External Attachment at NAKUJA ROCKET PROJECT

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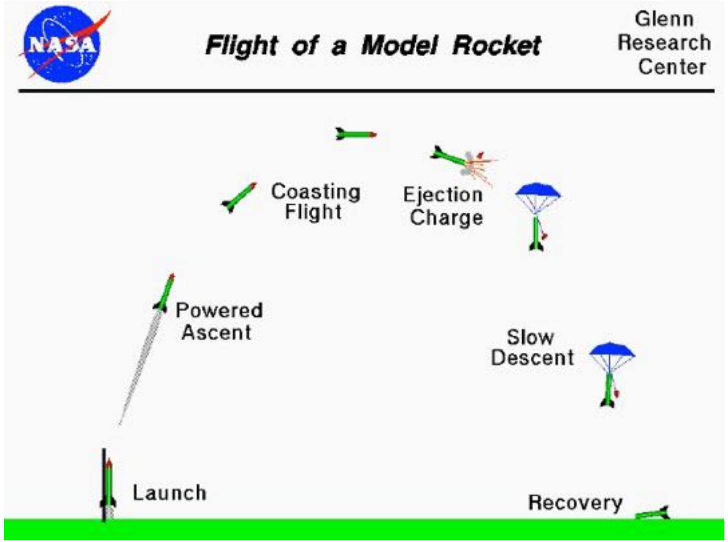
Freshly minted rocket scientists

Goals and Activities

Develop and launch of N1 Rocket to an **apogee** of 50 meters

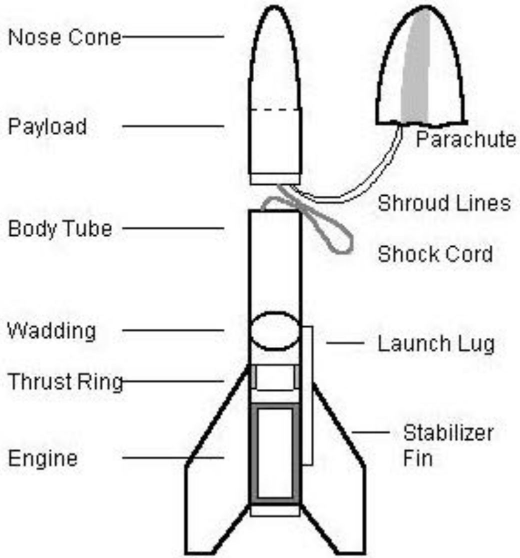


Develop a rocket motor motor

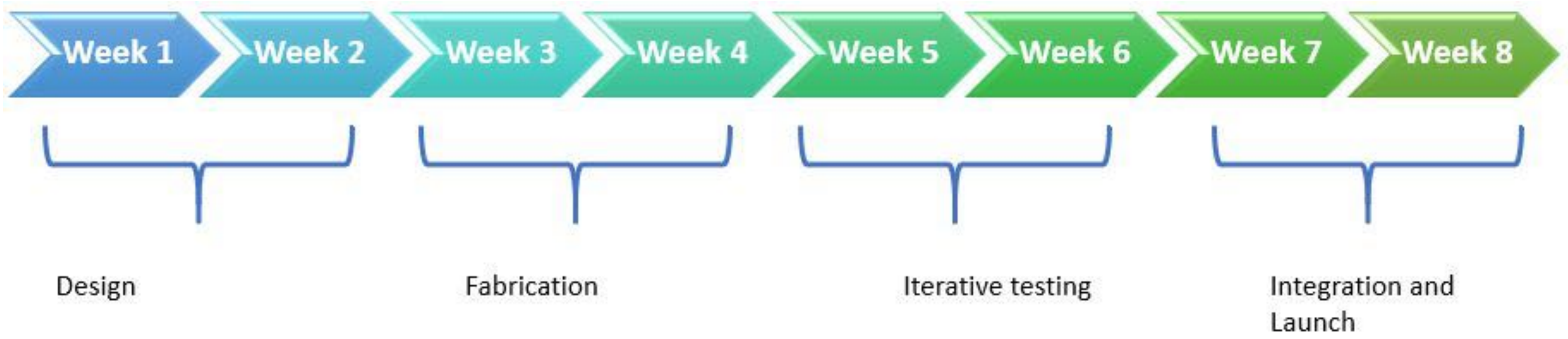
Record flight data

Develop the airframe

Launch and recover the rocket

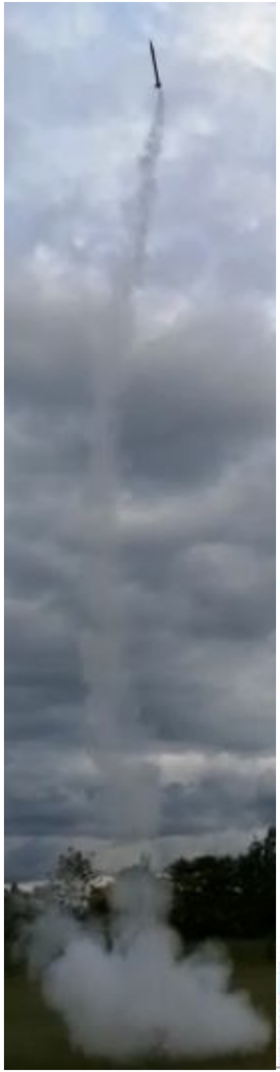


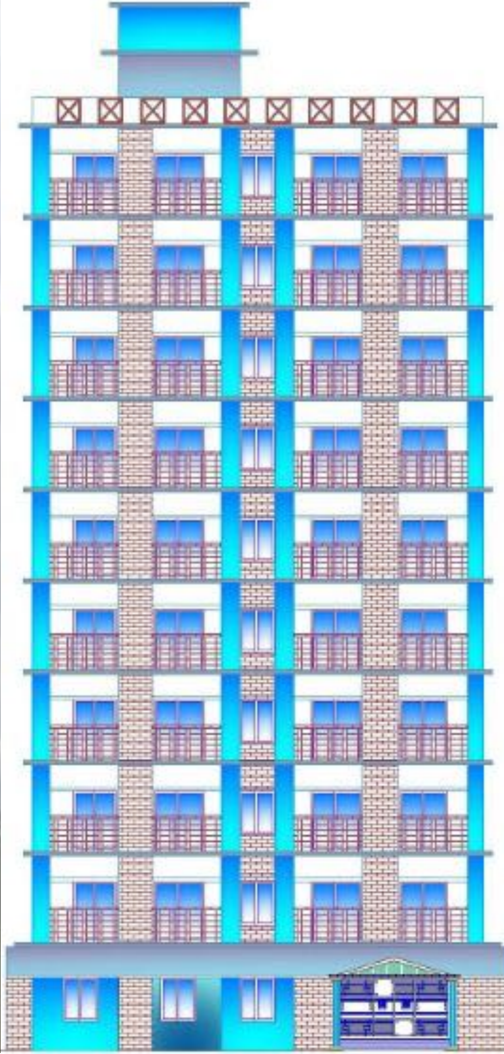
Timeline


Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Week 8
Design
Fabrication
Iterative testing
Integration and Launch

