

Multi-disciplinary University of Colorado Hybrid Student Rocket Project



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Resolution of
Prior Issues

Design
Summary

Test Plan

Current
Progress



Prior Issues

1. Ignition System Safety

1. Test Vessel- A new, safer test has been designed and will be discussed later on.
2. Material Storage- A safe minimal amount of material will be stored at CU while material to be used in hot fire testing will be shipped to Lockheed Martin. On day of test, pyrogen will be assembled by trained Lockheed employees with our guidance.

2. Availability of materials

1. Schedule and budget allowed for purchase of materials identical or comparable to previous designs

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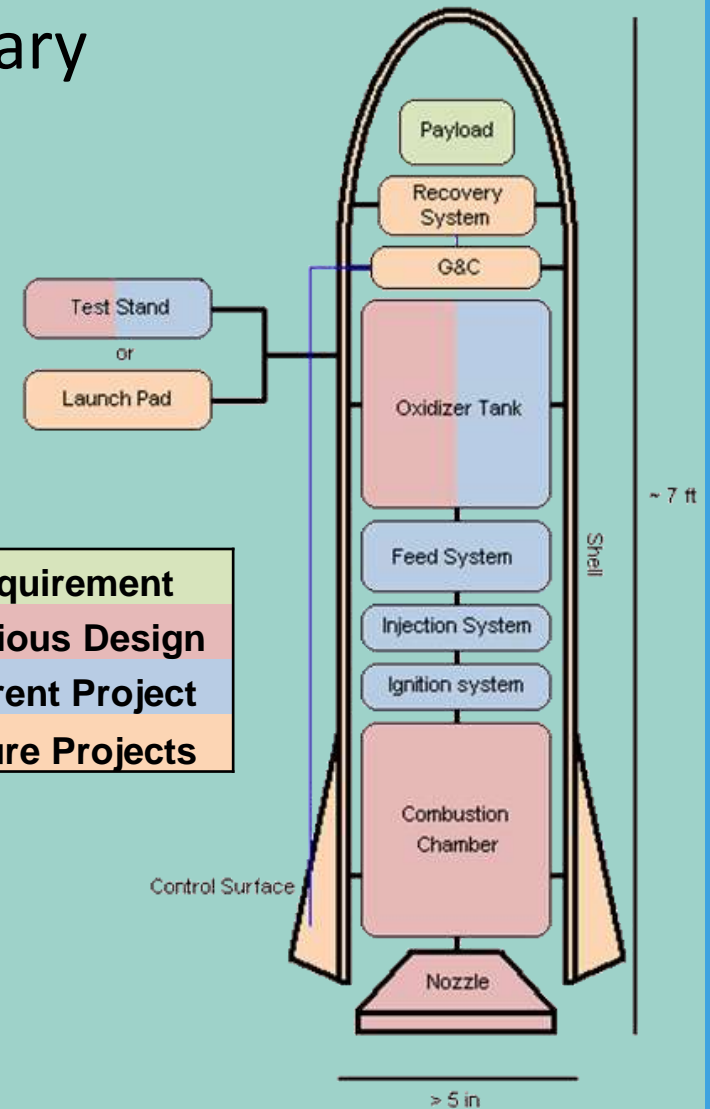
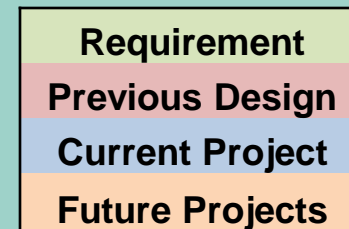
Test Plan

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Design Summary

- Oxidizer Tanks hold N_2O
- Feed system transports N_2O to the injector
- Injection system sprays oxidizer into the combustion chamber
- Ignition system (at start), or heat from fuel combustion dissociates the oxidizer, and vaporizes the HTPB fuel
- Oxidizer and fuel mixture combusts, raising temperature and pressure
- Nozzle accelerates combustion gases, increasing the force of the rocket motor
- Test stand and instrumentation take data on temperatures, pressures and thrust generated



