Western

UNIVERSITY · CANADA

MME 4499 Design Project
Design Day Presentation

Group # 13

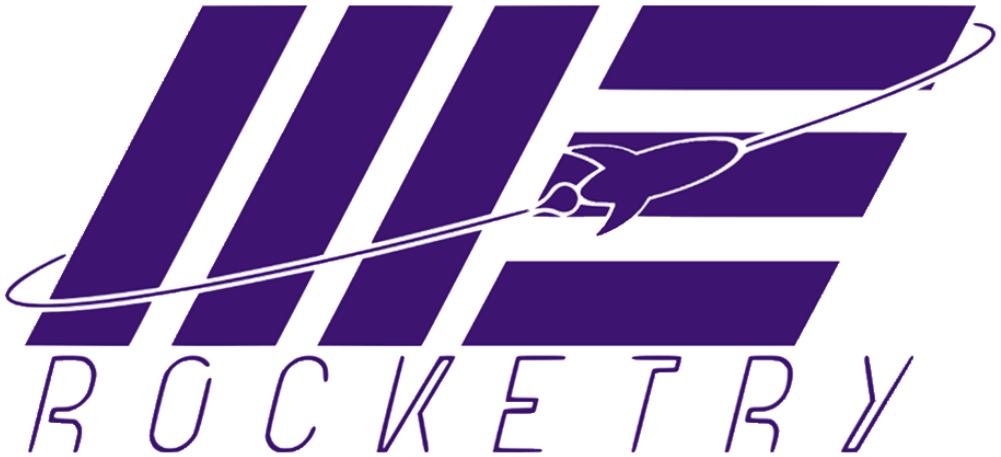
March 22nd, 2024

Advisor: Dr. John Makaran

Sponsor and Project Overview

Rocketry Airbrakes Capstone

Built for and in collaboration with the Western Engineering Rocketry Team



WE Rocketry Contact:
Jessica Kerr
Chief Engineer
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Sponsor and Project Overview

WE Rocketry competes annually at the Spaceport America Cup, the largest intercollegiate rocketry competition in the world. 35% of a team's score is based on how closely they achieve their apogee target.

The airbrakes system allows the rocket to target the required apogee with better precision than would be possible without an active control system. The airbrakes controller monitors the state of the rocket and induces drag by deploying flaps to the level it believes will bring the apogee as close as possible to 10 000 ft.

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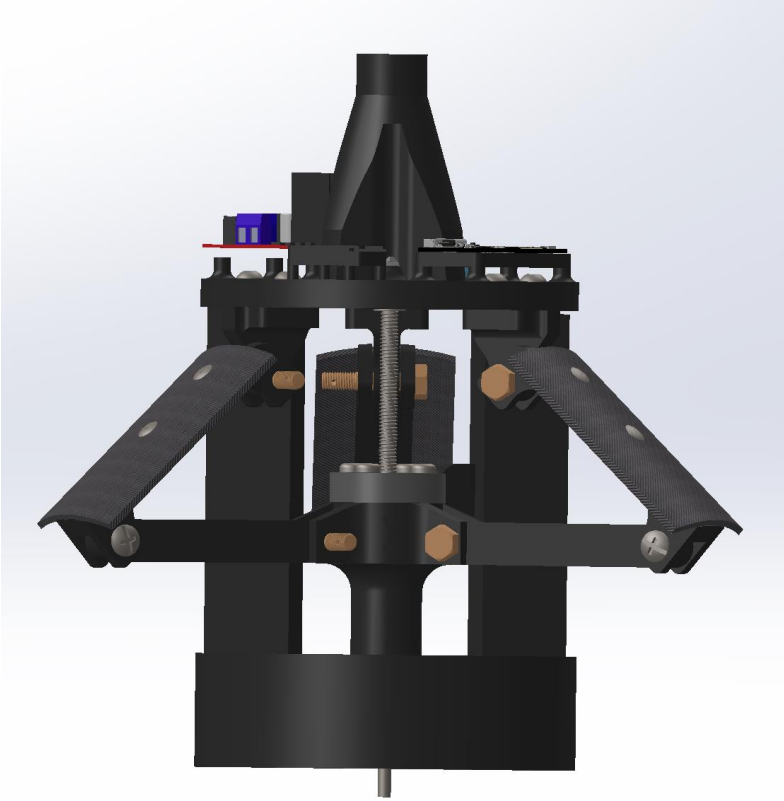
Team Members and Responsibilities