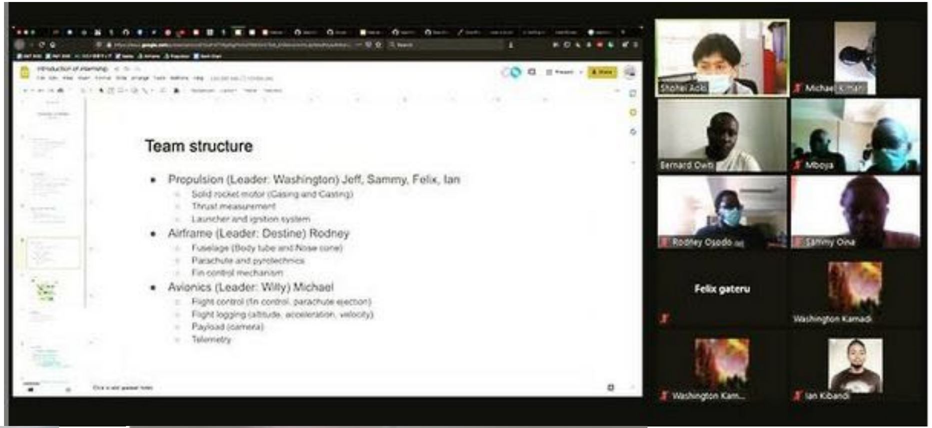
Achievements

Developed and launched N1 rocket to 32 meters (about the height of a 10 storey building)





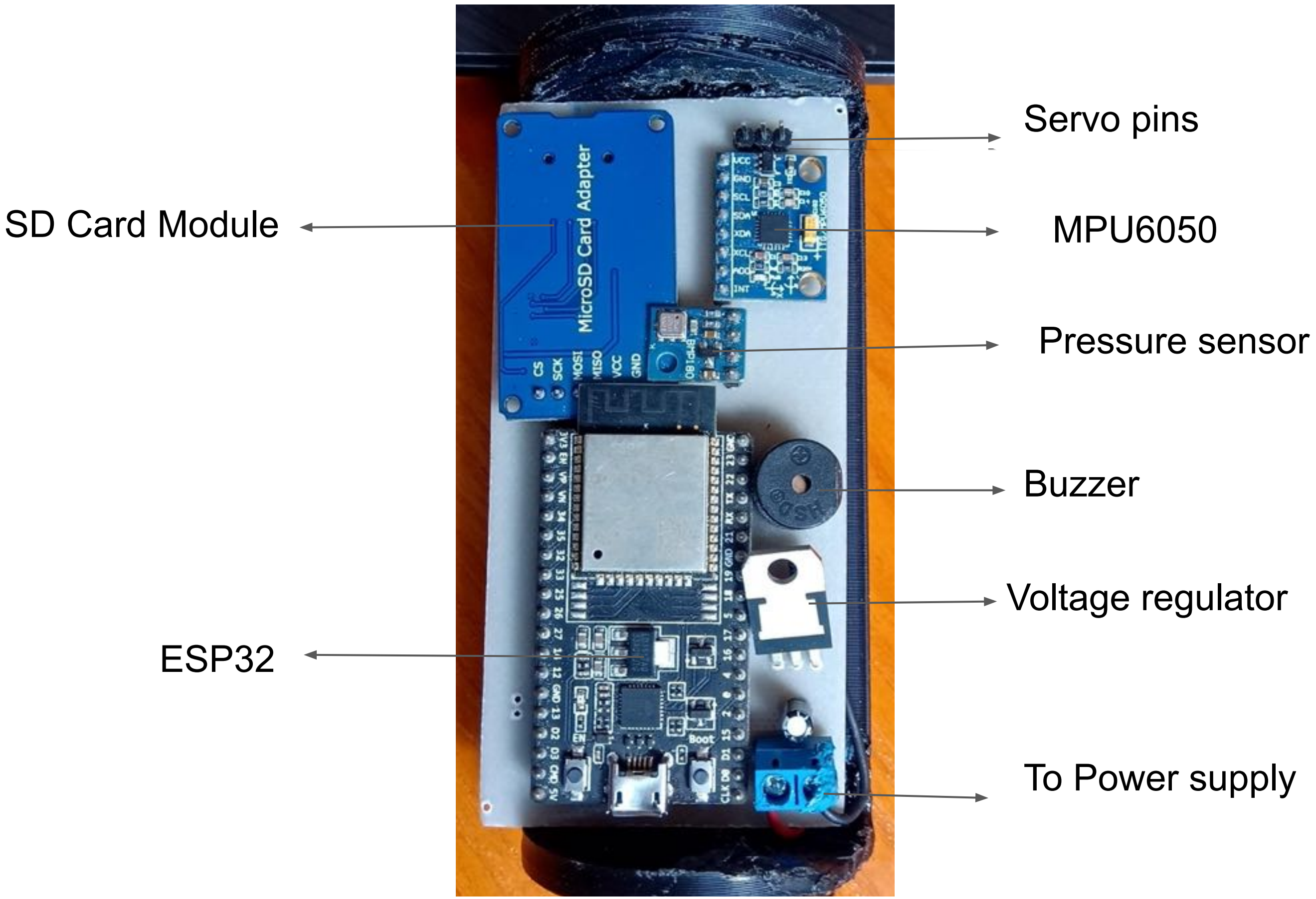
What was Learned



GitHub

AVIONICS
Goals and Activities

- Log flight data - velocity, acceleration and altitude.
- Detect apogee
- Flight control - Initialize recovery
- Build flight computer



