CSU IREC Team – ARIES I

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Project Overview

- Experimental Sounding Rocket Association (ESRA)
- Basic Category (10,000 ft AGL)
- 10 pound payload
- Recoverable in re-flyable condition
- Remote arming and launch
- Remote oxidizer filling
- Competing against 49 other universities

{{1, WFF Sounding Rockets, Wikipedia}}
Objectives

- Compete at the IREC on June 24th – 28th
- Design, build, and launch a sounding rocket capable of reaching a prescribed altitude
- Develop a payload to collect scientific data during flight
- Accurately position ten pounds of payload to 10,000 feet above ground level
- Recover rocket in re-flyable condition
Design Summary

• Airframe
  • Commercially obtained high power rocketry components

• Propulsion System
  • Hybrid rocket engine
  • Constitutes the majority of our initial design work

• Payload/Experiment
  • NASA Space Grant carbon dioxide sensor
  • Hybrid rocket motor fuel vibration analysis
  • In-flight horizon and solar tracking

• Recovery System
  • Altimeter
  • GPS Beacon
  • Dual deployment parachutes
Hybrid Engine Design

- Liquid oxidizer is combined with a solid propellant
  - Requires valve, injector, tank, and fluid systems at a minimum
  - The solid fuel is typically a polymer with additives such as powdered metal or wax to increase combustion energy

{[3], Space Safety Magazine}
Our Hybrid Rocket Engine

- Aluminum 4” OD and 36” long tube
- Encloses:
  - Injector
  - Fuel Grain
  - Nozzle
- Designed for:
  - 300 lbf average thrust
  - 12 second burn
  - Specific impulse of 230 seconds
1. The bottom washer fails due to the heat of the solid fuel ignitor
2. The top washer is insufficient to hold the tank pressure and fails
3. The piston is forced down by the pressure from the oxidizer tank
4. Oxidizer is able to flow into injector cavity and through injector orifices
Nozzle

- Medium grain graphite
- Area expansion ratio of 6.0
- Held with retaining ring and steel washer
Recovery System

• Dual parachute deployment
  • Toroidal main parachute, 15 feet in diameter
  • Hemi-spherical drogue parachute, 3 feet in diameter
• Black powder charges used to shear plastic pins and separate rocket sections

{{2}, West Rocketry}
Payload

- **Atmospheric carbon dioxide sensor**
  - Courtesy of Colorado Space Grant Consortium (COSGC)
    - Developed as a weather balloon payload in the summer of 2014
    - Collected atmospheric data up to 100,000 ft.

- **Rocket orientation logging program**
  - Raspberry Pi microcontroller with video module
  - Analyses pixels in image to determine the horizon
  - Runs a code to determine the angle between the horizon and the rocket’s orientation

- **Vibration analysis zone**
  - Test masses submerged in different fuel grain mixtures
Testing (the fun stuff)

- Ignition system testing
  - Performed nearly 50 tests of the ignitor/injections system to achieve a reliable design

- Injector water flow testing
  - First injector performed poorly
    - Resulted in a motor burnout
Testing

- Parachute ejections testing
  - Drogue ejection is nearly complete
- Hot fire rocket motor testing
3rd Hot Fire Motor Test

- First truly successful test of the motor
- Insufficient thrust, ~175 lbf average
  - Have a plan to modify parameters to receive the necessary thrust
3rd Hot Fire Test
Conclusion

• Still have some work to do, but should be able to finish by the end of this semester
• Will be ready for the competition and plan to perform well with our rocket
• Have had a blast creating this rocket and thanks to the Colorado Space Grant Consortium for your support!
Questions?