2016-2017 NASA Student Post-Launch Assessment Review (PLAR)
Rensselaer Rocket Society (RRS)

Rensselaer Polytechnic Institute

110 8th St

Troy, NY 12180

Project Name: Andromeda

Task 3.3: ***Roll Induction and Counter Roll***

Monday, April 24th, 2017

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2.1 Team Summary

The Rensselaer Rocket Society (RRS) is a student organization located at Rensselaer Polytechnic Institute (RPI). The RRS operates in the Ricketts Building at RPI. The RRS's faculty advisor is Dr. Jason Hicken, Assistant Professor in the department of Mechanical, Aerospace, and Nuclear Engineering. The Community Mentor for the RRS is Jody Johnson (NAR Level 3 Certified, NAR #85182 SR, TRA Level 3 Certified, TRA #10973). The mailing address for the RRS is:

Rensselaer Rocket Society
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2.2 Vehicle Summary

The launch vehicle is approximately 109 in long, with a body diameter of approximately 6 in. The selected airframe material is phenolic resin tubing supplied by Public Missiles Ltd (PML). The three main vehicle fins are custom ordered from PML and made of 0.125 in thick G10 fiberglass. The fiberglass nose cone was also supplied from PML.

In order to integrate with the payload subsystem, six slots approximately 0.5 in wide and 2.5 in tall were cut into the upper airframe, approximately halfway down the vehicle length. To address concerns of these slots becoming a failure point under launch stresses, the area around the slots was reinforced with fiberglass cloth suspended in West Systems epoxy.

The launch vehicle was propelled by a 54mm Aerotech L1000 single use motor. This motor was selected after the RRS was informed that the originally selected motor would not be available on the market due to a manufacturing accident that had occurred several months prior. An Aeropack 75mm-54mm adapter was used in conjunction with a 75mm motor retainer to secure the motor in the launch vehicle. The L1000 is a single use motor, which eased the assembly process and reduced the mass of the motor due to its lack of metal casing. It has an average thrust of 1000 N over 2.7 seconds, giving the motor a total impulse of 2714 Ns.

The recovery system consists of an electronic dual-deployment system that deploys a drogue parachute at apogee and two main parachutes at a much lower altitude during descent. The recovery system is controlled by a set of two electronically independent, redundant altimeters. The primary altimeter is a PerfectFlite Stratologger SL100. The secondary altimeter is a Featherweight Raven3. Each altimeter is powered independently, and is connected only to ejection charges for parachute deployment. The drogue parachute is a Ballistic Mach II 2 ft Drogue Chute from Rocketman Parachutes. There are two identical Skyangle Classic II 60 in parachutes used for the main descent phase. A second parachute was added after the full scale test flight to address concerns of excessive kinetic energy at landing. The attachment hardware consists of ⅜'' eye bolts inserted into ½'' bulkheads, quick links, and ½'' tubular nylon shock cord. The parachutes are protected during launch with nomex blankets.

2.3 Payload Summary

The payload design attempts to complete the requirements of the challenges outlined in section 3.3 of the *2017 NASA Student Launch Colleges, Universities, Non-Academic Handbook*. To achieve this, the payload includes two cam systems that deploy two sets of opposing blades to induce roll and counter-roll.

The Payload Module utilizes redundant gyroscopes to monitor roll and dynamically deploy blades to match an idealized rotational model. The two sets of three blades are asymmetric airfoils (NASA NLF15) with fixed angles of attack of 5° and -5°, respectively. Two independent motors drive the cam, and are controlled by a central microprocessor, which deploys each set as they are needed. Following the roll-counter-roll phase, the microprocessor will command the motors to equally extend both sets of blades, to act as active drag control, slowing the rocket to reach the target altitude.

The Payload Module was de-energized for the launch as it was not able to be verified during the test launch. The major issues surrounding the inoperability were the nonoptimal cam track design and the overwhelming amount of friction in the system. The design at the time of the test launch included metal-on-metal mating, between spacers and the cam/linear plates, which caused the intense friction. This design was later changed to include the use of teflon (PTFE) washers, which has self-lubricating properties. The original cam track design relied on a shape that was optimized for constant jerk, which would be useful in a more ideal scenario. However, this design caused an inconsistent amount of resistance to the motors. A simple spiral shape was proven to be more ideal as it demonstrated a more constant resistance to the motors.

This new system will soon be put to the test during a launch RRS will be attending the weekend of May 29th in western New York. The payload system will be energized and will log flight data, testing this new iteration.

