University Student Launch Initiative

HARDING UNIVERSITY

Critical Design Review

February 4, 2008

The Team

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Progress

Since Preliminary Design Review:

- Design revisions (primarily in avionics bay)
- Major construction progress on airframe and electronics bay
- Publicity with local papers and statewide TV

I. Technical Design

Airframe:

- 94″ (2.39 meter) length
- 3.1″ diameter
- 54mm hybrid (Contrail Rockets I through K motors)
- Designed to reach target altitude of one mile

I. Technical Design

- Aft section: 34” long 54mm motor mount tube

- Fins are composed of a composite sandwich:
  - 1/8 inch 3-ply birch plywood
  - 6 oz. fiberglass
  - carbon fiber
  - 6 oz fiberglass
  - 1/8 inch 3-ply birch plywood

- Fin joint with motor mount tube was reinforced with carbon fiber, as pictured.

I. Technical Design

Middle tube section (20″ in length):

- Aft 10″ section houses scientific payload (spectrometer) which gathers data on the exhaust plume via a fiber optic cable

- Forward 10″ section houses recovery electronics on a core electronics support structure surrounded by removable, transparent acrylic tubing.

I. Technical Design

Recovery electronics section: clear acrylic tubing around internal support structure (threaded rods not pictured)

I. Technical Design

Recovery electronics section: clear acrylic tubing around internal support structure (threaded rods not pictured).

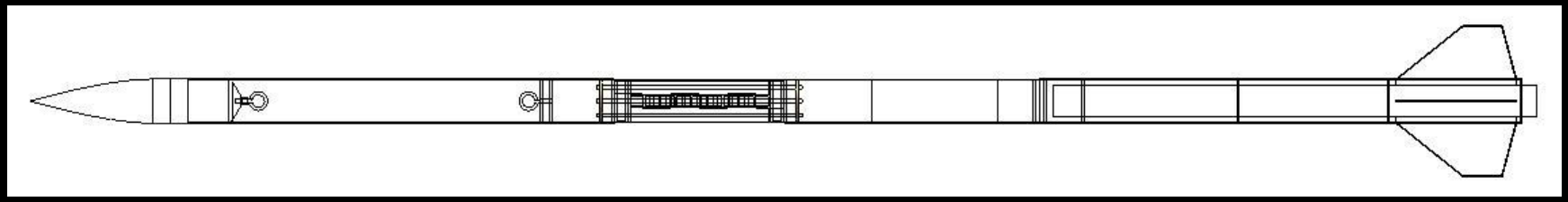
One 9 volt battery installed.

I. Technical Design

Forward body section

- 28″ tube and nose cone
- Contains drogue parachute, main parachute, Chute Tamer deployment device

