



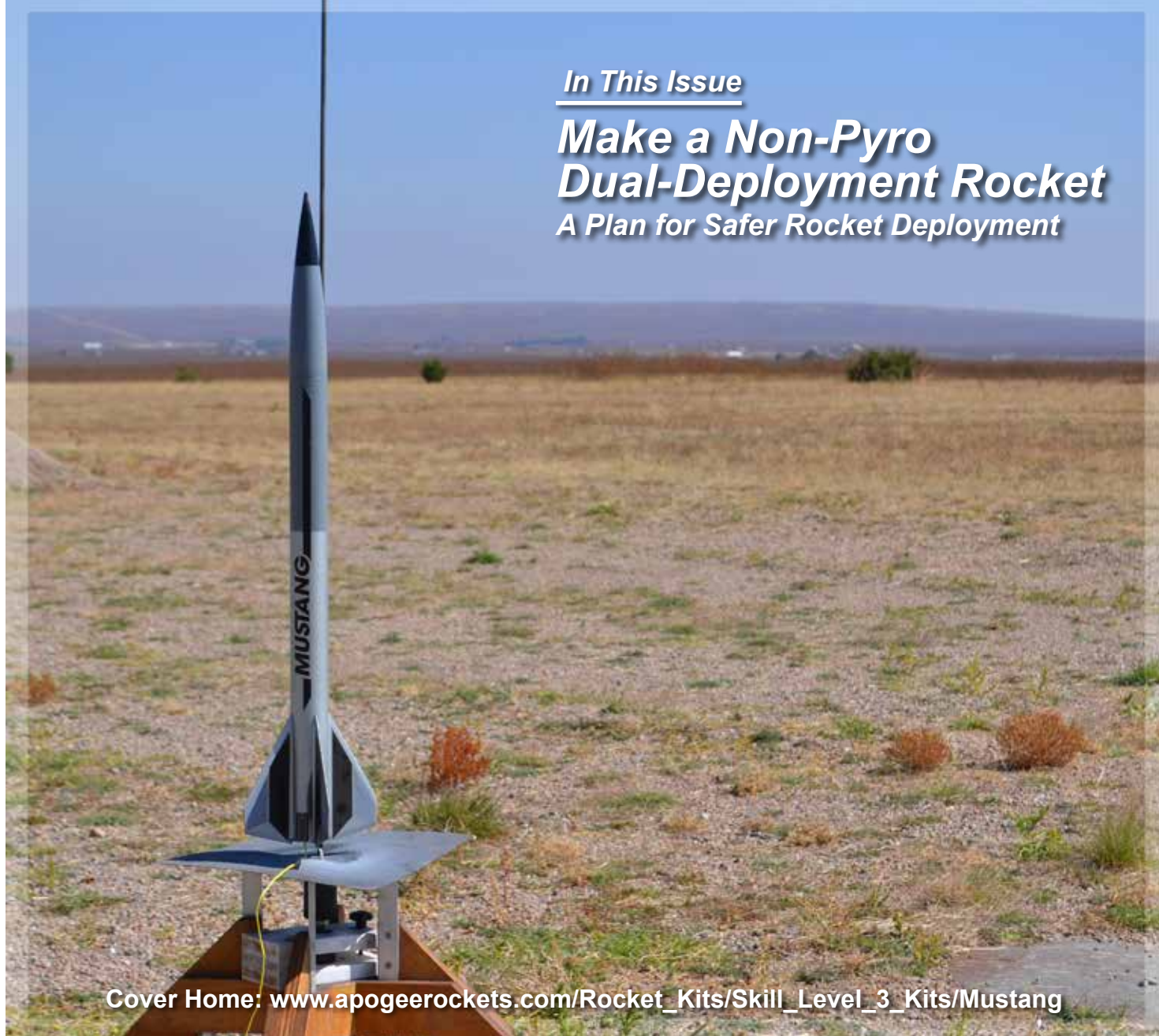
# PEAK OF FLIGHT

N E W S L E T T E R



*In This Issue*

***Make a Non-Pyro  
Dual-Deployment Rocket***  
*A Plan for Safer Rocket Deployment*



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Phone: 719-535-9335 Fax: 719-534-9050

