NC STATE UNIVERSITY

Tacho Lycos

NASA Student Launch Project

PLAR 2015

High-Powered Rocketry Team
911 Oval Drive
Raleigh NC, 27695
April 29, 2015

Table of Contents

1 Team Name 3

2 Motor Used 3

3 Payload Description 3

4 Vehicle Dimensions 3

5 Altitude 3

6 Vehicle Summary 3

7 Data Analysis and Results of Vehicle 4

8 Payload Summary 4

9 Data Analysis and Results of the AGSE/Payload 4

10 Scientific Value 5

11 Visual Data Observed 5

12 Lessons Learned 6

13 Summary of Overall Experience 6

14 Educational Engagement Summary 7

15 Budget Summary 8

16 Conclusions 8

1 Team Name

The team name is Tacho Lycos.

2 Motor Used

The motor flown during competition was the AeroTech K805G.

3 Payload Description

The payload used was the regulation payload provided to the team on launch day. The payload was approximately 0.75 inches in diameter and 4.75 inches in length. After being filled with sand and capped with domed PVC endcaps, the payload weighed approximately 4 ounces total.

4 Vehicle Dimensions

The vehicle flown during competition was 78 inches long with a 5.5-inch maximum diameter. Including the motor and regulation payload, the on-the-pad weight for the vehicle was 20 pounds.

5 Altitude

The vehicle successfully flew to 3396 feet according to the official, marked altimeter.

6 Vehicle Summary

The vehicle, Lobo Fuego, flown during competition was carefully constructed according to the team's FRR design. Weighing in at 20 pounds, the launch vehicle has a total length of 78 inches and a maximum diameter of 5.5 inches. The fiberglass nosecone was elliptical in shape and the airframe material was BlueTube 2.0, a reinforced cardboard. The fins and bulkheads were constructed out of 0.125-inch aircraft-grade birch plywood laminates. The two avionics sleds were 3D printed with ABS plastic, and the mold for the sample was carved out of high-density blue foam.

After reaching the target altitude, the vehicle came down on three different parachutes—an 18-inch drogue, a 36-inch main parachute for the nose section, and a 48-inch parachute for the fin section. During descent, the drogue deployed at apogee plus one second, the nosecone parachute at 1000 feet, and the fin section parachute at 700 feet. An ARRD separated the nose section from the fin section at 1100 feet. These parachutes were individually contained in three separate compartments, and their deployments were initiated by two Stratologger altimeters and two Entacore altimeters.

Upon touchdown, the two GPS units outputted the exact coordinates of the two independent sections of the vehicle, allowing the team to find the vehicle.

Using a 96-inch launch rail and an AeroTech K805G motor, the vehicle was able to obtain a launch velocity of approximately 72 feet per second. With its center of gravity located 46.5 inches from the nose and its center of pressure 56 inches from the nose, the vehicle had a static stability margin of 1.7 at takeoff.

7 Data Analysis and Results of Vehicle

The vehicle achieved an altitude of 3396 feet during the competition as determined by the officially designated altimeter. This altitude is higher than the predicted height of 3070 feet, most likely on account of the higher ambient temperature. We predicted that with the extra weight from the paint, and the launch rail being placed at 85 degrees instead of 90 degrees that our altitude would come down from the 3250 feet from our full scale test flight. We did not expect the warmer ambient temperatures to allow for such a large increase in altitude.

8 Payload Summary

The payload used during the competition was the regulation payload provided by Centennial Challenge officials. Using the robotic arm on the team's AGSE, the sample was picked up from a pre-determined location and placed within the sample mold in the vehicle. The arm was then able to close the door to the payload compartment, sealing the payload inside the vehicle.

Upon recovering the vehicle after launch, the team found the payload still intact in the sample compartment. As a result, it was concluded that the compartment remained sealed during the flight and recovery. Therefore, the entire process, from sample retrieval to recovery, was successful.

9 Data Analysis and Results of the AGSE/Payload

Because the radio unit was not used during the competition, no physical data was collected from the ATLAS (Autonomous Terrestrial Launch Ascent) AGSE (Autonomous Ground Support Equipment) while it was running. Consequently, the only data recorded from the AGSE was from inspection.

The AGSE was able to complete all of its tasks in 2:32 and erected the vehicle to an angle of 84.7 degrees. Due to the careful construction and analysis of the AGSE before the competition, only one attempt was required for the AGSE to meet all mission requirements. Moreover, the AGSE never had to be paused nor shut down because it posed a risk to personnel, validating its design and the team's experimentation. The pause and master switches were also successfully implemented into the design. As per the requirements, the pause switch allowed the AGSE to cease and resume its tasks on command. The status lights indicated whether the AGSE was paused and indicated the progress of system execution. Although no emergencies arose during the AGSE functioning, the master switch was used to power on the AGSE and immediately begin the program. Overall, the AGSE was successful in every way. It was partly due to the fluidity of the AGSE and its flawless run during the competition that the team was able to win the Centennial Challenge.

10 Scientific Value

The team set the goal for itself of developing a computer vision system to guide the robotic arm to the sample. This system faced several implementation challenges, but it was successfully used when running the AGSE control code from the terminal. When the team changed the system to begin on startup, the camera application could not detect a display, so the imaging subsystem was scrapped for the competition.

Despite the decision to eliminate the imaging system for the competition, the team believes that its design has scientific value. The team has shown that with careful analysis and design, a working, light-weight, portable Mars Ascent Vehicle can be created. The team's AGSE has also shown that existing technologies—such as gears, ratcheting stops, and actuators—can be combined to create a successful design, without the need to invent entirely new systems. Because the final design was relatively simple, it provides the foundation for more complex systems that can be used in real missions to Mars.

