Martian Soil Sampling Drone for Colonization

MECHANICAL ENGINEERING
COLORADO STATE UNIVERSITY

Katelyn Bartley, Jake Hulbert, Andrew Muterspaugh, Kenneth Reisbeck & Hunter Towle

WALTER SCOTT, JR. COLLEGE OF ENGINEERING
COLORADO STATE UNIVERSITY

ABSTRACT

Colorado State University's Competition Rocket Team's Payload team is tasked with designing and building a payload that will collect surface soil data on the planet Mars with an unmanned arial vehicle quadcopter. The purpose of the mission is to collect surface soil data of unexplored terrain inaccessible with current Mars rovers due to geographical discrepancies such as ravines or steep craters. To solve this issue, we have designed and are building a drone into a 5U CubeSat volume to interface with the rocket's airframe diameter. Once the drone jettisons from the vehicle, it will be able to hover in place at a specific waypoint while collecting samples and testing the soil. We are pursuing this project since we believe drones are the future for planetary exploration as they provide greater capability of surveying. The current industry is also looking towards colonization of Mars in the future, and this device would facilitate part of the research required to get there.

PERFORMANCE SPECIFICATIONS

A list of requirements was defined to gauge the criteria which the payload sub-team will be evaluated among their specific customers. The list of requirements was further broken down into subcategories, and performance specifications were defined in each. Some key specs are listed below that are to be researched and tested:

- Unfold Time
- Drone Propulsion
- Soil Sampling System
- Surface Visual
- Moisture & Temperature Sensor Accuracy
- Flight Accuracy
- Deploy Time from Rocket
- Telemetry Accuracy
- Power Consumption

