USLI

WORCESTER POLYTECHNIC INSTITUTE

PROJECT: MISSION SYSTEMS AT WPI

USLI PROJECT Post-Launch Assessment Review 2018 - 2019

April 26, 2019

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Section 1. Vehicle

Section 1.1. Summary

The final Launch Vehicle design had a diameter of 6.125 in, a length of 131 in. and a theoretical mass plus motors of approximately 13.656kg. The vehicle, named Batman, was designed to reach an apogee of approximately 4094 ft on the motor picked for launch. The Launch Vehicle split into four main sections over the course of its decent and each tethered section was designed to have a GPS, totalling 3 GPS devices. Upon full separation, the sections were defined as the upper airframe, the lower airframe, the payload retention system, which are all tethered together, and the nose cone. Housed within the upper airframe was the payload retention system made of airframe tubing dedicated to housing the selected payload for the duration of its flight. The vehicle had three parachutes, a nose cone parachute, drogue parachute and main parachute. The launch vehicle's flight data was recorded using a Raven 3 Altimeter that was housed in the electronics bay.

Section 1.3. Motor Used

Proposed in the FRR Addendum we had intended to change motors to L935 however the vendor notified us that it was no longer in stock last minute. Therefore we will be using our originally proposed back-up motor the L1030-RL. Unfortunately with this motor the team knew to expect a lower apogee and that we would not be close to our goal.

Motor Specifications	
Average Thrust	1,028.5500 N
Class	9% L
Delays	Plugged Seconds
Designation	L1030-RL
Diameter	54.0 mm
Igniter	E-Match
Length	649.0 mm
Letter	L
Manufacturer	CTI
Name	L1030
Peak Thrust	1,539.44 N

Propellant	APCP
Propellant Weight	1,520 g
Thrust Duration	2.7040 s
Total Impulse	2781.2100 Ns
Total Weight	2,338.0 g
Type	Reloadable

