PROJECT ARES

NASA SL PLAR 2014 – 2015

April 24, 2015

I TEAM NAME

Project ARES
University of Central Florida
4000 Central Florida Boulevard
Orlando, Florida 32817

II MOTOR USED

The motor used at competition was a Cesaroni J449.

III ALTITUDE REACHED (FEET)

The recorded competition altitude was 3,872 feet with the target altitude being 3,000 feet. The reason for such a large discrepancy in altitude was due to a different motor from vendor error, apart from what our projected motor would be for competition launch. Our main parachute deployed at around 600 feet with our target altitude being 500 feet.

IV VEHICLE DIMENSIONS/SUMMARY

Size: Rocket length: 79.25” Diameter: 4” Mass: 11.7 lb.
Motor Choice: Cessaroni J449
Recovery System: A system using 3 black powder charges hooked up to 2 altimeters (e-bay and Payload). Drogue of 22” deployed at apogee, main of 70” deployed at 500 ft. Additional Payload chute of 30” at 1000 ft.
Rail Size: 10 ft.

V DATA ANALYSIS & RESULTS OF VEHICLE

From the data on our altimeters, we greatly exceeded our target altitude by 872 feet, to which we infer that a more powerful rocket than we expected with not enough weight accounted for. Our main launch vehicle deployed at roughly 600 feet which was also more than we expected as our target altitude was 500 feet. The maximum temperature rose to just under 86 degrees Fahrenheit to be more than manageable for mission success. Our velocity readings read to just above 4,000 feet/second at maximum. The battery voltage never exceeded 11 Watts as it lasted the entire mission.