DESIGN SOLUTION

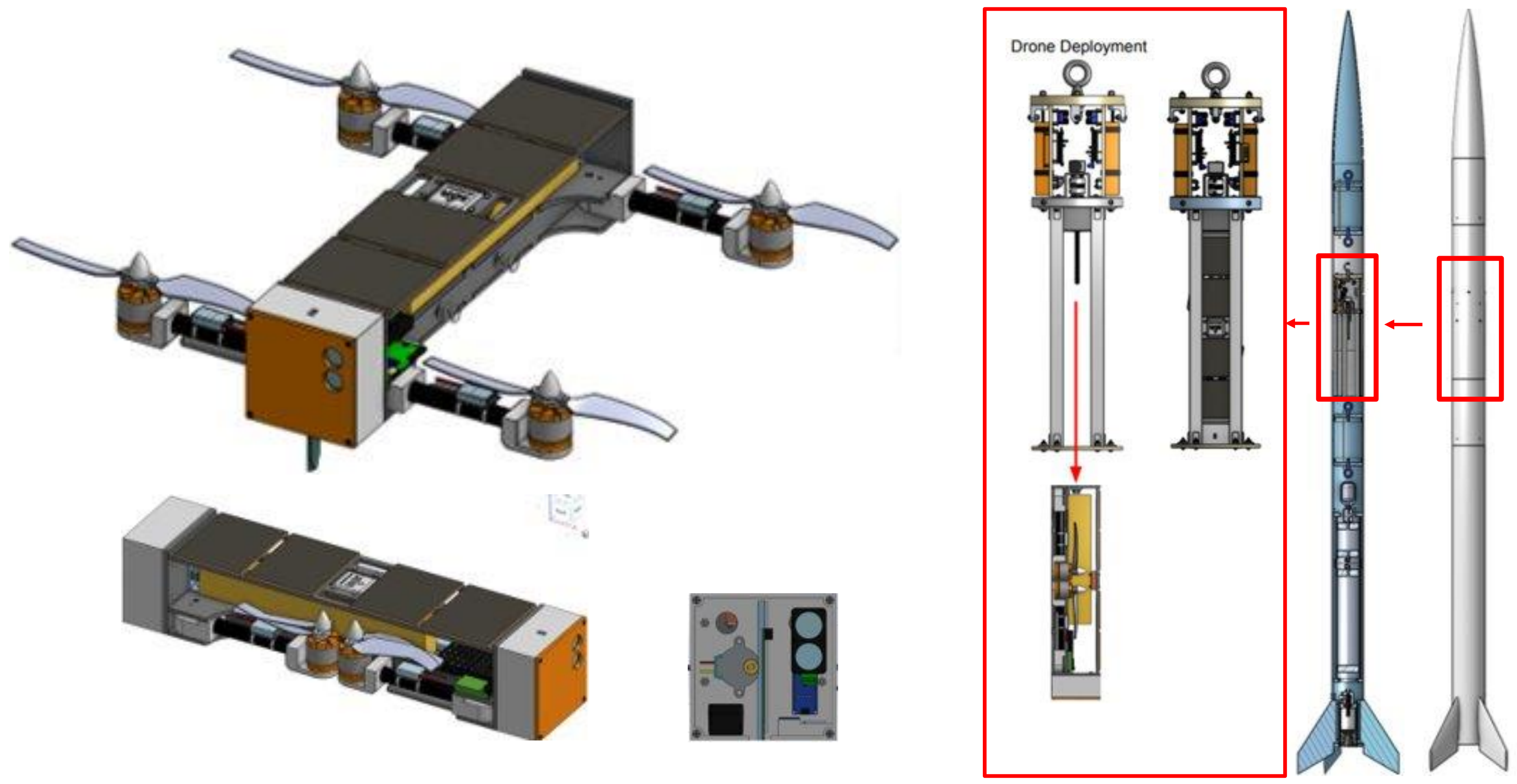

Figure 1: Graphic of drone deployment system and its interfacing with the rocket

The solution to the problem was a foldable drone into a 5U CubeSat design capable of being retained inside of the rocket until it reaches apogee. Once the payload module reaches 500ft on its recovery, the payload will deploy and unfold when jettisoned from the flight vehicle. Once deployed, the drone will conduct analysis on soil following pre-determined waypoints. The drone will encounter its final test during a full-scale launch with a liquid bi-propellant rocket at the Friends of Amateur Rocketry Competition.

PERFORMANCE EVALUATION

The designs were tested for their execution of the specifications through an on-ground electronics test, a drone flight test, a soil sensor suite test, a mock drone deployment test, and a preliminary in-flight electronics test. The vital test is the final test of deployment and drone operation with the full-scale liquid bi-propellant rocket. The test setups of the STEMMA sensor test, waypoint test, and mock drone deployment test are shown below.

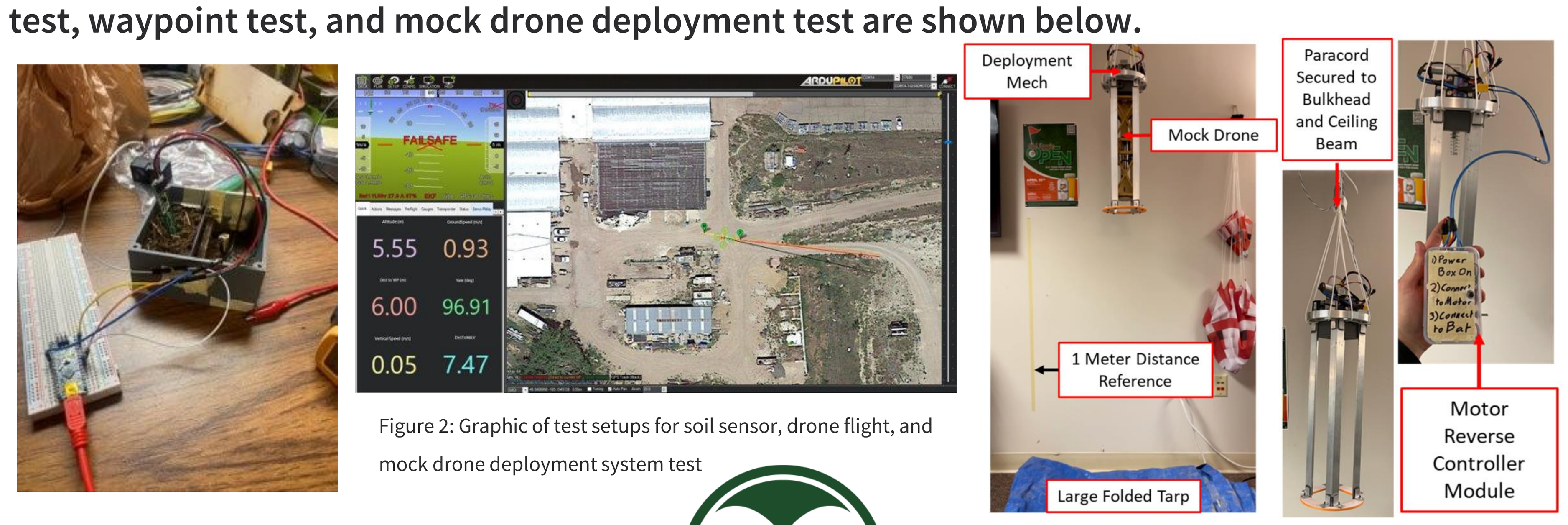

Figure 2: Graphic of test setups for soil sensor, drone flight, and mock drone deployment system test

