UVU MECHANICAL ENGINEERING
UTAH VALLEY UNIVERSITY

Capstone Project:

High Power Rocket

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Presentation Outline:

01 PROJECT OVERVIEW
- Summary of project background and objectives

02 PROBLEM DEFINITION
- Research of the rocket design problem, competition, codes, and standards.

03 CONCEPT GENERATION & SELECTION
- Design space exploration and concept selection processes

04 MODELING /PROTOTYPING
- Evidence of substantial modeling and prototyping

05 ANALYSIS /SIMULATIONS
- Methods of engineering analysis and simulations

06 MANUFACTURING
- Process of the rocket and ACS construction

07 FINAL DESIGN
- Explanation of final design

01

Project Summary/Overview

Project Goals

- Design and Build a rocket for competition in the Spaceport America Cup
  - Deliver an 8.8 lb payload to a precise altitude of 10,000 ft AGL
  - Safe recovery of rocket & payload
  - Reusable rocket
  - Using a commercial solid fuel rocket motor

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Adjustments

- Continued as if competing in SA cup
- Final launch scheduled April 23rd
- Apogee changed to 8,000 ft AGL due to 10,000 ft waiver regulations

TRIPOLI
ROCKETRY ASSOCIATION, INC.

02

Problem Definition

SPACEPORT AMERICA® CUP

- Create a rocket that will carry a 8.8 lb payload to a precise apogee of 10,000 ft.

Researching the problem:

- Referenced SA cup Handbook rules and regulations
- Talked with real world experts
    - UROC rocketeers
    - Tripoli prefects
    - SA cup competition forum
    - Dr. Nielsen (Physics department)
- Referenced NFPA 1122, 1127 regulations
- Referenced FAA regulations for rocketry in 14 CFR

02

Problem Definition

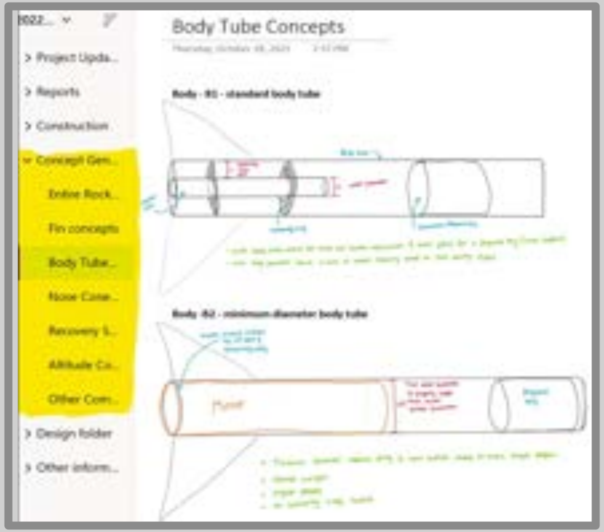
No.	Customer Need	No.	Rocket Metric	Value	Units
1	Removable payload of no less than 8.8 lbs	1	Removable payload minimum weight	8.8	lbs
2	Achieve an appoge of precisely 10,000 ft AGL	2	Achieve exact altitude	10,000 +-50	ft AGL
3	Installed impulse no greater than 40,960 Newton-seconds	3	Motor impulse maximum value	40,960	N*s
4	Carry a barometric pressure altimeter with on-board data storage	4	Bbarometric sensor(s)	2	sensors
5	Redundant electronic recovery system(s)	5	Electronic recovery system(s)	2	systems
6	Rocket survives recovery	6	Maximum Ground Impact speed	<20	m/s
7	Rocket is stable during flight	7	Rocket stability caliber	>1	Cal
8	Reusable rocket	8	Ability to relaunch	2	Launches
9	Afordable cost	9	Project cost	5500	$
10	Rocket ability to withstand launch acceleration	10	withstand max acceleration of	539.55	m/s^2

03

Concept Generation

Internal Search & Systematic Exploration

- Generated concepts individually, then met as a team to discuss and present
- Broke the concept generation down to rocket components which allowed for easy mix and match to create full concepts
- Created a concept database on Onenote



External search

- Talked to real experts locally
- Met with Utah Rocket Club
- Researched solutions online
- Experimented with software simulations

NASA

UROC

03

Concept Selection

- A concept generation/selection matrix was used to create ten complete concepts.
- Scoring Matrix was then used to select which design best fit the design requirements.
  - Cost and ability to accurately achieve altitude were some of the key criteria.

