Post-Flight Performance Report

Roaring Lions

Normandale Community College

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Executive Summary

On May 20th, 2018 at the Space Grant Midwest High-Power Rocket Competition, our rocket was successfully launched and recovered twice. An apogee was recorded on both the provided Altimeter Two and dual Stratologgers. Downward facing video of the second flight was recorded and shows a stable and reasonably vertical trajectory as well as the drogue and main chute deployments. The rocket was safely recovered after the first flight with only minor damage to the main chute and a failure of the SD card. The damage did not compromise the safety of the rocket and was launched again with a successful recovery. The roll mechanism was activated prematurely just before the second launch due to inefficiencies in the system electronics. During the two launches, the rocket reached an apogee of 3420 ft and 3406 ft respectively with an Aerotech J825R motor. Our predicted apogee was 3333 ft. During both flights the drogue parachute deployed at apogee and the main chute deployed at 700 ft as expected. An Xbee communication system was also integrated into the rocket for the second bonus challenge. This system was able to receive data from the rocket while in flight.

Rocket Operation Assessment

Flight Anomalies Analysis

During the first launch, our video recorder took a photo instead of footage during the launch. This was our means of visually measuring the effectiveness of our roll control system during flight. The lack of video during first launch was compounded by a lack of recorded sensor data when our main chute ejection charges, which were located just on the other side of the avionics bay bulkhead, activated and released a small, but notable amount of hot gas through the e-match wiring hole into the avionics bay during chute deployment. This event caused the data on our SD card data to become corrupted and lost.

During our second launch, we successfully recorded video, but our roll control system prematurely activated on the launchpad, timed out and went into standby before the motor ignited. We did not have a means of resetting it before launch, so a launch was made without a means of roll control. A second SD card was used to attempt data recording during the second launch, but the data recording card also appears to have been damaged during the first launch.

