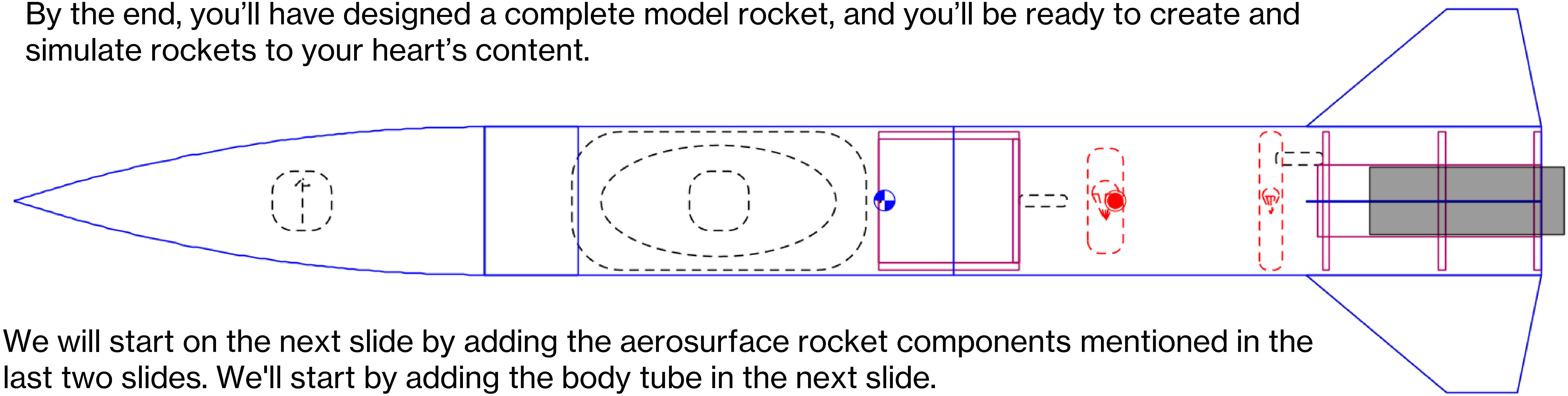
OpenRocket Download page



If we want to understand and predict how our rocket will behave, we need to simulate it. Luckily, OpenRocket does this for us and for free! OpenRocket can simulate all the components of our rocket, show the positioning of each part, and calculate how high and fast the rocket will go, as well as whether it will fly straight.

We'll go through how to implement all the aerodynamic surfaces, the internal components of the rocket, the motor that propels it, and the recovery system that prevents it from crashing into the ground. Finally, we'll simulate the rocket's full flight.

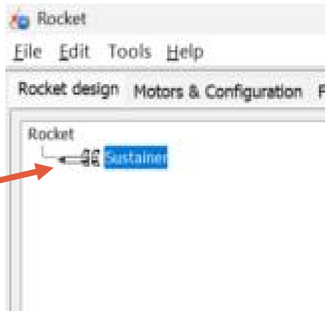
By the end, you'll have designed a complete model rocket, and you'll be ready to create and simulate rockets to your heart's content.



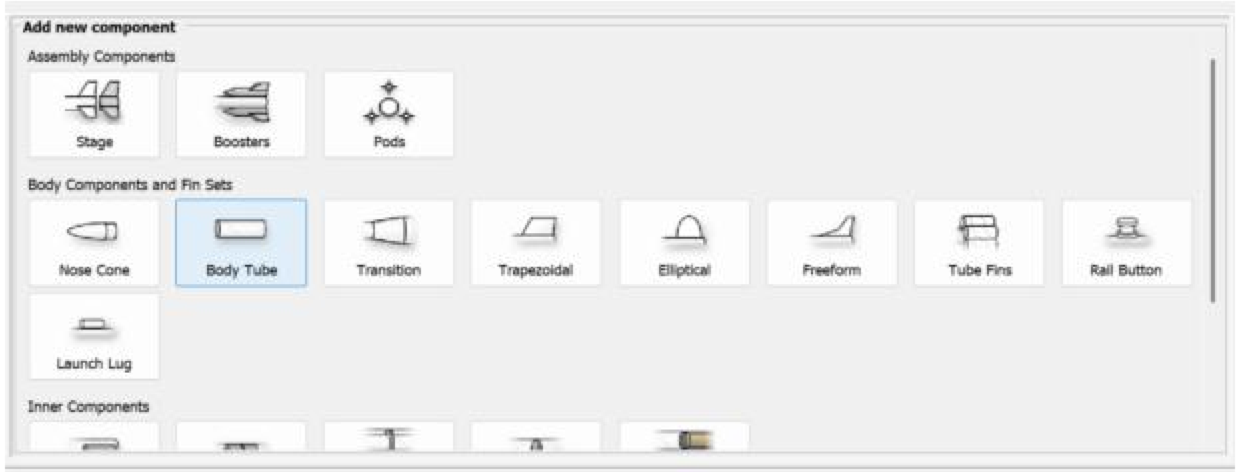
We will start on the next slide by adding the aerosurface rocket components mentioned in the last two slides. We'll start by adding the body tube in the next slide.

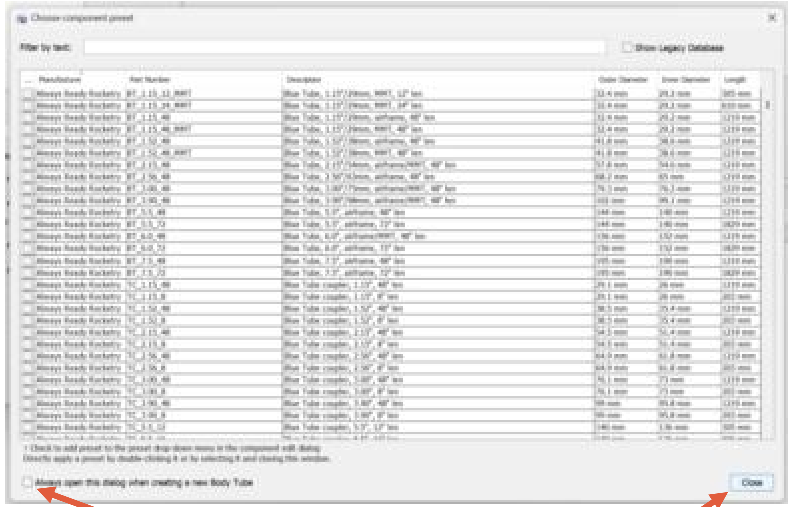
Rocket Design – Adding Rocket Components

1. Click the location where you want to add your part. For a new rocket that's the Sustainer. Your location will be highlighted in blue.



2. Now simply click on the component you want to add from the "Add new component" section. Start with a Body Tube.





3. Two pop-up boxes will appear, firstly untick the "Always open this dialog..." Box in the bottom left and close the box.

Rocket Design – Adding Rocket Components

4. Here we can choose some of our key values:

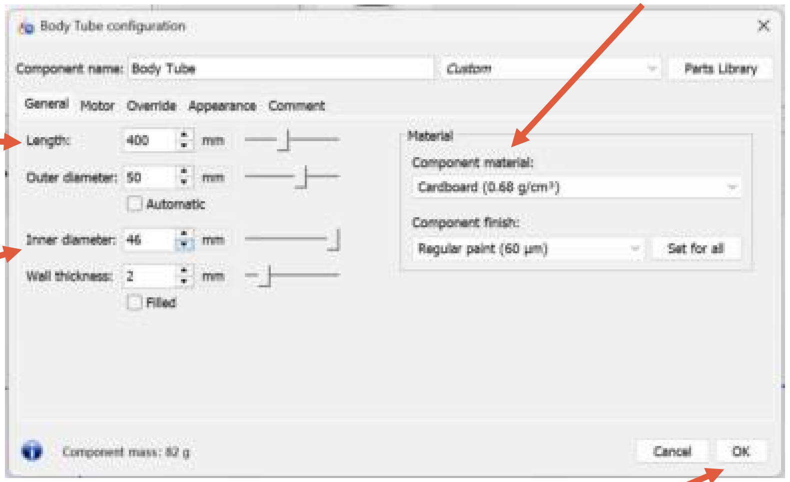
Let's change the **length** to 450mm

Be careful of the units! They can be edited under,
Edit -> Preference -> Units

Material

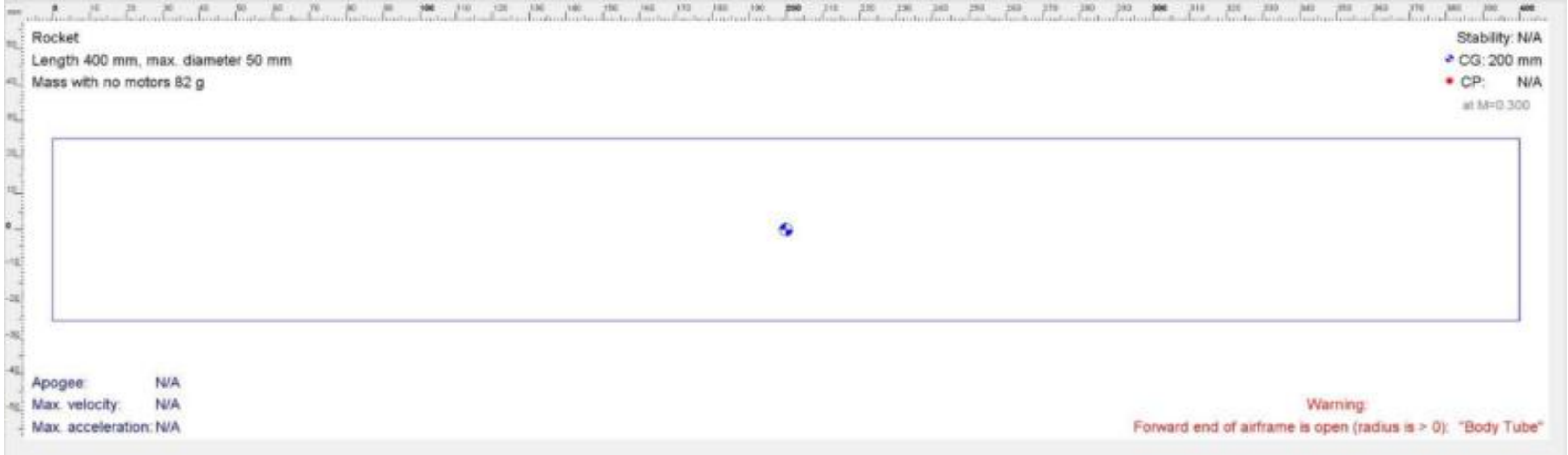
Length

Diameter



Click okay to add the components

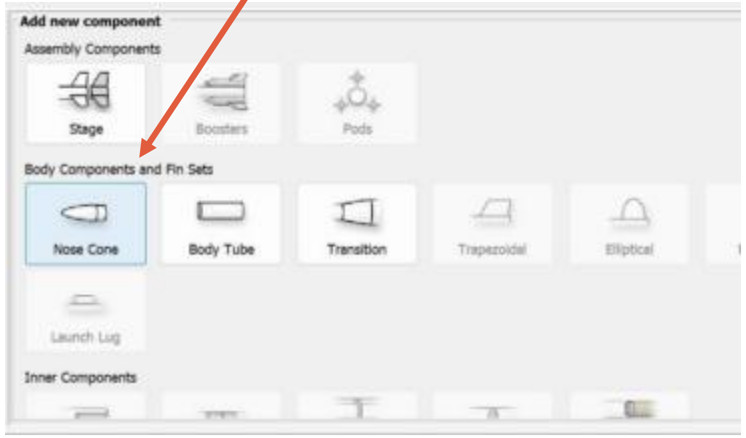
Now we can see our Body tube in the rocket view window.



Rocket Design – Adding Rocket Components

Great we have a body tube, lets now add the nose cone.

1. Repeat the steps but add a nose cone instead



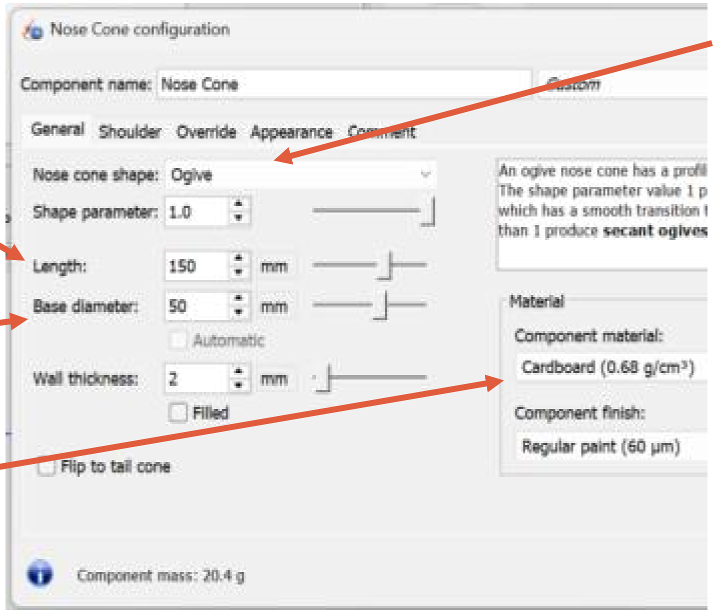
2. Again, untick the "Always open this dialog..." Box in the bottom left and close the box.

3. We can choose some of our key values

Length

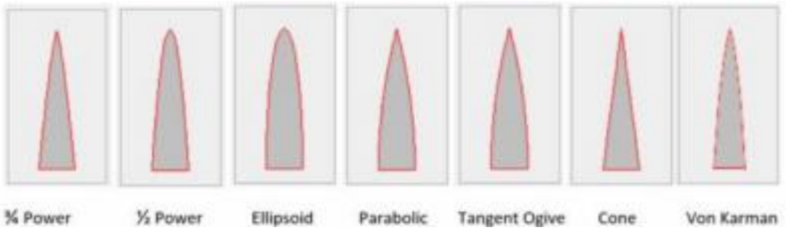
Diameter

Material



Nose cone shape:

There's a few shapes and they effect the aerodynamics of your rocket. You can see the shapes below

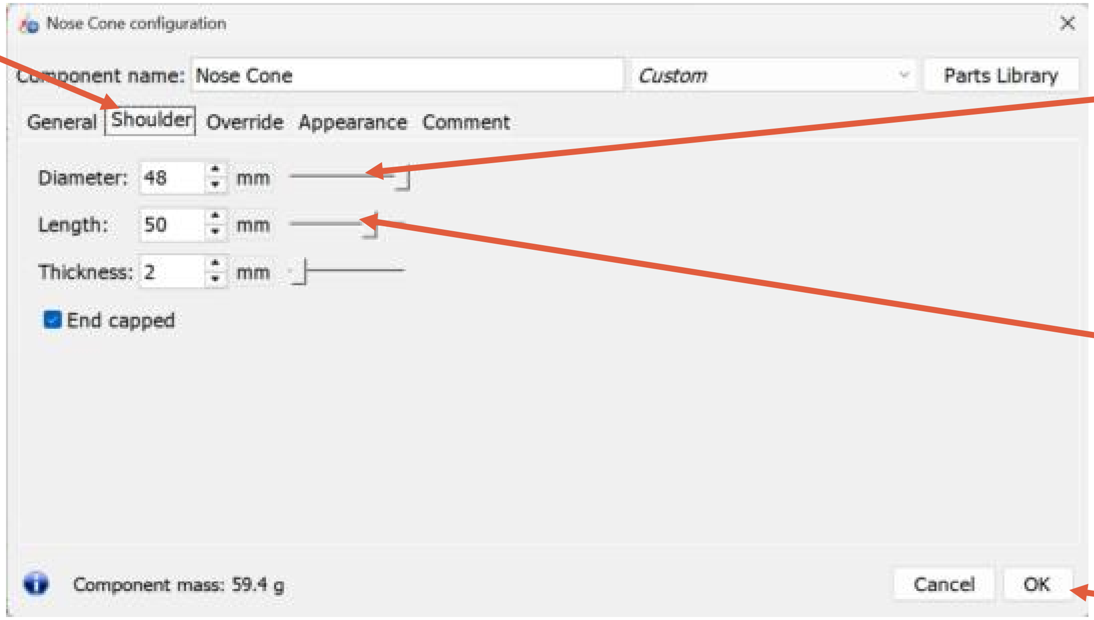


Rocket Design – Adding Rocket Components

1. Nose Cones additionally have an important "Shoulder" tab. This is the part that connects the Nose Cone to the Body tube.

2. We can choose some of our key values

Let's set the shoulder **Diameter** to 48mm and the **Length** to 50mm

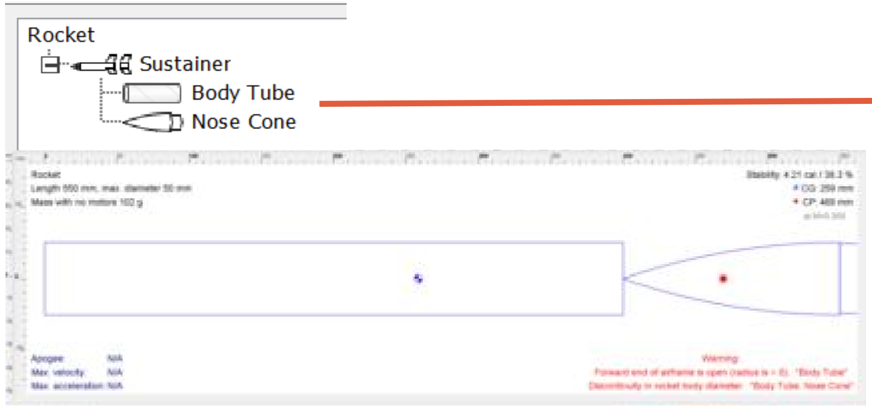


Diameter

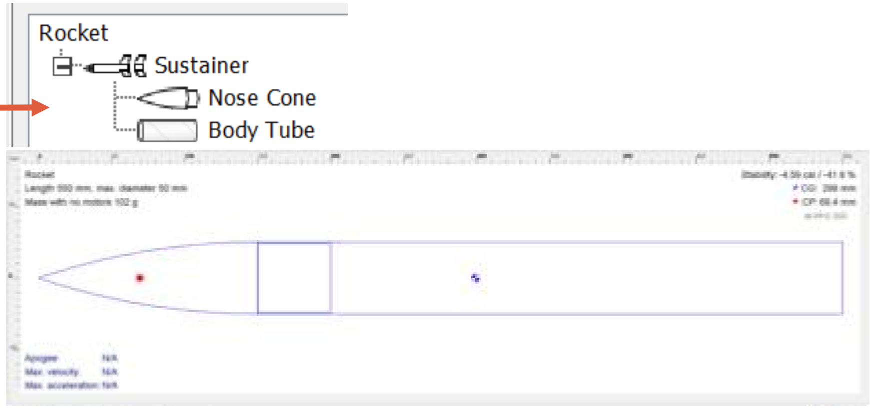
Length

Click okay to add the components

Rocket tree before



Rocket tree after



3. Now you will notice the nose cone and body tube are the wrong way round. The order of the parts is based on the rocket tree. Drag and move parts to change the order.

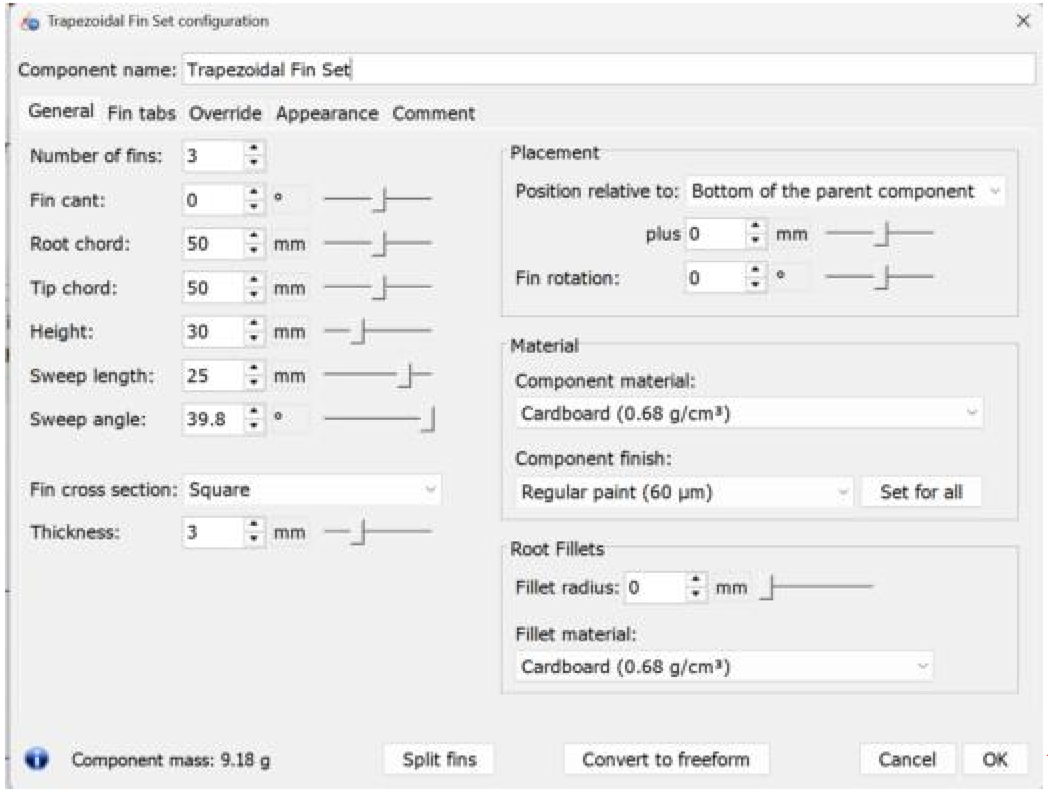
Rocket Design – Adding Rocket Components

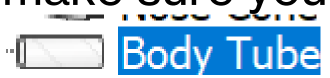
The final, and perhaps most important aspect of the outside surface is the fins. There are three options:

Trapezoidal, which is the standard and creates fins with four sides of any length you choose.

Elliptical, which creates a semi-circle of any height and width you choose.

Free-form, which allows you to create any shape, though it is rarely used except for uniquely designed fins.

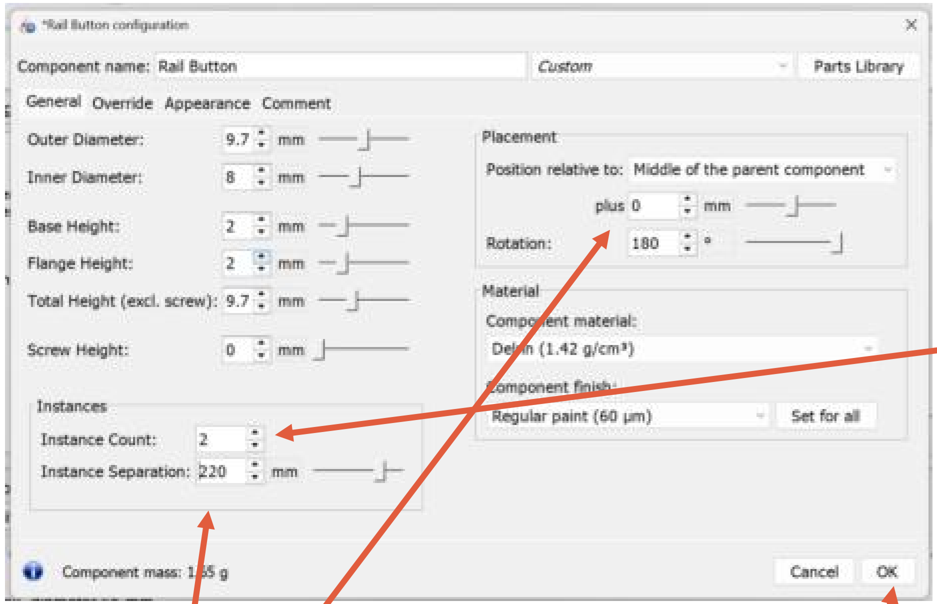


1. Repeat the steps but make sure you select the Body Tube in the rocket tree 

. Then click "Trapezoidal" from the "Add rocket component". There's lots you can do here but for now make the **"Root chord"** 110mm, the **"Tip chord" 4**0mm, the **"Height"** 55mm and the **"Sweep length"** 70mm. You will optimise these later, but this will get the example model working. Click "OK" to add the fins.