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## Make a Non-Pyro Dual-Deployment Rocket A Plan for Safer Rocket Deployment

By Benno Kolland

### INTRODUCTION

I started flying model rockets at age 6 with my local 4H. It was only a matter of time until I discovered club launches, and then high power rockets quickly became a favorite. With each new rocket build, I like to observe how they perform. As I've flown to higher and higher altitudes, I've needed to walk further to retrieve the rockets, which got me interested in improving deployment systems. Unfortunately, minors (under 18 years) are not allowed to use additional explosive charges to separate the payload section from the booster section of a model rocket. Because of this, I wanted to design a dual-deployment model rocket system that did not require explosive charges outside the motor, so for my NARAM B division R&D presentation this year (and for science fair) I developed this project, Separation Anxiety, A Plan for Safer Rocket Deployment.

Part of my design goal, beyond a non-pyro dual deploy, was that the rocket be strong enough to land on concrete at my local flying field, and also withstand the stresses of I-motor flights up to 400 mph and 20 Gs. I also targeted a lower cost-per flight than standard dual deploy (typically \$4-\$8 per deployment).

I started researching dual deployment and found good sources: Peak of Flight Newsletter 362 <https://www.apogeerockets.com/education/downloads/Newsletter362.pdf> for details on how dual deployment works; Modern High Power Rocketry 2 by Mark Canepa is a great resource if you're new to dual deploy; and there are several dual deploy links in the bibliography at the end of this article.

This was a very challenging project. In northern California there aren't many places to launch, and I ended up having to fly several more flights than planned. I also had several electronics malfunctions, early main parachute releases, component fatigue, and aerodynamic destruction on a prototype that lead to a crash landing. I went

over budget since I had to fly many more test flights than planned. However, once I got most of the problems debugged, the system proved to be reasonably effective.

### BACKGROUND

Current model rocket deployment systems are limited to single motor ejection charges, extremely complicated CO2 systems, or explosive charges controlled by electronics. Since explosives are regulated substances, I wanted to come up with a design that was legal, safe, and simple to use.

"Dual Deploy" is a recovery technique using not only a primary parachute, but also a secondary parachute to reduce drift away from a launch site. With lower altitude rockets, drift isn't often a problem. For instance, at 150m, a rocket won't usually drift more than 150-300m away – which makes recovery simple. For flights at higher altitudes, dual deploy first releases a small parachute at apogee (peak altitude), descends rapidly from apogee, and at a pre-programmed altitude (45-350m) deploys a large main parachute for a slower descent.

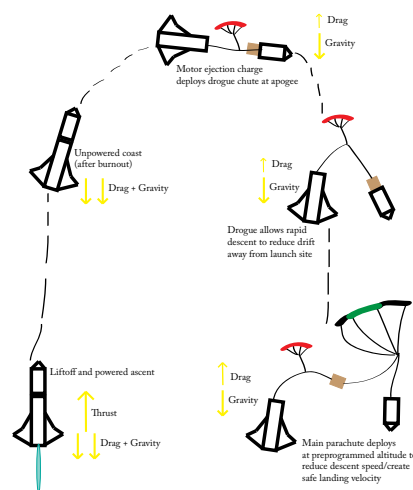


Figure 1: How Dual Deploy Works: The Trade-off between Drag and Gravity

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## A Plan for Safer Rocket Deployment

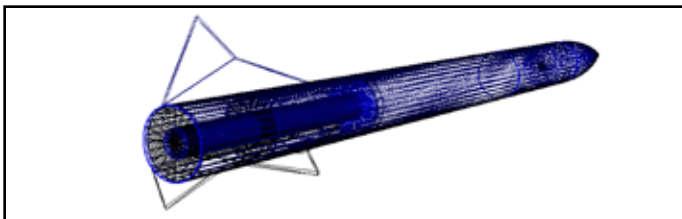


Figure 2: Early Speed and Altitude Data

Early on, I ran simulations in RockSim to collect early altitude and speed data so I could determine when to deploy the motor ejection charge.

## DESIGN ITERATIONS

I created and built two designs. Both designs used a typical 4" airframe booster with a 38mm motor mount (some flights were adapted down to 29mm). The booster used LOC tubing, Apogee 1/4" plywood centering rings, and laser cut TTW 1/8" plywood fins. For better durability and stability I would recommend using 1/4" plywood (or fiberglass) due to fin flutter.