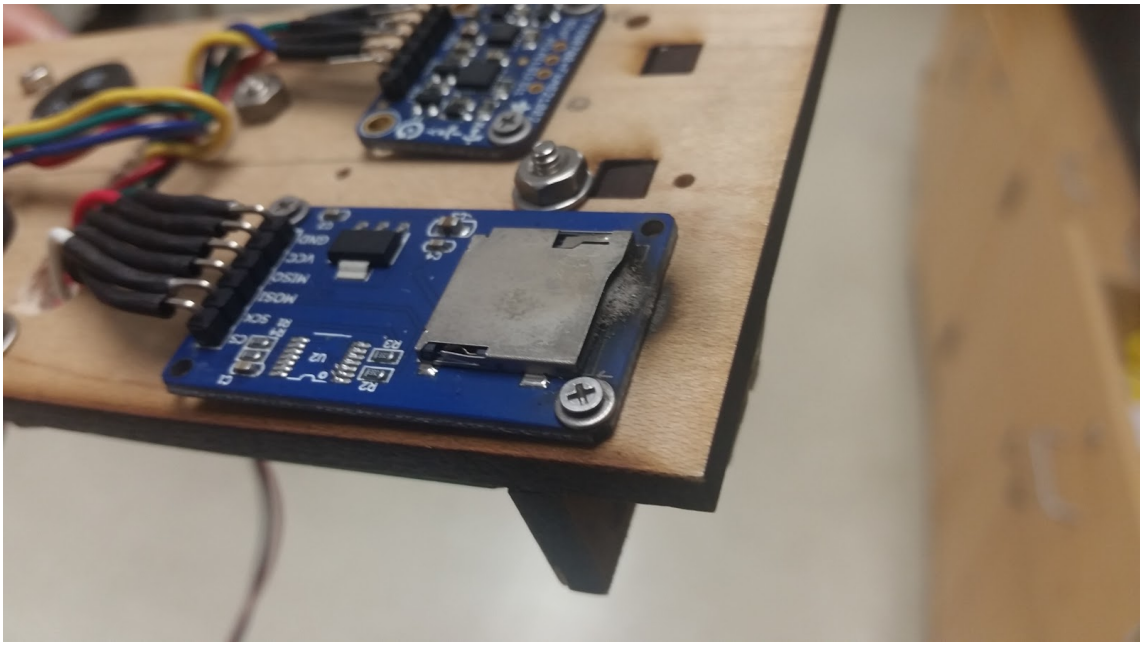

Figure 1 - Scorch marks on the top of the data recording card

Propulsion System Assessment

Propulsion data was recorded via the two Stratologgers as well as the Altimeter Two. The data matched closely to simulated and advertised values. OpenRocket simulated a burn time of 1.2 seconds with a max acceleration of 23.4 Gs and a max velocity of 648 ft/s (197.5 m/s). The

recorded max velocities for the two launches were 645 ft/s (196.6 m/s) and 646.8 ft/s (197.1 m/s).

Criterion	**Expected** (J825R)	**Launch #1**	**Launch #2**
Burn time (sec.)	1.2	1.3	1.3
Max. accel. (G)	23.4	21.6	22.9
Max. velocity (ft/s)	648	645	646.8

Table 1 - Motor expectations and performance

Flight Trajectory Assessment

Both launches had similar characteristics and propelled the rocket at a slight angle in the northeastward direction. The rocket continued to coast in this direction after the motor completed its burn phase. In the video from the second launch, the rocket rolls about seven times before reaching apogee. Once at apogee the drogue parachute deployed and the rocket began drifting southwest. The rocket continued to drift in the same direction after the main parachute was deployed. In both launches, the rocket eventually landed in the field in front of the spectating area just west of the launch pad.