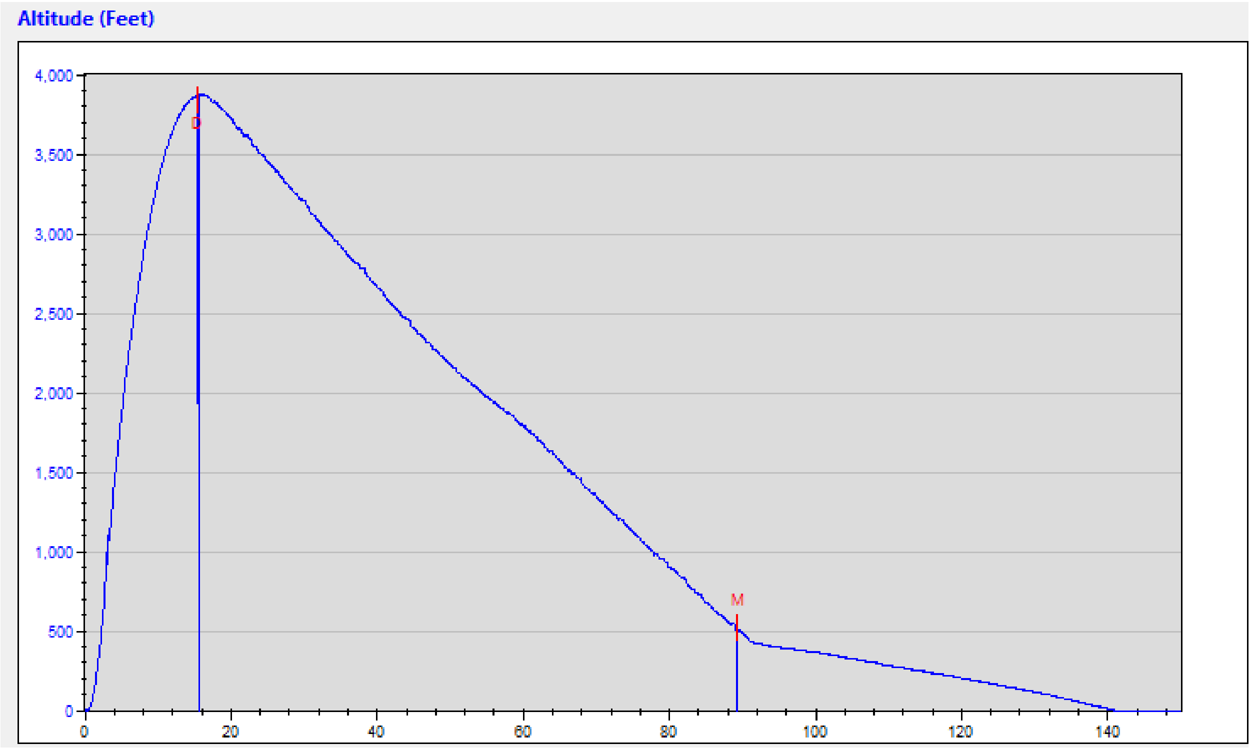

Figure 1: Altitude vs. Time

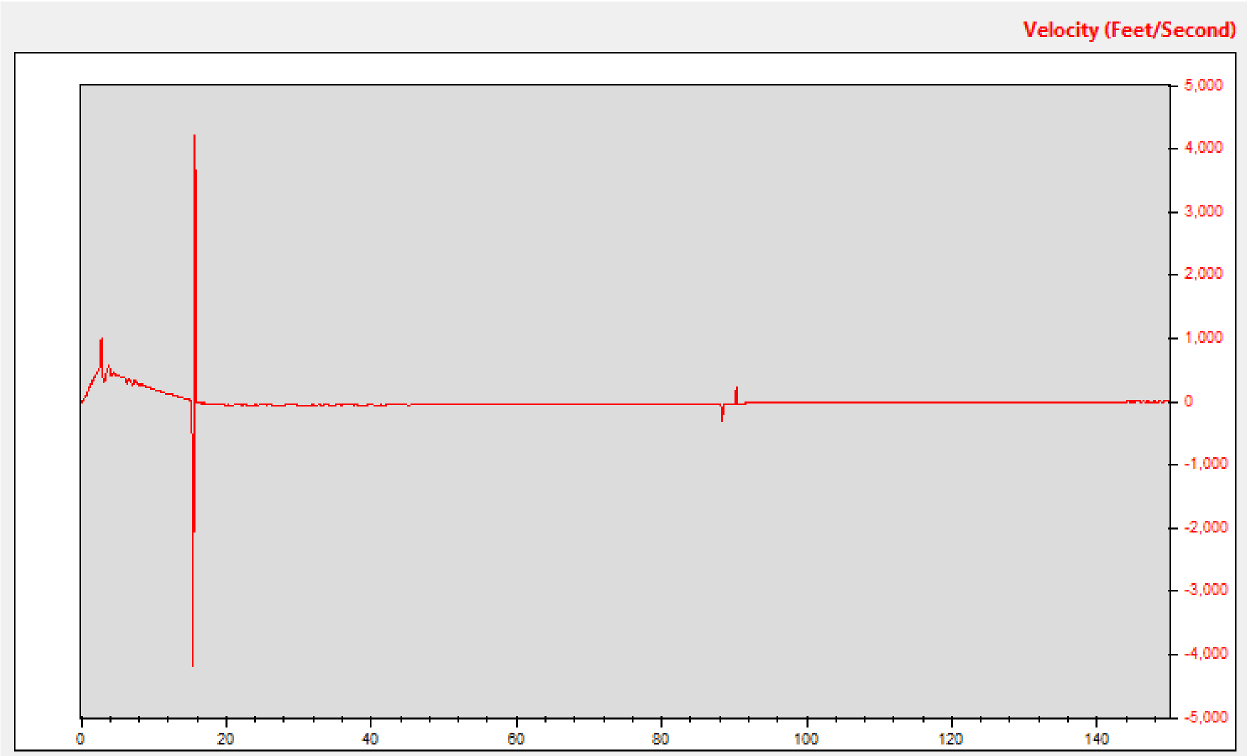

Figure 2: Velocity vs. Time

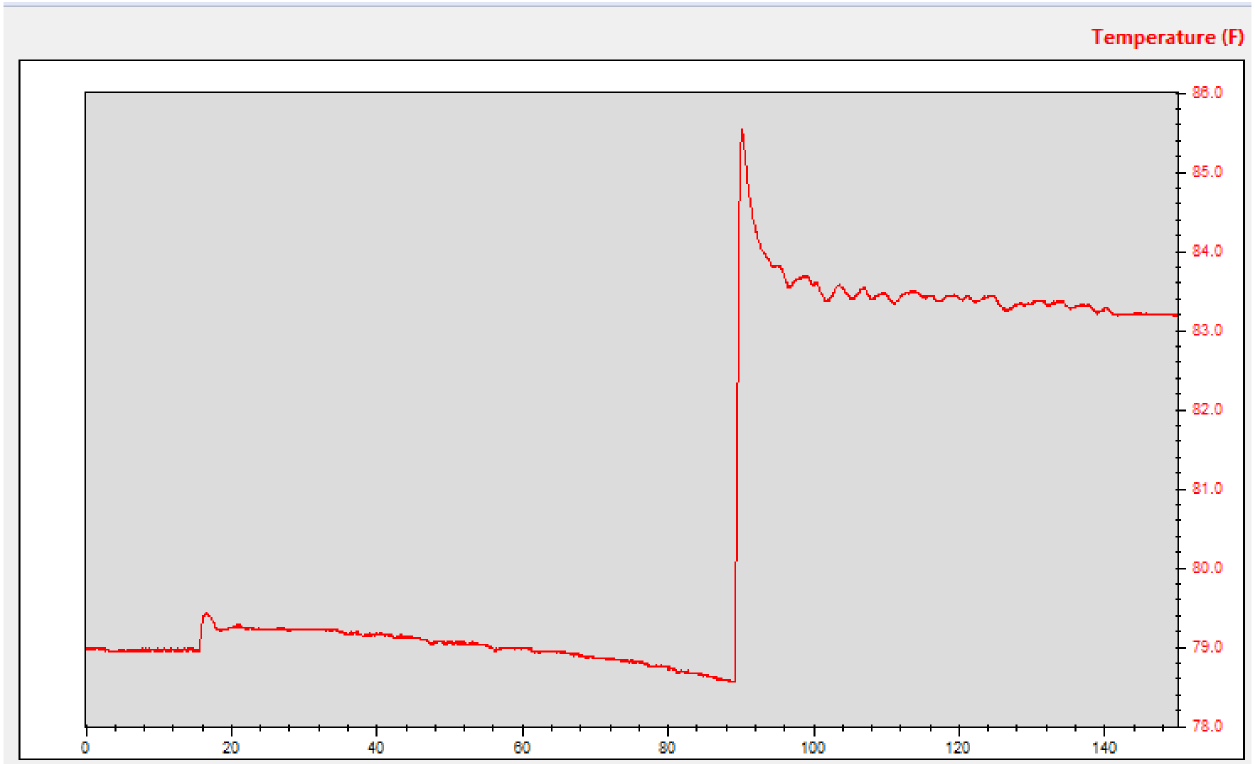

Figure 3: Temperature vs. Time

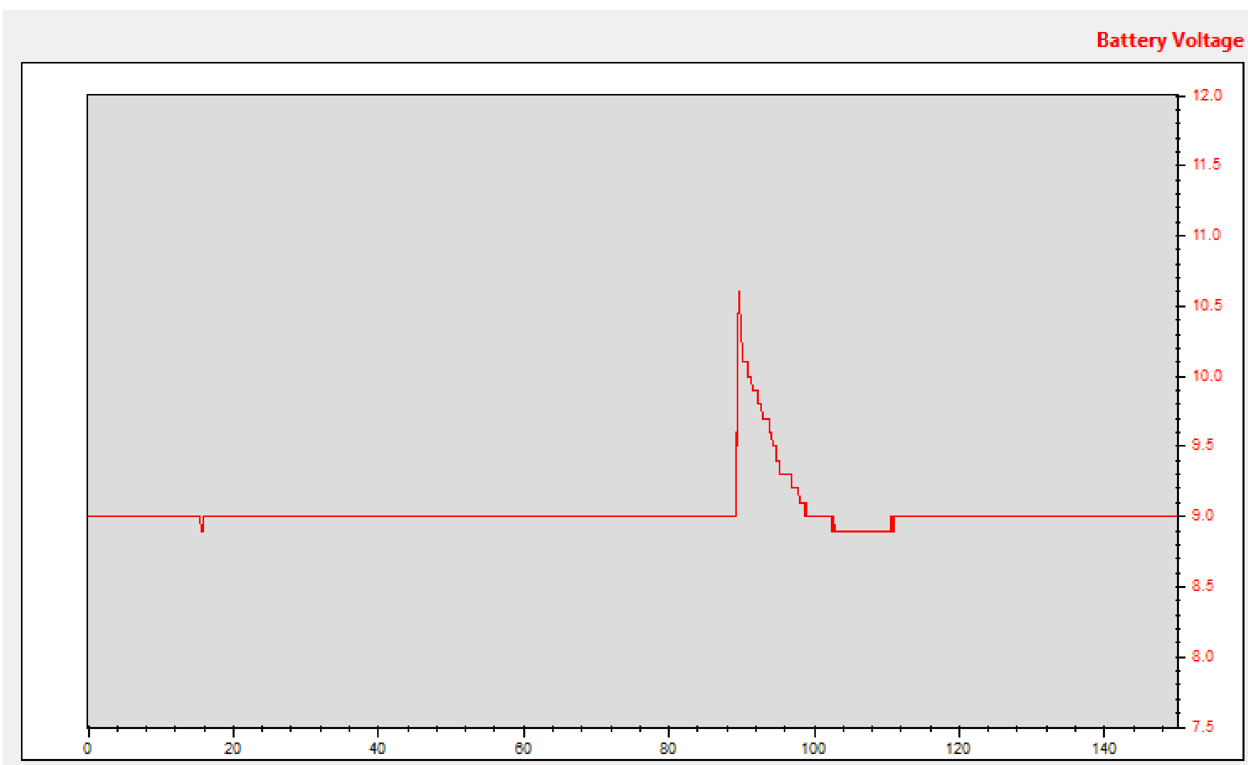

Figure 4: Battery Voltage vs. Time

For our AGSE Payload performance, the AGSE was able to effectively locate the payload anterior to it and deploy the payload within our insertion point on our rocket completely autonomously. The performance needed only one attempt and had no interference from any team members or NASA officials/judges.

VI PAYLOAD SUMMARY

The launch vehicle utilized a payload compartment on the forward section of the launch vehicle. The external door started opened and used a passive closing system. This design has a series of ribbons which the sample payload would be dropped on. When the payload contacts the ribbons, the down force from the weight of the payload will pull the door closed. The white and pink color of the inside of the payload compartment was chosen to interface with the color recognition of the AGSE system. Rare earth magnets provided sufficient attractive force to keep the door closed during flight. The passive closing mechanism proved to be an efficient method of enclosing the payload compartment and an effective setup to interface with the AGSE Rover. A 20 inch parachute was utilized for recovery and a TrackR locator for location upon landing on the surface. The images below show the payload interface into the launch vehicle as well as the integration between the AGSE Rover and the launch vehicle.

