LCCC Team Orbit Final Report: Wisconsin Space Grant Rocket Competition 2013
Peter V. Buca, Captain, May 20, 2013

The Final Report:

In April, our team was represented by myself and our advisor, Marlin Linger, at the 2013 Wisconsin Space Grant Consortium Collegiate Rocket Launch. This report will summarize the results of the launch, assess the condition of the rocket after launch, and evaluate our accomplishment of the competition objectives. On behalf of Marlin and LCCC Team Orbit, we would like to express our sincere….

…Thanks to Wisconsin Space Grant Consortium!!

Launch day was as perfect as can be imagined for a rocket competition. The sky was blue with scattered high clouds and the day was warm reaching over 90 degrees F in the late afternoon. The competition field at Bong Recreational Area was dry and clear with little to no standing water in the recovery areas. The wind was light but grew gusty in the late afternoon. Even with winds exceeding 10 mph, recoveries went very well and no one lost a rocket to the landscape.

Presentation Day:

Team Orbit arrived at the Milwaukee School of Engineering just AFTER we were supposed to have presented to the audience. The competition committee graciously allowed us to present later in the program and no one seemed to mind. We were lucky as we were able to enjoy the presentations of the other teams. Every rocket was unique and interesting and the teams were all passionate and engaged in the competition. We noted how assured everyone was and how excited they were to launch their rockets – some for the first time. The various active braking systems were amazing. We had consciously avoided any complexity in our design as we had learned in the numerous test launches we made preparing for the competition how uncertain a rocket's performance could be. The highlight of the presentations (before ours) was certainly the Indigenuity Rocket made from barrel staves and elk sinew glue. We all wanted to see that one go up successfully.

Figure 1: Idigenuity Native American Rocket

As one of the last two presentations, we wondered how we would top the previous presenters. We resolved that by focusing on explaining our simple strategy and rocket design. We were going to fly the rocket to 3,000 feet exactly by controlling the weight. Our calculations and simulations showed that the "Goldilocks" – when weighted to 7.2 lbs – would fly to 3,006 feet. Our strength was our testing and preparation along with our faith in the analysis of the rocket and its ability to match our predictions on our home field in Amherst, Ohio. Our rocket, "Goldilocks", was beautifully crafted and was the result of many hours of hard work. After the presentation, it seemed that we were welcomed and appreciated – just another of the many wonderful teams present. It was a very satisfying experience. We hoped that "Goldilocks" would have just the right amount of stuff to do well in the competition the next day.

Figure 2: Pete and "Goldilocks"

Launch Day:

We woke up early on launch day and began preparation of the rocket at about 6:00AM. The method we had settled on to add weight to the rocket was to add oil-based modeling clay similar to Sculpey into the electronics bay above the altimeters in an area created by the addition of a second bulkhead. The clay was weighed and clumped around the threaded rods that made up the central portion of the bay. We then tied it in place using plastic pull-ties. After attaching the clay, we re-weighed the rocket and shook it to check the clay mount. It held well and we felt would not be a problem during the flight.

We had a second modification we had decided to make during the long drive up the previous day. "Goldilocks" was operated by a push button protruding from the outside of the electronics bay. This worked well in testing but we were concerned that it might be accidentally pushed during landing and we might lose data. We set about moving the button to the interior surface of the instrument sled so there could be no accidental push. This seemed simple enough but with the need to mount the working charge altimeter – a Missle Works RRC2 – the primary Raven 3, and a secondary Raven 3 both used only for data collection, the job took several hours. Did I mention that our experience with rockets told us that you can never be too redundant.

We arrived at the Bong launch area a bit late but in time to see the first launches of the day. It was an amazing experience. As teams worked and launched during the morning, we continued to fine tune the rocket and prepare it for a successful flight. It wasn't until later in the afternoon that we were able to get "Goldilocks" up the inspection line. When we were inspected, there was discussion regarding the Binder Designs motor retention system which is designed to grip the Cesaroni Pro38 motor casing between the rocket nozzle and the casing using thin washers. We agreed with the inspector that this looked a bit weak. He helped us find a better way to lock the motor in place without any modification to the rocket and so we were ready to fly.