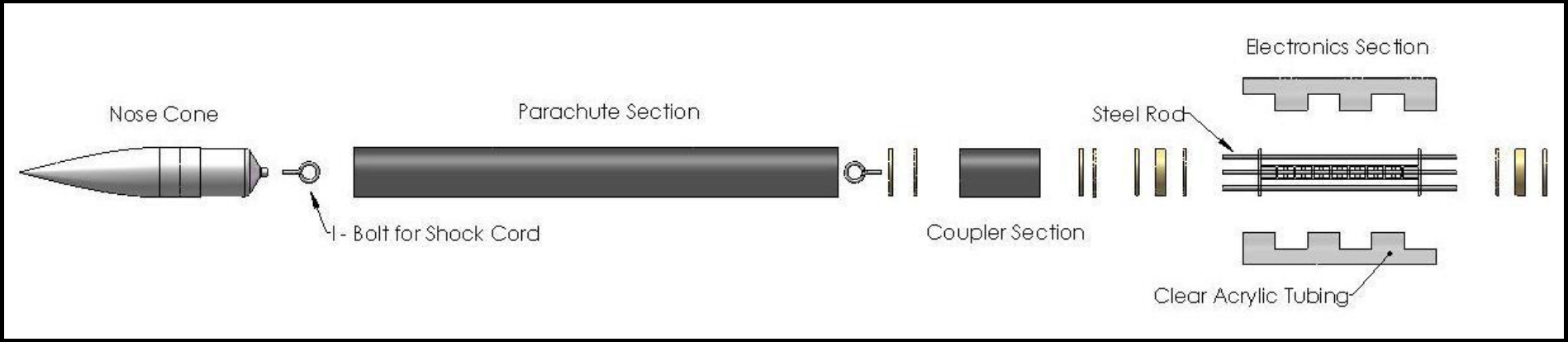
I. Technical Design



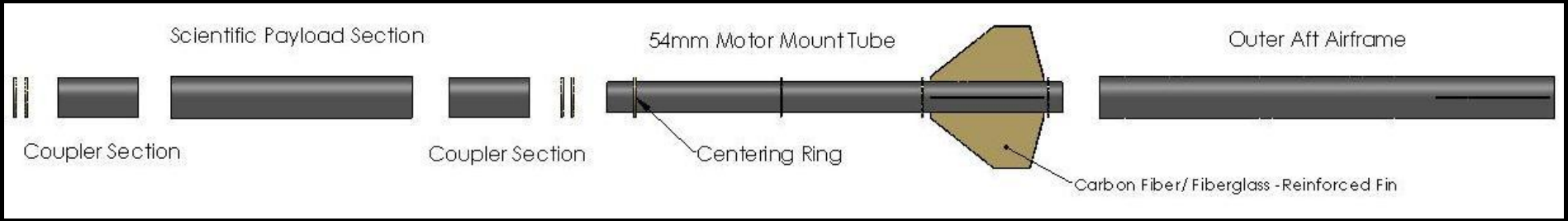
Side View with SolidWorks 2007

Left to right: nose cone, 28″ parachute section, 4″ transition section, 10″ clear acrylic electronics bay (with internal structure shown), 10″ scientific payload bay, 34″ main aft tube with fins.