Name	Email	Primary Responsibilities
Cameron Brooks	cbrook49@uwo.ca	Electrical Design, Software Design, Electrical Material Procurement and Selection, 3DP
Giorgio Chassikos	gchassik@uwo.ca	Project Lead, Co-ordination with WE Rocketry, Flight Simulations, Manufacturing, Testing
Brett MacDonald	bmacdo82@uwo.ca	Mechanical Design, CAD, Mechanical Material Selection and Procurement
Shelby Mior	smior2@uwo.ca	Simulations, Drawings, Documentation, Calculations, Analyses

Design Targets

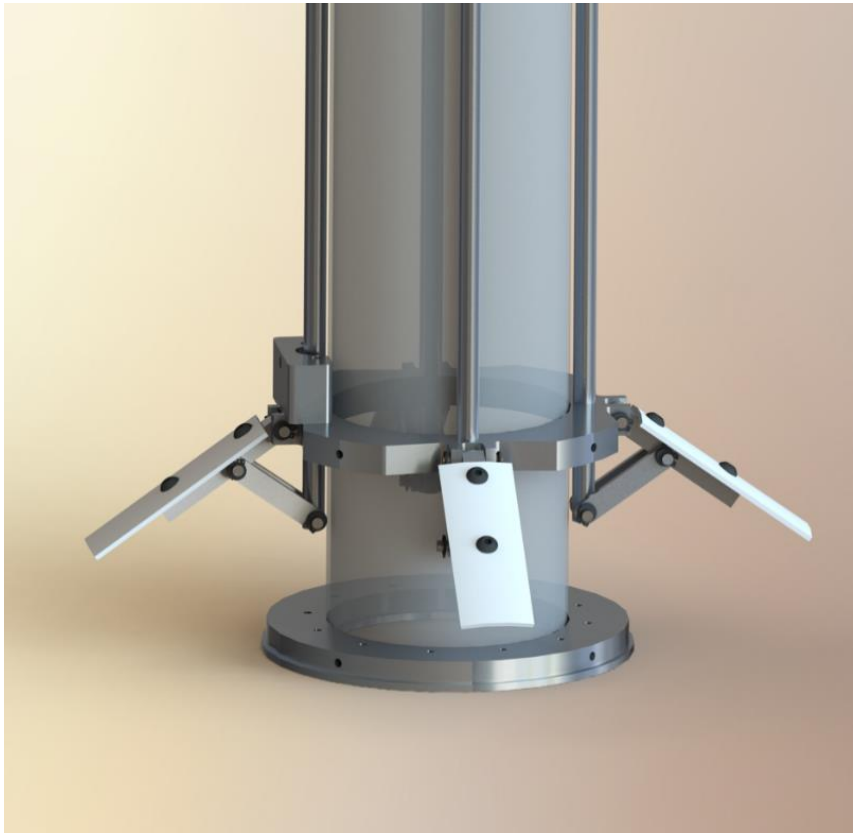
- Withstand expected aerodynamic and flight loads
- 5.5" diameter in neutral/stowed state
- Mass less than 4 kg
- Length less than 30 cm
- Budget of $3000
- Fail-safe logic to return to a neutral state on loss of power or tilt greater than 30°



