Texas Tech University – Space Raiders

Post Launch Assessment Review 2017 – 2018

Table of Contents

1. **Launch Vehicle Summary ……….…………………………………… 3**

1.1 Opening Statement

1.2 Launch Day Simulations

1.3 Payload Summary

2. **Recovery Subsystem Summary ……..……………………………...7**

2.1 Vehicle Changes

2.2 Recovery Changes

2.3 Payload Development

3. **Brief Payload Description …......….………………………………10**

3.1 Payload Summary

3.2 Data Analysis & Results of the Payload

4. **Education Outreach…………..………………………………… 12**

5. **Finances………...…..……………………….……………….. 13**

1. Launch Vehicle Summary

- Size and Mass: 6 inch Diameter | 44lbs | 10.37 feet
- Launch Day Motor: Cesaroni L1395-BS
- Recovery System: 16 foot Main | 2 foot Drogue
- Rail Size: 1515 | 12 feet

1.1 Opening statements:

In the wake of the first launch of Raider II, a second launch was planned and executed before the required date of March 28th, 2018. The Raider II launch vehicle flew its final mission on March 17th, 2018 just north from Dallas Texas. The original location for the launch was planned to take place at our local launch site at Cal-Farely's Boys Ranch, but was canceled due to extreme fire conditions and the lack of necessary fire-department support. Thus, the Dallas Area Rocketry Society proctored the second launch with additional supervision of our mentor Bill Balash.

While the entirety of week leading up to the launch, spring break for most, was spent making necessary repairs, prepping the DACS and other systems, as well as running setting up logistics for launch, more work needed to be done to assure a successful launch.

Among a different launch site, there were a handful of changes made to the launch vehicle since the previous launch. While most of these changes were documented, some were not, as they were very situational and deemed necessary for one reason or another. Among these changes were, as noted, the repaired nose cone, new reinforced, payload section, flying with the payload housing installed, including ballast weight, using a twenty-foot-tall launch rail, and incorporating an on-board camera.

While assembling the Raider II at the launch site, the team made multiple friends and gained much support from the fellow flyers. A neighboring Rocketeer was kind enough to let the TTU team borrow an on-board camera to record in-flight data of the launch. The camera was secured using a proven method of adhering high-strength frog tape to the airframe and creating an aerodynamic hood over the relatively small camera. It was estimated that the addition of this camera would have negligible effects to the flight trajectory and ultimately the data that was recovered was crucial to post-flight failure analysis.

1.2 Launch Day Simulation:

It was a beautiful day in North Texas and the atmosphere at the DARS launch was one for the books, with multiple boy-scout troops attending, TARC teams, and hobbyists alike. The launch vehicle was weighed, and simulation updated with the corresponding weather conditions in preparation for the launch.

Recorded Launch Day Conditions	Numerical Value
Temp (F)	**59**
Altitude (Ft)	**705**
Latitude (deg)	**33.4**
Longitude (deg)	**-96.4**
Wind (Mph)	**7.5**

The flight profile was slightly altered from the previous launch in that the DACS was being tested to correct the apogee, if the rocket was in a path that would lead to overshooting above one mile above ground level. The predicted data shows that the apogee should have been around 5383 feet. With a stability that is 2.6 and stays at 2.6 when including the camera. *Special attention was taken to put the camera as close to the center of pressure as possible to maintain stability.