I. Technical Design

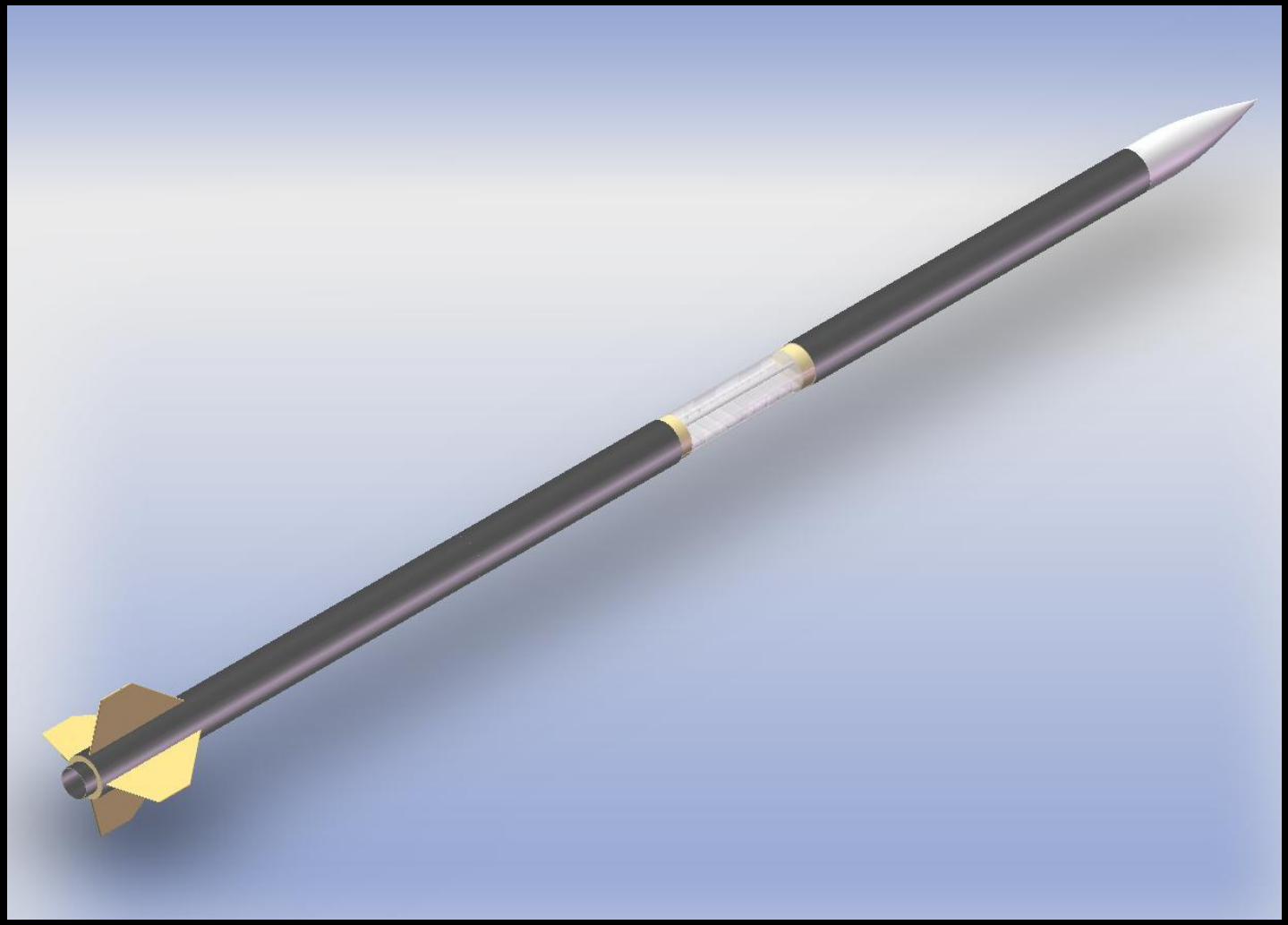


3-D Rendering of Forward Section with SolidWorks 2007



3-D Rendering of Aft Section with SolidWorks 2007

I. Technical Design



3-D Isometric Rendering with SolidWorks 2007

I. Technical Design

- Motor: Contrail Rockets 54mm J-234 (total impulse of 1033 Newton-seconds).
- Nitrous oxide oxidizer, stored in portable tank (complete filling system owned by Harding)
- Rocket design can accommodate up to 36” long 54mm motor