Figure 4.1. Motor Specifications

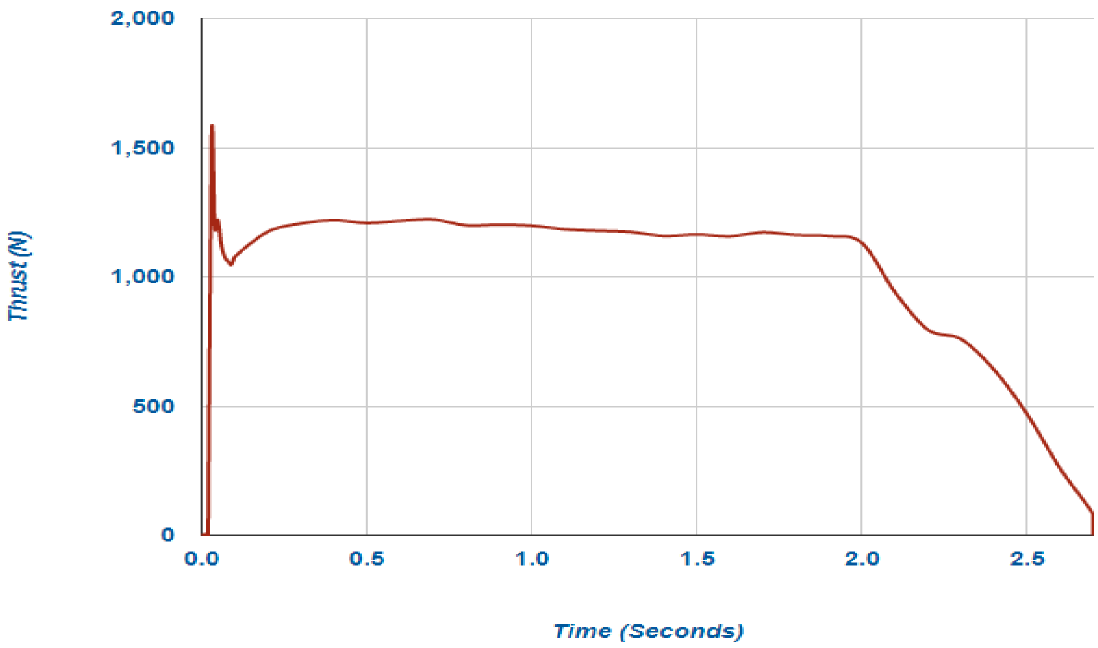

Figure 4.2. Motor Thrust vs Time

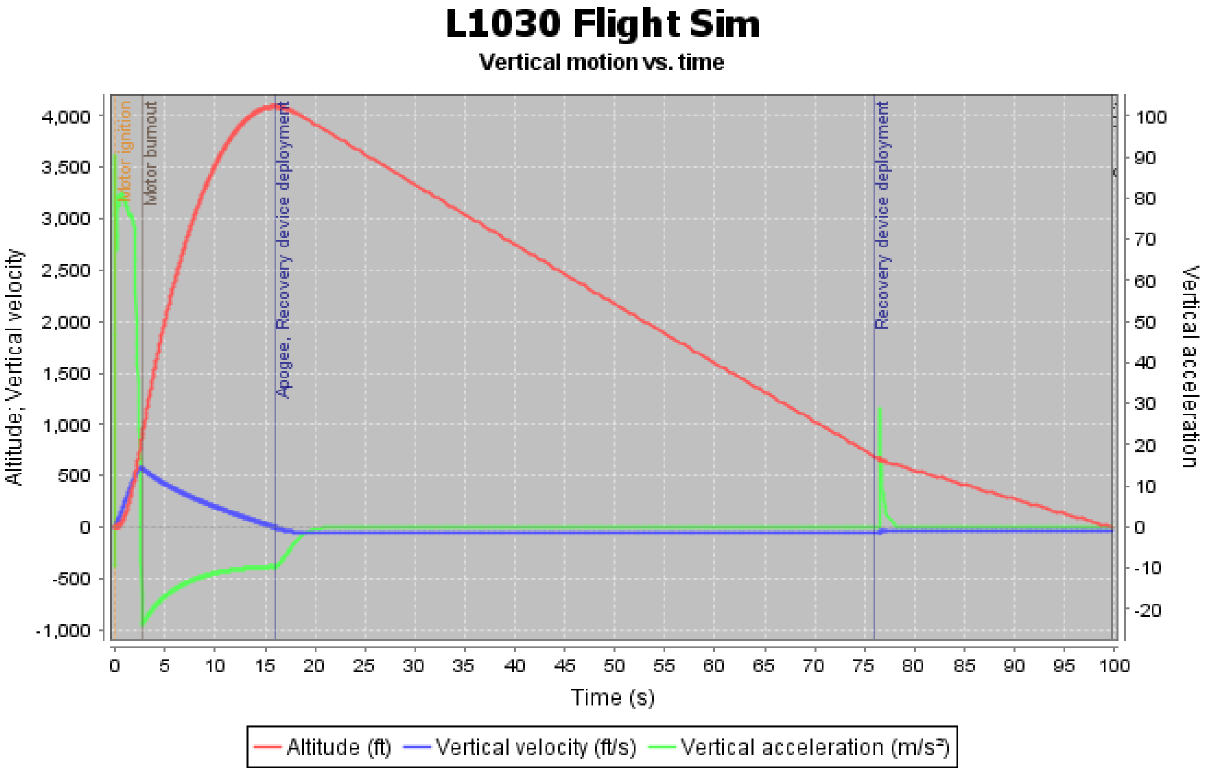

Figure 4.4. Motor Flight Simulation weighted

Section 1.4. Launch Vehicle Data Analysis

Section 1.4.1 Analytical Data Analysis and Results

Unfortunately, the L1030 the team received appears to have been a faulty motor. Because of this the maximum altitude the Launch Vehicle reached was about 716ft as can be seen in figure 1.4.2.1. According to the graph in the figure the motor blew up around 3 seconds into flight.