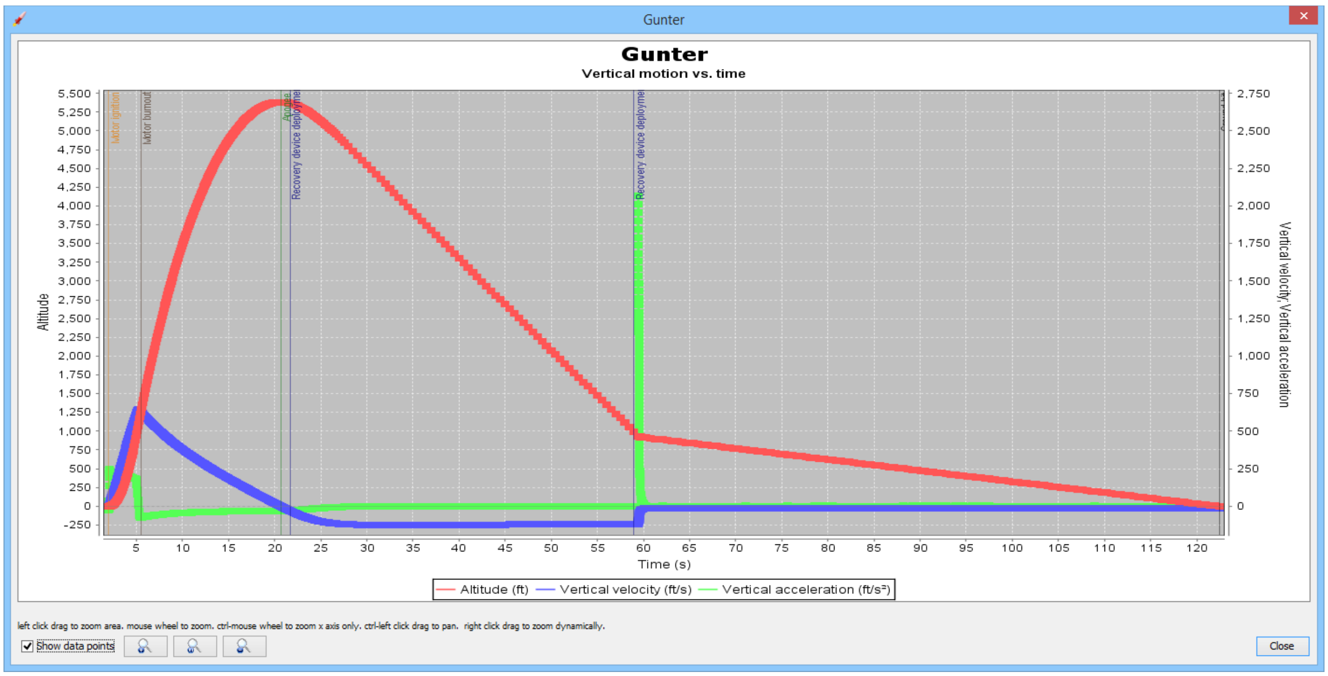

Figure 1

At the launch site, the Raider II was assembled, following all published checklists in the safety section of the FRR, and under supervision of a member of the safety team, and our mentor. The launch vehicle was prepped, and continuity was ensured from the altimeters' three consecutive chirps.

1.3 Flight Data

During the flight, the Raider II suffered multiple anomalies, causing a less-than-ideal take off trajectory, which resulted in an apogee that was lower than predicted, and then a recovery system failure that resulted in the main parachute not deploying and the demise of the rocket. Because the main parachute failed to deploy, the rocket was not recovered in flight condition and only hardware was deemed salvageable. Only one of the two altimeters are functional and could deliver a graph of the flight data. This data is shown below.