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Design Changes

System	Change Made	Reason
Injector	Safety head removed	Unnecessary as there is no pressure source above 1200 psi and all equipment is rated to 1500 psi
Feed	Flowmeter changed	Vibrations in test would interfere with previous model
Feed	Line lengthened to incorporate flowmeter	Allows smooth flow into flowmeter
Feed	Number of solenoid valves reduced from 5 to 2	3 valves determined to be unnecessary for testing
Test Stand	Outer frame and bearings removed	Lockheed Martin will supply frame and bearings
Fuel	Ratio of material in fuel changed	Castor oil and carbon black ratios in previous report flipped

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Safety - Issues

System	Problem	Solution
Ignition	Projects lab poorly equipped to store current amount of material	(a) Ship excess to Lockheed (b) Split up storage locations (c) EH&S disposal of excess by Feb. 15 th
	Need material for calorimeter test at NCR	Retain 0.5 lb Mg and 1 lb KNO ₃ at projects lab (NFPA code does not apply to these amounts)
	Previous test vessel unsafe	New test is a calorimeter test where ignition happens in closed vessel submerged in water. Testing will occur off campus.

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Safety - Issues

- ▣ Packaging/Transportation
 - Transportation laws will be thoroughly examined
 - EH&S will be asked to aid in packaging (Mg and KNO_3)
- ▣ Material Safety and Data Sheets (MSDS)
 - ▣ Check-off sheet will be posted in locker
 - ▣ Electronic copies of MSDS kept online
- ▣ Hot-Fire Testing
 - Failure Mode and Effects Analysis for Lockheed to be completed

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Test Overview

- ▣ Seven tests planned to verify, validate the rocket
- ▣ Multiple test sites will be used
 - ITLL
 - Lockheed Martin
 - Northern Colorado Rocketry Range

Number	Test	Date	System(s)	Data Taken	Purpose
1	Hot Fire	3/17	All	Thrust, pressures, temperatures, mass flow rate of N ₂ O	Fire rocket engine
2	Weigh In	3/16	All	Mass	Validate weight of rocket

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System Tests

Number	Test	Date	System(s)	Data Taken	Purpose
3	N ₂ O Flow	3/10	Feed and Injector	Pressure drop and mass flow rate of N ₂ O	Verify pressure profile of feed system
4	Coefficient of Discharge	11/20	Injector	Pressure drop and volume flow rate of H ₂ O	Find ideal plate for required discharge
5	Ignition Calorimeter	2/18	Ignition	Temperature	Verify energy output of ignition system
6	Carbon Fiber Tensile Test	2/02	Combustion Chamber	Stress/Strain	Verify strength of carbon fiber
7	Oxidizer Tank Pressure Test	3/8	Feed	Pressure	Verify strength of oxidizer tank

- ▣ Discharge coefficient test completed in fall

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Testing at Lockheed Martin



- ▣ Hot Fire Test at Lockheed Martin on 3/17
- ▣ Prior to test-
 - Complete setup integrated at Lockheed Martin on 3/10
 - Safety meeting held week before test
 - Ignition material shipped ahead and prepared on day of test
 - Coordinate integration of feed system
 - Fill up oxidizer tanks at Airgas
 - Prepare official test plan and Failure Mode and Effects Analysis

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Ignition Calorimeter Test

- ▣ Ignition system to be tested in a calorimeter
 - Pressure Rated at 1500 psi
- ▣ System is detonated in container surrounded by water and temperature difference in water used to find energy output
 - Temperature recorded radially in test chamber
 - Data recorded until temperature equilibrium is reached
 - Temperature data logger used