Servo pins
SD Card Module
MPU6050
Pressure sensor
Buzzer
Voltage regulator
ESP32
To Power supply

What was learnt

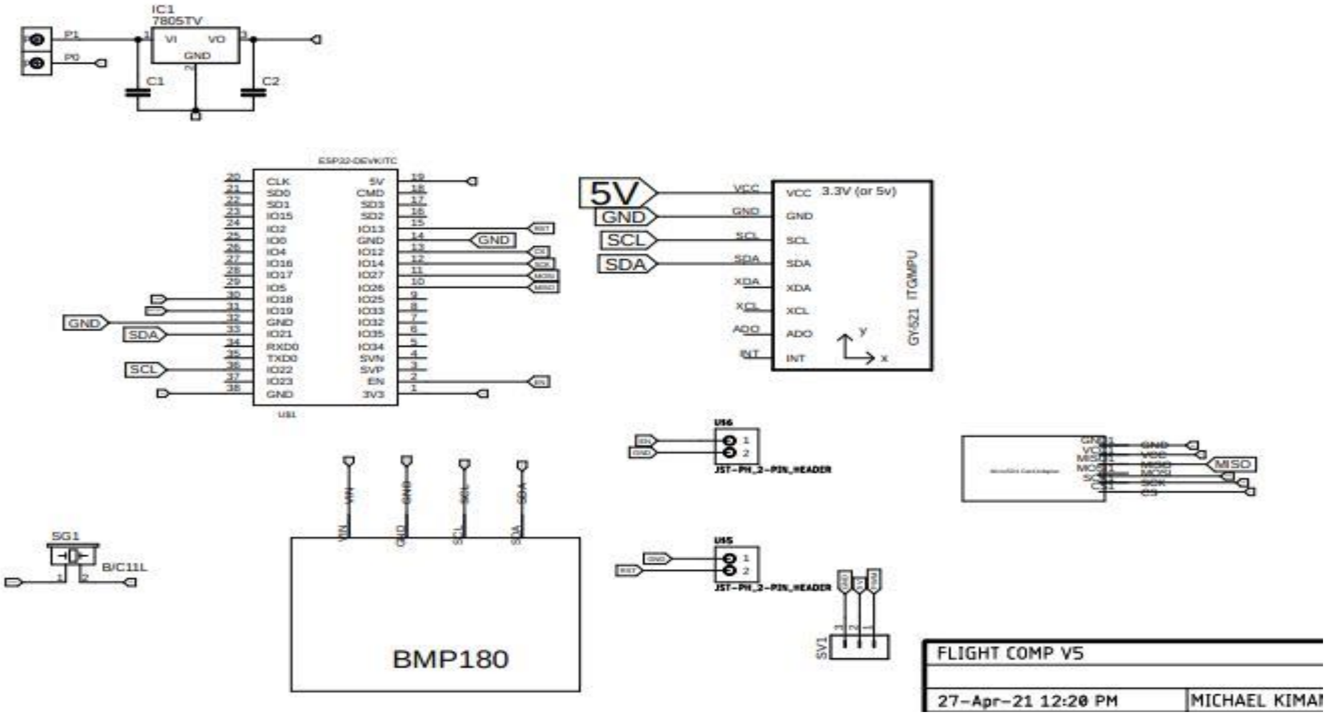
Hardware

PCB schematic and board design

Software

Filtering sensor noise using Kalman filter

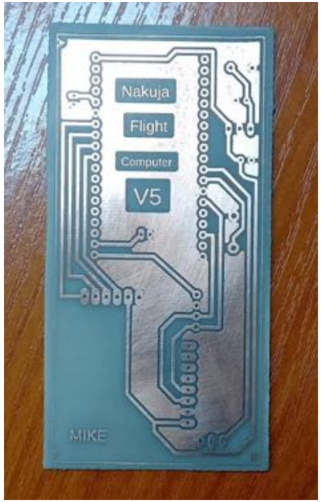
PCB SCHEMATIC



PCB Design and Etching

There were 5 iterative designs for the flight computer.

Each design had improvements in various forms



Kalman filter

$$\underline{\textit{Time update (prediction)}}$$

$$\textit{State prediction} : X_{pred} = A\,X_{k-1} + B\,U_k$$

$$\textit{Covariance prediction} : P_{pred} = A\,P_{k-1}\,A^T + Q$$

$$\underline{\textit{Measurement update (correction)}}$$

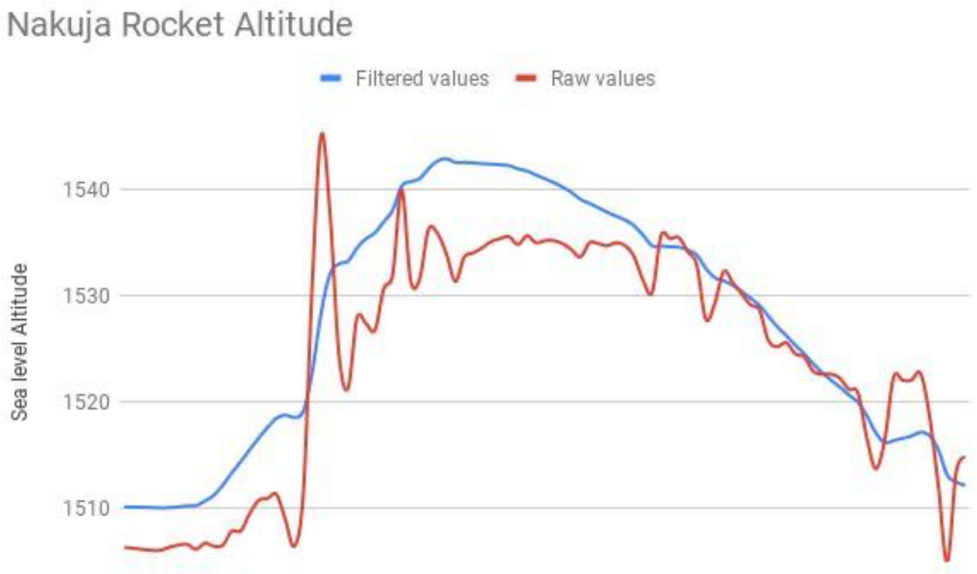
$$\textit{Innovation} : \hat{y} = Z_k - H\,X_{pred}$$