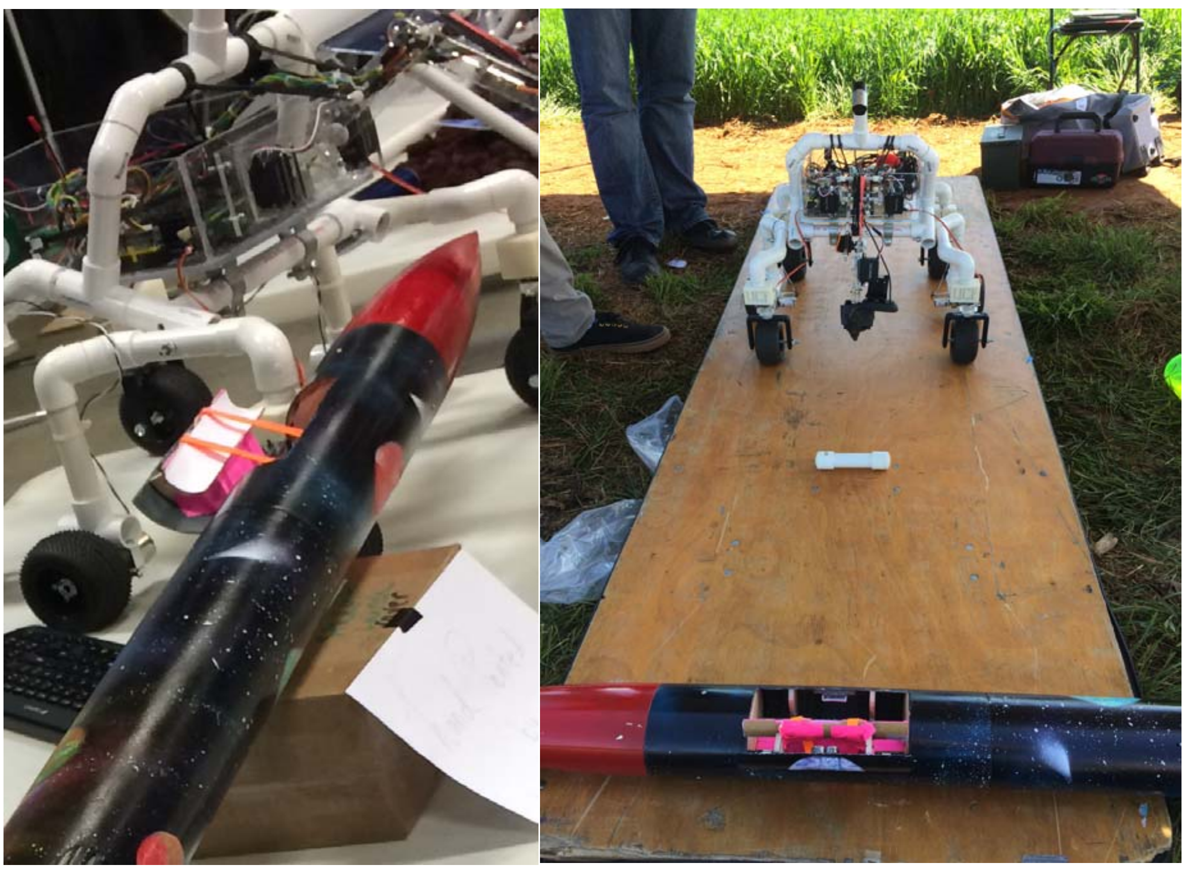

Figure 5: Launch Vehicle and AGSE

VII DATA ANALYSIS & RESULTS OF AGSE/PAYLOAD

Retouching on the functionality of the AGSE, we managed to achieve autonomous navigation through the use of color recognition computer vision software. Due to time constraints, our method of navigation was only implemented to work in a single dimension, which required that the rover be in line with the payload and rocket. With more time, it wouldn't have taken a very large amount of work to increase capabilities to steer the rover to search and center itself toward the payload and containment vessel.

