1 Summary

1.1 Team Summary

Team name: Knights Experimental Rocketry

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Certification Level: 3

Hours Spend: 33 hours

Social Media:

Instagram @ucf_rocketry

Twitter: @KnightsRocketry

YouTube: Knights Experimental Rocketry

1.2 Purpose of Flight

The purpose of this flight was to fulfill the requirements of the payload demonstration flight and the vehicle demonstration re-flight.

1.3 Flight Summary Information

Date of Flight: 3/18/2023

Location of flight: Palm Bay Florida with Spaceport Rocketry Association

Launch conditions: 14mph winds with clouds at 16,000 feet

Motor flower (brand and designation): K1000T

Ballast flown (lbs.): 0

Air brake system status during test flight: N/A

Official target altitude (ft.): 5507

Predicted altitude from simulation (ft.): 4044ft

Measured Altitude: 4088ft

Identify any off-nominal events during mission execution: Everything performed as intended. Only off-nominal events we had was upon landing when we landed in a canal filled with water and we couldn't

1.4 Changes made since FRR

1.4.1 Changes to Vehicle design

Explain changes and why they were necessary.

The changes that we made to the vehicle after our vehicle demonstration flight was that we cut the end off of the motor tube and installed an aeropack retainer to properly retain our motor during flight. During ground testing we had the motor get kicked out the end of our rocket because we were using a 3D printed retainer because of our tailcone. We had to take an inch off from our upper body tube because after our rocket hit the ground at 150 ft/sec we had a little bit of delamination of the carbon fiber, so we decided to cut an inch off. When the rocket hit the ground at 150 ft/sec roughly our steel bolts holding the shoulder to the nose cone tour through the nose cone so we had to make an identical one.

1.4.2 Changes to Payload design

The primary experiments design has been fleshed out and will remain largely the same. The only change that will be implemented is a magnet located on the outer casing's hatch to ensure black powder does not seep into the inner sled during flight. The aforementioned Nomex Blanket (see FRR) will still be located on the experiment.

The secondary experiment, the Run Cam Split, will now have to be lost. Due to events of the vehicle demonstration flight, the camera is no longer operable and the required parts are not currently available in time. As the secondary experiment was not mission critical and only served as promo material, we've decided to abandon it.

2 Payload Demonstration Flight Results (If applicable)

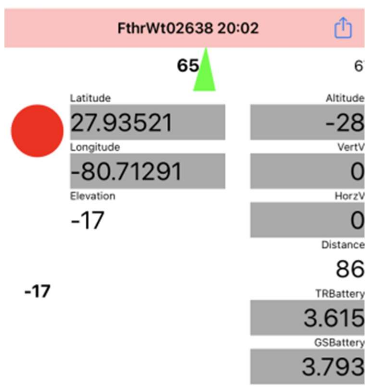
2.1 Payload Mission Sequence

The payload mission sequence was largely executed properly. Data was being received during flight in regards to the primary GPS and other avionics. Subsequnetly, the Payload deployed as expected during main deployment. Upon landing the, Payload was expected to land parallel to the horizon, begin it's command sequence and initiate all the possible commands described in the handbook.

However, whilst testing corroborated our capacity to do this, the rocket's unfortunate landing in a canal prevented us from observing these results directly after flight.

Main (Top Left) Drogue (Bottom Right) Payload (Submerged)

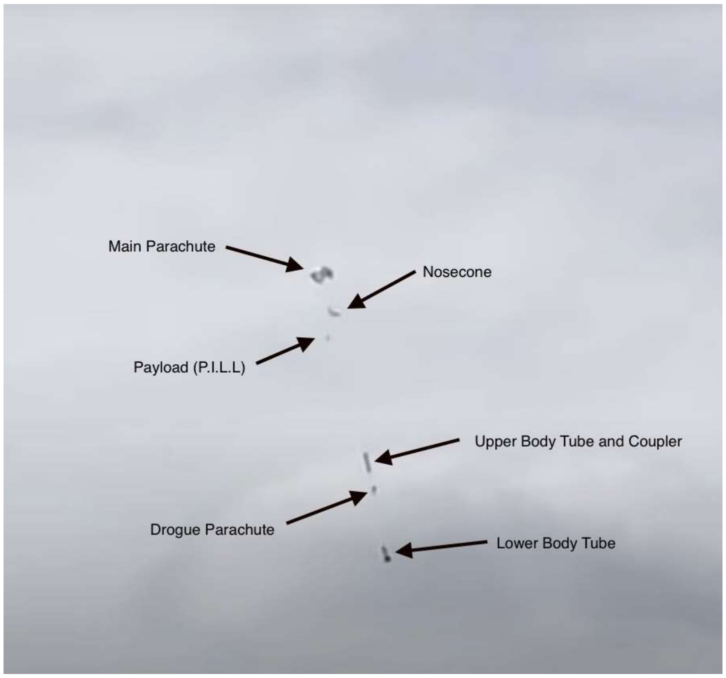
Coordinates as well as videos are able to corroborate this fact.