Concepts Considered

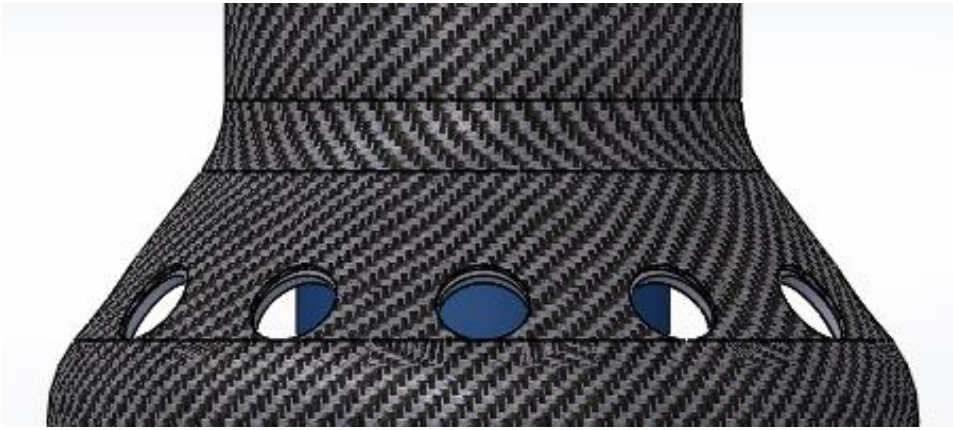
Pancake Airbrakes

Flap Airbrakes

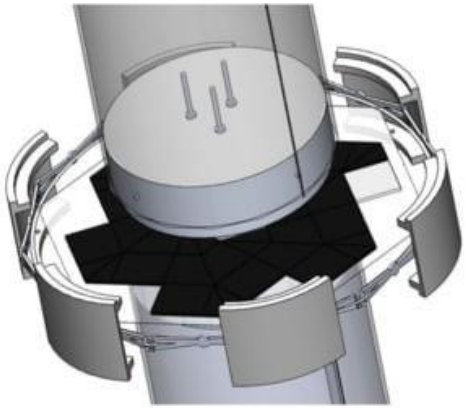


Concepts Considered

Doppler Hole Airbrakes



Origami Flasher Airbrakes



Selected Design Concept

Concept Evaluation

- Pugh Matrix and HOQ used to guide concept selection
- Flaps style airbrakes earned highest overall score

		Pancake		Flaps		Doppler Holes		Origami Flashers	
Criteria	Weighting	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Precision Apogee Targeting	8	8	64	9	72	4	32	10	80
Safety	10	4	40	9	90	8	80	2	20
TRL	7	10	70	10	70	1	7	2	14
Electrical Simplicity	5	4	20	6	30	10	50	8	40
Ease to Simulate	2	10	20	10	20	7	14	2	4
Simulation Accuracy	3	8	24	9	27	8	24	2	6
Cost	8	9	72	7	56	4	32	1	8
Ease of Manufacture	8	7	56	8	64	4	32	0	0
Mass	6	8	48	6	36	8	48	3	18
Length	6	9	54	5	30	7	42	8	48
Total		-	468	-	495	-	361	-	238

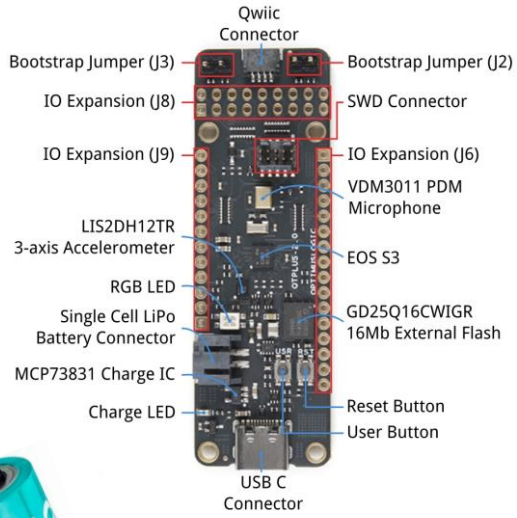
Selected Design Concept

Mechanical Design

- Four flaps
- Push rod, lead screw mechanism

Electrical Design

- Preliminary electrical system components based off concept selection

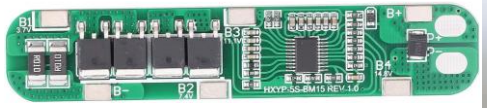


Accelerometer, Gyroscope Sensor

Barometric Pressure + Temperature

Differential Pressure Sensor

Li-Ion Battery Cells



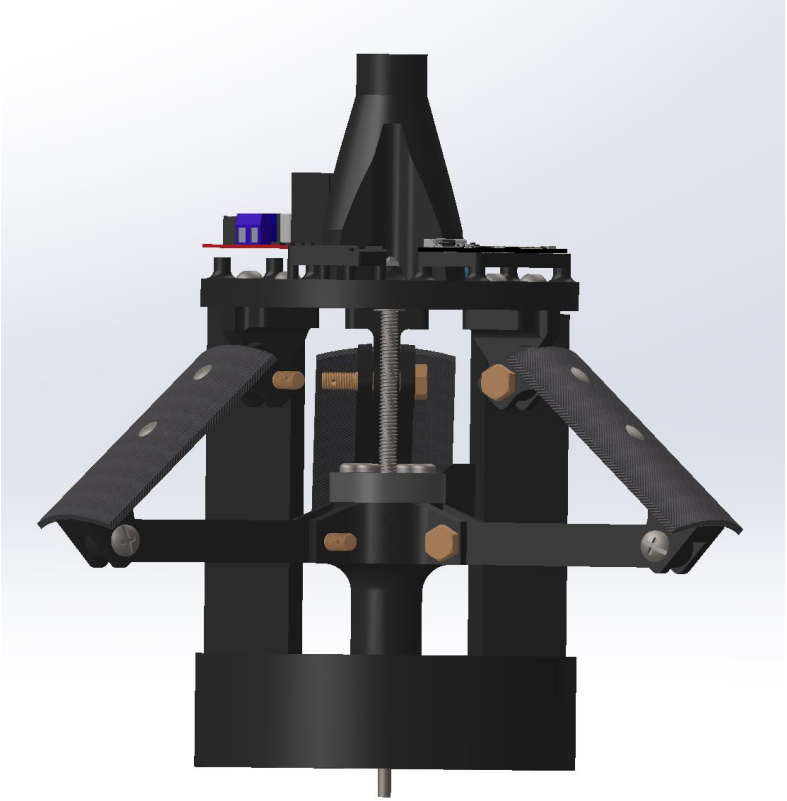
Battery Monitoring System / Voltage Regulator