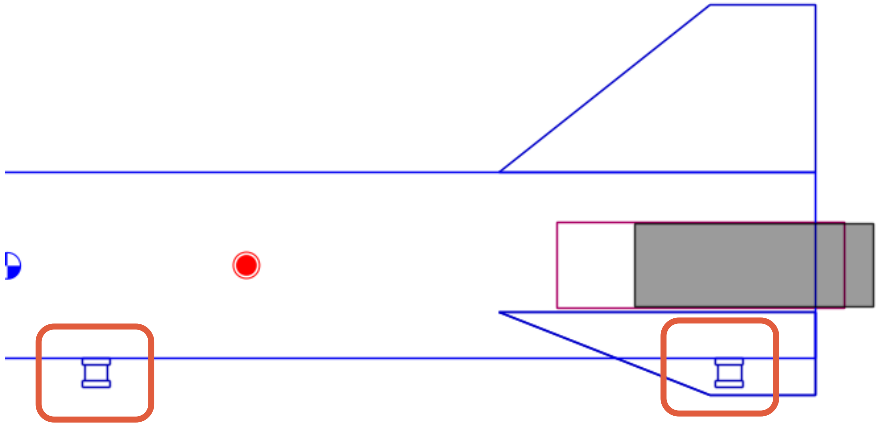
Rocket Design – Adding Rocket Components

Lastly, we need to add some rail buttons, these keep it straight on the launch rail during take-off.



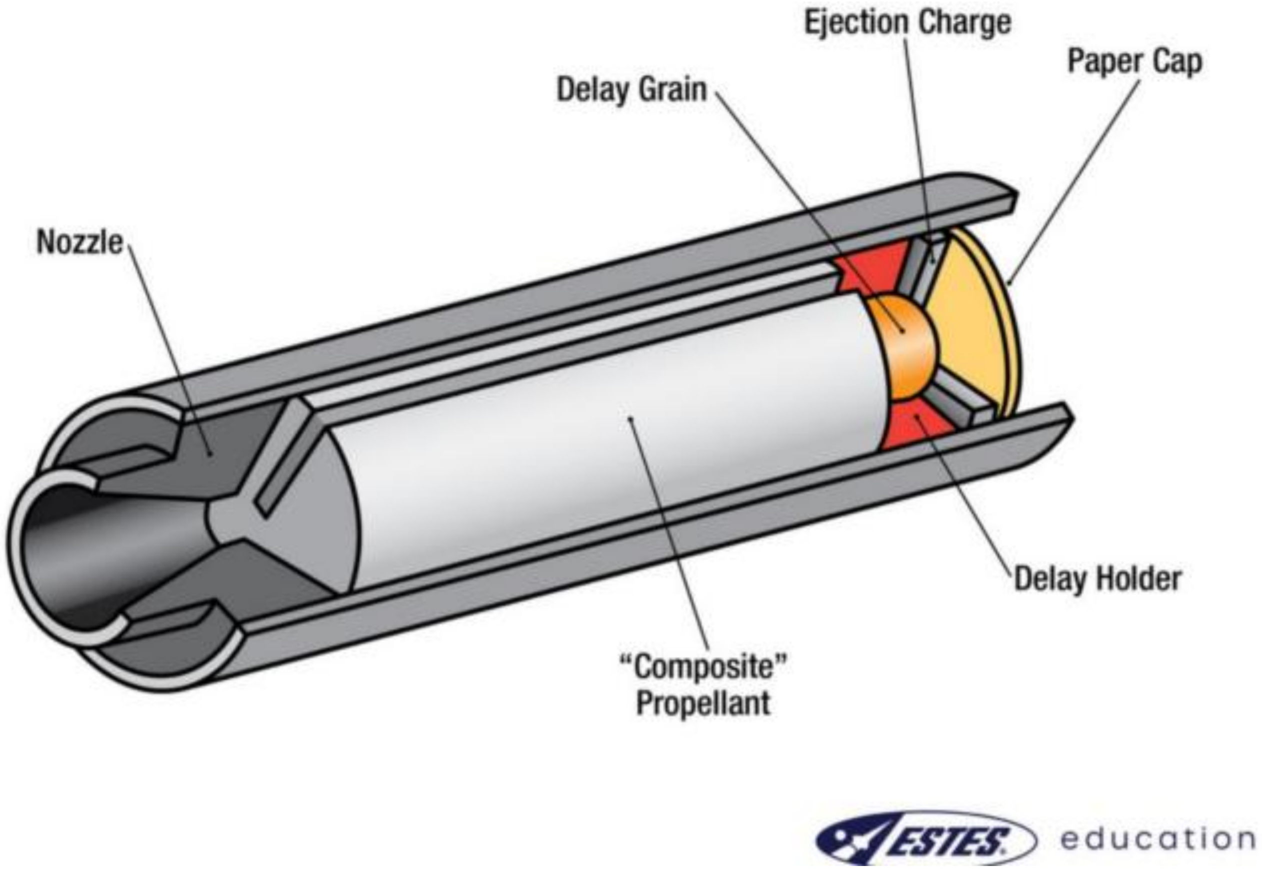
1. Repeat the steps but make sure you select the Body Tube in the rocket tree. Then click "Rail Button" from the "Add rocket component". All you need two do for this is to create 2 of them. You can do this by changing the instance count to 2.

2. We can place one rail button near the fins at the bottom of the rocket, so it stays on the launch rail longer and builds maximum speed before free flight. A second button should be placed around the centre to provide support. Click "OK" to add the component.



Rocket Design – Aerosurfaces Done!

Great! We have all the aerosurfaces we mentioned successfully added to our simulation. We are very close to be able to start simulating our rocket's flight! But first we need to add the rocket motor/engine that will push our rocket into the sky



Rocket Design – Rocket Motors

Let's look at how rocket motors work.

Anatomy
A rocket motor consists of an outer casing, a nozzle, the propellant, a delay, an ejection charge and forward closure.

There are two types of motors: black powder (BP) motors, which are smaller and lower-power, and composite motors, which are used for larger, higher-power rockets.

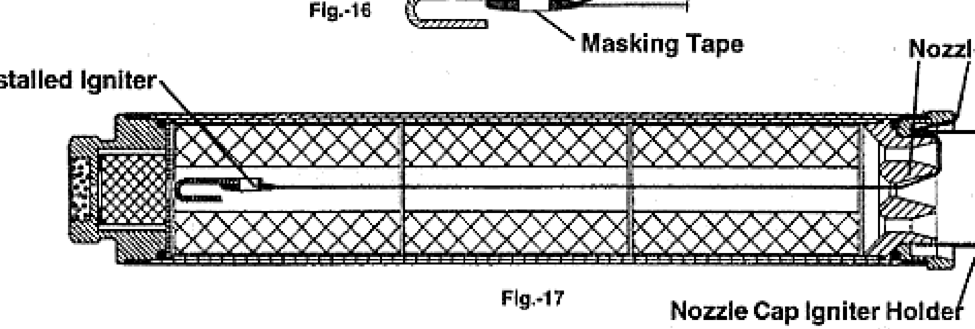
BP motors are ignited from the bottom, while composite motors are ignited from the top, usually using an electric igniter.

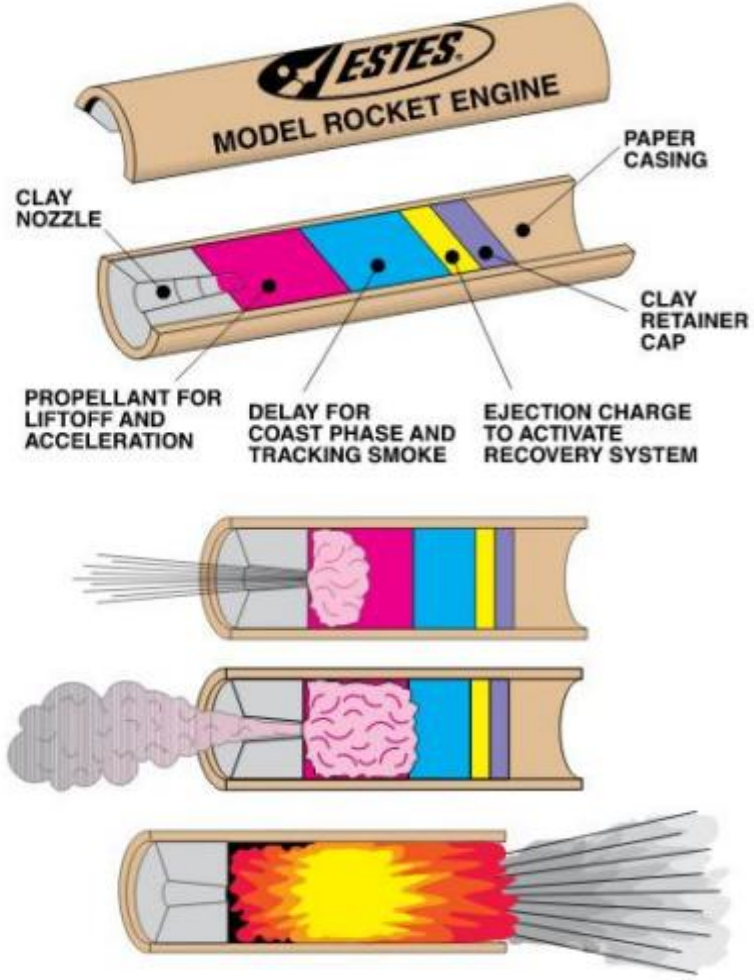
This causes the propellant to burn and eject hot gasses with sufficient force (hopefully) to lift your rocket.

Once the propellant has been burned through, the delay starts to burns for its designated duration before igniting the ejection charge to deploy the recovery device (e.g. parachute or streamer).

https://ukra.org.uk/2025/04/30/rocket-motors/

Composite Motor





Black powder motor

Rocket Design – Rocket Motors

How motors work

The motor burns in four stages:

1. Ignition – a current through the igniter sets off the pyrogen and ignites the propellant.

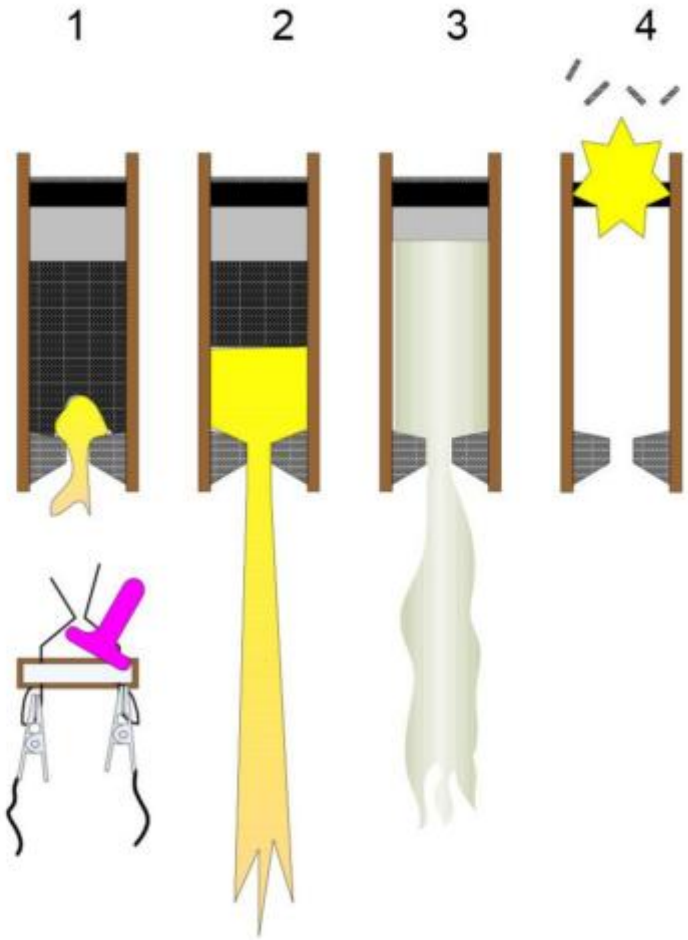
2. Thrust phase – the propellant burns, accelerating the rocket to its maximum velocity.

3. Coasting phase – the motor burns a smoke emitting delay charge as it coasts to apogee (the highest point reached).

4. Ejection phase – a small charge blows the nose off the rocket and deploys the parachute

Slow motion footage of a rocket motor firing.

https://studio.youtube.com/video/pkGWlFFmG-k/edit



https://ukra.org.uk/2025/04/30/rocket-motors/

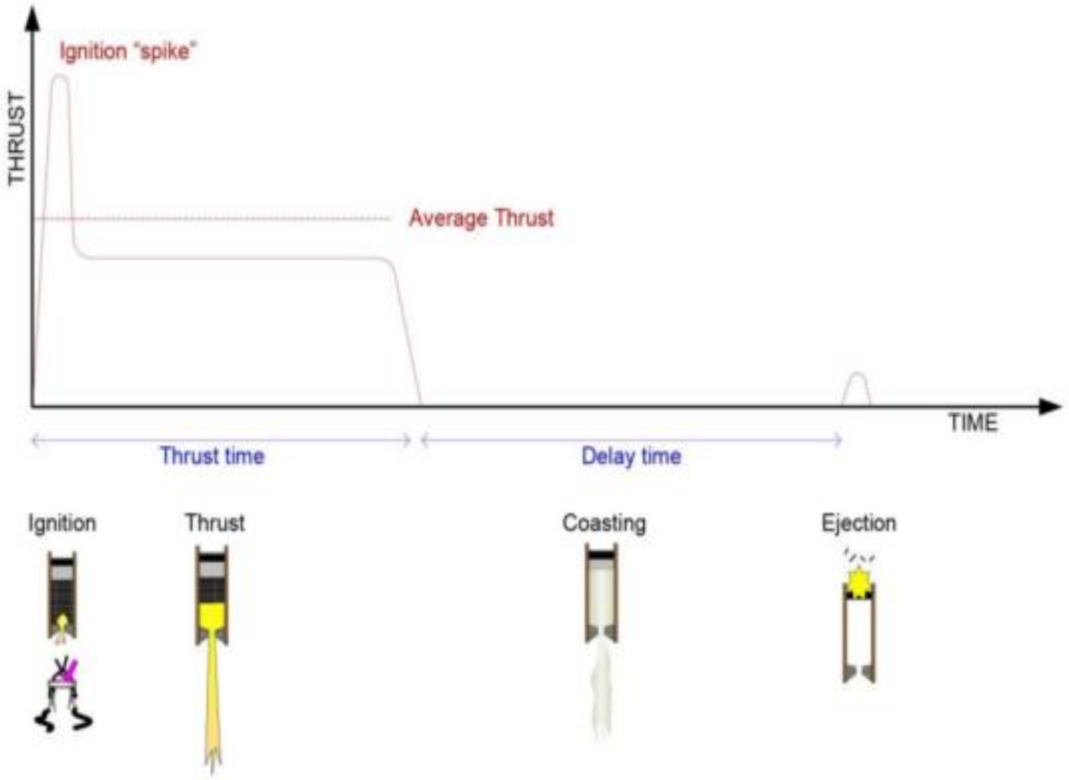
Rocket Design – Rocket Motors

Thrust Curves
A rocket motor's thrust output is not constant over the entire burn time. Usually there is an initial spike in thrust followed by a lower plateau. You usually **needn't be concerned** with this for small rocket motors.

Motor Stages and Thrust Curve
When the motor ignites it gives a short "spike" of thrust. This helps to get the rocket started up the launch rod.

The motor then burns its propellant until all the propellant is consumed. The rocket then coasts while the delay grain burns and emits tracking smoke.

The ejection charge is fired when all the delay grain has been consumed.



https://ukra.org.uk/2025/04/30/rocket-motors/

Rocket Design – Rocket Motors

F20 - 4

Total impulse = Thrust x Time

The total impulse is broken down into **Classes** it starts at A which is in the range 0 - up to 2.5 Ns. It then doubles with every letter as seen in the table

Class	Total Impulse	Comments
A	Up to 2.5 Ns	
B	2.5 – 5 Ns	
C	5 – 10 Ns	
D	10 – 20 Ns	
E	20 – 40 Ns	
F	40 – 80 Ns	
G	80 – 160 Ns	
H	160 – 320 Ns	Level 1 Certification Required
I	320 – 640 Ns	Level 1 Certification Required
J	640 – 1,280 Ns	Level 2 Certification Required
K	1,280 – 2,560 Ns	Level 2 Certification Required

Power levels

Low Power covers A-D motors. **Mid Power** is generally considered to be D-G and **High Power** is H+.

However, what will really classify your rocket as being low/med/high power is the total impulse of **all** of your rocket motors combined. So if you rocket is a cluster of 3 Ds it is Mid Power. If it has three Gs it is most likely High Power (depending on exact motors used).

https://ukra.org.uk/2025/04/30/rocket-motors/

Rocket Design – Rocket Motors

The combination of thrust and time is called the IMPULSE of the motor. More scientifically:

impulse = average thrust x burn duration

As thrust is measured in Newtons, and time is measured in seconds, then impulse is measured in Newton-seconds. The impulse is thus directly related to the amount of propellant. The more propellant, the greater the impulse of the motor.

We specify motors by three factors:

1. the average thrust which they produce
2. the time for which they produce that thrust
3. the delay before the ejection charge is fired.

Avg. thrust

F20 - 4

Delay time

Total impulse = Thrust x Time

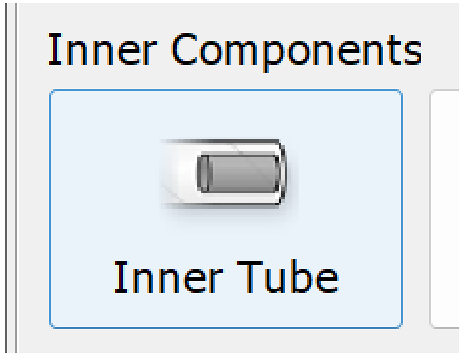
Clearly 1 and 2 are related. The same amount of propellant can be burned quickly to produce high thrust for a short time, or slowly to produce a small amount of thrust for a long time.

https://ukra.org.uk/2025/04/30/rocket-motors/

Rocket Design – Adding Rocket Motor

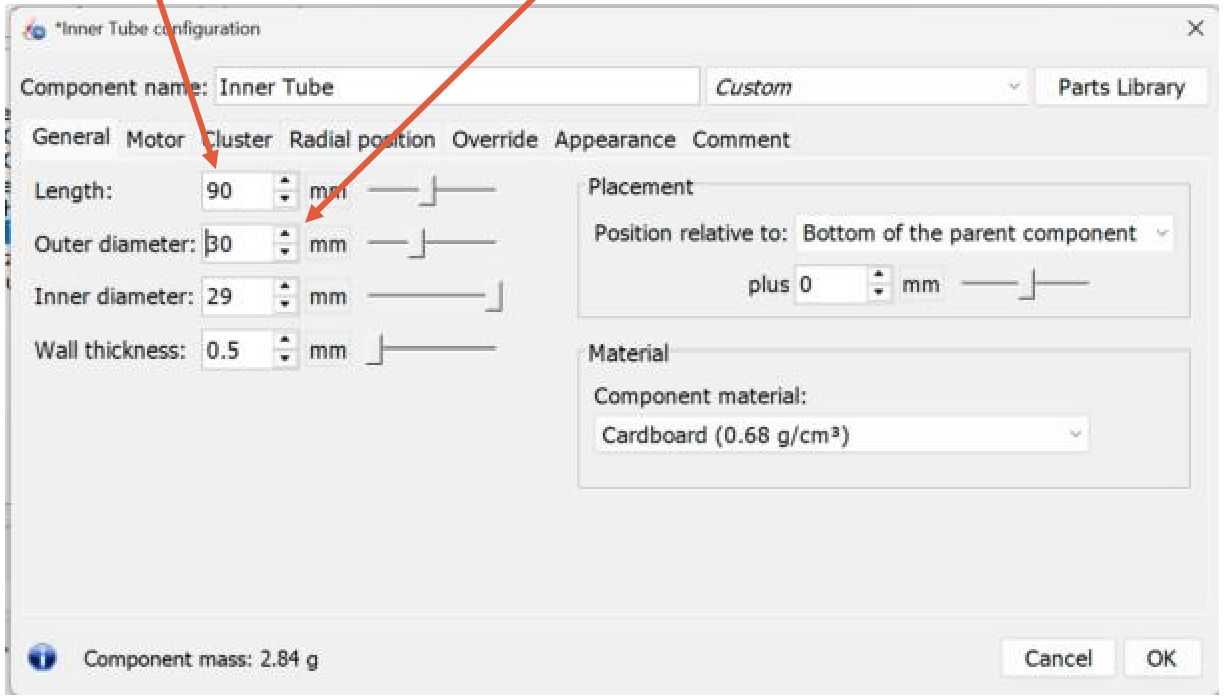
To start with we need to add an "Inner Tube" that we will make our "Motor Mount". This is an "Inner Component" that will hold the motor and transfer the thrust from the motor into the rocket to create motion.

1. Select the Body Tube in the rocket tree. Then click "Inner Tube" from the "Add rocket component", you might have to scroll down to get to "Inner Components".



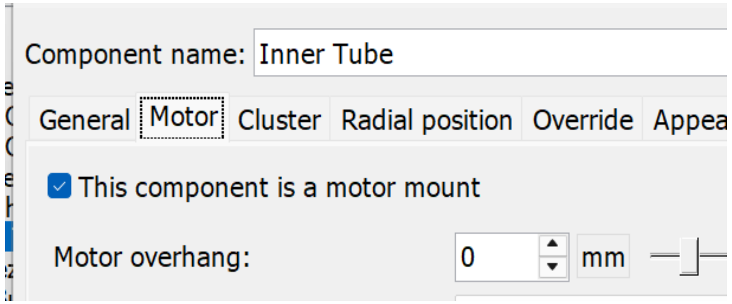
Length

Diameter



2. For now, let's change the length to 90mm and the outer diameter to 30mm, as this is the size of the motor we will use in the example.

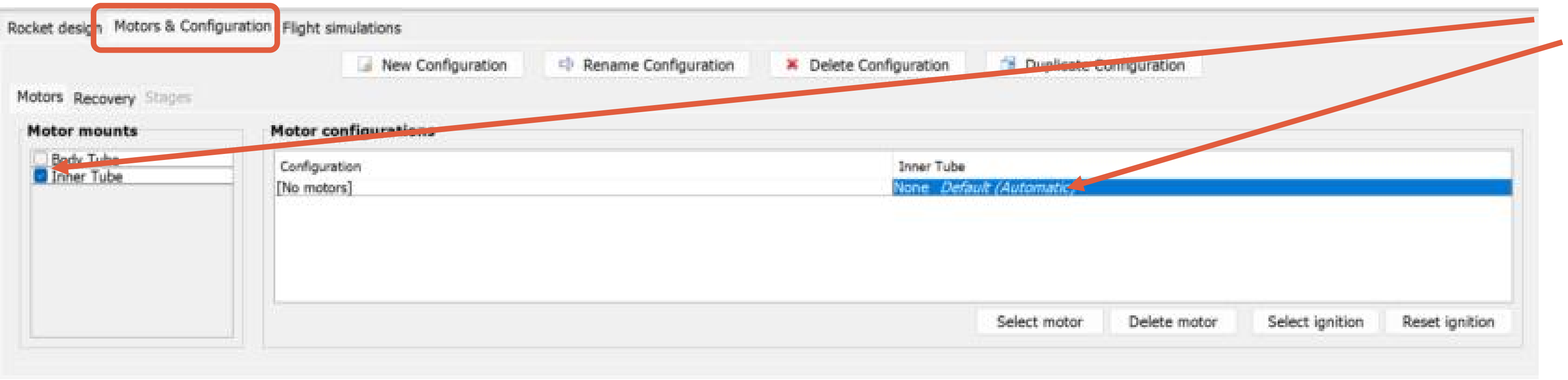
3. To make it a motor mount, click on the "Motor" tab. And tick "This component is a motor mount".