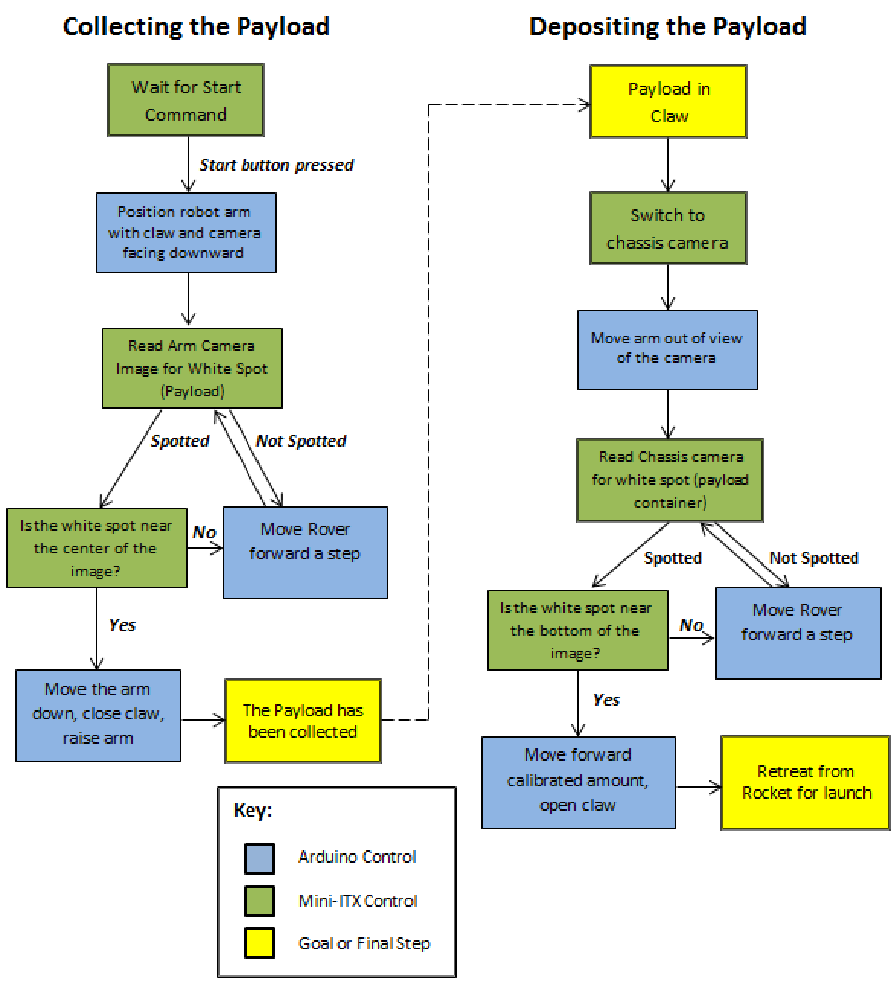

Figure 6: Resulting Navigation process

As the diagram above illustrates, the navigation sequence consisted of several steps within software. The rover, using it's claw mounted camera, faced downward and the rover continued to move forward until it found the payload in the center of the image. Once this was achieved, it reached down to pick it up.

With the payload in the claw, the computer vision software switched to the camera mounted on the chassis. With the intention of finding the payload bay of the rocket, the same process was used for navigation, except this time, the rover needed to get as close as possible to the rocket as it could before losing sight behind the arm. From here, it simply drove forward for a set amount of time, dropped the payload, and moved in reverse to retreat from the launching rocket

Below is the autonomous sequence written in C#. Note that submitMove() is a method that sends 8-bit packets to the arduino through a serial connection with a character value representing a function to perform.

```
int state = 1; //Keep track of autonomous state
while (true)
{
        switch (state)
        {
                case 1: //initialize
                        submitMove("i"); //initialize state
                        submitMove("o"); //open claw
                        state++;
                        try { (new SoundPlayer("R2-8.wav")).Play(); } catch { }; //Play audio file, ignore if exception thrown
                        break;
                case 2: //align over payload

                        int moves = 0;
                        try
                        {
                                //y is the y coordinate of the object in the camera image
                                if ((y < (frameHeight / 2) + 75) && (y > (frameHeight / 2) - 75))
                                {
                                        Thread.Sleep(500);
                                        if ((y < (frameHeight / 2) + 75) && (y > (frameHeight / 2) - 75))
                                        {
```

```
                        Thread.Sleep(500);
                        if ((y < (frameHeight / 2) + 75) && (y > (frameHeight / 2) - 75))
                        {
                            state++;
                        }
                    }
                }
                else if (moves > 200)
                {
                    try { (new SoundPlayer("R2D2.wav")).Play(); }
                    catch { }
                    Application.Exit();
                }
                else
                {
                    submitMove("8");
                    moves++;
                    Thread.Sleep(500);
                }
            }
            catch { }
            break;
        case 3: //Move claw down to pick up payload
            try { (new SoundPlayer("R2-2.wav")).Play(); } catch { };
            for (int i = 0; i < 6; i++)
            {
                submitMove("8"); //forward
                Thread.Sleep(350);
            }
            for (int i = 0; i < 4; i++)
            {
                submitMove("d"); //move shoulder down
                Thread.Sleep(300);
```

```
        }
        for (int i = 0; i < 18; i++)
        {
            submitMove("d"); //shoulder step down
            submitMove("q"); //wrist up a step
            Thread.Sleep(300);
        }
        state++;
        switchCameras();
        break;
    case 4: //close claw and move forward
        try { (new SoundPlayer("R2-3.wav")).Play(); } catch { } ;
        submitMove("c"); //close claw
        for (int i = 0; i < 10; i++)
        {
            submitMove("ee"); //move up a step
            Thread.Sleep(300);
        }
        state++;
        break;
    case 5: //until pink spots are at the bottom of the image, keep moving forward
        try { (new SoundPlayer("R2-4.wav")).Play(); } catch { };
        while (true)
        {
            if (y > frameHeight - 50)
            {
                submitMove("8");
                Thread.Sleep(500);
                if (y > frameHeight - 50)
                {
                    state++;
                    break;
                }
```

```
                }
                else
                {
                        submitMove("8");
                        Thread.Sleep(500);
                }
        }
        break;
case 6: //move to initial pose and move a predefined amount
        try { (new SoundPlayer("R2-5.wav")).Play(); } catch { };
        submitMove("i");
        for (int i = 0; i < 25; i++)
        {
                Thread.Sleep(300);
                submitMove("8");
        }
        submitMove("8");
        state++;
        break;
case 7: //drop the payload into rocket
        try { (new SoundPlayer("R2-6.wav")).Play(); } catch { };
        Thread.Sleep(1000);
        submitMove("o");
        state++;
        break;
case 8: //retreat
        try { (new SoundPlayer("R2-1.wav")).Play(); } catch { };
        for (int i = 0; i<30; i++){
                submitMove("2"); //back up
        }
        state++;
        break;
default:
```

```
                    break;
        }
}
```

Figure 7: Arduino Coding

In the end, we our rover was able to achieve a successful payload collection and deposition on its first try in under 30 seconds.