High-torque Servo

Design Details

Mechanical:

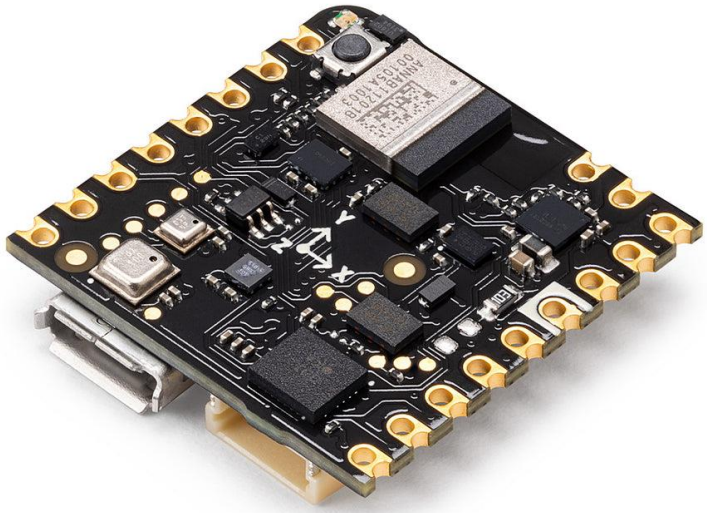
- Three flap, centre lead screw
- Hinged through fasteners
- Adjustable push rod length
- Mix of 3D-printed (PLA) and carbon fiber parts
- Designed for manufacturability and simplicity



Design Details

Electrical:

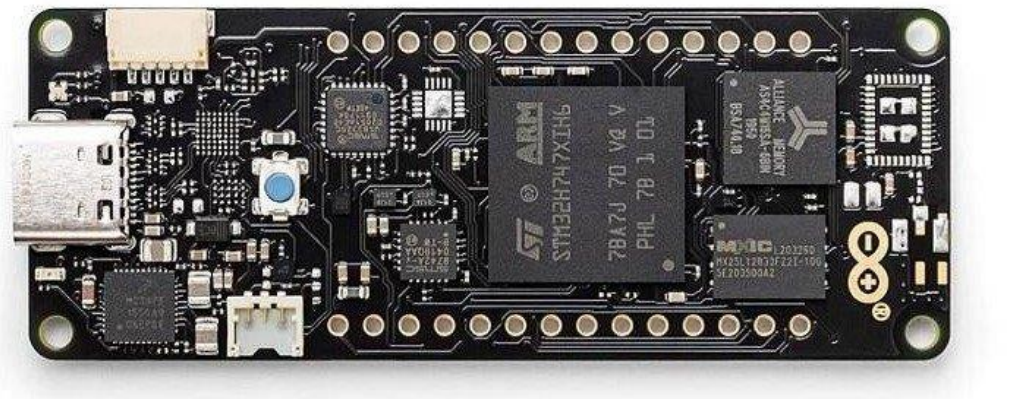
- Barometer
  - BME688: AI-enabled pressure, humidity, [temp. measurements
  - Sense ME dev. board
- Inertial Measurement Unit (IMU)
  - BHI260AP: AI-enabled 6-axis IMU, corrected by BMM150 magnometer
  - Sense ME dev. Board



Design Details

Electrical:

- STM32H7 Microcontroller
  - Arm Cortex-M7 and Cortex-M4 core
  - Portenta H7 Lite dev. board