Figure 3: Main Components of Coupler Release Design.

The preliminary design had two hatches to release the two parachutes at specified times (the preliminary dual deployment system used hatches). The hatches were to be controlled by an EggTimer altimeter I soldered from a kit. After ground testing, I had to switch hatch control over to a remote control system because I couldn't make the altimeter interface with the servos due to an initial firmware bug.

The payload section of the prototype design was 40" long and had an altimeter bay with two hatch compart-

ments actuated by model aircraft retract servos, which held the parachute assemblies. (Note the hatches and retract servos in the preliminary design in the next section.)

The preliminary design using hatches failed to deploy in its first test flight and was seriously damaged when it impacted the ground. Failure analysis of the flight caused me to rethink a design that would function better if I switched to a gravity release rather than hatches. Rather than building another copy of the questionable design, I adapted my design to simplify the non-explosive deployment mechanism using a coupler release.

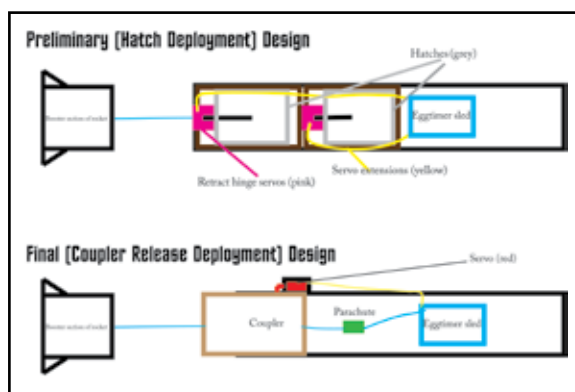


Figure 4: Design Changes

The preliminary design failed to deploy, so I switched to a new coupler design. A servo released a coupler, which then used gravity to pull out the main chute.

The Final Design I created and built had a single coupler release held in place by a servo. The idea was that the black powder ejection charge in the motor itself would eject and separate a small parachute at apogee, with the payload section hanging underneath the drogue chute. When the rocket reached the pre-programmed altitude (between 150m and 50m) the EggTimer altimeter would release the servo, causing the payload section to separate from the coupler it was linked to. This would pull out the main parachute for a soft final descent. (Note the coupler and red servo in the Final Design diagram above.)

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## A Plan for Safer Rocket Deployment

### BUILD PROCEDURE

Currently all off-the shelf deployment altimeters are set up to fire a burst of current to light an e-match to fire black powder, but lack the PWM modulation needed to control the external servo used for the coupler release. While possible to retrofit a standard altimeter, an easier, more reliable solution was an Eggtimer altimeter kit. This altimeter is sold as a solder kit, and costs \$35. It's very capable and in addition to data recording, pyro channels, airstarts, and dual deploy, it also has the software needed for servo controlling. While I had a few challenges with initial setup, designer Cris Erving released a software patch and it's been a great altimeter and servo controller for this project.

### ELECTRONICS BUILD

1. Inventory parts for Eggtimer altimeter; confirm all parts present.
2. Purchase any missing parts.
3. Solder Eggtimer kit components onto board (60+ solder points)
4. Attach resistors and servo wiring to Eggtimer for interfacing with servos
5. Test: Power up. Debug. Solder.