Pictures of AGSE in action

Figure 8: AGSE in Rocky Terrain

Figure 9: AGSE during Competition

VIII. SCIENTIFIC VALUE

The Autonomous Ground Support Equipment (AGSE) is an autonomous rover to be constructed with the objective of designing it to simulate a scenario that could be used by NASA on a foreign planet. This AGSE is designed to be scaled up and modified to be used for multiple scenarios.

The University of Central Florida's AGSE is a rover that will autonomously find, collect and displace a payload. The mission is to develop equipment, processes, and technologies for the rover that could be implemented in a Martian environment. The rover will employ two webcams that will serve as the major sensors for collecting digital imagery information and aiding in rover navigation.

IX. LESSONS LEARNED

A. AGSE

The entire experience of creating the rover was rather overwhelming at times, but very rewarding. As expected, we ran into issues, but nothing that set us too far back. If we had the opportunity to do this all over again, we would probably look into another means of controlling the joints of the arm. We had several issues with servos that involved them occasionally breaking, but also insufficient strength. Stepper motors would be the better choice, although they are often larger and heavier than servos.

From the software perspective, this proved to be a great opportunity to attempt to use computer vision for an exciting purpose. The largest hurdle to overcome was primarily attempting to effectively isolate the appropriate color object(s) from the camera image. This took some time, but we were successful in finding the correct HSV values after a series of filters was applied to the image.

From a general perspective, we found that the simplest method of creating or completing something is usually the most effective.

B. LAUNCH VEHICLE

We have to ensure that all parts are purchased before travel to launch site, to minimize any last minute mishaps with sellers. It would greatly help to double check all sections of written reports to ensure validity, grammar and correctness. Be more proactive in time management and spread out work evenly across a time period. Hold more people accountable towards completing tasks and fulfilling duties.

X SUMMARY OF OVERALL EXPERIENCE

It was a great experience towards furthering an understanding and interest in aerospace engineering and rocketry. We expected to compete with the other universities and have our rocket perform as intended. Unfortunately our altitude was greatly divergent from our expected apogee which we were disappointed with. We were pleased with the deployment of all 3 parachutes and the retrieval of our rocket, where all parts were within a close distance from each other. Overall it was a tremendous opportunity and experience that we greatly appreciate having the chance to participate in.

XI EDUCATIONAL ENGAGEMENT SUMMARY

The goal of our team in our endeavors to engage in outreach with the surrounding community of the Orlando area is to generate interest in the STEM fields, especially relating to those fields of study integral to the advancement of the space industry, as well as to promote general interest in the industry in the community at large. To achieve this engagement in multiple outreach events directed at middle school and high school students were carried out throughout competition. The purpose of these events was to expose students to the basic principles of rocketry, as well as the space industry as a whole. It is critical that events, such as the ones conducted, be directed at students of this specific age group because it is at this point in their lives they are discovering the things that interest them and what they plan to do with their lives and careers, and as such it is our responsibility to introduce them to STEM, and in particular rocketry, as it may be their first chance to learn about these fields of study and to gain the same level of passion that we hold for them.

BUDGET SUMMARY

Table 1: Total Summary of Budget

Expense	Amount
Parts	$2,000.79
Kickstarter Fees and Rewards (estimated)	$541.50
Travel (Hotel and Gas, estimated)	$1600
Total	$4142.29

Table 2: Total Summary of Funding Sources

Funding Source	Amount
Individual Donations	$200
Sponsor	$1,235.41
Kickstarter Campaign	$2,166.98
ATK Stipends	$600
Total	$4302.39

ACKNOWLEDGEMENT

University of Central Florida would like to thank NASA for the opportunity to compete in this year's student launch.