4. Click "OK" to add the component.

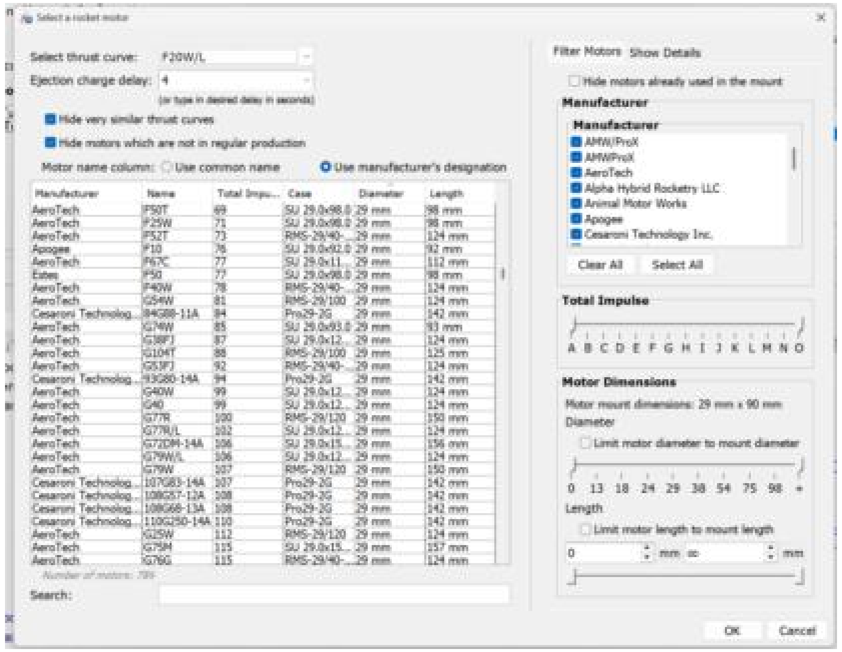
Rocket Design – Adding The Rocket Motor

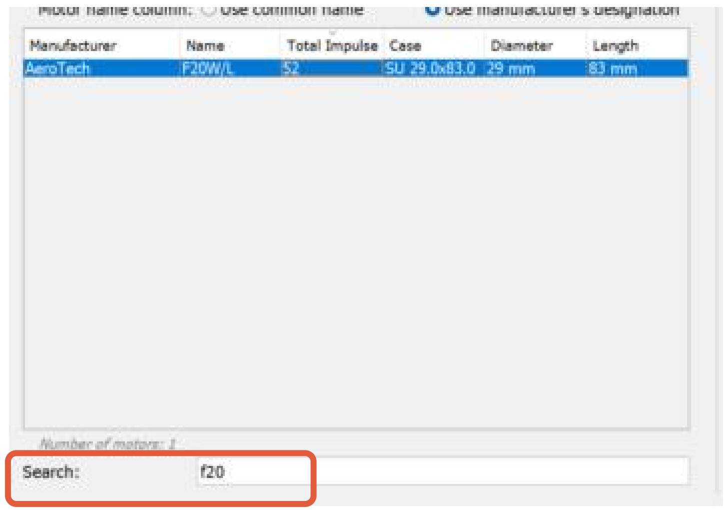
Now to add a motor to our motor tube we need to, select the Motors & Configuration tab in the top left.



1. You need to have the Inner tube ticked under motor mounts. Then you can click on the inner tube under motor configuration.

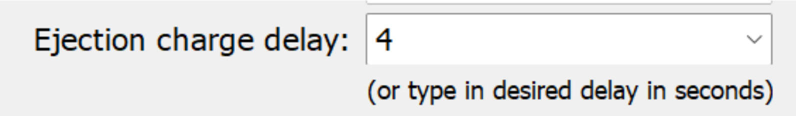
2. There's a lot of information under "Select motor". But for now, we can search "f20" in the search bar. Only one option should appear on the list, the AeroTech F20W/L.





Rocket Design – Rocket Motors

Let's look at what some of these numbers in OpenRocket. If you click on the "Show Details" tab on the right, we get some more information on our selected motor.



Avg. thrust

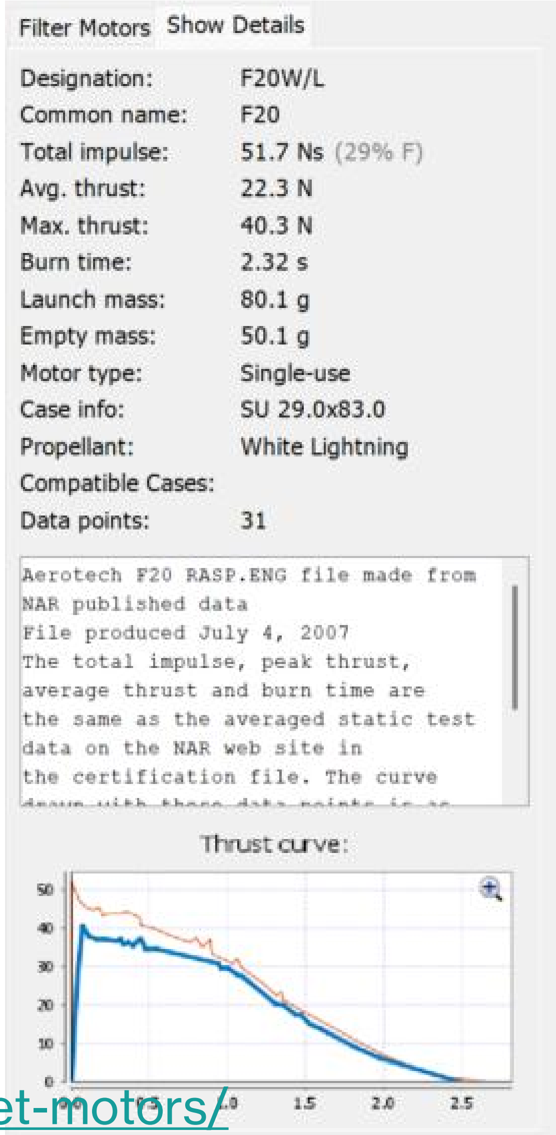
F20 - 4

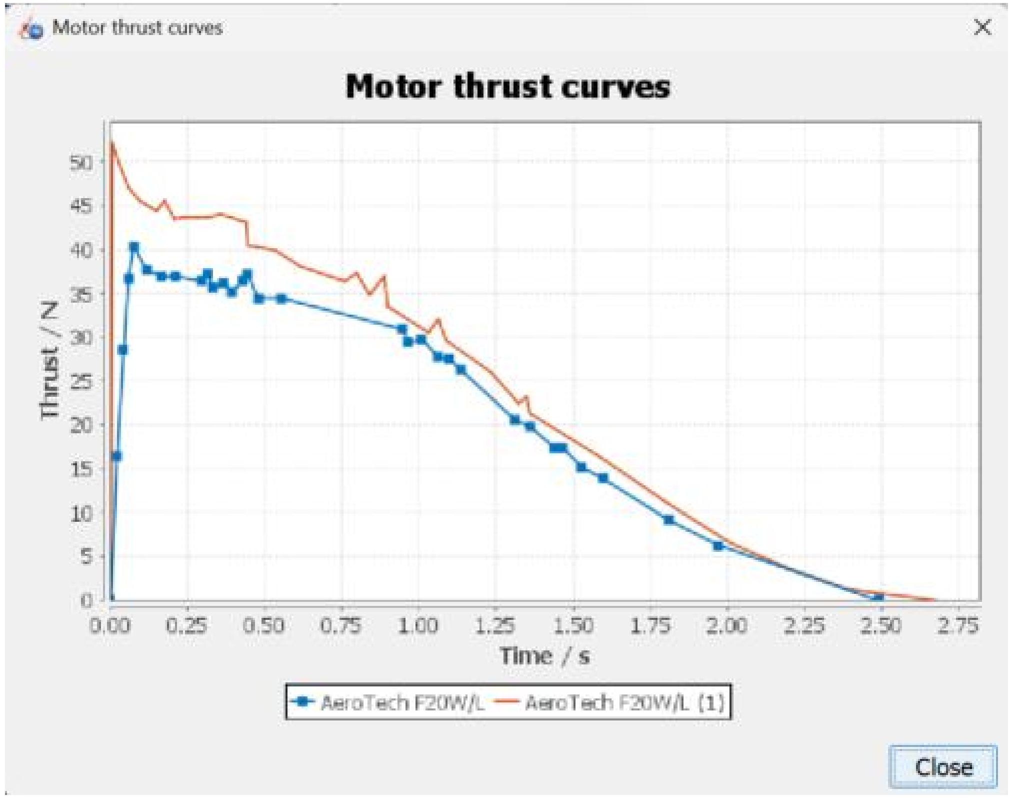
Delay time

Total impulse = Thrust x Time

The name of the motor encodes a lot of the important information and can be read as above.

Under the 'Show Details' tab, we have a lot of data about the motor.





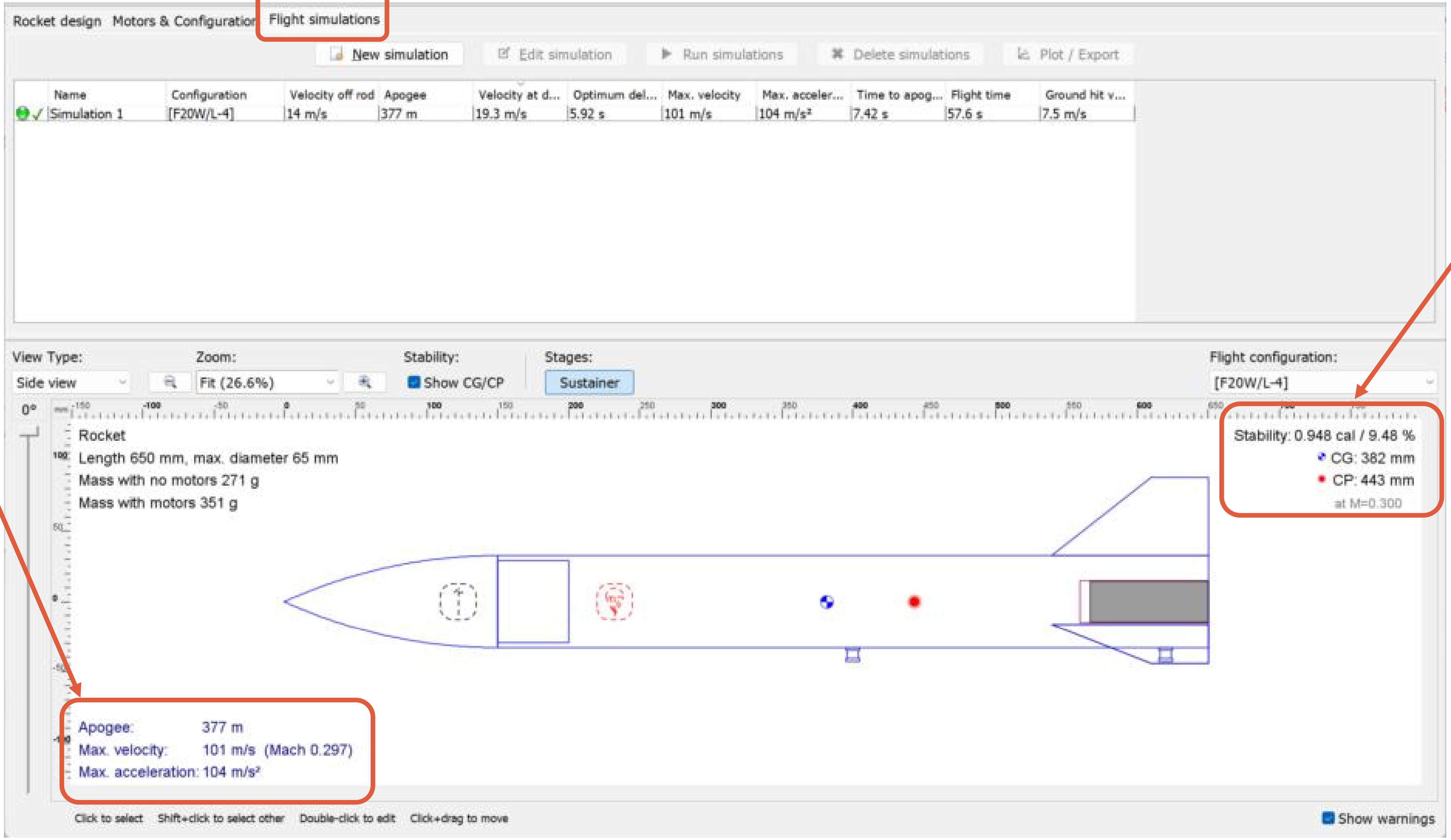
We can also see the "Thrust curve", which is the thrust the motor produces as it burns.

https://ukra.org.uk/2025/04/30/rocket-motors/

Rocket Design – Flight Sim

We now have all the requirements for a flight simulation, all the key values you can see in the rocket window. But you can see and graph extra data from the Flight simulations tab.

Key flight values, the **Apogee** or how high the rocket reaches above the ground, and **how the competition is scored.** The Max velocity and acceleration is also displayed.



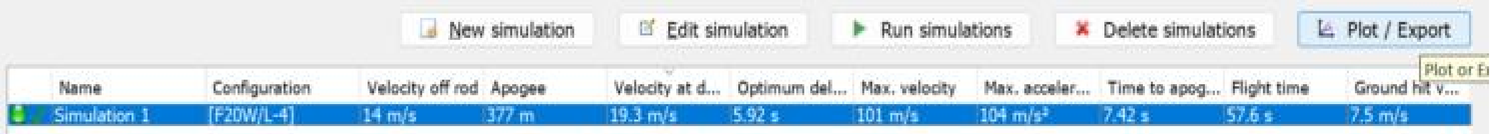
The **stability** is very important. And we will cover it in the next slide. But this value must be above 1.5 cal to be considered stable to fly.

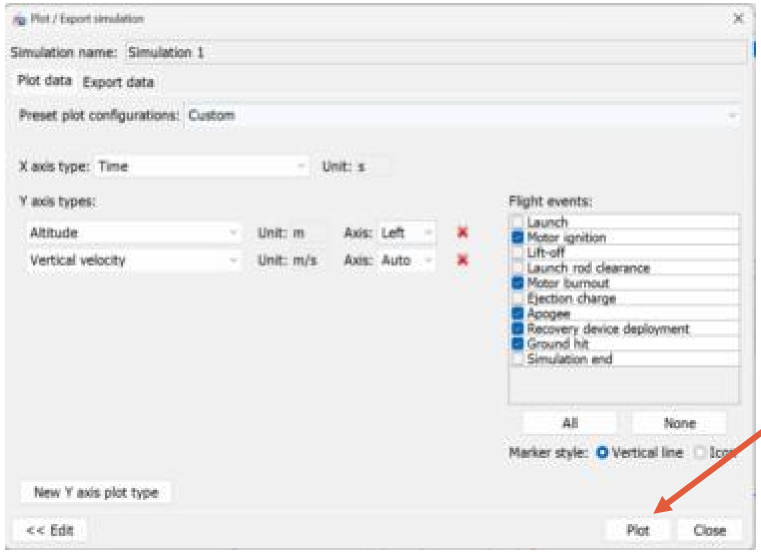
Rocket Design – Rocket Flight

Rocket Flight Profile
The picture to the right shows the 5 phases of a rocket flight.

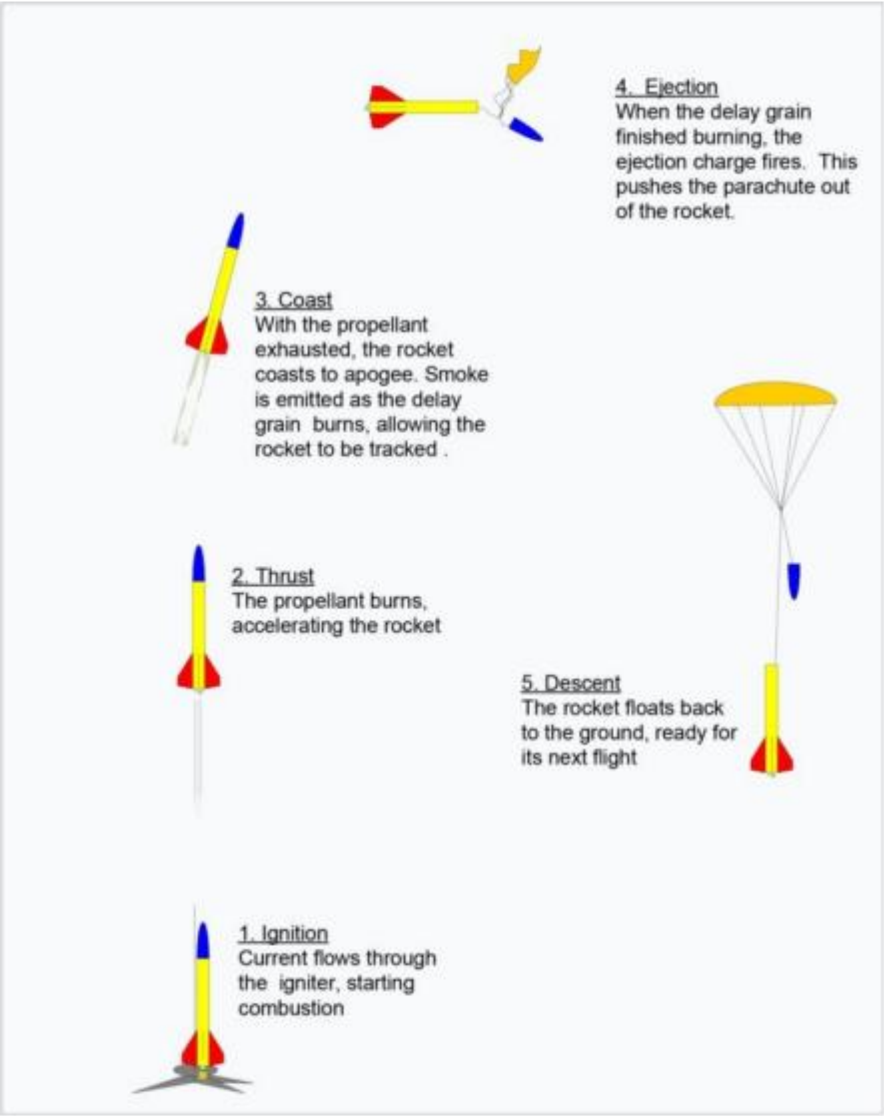
After ignition, the rocket accelerates vertically, then coasts to its highest point (apogee). At apogee, a small charge deploys the parachute, allowing the rocket to float gently back to the ground.

We can graph our flight by selecting the simulation (make sure it has the correct motor), then click on "Plot / Export"





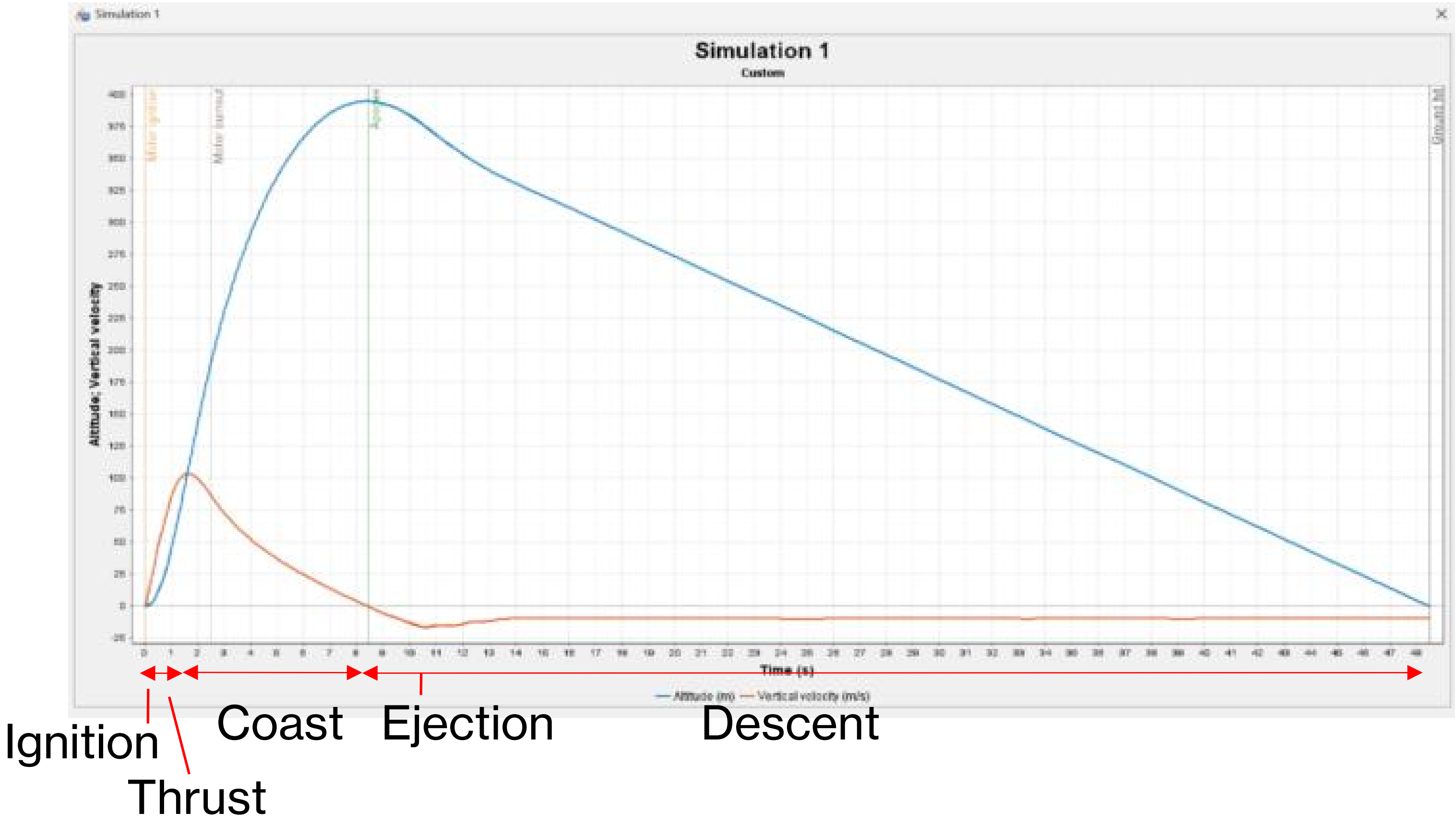
In the new window you can select what's plotted. You can play with this later but for now just click "Plot" to plot the altitude and velocity against time.

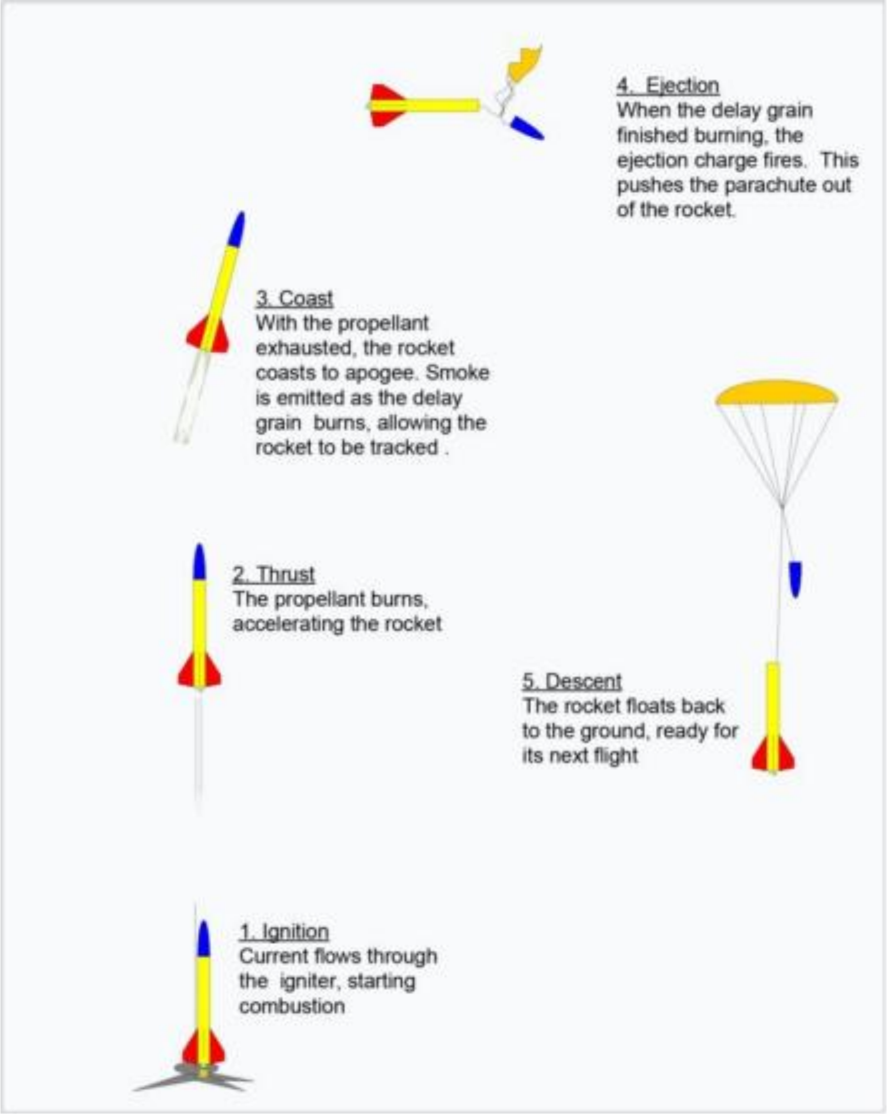


Rocket Design – Rocket Flight

Rocket Flight Profile

The picture to the right shows the 5 phases of a rocket flight.





https://www.youtube.com/watch?v=X_R7mnI4klo - On board rocket footage to 3 km

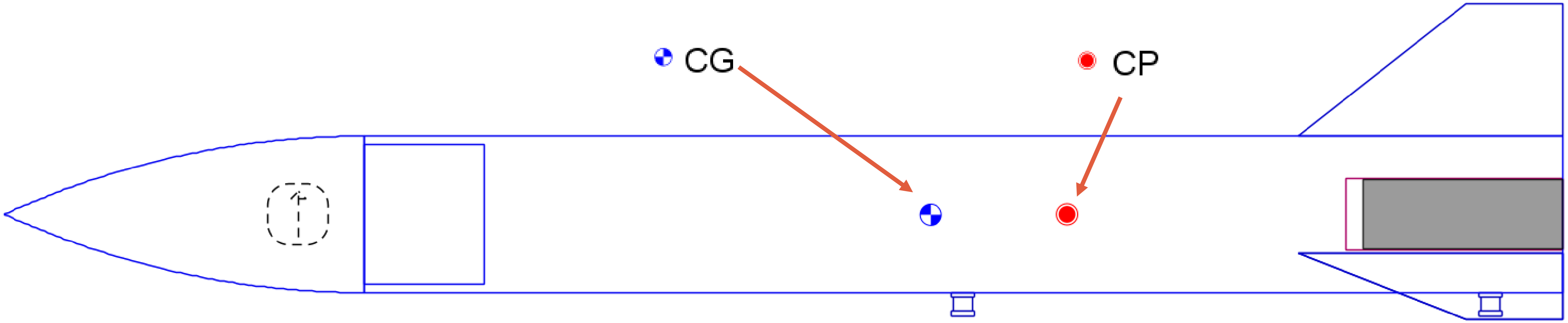
Rocket Design – Rocket Flight Stability

Stability is a very important design consideration. Stability is the ability of the rocket to keep flying in the same direction.