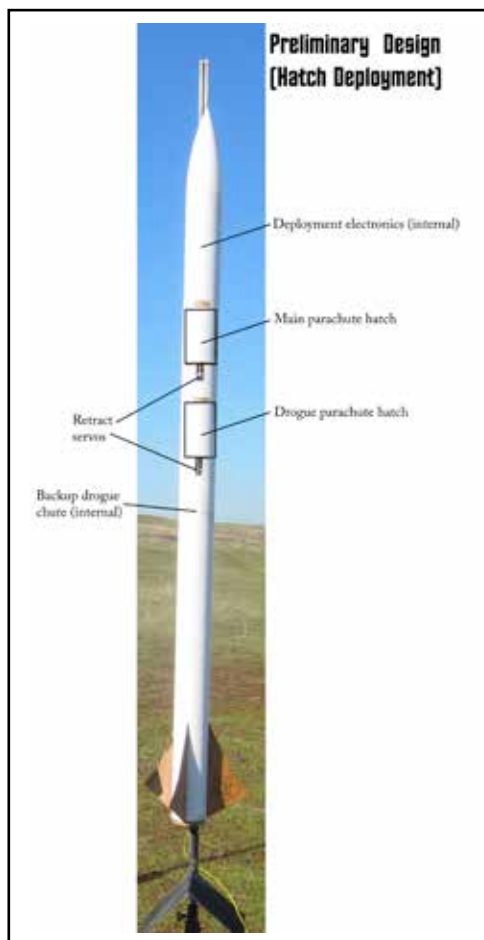


Figure 5: Preliminary Design – Hatch Deployment

Note: I had to go back and find a missed jumper and solder it before I could get the altimeter kit working. This took multiple debugging sessions.

### BUILD PROCEDURE/FINAL DESIGN

1. Using an existing length of 98mm body tube, use a hacksaw to cut a 23cm length. Cut off the back plate from nose cone to provide room for electronics.

2. Mark 76mm on the 98mm tube (bulkhead disk placement position). Glue (wood glue) a bulkhead disk 76mm into 23cm tube. Glue another bulkhead into 98mm coupler to provide anchor points. Drill 3 holes, evenly spaced on each bulkhead for pressure relief.

3. Use mouse sander to sand the glued coupler until the fit in the 98mm tube is extremely loose (for release ease).

4. Mark 5mm x 25mm slot in 98mm tube, and insert coupler 76mm into tube against the bulkhead disk previously glued. Cut out previously marked slot, cutting both tube and coupler. Mark an arrow on exterior of tube and coupler to be able to line

Continued on page 5

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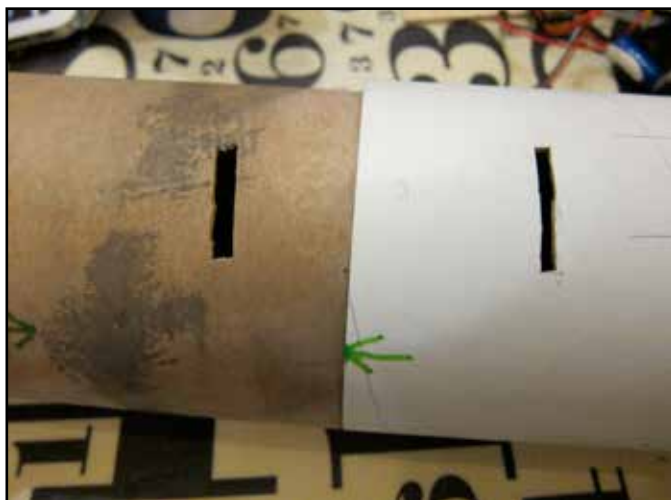


Figure 6: Servo Locking Slot

up the tube and coupler slots.

5. Line up servo so that servo arm is over tube slot and mark position. Use epoxy to glue servo in place once servo position is verified as correct.

6. Insert avionics sled (previously built and recovered) into nose end of 98mm tube. Check that sled is seated correctly. Mark 5mm servo slot line above center of sled and cut small slot in line using Xacto knife. Thread servo wire through slot and connect into electronics. Tape down external portion of servo wire with masking tape to prevent aerodynamic disassembly.

7. Affix nose cone to rocket using masking tape to provide a snug fit. Add piece of Velcro to be able to secure additional altimeter.



Figure 7: Final Design with Gravity Coupler Release Deployment

### DATA

Initial static design testing using the remote control system worked successfully, so the hatch setup was flown. However, the hatches didn't stay closed during



Figure 8: Completed Coupler Release

boost or deploy as planned. Motor eject backup prevented major damage to the booster, but the payload section was seriously damaged.