Criteria	importance	1
Cost	15.00%	5
Manufaturing feasability	10.00%	5
Reliability of multiple use	10.00%	3
light weight	10.00%	6
Ability to accurately achive altitude	25.00%	7
Heat resistance	5.00%	5
Recovery redundancy	15.00%	5
Creativity	5.00%	4
Aesthetics	5.00%	3
total score	100.00%	43

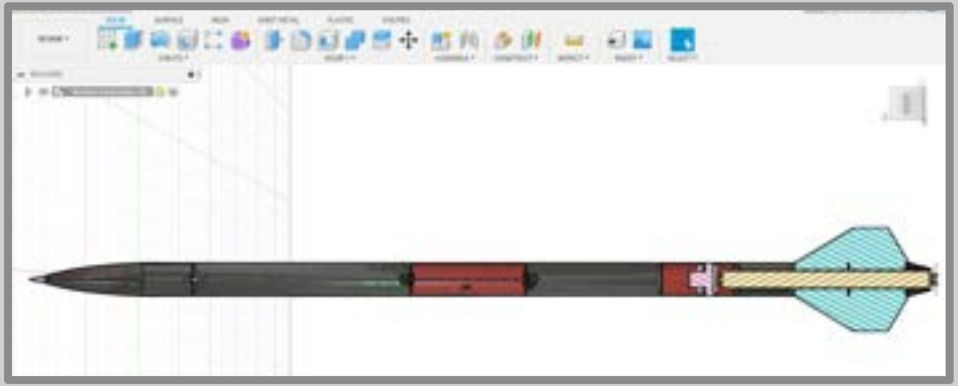
	A	B	C	D	E	F	G	H	I	J	K
1						Concepts					
2	component	1	2	3	4	5	6	7	8	9	10
3	Fin	M1	S13	C2	B3	M1	C1	B2	S8	S14	B4
4	Body tube	B2	B1	B3	B2&C1	B1	B2	C1	C1	B2	B1
5	Nose cone	S6	S3	S4	B1	S5	B5	S	B1	S3	S2
6	Recovery system	B3	B1	C5	B3	M1	B2	C1	C3	B1	C1
7	Altitude control system	C2	C1	B2	B1	C4	C2	B	C3	B3	C3

04

Modeling

CAD Modeling: Fusion 360

- Using Fusion 360, a full rocket design was created to determine the dimensions of final design.
- ACS was modeled in Fusion 360.
- Fabrication of rocket needed precise placement of fins and couplers which were machined based of modeling.



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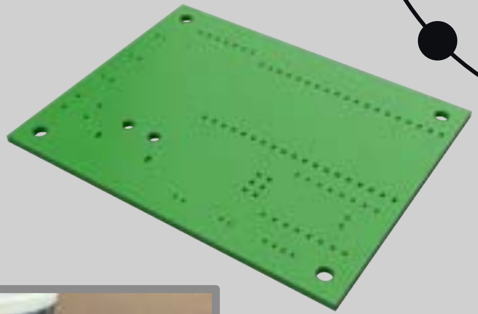
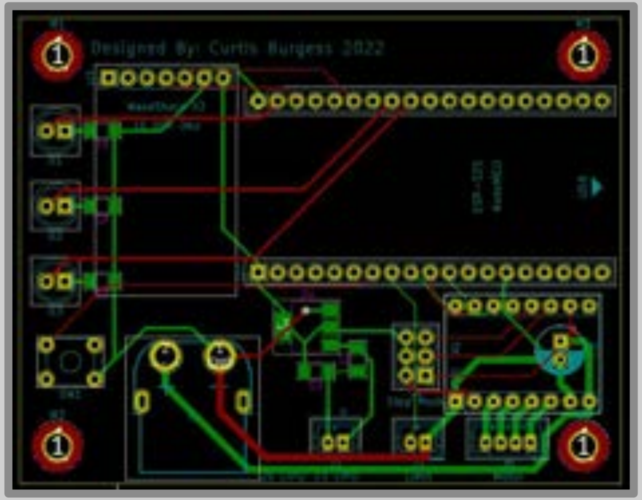
Modeling: Electronic Systems



ACS Control Board



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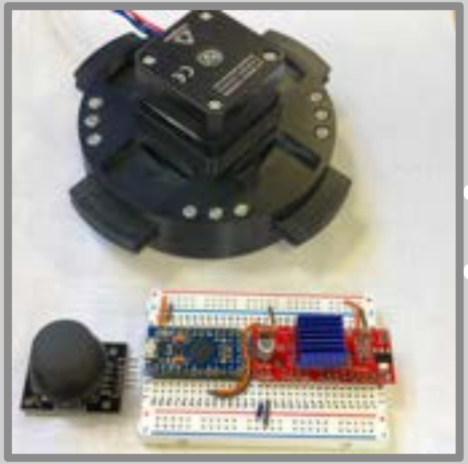
Prototyping

3D Printing

- 3D printed various rocket components to explore spacial and kinetic functionality.
- 3D printed prototype of ACS was used to determine functionality.
    - Refined versions resulted in better movement capabilities.