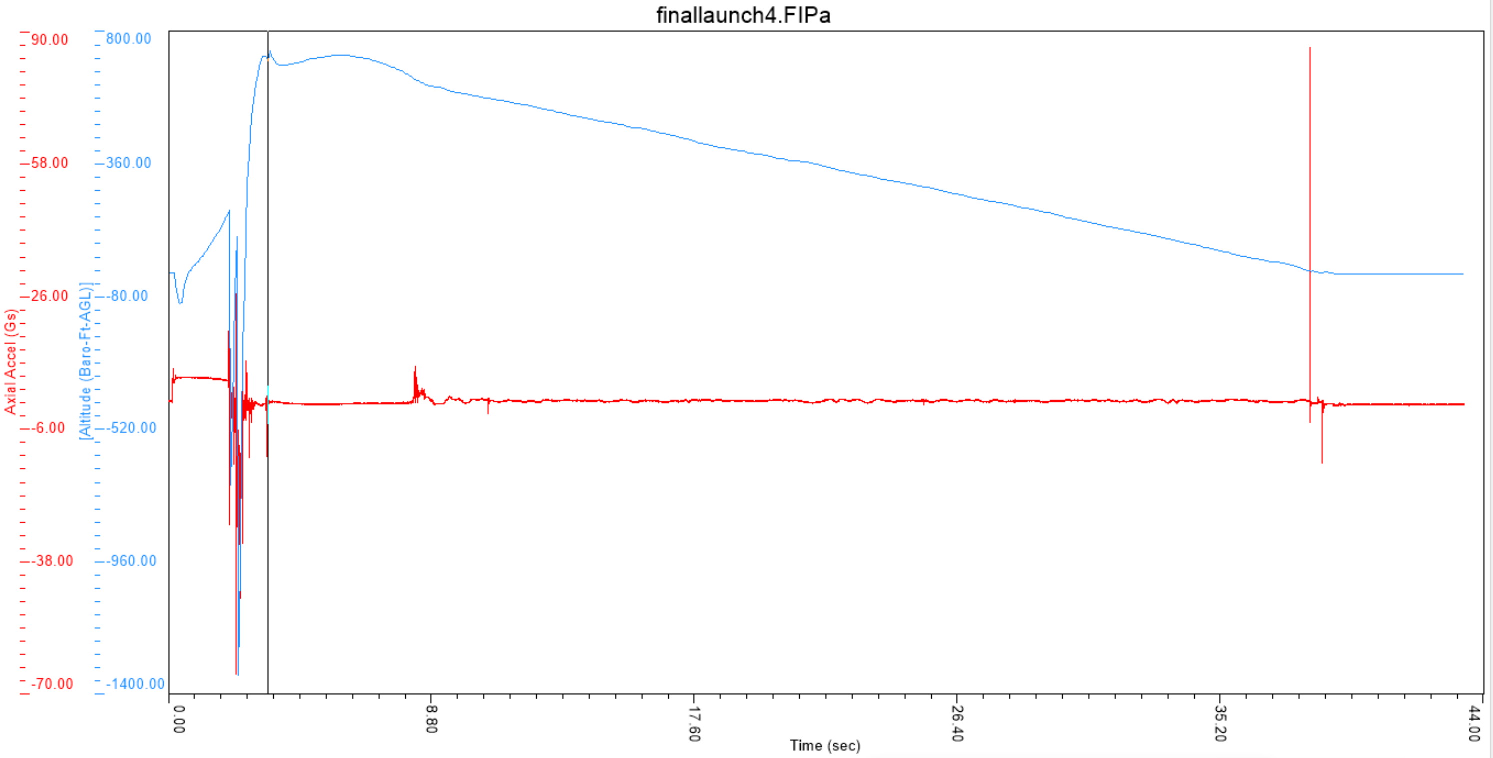

Figure 1.4.2.1 Altimeter Flight Data

Section 1.4.2 Visual Data Analysis and results

Upon visual inspection after landing it was confirmed the motor was at fault. As can be seen in figure 1.4.2.4 the motor blew up ripping a whole through the motor casing and lower airframe. The drogue parachute was destroyed and the lower airframe was ripped into two pieces as can be seen in figure 1.4.2.1. They electronics bay stated intact attached to the upper airframe. However the shock cord in the upper airframe tore through the upper airframe. The nose cone parachute was lost along with the tip of the nose cone. All that was recovered was the fiberglass body and tip screw for the nose cone.