There's two important components to understand:

The centre of gravity (**CG**) which is average point of all the masses and where the pivot point rocket rotates around**.**

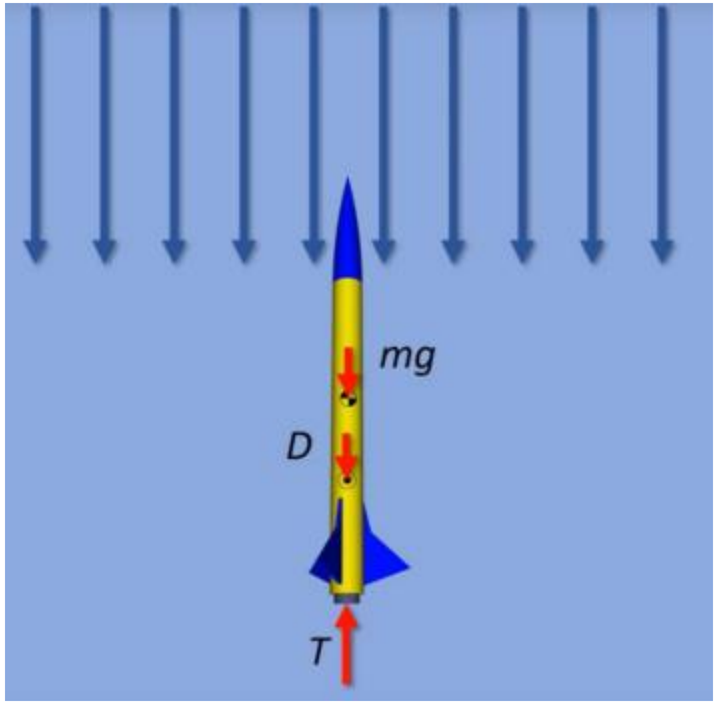
The centre of pressure (**CP**) which is the average point of all the aerodynamic forces and the location where these aerodynamic forces appear to act.

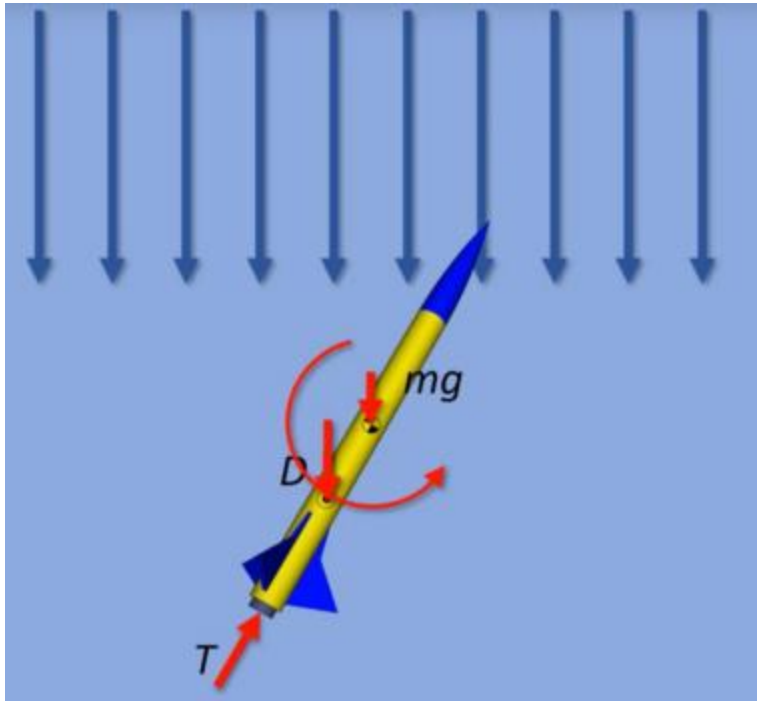


Rocket Design – Rocket Flight Stability

Stable rocket setup:

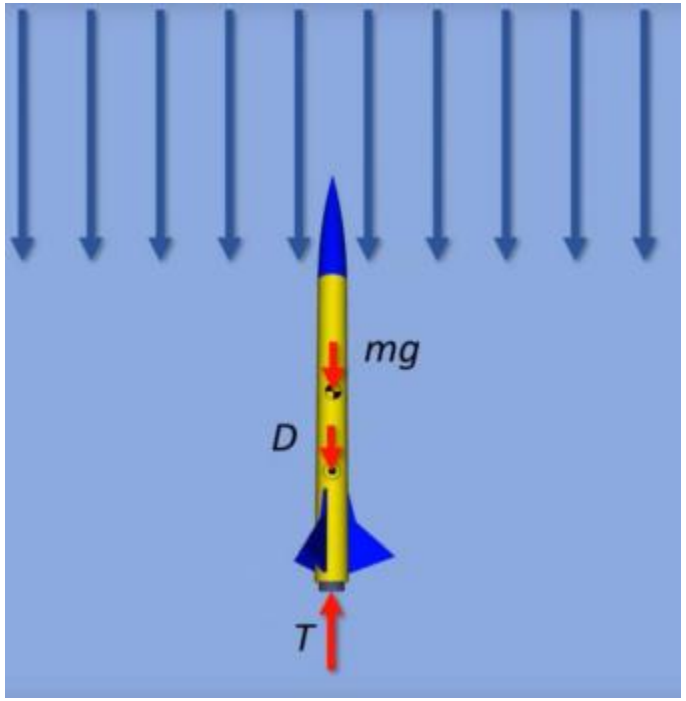
We have our CG in front of our CP. Looking at the forces, the weight (mg) at the CG, the drag (D) at the CP and thrust (T) from the motor.





If the rocket gets deflected from a gust of wind, more of the rocket is into the wind so the drag force increase. This creates a turning moment about the CG which turns the rocket back straight again

The rocket is now pointed back in its original direction, as such the rocket is stable.

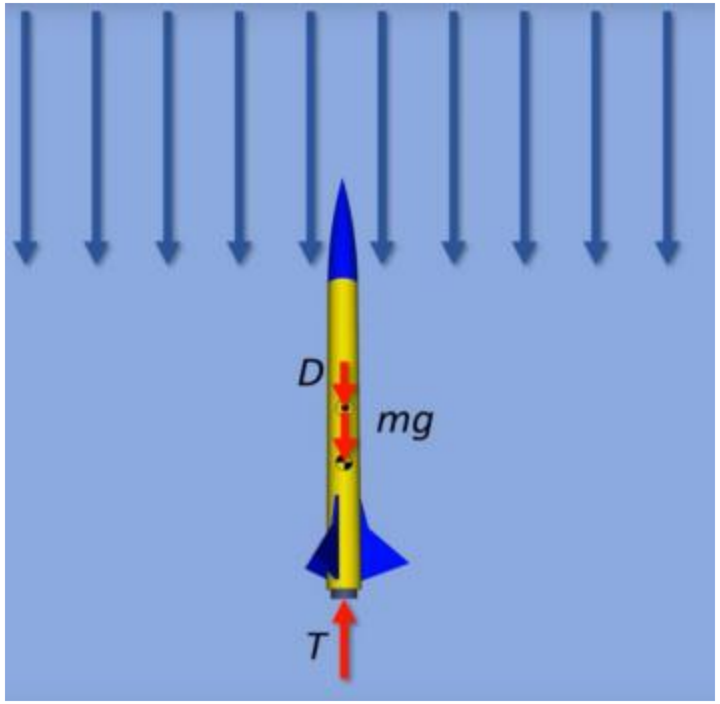


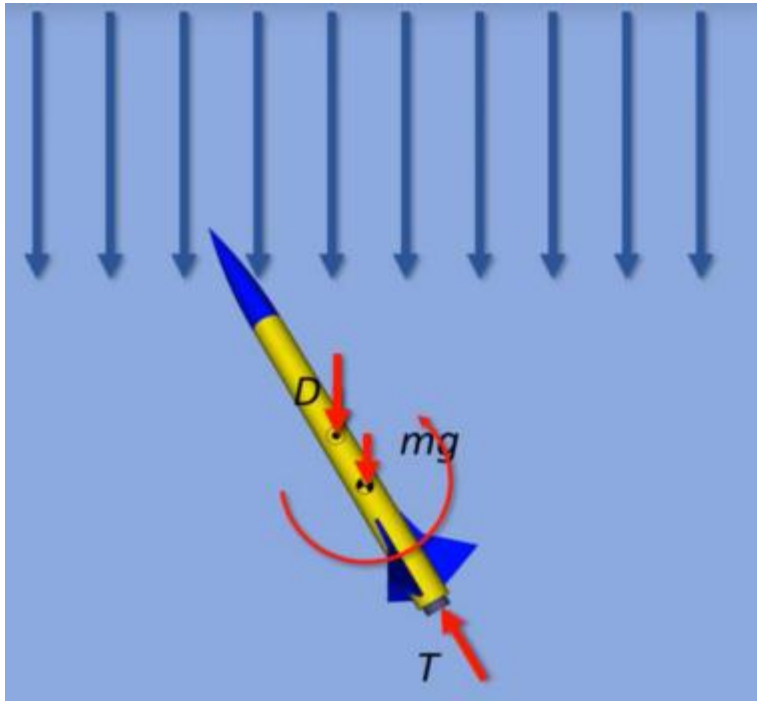
https://youtu.be/pnY5hkmJS58?t=162 - Video describing rocket stability

Rocket Design – Rocket Flight Stability

Unstable rocket setup:

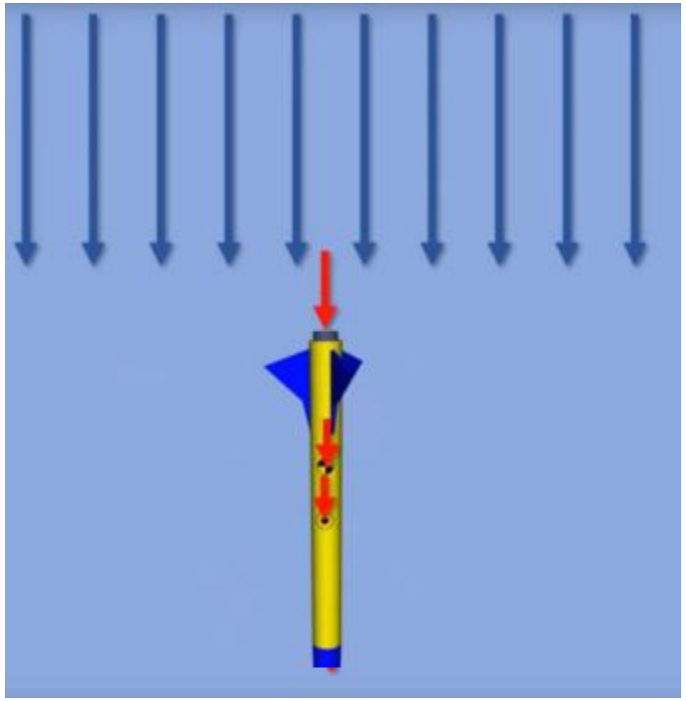
Now we have our CG in behind our CP. Now the weight and drag force are the other way around, the thrust hasn't changed.





Now if the rocket gets deflected from a gust of wind, the turning moment now is in the opposite direction. And causes the rocket to continue to turn until its backward.

The rocket is now pointed the opposite direction and has probably broken into pieces by this point. As such this is considered unstable and obviously a bad rocket setup.

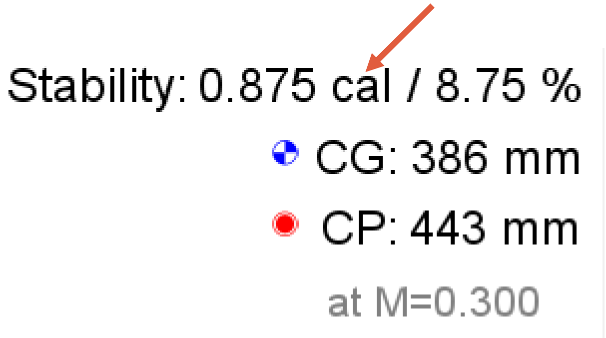


https://youtu.be/pnY5hkmJS58?t=162 - Video describing rocket stability

Rocket Design – Rocket Flight Stability

How stable (or unstable) a rocket set-up is, is the distance CG is in front of the CP. The greater the distance the more stable it is.

To quantify how stable we need the rocket set-up to be we divide the distance by the rocket body diameter. We call this the **stability calibre (cal).**



We say anything over 1 cal is stable but to be sure we design rockets to be 1.5 cal and over.

How to increase your stability:
We can change both CG and CP;

CG
CG is the average of the masses so placing masses in places far from the centre has a large effect on the CG. Commonly you can add masses to the nosecone to move the CG forward and increase the stability. However, adding mass reduces height, requires more building and you must consider where you can feasibly add mass.

CP
The CP is largely affected by the fins and a little bit effected by the nosecone. Optimising the fin size and shape in conjunction with the nosecone is a big part of the design and is the number 1 way you will change stability.

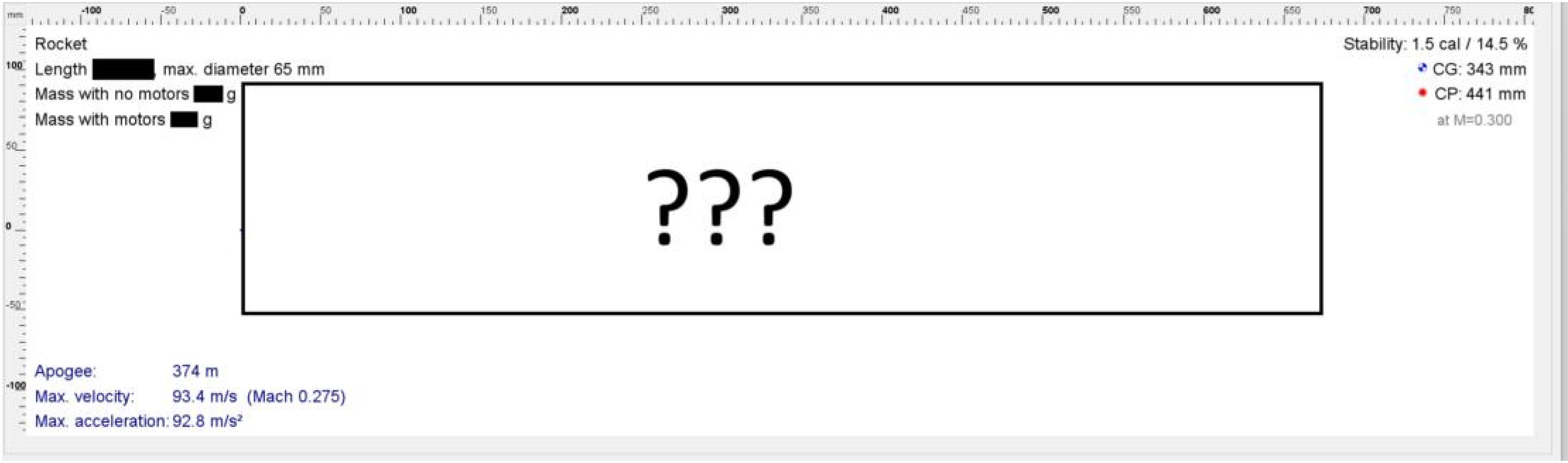
Rember you can also change the lengths of the body tubes, and this moves both the masses and fins' locations effecting your stability

Rocket Design – Rocket Flight Stability

As a challenge now try and create a stable rocket with the rules:

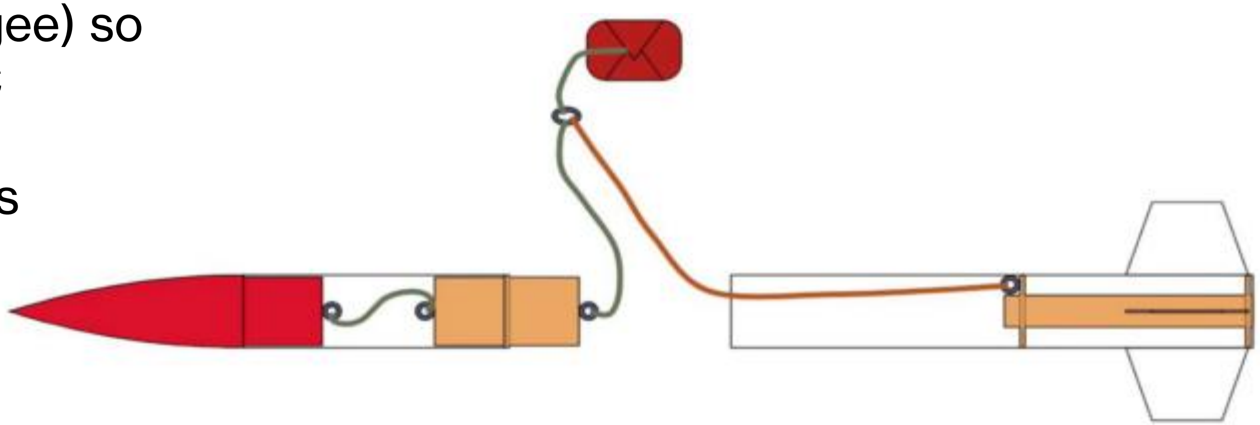
- Stability >= 1.5 cal
- Diameter >= 65mm
- Length >= 650mm
- Motor = F20-4

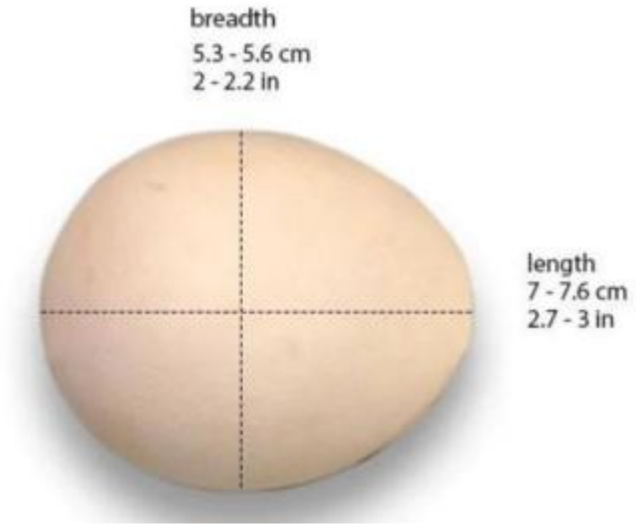
See how high you can get it in 5-10 mins try for above 370 m.



Rocket Design – Internal Components: Coupler

As we said, the mass effects the stability (and the apogee) so before you can optimise your rocket to win the UKROC competition you need to include more of the internal components, so we have the masses and their locations accounted for.

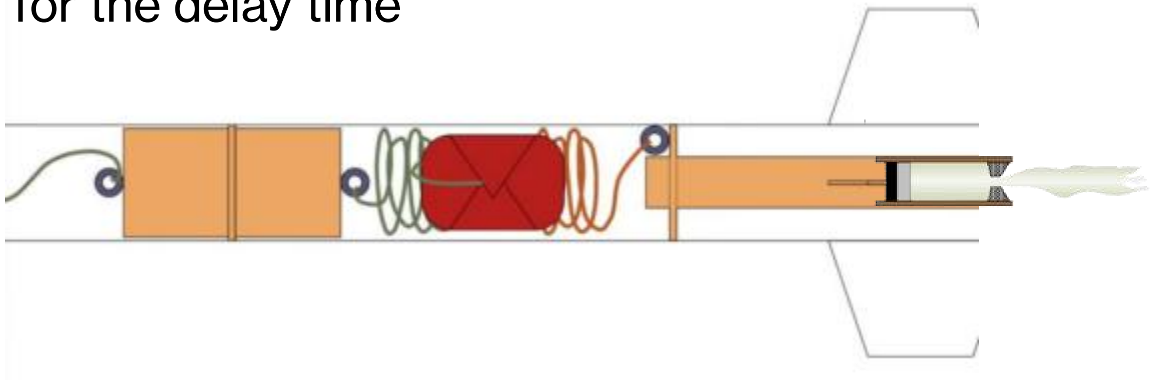




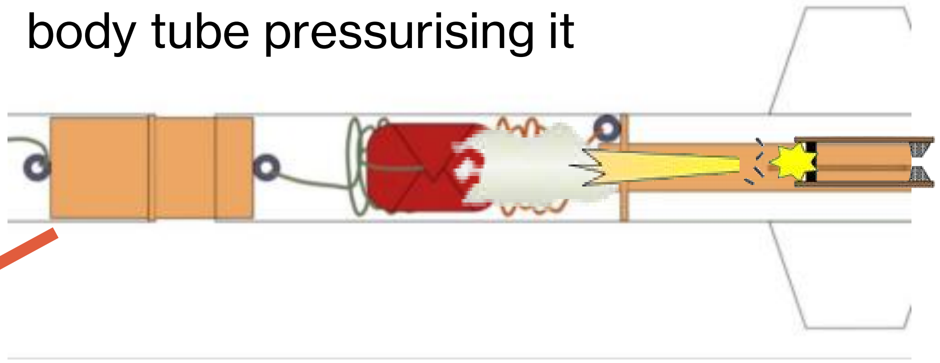
You can see from the diagram above that the rocket needs to split in the middle so we can deploy our parachute. We do this by adding a "coupler tube". This fits snugly inside the body tube, which the bottom tube can slide out off to deploy the parachute with the motor ejection. We will cover the deployment and parachutes later.