Scaled Prototypes

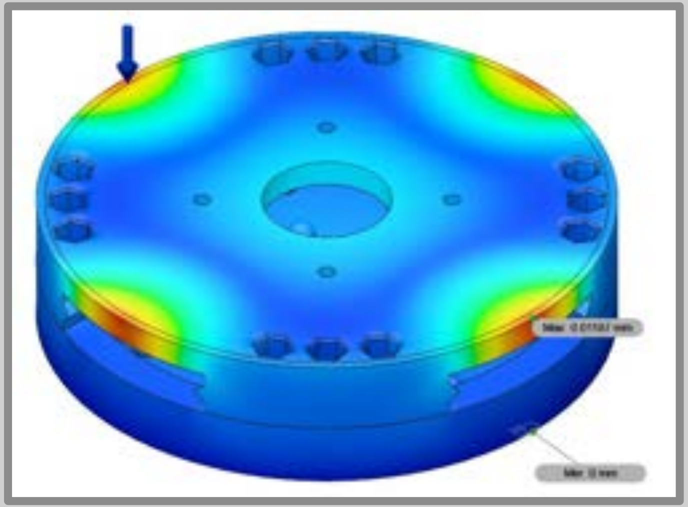
- Smaller scale rockets were launched to prove concept viability.
    - These prototypes doubled as Tripoli level 1 & 2 certification rockets.



Analysis/Simulations

- FEA was used to determine the deformation of flaps.
- Boundary conditions:
  - Fixed base
  - Vertical force on loading band
- Safety factor of 9
- Max displacement of 0.012 mm

- Determined to manufacture the ACS out of aluminum to avoid pinching of the flaps



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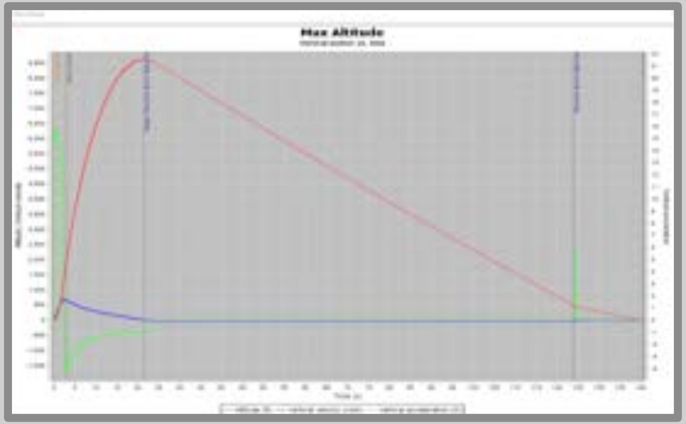
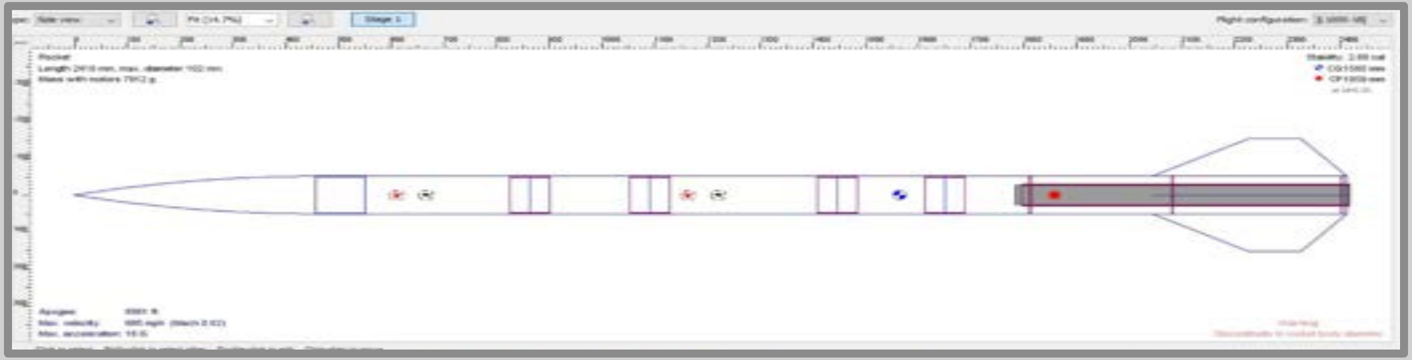
Analysis/Simulations

- Rocket simulation in OpenRocket for stability, center of pressure, and center of gravity.
- OpenRocket simulation will have max velocity, apogee, and flight time.