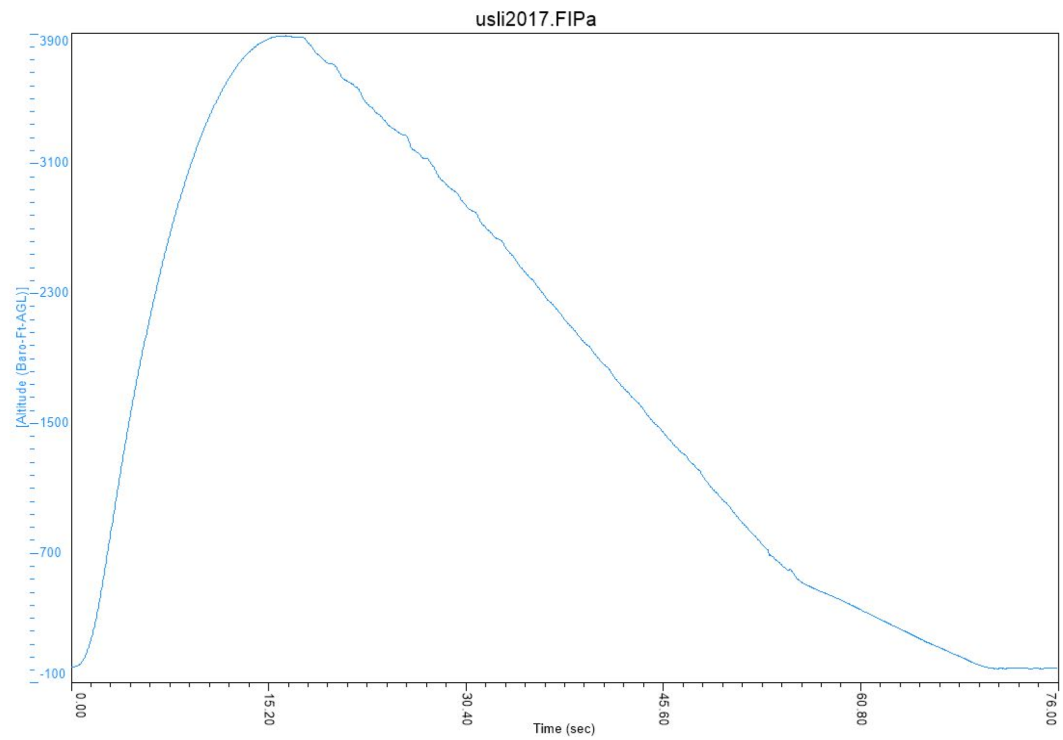
RRS has learned a tremendous amount from this NASA Student Launch experience as it is the first time since the club's inception that the team as traveled to Launch Day. Time management, communication, and the effective use of resources have reared themselves as pressing issues that the team must tackle in order to become more successful in subsequent years.

2.4 Flight Summary

2.4.1 Flight Details

On launch day, Messier 31 had a nominal flight reaching an altitude 3882 feet. Two main parachutes were deployed; however, only one fully deployed due to shock cord running through the shroud lines of one of the main chutes. Thus, the rocket came in with a higher kinetic energy than expected. There was damage to the upper airframe due to zippering and a small crack in the coupler from a high impact landing.

The payload was inactive during the flight thus, there is no data to report. Vehicle data came from the Raven 3 altimeter. The Raven 3 shows a decent rate of approximately 39 feet per second. A plot of the altitude vs time is shown below.



2.4.2 Scientific value

Vehicle data was provided by the Raven 3 altimeter. Due to the payload being inactive and and an unfortunate electronics error, no other data was recorded. Nonetheless the data from the Raven 3 altimeter may be use for future team launches.

2.5 Lessons learned

The RRS, being a new club to NSL, have learned many lessons this year that will guide the team in the future. One of the biggest lessons was regarding OpenRocket simulations. The model used in OpenRocket failed to account for numerous small details of the vehicle design which led to an inaccurate mass representation of the vehicle. In turn, the apogee from the first full scale test flight was far lower than our simulations projected. Furthermore, the simulated center of gravity was inaccurate, which raised concerns of the payload fins being classified as forward canards. In the future, the RRS will make better effort to develop a more mature simulation model earlier in the design process so that more accurately informed design decisions can be made.

Furthermore, the team could have benefited from more rigorous and thorough launch operations. If parachute shock cord assembly had been double checked, the error in threading the shock cord through the shroud lines of the parachute would have been caught. The batteries for the circuit board were also put in incorrectly causing this component not to work during launch. Though non-essential to launch given an inactive payload, more thorough verification of on board electronics is necessary to safe and successful future launches.