Bomb Calorimeter

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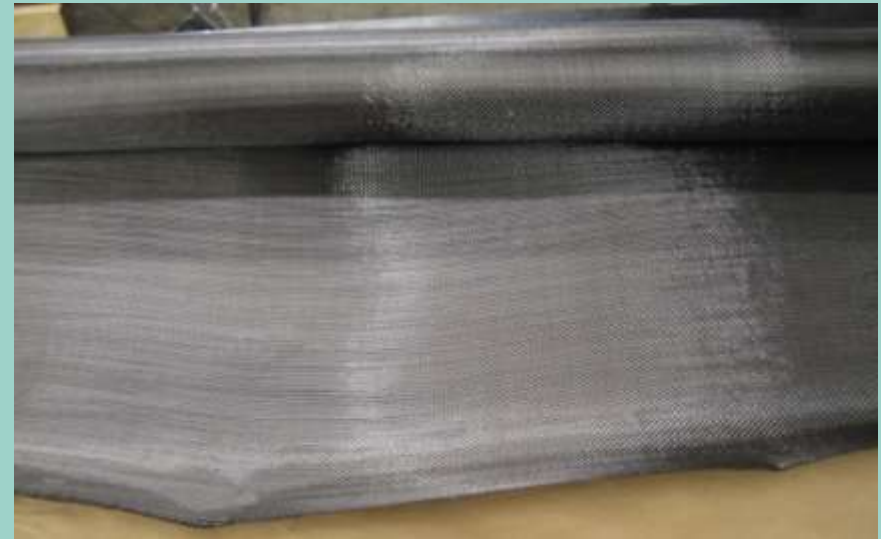
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Carbon Fiber Tensile Test

- ▣ Strength of carbon fiber can vary by manufacturer. Accurate knowledge of strength can only come through testing.
- ▣ Strips of carbon fiber will be cut, epoxied and cured in oven
- ▣ Tested in Tinius-Olsen machine
- ▣ The strength of fabric determines how many wraps are required for combustion chamber.



Carbon Fiber Fabric
Before Cure

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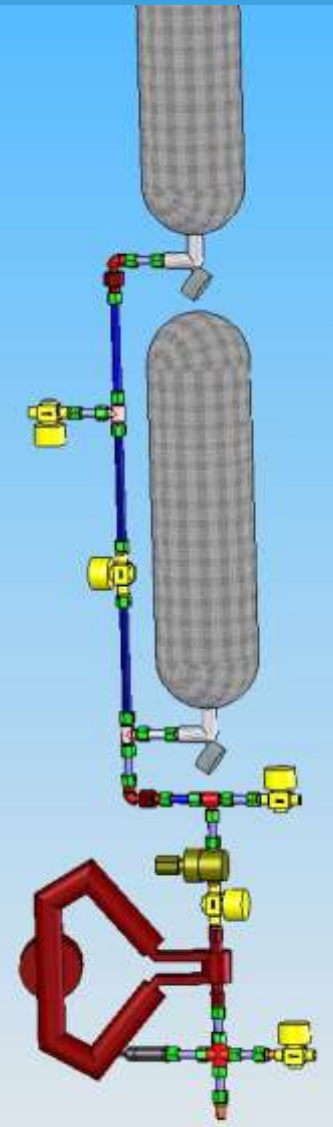
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N₂O Flow Test

- ❑ Oxidizer will be run through the feed and injector systems in simulation of a launch.
- ❑ The pressure at several points in the feed line will be measured.
- ❑ The mass flow will be measured using Lockheed's turbine mass flow meter
- ❑ Test conducted at Lockheed Martin in hot fire setup (excluding combustion chamber/nozzle) before hot fire test



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Current Progress

- ▣ Titanium plate, IPDI, and HTPB donated
- ▣ Constructed the oven and one end cap
- ▣ Concerns
 - Pressure Regulator- Adviser approval and long lead time
 - Everything ready for integration by 3/10



Aluminum end cap for combustion chamber

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Schedule

	1/12-1/18	19:25	1/26-2/1	2:08	9:15	16:22	23:29	3/1-3/7	8:14	15:21	22:28	3/29-4/4	5:11	12:18	19:25	4/26-5/2
Deadlines				IR		CP		RV2		HOT		HOT 2	FR		Expo	SR
Ignition System																
Test																
Integrate																
Combustion Chamber																
Fabricate																
Integrate																
Fuel																
Fabricate																
Nozzle																
Integrate																
Oxidizer Tank																
Integrate																
Feed System																
Test																
Fabricate																
Integrate																
Injector System																
Fabricate																
Integrate																
Test Stand																
Fabricate																
Integrate																
Hot Fire Test																