$$\textit{Innovation covariance} : S_k = H\,P_{pred}\,H^T + R$$

$$\textit{Kalman gain} : K_k = P_{pred}\,H^T\,S^{-1}$$

$$\textit{State update} : X_k = X_{pred} + K_k\,\hat{y}$$

$$\textit{Covarinace update} : P_k = (1 - K_k\,H)\,P_{pred}$$

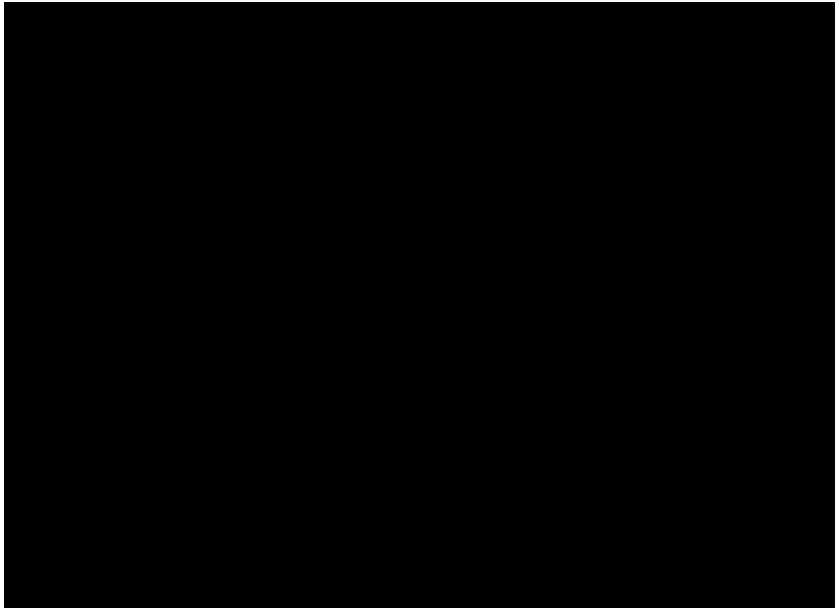


Kalman filter was applied for more sensible flight data.

Challenges

- Difficult to carry out proper preliminary apogee detection tests

Overcome this by using a water rocket

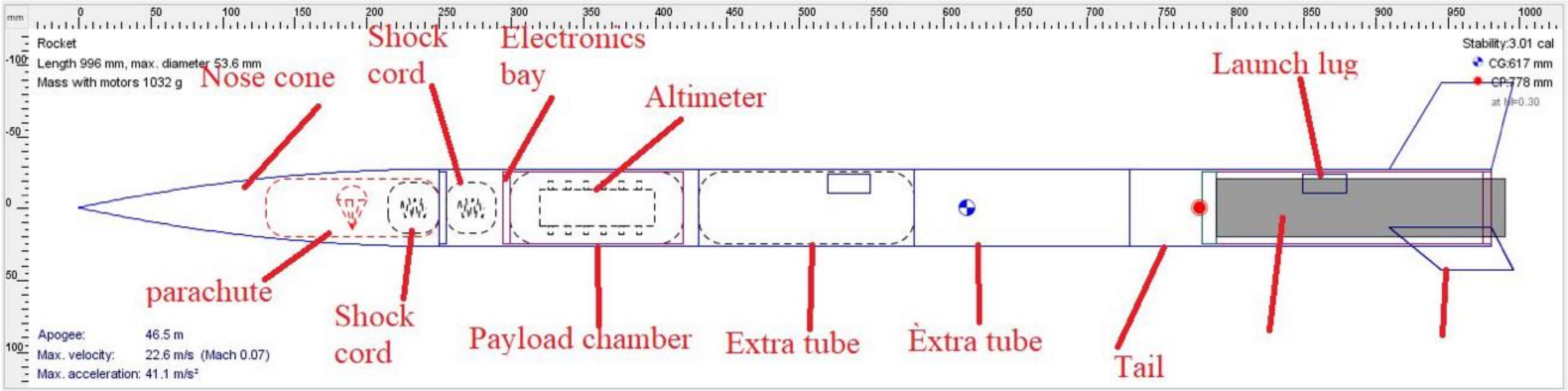


AIRFRAME

<u>Goals and Activities</u>

- Develop airframe with 450mm height
- Work on parachute and pyrotechnics
- Build the fuselage

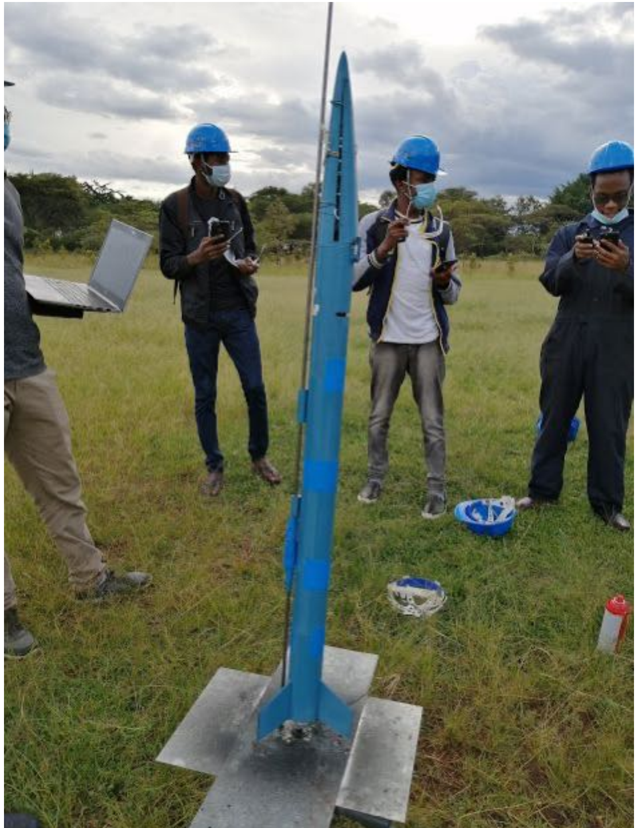
Model Rocket



Parachute Ejection Mechanism

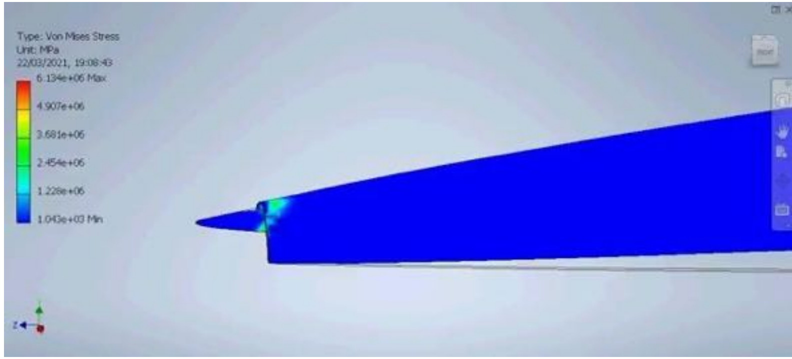
Achievements (airframe)