I decided on a new design with a simpler gravity release

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# PEAK OF FLIGHT

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## A Plan for Safer Rocket Deployment

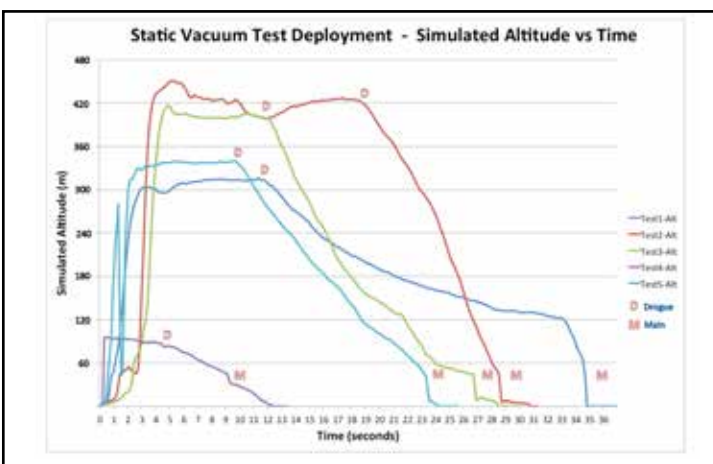
deployment system with only one servo. I built, ground tested, and then flight-tested it to 166m with the main release via radio control (RC) at approximately 75m (flight three).



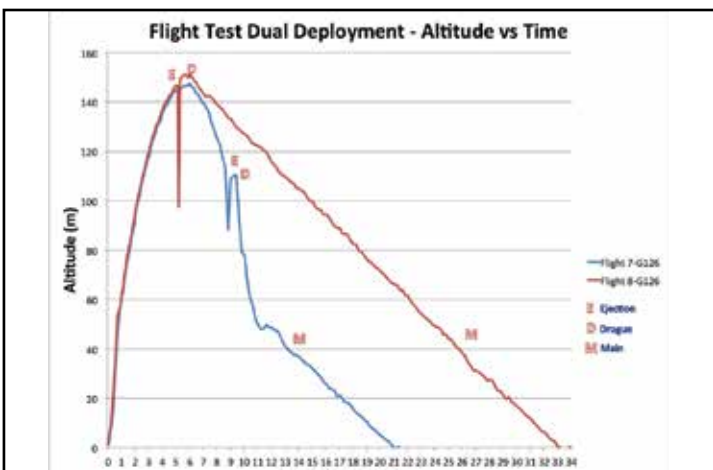
**Figure 9: Vacuum Testing to Confirm Altimeter Functionality**

I then set up the Eggtimer altimeter to deploy the main parachute rather than using RC control and flew three more test flights. None of the three flights deployed as planned. On the first flight the Eggtimer released the main chute at apogee; on the second flight, the chute was not released; on the third flight I switched to RC control and my error led to the main chute being released at apogee again.

After these altimeter difficulties, I rechecked my wiring and servo outputs and ran five "vacuum" tests that used



**Figure 10: Vacuum testing dropped the pressure, tricking the altimeter into gathering "flight" data.**



**Figure 11: After two successful low altitude flights (Flights 7 and 8), a successful flight to 750m (Flight 9, green flight path) confirmed the coupler release worked for dual deploy recovery from higher altitudes. A failed flight to 750 m (Flight 10, purple flight path) shows the longer descent rate due to early main deployment.**

Continued on page 7

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## A Plan for Safer Rocket Deployment



Figure 12: Successful Coupler Deployment!

a vacuum to trick the Eggtimer altimeter into thinking it was flying. Five successful runs showed that the altimeter successfully opened the servo at the right point during the simulated flight. The Static Vacuum Test graph points show chute release in static test. D is marked for Drogue channel output, and M for Main chute release.

After the static tests, the rocket was flown two times to altitudes of 147.5m and 151.2m with the main parachute being deployed at 45m. For these two flights, the gravity coupler release design for the main parachute worked successfully using the Eggtimer altimeter, allowing for data collection. See graph points on the Flight Test Dual Deployment graph above, marked E for motor ejection, D for Drogue parachute deployment, and M for Main chute deployment.

Finally, I flew the rocket several times to higher altitudes. The first flight used an I195 motor reaching 750m, deploying a small drogue parachute at apogee, and the main parachute deploying correctly at 100m for a successful flight.

