

Multi-disciplinary University of Colorado Hybrid Student Rocket Project



Stacey Bagg

Richard Bell

Bradley Crittenden

Wesley Haigh

Robert Wuest

Jared Santistevan

Leon Slavkin

Design Changes

Technical
Progress

Test Plan

Current Status



Prior Issues

1. Multiple Tests

- A second combustion chamber is being fabricated. With two combustion chambers a second test may happen.

2. Ignition System Safety

- Extinguisher powder purchased, by Trudy, to allow safe storage for magnesium in Projects Room.

3. Component/Subsystem Testing

- We will be verifying all subsystems during setup at Lockheed Martin



Ansul Met-L-X Class D
Extinguisher Powder

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Design Modifications

System	Change Made	Reason
Injector	Holes drilled in side of injector plate and housing	For placement of thermocouples to measure temperature during test
Injector	Inner radius of housing widened	Not enough tolerance in drawings
Combustion Chamber	Inner radius of endcaps widened	Not enough tolerance in drawings
Feed	Changed order of components	Will give more accurate flow data from Turbine mass flowmeter

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Current Issues and Risks

- ▣ Remanufacturing parts
 - ▣ Unexpected delay caused by injector housing jamming on first combustion chamber. Housing was cut in order to remove it.
 - ▣ We are mitigating this by constructing a second combustion chamber for the first test, and a new injector housing has been machined.
 - ▣ All components (except new combustion chamber) need to be completed for March 10th integration at Lockheed
 - ▣ New combustion chamber with fuel needs to be completed for testing March 19th

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Manufacturing Progress

System	Complete	What's Left
Combustion Chamber	One chamber done	Second chamber needs to be complete by 3/12, and fuel cured by 3/19
Feed	Connection to injector complete	Waiting arrival of tank connectors (this week) and regulator (3/17); cannot be finished until integration with mass flowmeter at Lockheed
Injector	Injector plate and top injector fitting done	Remake injector housing
Test Stand	Brackets and frame welded	Make and attach belly bands, and we need to talk with Lockheed about the interface plate

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Electronics and Software Progress

Electronics	Status
Ignition System	All wiring and power supply acquired and tested
Hot Fire Test	All pressure transducers acquired and thermocouples purchased. Connections with Lockheed Martin setup to be made during integration, week of 3/10.

Software	Status
Hot Fire Test	Labview software, used by Lockheed Martin, has a set of variables to be customized for specific tests. All software to be finalized during integration, week of 3/10.

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Completed Tests

Test	Data Taken	Conclusions
Coefficient of Discharge Test	Found the volume flow of water through different designs for injector plates	Determined hole size and number that gives required coefficient of discharge
Carbon Fiber Tensile Test	Found tensile strength of carbon fiber struts	Twelve wraps of carbon fiber will give safety factor of 3; this is the same number of wraps used by previous teams

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Completed Tests- Ignition

Ignition			
Test	Date	Data Taken	Purpose
Ignition Calorimeter	3/2	Temperature of water	Verify energy output of igniter

- ▣ Lessons from the initial testing-
 - Finished igniter does not react with water
 - Finished igniters require solid connection to battery; pyrogen is very safe to make and handle
 - Epoxy determines how easily the igniter can be molded; low viscosity epoxy is recommended
- ▣ Extra material left for further testing
 - Further testing planned to refine molding techniques and determine geometry-dependant burn rates
 - Also possible tests with cerafiber to insure that injector will be protected

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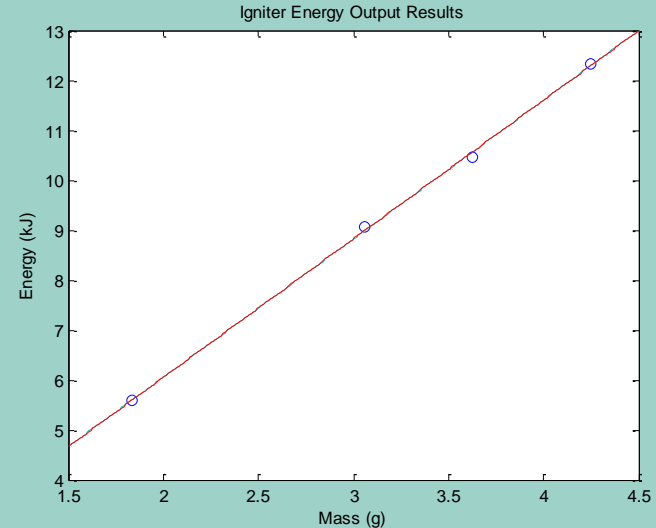


Completed Tests- Ignition

- ▣ Ignition testing averaged 2.95 kJ/gram output
 - 2.4% STD (0.072 kJ) in test results
 - 3.1% (0.094 kJ) greatest variation
- ▣ Analysis predicted 2.38 kJ/gram output

- ▣ Spherical igniters burn ~1 sec
 - Not micro-seconds

- ▣ Safe to work with



Linear Relationship!