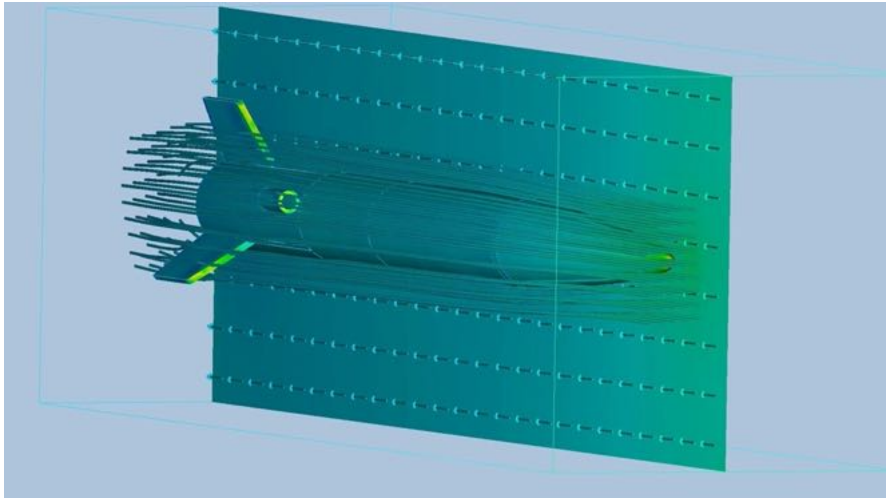
- Tested parachute ejection
- Integrated all the subdivisions
- Flew 32m high



What was learnt (airframe)

- Additive manufacturing (104.6 hr)
- Computational fluid dynamics
- Finite element analysis





Challenges (airframe)

- Lines of weakness after fabricating the model rocket
- Apogee detection for low altitude model rocket

Launch Pad and Payload Camera Goals and activities

Provide a cheap, light-weight, stable and portable launchpad
Visualize flight

Purchase and assembly of the launch pad base

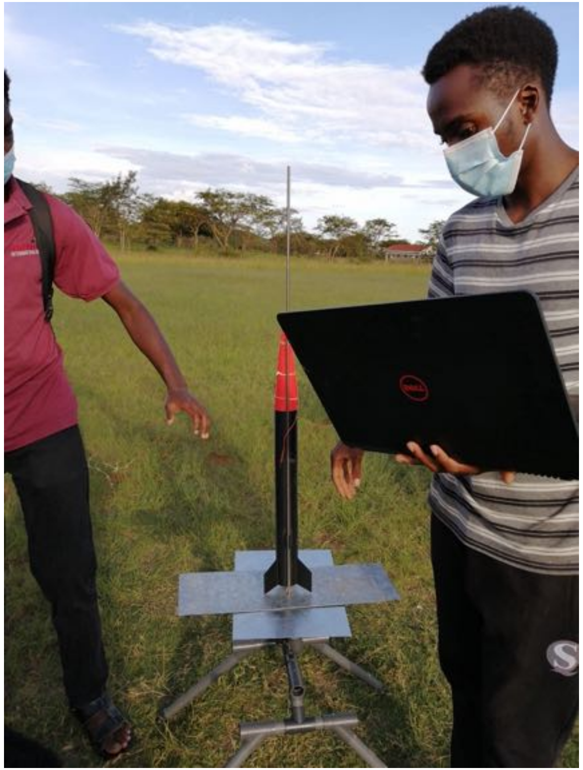
Assembling and strengthening the launch pad

Programming the payload camera microcomputer

Payload camera

Launchpad

Light-weight, portable and stable PVC launch-pad base.



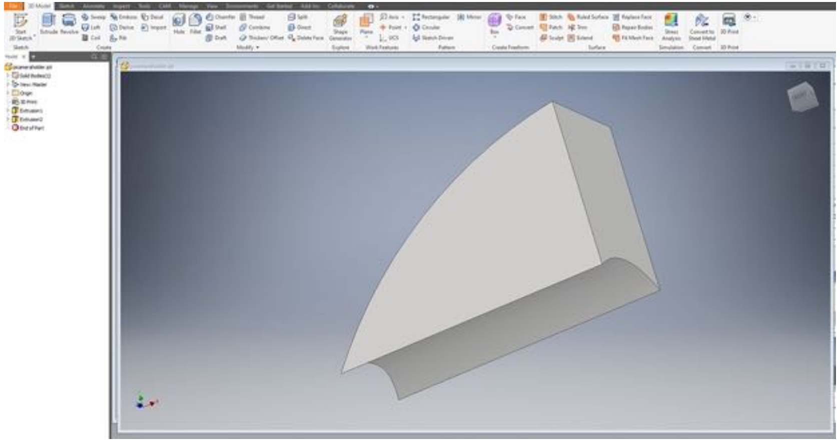
Aluminium blast pad and steel launch rod

What was Achieved

- Provided a stable,light and portable platform for launching our rocket
- Conducted 2 successful launches with the launchpad.
- Guided the rocket for the first few feet

What was Learnt

- Microcomputer python programming (Raspberry pi zero)
- 3D printing
- Computer Aided Design (Autodesk Inventor)