11 Visual Data Observed

The team has watched the launch and competition AGSE demonstration multiple times to find places to improve. The launch went as planned as far as execution of the launch and recovery system. We would have liked another chance to get closer to the 3000 feet requirement. A test flight in Huntsville would have allowed for a better understanding of the atmospheric conditions and how our altimeters would handle those conditions.

The AGSE was successful in all the tasks, but the team feels with more work on the code for the arm the sample could be picked up quicker and the arm movements made to be more fluid. The other place where the AGSE was lacking was the imaging system. The team came very close to implementing the imaging system during the competition and was disappointed that it was not able to be used during the competition demonstration run.

12 Lessons Learned

Over the past eight months, our team has learned several lessons through the design and construction process. One of the earliest learning experiences occurred when the parachutes failed to deploy on our first subscale flight. We narrowed the failure down to a drop in voltage in the Rayovac batteries powering the altimeters. After researching, we learned that Rayovac batteries are constructed of lower quality materials than other more expensive 9 V batteries. Realizing this, we switched to Duracell 9 V batteries and had no ejection charge firing issues on any subsequent flights. This experience taught us that even the smallest and least expensive components can have a significant impact on the success of a project. Furthermore, it has taught us to put as much emphasis on these components as the more expensive ones during the design and construction process.

Another lesson learned involves the avionics sleds. On our subscale, we used a fiberglass sled with holes drilled for each altimeter. Epoxied to the back were tubes that the avionics bay's threaded rods passed through to hold the sled in place. These fiberglass sleds took significant time to measure, drill, and epoxy. Realizing this, we decided to try 3D printing sleds with recessed areas and screw holes to secure each altimeter and hollow sections for the threaded rods to pass through. Moving to 3D printing saved construction time, weight, and yielded more refined and durable components. Thanks to this lesson learned, future teams will use 3D printed avionics sleds as well.

13 Summary of Overall Experience

The team feels that it has been successful in the overall goals that were set forth at the beginning of the year. We were able to pick up the sample, place the sample in a payload compartment, close and secure the payload compartment, raise the rocket to 84.7 degrees, insert an igniter into the motor, launch the rocket to 3000 feet, and deliver the payload from 1000 feet. The only place that we were disappointed was the imaging system. Even though it was an optional system, we felt that it brought a high level of complexity and skill to the project.

The team also felt that there could be a better way to implement the "competition" altimeter. Using a standardized altimeter separate from the recovery system would allow for a better check of the team's true altitude. This would also eliminate a team being able to program a flight into their competition altimeter and then never turn it on, so that the last flight will be the pre-programmed flight. We do not feel that that was an issue in this competition, but there is always a possibility and eliminating variations in altimeters and calibrations would allow for a more accurate and fair judging of altitude.

The team has greatly enjoyed participating in this competition. While it was much less of a pure rocketry competition, it was a true aerospace project. It required knowledge from multiple engineering disciplines and really pushed our team, because we are made of aerospace engineering majors and one computer science major. The team has learned a lot about what it takes to put all the little parts of the project together, which is what we found to be the hardest part of the competition.

14 Educational Engagement Summary

In January, the NCSU team engaged the greater Raleigh community at the Museum of Natural History at the Astronomy Days event. 14,000 people attended the event and many of them chose to visit with the NCSU team. The team spoke about the basics of rocketry and some of the finer points of this year's Student Launch project. Most of the visitors where students between kindergarten and late high school and showed great interest in the club's activities. Approximately ten team members attended the two day event, and they received positive feedback from both the museum and the Tripoli members in the adjacent booth.

The NCSU team was asked to send students to help with this year's NC Science Olympiad competition. Four club members set up and judged a variety of competitions for K-12 students including the Egg-O-Naut which was a water-powered, egg-carrying rocket competition. Through all competitions, the event had some 250 participants. The club members who attended this event thoroughly enjoyed the opportunity, and they look forward to it next year.

In late February, the president of the Raleigh Charter High School Astronomy Club contacted our outreach coordinator and asked for our club to give a presentation on rocketry. The team was able to send six members to speak with approximately fifteen high school students about what our team does. We presented on the principles of flight, rocketry, and stability, and we tied these concepts into the Student Launch projects from the last two years. The high school students were very interested in space and rocketry, so the majority of the hour long presentation was spent answering their questions.

The team enjoyed each of the outreach events this year, and they look forward to the opportunities next year. We hope to engage more members of the community in more meaningful ways. Emily Gibson is moving into a newly-created Outreach Officer position to find ways to get the club more involved in educating and inspiring younger students.

15 Budget Summary

The team has spent a total of $12,967 on this project. This included $6,518 on hotel, van rental, food stipend, subscale rockets, and tools. That gives a "on the pad" cost of $6,449. That is well below the required budget of $10,000 "on the pad" budget required for this project. This allowed the team to stay within the total budget of $13,500 it received from Space Grant of North Carolina, the Engineering Technology Fund, the Engineering Council, High-Powered Rocketry Club Funds, and the Student Government Association.

16 Conclusions

The team is proud of the work that it did for the Student Launch Competition and Mars Ascent Vehicle Centennial Challenge. Due to the team's careful design and analysis, we were able to produce a vehicle and AGSE that met all mission requirements. Although the imaging system was not able to be implemented for the competition, the vehicle and AGSE were successful and provided scientific value. Through its personal growth and lessons learned, the team hopes to continue to influence thousands of students and to be a major competitor once again in next year's competition.