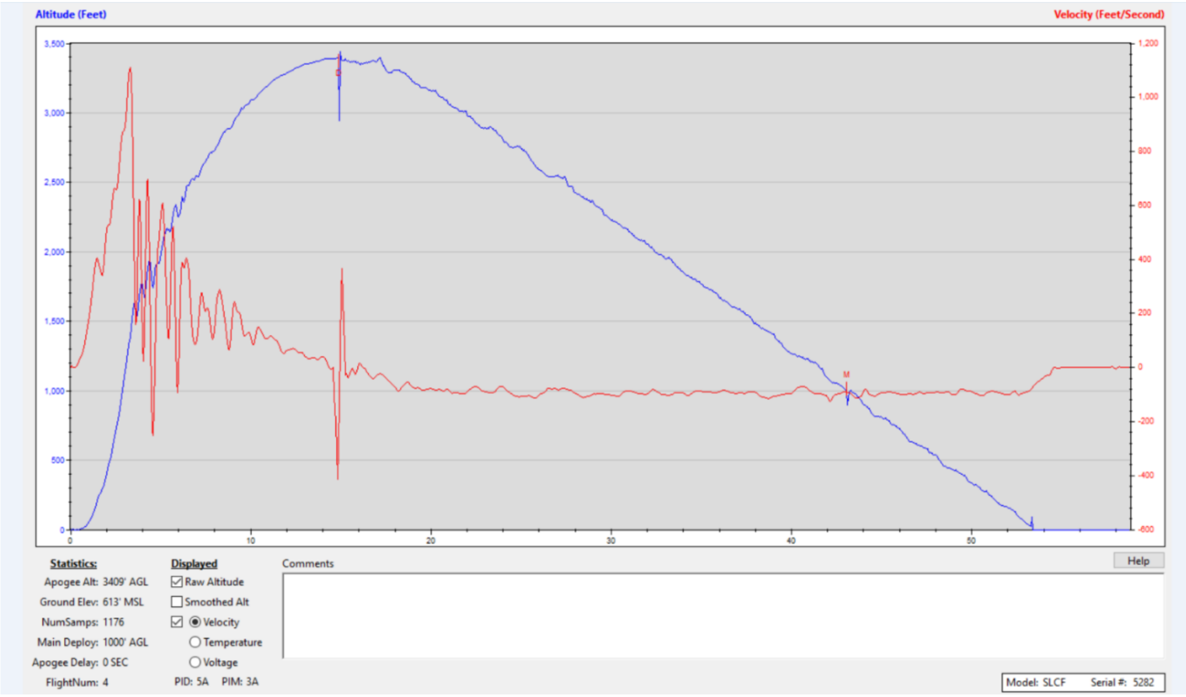

Figure 2

This data does not accurately represent the flight however due to the massive fluctuations of velocity that did not occur in the flight.

The reasoning behind the low total apogee was decided after watching multiple videos from different angles of the launch. It was observed that the rocket left the launch rod at an angle that was not ideal, and that the Raider II suffered from Rod Whip. The rocket corrected this improper orientation shortly after it had left the rod, however it was not instantaneous, and thus we lost about 2,000 feet off our predicted apogee, with an actual apogee of 3,409 feet.

We believe that rod whip occurred on the rod that was supplied due to the height and lack of any external support on the 20-foot rail. The rail was secured on a hinge on the bottom of a frame and was made from two spliced 10-foot lengths of 1515 aluminum rail. In the future we will be rigorous about rail selection and may invest in a club-built launch rail to ensure consistent testing.

2. Recovery Subsystem Summary

The recovery subsystem for the Raider II was broken up into three distinct sections and or stages. The first of these stages was the drogue parachute. The Drogue stage was positioned directly above the electronics bay inside the rocket and was to be triggered at apogee with the backup charges delayed by one second in case the initial charge did not cause separation. The next stage in the recovery system was main parachute deployment which was to occur at 1100 feet with the back up programmed for 1000 feet. The final stage of the recovery system was nose cone ejection, which was to occur upon landing and clear the way for the rover to successfully complete its mission. A closer look at the different stages of the recovery system is in the breakdown below.

2.1 Drogue Parachute

As part of the requirements set by NASA, we were required to have separation of the rocket at apogee and we were to deploy a streamer or drogue parachute. We decided to go with the later of the two options as it would help reduce the terminal velocity at this stage of the mission. For our drogue parachute, we decided to go with a 2-foot diameter X-shaped parachute made from 1.9 Ripstop nylon. The relatively small drogue parachute was chosen to help eliminate drift as our rocket was descending. The drogue itself was attached directly to a 10-foot 1–inch tubular nylon shock cord which kept the payload connected to the rest of the rocket. For our recovery harness, we used 5/16" stainless steel quicklinks connected to a Paracord 550 webbing that worked to help reduce the impulse force the airframe felt upon chute deployment. For the ejection charges, we chose to make our own by using 4F black powder and decided to go with 1 gram as our primary charge and 1.5 grams as our backup charge. This stage was connected to the electronics bay with the assistance of three 2-56 nylon shear pins.

