AIAA Orange County Section
Student Launch Initiative 2011-2012

Post Launch Assessment Review

Rocket Deployment of a Bendable Wing
Micro-UAV for Data Collection

Submitted by:
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Submitted to:
Marshall Space Flight Center
Huntsville, Alabama

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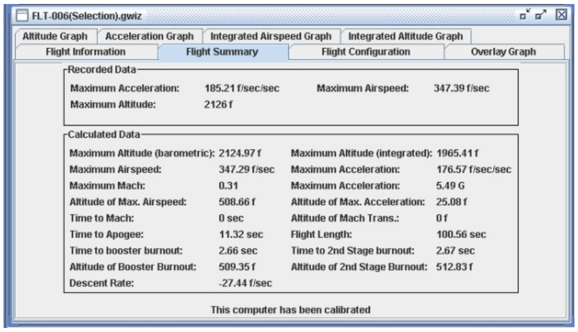
Post-Launch Assessment Review (PLAR)

1. **Team Name**
   The team name of the AIAA OC Section SLI team is The Rocketeers.
2. **Motor Used**
   The motor that was used was a Aerotech K1050.
3. **Brief Payload Description**
   Our initial payload was to be a UAV deployed at altitude that would release from its parachute and descend via auto pilot or RC control all while recording and transmitting live video and telemetry to a ground station. Unfortunately, we had a faulty batch of motors and both the prop shaft on our main motor and the prop shaft on out back up motor snapped with not enough time for use to replace them with a powerful enough motor for our UAV. Fortunately, we had proposed an alternate payload during our FRR witch we dubbed our “Wingless UAV.” It was a 4in, 12in long coupler that housed all of our payload electronics. It descended via parachute while transmitting live video and telemetry.
4. **Rocket Height**
   The height of the rocket is 130.1 inches.
5. **Rocket Diameter**
   The diameter of the rocket is 5 inches.
6. **Rocket Mass**
   The mass of the rocket is 35.6 pounds.
7. **Altitude Reached (Feet)**
   The altitude that our team’s rocket reached was 2,126 feet.
8. **Vehicle Summary**
9. **Data Analysis and Results of Payload**
   We used a G-Wiz partners HCX Flight computer as the main computer in the dual redundant recovery system. The HCX measures altitude using a barometric sensor AND an accelerometer, and records this data on a removable memory card. After the flight we downloaded the data from this card and let the G-Wiz Partners FlightView program analyze and present the data. The Flight Summary tab provides the data that until now we had only been able to simulate using Rocksim.

   9.1. Flight Summary

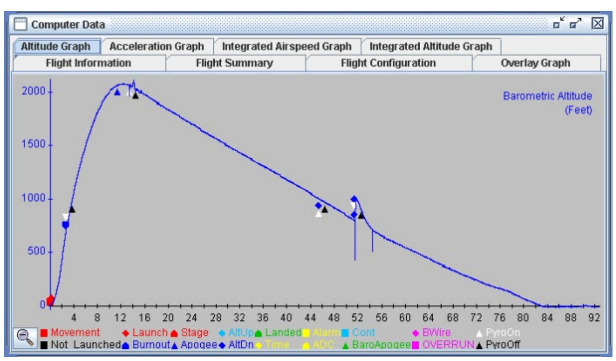


We can then compare this actual data against the data from the Rocksim flight simulation (data from the flight summary sheet and the details during the simulation):

Parameter	RockSim	Flight Data from HCX	Rocksim as a percentage of HCX
Altitude	3906	2125	183.81%
Maximum Speed (ft/s)	537	347	154.76%
Maximum Air Speed (mach)	0.48	0.31	154.84%
Altitude at maximum airspeed (ft)		347.29	
Maximum Acceleration (ft/s/s)	312	176.57	176.7%
Maximum Acceleration ("G's")	9.70	5.49	176.69%
Altitude of maximum acceleration (ft)		25.08	
Time to booster burn-out (s)	2.55	2.66	95.86%
Altitude of booster burn-out (ft)		509.35	
Time to apogee (s)	15.156	11.32	133.89%

Our rocksim values very greatly from our launch data (up to 83% error in some cases). We believe that this is due to strong winds causing us to weather cock during flight. This not only would bring our altitude down, but max velocity and acceleration as well because of the work done to change directions, and the added friction of strong head winds. We believe that this explains our difference in simulated and actual flight values.