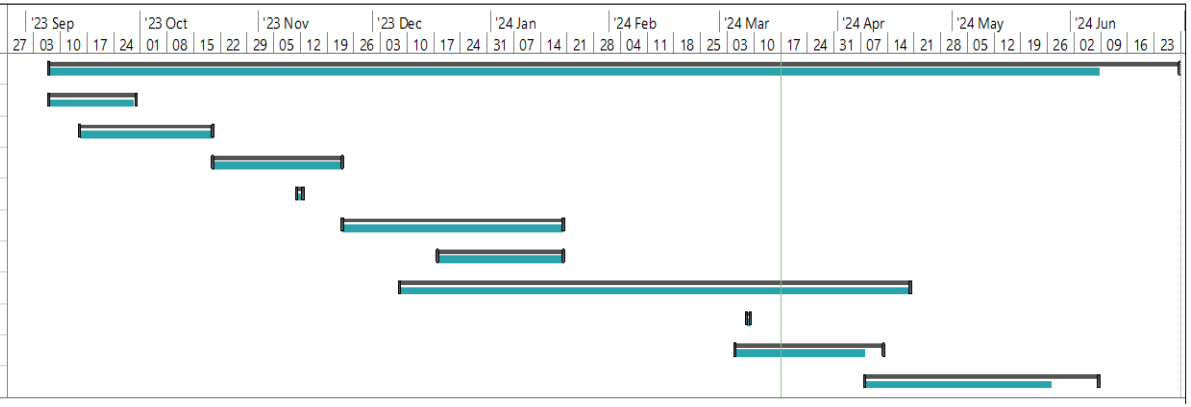
Design Details

Electrical:

- Motor
  - Planetary Gearmotor with Encoder
  - 12V, 515RPM (nl), 0.65 kg·cm (rated)

Baseline Milestone Timing

Task Name	Start	Finish	% Complete
MME 4499 Design Project	Thu 23-09-07	Sat 24-06-29	97%
Design Specification/Requirements	Thu 23-09-07	Fri 23-09-29	100%
Conceptual Design	Fri 23-09-15	Thu 23-10-19	100%
Design Refining	Fri 23-10-20	Wed 23-11-22	100%
Initial Material Purchasing	Sat 23-11-11	Sun 23-11-12	100%
Detailed Design	Thu 23-11-23	Fri 24-01-19	100%
Final BOM	Mon 23-12-18	Fri 24-01-19	100%
Prototype Creation	Fri 23-12-08	Fri 24-04-19	100%
Protoype Testing	Fri 24-03-08	Fri 24-03-08	100%
Final Assembly	Tue 24-03-05	Fri 24-04-12	80%
Rocket Installation	Mon 24-04-08	Sat 24-06-08	45%



Current Tasks:

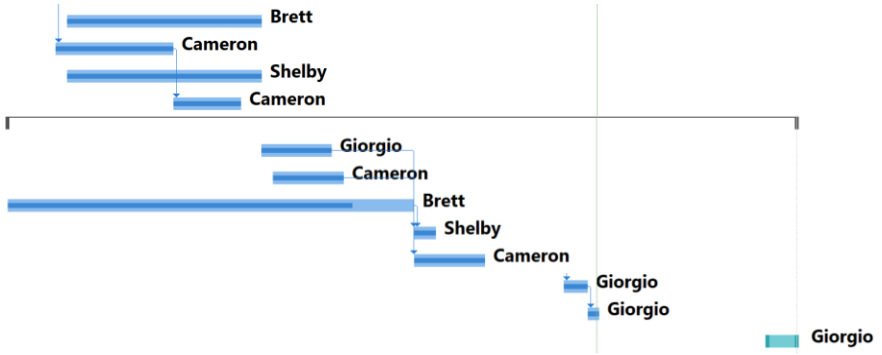
- Prototype Manufacturing: Underway
- Controls Implementation: Underway

Next Steps:

- Wind Tunnel Testing: Mid-late April
- Final rocket Installation: Mid May
- Competition: June 17th – 22nd