Rocket Design – Internal Components Coupler

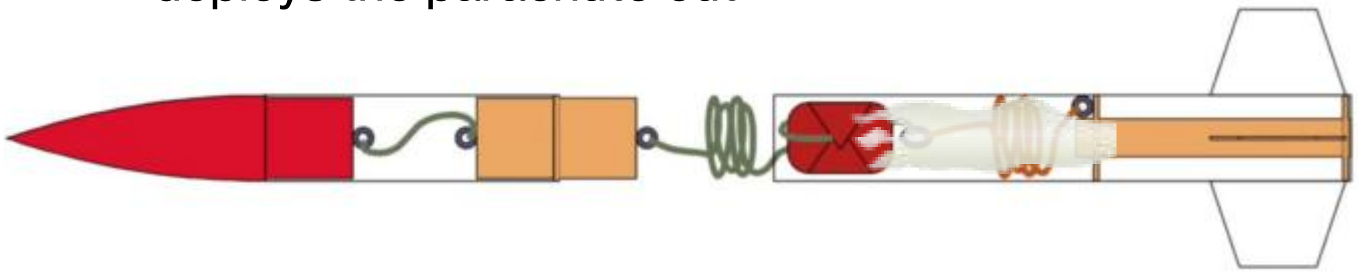
1. After motor burn out the delay grain burns for the delay time



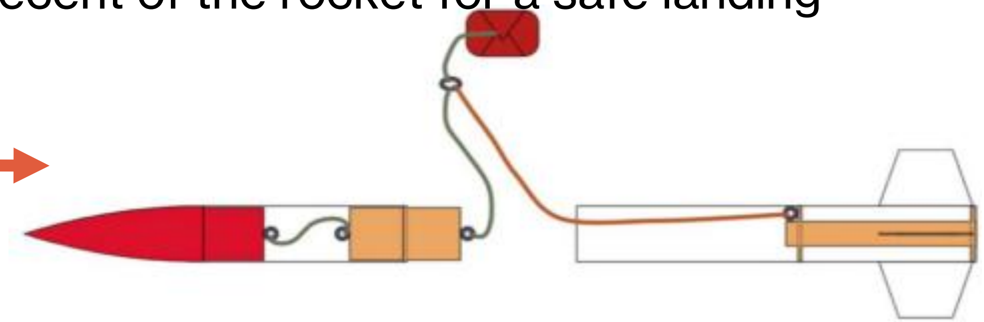
2. Then the motor ejection charge ignites, and hot gas fills the body tube pressurising it



3. This pushes the body of the tube cupper and deploys the parachute out

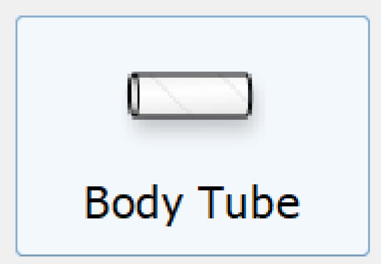


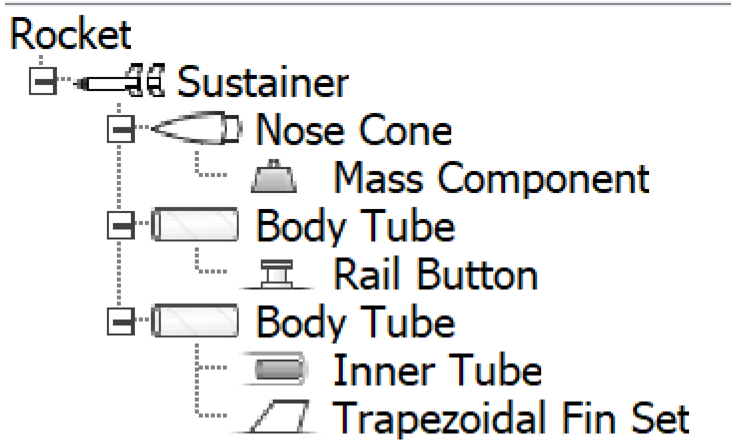
3. The parachute, attached to both parts by a shock cord inflates in the air and slows the decent of the rocket for a safe landing



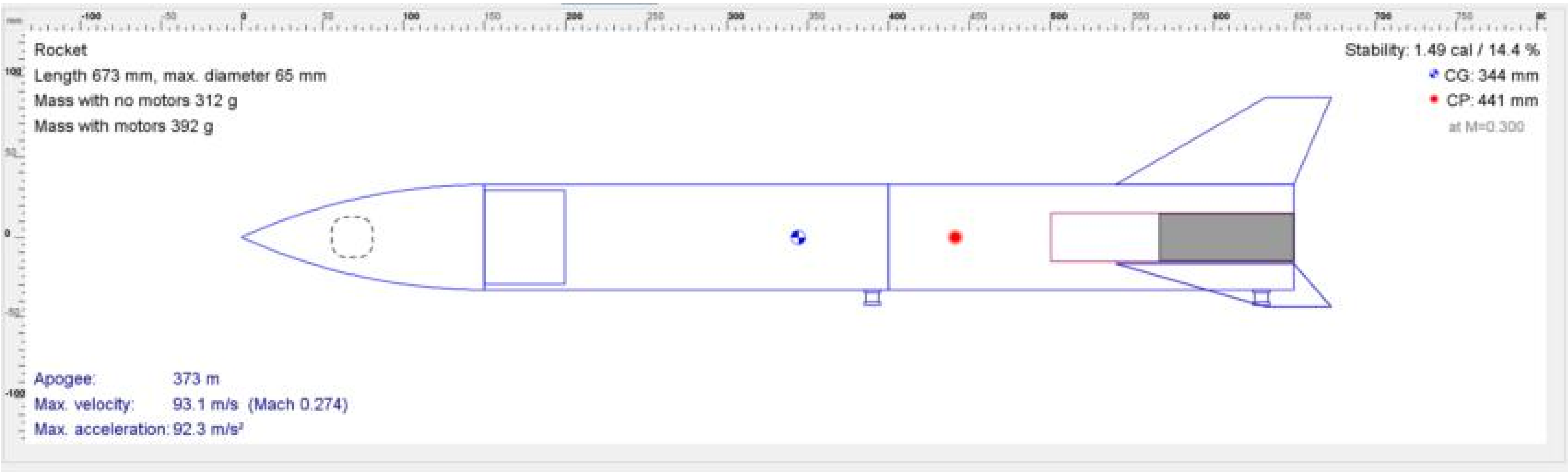
Rocket Design – Internals Tube: Coupler

1. Firstly, let's add a new body tube that will be in-between the current body tube and the nosecone. Remember you might have to change the order in the rocket tree.





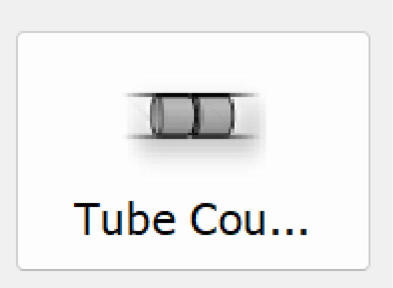
2. You will see as we added another body tube our length got a lot longer, we can edit the body tubes, to get a length your happy with.



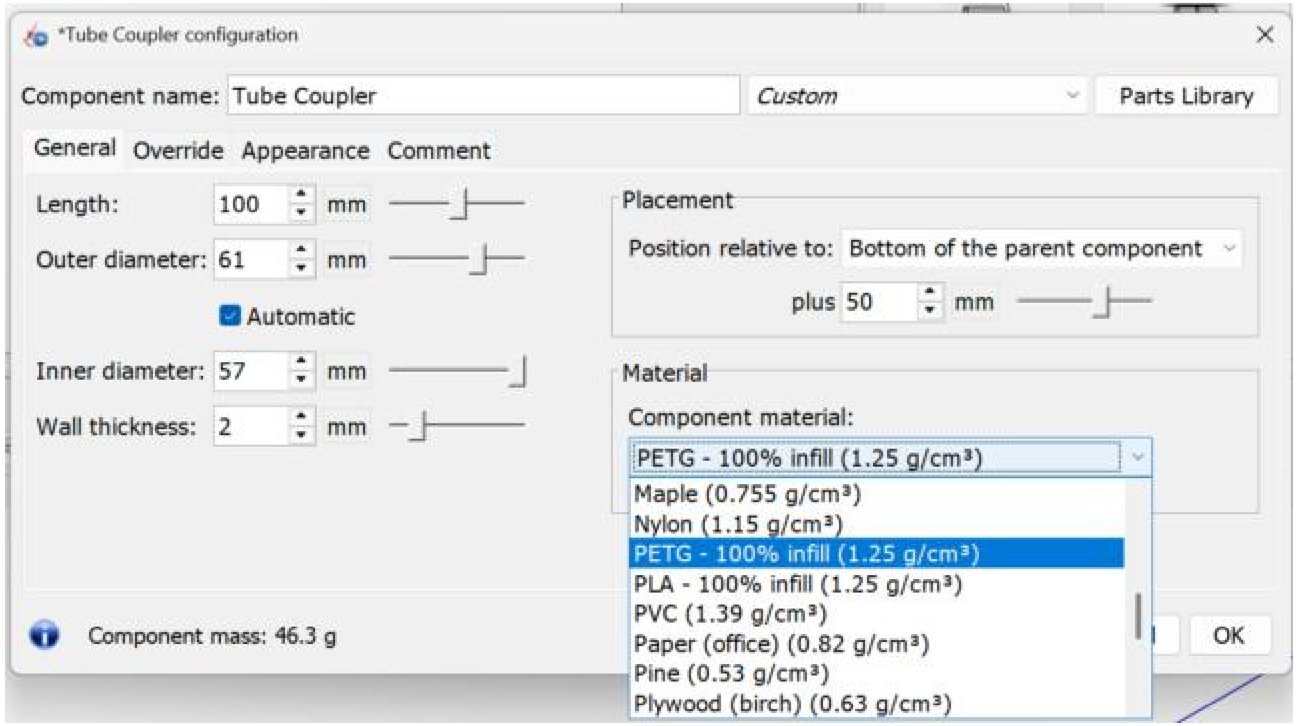
3. Lastly the rail button position is now off as we've shortened the bottom body tube. Edit to so that the launch buttons are in the correct position.

Rocket Design – Internals: Tube Coupler

Let's add the tube coupler to our sim.

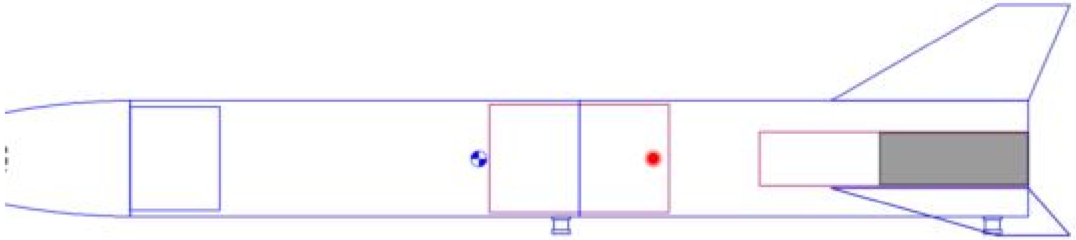


1. Add the "Tube Coupler" from the "Add rocket component". You can add it to either body tube but I normally place it in the top body tube.



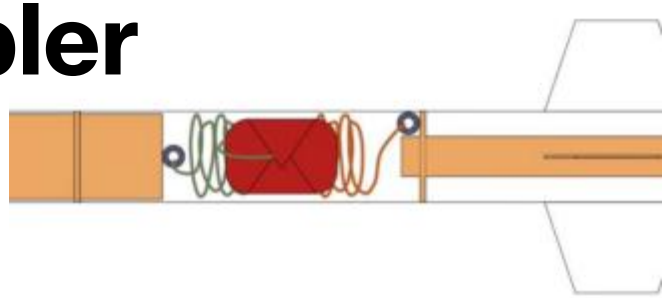
2. Firstly, change the length - it's recommended to have around 0.75-1 calliper length (calliper length = body diameter) on each side.

So, the total length should be about 2 calibres, and to centre it between the two tubes, set the placement to half that length.



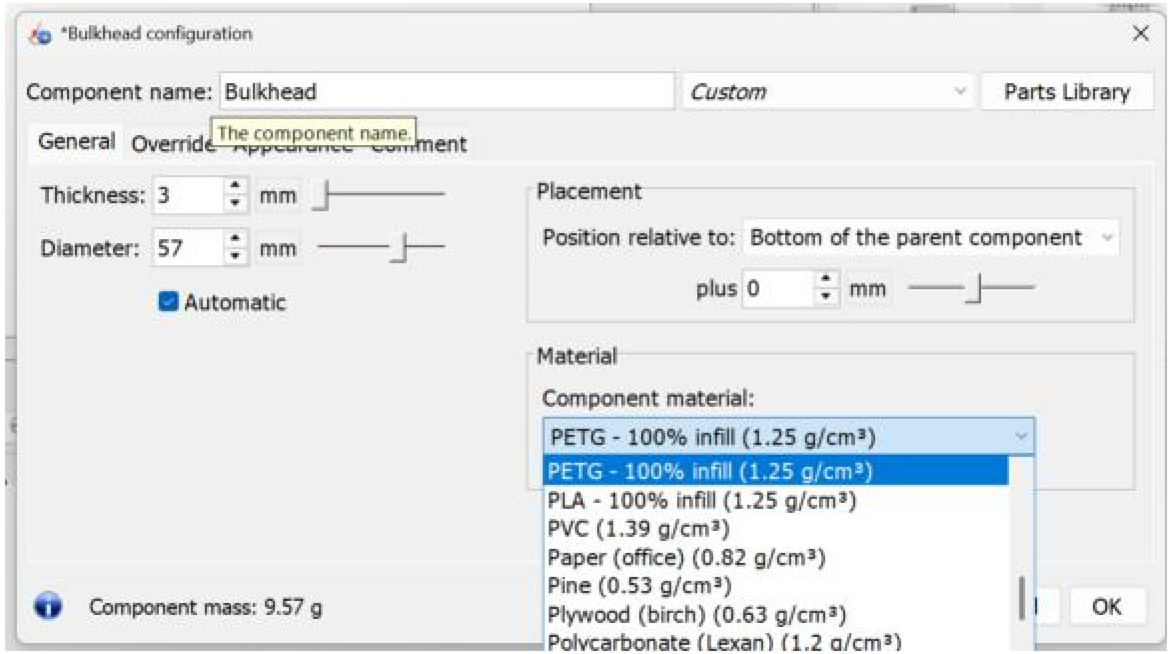
3. Lastly you can change the material to match that you will use. This might be PETG if you 3D print this component.

Rocket Design – Internals: Tube Coupler

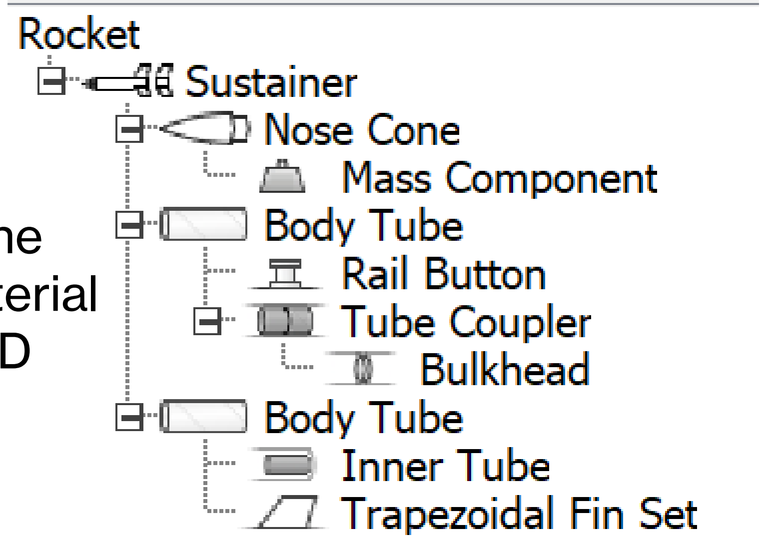


Lastly, we need to attach the shock cord to the bottom of the tube coupler. For this we will need a bulkhead, which is just a flat solid disc inside the rocket.

1. Add the "Bulkhead" from the "Add rocket component" to the tube coupler. Similarly to the body tubes, if you select the tube coupler in the rocket tree you can add the bulkhead directly to the tube coupler.



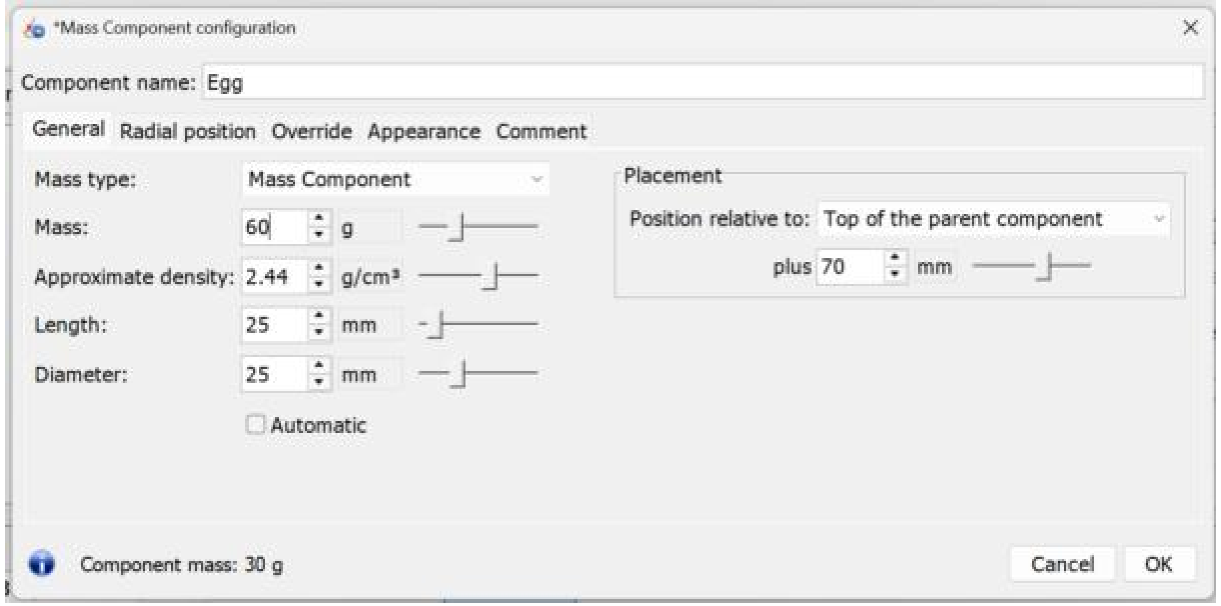
2. Again, we change the thickness and the material to match that of the 3D printed coupler.



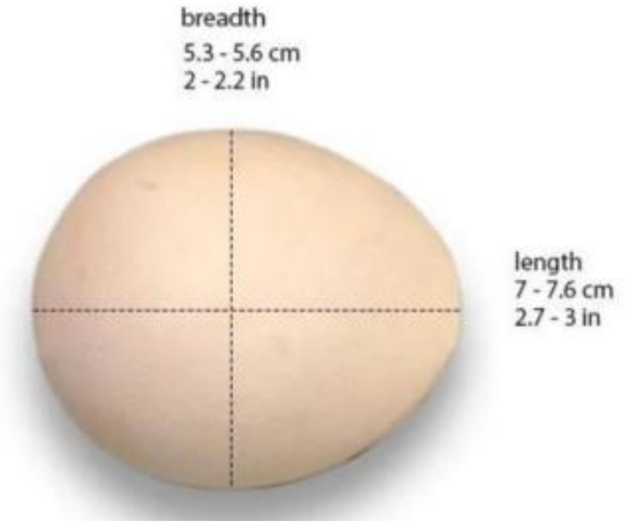
Rocket Design – Internals: Adding EGG mass

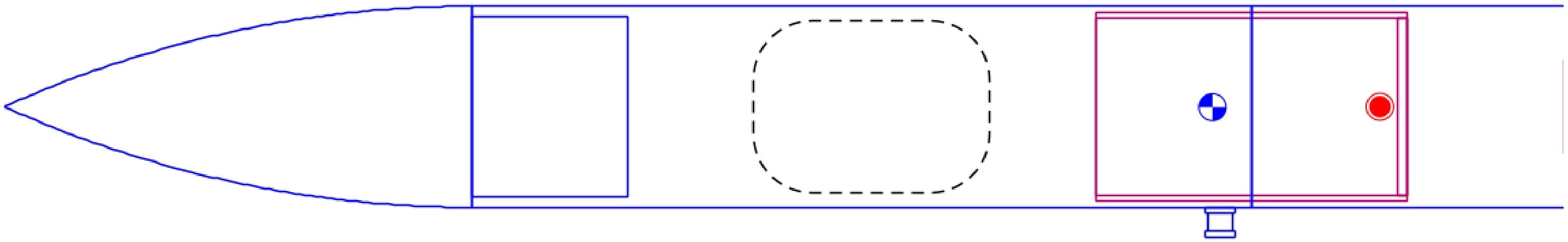
As part of the UKROC competition your rocket needs to carry a large raw egg as a payload. It must remain unbroken at the end of the flight otherwise that flight doesn't qualify.

1. In OpenRocket you can a "mass component" to nose cones, body tubes and tube couplers.

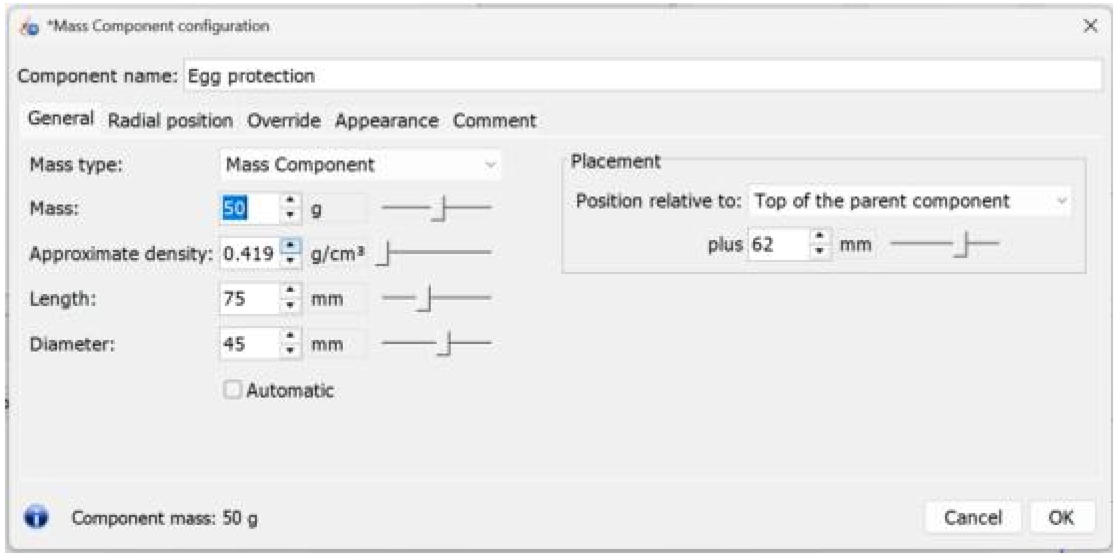


2. You can change its name to "Egg" and set the mass to 60g. *The egg will weigh between 55-63 grams* – from the UKROC rules. Additionally, you can set the size as shown below from a quick google.

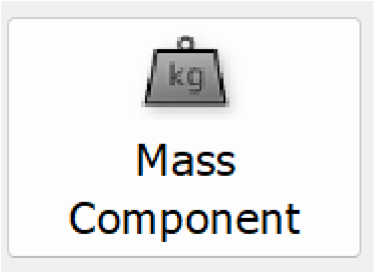




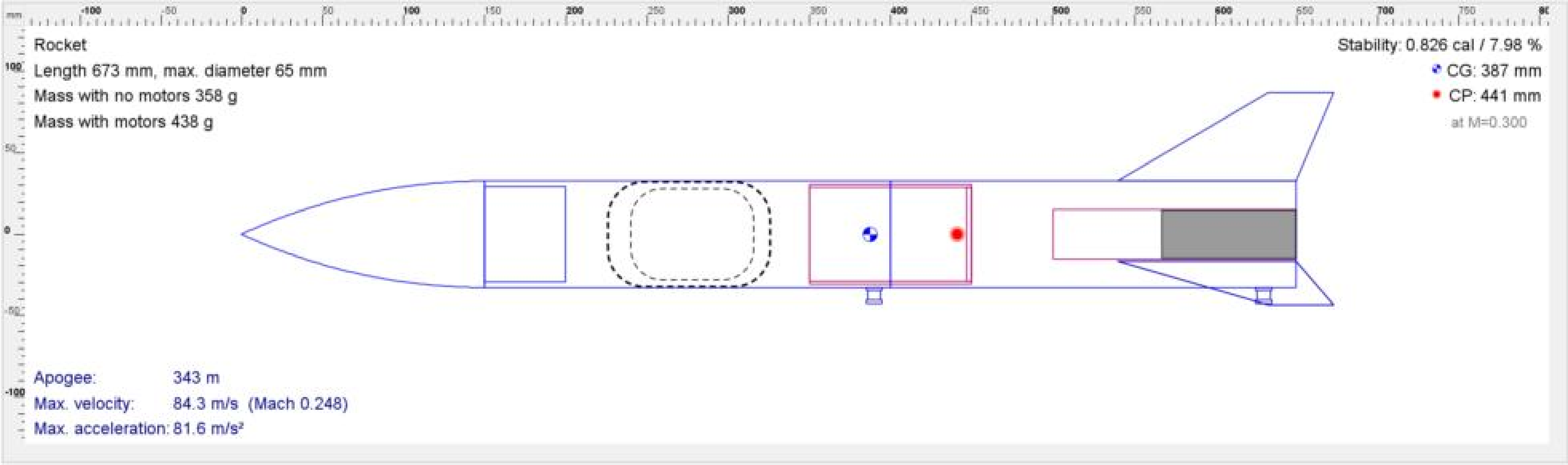
Rocket Design – Internals: Payload bay



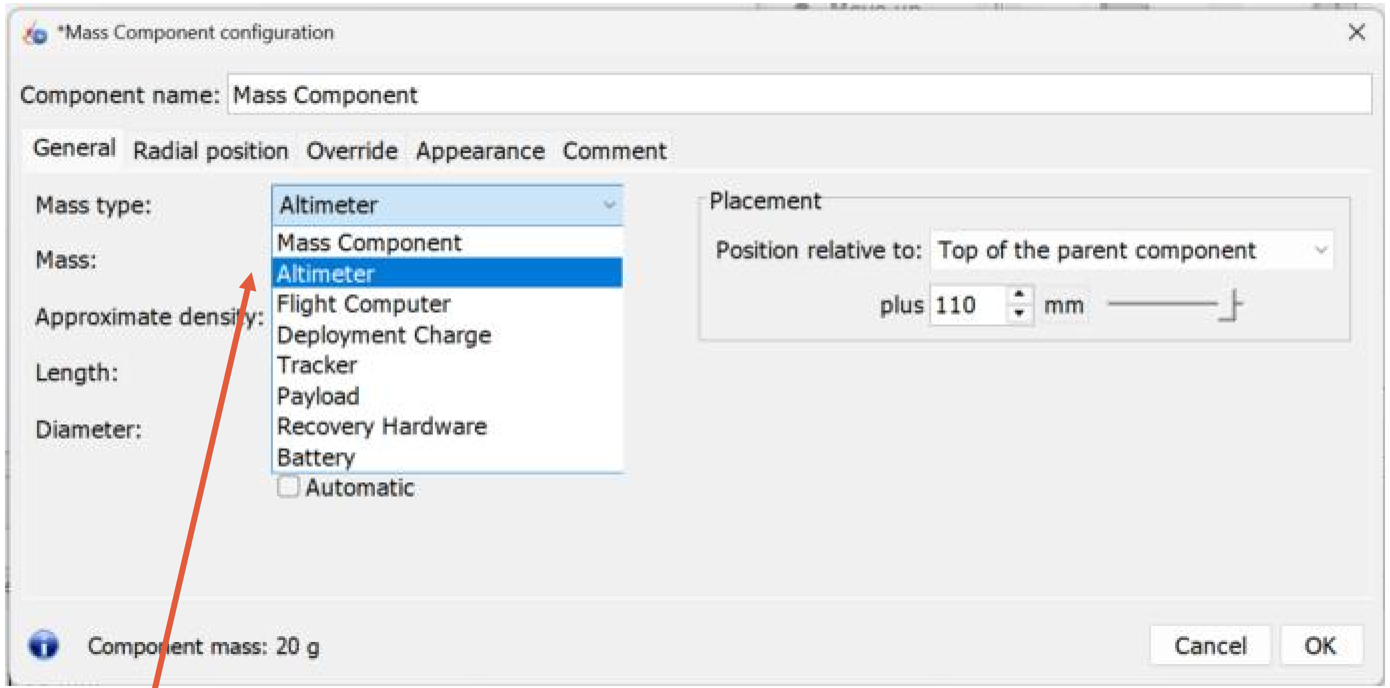
We are going to need protect the egg in some way, so let's add some mass using the "Mass Component" for our Egg protection.