RESULTS

After integration, the STEMMA sensor failed and responded to the slightest amount of water, and therefore, cannot calibrate moisture variance of soil samples yet. The initial drone flight waypoint test proved successful and will need slight modifications before another test. The mock drone deployment test was also successful since it achieved the performance threshold of unfolding in < 3 seconds with a 100% success rate.

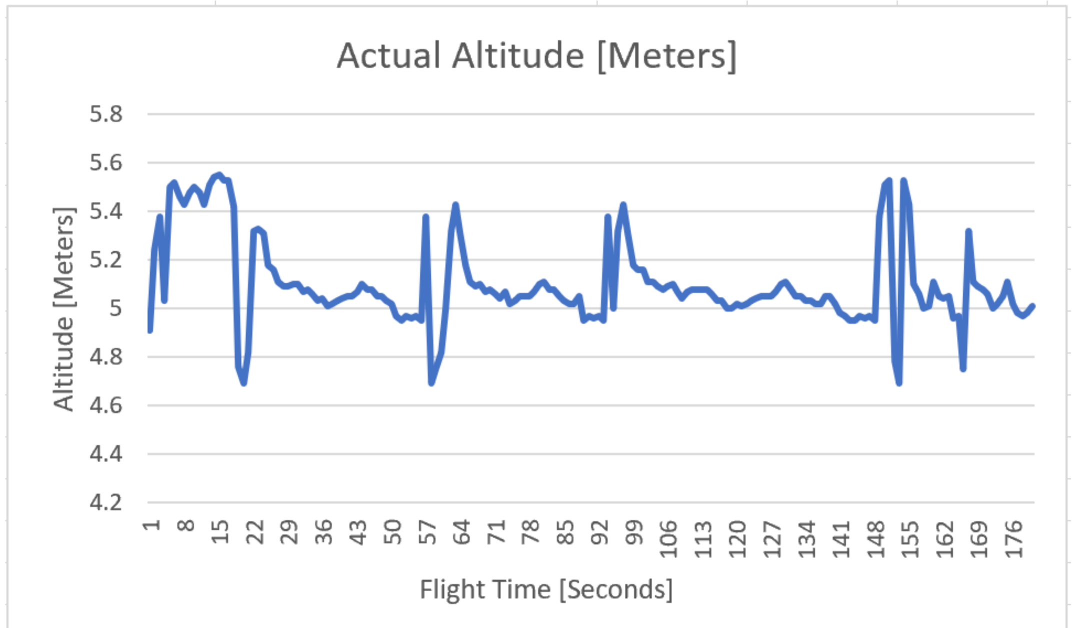

Figure 3: Drone flight data

Table 1: Mock drone deployment and unfold test data

Test Motion	Trial Number	Deploy (Y/N)	Time to Deploy and Unfold (Seconds)	Final Velocity (Meters/ Second)	Delta Height (Meters)
Static	Trial 1	Y	0.89	0.88	0.78
	Trial 2	Y	0.35	2.05	0.72
	Trial 3	Y	0.38	2.11	0.81
	Trial 4	Y	0.38	2.13	0.82
Swing	Trial 1	Y	0.48	1.65	0.80
	Trial 2	Y	0.37	2.07	0.76
	Trial 3	Y	0.42	1.60	0.67
	Trial 4	Y	0.38	1.84	0.70

CONCLUSIONS

The 1st flight test of the drone was eye opening to see what improvements needed to be made as far as the propulsion and GPS systems go. The electronics that power, provide instructions, and store data for the drone have been through initial testing, but it isn't without a couple more rounds that this needs to be fine-tuned and robust. The deployment system is only in its initial stages of testing. So far, the testing has proven successful, but a sub-scale deployment test with a mock drone is still needed to ensure that it is fully functional with air resistance and drag. With these aspects combined, payload should be more than capable of designing an effective drone that satisfies its specifications.