Payload camera holder design and assembly

Challenges

Unavailable pvc fittings
Short launch rod

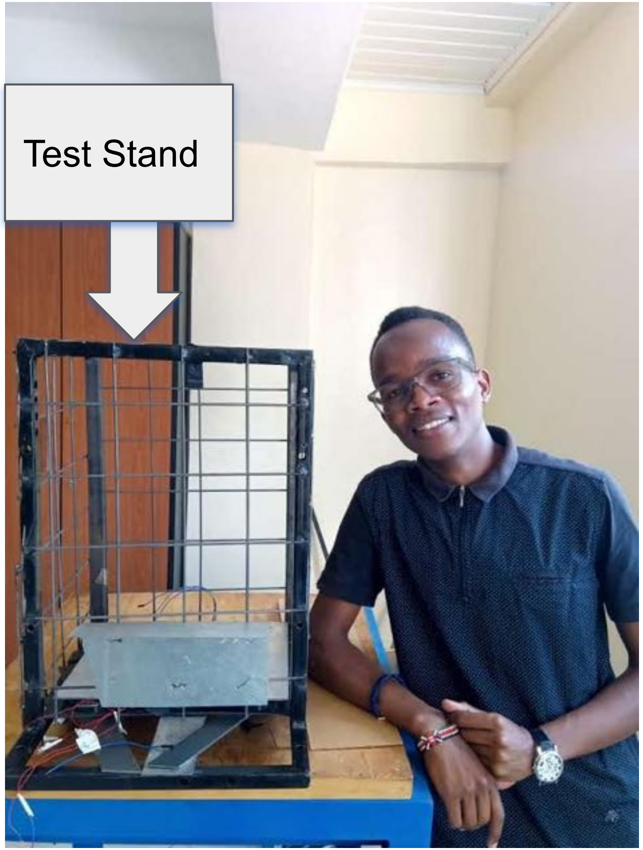
Longer Launch Rod

45 elbow replaced by Y elbow fitting

Test Stand

Expected Goals and Activities

- Design test stand
- Fabricate the test stand
- Design electronic thrust measurement circuit
- Test the rocket motor



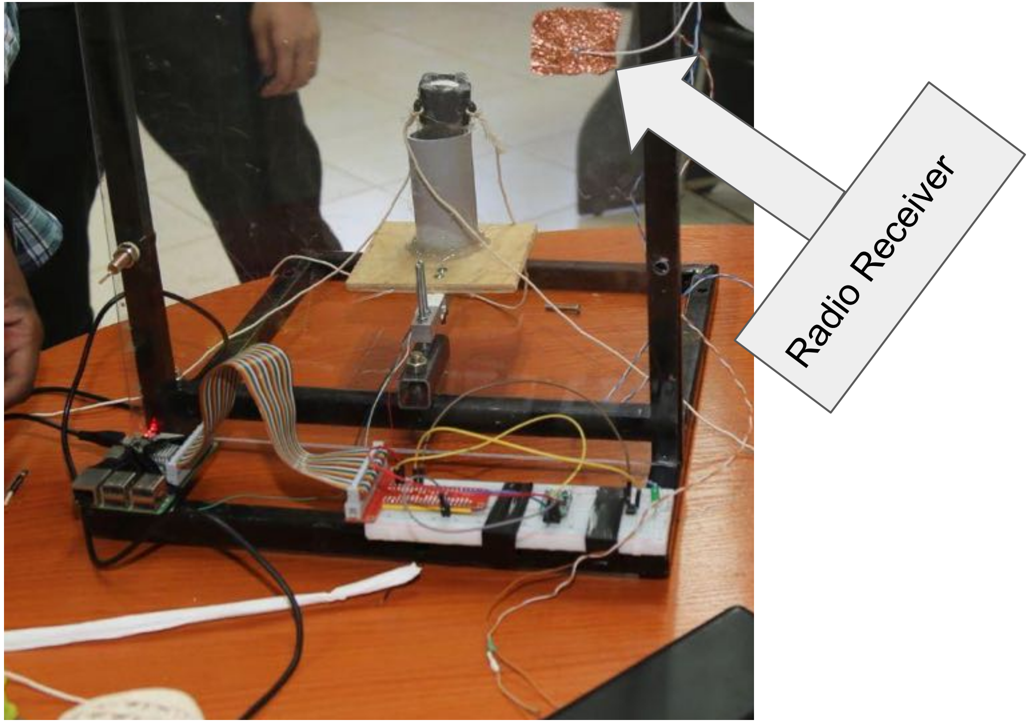
Test Stand Design and Fabrication

V1.1(not shielded; one load cell)

V1.2 (steel frame; remote ignition; acrylic shield)

V1.3 (4 load cells; metal caged; LED indicator; robust base plate;remote ignition)