2.2 Main Parachute

For our main recovery stage, we decided to go with a 16-foot diameter 1.1 Ripstop nylon X-shaped parachute. When comparing this parachute to the drogue chute we noticed a very large size difference especially in comparison to how big the rocket was all together. The main reasoning for the large main parachute was to comply with the kinetic energy limitation upon landing and with the sheer size of our rocket and corresponding mass of the three different sections a high impact velocity would infringe upon the safety of the payload and launch vehicle itself. With the rocket having such a massive deceleration upon main parachute deployment it was important to try and reduce this impulse the airframe would experience to help protect the longevity of the payload. In order to minimize the impulse on the airframe we utilized a 40 foot shock cord that was bundled into 30 separate 1-foot sections secured with electrical tape. This stage of the recovery system was located directly above the motor housing and below the electronics bay. The shock cords utilized the same recovery harness of woven Paracord 550, this was woven between four eyebolts instead of the two for the drogue parachute. For the ejection charges, we went with a primary charge of 1.5 grams of 4F black powder and a backup charge of 2 grams both of which proved to successfully separate the stages in ground testing.

2.3 Payload Deployment

This system was designed to be triggered remotely through the use of a 2-channel transmitter but was never fully tested due to the unfortunate crash landing of our launch vehicle at our second test launch. The final design was to create an isolated pressure chamber that would propel the nose cone forward while resting on the bearing housing. The momentum from the nosecone would pull out the blast isolate which protected the rover. The final amount of black powder was going to be determined experimentally but we never had the chance once the launch vehicle crashed upon our second launch.

2.4 Electronics Bay

The electronics bay was set up in the typical fashion with 2 completely isolated staging systems. For our altimeter we went with 2 StratoLogger PerfectFlightCF altimeters that were commercially bought. Each of these altimeters controlled both primary ejection charges or both back up charges. The entire housing of the electronics bay was EM shielded to help prevent premature detonation. With each system needing to be completely independent from the other the power to each system independent and both system could be armed independently from the outside of the rocket. This electronics bay was located close to the center of enter of mass of the rocket and between both the main and drogue parachutes.

3. Brief Payload Description

The payload for the 2017-2018 Space Raiders team was an autonomous rover. The objective of the rover was to exit the rocket after landing, travel to a distance of at least 5 feet from any section of the rocket and deploy solar panels.

3.1 Payload Summary

The payload consisted of 3 major components: the rover, the bearing housing, and the rear assembly. The rover was the primary payload for fulfilling the mission objectives. The bearing housing acted as the interface between the rover and the rocket airframe and ensured that the rover was oriented upright upon exit from the rocket. The rear assembly contained a counter-weight to bring the center of mass of the entire payload near the centerline of the rocket, and also housed various electronics. Figure 3 shows the fully constructed rover.