9.2. Flight Altitude

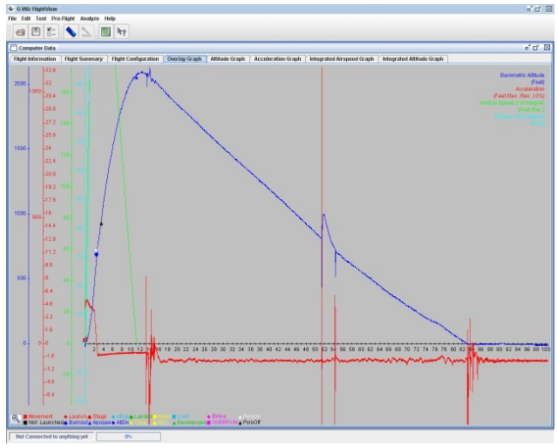


This altitude graph from the HCX shows the altitude over the time of the flight. The table below summarizes the altitude at apogee

Flight Time	Flight Altitude	Descent Time	Descent Distance	Descent Rate
Drogue				

13.5 s	2070 ft	32 seconds	1063ft	33.21 ft/s
45.5 s	1007 ft			
Main				
45.5 s	1007 ft	37.5 seconds	1007 ft	26.85 ft/s
83 s	0 ft			

9.3. Time vs. Altitude, Acceleration, and Speed



This graph, again from the HCX flight computer plots our flight time versus barometric altitude as well as acceleration, altitude, and speed as calculated from the accelerometer.

9.4. Results of Payload

At 800ft, our sabot was successfully pushed out of the upper section by the piston and opened to deploy our Wingless UAV. The Wingless UAV successfully recorded and transmitted video and GPS data to our ground station.

10. Science Value

Our payload objectives on launch day:

- The wingless UAV exits the rocket at 1000ft
- The Wingless UAV exits the sabot
- The Parachute attached to the UAV opens
- The video footage is captured and sent to the ground station.
- The ground stations shows the video footage

- The Big Red Bee Beeline GPS system works and can accurately reported where the UAV is located
- The ground station for the GPS unit on the UAV can accurately display where the GPS says it is located.
- The wingless UAV and all on board equipment is reusable/not damaged.

Our payload successes on launch day:

- The Wingless UAV exits the sabot
- The Parachute attached to the UAV opens
- The video footage is captured and sent to the ground station.
- The ground stations shows the video footage
- The Big Red Bee Beeline GPS system works and can accurately report where the UAV is located
- The ground station for the GPS unit on the UAV can accurately display where the GPS says it is located.
- The wingless UAV and all on board equipment is reusable/not damaged.

Payload failures on launch day:

- The wingless UAV did not exit the rocket at 1000ft

A review of payload events during flight:

Our Wingless UAV payload ejected from the rocket in its sabot at apogee by the force of a piston with a black powder charge set off by one of our black powder charges. Upon exiting from the rocket, the sabot opened with the force of gravity on the non-tethered side of the sabot. The wingless UAV came down on a 36in parachute while the nosecone and the sabot had their own parachute. The fact that the UAV deployed at apogee was something we thought we had fixed in our four flights before Alabama, but it did not endanger the crowd or the rocket itself. Video was successfully transmitted live from the wingless UAV to our ground station and recorded, albeit inconsistent and static-y. The GPS also displayed properly the direction and distance to our payload. The payload landed safely and all electronics were undamaged. We concluded that, had our original winged UAV been approved and ready to fly, it would have had an equally high chance of working as our wingless UAV, only having the added job of guiding it to the ground manually.

11. Visual Data Observed

The rocket weather cocked due to high wind during the flight. The rocket separated near apogee, but due to a recovery malfunction the drogue, main and upper parachutes deployed at the same time. The payload parachute followed shortly after. This brought our rocket down slower than we expected because of the deployment of parachutes at a higher altitude. The rocket was returned with no damage.