1. Think about how thick you might need the to make the egg protection and how will this effect the diameter of your body tube.



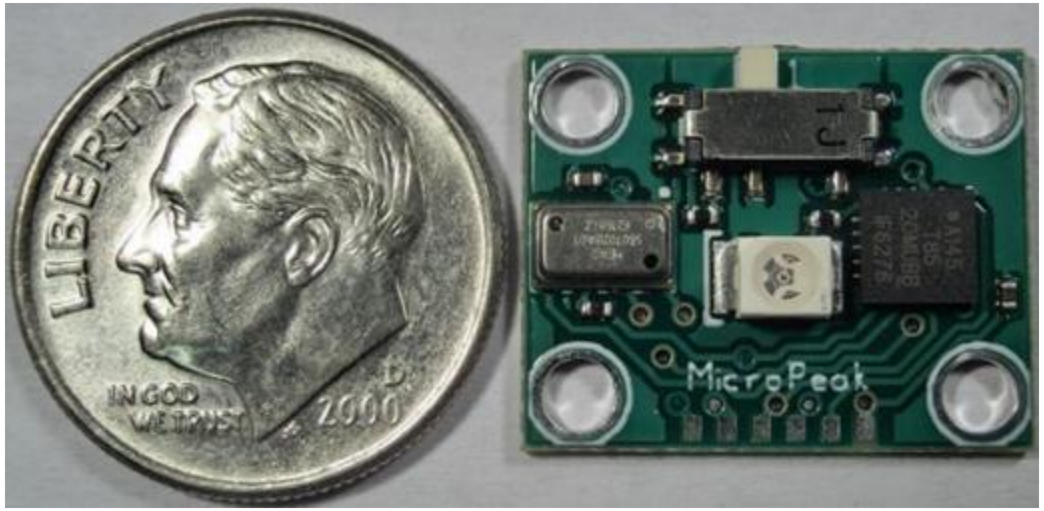
Rocket Design – Internals: Altimeter



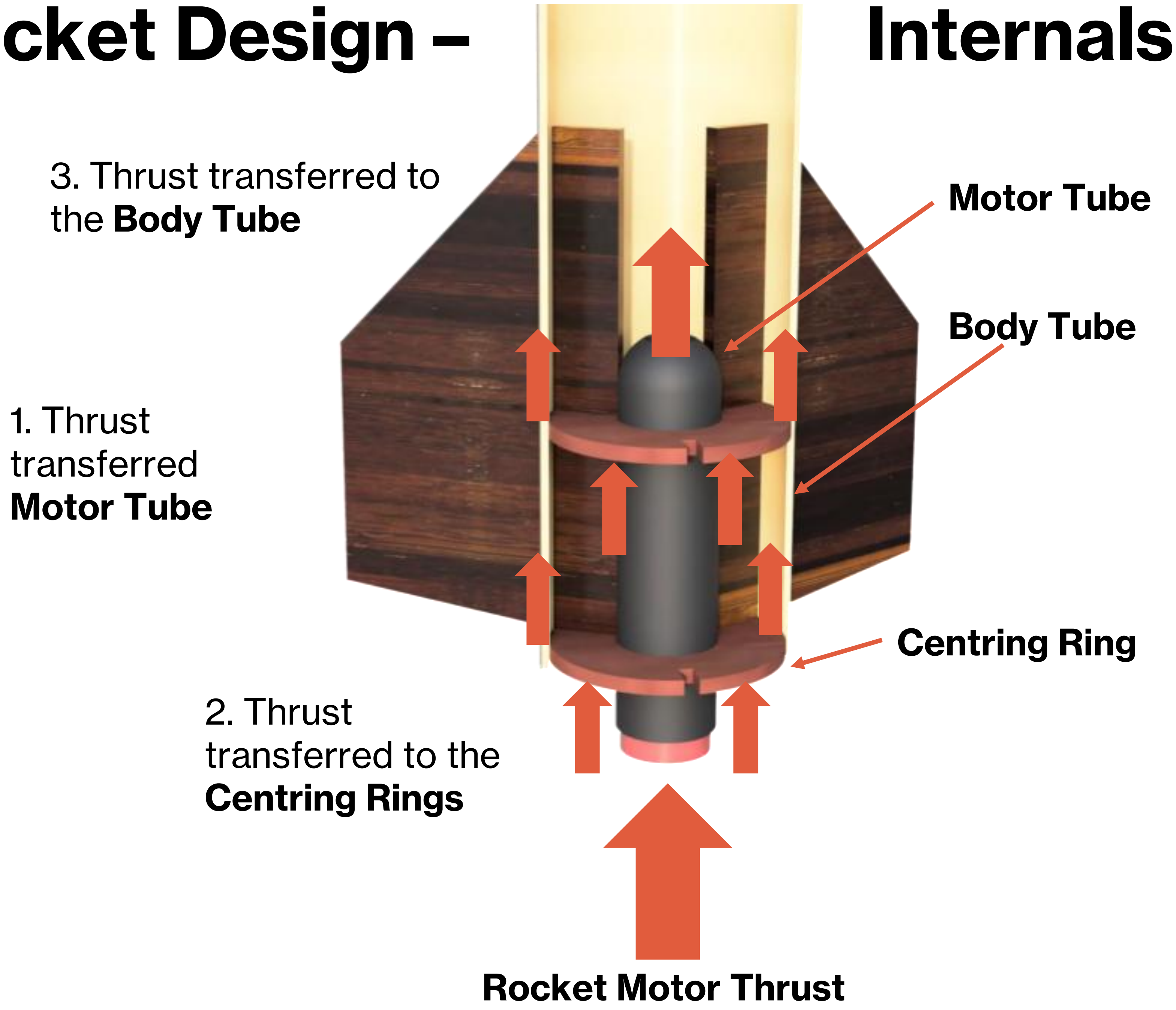
We use small electronic flight computers to measure the how high our rocket has gone, we call them altimeters.

There are a few different models but they are all small and will weigh around 20g.

1. We can add it to the nose cone, although it can go anywhere. This time, on the new page under "Mass Component", we can use the "Mass type" drop-down menu to designate it as an Altimeter. This is just a visual change, allowing us to distinguish between the Altimeter and the Egg & Egg protection payload.



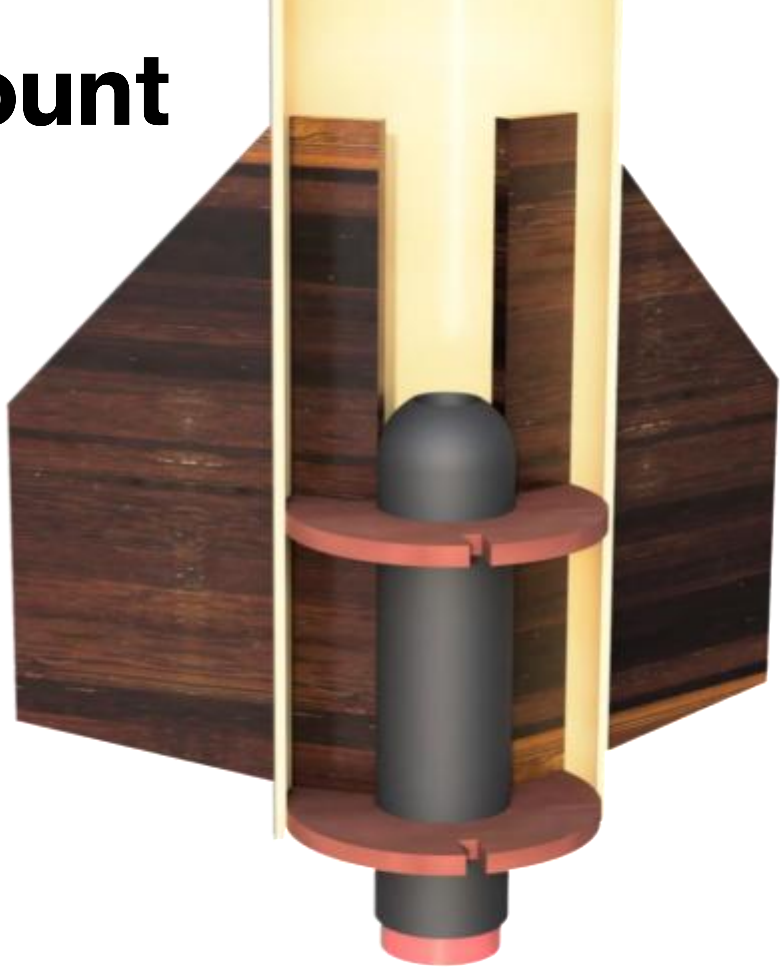
Rocket Design – Internals: Motor Mount



The rocket motor's thrust must be transferred to the rocket to push it upward.

We achieve this using a **Motor Mount System**. The motor's thrust is first transferred into the motor tube, then into the centring rings (which are glued to the motor tube), and finally into the body tube, which is glued to the centring rings.

Rocket Design – Internals: Motor Mount



With the Single use motors like the F20, they have a **Thrust Ring** included on them.

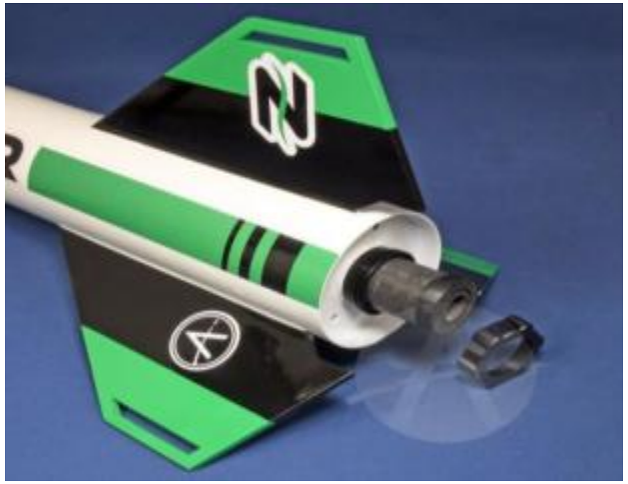
The Thrust Ring pushes on the motor tube transferring the force to the motor tube.

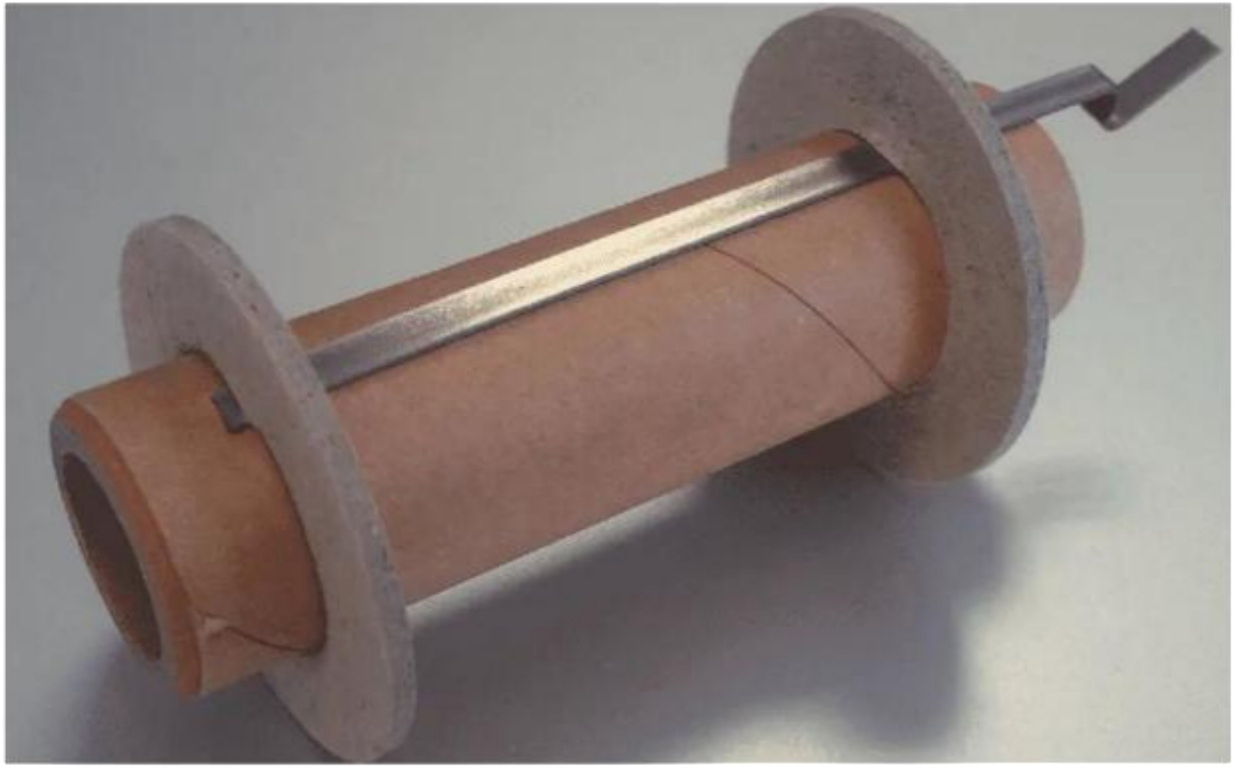
You will notice both the motor sticks out the back of the motor tube and the motor tube sticks out the back of the body tube.
So, we'll need to update our OpenRocket sim to reflect this.

Additionally, you can see the fins protrude into the body tube on to the motor tube. This helps to secure the fins strongly and keep them straight. We call these **Fin Tabs** and we will add them to our fins in OpenRocket.
Fin tabs are **not necessary** - they add strength but require more time and complexity to the design and build of the rocket. It's up to you to decide if you need them. to decide if they need them.

Rocket Design – Internals: Motor Retention

Lastly, we need a way of retaining the motor in the motor tube so it doesn't fall out or get pushed out after motor ejection.

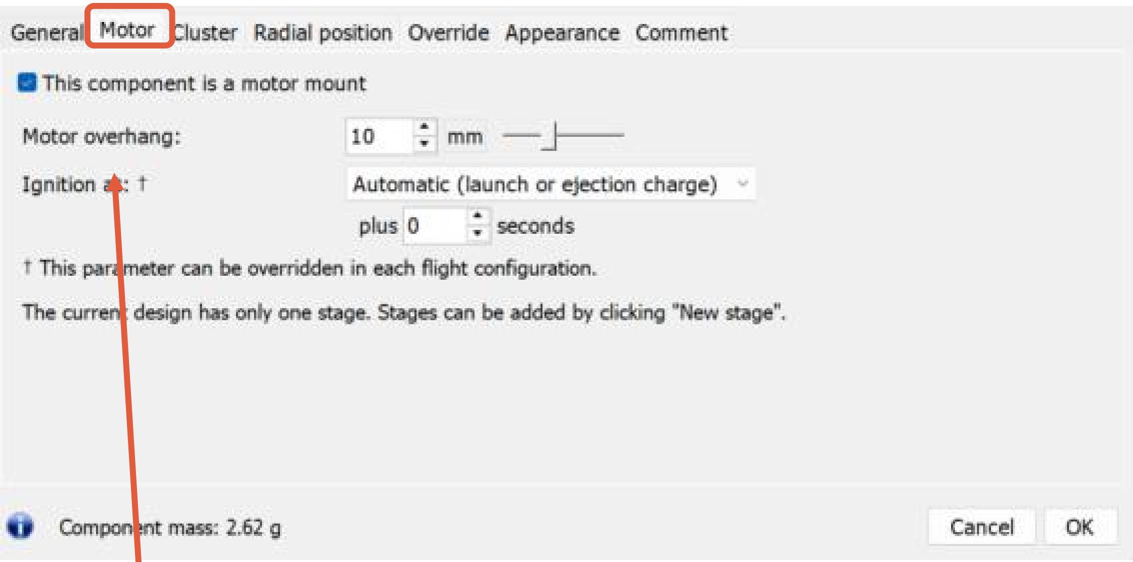


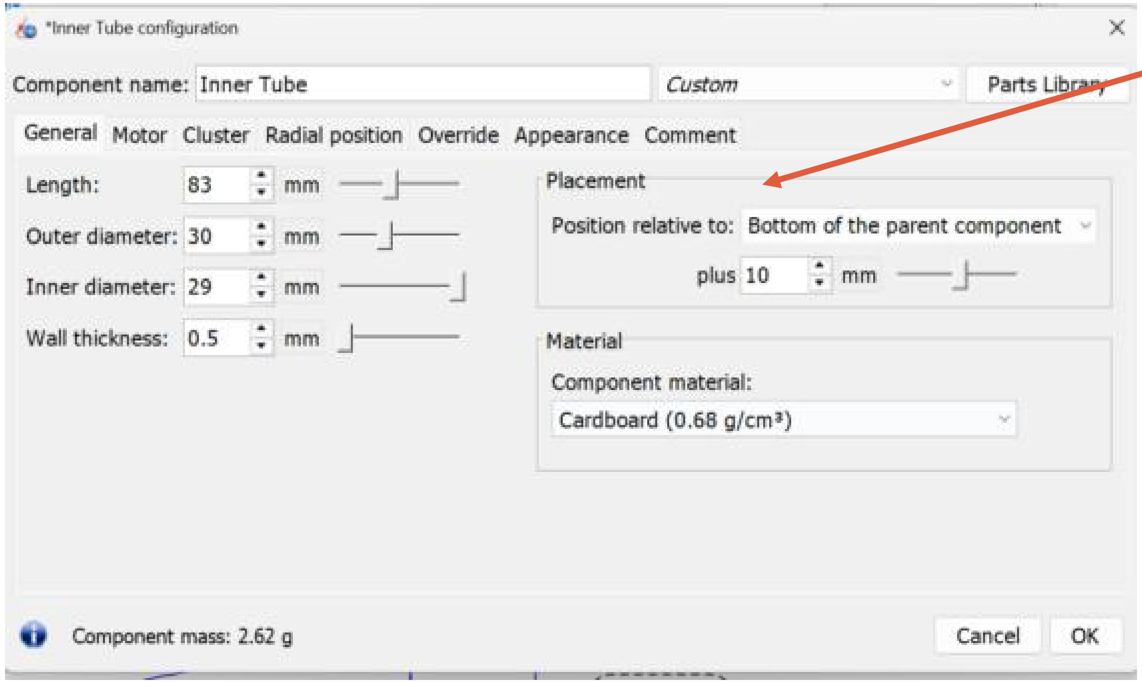


Common methods include screw-on retainers (glued with high-temperature epoxy like JB Weld) or spring-steel hooks. Off-the-shelf hooks for 13 mm and 18mm motors are inexpensive and reliable, though you can also make your own from flat wire (e.g., old windscreen wipers).
If retainers aren't an option, a friction fit using masking tape around the motor casing can also work.

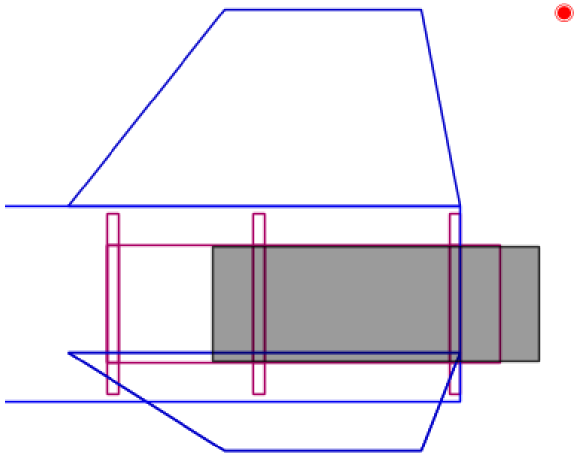
https://www.apogeerockets.com/How-To/Motor_Retention https://ukra.org.uk/2025/04/30/rocket-motors/

Rocket Design – Internals





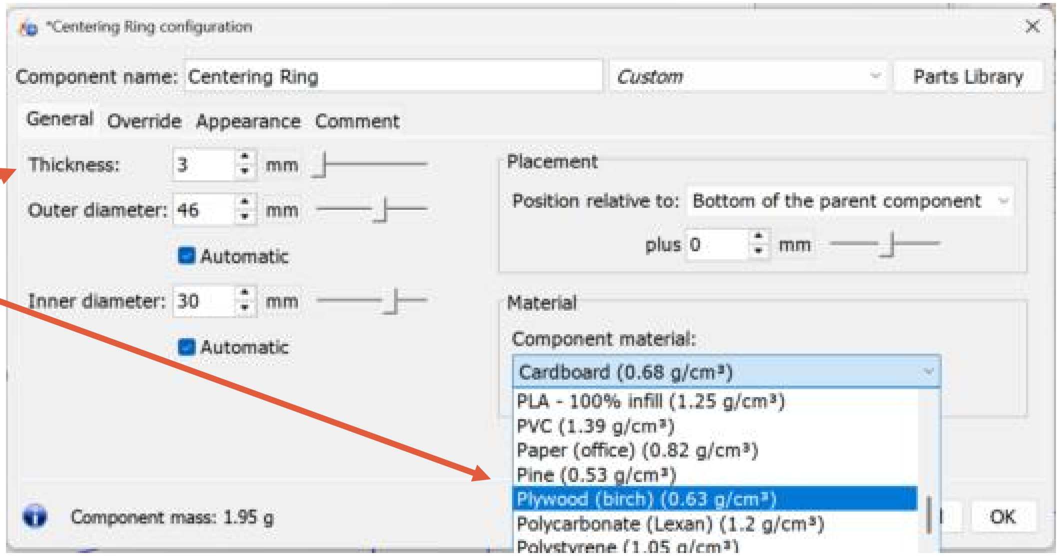
1. We can adjust the placement of our motor mount and motor overhang in the Motor tab to reflect the motor tube and motor sticking out.