1.4.2.1 Severed lower airframe

1.4.2.2 Lower airframe and Electronics Bay

1.4.2.3 Entire Rocket

1.4.2.4 Motor casing and lower airframe

Section 2. Payload

Section 2.1. Summary

Our selected design for our payload, named Robin, was a quadrotor UAV housed within a cylindrical retention system composed of Blue Tube. The tube held the UAV as well as a 3D printed base to hold the UAV in place and was to be ejected from the rocket during descent. When activated, the system was designed to unfold, opening its four arms to right itself in the process to deploy the UAV. This unfolding design allowed for a very simplistic and reliable system, containing few moving parts to minimize points of failure as well as being highly spatially efficient.

Section 2.2. Analysis and Results

During all launches of the full scale launch vehicle the payload and retention system in many ways performed very closely to how it was designed, both sustaining no visible damage when inspected after each flight. Being made from Blue Tube, carbon fiber, and high-strength 3D printed material, these designs were made to withstand higher forces than expected to sustain during the mission to add a greater safety factor for improving reliability. The mathematical analysis used in designing the sensitive geometry of both systems though very reliable produced oversight towards the capability of their full physical realisation, as the manufacturability of parts was the main detriment towards the completion of the UAV, specifically the 3D printing of the meticulous yet robust Matterhackers NylonX filament. It goes without question that the experience of working to overcome this issue provided great insight to the difficulties of moving from design to product and will act as a lesson learned to improve our build process in the future.

Section 3. Overall Experience

Even though our payload was unable to fly and our rocket ended up sustaining severe damages, the overall experience especially as a first year team was incredibly rewarding. Throughout the course of the year, the team overcame many challenges and bumps in the road. One of the biggest lessons we learned is to always expect the unexpected and be prepared to find a solution and never give up hope. As we look forward to next year we hope we can take everything we learned from this year and leave plenty of time for bumps in the road in next year's schedule. With WPI’s four seven week terms incorporated within a semester system, one of the most difficult challenges was the due date for every major document occurring during our finals. With a small team of only 25 active members, the majority of which were sophomores or below, the task of completing major documents especially during finals became very daunting. We are hoping next year to be able to recruit a larger team, that will be more experienced with the current members and be able to set our own earlier deadlines such that we are no longer completing documents during finals.

For the students involved with the leadership of the team this experience provided an interactive challenge towards leadership and growth in terms of responsibility. For many of us we had never had to be the chaperone or be the person making all the logistical decisions to get an entire team, a rocket, and a payload safely to another state for competition. This experience taught us valuable skills in terms of leadership, logistics, and coordination.

We have also greatly improved the way we approach the design process. While most team members have previous experience creating technical presentations for other competitions, writing the reports helped the team to improve our writing while also getting a chance to access our progress.

Perhaps the best part of the experience was attending the actual competition. Through meeting other team's at the rocket fair and talking with NAR and NASA officials, we learned many new facts, practices, and ideas about rocketry. This has prompted us to look at the tools and techniques we use and how we can improve for next year. Through the examples of other teams, we have seen there are many common practices we use that, while they work, are not the most effective strategy. For example, the construction of our electronics bay and the type of epoxy we use in construction.

Above all, the team was impressed with how friendly and helpful everyone involved in the competition was. The team faced many roadblocks that, without other people's help, would have kept us from getting to launch. NASA officials at the competition made every effort to help us solve problems and other teams were constantly reaching out to give advice or lend materials. Without our friends at the Maine and Lake Winnipesaukee Launch sites' help, it is doubtful that the team would have found the time to get in the test launches we needed. It was an amazing experience to see everyone come together over a mutual excitement about aerospace.

Section 4. STEM Engagement

Educational engagement was planned in collaboration with WPI's Pre-Collegiate Outreach Programs. Both groups worked together to reach out to children to expand their interest in STEM. Some annual events that the team participated in are *Engineering on the go* and *Introduce a Girl to Engineering*, both of which are events aimed at encouraging the increase of interest for both men and women in STEM. In addition, the team participated weekly in Friendly House which is an after school program for low income pre collegiate students in order to appeal towards their love of STEM with many fun STEM related activities. Next year we are hoping to team up with our AIAA chapter in order to plan more widespread outreach events. We are hoping to not only have fun activities but to also spend time teaching the kids about our own experiences.

Section 5. Final Budget

Category	**Amount (USD)**
Sub-Scale Rocket	$176.08
Full-Scale Rocket	$1,532.80
Payload	$945.97
Logistics	$7,718.00
Shipping costs	$500.00
Total	**$10,872.85**