NC STATE UNIVERSITY

NASA Student Launch

Aerospace Engineering Capstone Senior Design 2021-2022

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Course Instructor: Dr. Ewere | Section Instructor: Jacob Daye | Customer: NASA

Mission Performance Predictions

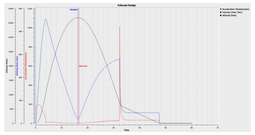
Apogee Prediction

3,920 ft

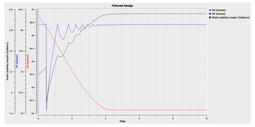
Key Performance Metrics

Thrust to Weight Ratio: 5.1
Speed at Rail Exit: 58 fps
Max velocity: 452 fps
Max acceleration: 198 m/s^2

The team uses RockSim, a launch simulation software to predict important launch metrics such as apogee, stability margin, thrust to weight ratio and more. The weight and design of the vehicle are modeled in RockSim as accurately as possible and adjusted when changes are made. The predictions are to ensure that the vehicle design meets NASA and team standards.



Altitude/Velocity/Acceleration Profile

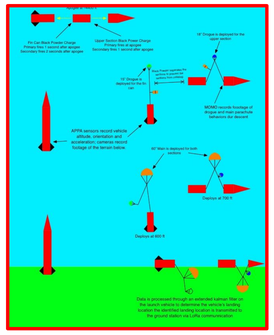


Stability/CG/CP to apogee

ConOps

The ConOps of the rocket consists of two phases. The launch and recovery of the rocket then the data processing.

The vehicle is launched to an apogee of around 4,000 ft. The recovery system separates the rocket using 4 redundant black powder charges to allow the parachutes to deploy.

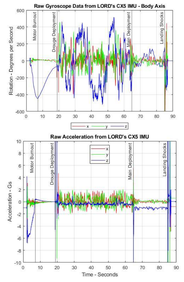


The payload system collects images and inertial data during flight. This data is processed once the system detects that the vehicle has landed.

The payload system transmits the landing location back to the ground station via LoRa.

VDF & PDF Flight Results

Payload Data



VDF and PDF stand for vehicle and payload demonstration flight. The team launched our VDF flight on February 19, 2022. The launch vehicle went to an apogee of 3,294 ft. The payload successfully gathered data from the IMU but was unable to get camera data. Additionally, the fin can main parachute did not deploy. Despite these issues, the launch vehicle was unharmed. The errors were corrected and the subsequent PDF flight was successful. Competition flight is scheduled for April 23rd.

PDF Takeoff

PDF Successful FC Main Deployment

Manufacturing

Launch Vehicle

The launch vehicle was cut from fiberglass tubing shown below. All wooden sections (bulkheads/fins) were epoxied and vacuum cured. Components like the nosecone and other hardware like screws were purchased from manufacturers

Bulkhead Layup

Body Tube Cutting

Payload

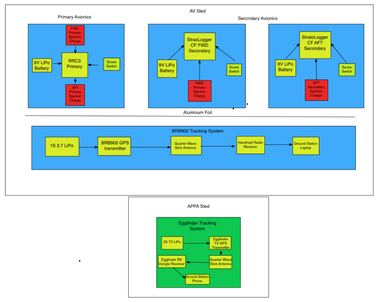
Payload structural components were 3D printed in PLA. These components were secured together or to the launch vehicle with epoxy.

Printing Camera Housings

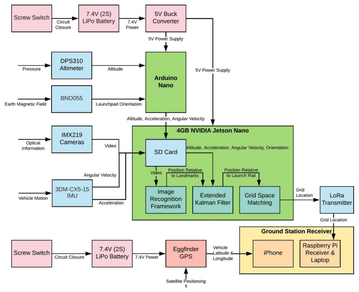
Epoxying APPA Sled

Functional Block Diagram

Launch Vehicle



Payload

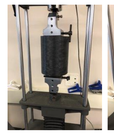


Testing

Launch Vehicle

Many tests were performed to ensure that the launch vehicle was ready for launch challenges including:

- GPS Test
- Altimeter Test
- Bulkhead Stress Test
- Fastener Shear Test



Bulkhead Stress

Fastener Shear

GPS

Payload

To ensure that APPA works as intended multiple tests were performed, these tests included

- APPA Battery Capacity Test
- APPA Data Collection Test
- APPA Sled Stress Test
- Image Processing Test
- APPA Radio Communication Test

APPA Sled Stress

Radio Range Test

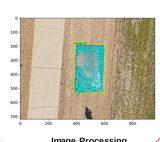
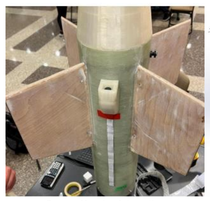


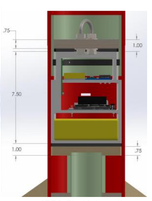
Image Processing

Payload Design

Payload Challenge: To identify the location of the launch vehicle without using GPS
Payload Method: Image recognition will be used throughout flight to calculate the launch vehicle's position. Once image recognition can no longer identify pick up landmarks, IMU data will be used to track the launch vehicle's fall and get its final location.



Camera Housing Integration



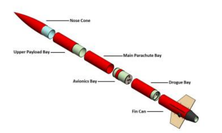
APPA Sled Integration

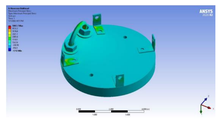
Two cameras are secured in camera housings on the side of the launch vehicle. Ribbon cables connect the cameras to a Nvidia Jetson Nano, which processes all data post-flight. The ribbon cables thread into the vehicle through ports and are protected by aluminum tape during flight.

The fin can houses the Aerial Photographing and Positioning Apparatus (APPA) sled. On the sled is the Jetson Nano, a DPS310 Altimeter, BNO055 IMU, Arduino Nano, Lord 3DM-CX5-15, LoRa transmitter, Eggfinder GPS (for recovery), and batteries. The sled is secured in the launch vehicle with Velcro.

CAD Models and Final Prototypes

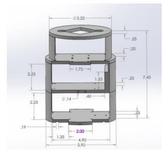
Launch Vehicle



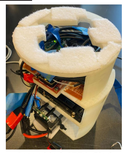


ANSYS Bulkhead Simulation

Payload



APPA Sled CAD Model



Assembled APPA Sled

Camera Housing Cover

Huntsville

The team traveled to Huntsville, Alabama on April 23rd and launched Catastrophe for the competition. Catastrophe was safely recovered and had a final apogee of 3353 feet. The team won "best looking rocket" for our paint design, 2nd place in payload design,1st place in social media and 2nd place in team spirt!

Catastrophe launching in Huntsville

Full Team on Launch Day!