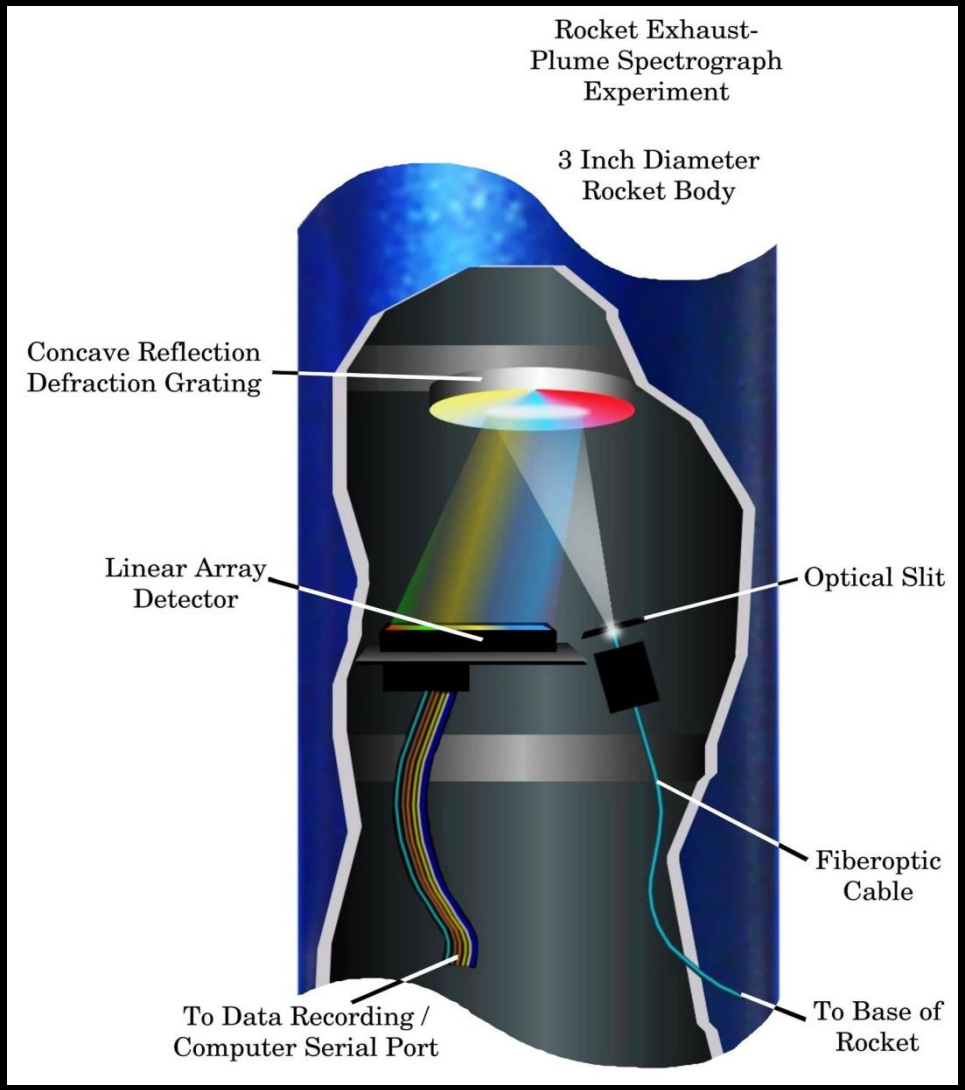
I. Technical Design

Electronics include:

- Perfectflite MAWD logging altimeter unit
- Boostervision wireless color 2.4Ghz Wireless Micro Camera will record in-flight video.
- R-DAS flight computer (measurements and transmission of telemetry) backup for parachute deployment and data logging
    - stores information from spectrometer
    - GPS board
    - telemetry transmitting and receiving capabilities.

I. Technical Design

Cutaway diagram of custom-built spectrometer in avionics bay.



I. Technical Design

Experiments to be flown in rocket:

- Custom spectrometer (based on a commercially available SpectraWiz compact spectrometer) to study hybrid rocket exhaust plume via fiber optic cable

- R-DAS GPS system (allowing in-flight tracking of the rocket)

- R-DAS accelerometer and altimeter components.

- Perfectflite altimeter.

I. Technical Design

Experiments to be flown in rocket (continued):

- Onboard spectrometer will yield spectral data from the hybrid rocket exhaust plume in flight.
- Combustion intermediates such as hydroxyl radical will be identified in the spectra.
- In-flight video will allow for frame-by-frame analysis synchronized with the spectrometer and positional data

I. Technical Design

Project goals:

1. Build a rocket capable of reaching 5280 feet and capable of being reasonably retrieved via dual deployment recovery techniques.

2. Build a working science package including a spectrometer that can be used to analyze the plume gradients.

3. Complete construction, testing, and flights safely, on schedule, and on budget.

4. Share information about science, rocketry, and NASA with local media and schoolchildren through outreach programs

2. Outreach

- **Harding USLI team has been featured several times in Searcy's Daily Citizen newspaper.**

- **Project Leader Brett Keller presented this poster at the Arkansas INBRE scientific conference and won 2nd place in the physics division.**

In-Flight Recording of Exhaust Plume Spectra of a Hybrid Rocket

Brett D. Keller, Department of Chemistry, Harding University, Searcy, AR 72149

Abstract

NASA Marshall Space Flight Center is sponsoring a collegiate competition in rocket construction so that students will have the opportunity to go through a complete engineering systems problem as they propose, design, defend and fly a rocket that will go exactly one mile high and carry a scientific payload. The design and construction project will be monitored by NASA engineers who will evaluate and make suggestions during the various reporting stages: Preliminary Design Review, PDR, Critical Design Review, CDR, and Flight Readiness Review, FRR. A final report is also required. The Harding University Flying Bison team of eight members has submitted its proposal and is presently designing a hybrid rocket to reach the required altitude and carry a spectrometer to measure the exhaust plume of the rocket as it is deployed. Design characteristics of the rocket and the payload are given.

Figure 1. 2006-07 Harding USLI team with competition rocket.

Figure 2. USLI 2006-07. Readying the rocket for flight at the Army's Redstone Arsenal.

Introduction

The NASA University Student Launch Initiative is an educational program where teams of undergraduates representing universities across the nation compete to design, build, fly, and document a rocket vehicle carrying an original scientific payload. The Harding University "Flying Bison" team competed in the first (2006-07) year of the USLI competition (Figures 1-2). A simple photodiode was flown as a payload to measure the emission intensity of a hybrid rocket exhaust plume in flight. The rocket flew to a maximum altitude of 1100 feet instead of the intended 5280 feet due to fueling problems in the hybrid rocket motor. Due to an electronics malfunction, no data was obtained from the photodiode detector assembly.