Coordinates of Asclepius at 3:53pm, 3/18

2.2 Payload Retention System

The payload retention system functioned as expected. The payload did not come out until the main parachute deployed and as can be in seen in videos, was retained as planned.



Asclepius descending under Main Parachute

Payload Deployment at Main Ejection

From the limited data we were able to salvage, we can say with confidence that our descent velocities were safe and were it for not the landing in water, the Experiment would of most definitely been unharmed. In fact, besides the electronics, the physical components of the Payload were undamaged – besides dirt from the canal staining the outer casing.

Payload After Launch

Overall, when it comes to the terms of payload retention, we do believe we've successfully met the criteria outlined in the hand book. Most importantly, the design is safe as we were able to successfully and consistently deploy our main parachute this time and our no subject to the events of our previous vehicle demonstration flight, which matters more than the efficacy of our payload.2.3 Altimeter Flight Profile Data

2.3.1 StrattoLogger CF and RRC2+

The altimeter flight data recovered is minimal but present. Despite trying to clean our electronics in alcohol, we were unable to salvage any avionics components. We do have recordings of the FeatherWeight GPS reading out certain values during flight and the RRC2+ oddly enough beeping its altitude before permanently dying.

RRC2+ Altitude Reading.MOV

RRC2+ Altitude Reading

Commented [NS1]: this shit dont work

Although we exclaimed 4188ft in the video, it is important to note that we mistook the inputs for the StrattoLogger CF at first. However, we then realized upon further inspection, the prolonged "beep" representing 0 is indicative of the RRC2+. That being said, our actual apogee was 4088ft.

2.3.2 FeatherWeight

The FeatherWeight was also caught on video announcing certain data points, whilst admittedly far more inaccurate then any of our other avionics, it is one of the few limited pieces of information we have available to us so we will incorporate it into this addendum. From this we were able to get an apogee of 4200ft, which is typical as the featherweight tends to be off, and a descent velocity of about 97ft/s **before** main deployment. Sadly, we were not able to verify the descent velocity after main deployment. However, our simulations compound the 97ft/s descent velocity using the 3ft X-form parachutes and an impact velocity of about 21ft/s with the main in addition to this. Flight data from the FeatherWeight in the video can be heard here – although admittedly hard to here amongst the noise.

Commented [EP2]: Nate do you have the feather weight readings video

FeatherWeight Flight Data.mov

FeatherWeight Flight Data Reading

2.4 Functional Systems

The most important fact as the recovery avionics worked as intended and subsequently the retention of the payload itself. The telemetry was able to be verified as said equipment was lost and secondary ground station was not available at the time. The primary payload is also believed to be functional as we had tested it before, but it cannot be truly verified due to the nature of our landing. Frankly, its very hard to definitively say what failed and what didn't. The only components we can argue truly worked is the recovery units which is certainly the most important, but leaves more room for testing of the telemetry and primary payload components upon rebuilding.

2.5 Software or Hardware failures

2.5.1 Software

One software failure that will be remediated is the payload deployment detector. The current software used a timer based on OpenRocket Calculations before allowing itself to receive RAFCO commands. The issue is that different wind speeds and other extraneous conditions can change the time from launch to ground hit. In order to remediate this issue, we will be programming our IMU to detect ground hit. There are two approaches. A Kalmann filter, similar to what is being used in our live telemetry system; detecting prolonged zero acceleration after a massive spike in vertical acceleration. The Kalman filter is much more difficult and frankly unnecessary, so we will be utilizing the second idea to make sure there are no accidental RAFCO sequences commenced as defined by requirement 4.3.3.3.

