Pioneer Rocketry

2018 WSGC Collegiate Rocketry Competition

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Abstract:
The Wisconsin Space Grant Consortium hosts the Collegiate Rocket Launch Competition every year. The goal of the competition this year was to design and build a rocket to fly to 3000 ft and take a 360° photo upon landing. The rocket, Focal Point, used a single external camera that would rotate to achieve a panoramic video. After recovery, the video was stitched into a panoramic photo. Despite several unforeseen challenges on the day of the launch, Focal Point achieved three flights. In order to reduce weight and achieve an altitude closer to the goal of 3000 ft, six inches of body tube was removed for the final flight. This drastically improved our flight performance. Pioneer Rocketry is very proud to be able to win third place in this competition.

Rocket Operation Assessment:

Propulsion system specifications: The Aerotech J350 White Lightning was selected as the motor for this competition because it was one of the highest impulse motors allowed that provides a consistent flight profile. We decided not to use the highest impulse motor, the J500, which seemed to be the most popular motor at this year’s competition. This was because of some inconsistencies in the motor burn from the previous year's competition where there was a loud bang right at burnout which was caused by parts of the motor coming loose at the end of the burn and plugging the nozzle.

Flight trajectory assessment: Focal Point flew nominally on all three flights. There was a slight amount of weathercocking off the rail on each flight. This can be attributed to the large margin of stability our rocket had which was around five calibers. The amount of weathercocking was likely reduced due to the high thrust off the pad which was twice the off the rail velocity which was required at 90 ft/s. The second flight had the worst weathercocking due to the camera turning sideways during ascent.

Figure 1: Focal Point's first launch of the Competition

Figure 2: Focal Point during its second launch. The sideways camera pod can be seen.

Recovery System Assessment: Since our payload took up the entire forward section of Focal Point, we implemented a single deploy, dual event recovery scheme. This included a 24 in drogue parachute that came out at apogee with a 42 in main parachute restricted with a Chute Release until 600 ft. This allowed the rocket to descend reasonably fast at 60 ft/s for shorter recovery time, yet have a slow landing speed at 18 ft/s. This worked really well, as after the first and last flight the rocket landed less than 100 ft away and 500 ft away respectively. There were two anomalies in the performance of the recovery system. The first anomaly occurred on the first flight where the main parachute was accidentally deployed at apogee. We believe this was caused by an old rubber band that broke on the Chute Release. Despite this the rocket was recovered safely. The only other anomaly in the recovery system occurred during the final flight when the shock cord connecting the two halves of the rocket became tangled. This did not affect descent rate but caused the nose cone and the fins to collide many times. There was no structural damage, but the rocket came down in such a way that caused the upper half with the payload section attached to be impaled into the soft ground, so the rocket did not lie flat as planned.

Ground Recovery Assessment: Focal Point was successfully recovered after each of its three flights. This can partially be attributed to the EggFinder GPS that was in the nose cone. The GPS was not necessarily needed, as the rocket was in the field of view when landing on two of the flights. The GPS was still nice to have because it gave us the peace of mind that we will be able to know exactly where the rocket landed and the general direction that we need to walk to find out rocket.

Figure 3: Recovery after Focal Point's first flight. The camera is not attached to the mount.

Figure 4: Successful recovery after third flight.

Pre and Post Launch Procedure Assessment: All three of our launches were completely successful with a few non-critical anomalies. Our team was able to accomplish this safely due to the implementation of pre-flight checklists that were developed and streamlined over our test launches. One anomaly that was not accounted for was having a dead battery in our camera. When the camera broke out of its 3D printed mount during the first flight, due to the force of the separation charge, it had fell to the ground from 2200 ft. We found the camera after about an hour of searching and was still recording when it was recovered. We did not realize the camera's limited battery life, so we didn't think that we needed to charge it, causing it to die while on the launch pad before the second flight. This caused us to not get any video data from any part of the flight. In the future, we will incorporate battery checks on all devices in between flights.