Project Timing Adjustments

Final BOM Creation	Mon 23-12-18	Fri 24-01-19	100%	Brett
Algorithm Testing	Sat 23-12-16	Thu 24-01-04	100%	Camero
FEA & preliminary CFD	Mon 23-12-18	Fri 24-01-19	100%	Shelby
Final Algorithm Review	Fri 24-01-05	Tue 24-01-16	100%	Camero
Prototype	**Fri 23-12-08**	**Fri 24-04-19**	**90%**	
Part Manufacturing/Trials	Sat 24-01-20	Wed 24-01-31	100%	Giorgio
Mechatronic Model - 3D Printing	Mon 24-01-22	Fri 24-02-02	100%	Camero
Material Purchasing	Fri 23-12-08	Wed 24-02-14	85%	Brett
Component Fit Testing	Thu 24-02-15	Sun 24-02-18	100%	Shelby
Mechatronic Model - Integration Testing	Thu 24-02-15	Mon 24-02-26	100%	Camero
Component Modification	Mon 24-03-11	Fri 24-03-15	100%	Giorgio
Final Assembly and Testing	Fri 24-03-15	Sun 24-03-17	100%	Giorgio
Wind Tunnel Testing	Mon 24-04-15	Fri 24-04-19	0%	Giorgio



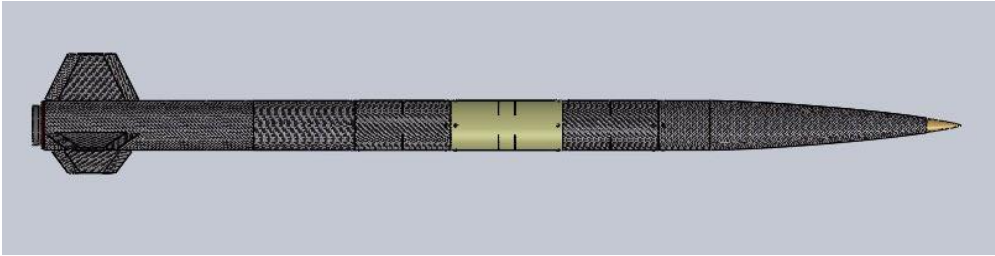
- Final Design: Delayed due to 4 to 3 flap change
- Material Purchasing: Experienced shipping issues, parts were delayed
- Wind Tunnel Testing: Delayed as rocket exterior not finished

Completed Validation

Test	Outcome
Mechatronic Model Assembly	Validation of the mechanism assembly and motion.
Compression Test Tube	Tube with cutouts took a compressive load of 2.37 kN, 1.4 times the expected thrust transfer at max g-loading, before failure
Strength Test the Assembly	Loaded the assembly with worst-case flight loads. No visible deformation.
Electromechanical Integration	Integration of the electrical system with the physical mechanism. Deployment of the airbrakes from neutral to full deployment using the motor within deploy time.

Validation Plan

Test	Description	Acceptance Criterion	Targeted Completion Date
Algorithm Testing on Simulated Data	Testing of the drag control algorithm that feeds to the motor	Control algorithm generates motor profile that corresponds to desired drag profile	Early April
Integration with Airframe	Fit test within final rocket assembly	Airbrakes system fits and can function within rocket	Early-mid April
Wind Tunnel Testing	Characterize drag at different Reynold's numbers and as a function of flap deployment angle	No acceptance criterion; test results serve to fine-tune algorithm used during flight	Mid-late April



Project Technical Challenges

- Failed Forged Carbon Fiber Flaps
- CFD
- Airbrakes simulation software

Project Cost Challenges

- No cost challenges
  - Project completed under budget

The Boundary Layer Wind Tunnel Laboratory

Takeaways and Lessons Learned

- Communication
- Good planning
- Project scoping
- Task management

Conclusions and Way Forward

- Working on a complex electromechanical assembly as our capstone has been a fantastic learning experience
  - Thanks to our departments for allowing a cross-discipline capstone team

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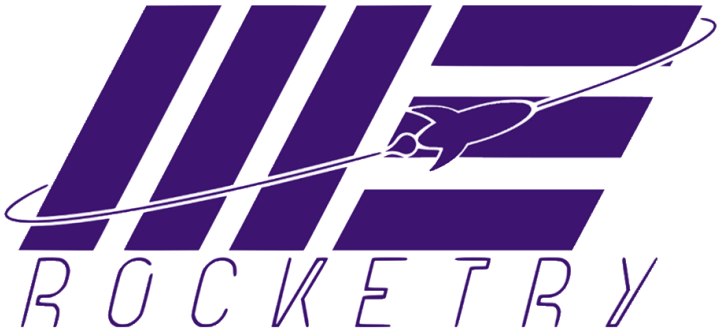
Conclusions and Way Forward

- Optimistic about our how we'll progress the next few months and how we're going to perform at competition
- Follow our socials to see how our launch goes!



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Questions ?

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