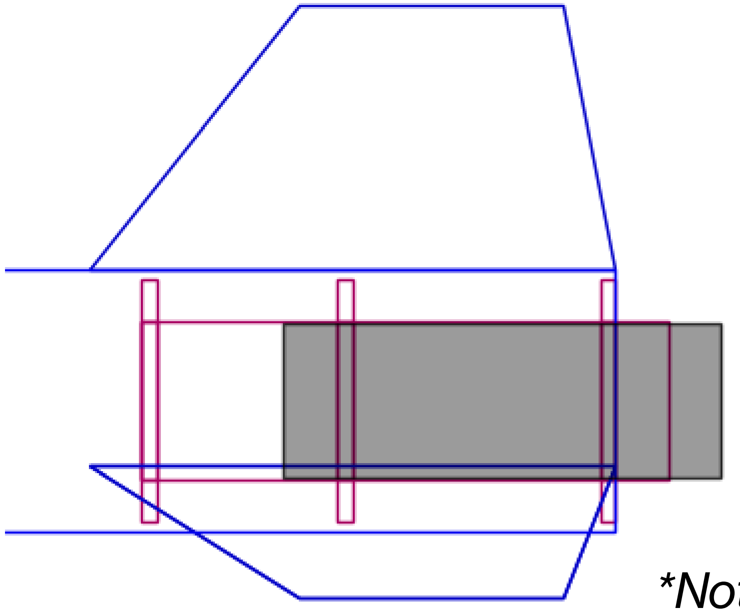


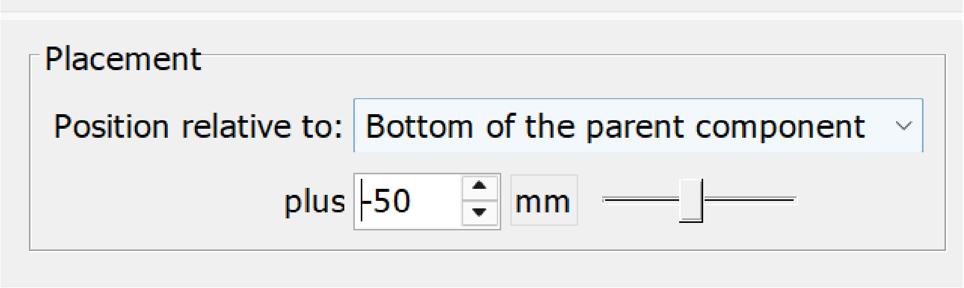
Rocket Design – Internals: Centring Rings

Let's add the "Centring Rings" to our sim.

1. On the lower body tube, you can add "Centering Ring" from the "Inner components". Like the bulkhead we often laser cut these out of 3mm plywood. You can change the materials and the thickness to match your manufacturing.







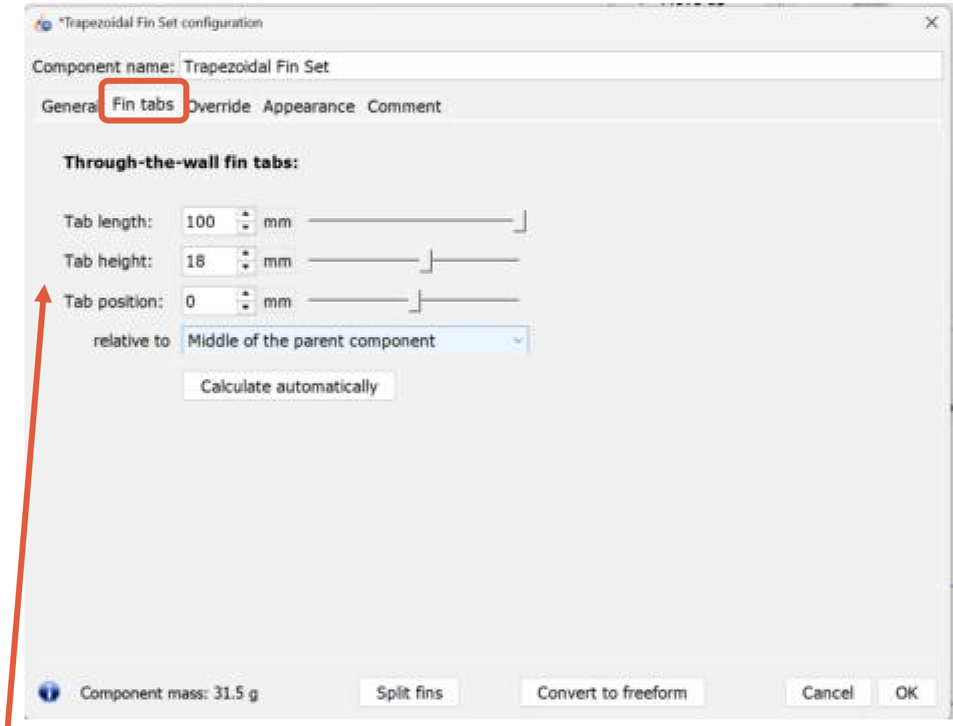
2. We need three centring rings*, one at the bottom of the body tube, one at the top of the motor tube and one around the middle. You can do this by changing the placement of the centring ring components.

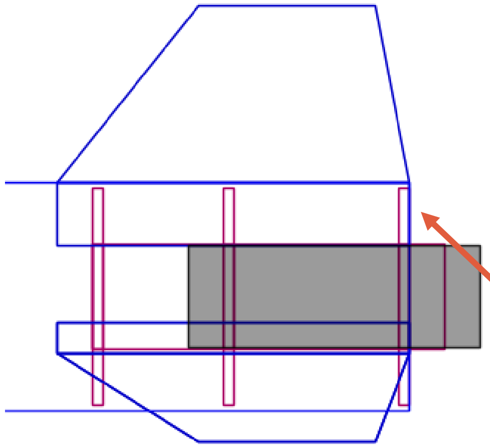
**Note, you can use keyboard shortcuts CTRL+C, CTRL+V, CTRL+D to copy, past and duplicate components to help speed up your work.*

Rocket Design – Fin tabs

If you have Fin tabs we can now add them to our sim.

1. If you select the fin set and click edit, you get the stander pop up window. Under the "Fin tabs" tab you can add fin tabs to your fins.

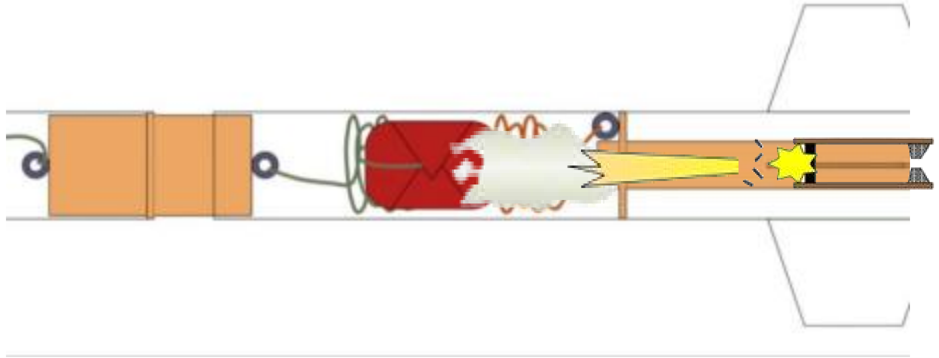




2. You can change the length and height here. Often if you click the "Calculate automatically" it does a good job, but you need to make sure they go the entire length of the fin and all the way down to the motor tube.

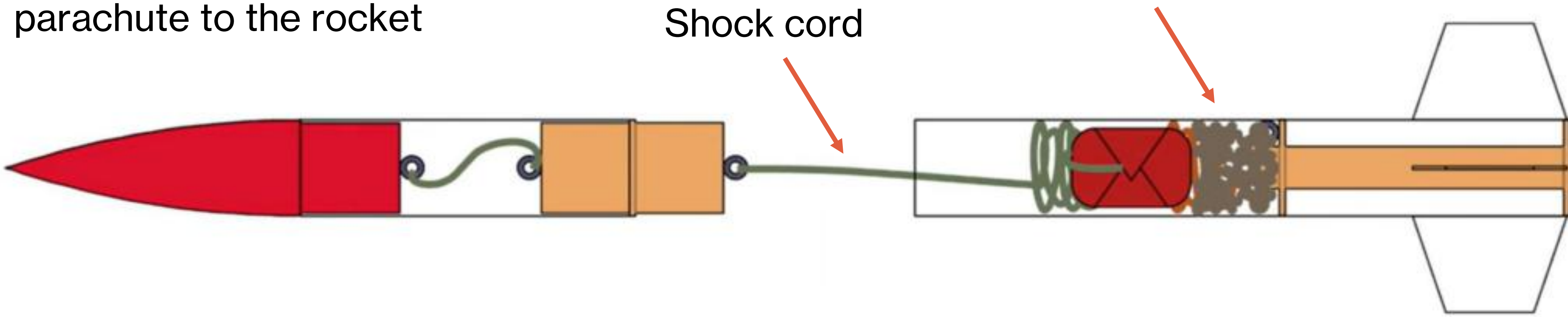
Rocket Design – Internals: Recovery

“What goes up must come down” – and for UKROC rockets, it must come down slowly enough to avoid damage and within the 36–39 s time window for maximum points.



We achieve this by deploying a parachute a few seconds after motor burnout. The ejection charge releases hot gases, so to protect the parachute we place fireproof disposable wadding beneath it.

Shock cord is used to tie the parachute to the rocket

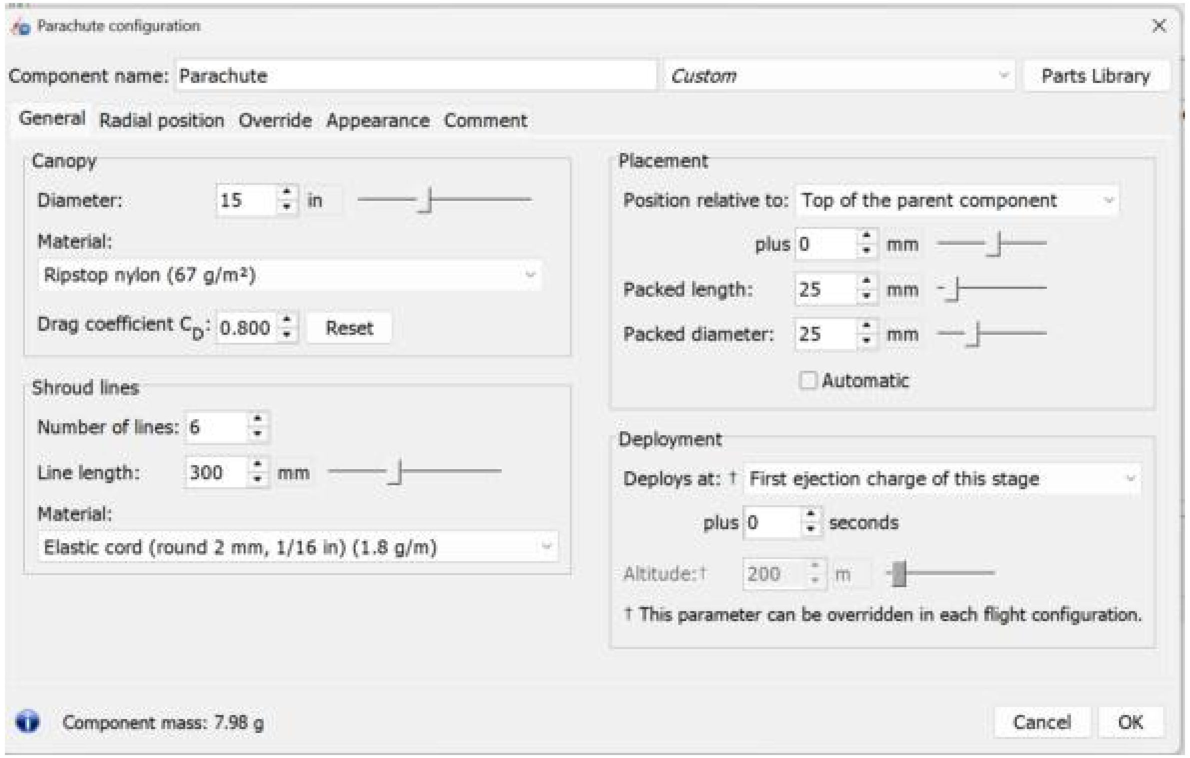


We can change the size of our parachutes to change how slow the rockets fall, making sure they land both softly and within the time window.

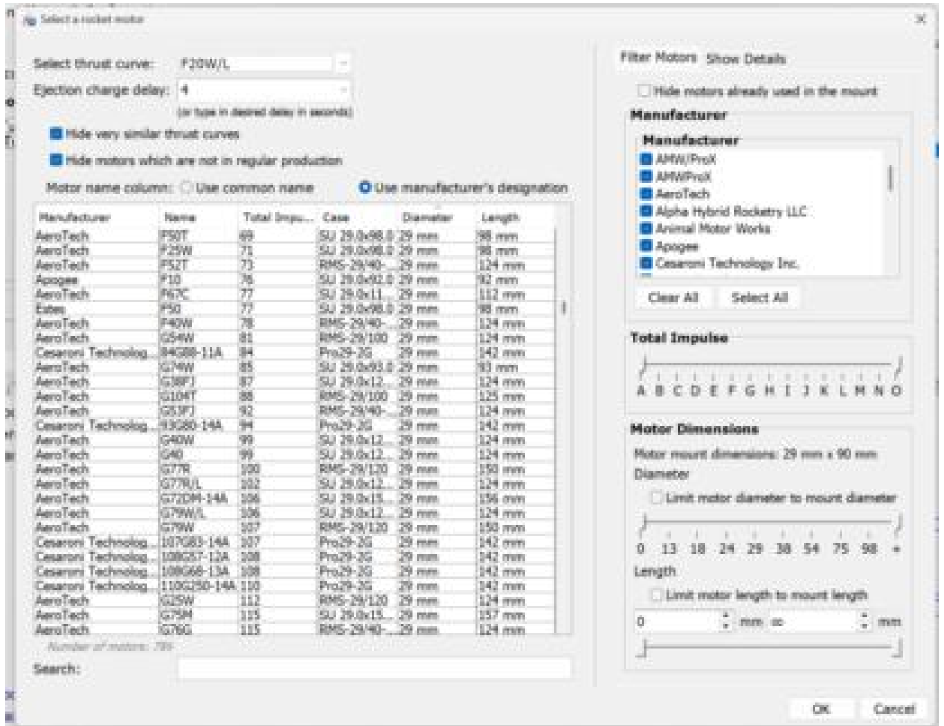
Rocket Design – Internals Recovery

Setting up our recovery

1. On the lower body tube, you can add a "Parachute" from the "Mass Components". You can edit the diameter here and we will see how that effects the decent rate and flight time.



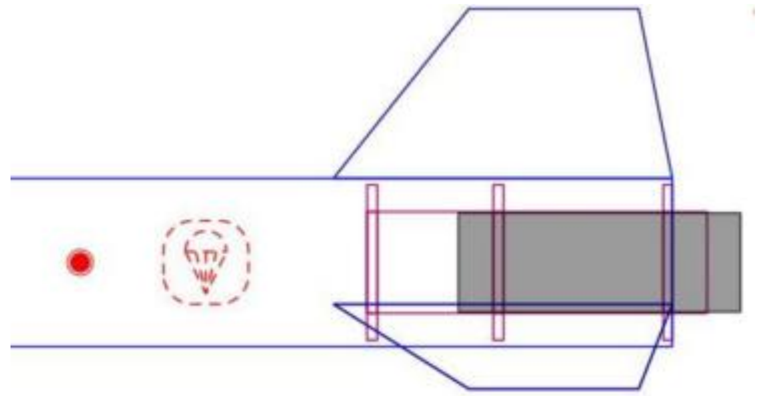
2. We also need to set the "Deployment", for motor ejection. We set it to "First ejection charge of this stage". This uses the motor's deploy timer to time it. You can edit the motor deployment in the motor selection window. However, motors only come in specific delays.

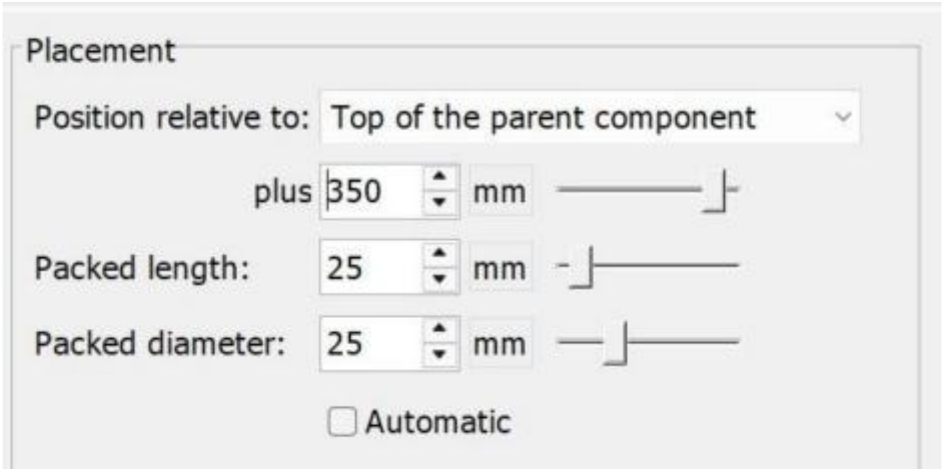


The F20 can only come in 4 or 7 second delay.

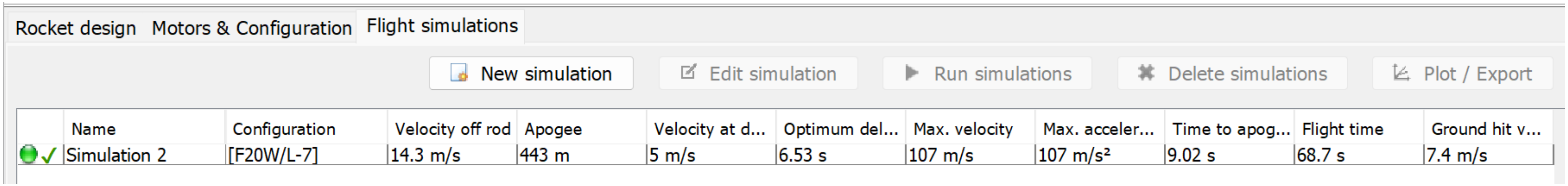
Rocket Design – Internals: Recovery

3. We can set the position to be above the motor mount.





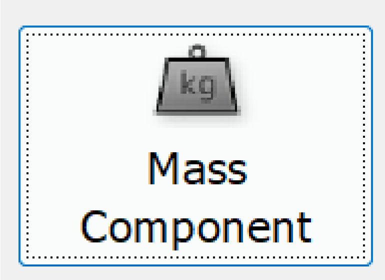
Under the Flight simulations tab, we can see how our parachute is doing. We have the Flight-time, Ground hit velocity and Time to apogee.



	Name	Configuration	Velocity off rod	Apogee	Velocity at d...	Optimum del...	Max. velocity	Max. acceler...	Time to apog...	Flight time	Ground hit v...
	Simulation 2	[F20W/L-7]	14.3 m/s	443 m	5 m/s	6.53 s	107 m/s	107 m/s²	9.02 s	68.7 s	7.4 m/s

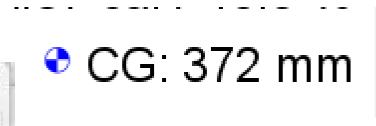
Time to apogee is important. We want to deploy our parachute at apogee to ensure the rocket reaches its calculated maximum altitude. This is also the point at which the rocket is moving the slowest, meaning the parachute experiences the lowest force when deployed, helping to prevent any damage.

Rocket Design – Other Mass components

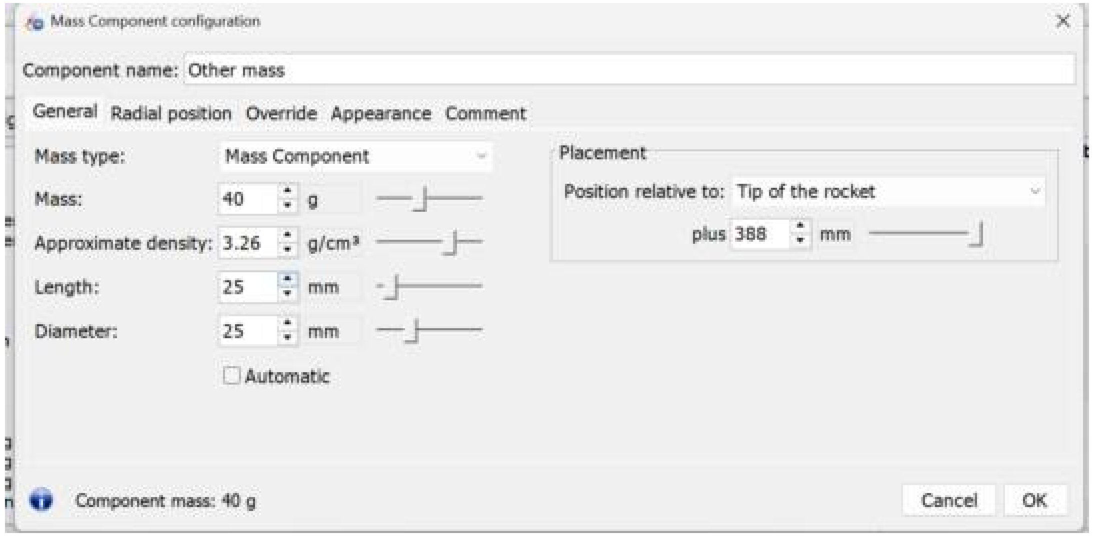


There's a few other minor masses that when added together are going to influence our predicted apogee, but as they are spread equally over the rocket hey won't have a large effect on the CG.

The best way to account for these is to add another mass component around the CG with the mass of all these smaller components added together.



Glue – 10g
Paint – 10g
Metal hardware – 5g
Wadding – 2.5g
Tape – 2.5g
Ballast – 10g
Total ~ 40g

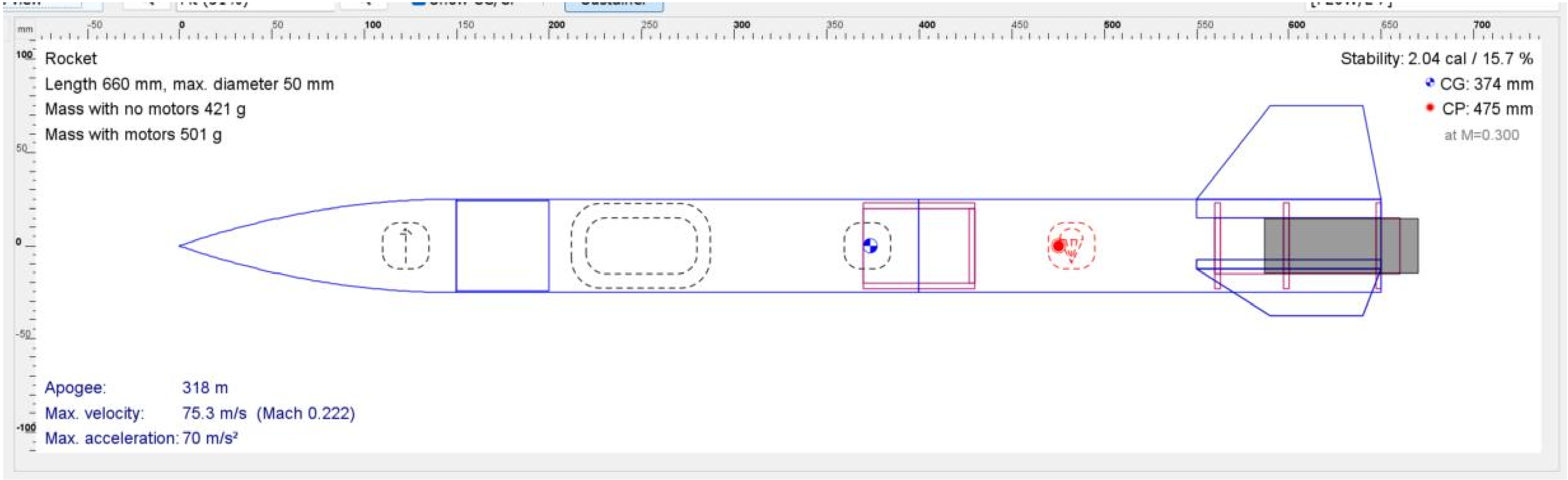


We have also included a ballast mass; this is a mass that we can add which isn't a rocket component, for example some Blu Tack, batteries, or anything heavy and available. We add this to the simulation in case, after we build the rocket, it's heavier than expected; it's a lot easier to add mass than it is to remove it. Another reason is that the simulations aren't perfect; after your first flight, you might find the rocket has gone too low or too high, and this can be easily adjusted for the second flight by adding or removing some of your ballast mass.