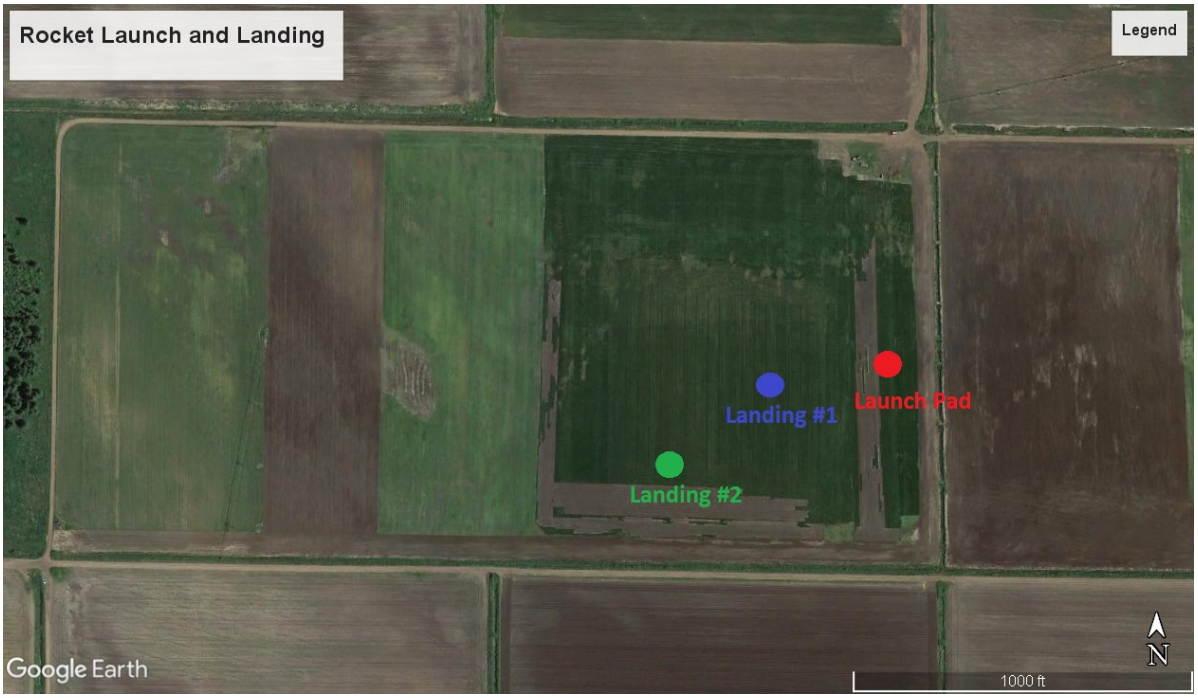

Figure 2 - Rocket launch and landing locations

In Flight Recovery Assessment

Throughout both flights, our recovery system operated flawlessly. Our dual stratologgers fired all charges starting with the drogue at apogee each flight. One Stratologger was set to fire the main chute charges at 700 ft and the other at 500 ft. This allowed for verification of Stratologger operability and redundancy. During both flights, the first charge fired at 700 ft and the main chute opened around two seconds later without the need for the second charge. All our recovery system operated as expected throughout the entire flight.

Ground Recovery Assessment

During the Competition launches the GRA (Ground Recovery Assessment) consisted of multi-step procedure. First, after the rocket successfully deployed the drogue and the main parachute, the team waited until the rocket would safely land on the ground. Second, the team walked over to the landing zone, ensuring to take the shortest path to the landing zone to minimize the damage to planted crops on the field. Third, once at the landing zone, one of the members proceeded to turn off both of the avionics switches. Fourth, all ejection charges were checked to confirm no live charges remained. Fifth, the recovery team took several pictures of the landing zone as well as the position/orientation of the rocket's fully deployed recovery system, while making sure to not touching anything. Once the pictures were taken of the landing zone, the team proceeded to taking individual pictures of each section of the rocket. The sixth step was to go through post flight checklist, marking off every step. Once finished, the rocket was picked up from the ground and was carried to the post flight check in table to record the previous achieved apogee.

Pre- & Post-Launch Procedure Assessment

Before the launch a procedure was created to ensure that the rocket was assembled properly and in a safe manner. The procedure covered the order in which the rocket should be put together and location of where each part goes. It was discovered on the launch pad that an accurate count of the pop rivets and shear pins needed to be listed. Some rivets were misplaced while others were not inserted to give better access to the stratologgers. These rivets were eventually inserted when the rocket was on the launch rail. Another problem that was encountered was the camera settings. Unknowingly, the camera was set to take pictures instead of recording video. This mistake was addressed in the procedure and was fixed on the second launch. A place for accurate measurements of the black powder charges was also added. The procedure is listed below.

Pre and Post-Launch Procedure

Pre-Flight Checklist

Avionics

- ❑ Visually inspect rocket
- ❑ Inspect all wiring and connections
- ❑ Test power supply
- ❑ Connect power supply to electronics
- ❑ Inspect altimeters
- ❑ Secure main parachute bay to avionics bay with bolts

Main Parachute

- ❑ Inspect main parachute (ensure there are no holes or tears)
- ❑ Inspect shock cord, eyebolts, and Nomex blankets
- ❑ Insert primary black powder charge with e-match and cover with tape
    - ❑ Charge mass:_____g
- ❑ Insert Secondary black powder charge with e-match and cover with tape
    - ❑ Charge mass:_____g
- ❑ Prepare and pack main parachute into main chute bay
    - ❑ Connect carabiners to closed eye bolts
- ❑ Secure nose cone to the main bay with the plastic shear pins
    - ❑ Number of shear pins:_____

Drogue Parachute

- ❑ Inspect drogue parachute (ensure there are no holes or tears)
- ❑ Inspect drogue shock cord, eyebolts, and Nomex blankets
- ❑ Insert black powder charge with e-match and cover with tape
    - ❑ Charge mass:_____g
- ❑ Prepare and pack drogue parachute into the drogue chute bay of the tail section
    - ❑ Connect carabiners to closed eye bolts
- ❑ Secure tail section to main body with plastic shear pins
    - ❑ Number of shear pins:_____

Motor

- ❑ Assemble motor
    - ❑ Type_____, Mass_____
- ❑ Insert motor into the rocket
- ❑ Ensure that it is secure