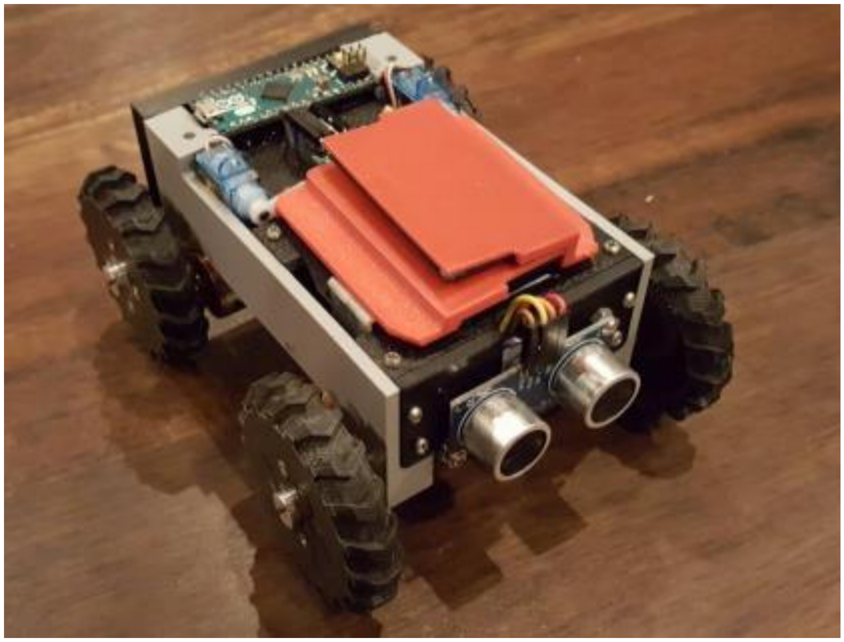

Figure 3

The rover was largely 3D printed, with a modular body for ease of assembly and maintenance. The 3D printed wheels utilized 4 in-wheel motors, which drove a set of gears within the housing of the wheels. An ultrasonic sensor at the front of the rover allowed for the detection of obstacles, and the in-wheel motors gave the rover a small turn radius for obstacle avoidance. Two servos on the top panel of the rover body actuated the solar panel deployment, which was a tri-fold configuration with three rectangular panels

The bearing housing consisted of 2 6” diameter bearings, with an inner diameter of 4.88”. The bearings were custom manufactured after several prototypes, and consisted of Space Raider designed races and cages, as well as Delrin ball bearings. The two bearings were connected via a bottom structural platform and two rails in the 3 and 9 o’clock positions. The rover wheels rested on the bottom platform, while the axles extended into the rails to constrain the rover within the housing. A weight underneath the bottom platform brought the center of mass of the rotating structure below the centerline, allowing a torque to bring the rover to an upright position upon landing.

3.2 Data Analysis & Results of the Payload

Due to issues with the final full-scale launch, the rover was never tested within the context of a launch. However, the rover was tested for the various aspects of its mission objectives. Testing done on the rover successfully demonstrated signal transmission, egress from the bearing housing, and the ability to traverse several different terrains and soil types. These components tests indicated the ability of the rover to successfully complete the mission objectives in a full-scale launch and payload deployment.

4. Education Outreach

Wester Elementary, Family STEM Night:

The Texas Tech Space Raider Team volunteered to be guests to an event hosted by Wester Elementary. We attended the event early in order to assist with the set up and then distributed our manpower to stations across the school. These stations included straw rockets, orbiting systems, and spin gliders. These were great introductions of basic physics to these k-5 students and opportunity to engage with them as a role model.

Lubbock, TX Science Spectrum, Dream Big:

The Science Spectrum hosted an event where the Space Raiders had a table set up and we spoke with many kids and parents as they walked around the room speaking with other STEM university organizations. We had table props such as R/C planes and our 2017-2018 USLI sub-scale rocket as displays and hand props for unforgettable pictures. We spoke with the kids about our rockets and gave them well known comparisons such as the Statue of Liberty to make sure they grasped useful information during our engagements.

Texas Tech University, Meet ME:

Texas Tech Mechanical Engineering Department hosted Meet ME, where Middle School Students were lectured by our team about our whole USLI project, and many other engineering engagements our organization, the Raider Aerospace Society, partakes in. We opened it to questions and even encouraged engagement during the lecture where we helped the young students better understand what areas of education they should focus on in order to partake in exciting events such as USLI.

5. FINANCES

We raised money for the USLI organization by utilizing the following:

- GoFundMe (Facebook)
- Family Donations
- Raider Aerospace Society allotted funds
- Company Sponsorships
- Member Donations

We clearly could only afford the bare minimum when it came to our testing and material selection, which was an encouragement in itself to mitigate mistakes. We were still able to afford a makeup launch in order to correct our first failed launch, however time ended up being our limitation. Currently, we are still contacting companies and are hoping to return next year with not only the skill and familiarization, but with the funds to afford proper testing to ensure optimal performance