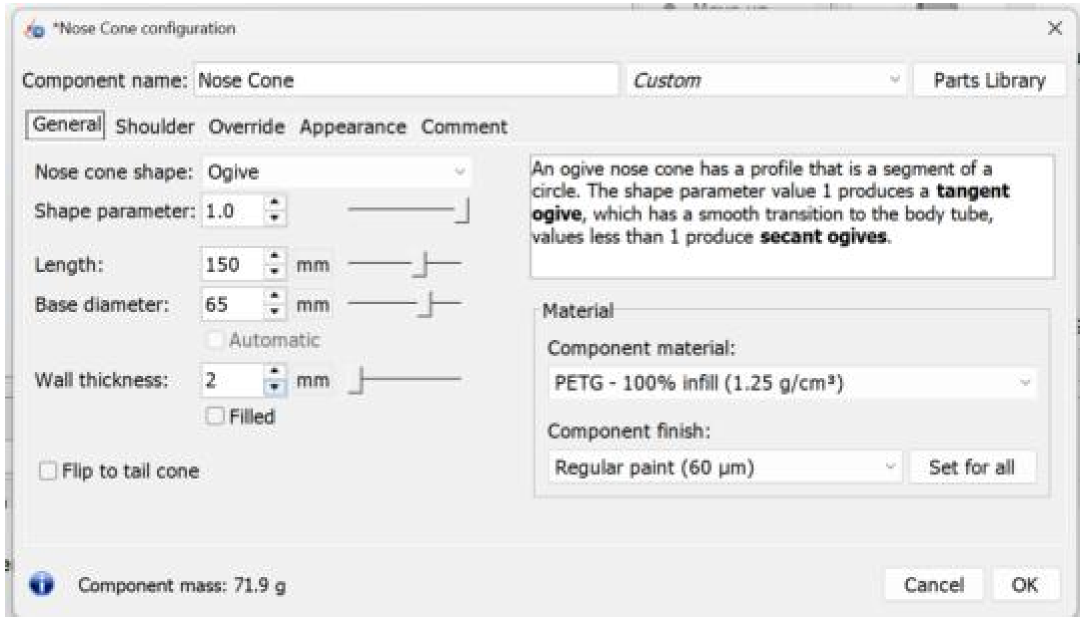
Rocket Design – Rocket V1 Done

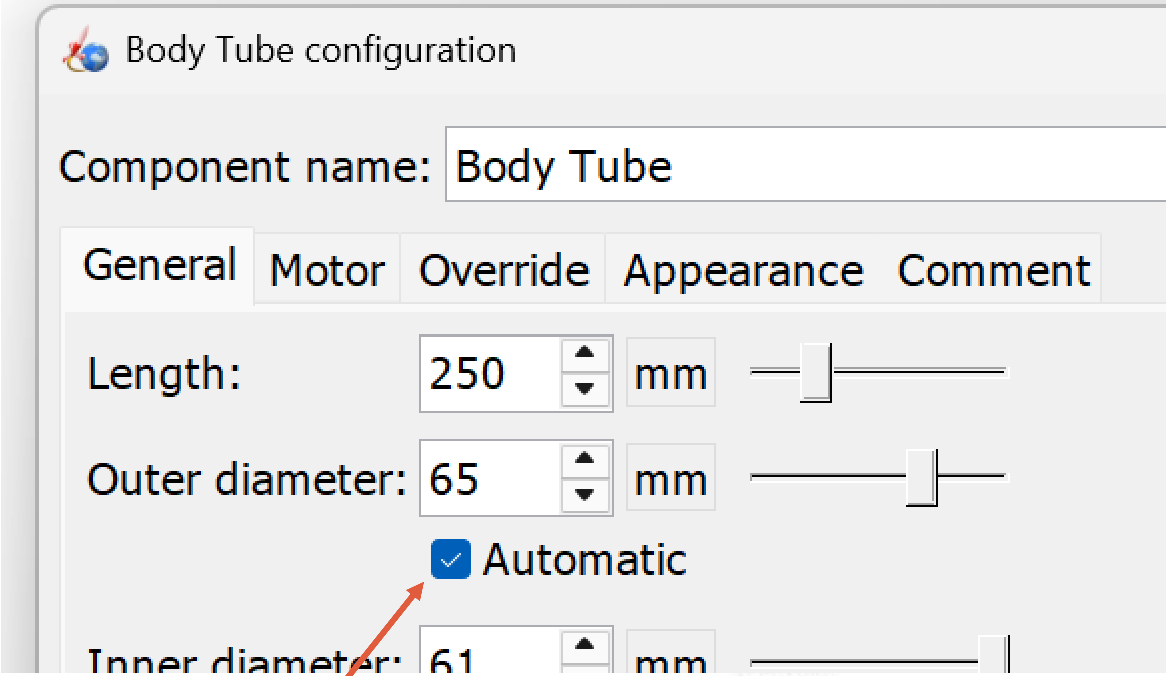
You now have a complete rocket simulation, including a payload (Egg), an Altimeter, a working recovery system, and a complete motor mount.

You should also hopefully understand what makes a stable rocket, how rocketry recovery works, how rocket motors work and the anatomy of a rocket. You can now start deigning your UKROC Rocket!



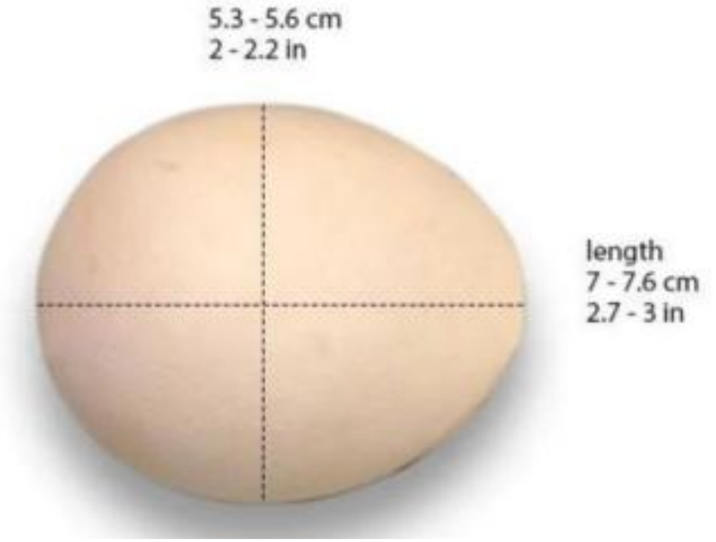
Rocket Design – Optimising Diameter



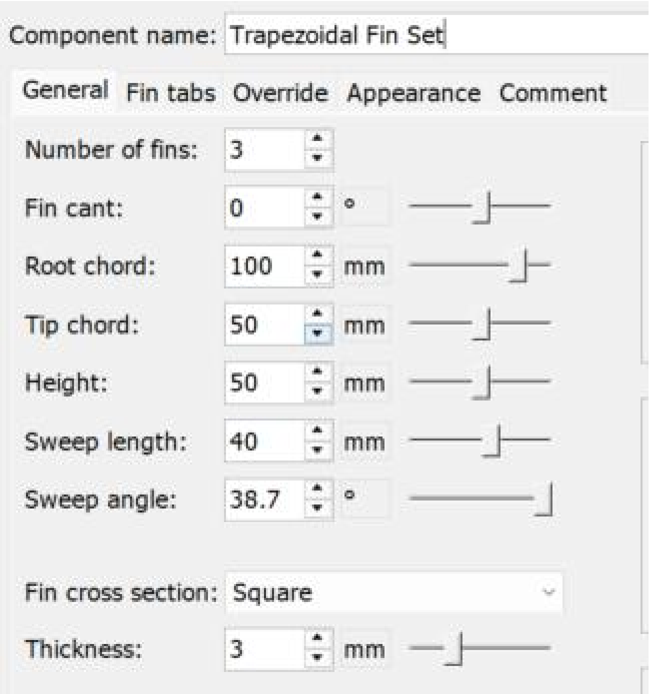


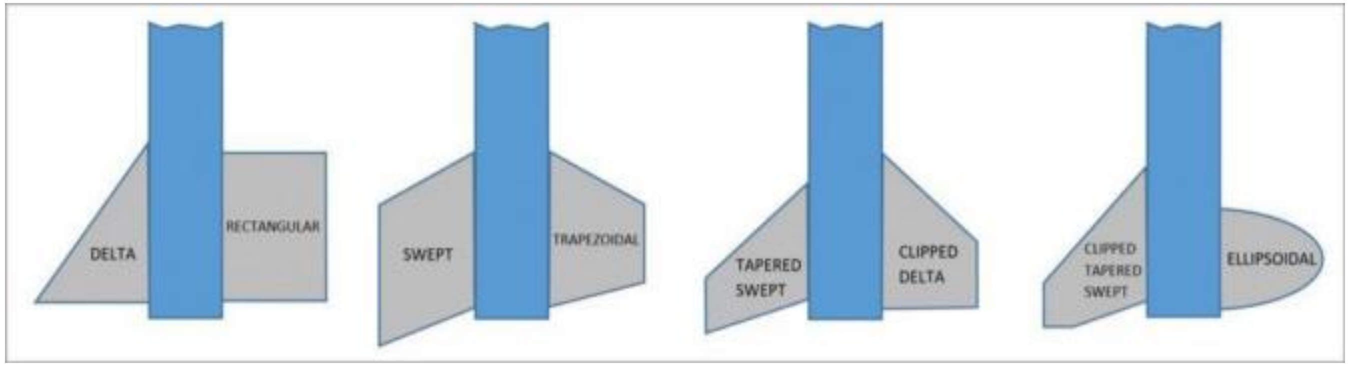
Remember the Diameter must be big enough for the egg and the egg protection.

You can set the body tubes diameter to "Automatic" then when you change the diameter of the nose cone it will automatically change the body tube diameters to match.



Rocket Design – Optimising Fins and Nose Cone



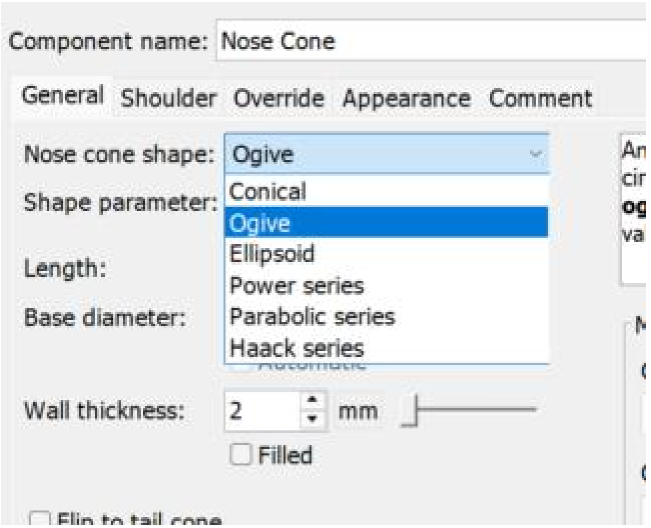


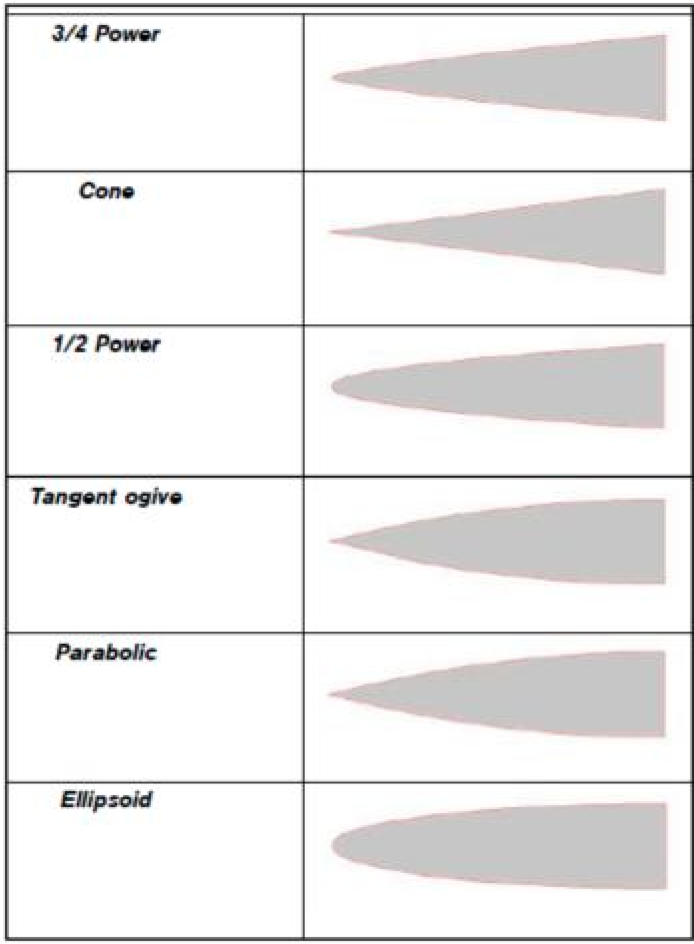
The fin design changes effects the stability and apogee a lot so play around and see what works.

You can also play with the number of fins, any number above 3 can be a stable set-up.

https://apogeerockets.com/education/downloads/Newsletter442.pdf

Rocket Design – Optimising Fins and Nose Cone





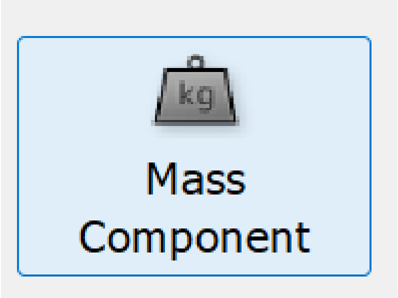
The nose cone effects the stability and apogee but has less effect than the fins. Try the different shapes to see what works best for your rocket. Having it look good is also important.

https://www.apogeerockets.com/education/downloads/Newsletter376.pdf

Rocket Design – Optimising Fins and Nose Cone

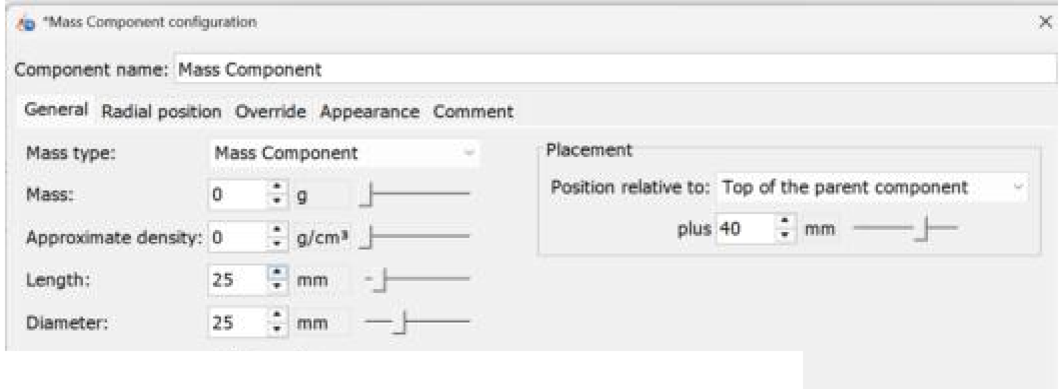
When it comes to stability remember it might be most efficient to add some mass in the nose cone to move the CG forward.

However it will also reduce your apogee.

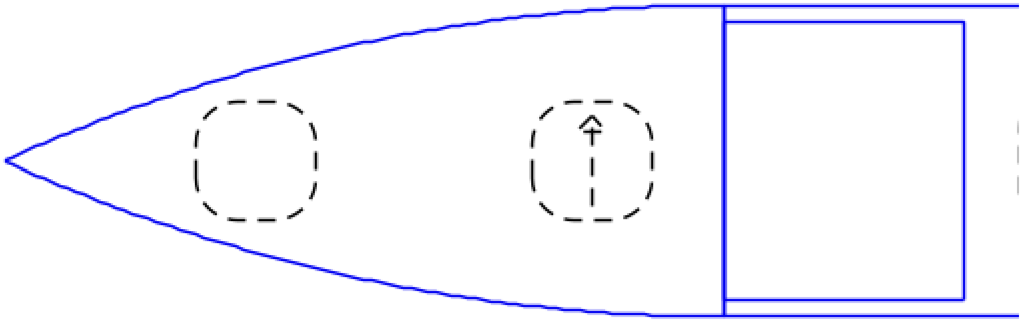


Stability: 0.8 cal / 8 %
CG: 376 mm
CP: 428 mm
at M=0.300

You're looking for greater than 1.5 cal stability.

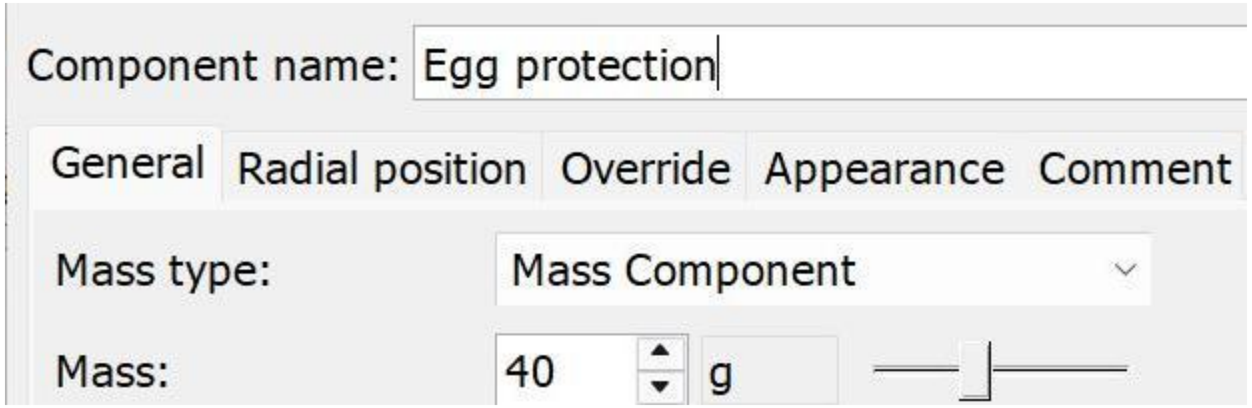


Apogee:	236 m
Max. velocity:	60.9 m/s (Mach 0.180)
Max. acceleration:	57.1 m/s²

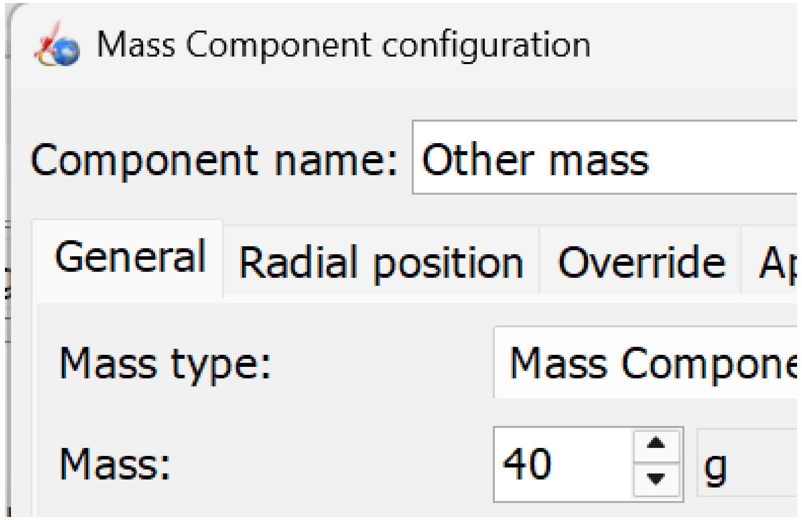


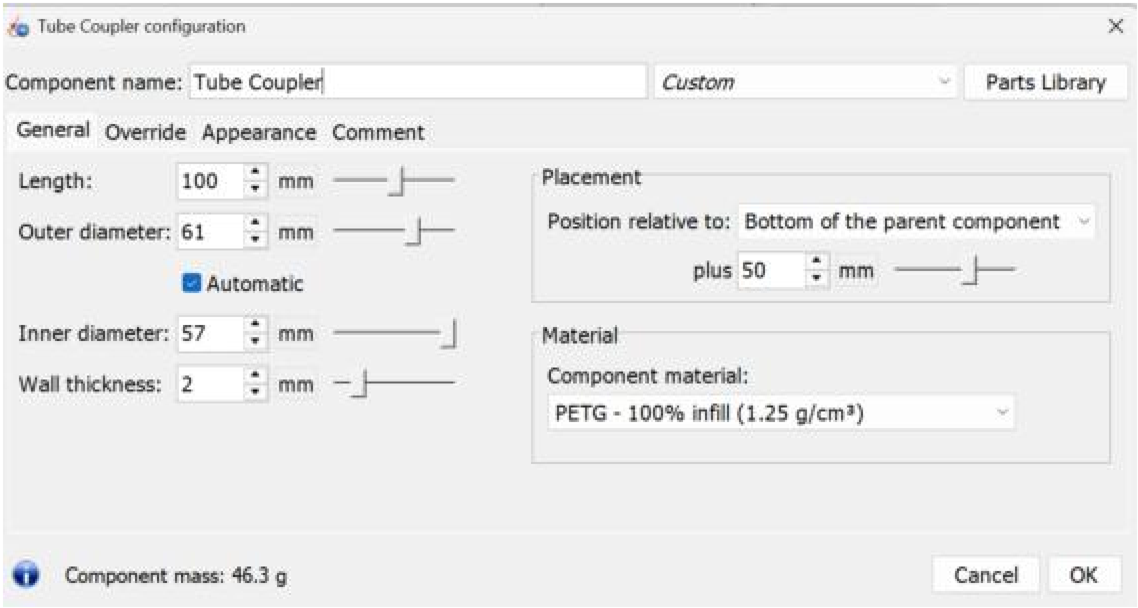
Rocket Design – Optimising Diameter

If you're struggling for height you can reduce the mass of some components, but you then must build them to that mass!

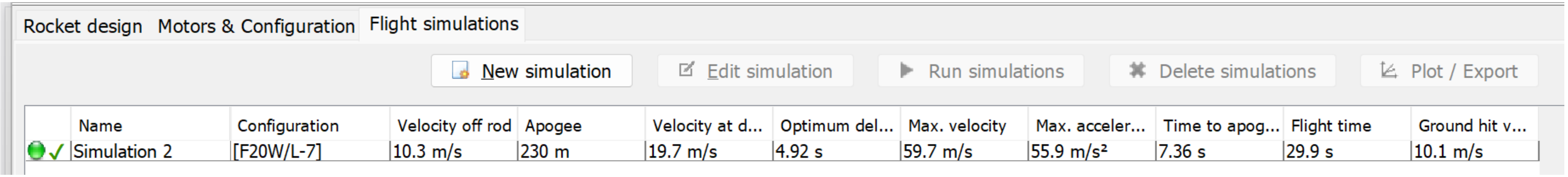


Remember it's always easier to add mass, so overestimating your mass in the sim is great and will give you more freedom when it comes to building.





Rocket Design – Optimising Parachute/Recovery



	Name	Configuration	Velocity off rod	Apogee	Velocity at d...	Optimum del...	Max. velocity	Max. acceler...	Time to apog...	Flight time	Ground hit v...
	Simulation 2	[F20W/L-7]	10.3 m/s	230 m	19.7 m/s	4.92 s	59.7 m/s	55.9 m/s²	7.36 s	29.9 s	10.1 m/s

Remember you are aiming for a flight time window. If you need to adjust your flight time slightly you can add holes to your parachute to make your rocket fall faster.

Additionally think about the ground hit velocity, if you remember your SUVAT you can calculate how high you need to drop it from to test if your egg will break at that speed. If it breaks you can add more protection around your egg and/or a bigger parachute, so you hit the ground slower.

Remember if your egg breaks the flight is disqualified better to have an overprotected egg with too long a flight time than a perfect flight time and a broken egg!!

Rocket Design – UKROC Rules Summary

Rocket
- Length ≥ 650 mm
- Mass ≤ 650 g
- Body tube continuous diameter ≥ 47 mm
- Stability: ≥ 1.5 calibres
- All parts connected together

Payload (Egg)
- 1 raw egg (55–63 g)
- Must land uncracked
- Padding must be removable before and after flight

Motors & Propulsion
- Commercial motors, class F or lower
- Total impulse ≤ 80 N·s
- Must be mechanically retained
- Must be on the UKROC motor list

Launch System
- Rail launchers only
- Minimum 2 m guidance rail

Electronics & Altimeters
- UKROC-approved commercial altimeter required

Judging Targets
- Altitude target: 750 ft (229 m)
- Flight duration: 36–39 seconds

Recovery & Safety
- Parachute(s) must deploy
- All parts descend together

https://www.ukroc.com/wp-content/uploads/2025/07/UKROC-Approved-Motor-2026.pdf - **UKROC Motor List**

Additional Resources

https://www.youtube.com/watch?v=vopmnHh4OhQ&ab_channel=Mr.T%27sSTEM

https://co4h.colostate.edu/projects/manuals/Model-Rocketry-Basic-U1.pdf

https://www.youtube.com/watch?v=aXq2AdKqtJY&ab_channel=GravitonMedia