Final visualization

- ❑ Ensure there is no damage

- ❑ Ensure all section connections are secured with pop rivets
    - ❑ In order (nosecone, main chute bay, AV, roll bay, tail)
    - ❑ Number of rivets:_____
- ❑ Ensure motor is secure
- ❑ Ensure camera is on and secure
    - ❑ Ensure camera is in video mode (not picture mode)

Launchpad Checklist

Cameras

- ❑ Inspect camera and camera mount
- ❑ Turn on camera (listen for beeps and look for flashing light for confirmation)
    - ❑ Camera #1
- ❑ Securely mount cameras (ensure that they won't come loose)

Avionics

- ❑ Turn altimeter #1 on (listen for confirmation)
    - ❑ 3 beeps per 0.8 seconds
- ❑ Turn altimeter #2 on (listen for confirmation)
    - ❑ 2 beeps per 0.8 seconds

Motor

- ❑ Insert E-match
- ❑ Test for continuity

Launch

- ❑ Maintain visualization of rocket
- ❑ Take pictures

Post-Flight Checklist

- ❑ Locate Simba
- ❑ Take pictures of landing site and rocket
- ❑ Inspect rocket for damage
- ❑ Cover Pitot tube hole
- ❑ Turn off altimeters
    - ❑ Altimeter #1
    - ❑ Altimeter #2
- ❑ Remove camera from rocket
- ❑ Turn off camera
- ❑ Disconnect power supplies
- ❑ Retrieve flight data
- ❑ Record empty mass of motor

Actual vs Predicted Performance

Predicted performance

Below is the open rocket simulation data for our anticipated launch conditions:

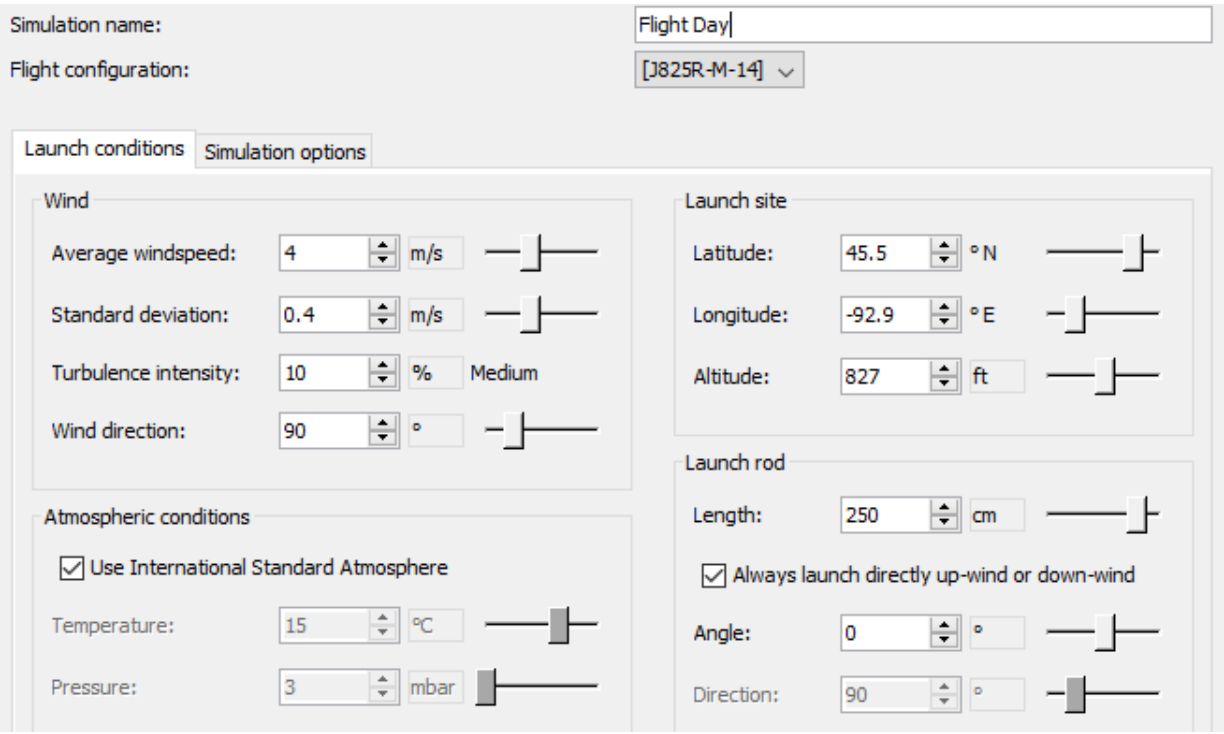

Figure 3 - Simulated conditions for launch

OpenRocket Predicted Launch Conditions

Configuration	J825R-M-14	Max. velocity	168 m/s
Velocity off rail	19.5 m/s	Max. acceleration	192 m/s^2
Apogee	3333 ft	Time to apogee	13.9 s
Velocity at depl...	21.3 m/s	Flight time	80.8 s
Optimum delay	12.5 s	Ground hit velocity	6.57 m/s

Table 2 - Expected launch simulations
OpenRocket Predicted Performance

Actual Performance

With the failure of the data logging system mentioned earlier, our Stratologgers were our primary means to measure flight performance.

Both of our flights were nearly identical in performance and recorded a peak velocity of approximately 645 ft/s 1.75 seconds after liftoff. Our coast period lasted 11.85 seconds and our two flights achieved an apogee of 3420 ft and 3406 ft. The drogue chute was deployed and the rocket descended at an average 48 ft/s to 700 ft where the main chute was deployed. Following main chute deployment, average descent speed decreased to 12 ft/s until landing shortly thereafter.