06

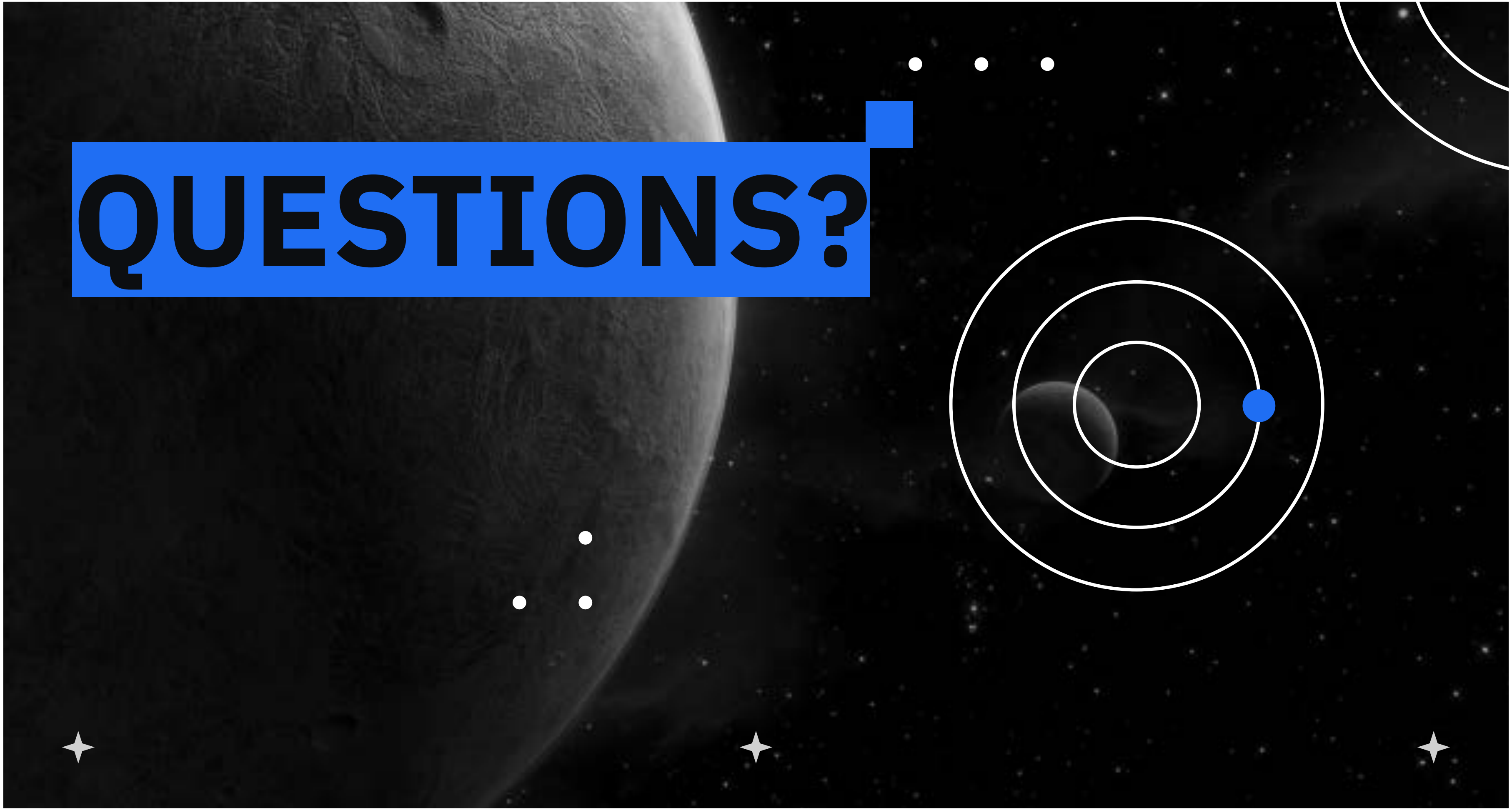
Manufacturing

- CNC machine was used to cut fins, centering rings, and bulkheads.
- ACS was machined out of aluminum
- Fin slots were milled into fiberglass body tube
- Rocket body sections epoxied and or riveted together
- 3D printed fin stabilizers used for accurate placement
- Carbon fiber was added to epoxy on fins for added strength

07

Final Design

- **Rocket body:** G12 wound Fiberglass tube
- **Recovery system:** Parachute dual deployment
- **Drag System:**
  - Machined Aluminum ACS
  - Stepper motor
  - Custom PCB and flight computer
- **Motor:** Aerotech L-1000
- **Fins:** Offset trapezoidal
- **Expected apogee:** 8561 ft.
- **Estimated corrected apogee:** 8000 ft.
- **Expected ground impact speed:** 8 m/s


QUESTIONS?