Schedule

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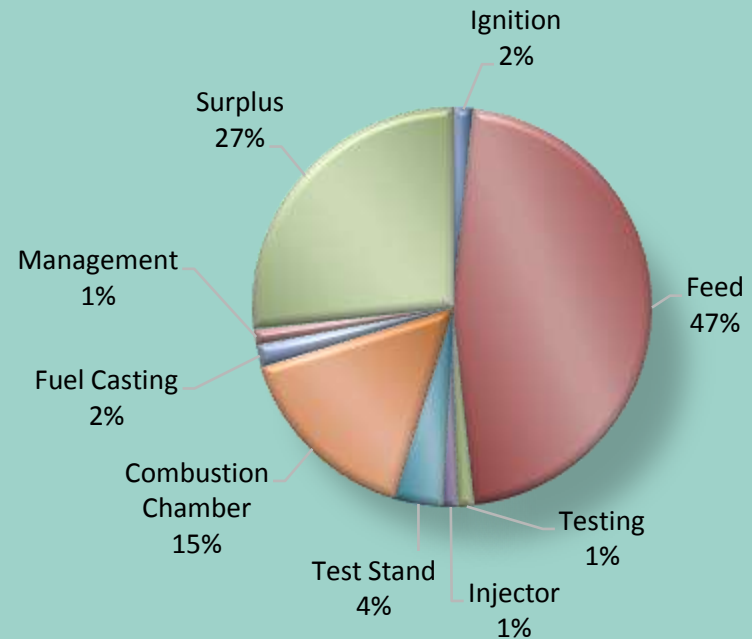
Test Plan

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Budget

Combustion	\$ 1,081.23
Ignition	\$ 117.59
Injector	\$ 88.00
Test Stand	\$ 276.60
Feed	\$ 3,259.31
Testing	\$ 91.42
Management	\$ 84.45
Fuel Casting	\$ 130.49
Total Expense	\$ 5,129.09
Aero Dept	\$ 4,000.00
UROP	\$ 3,000.00
Surplus	\$ 1,870.91
Margin	27%



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Conclusion

- ▣ Experiencing unexpected delays in getting materials and in manufacturing
- ▣ Budget has been improved through donations and reducing high cost materials
- ▣ Testing schedule has been solidified through frequent communication and visits to Lockheed Martin
- ▣ Team continues to be motivated and eagerly tackles new obstacles on the path to seeing our hot fire test

It's Over!



Deadlines

C- Construction T- Testing	Planned			Actual	
	Start	Finish	Margin	Started	Finished
Ignition System- C and T	1/16	2/22	2/15		
Combustion Chamber-C	1/16	2/1	2/20	2/1	
Injector System- C	1/26	2/9	2/18	2/1	
Feed System- C	1/26	2/1	2/16		
Interim Review	1/26	2/4	Deadline	1/26	2/4
Carbon Fiber Test	1/31	2/8	2/11	1/31	
Conference Paper	2/2	2/18	Deadline		
Fuel-C	2/7	2/22	3/5		
Software	2/5	2/22	3/10		
Test Stand- C	2/10	3/3	3/8		
Feed System- T	2/20	3/4	3/8		
Test Stand- C	2/20	3/7	3/9		
Interim Review 2	2/23	3/3	Deadline		
Complete Integration	3/7	3/10	Deadline		
Hot Fire Test 1	3/17	3/17	Deadline		
Final Review	3/29	4/14	Deadline		
Hot Fire Test 2	4/1	4/1	Deadline		
ITLL Expo	4/15	4/28	Deadline		
Spring Final Report	4/15	5/1	Deadline		

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