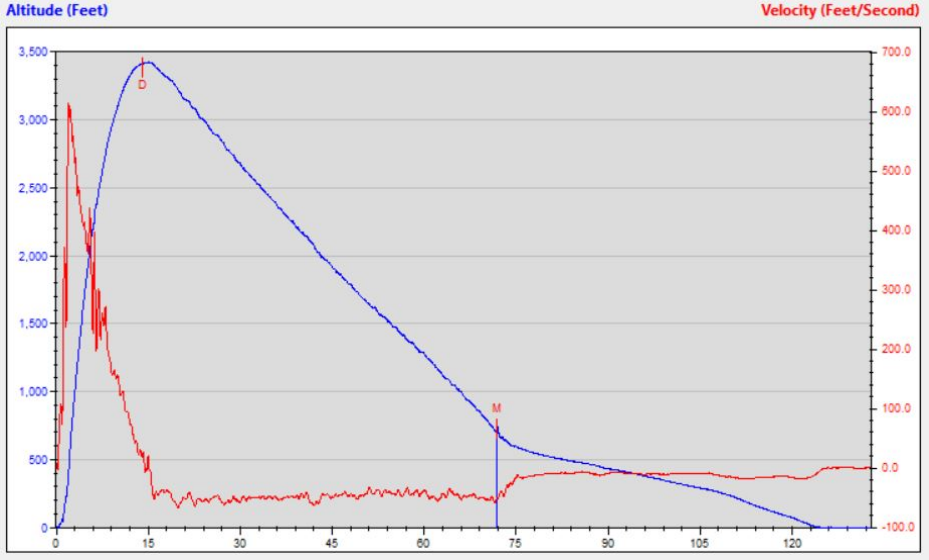

Figure 4 - Stratologger data plot of launch #1

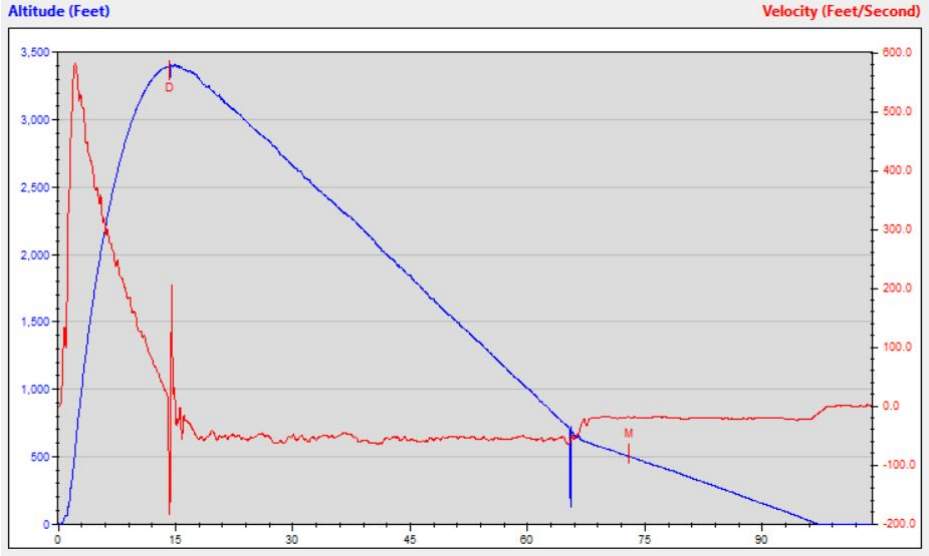

Figure 5 - Stratologger data plot of launch #2

Active Roll/Orientation System Data Collection and Analysis

Roll/Orientation Monitoring Data

The rocket was fitted with one FireFly Q60 video camera which was housed in a 3D printed unit attached to the main parachute bay. The camera was oriented to face downward so the roll system and drogue deployment could be easily monitored. On the first launch, the camera was set to take pictures instead of recording video. One picture was taken of the rocket sitting on the launch pad. This mistake was corrected before the second launch and changes to the procedure were implemented. During the second launch the camera was monitoring the three LED lights mounted below the avionics bay. In the video the lights were difficult to see and no real data could be collected from them. Images taken from the second launch are posted below.

The Arduino acted as secondary device to monitor the active roll mechanism which then logged data on an SD card. Due to a small opening in the forward bulkhead, hot gases were able to seep into the avionics bay. This corrupted the SD card and no data could be retrieved. The second launch also failed to log any usable data other than a small amount of XBee data.

Video Images and Links to Posted Flight Videos

Launch

Drogue Deployment

Main Deployment

Landing

Onboard video link:

https://www.youtube.com/watch?v=x_TdXWpuWb0&feature=youtu.be

XBee Bonus Challenge

The second bonus challenge to wirelessly transmit information was attempted. Only time, “T,” and orientation, “Deg,” every 2.5 seconds were chosen for communication preceded with security code “NC”.

An attempt was made to receive data on the first launch, but no usable data was received. Prior to the second launch, the XBee communication was established and began recording data. The data shows the orientation of the rocket on the launchpad facing south at approximately 180° in the moments before launch. Following launch, data was received much less consistently with only three data points following launch. This may be due to the limitation in the XBee’s antenna capabilities.

Data received via XBees:

NC T: 319.90 Deg: 180.31
NC T: 322.49 Deg: 181.29
NC T: 325.08 Deg: 180.77
NC T: 327.67 Deg: 181.20
NC T: 330.26 Deg: 181.31
NC T: 332.85 Deg: 181.04
NC T: 335.43 Deg: 181.35
NC T: 338.02 Deg: 182.08
NC T: 340.61 Deg: 183.47
NC T: 343.21 Deg: 182.98
NC T: 346.13 Deg: 181.90
NC T: 349.04 Deg: 180.83
NC T: 414.40 Deg: 203.25 <- Launch
NC T: 516.34 Deg: 220.77
NC T: 820.18 Deg: 230.73

Table 3 - XBee data received
NC - Security code, T - time (seconds) , Deg - Cardinal orientation of camera

While the data received was limited, it shows that orientation changed and rotation was achieved after launch.

Sponsors

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