We turned in the card and mounted the rocket on the launch pad. I installed a video camera about thirty feet from the launch pad and pointed it upward to catch a good view of the takeoff. We got the go ahead to install the ignitors and ready the rocket. We did so then I turned on the video camera and headed back to the launch area. We listened to the countdown and watched as "Goldilocks" roared into the sky straight as an arrow and in perfect flight condition. The sound of the I540 motor is just incredible with a deep throaty roar and outstanding acceleration. "Goldilocks" soared upward without any wobble or rotation – nice job with the build – and we saw the puff of smoke at apogee that signaled the deployment of the 24" drogue chute. It settled gently until about 500 feet from the ground when the second charge went off. The main, however, did not get out of the rocket body and the rocket descended the remainder of the distance on the drogue. Luckily, the rocket was very well built AND we had used a slightly larger drogue to accommodate the heavier load. We walked about 1,000 feet to the landing zone and saw that the rocket was in perfect condition. We brought it back to the launch table and submitted the flight data.

After that thrilling beginning, we were very anxious to fly one more time that day. Initial barometric data had our first flight as "legal" but a bit higher than predicted. As you'll see later, the Raven 3's acceleration estimate of peak altitude was nearly dead on to 3,000 feet at 3,045. We cleaned the rocket up, reloaded it with more clay, and prepared it for another launch. By the time we were completed with preparations, we were the very last rocket launch of that glorious day. The launch was as perfect as the first, perhaps even more so. "Goldilocks" flew straight and true and just a bit lower than the first flight. All in all, it was a marvelous end to a wonderful day.

Altitude:

During the presentations on Friday, a student asked the committee which altitude reading was going to count, Barometric or Accelerometer. The answer was whichever was closer to 3,000 feet. Looking at the flight data from the Raven 3, the Barometric reading was 3,315 feet BUT the Accelerometer reading was **<u>3,045 feet</u>**. Team Orbit would like to go with the 3,045 feet reading, please, but we trust that the competition committee will make a good decision on which is the correct altitude for our flight.

Unfortunately, our second flight although lower was not recorded by the Raven 3's due to a battery connection breaking during the second flight. Our Missleworks RRCS had the second flight at 3,150 feet.

Lessons Learned:

Our primary learning was associated with the error in weight estimate we made in Wisconsin. In reviewing the build and testing, we noted that the rocket was only finished in primer on the last test we ran in Ohio. We calculated the Cd based on that test and predicted the weight with that Cd. Afterwards, we spent a great deal of time dressing the rocket in launch day color. This also had the unintended effect of decreasing the Cd. That slight but significant change in Cd could easily have accounted for the difference in performance. Lesson? Paint the rocket in final flight configuration BEFORE you run the final qualifying tests.

Another lesson was to be certain to preserve the redundancy in the electronics bay. Although we installed THREE (3) altimeters in "Goldilocks", the two Ravens failed on the second flight due to a battery breaking its mounting and pulling a wire from one of the Ravens out of the circuit block. We had two altimeters but had wired both with a single wire. It did us no good to have 3 altimeters and one wire. In the future we will establish separate battery connections for both backups and also provide direct wiring back to the main switch for each. We will also use a different method to attach the battery in the electronics bay that being a battery holder and strap system.

Finally, we learned that our method of main chute deployment was incorrect. We had screwed the nosecone to the upper rocket body tube with metal screws and used shear screws for the electronics bay to upper rocket body connection. The idea was to blow the upper body and cone off with enough force to pull out the main chute – except that the explosive force actually appeared to drive the chute bundle further into the rocket body. In the future, we will reverse that procedure installing the nose cone to rocket body with the shear pins and the electronics bay to rocket body with a durable connection.

Conclusion:

Our simple strategy worked very well. Most of the active control rockets with complex braking systems either failed during flight or failed to control the rocket altitude as predicted. We launched 6 tests before we were ready for the competition. Our only wish was to have had just one more test!

This was incredibly educational and tremendous fun. We met great people at every turn and we met no one we would not call friend. The competition is something that no one should miss. Unlike any other competition with which I ever associated, a rocket competition is not team vs. team or person vs. person. A rocket competition is man against gravity, chemistry, and mechanical systems. Winning teams represent everyone in the competition, not just themselves. We applaud every participant in this competition and congratulate whoever managed to win. It was a great experience.