In the 2007-08 competition the Harding team is designing a rocket to build on the partial success of the previous year's competition. A 3.1" diameter airframe is being used instead of 4.0" airframe to improve performance and reduce fuel requirements. A specially designed rocket plume spectograph is being constructed, to be housed in a custom-built avionics bay and interfaced with the AED Rocket Data Acquisition System (R-DAS) which transmits data to the ground via radio telemetry signals in flight. Contrail Rockets brand hybrid rocket motors, which use solid polyethylene as fuel and liquid nitrous oxide as oxidizer will be used. The target altitude (specified by the NASA competition managers) is 5280 feet.

Figure 3. Rocket exhaust plume spectograph experiment. The light from the fiber optic cable passes through an optical slit and is reflected off a concave defraction grating onto a linear ray detector connected to the R-DAS flight computer.

Experiment

The experiment around which the 2007-08 rocket vehicle is designed is represented in Figure 3. The goal is to measure the spectrum of the exhaust plume in flight. A fiber optic cable terminates at the aft end of the rocket where it is directed at the hybrid rocket exhaust plume. The forward end of the fiber optic cable terminates at an optical slit in the experimental chamber. The light is reflected off a concave refraction grating onto a linear ray detector, which measures the intensity of light at various wavelengths and communicates the data to the R-DAS flight computer. The R-DAS stores the data and simultaneously transmits it to the ground via radio telemetry for retrieval in recovery of the rocket vehicle is not possible.

Figure 4. SolidWorks rendering of 2007-08 test vehicle. A test rocket was constructed to allow flight testing of electronics components without the use of full flight power. The test vehicle has been flown an Aerotech H168 Redline solid fuel motor and will next be used to flight-test the R-DAS flight computer and associated telemetry components.

Figure 5. Test flight of Brett Keller's Level 2 certification rocket on an Aerotech J350 solid fuel motor. Exhaust plume size and intensity allows for spectroscopic analysis.

Design Process

The NASA USLI process requires the submission of progress reports throughout the design, construction and testing phases of the competition, in order to simulate a complete systems engineering. As of November 2007, an initial proposal has been submitted and approved. Upcoming reports include the Preliminary Design Review and Critical Design Review as the plans for construction become more certain. The Flight Readiness Review is a final check in the process to assure the flight vehicle may be flown and recovered safely via parachute. After the competition flights a final report is submitted to document the actual performance of the vehicle. The self-determined criteria for success of the Harding USLI 2007-08 project are 1) the attainment of 5280 feet altitude to as close a margin of error as possible, 2) safe recovery of the rocket vehicle in reusable condition, and 3) return of spectroscopic data from the hybrid rocket exhaust plume allowing the identification of at least one significant combustion intermediate, such as hydroxyl radical.

Acknowledgement

Funds for this project are being provided by the NASA EPSCoR (Experimental Program to Stimulate Competetive Research and the Arkansas Space Grant Consortium. Special appreciation to Harding University Student Launch Initiative team members Paul Elliot, Greg Lyons and Dr. David Stair for design assistance and illustrations, and to Dr. Ed Wilson for experiment design and guidance.

2. Outreach

Flying Bison Outreach Coordinator Megan Bush and Harding University President David Burks appeared on Channel 7's *Good Morning Arkansas*, Arkansas' most-viewed morning show, to talk about the USLI competition.

3. Project plan

- **January: Bench testing of spectrometer with R-DAS and other electronics components**
- **February 4: Critical Design Review (tentative)**
- **February 9: Memphis launch; test fly Perfectflite MAWD in Dr. Wilson's Level 1 rocket with hybrid I motor.**
- **February: Complete airframe construction of competition vehicle**
- **March 8: Memphis launch: test flight of competition vehicle on hybrid I motor**
- **March 31: Flight Readiness Review Presentation Slides and FRR Report due**
- **April 7: Flight Readiness Review (tentative)**
- **April 12: Memphis launch: test flight of competition vehicle on J-234 hybrid motor (full power, full scale test flight)**
- **April 18: Flight Hardware Check (tentative)**
- **April 19: Launch Day (Rain date of April 20)**
- **May 12: Post-Launch Assessment Review**


HARDING
FLYING BISON