2.5.2 Hardware

Hardware functioned as expected, however the zipties we used on the hatch to hold it in came off. The hatch was luckily not lost and can be reused, but we intend to use a piece of nylon shock cord to replace the zip ties as it's generally more reliable. All other hardware functioned as expected.

2.6 Hardware Damage

On the electronics side we have lost quite a bit of hardware due to the water damage. The list is as follows.

Parts Lost

- *FeatherWeight GPS Tracker*
- *RRC2+*
- *StrattoLogger CF*
- *Raspberry Pi Model 4B 4gb*
- *Smarza Pi Cam*
- *Pi Battery Hat*
- *2x 18650 LiPos*
- *BNO055*
- *3.7V FeatherWeight LiPo*
- *Male to Female USB adapter*

However, while this was a major setback and disappointment to the team. Management immediately began running through procurement procedures. We have immediately filed a bill with student government and requested more funds to finalize purchases. Everything that was lost has been ordered and has arrived or is currently on the way. We've begun immediately looking for sponsors and are optimistic about being reimbursed for the payments we've now put into remediate this issue. We've taken every measure within our means to acquire all the necessary parts and begin working on rebuilding Asclepius and our payload.

2.8 Payload Lessons

We've learned that our retention system is not functional which is extremely important but are unable to acquire much information regarding the telemetry and experiments systems.

Frankly, the main lesson we've learned is to be ready for any contingency. The 20-foot canal in our 2200ft possible drift radius is not something any of us anticipated. And while it was high unlikely for us to land there, we just so happened to. Had we planned for the truly worst case scenario such as this, we would not be scrambling for sponsors or parts to meet our deadline.

Frankly, we don't see UCF's NSL team ever being this unprepared in the future. As our groups first-year on such a project, such lessons are welcome and said lessons will translate over to the next year.

3 Vehicle Demonstration Re-Flight (If applicable)

3.1 Systems Functions

The rocket as a system performed as intended and there were no issues pertaining to the vehicle. The only issue from a vehicle perspective that occurred was when we landed in the canal our two altimeters and GPS stopped working. The RRC2+ was still beeping out the altitude after the flight but as soon as we powered it off, we could not get it to turn back on. The drogue and main parachutes deployed normally and on time from what we can tell, we have no flight graphs to prove they happened on time but listening to our featherweight GPS during the launch was calling out normal values that we would expect with the different stages of flight. The motor was retained properly and was not ejected out of the airframe. When we pulled the rocket out of the canal everything was still attached to the shock cords. There was no damage to any structural parts of the rocket, only the electronics. Our apogee is under our stated apogee from PDR due to the fact of the roughness of the airframe and not being sanded smooth.

3.2 Hardware or Software Failures

There were no hardware or software failures that occurred during this flight.

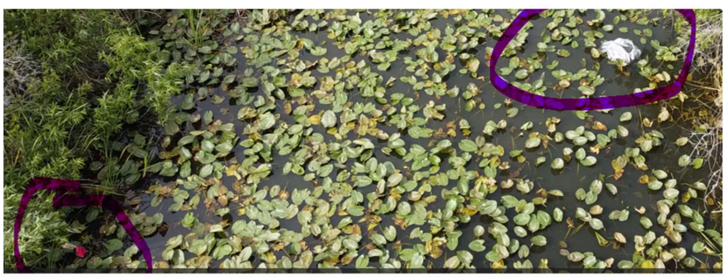
3.3 Payload Simulation (if applicable)

We used our actual payload for this flight since we were re-flying with our vehicle demonstration flight and we still needed our payload demonstration flight.

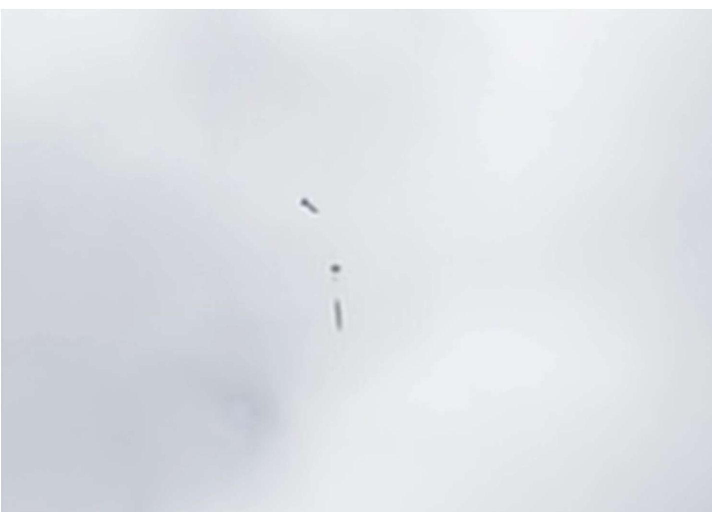
3.4 Altimeter Flight Profile Graph(s)

We do not have any flight data due to the fact of landing in water which destroyed all our electronics. But we can confidently say we are confident in our OpenRocket results due to only being off of our predicted apogee by 44 feet.