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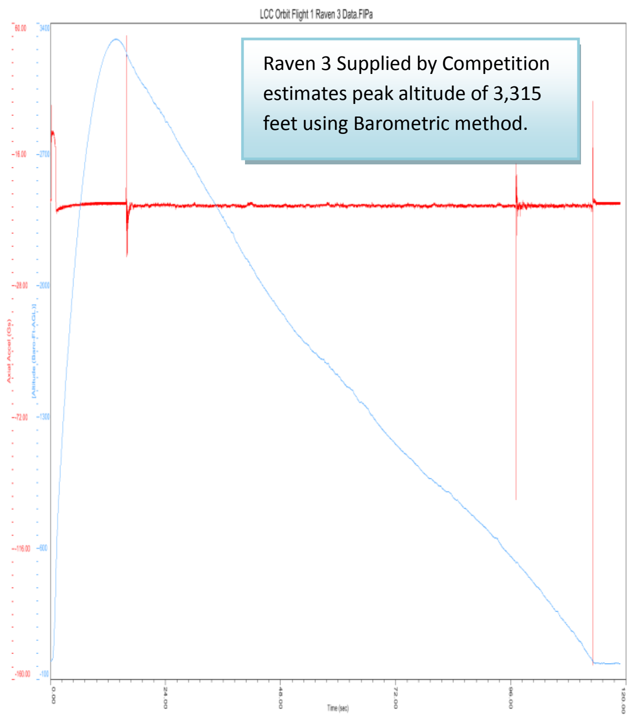
FILE: C:\Users\PeterVB\Dropbox\Wisconsin Flight Data\LCC Orbit Flight 1 Raven 3 Data.FIPa

Graph 1: Flight 1, Raven 3 Barometric Data



Graph 2: Flight 1, Raven 3 Acceleration Data

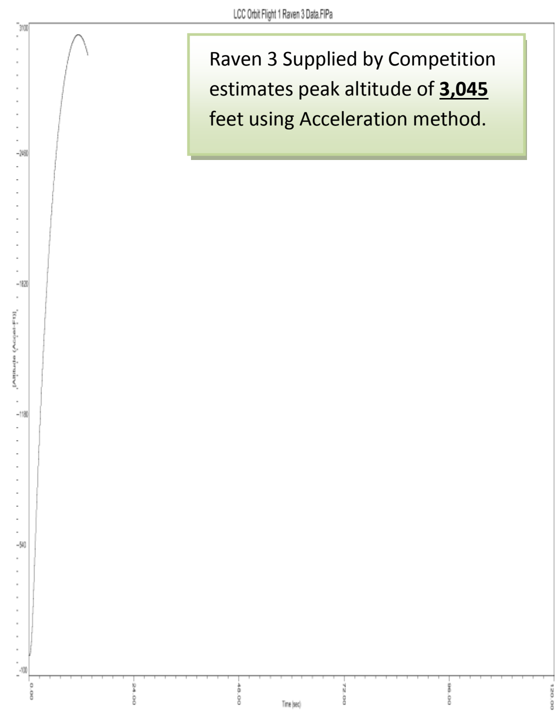


Table 1: Data taken by Raven 3 Supplied by Competition Flight 1

Parameter	Value(s)	
Average PreLaunch Altitude (ft)	539.00 feet	
Average PreLaunch Axial (Gs)	1.05 g's	
Average PreLaunch Axial Offset	1.05 g's	
Axial Accel (Gs)	Min: -3.68 g's Max: 32.59 g's	
Baro (Atm)	Min: 0.8684 atm	Max: 0.9807 atm
Current Draw (A)	Min: 0.00 A	Max: 0.06 S
Flight Count	4.00	
Motor Ignition Time (sec)	0.150 s	
Temperature (F)	Min: 91.01 °F	Max: 91.22 °F
Time (sec)	Min: 0.000 s	Max: 13.530 s
Velocity (Accel-Ft/Sec)	Min: -1 ft/s	Max: 641 ft/s
Volts Battery (V)	Min: 8.92 V	Max: 9.00 V
Volts Pyro 3rd (V)	Min: -0.02 V	Max: 0.00 V
Volts Pyro 4th (V)	Min: -0.02 V	Max: 0.00 V
Volts Pyro Apogee (V)	Min: -0.02 V	Max: 0.00 V
Volts Pyro Main (V)	Min: -0.02 V	Max: 0.00 V
[Altitude (Accel-Ft)]	Min: 0 feet	Max: 3045 feet
[Altitude (Baro-Ft-AGL)]	Min: 0 feet	Max: 3315 feet
[Altitude (Baro-Ft-ASL)]	Min: 539 feet	Max: 3854 feet
[Velocity (Accel-Ft/Sec)]	Min: -93 ft/s	Max: 635 ft/s
[Velocity (Accel-MPH)]	Min: -64 mph	Max: 433 mph

Photos & Video Links:

Video of Launch 1 on YouTube: http://www.youtube.com/watch?v=wF9pI7r_aHk

Figure 3: Goldilock on Pad 3

Figure 4: Team Orbit at Ohio Aerospace Institute

Figure 5: Community Fire Stomp