2.6 Overall Experience

Messier 31 performed as expected, and the RRS had an excellent experience at NSL which has given the club further motivation to pursue the competition. Despite the inactive payload and lower than expected apogee, the rocket had a nominal flight. The opportunity to partake in launch week events and see the hard work that other teams put into tackling the challenges of this competition really inspired the team members to improve in future NSL efforts.

3. Educational Engagement summary

Over the course of the competition, the RRS participated in three education engagements: Navigating Rensselaer & Beyond, Manufacturing Day at RPI, and Explore Engineering Day.

At Navigating Rensselaer & Beyond the RRS had a bottle rocket competition where students were taught the basics principles of rocketry. Students were able to create their own bottle rockets and safely launch them. RRS members gave a tour of some of the RPI lab space to new students.

The RRS took part in Manufacturing Day at RPI is an event that gives high school students a look at higher education in STEM fields. Members of the RRS participated in this event by holding an interactive building session with 3d printed parts and giving a presentation about manufacturing at RPI.

Finally, member of RRS participated in Explore Engineering Day (EED). This event held by the Society of Women Engineers gives children in the neighboring areas an opportunity to experience engineering through fun activities. Members of RRS participated in the event by chaperoning children from each event.

4. Budget Summary

Income			
Income in Accounts (begin Fall 2016)	$4,445.00		
Membership Dues	$1,280.00		
School Funding	$1,600.00		
Fundraising Goal	$2,500.00		
Total	$9,825.00		

Vehicle Design Team			
Item	**Unit Cost**	**Quantity**	**Total Cost**
Fiberglass Nose Cone	$104.99	1	$104.99
Phenolic Airframe Tubing (48")	$41.99	2	$83.98
Airframe slotting	$2.50	3	$7.50
Motor Mount	$18.99	1	$18.99
Motor Retainer	$44.00	1	$44.00
Adapter Assembly, 54-75mm	$36.00	1	$36.00
Centering Ring	$7.29	2	$14.58
Airframe Fins	$83.56	1	$83.56
Phenolic Coupler Tube (12")	$14.99	3	$44.97
Vehicle Motor (Aerotech L1000)	$132.95	3	$398.85
Epoxy	$40.00	1	$40.00
Bulkplate	$6.89	4	$27.56
Fiberglass cloth			$15.08
Misc hardware			$50.00
Estes Pro Series II Kit (subscale vehicle)	$24.99	1	$24.99
Subscale Vehicle Motor (Aerotech G80)	$27.99	1	$27.99
Total	$1,023.04		

Recovery Design Team			
Item	**Unit Cost**	**Quantity**	**Total Cost**
PerfectFlite Stratologger SL100	$54.95	1	$54.95
Raven3 Altimeter	$115.00	1	$115.00
Rocketman Standard Parachute (2’)	$40.00	1	$40.00
Skyangle Classic II (60”)	$115.00	1	$115.00
Ejection charge starters	$1.80	16	$28.80
Motor starters	$3.38	6	$20.25
Miscellaneous hardware			$50.00
Total	$424.00		
Payload Design Team			
Item	**Unit Cost**	**Quantity**	**Total Cost**
Threaded rod, 6' section	$2.55	1	$2.55
Delrin bar (for airfoil blades)	$68.78	1	$68.78
Cam Plates	$11.74	2	$23.48
Straight Guide Plates	$11.74	2	$23.48
Motor Mount Plates	$11.74	2	$23.48
Stepper Motors	$38.81	2	$77.62
Pin Rollers	$5.28	14	$73.92
Threaded Rods for cam assemblies		6	$37.00
Motor Controllers	$35.00	2	$70.00
Bulkhead	$9.00	2	$18.00
Payload L-brackets	$0.84	24	$20.16
Arduino	$50.00	1	$50.00
Rollers - Exit Guides	$5.00	12	$60.00
Threaded Rods for Constraints		3	$23.55
Triple Axis Accelerometer + Magnetometer	$14.95	2	$29.90
GPS Receiver	$20.00	1	$20.00
Xbee wireless transmitter	$35.00	1	$35.00
SD module	$15.00	1	$15.00
Misc electronics			$100.00
Teflon washers	$8.21	2	$16.42

Total	$788.34		
Travel			
Item	**Unit Cost**	**Quantity**	**Total Cost**
Hotel Rooms (nights)	$115.00	15	$1,725.00
Gas, tolls (per car, round trip)	$370.00	3	$1,110.00
Total	$2,835.00		

Income	$9,825.00
Spending	$5,070.38
Difference	$4,754.62