3.5 Quality Pictures




KXR

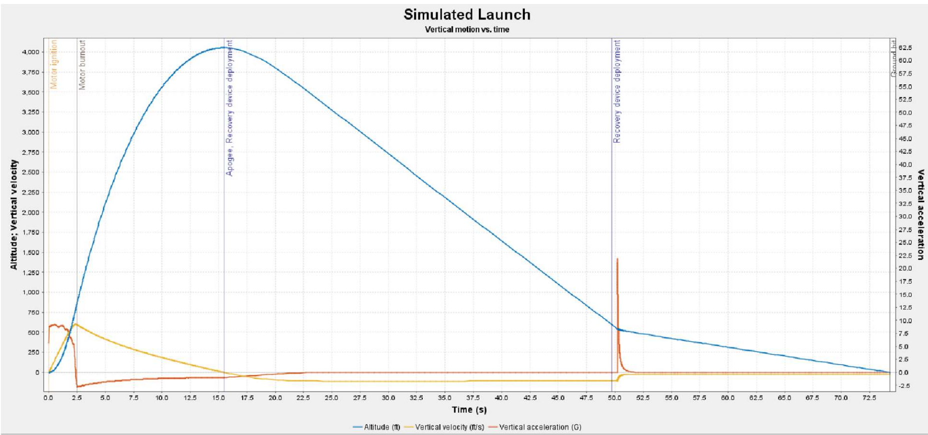


3.6 Kinetic Energy Calculations

While we do not have any way to calculate our kinetic energy upon impact due the loss of flight data, we may still use our subscale flight as a point of reference. Taking a look at our subscale flight, our ground hit velocity was 18 ft/sec, well under our OpenRocket simulation's prediction of 21 ft/sec. Keeping this precedent, we can safely assume, due to the accuracy of our OpenRocket simulations, the ground hit velocity of 22 ft/s must be an overestimate with a generous clearance; thus, the maximum ground hit velocity that we can experience before we break the kinetic energy limit is 25.12 ft/sec.

3.7 Vehicle Demonstration Flight Analysis

Perform an analysis of the vehicle demonstration flight. Update your stimulated flight model with launch day condition data and compare the predicted flight performance to the actual flight data. Discuss the results.



Above is the simulation ran on launch day to predict what our apogee was going to be given the current conditions. The simulation said our apogee was going to be 4044 feet. Our actual apogee ended up being 4088 feet based off of the RRC2+ flight computer. Sadly we have no way of getting any of the flight graphs off of the altimeters due to them being submerged in the water for over 45 minutes while we searched through dense bushes in order to find the rocket. We used our featherweight to give us the general location since we had the last known location of the rocket before it died, it led us close to the actual location, but we had to use a drone in order to find the rocket due to the bushes being to thick the side of the canal we were at the time. While the rocket was under drogue we heard descent velocity callouts from the featherweight and the descents ranged anywhere from 75 ft/sec to a maximum of 97 ft/sec. The descent velocity that OpenRocket gave us under drogue was 106 ft/sec. All though we do not have our descent velocity under our main parachute, OpenRocket said the ground hit velocity is at 22 ft/sec and we are confident that the true ground hit will be around 22 ft/sec due to how closely the data we were able to get matched up with the OpenRocket simulation.

3.8 Estimated Drag Coefficient

When are unable to estimate our drag coefficient due to not having any flight data. The only data we have is the altitude, but we don't know how long it took to get to the apogee.

3.9 Hardware Damage

There was no damage to any hardware during our re-flight.

3.10 Lessons Learned

The lessons we have learned from this flight was how to better communicate as a team while preparing the rocket for flight. Between our first vehicle demonstration flight and then our payload demonstration flight we have done serval dress rehearsals as a team so when can better understand where our issues lie when assembling the rocket and where we can improve on.