Rocket CAD Designs

Launch 1

Airframe

The airframe design for the first launch is aerodynamically stable due to its conic shape that greatly increases the drag force that the rocket experiences. The large cone design was kept as it reduced the maximum height the rocket would reach and improved the aerodynamic stability. While the conic section was based off the 2017 rocket design, the overall airframe has been greatly expanded with the addition of an extension to the nose of the rocket to house the battery and improve its stablity. It contains a mount for the PCB (revision 3) and a 7.4 V 2-cell LiPo battery. The PCB and sensors are mounted below the conic section, next to the motor. The motor used for this rocket is a D-class model rocket motor.

The motor mount is incorporated directly into the gimbal in the centre of the cone and a hole is in the cone is placed directly above the motor to vent the ejection charge. An ejection chamber above the large cone allows the ejection charge to safely discharge without damaging the battery.

Limiting the rocket apogee height was done with aerodynamic drag and also increasing the rocket’s weight because it also improved the rocket’s aerodynamic stability. A second (square) hole was placed adjacent to the motor mount to allow the rocket to be placed on the launch rail. This reduced the aerodynamic stability of the rocket, but due to the low apogee point, this was deemed to be an acceptable drawback. At the base of the cone, six evenly distributed structural supports extend from the cone to a ring in the center to which the Gimbal is mounted. Sections of the ring were removed, between two of the support structures on opposite sides, so that three support beams were connected together on each side of the cone. This was done to allow the gimbal to be placed within easily and to create space for the electronics. This design is based on the 2017 cone, it has been improved to fit a larger gimbal as well as increased structural strenth. The CAD file for the airframe can be viewed at: OnShape Document

Simulation

Centre of gravity and centre of pressure were calculated using OpenRocket to ensure the launch vehicle is aerodynamically stable. The rocket has an overall height of 286 mm and weighs 600 g when fully assembled.

- Centre of gravity: 13.75 cm from the base of the rocket when standing upright
- Centre of pressure: 12 cm from the base of the rocket when standing upright

From an openrocket simulation, based on 10km/h winds the rocket will reach an apogee of 16 m and hit the ground 4.50 sec after motor ignition. 10kmh Wind simulation

Motor Gimbal

The rocket is actively stable with the use of the gimbal with its outer ring and support structures directly connected with the rocket body. The gimbal used for this launch is the G-Max MK4, designed by the 2017 team. The gimbal's outer ring is screwed into the airframe's support structures. The gimbal motor mount is designed to fit an E-class model rocket motor. We have modified the motor mount to improve stability of the motor placed in it. A motor adapter allows the gimbal to fit a D-class motor. Gimbal and adapter viewable at: OnShape Document. Further documentation regarding the operation and design of motor gimbals can be found in the Gimbal Documentation page

Electronics

The electronics placed within the airframe were the Avionics Package and two servos for controlling the motor gimbal. The package is held in a 3D printed part that is attached to the base of the rocket via pins on the rocket and holes on the pcb holder. For final assembly before the launch, the PCB holder was glued to ensure it would not come loose during flight. In addition to the Teensy 3.6, a RFM9X LoRa radio unit, RFM9X LoRa GPS module, and an MPU 9250 IMU are present. The electronics are powered by a 2S 7.4 V LiPo battery. Loose wires, leading from the servos, IMU, and battery are held securely by zip ties. The battery wires run past the ejection charge site and are thus protected by silicon tubing around the wires.

Hardware Used

```
    * Avionics Package
    * 2S LiPo
    * 2X M3x6mm
    * 2X M3x10mm
    * 2X Silicone tubing 10cm
    * Electrical tape
    * Superglue
```

N.B. Hardware for the gimbal is listed seperately in the Gimbal Documentation page.

N.B. Launch results can be found here.

Launch 2

Airframe - Rev 0

For the second iteration of the rocket airframe, the body and nose of the rocket have been extended to have a longer, more aerodynamically design.