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Planned System Tests

Feed			
Test	Date	Data Taken	Purpose
N ₂ O Flow	3/10	Pressure drop and mass flow rate of N ₂ O	Verify pressure profile of feed system
Oxidizer Tank Pressure Test	3/10	Pressure	Verify strength of oxidizer tank
Leak Test	3/8	None	Verify no leaks in feed systems

- ▣ The N₂O Flow test necessity is currently being discussed
- ▣ The Oxidizer Tank Pressure test will pressurize an oxidizer tank up to 1.5x MEOP, 1800 psi, and will be done only if Lockheed needs to verify the oxidizer tanks

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Final System Testing

Number	Test	Date	Data Taken	Purpose
1	Hot Fire	3/17- 5/4	Thrust, pressures, temperatures, mass flow rate of N ₂ O	Fire rocket engine and validate performance
2	Weigh In	3/16	Mass	Validate weight of rocket

- ▣ These two tests validate the performance of the assembled engine. The mass and thrust found in these tests will be used in our code that assesses altitude. Our goal altitude is 15000 ft.
- ▣ Thrust is measured using a load cell on the test stand
- ▣ Temperatures and pressures are measured to provide data about the system. These can be used to assess any variations in expected results.
- ▣ Two hot fire tests can be conducted at Lockheed Martin
- ▣ Need to buy oxidizer for each test; we have enough fuel for two tests

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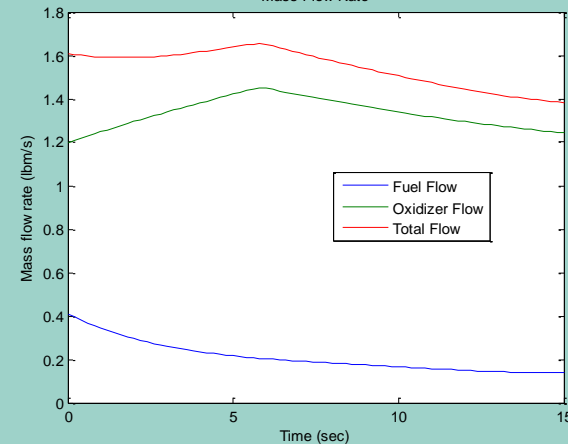
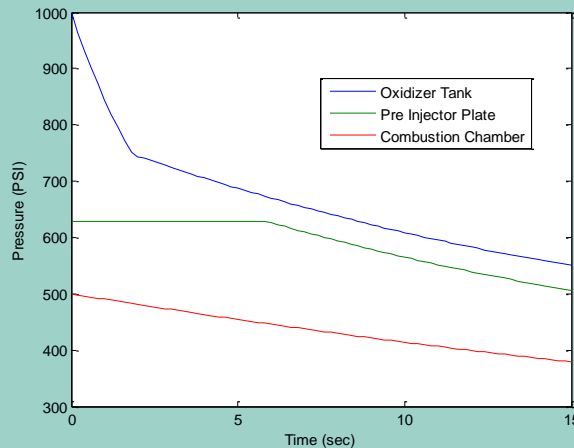
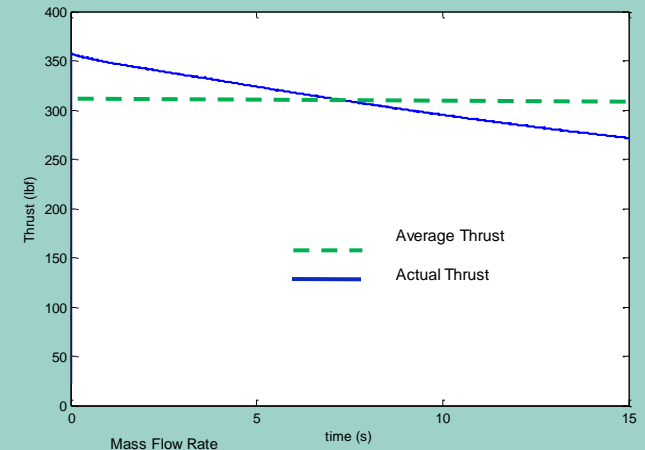
Test Plan

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Analysis of Test Results

- Analysis completed in the fall provides models for-
 - Thrust Profile
 - Pressure Profile
 - Igniter Energy Output
 - Igniter Pressure Output
- The analytical results developed in the fall will be compared to the empirical results achieved through testing



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Current Status

- ▣ Integration with Lockheed Martin is on Monday the 10th
 - ▣ Need a complete test stand, feed system, injector system, combustion chamber, nozzle and sensors for integration
 - ▣ Expecting to make multiple trips that week to ensure everything is ready for the test
- ▣ Hot-Fire Test is during the week of the 17th
 - ▣ For the hot fire test need fuel cured in combustion chamber, ignition materials at LM and igniters prepared in advance, software set up, and test plan approved
 - ▣ First and second hot fire tests can go ahead whenever we are ready and the engineers at LM are available. Test date is flexible.
- ▣ Final Review for PAB is on 4/14
 - ▣ First test will be completed almost a full month before final review

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Budget and Schedule

- ▣ Integration on Monday
- ▣ Current expected cost is less than \$7000
- ▣ \$8400 Budget [Thanks to UROP (\$3000) and EEF (\$1400)]
- ▣ 20% Margin

3/1-3/7	3/8-3/14	3/15-3/21
IR#2	Integration at Lockheed Martin	First Hot Fire Test! (3/19)
Complete Manufacturing	Second Combustion Chamber Complete by 3/12	Analyze state of CC, determine which chamber could be used for a second test
Finish Test Plan and FFMEA for Lockheed Martin	Start Fuel Casting in Second CC	If second test, start curing fuel by 3/21
Leak Test of Feed System, Ignition Test	Dry run/system testing at Lockheed Martin	Begin analyzing results of first hot fire test
AIAA Conference Paper		
Exploring Engineering Day		

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Conclusion

- ▣ Experiencing delays in getting materials and in manufacturing
- ▣ Budget still has 20% margin
- ▣ Testing schedule has been solidified through frequent communication and visits to Lockheed Martin
 - Recently, some (minor) problems communicating with LM
- ▣ Team continues to work cohesively and with dedication towards our hot fire goal

It's Over!



Questions?