12. Lessons Learned

There are many things that our team has learned not only things have to do with the vehicle. The team learned that to be able to do this project that there needs to be constant communication because if not multiple people will do the same section, or have two different sets of information. Next is a high level of team work, if you don’t work as a team then your project won't be completed because a single person can't work alone when there's fifteen others trying to do the same, information would lost. Everyone is important because they bring something different to solve problems, if not everyone had helped then problems would have stayed and continued to cause more problems. If you're not patient then team members will become frustrated, but if you're too patient things will not get done. As a project manager you learn how to manage people and how to overcome problems without losing time.

1	Always Ground Test
2	What works for someone will not necessarily work for someone else
3	It is a lot easier to correct errors on the scale model than the full scale model
4	Modifying a RC plane is a lot harder than it looks
5	Allow plenty of time
6	This is a huge, huge project

These are tables of some of our lessons learned throughout the project:

Sabot Ejection	Use a piston with flat ends (nothing protruding such as eyebolts or "U" bolts) We want bulkhead to bulkhead or padded with parachute or shock cord
Piston Construction	Use fiberglass coupler tube, ¼" bulkheads reinforced with fiberglass, foam filled, with recessed "U" bolts
Sabot Construction	Use fiberglass coupler tube, ¼" bulkheads reinforced with fiberglass, "pushed" end needs to be flat with hinge to assure even pressure
Black Powder Charges	Some additional black powder is necessary to overcome the friction of the Sabot being pushed out, but the piston is very effective so care must be taken to not add too much. Careful testing is required
Piston Shock cord length	The shock cord on the piston needs to be shorter so the piston barely clears the body tube to prevent fouling
Avionics Bay Sealing	The avionics by needs to be sealed much, much better to avoid ejection charge leakage

13. **Summary of Overall Experience (what you attempted to do versus the results and how you felt your results were; how valuable you felt the experience was**

Everyone in this project can agree that this was a very valuable experience. Each of the team members learned and grew in respective areas. This was a real world experience of what to expect in other projects. This project also taught all of us that there is many types of jobs involved in one project and many different people are required to fill these jobs. This project helped the team members develop stronger communication skills and a deeper understanding of what the project requires to be successfully completed. This project has helped fuel more inspiration in pursuing an aerospace and/or engineering as a carrier.

Our project this year was much more difficult than last year. We learned that we had to adapt to our circumstances, the first was when we did not have enough space in the fuselage for all the electronics and the second was the wingless UAV. We have decided to continue our original project and complete it during the summer. The results that we got from the Wingless UAV were what we expected. The video worked successful along with the GPS.

14. **Education Engagement summary**

Event	Date	Number of Kids	Number of Adults
Space 2011 (Education Alley)	September 27-29, 2011	400	80
Girl Scouts Build	October 22, 2011	34	
Girl Scouts Build	November 5,2011	12	6
Girl Scouts Launch	November 20,2011	35	
Presentation to St. Norbert School	January 5, 2012	300	20
Presentation to Montessori School	January 6, 2012	40	3
Eastwood Elementary School	March 30,2012	20	10
Youth Expo	April 13th – April 15th , 2012	100	150
Cloverdale 4-H	May 1, 2012	13	7
ASAT Conference	May 19, 2012	n/a	n/a

Our team did many educational engagement events. October 22nd, November 5th and November 20th our team helped the girl scouts build a rocket and then helped them learn how to prep the rocket for launch. There was a different set of kids at the launch. On January 5th our team gave a presentation to St. Norbert School and on January 6th our team gave another presentation to Montessori School about rocketry, TARC and SLI. On March 30th we had a booth at science night at Eastwood Elementary school in Brea. April 13th to April 15th was Youth Expo in which our team informed the public about rocketry, TARC, and SLI. Attendance was down this year compared to last due to bad weather (rain!). We had a booth at the AIAA Space 2011 Education Alley, but this was technically too early to count for Educational Engagement. And we are presenting at the AIAA ASAT (Aerospace Systems and Technology) conference later in May, which may technically be too late to count.

15. Budget Summary

Our predicted budget was $6,526 and our actual spend was $10,816. This occurred because of a few reasons. First is that Body tube material was more expensive than we originally thought. Second the vacuumed bagging material and tooling board was also more expensive than what we originally thought. Thirdly the UAV parts were also more expensive that we thought. Lastly we had to launch our rocket multiple times on a larger engine.