The motor mount is incorporated directly into the gimbal in the centre of the cone and a hole is in the cone is placed directly above the motor to vent the ejection charge. An ejection chamber above the large cone allows the ejection charge to safely discharge without damaging the battery. The rocket is aerodynamically stable due to the large “cone” that greatly increases the drag force that the rocket experiences. The large cone design was kept as it reduced the maximum height the rocket would reach and improved the aerodynamic stability. The CAD file for the cone is viewable here: OnShape Document. Limiting the rocket apogee height was done with aerodynamic drag and also increasing the rocket’s weight because it also improved the rocket’s aerodynamic stability. The CAD file for the rocket is viewable here: OnShape Document.

The Avionics Package, battery, and exteroceptive sensors are housed within a chamber within the nose. The airframe is now modular, with internal screws and printed tabs holding it together. Superglue will be used on the exterior to more securely hold parts together prior to rocket delivery. A second (square) hole was placed adjacent to the motor mount to allow the rocket to be placed on the launch rail. Centre of gravity and centre of pressure were calculated using OpenRocket to ensure the launch vehicle is aerodynamically stable. The motor used for this rocket is a D-class model rocket motor. The CAD file for the nose section of the rocket is viewable here: OnShape Document.

Housing the package in the nose of the rocket presents some benefits:

- The location of the package close to the battery reduces and protects the wiring, especially running along the exterior of the airframe.
- The package will be better protected from any motor exhaust by being fully enclosed.
- Having the weight of the package forward of the centre of pressure further improves the stability and maneuverabiity of the rocket [1].
- This design will further reduce the vibrations that the PCB will experience as strong vibrations can affect the lifetime and reuseablity of the package [2].

Simulation - Rev 0

Centre of gravity and centre of pressure were calculated using OpenRocket to ensure the launch vehicle is aerodynamically stable. The rocket has an overall height of 474 mm and weighs 500 g when fully assembled. OpenRocket simulation results for different motors can be found in Simulation document.

- Centre of gravity: 21.2 cm from the base of the rocket when standing upright
- Centre of pressure: 14.1 cm from the base of the rocket when standing upright

Aiframe - Rev 1

A second cone has been printed which tapers off to a smaller base. This is lighter than the larger cone (79 g vs 97 g) and will decrease the aerodynamic stability, increasing the amount of control the control system will have on the flight trajectory. The CAD file of the modified cone can be found here:Onshape Document

N.B. The gimbal and hardware are identical between the two revisions.

Simulation - Rev 1

Centre of gravity and centre of pressure were calculated using OpenRocket to ensure the launch vehicle is aerodynamically stable. The rocket has an overall height of 474 mm and weighs 500 g when fully assembled. OpenRocket simulation results for different motors can be found in Simulation document.

- Centre of gravity: 24.9 cm from the base of the rocket when standing upright
- Centre of pressure: 23.1 cm from the base of the rocket when standing upright

Motor Gimbal

The gimbal used for this launch will be based off the G-Max MK4, further modifications will reduce the weight and increase the range of motion of the motor. The gimbal's outer ring is screwed into the airframe's support structures. The gimbal motor mount is designed to fit an E-G class model rocket motor. A motor adapter will be used to allow the gimbal to fit a D-class motor. Gimbal and adapter viewable at: saw con Further documentation regarding the operation and design of motor gimbals can be found in the Gimbal Documentation page.

Electronics

The electronics placed within the airframe were the Avionics Package and two servos for controlling the motor gimbal. The Avionics Package is based on a new PCB design which features a more compact design with more secure power connections. Documentation relating to the PCB revision can be found in the PCB directory

The servo control wires are connected to the PCB by wires built into the airframe. We used sixteen strand ribbon cable for this; using two 20 cm lengths of 3 strands. A 3-pin header wsa soldered to the motor end of the cable; this plugs into the servo wires. The wires are run through the ejection chamber, silicone tubing was run through the chamber, shielding the wires from the the ejection blast.

In addition to the Teensy 3.6, a RFM9X LoRa radio unit, RFM9X LoRa GPS module, and an MPU 9250 IMU are present. The electronics are powered by a 2S 7.4 V LiPo battery.

Hardware Required

```
    * Avionics Package
    * 2S LiPo
    * 8X M3x10mm
    * 2X Silicone tubing 10 cm
    * Electrical tape
    * Superglue
```

N.B. Hardware for the gimbal is listed seperately in the Gimbal Documentation page