On the subsequent flight to 750m the main parachute

deployed at apogee. The main coupler was getting very worn after 8 flights, and had bent leading to an early main parachute release. I tried an on-site repair with an epoxy patch on the coupler, but it bent again on drogue deployment leading to another early main parachute release. A coupler assembly made of reinforced cardboard, fiberglass, or carbon fiber could fix this malfunction.



Figure 13: Launch Summary

## LAUNCH SUMMARY

The eleven launches included an airframe test, preliminary hatch deployment system testing, and final flights using a coupler release deployment

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## A Plan for Safer Rocket Deployment

system. Only flights 3 and 7-9 worked successfully with dual deployment. The final two flights deployed early due to fatigue of the airframe and coupler.

### CONCLUSION

While my initial design was not successful, my final design based on a gravity coupler release worked well. Static vacuum testing showed consistent results. Of the nine flights of the final design, four had successful deployment of both chutes, and three deployed successfully using the Egg timer altimeter. The system worked successfully even in high altitude, high velocity situations. The release design for the main parachute worked reliably and was easy to prep for flight. However, after many flights the cardboard coupler assembly started to fail leading to early main parachute deployments.

This system enables a lower cost and simple alternative to handling black powder charges for dual parachute deployment. Total cost per flight is no more than the cost of the motor, as resetting the electronics and prepping the deployment system does not require black powder or igniters. My alternative design saves approximately \$3-\$5 per flight compared to the black powder ignition systems, and is legal for minors to use.

### NEXT STEPS

I would like to investigate building a smaller, lower drag system to fit a sub-75mm diameter fiberglass airframe, with an internal servo to reduce drag. A fiberglass airframe should prevent the airframe and coupler from weakening, and a smaller airframe would make higher flights possible. I would also like to explore other kinds of high power rocket deployment and recovery systems.

### BUDGET FACILITIES

I flew the rocket design at LUNAR club launches, both at Moffett Field, CA, and Snow Ranch, Farmington, CA. I laser cut the fins at Techshop San Jose. Static testing and build were done in Santa Cruz, CA.

The primary costs of the project were motors, as building supplies were fairly inexpensive and I already had all of the R/C gear used in early tests.

Model Rocket Booster:

98mm cardboard tubing-\$12

Plywood Centering rings (3)-\$6

38mm motor mount tube-\$6

Assorted hardware-\$10

Assorted test motors (in order flown:

H140, H100, G250, I170,

H100, I242, G126, G126,

I195, I195, H225)-\$358

Payload Section:

98mm cardboard tubing-\$12

Hardware-\$20

Egg timer Altimeter-\$30

RC Servo-recycled but typically costs \$10

Other parts repurposed from previous projects (servos, batteries, transmitter, receivers, backup altimeter, misc. building supplies).

Total costs: \$454, versus planned \$250. The extra cost is due to flying 11 flights instead of the originally planned 6. Extra flights were needed after redesign.

No analysis would be complete without a cost comparison between this system and conventional explosive dual deploy. Conventional dual deploy typically costs around \$4 per flight in addition to the motor due to needing electric matches and black powder. However, this design does not require any ignition systems or explosives, and so the only cost per launch is the motor.

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## A Plan for Safer Rocket Deployment

The Eggtimer and servo cost \$35, which is quite inexpensive compared to similar black powder deployment altimeters.

## ACKNOWLEDGMENTS AND HELP RECEIVED

Many thanks to: David Raimondi (President, LUNAR/Livermore Unit National Association of Rocketry) for suggestions based on his experience with parachute systems. Dave Cornelius (Vice President, AMA Engineering, Hampton, VA) for failure analysis help on my initial design. Cris Erving for Eggtimer design and software support. The judges at Santa Cruz County Science Fair and California State Science Fair. Zach Dunn for support and encouragement. And my dad, Jay, for driving to launches, for ground support at launches, and for programming/debugging help with the altimeter editing interface (vi).

### About the author:

Benno Kolland, age 16, has been flying rockets since 2005 and certified Junior L1 in October 2014. He's especially interested in the propulsion aspects of rockets and high altitude flights, but also likes designing efficient recovery systems. He recently completed his first year as a TARC team captain, received a 4th place category medal at the California State Science Fair, and placed 1st

in the NARAM 57 R&D B division. He is already planning for his L2 and L3 certification flights to take place in February 2017, right after he turns 18.

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