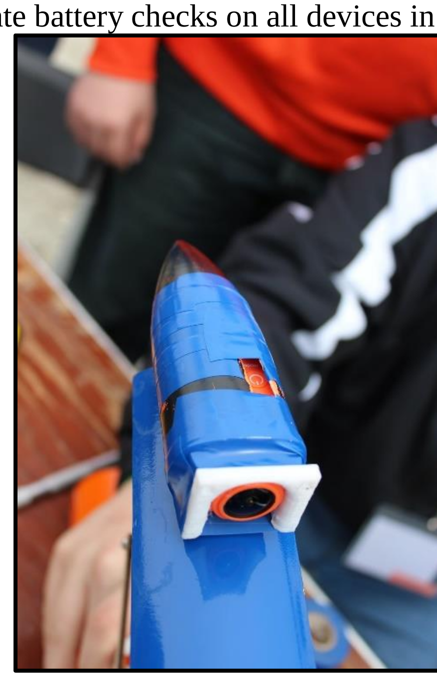

Figure 5: Improvised covering for the camera after the first flight

Discussion of Results:

Table of flight characteristics:

Stratologger Data			
Flight 1	Max altitude (ft)	Max velocity (Mach)	Max acceleration (G)
J350	2249	0.67	10.8
Flight 2	Max altitude (ft)	Max velocity (Mach)	Max acceleration (G)
J350	2107	0.61	11.3
Flight 3	Max altitude (ft)	Max velocity (Mach)	Max acceleration (G)
J350	2506	0.65	13.4
Openrocket			
Motor	Max altitude (ft)	Max velocity (Mach)	Max acceleration (G)
J350	3031	0.69	16.6

Table 1: Table of flight characteristics

Altimeter data analysis: We modeled Focal Point in OpenRocket and ran simulations to predict its flight performance. During the construction process we continually updated the model to accurately reflect the masses of all included components. The simulation predicted an altitude of 3031 ft However, the altitudes of each of the three flights were 2249 ft, 2107 ft, and 2506 ft respectively. We believe that the large decrease in altitude was because of the externally mounted camera. OpenRocket cannot account for camera pods and we didn't think that it would have such a large effect on altitude. We discovered this issue after the first flight. We tried to fix this by installing a makeshift “fairing” over top the camera to improve aerodynamics. Unfortunately, the camera was able to rotate during the second flight due to the way it was mounted to take the 360° photo. During the second flight the camera pod turned sideways causing a huge increase in drag and decreasing our altitude. On the last flight the camera pod was rotated 180° so that the camera was pointing up to prevent it from rotating. We also made one other major modification to the rocket. To reduce weight and a small amount of drag, six inches of body tube was cut off the bottom section. These modifications resulted in our most successful flight with our altitude of 2506 ft.

Flight 1 altitude profile:

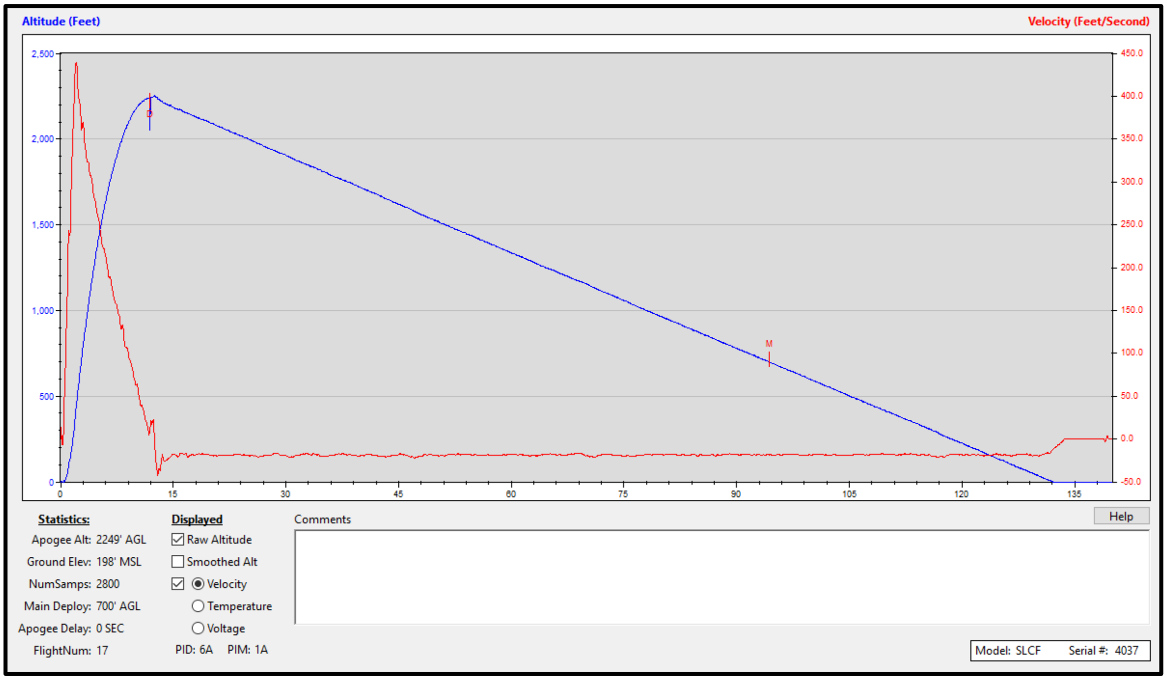

Figure 6: The Stratologger graph of the first competition flight of Focal point. This shows the anomaly of the constant descent rate indicating main parachute deployment at apogee.

Flight 2 altitude profile:

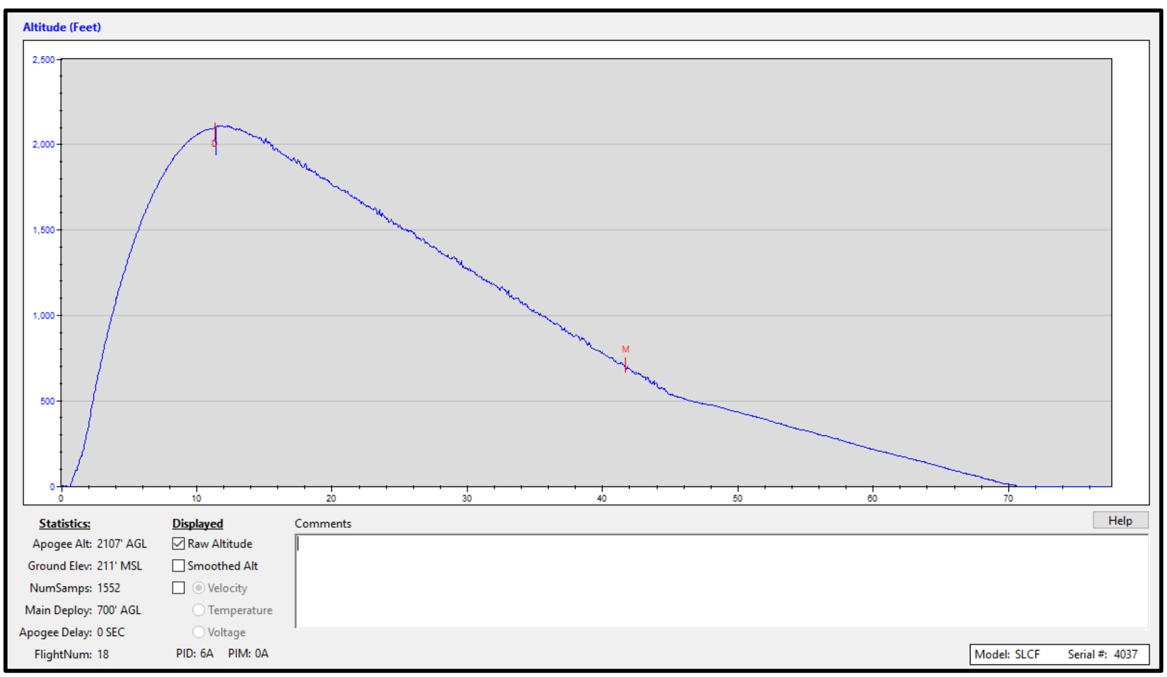

Figure 7: Stratologger graph of the second competition flight. This was the lowest altitude of all the flights due to the camera turning sideways mid-flight, even though the effects of when the camera turned cannot directly be seen on the graph

Flight 3 altitude profile:

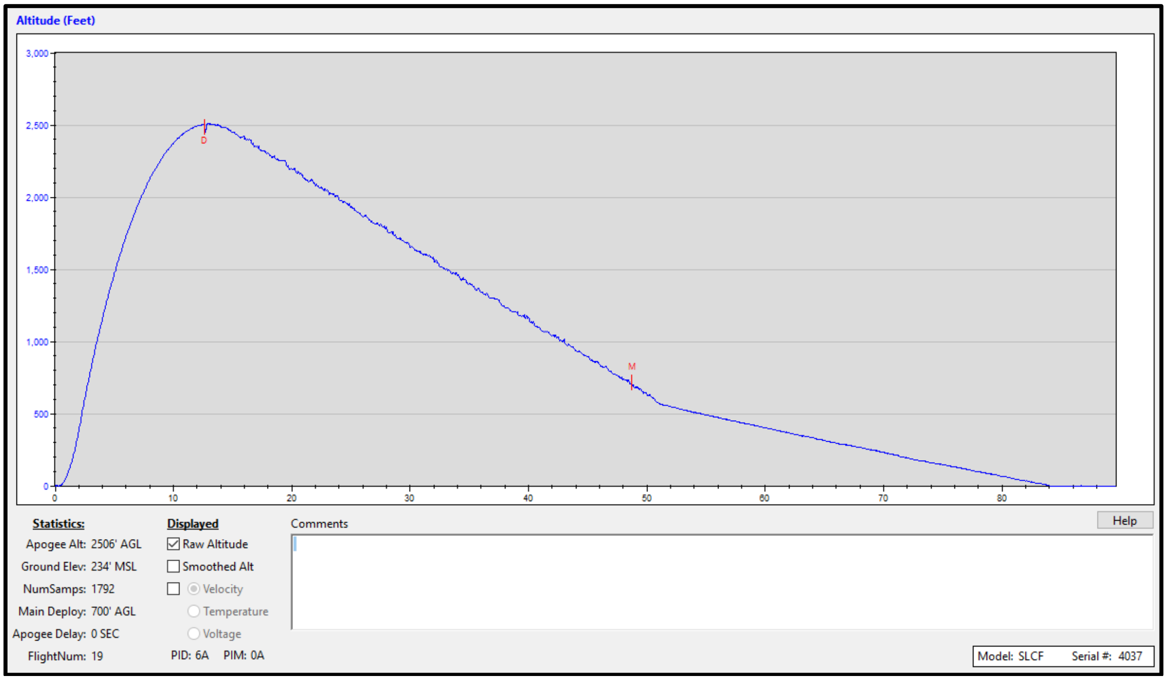

Figure 8: Stratologger data from the third competition flight. This flight had a tangled shock cord when main parachute deployed but it had no effect on decent rate.

Panoramic photo capture system: Overall, the design of the panoramic photo capture system was a success. On all three landings the spring-loaded scissor lift extended, allowing for the ability to capture a panoramic video. Although the deployment system worked, issues with the camera malfunctioning or the landing of the rocket prevented the full panorama from being captured. On the first flight, the camera mount had broken which caused the camera to fall off the rocket at 2200 ft. After the camera was found, the battery did not have much charge left and had died before it was able to record any useful video on the second flight. On the third launch, the precarious way the rocket had landed prevented the stepper motor, which rotates the camera, from making a full rotation. This caused the camera to capture only a 220° panoramic video. After the launch, the video from the camera was stitched together in photoshop to create a panoramic photo.

Figure 9: Panoramic photo captured after the third flight.

CRL 2018 3rd flight video	https://youtu.be/EArGJo6HNgA

Table 2: Video links for the 3rd flight which shows the nose cone and fins colliding during descent as well as the landing orientation of the rocket

Conclusion:

The CRL team was very pleased that we were able to fly our rocket three times at the competition. After losing the camera on the first flight, we were not optimistic that we would have been able to achieve three flights. With many members of the CRL team, as well as general members of Pioneer Rocketry, we were able to find the small camera in an hour, which fell from over 2000 ft. With the relief of finding the camera, we worked efficiently to have two more flights with the last being the best. Although each flight had anomalies, we will learn from these and continue to improve as an organization.

We are thankful to have the opportunity to participate in this competition year after year. The new members that have participated this year are eager to see what next year has in store for us. Every year, our team gains new knowledge about rockets and we have a blast working together. We are thrilled to have this opportunity to share our enthusiasm for aerospace with the world.

Acknowledgements

Katie Rabidoux, Advisor
Jane Dickler, High Power Mentor
Wisconsin Space Grant Consortium
University of Wisconsin - Platteville
UW-Platteville Pioneer Farms
Packaging Corporation of America
Midwest Prototyping
Tim Lehr, Wildman Rocketry