University of South Florida – Tampa

NASA Student Launch // Centennial Challenge April 2016

27 April 2016

POST LAUNCH ASSESSMENT REPORT

Society of Aeronautics and Rocketry

15219 Plantation Oaks Drive, Apt 4.

Tampa, FL, 33647

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1) Summary of PLAR Report

1.1 Team Summary

Institution: *The University of South Florida*

Organization: *USF Society of Aeronautics and Rocketry (SOAR)*

Location: 15219 Plantation Oaks Drive, Apt 4.

Tampa, FL, 33647

Mentor: Rick Waters

Launch Certification: Level 3 Certified TRA #: 8543

2) Launch Vehicle Summary

2.1 Launch Vehicle Specifications

The launch system was designed and built in order to meet every requirement specified by the competition committee. To ensure mission success and launch safety, strict procedures were maintained throughout the duration of the fabrication and testing stages. The launch vehicle was fabricated using materials such as G-12 and G-10 fiberglass, kraft phenolic tubing, polystyrene PS and a variety of other manufacturing materials. A brief vehicle overview can be seen in table 1.2.1 listed below.

Table 2.1.1 List of launch vehicle attributions

Vehicle Overall Mass (lbs)	22.82
Vehicle Length (in)	138.6
Vehicle Diameter (in)	4.00
Recovery System	Dual deployment (RRC3 altimeter)
Vehicle Motor Selected	CS L910s
CP	116” from tip
CG when loaded	107” from tip

2.2 Launch Vehicle Data Analysis

Figure 2.2.1 shows the altitude of the rocket as a function of time. Figure 2.2.2 shows the velocity of the rocket as a function of time. Both figures are from ignition to apogee.