Thrust Measurement Circuit



Static Fire Test Videos

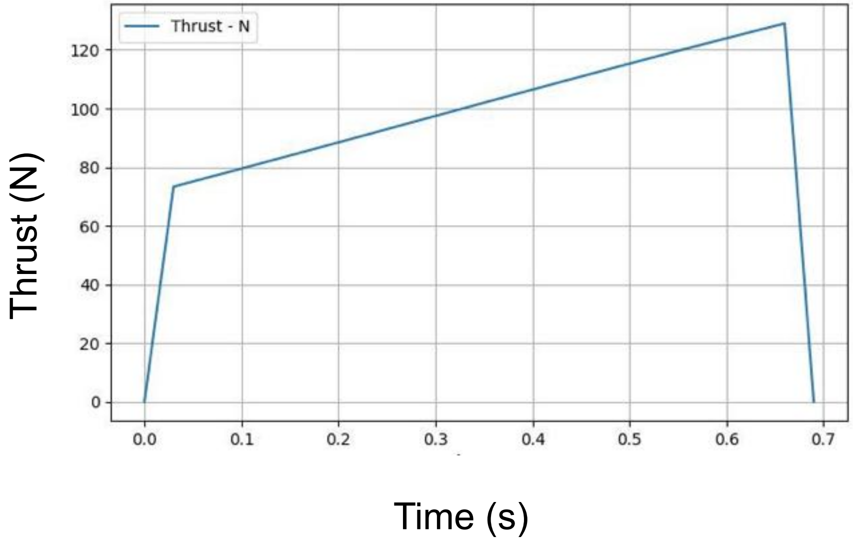
v1.1

v1.2

v1.3

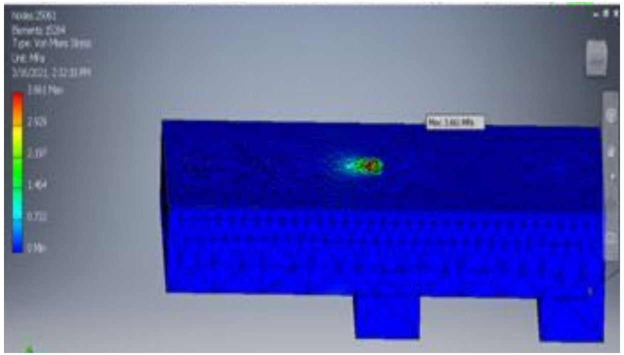
Achievements

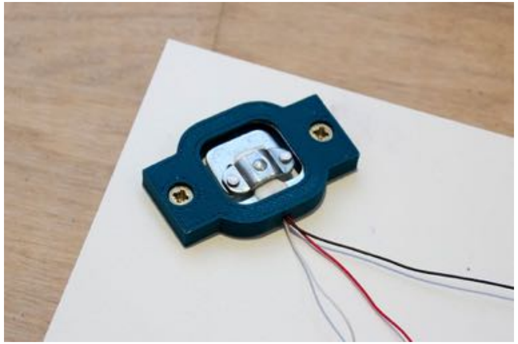
- Conducted 6 successful static fire tests.
- Obtained thrust curves.

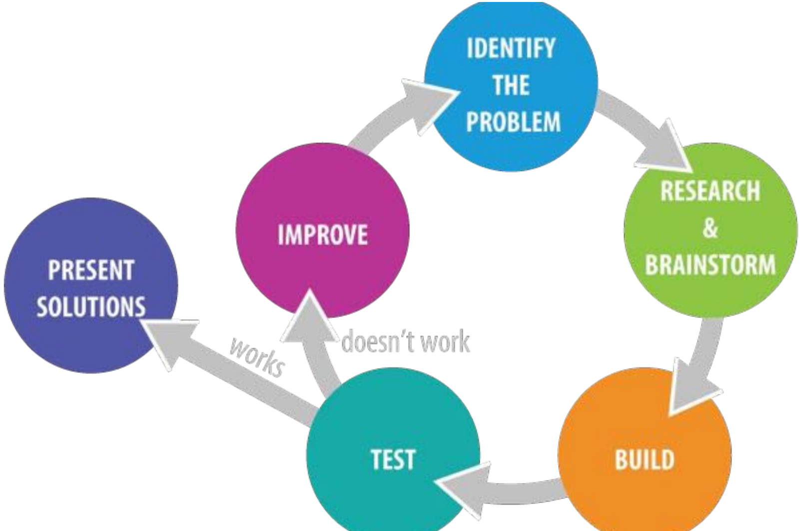


What was learnt

- Finite Element Analysis
- Additive Manufacturing
- Engineering design







PROPULSION

The Team

Goals

- Build a working solid propellant rocket motor for the N1 rocket

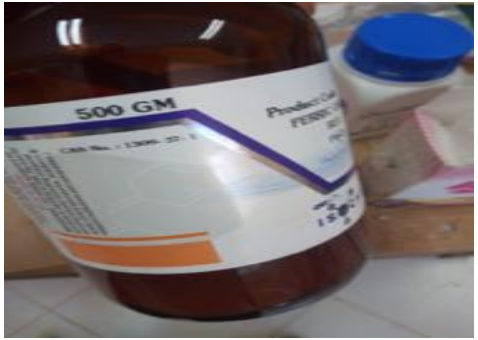
- Maintain safety as well as create safety guidelines for future development

Activities

1. Research on solid motor rockets
2. Design of motor and ignition system
3. Testing of propulsion systems
4. Integrating with the rest of the rocket
5. Launching

The Propellants

A propellant is a mixture of oxidizer and fuel that burns to produce thrust.
We settled on three propellants each using potassium nitrate as oxidizer:



Iron oxide(catalyst)

Potassium Nitrate

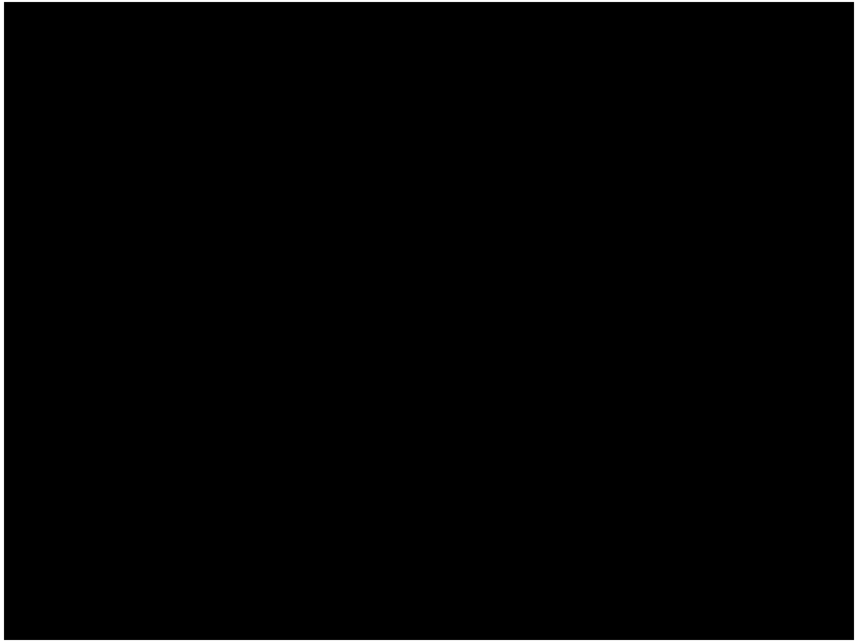
Sucrose

Grain

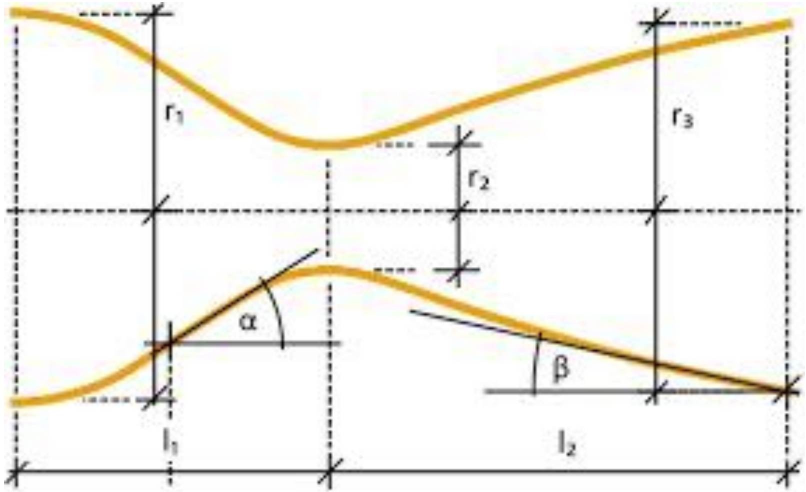
Casting

Procedure:

1. Measuring out KNO3 sugar and iron III oxide
2. Mixing
3. Grinding
4. Heating the pan
5. Adding the mixture
6. Stirring until fully molten
7. Pouring into mould
8. Coring to create a combustion chamber



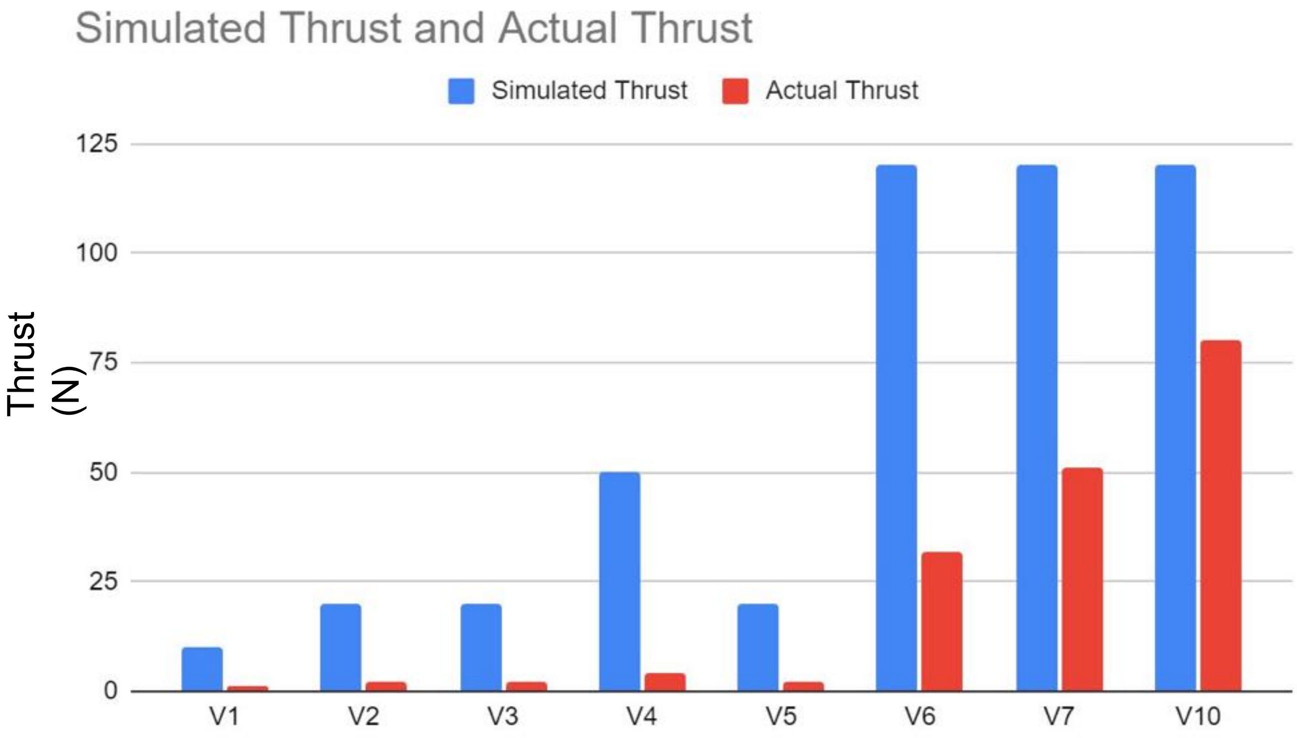
The Nozzle



Above is a typical de laval nozzle it has a converging and diverging side
Our first iteration used grout to make the nozzle

Nozzle made using hydraulic cement

V1 to V10



Simulated Thrust and Actual Thrust
Simulated Thrust
Actual Thrust
Thrust (N)
125
100
75
50
25
0
V1
V2
V3
V4
V5
V6
V7
V10

What was learnt

1. Additive manufacturing
2. Thermodynamic analysis
3. Material Analysis
4. Nozzle theory

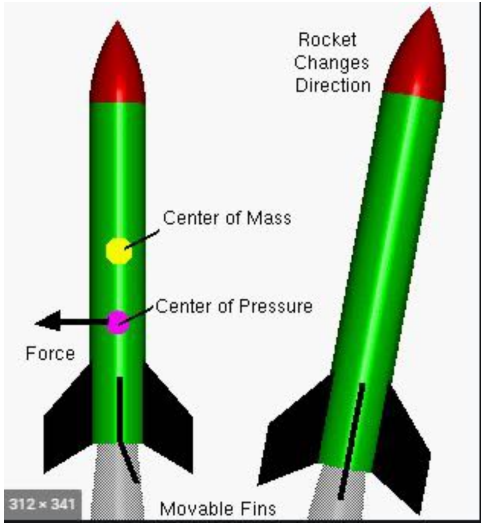
Challenges

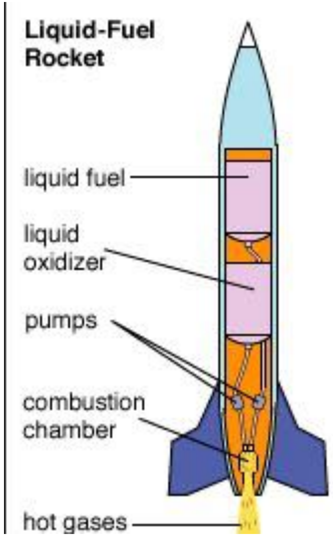
- A major challenge encountered was sourcing high strength pvc locally we had to order it to be manufactured.

Conclusion

Way forward

- Development and Launch of high powered N2 rocket with active control
- Design of N3 Liquid Propellant rocket
- Development of nano-satellite





Where to find us

https://nakujaproject.com/