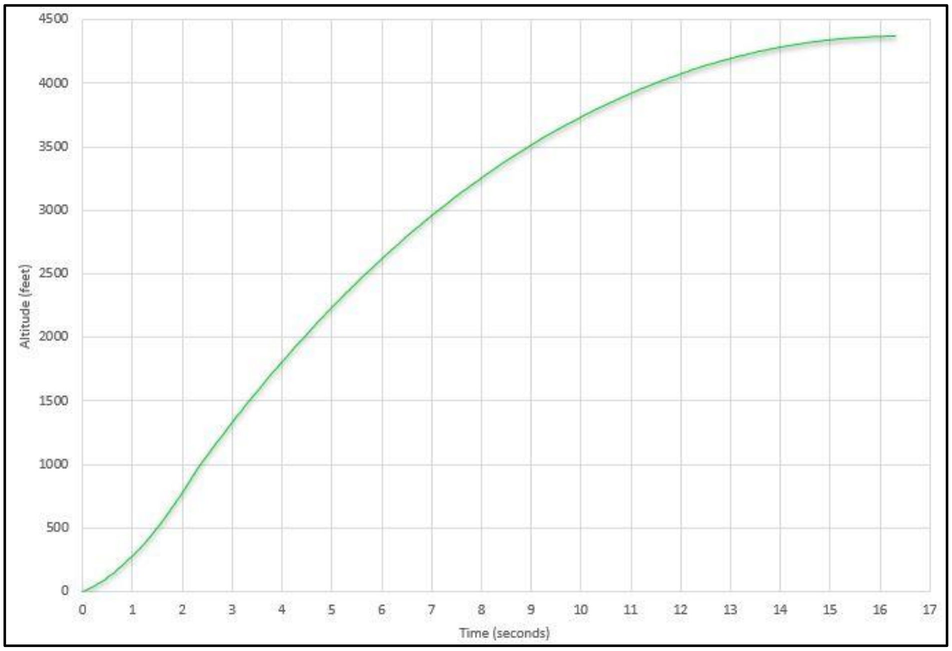

Figure 1 - Altitude versus time from the altimeter data

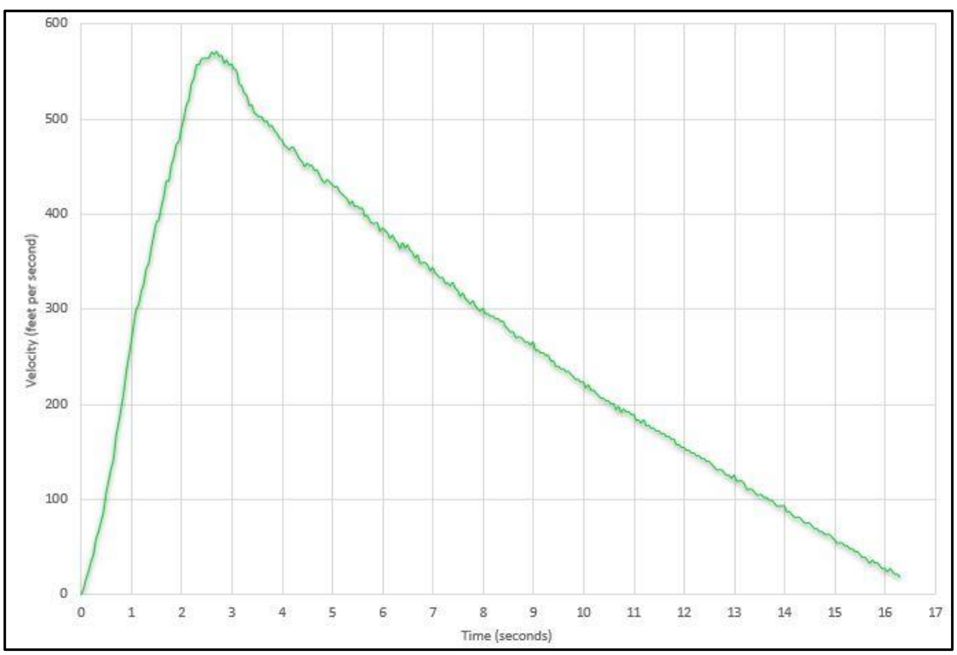

Figure 2.2.2: Velocity versus time from the altimeter data

3) AGSE/Payload

3.1 Payload Description

The goal of the payload part of the challenge is to autonomously place the payload in the rocket with the use of a robotic arm and secure it for launch. The launch rail is then supposed to raise the rocket to 5 degrees from vertical. The payload for this competition was a weighted piece of PVC tubing. This piece of tubing was to be picked up by the robotic arm and placed into an opening in the payload bay of the rocket. Once the payload was placed in the rocket, a linear actuator is set to close the payload bay and secure the payload in the rocket.

3.2 AGSE/Payload Summary

The robotic arm was 3D printed out of wood and assembled with a servo at each pivot point. In the competition, the robotic arm was able to move over to the payload, however, the arm was unable to close the grippers and pick it up. The linear actuator malfunctioned prior to the judging so the payload bay had to remain closed to ensure the rocket could be lifted safely. Once the arm was finished with it's motion, the winch was enabled to bring the rocket vertical. The winch ran off of batteries so the lifting phase of the rocket was set on a timer. The timing of this was difficult to predict since it changed each time the batteries were used. We learned a simpler arm design would be more cost effective and more reliable.

3.3 Payload Data Analysis

Table 3.3.1: Payload Data Analysis

Task	Analysis	Was the task satisfied?
Have Robotic Arm pick up payload and place in payload bay	The servos on the arm failed during testing and the grippers were unable to close. This resulted in the payload not being picked up.	No
Linear Actuator closes payload bay	The linear actuator failed near the time of judging. Therefore, it was kept close to be able to raise the launch vehicle.	No
AGSE system lift rocket to launching position	The AGSE did lift the rocket to a more vertical position, however, it was not the 5 degrees from vertical we were looking for.	Partially

4) Scientific Value

The value of the final product in most cases isn't worth what it took to create it. The process of creating an electrical/mechanical system to complete the NSL was, in our view, of great scientific value. For instance along the way securing the elbow joint of our robotic arm was a hurdle. This obstacle involved not only securing the servo but also allowing it to rotate freely. In the end a member of our team came up with a pretty amazing idea that involved a futuristic design that achieved our main objective (See figure 5.1.1). The value alone from creating that one piece of servo securement may have been more valuable to our team and science than our completed robot arm as a whole. Beyond the robotic arm we had to develop a containment system and a rail system to hold and lift the rocket, respectively. The learning experience alone was worth more than the final product. The learning experience itself also goes hand in hand with the scientific value that was achieved.

By researching and developing an AGSE system we as a team feel like the scientific value gained was important to ourselves and the scientific community. Through our elaborate fabrication process in which was presented in the PDR and CDR we gave a pictographic view of how to bring a rocket to life. Through the SolidWorks files you saw how a robotic arm got its movement. Finally, through the launch of our rocket we saw hundreds of hours coalesce in 4 to 8 seconds of one wild ride. The scientific value we as a club produced was enough to fill hundreds of pages of reports and hopefully enough to one think critically about our ideas.

5) Visual Data

Figure 5.1.1: Launch Vehicle and AGSE

5.1 Launch Vehicle

The launch vehicle left the launch rail straight and immediately after motor ignition. The altimeters worked correctly and fired the black powder charges to have the drogue parachute go off at apogee and the main parachute go off at 800 feet. The parachutes came out cleanly since the parachutes were packed correctly and the fiberglass tube's low resistance. In terms of flight altitude, it did not get enough thrust off the pad for a long enough time to go the full mile. We would change the motor from a L910 to a L1115, which has a longer burn time and more thrust to get us closer to the mile. We also found that the compact nature of the vehicle made it more difficult to work with in terms of altimeter prepping and parachute packing. We learned that if we increase the diameter to 6 inches, it would be easier for us to prep the rocket for launch. With the increased diameter, the length could also be decreased while still keeping it stable.

5.2 AGSE

While the performance of the AGSE was satisfactory to the team, there were some areas that could have been improved. In terms of mechanical design and electrical control the arm performed almost all of the necessary functions. The arm was able to complete a full range of motion for the sequence of retrieving a payload with the exception of the gripper which was unable to open or close. It was unclear if the issue with the gripper was due to insufficient servo torque, gear friction, or wiring discontinuities. Wireless communication for the purpose of initiating the sequence to close the payload bay performed reliably during all system tests.

However, during the night between setup and the final demonstration day, the battery powering the actuator in charge of closing the payload bay died. Unfortunately there were no replacement batteries available on the day of the final demonstration so the functionality of wirelessly closing the payload bay could not be demonstrated. Finally, the rail design lacked a feedback mechanism monitoring the current angle of the rail. The rail raising was controlled by the amount of time the winch remained powered, and the amount of time required to raise the rail to the proper angle varied heavily with the charge of the battery powering the system.

Although the rail raising was successfully initiated autonomously, the proper angle could not be achieved consistently. Overall the AGSE did not complete all required functions. However the experience working towards a difficult goal as a first year team proved rewarding along with the progress made towards an end to end completion of the MAV challenge.

6) Educational Engagement

For our educational engagement this year we participated in Engineering Expo. It was a two day event in the engineering buildings on campus where USF invites schools from the local area and the public to show how interesting the various STEM programs can be. We presented the rockets that we have worked on over the past few years and showed a powerpoint full of interesting facts and trivia. It was a rewarding experience to see the students become interested in rocketry and science throughout the presentation. Though, not only the students but the parents themselves got interested in what we were presenting. It was a phenomenal experience showing kids and their parents just how amazing STEM can actually be.

7) Budget

The total project budget is summer below in Figure X. Throughout the project lifetime we managed to stay within our projected budget. Our estimations for the development of our launch vehicle were most precise with us underestimating the cost that would go into the development of the AGSE. In the future we will be allocated more funds towards the AGSE project and maintaining the budget and methodology used to create the launch vehicle.

Table 7.1: Total Budget Expenditures

BUDGET	Amount
Structure	$766.64
Recovery	$697.28
Propulsion	$710.85
AGSE	$2,761.80
Subscale	$1,175.58
Travel	$4,200.00
TOTAL	**$10,312.15**

8) Overall Summary of the Experience

The experience we gained trudging through an eight month project was to put simply… Amazing. We learned everything from rocket fabrication to robotic manipulation. Though we may not have won money, we won a learning experience no one could ever take away from our team. Throughout this initiative we learned how to meet deadlines, write proposals and build systems we, as students, have never built before. Though, not only was the eight months leading up to the Initiative a learning experience but the week of the competition itself was also a tremendous occasion to learn new things. In Huntsville we ended up learning even more things that we never thought of during our build process over the last eight months. Talking to the other teams and listening to their challenges and their successes left marks on our whole team that we will carry with us moving forward. In the end the hardships and successes we went through as a team will always be with us, they were that mountain we had to traverse. Now though that mountain looks more like a hill and we as the Society of Aeronautics and Rocketry have new tools in our toolbox for approaching, hopefully, the NASA Student Launch Initiative in the near future.