Team 511

MICROGRAVITY MACHINE

Design Review 6

TEAM 511

Samuel Duval

Propulsion Engineer

Pedro Siman

Recovery Engineer

Thomas Lenz

Test & Systems Engineer

Collin Gainer

Aero Design Engineer

John Tietsworth

Controls Engineer

Samuel Duval

Sponsor and Advisor

Dr. Mohd Yousuf Ali

FAMU-FSU College of Engineering

Mike Conroy

Florida Space Grant Consortium

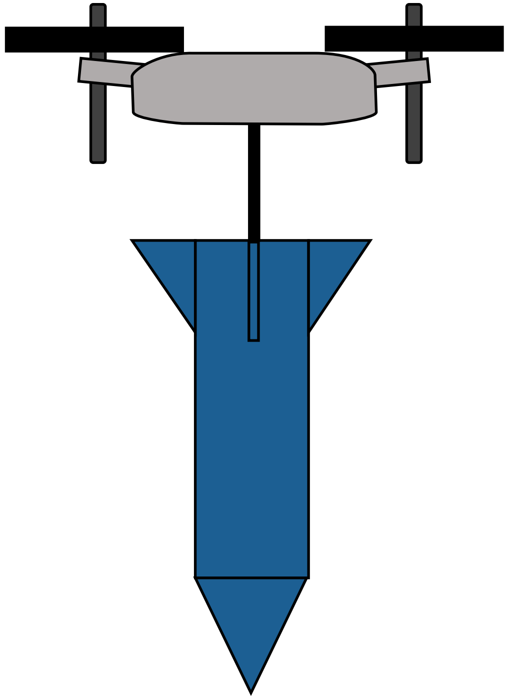
Dr. Shayne McConomy

FAMU-FSU College of Engineering

Samuel Duval

Project Objective

The objective of the project is to design a reproduceable system that can be dropped, achieve microgravity during its descent, and be safely recovered for reuse.

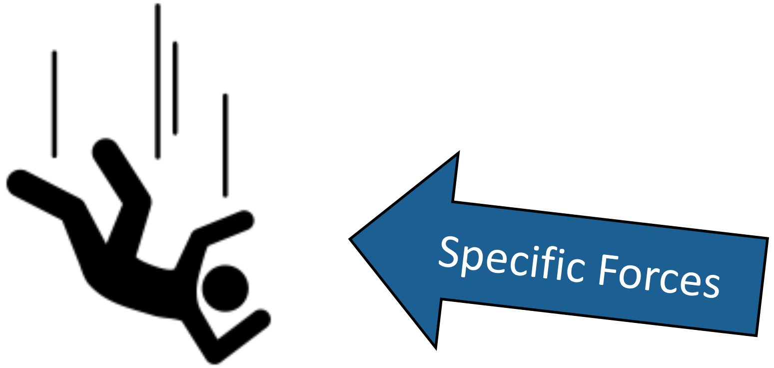


Samuel Duval

What is Microgravity?

$$\vec{F}_{Specific} = \frac{\sum \vec{F}_{nongravitational}}{m} \approx 0\,\frac{m}{s^2}$$

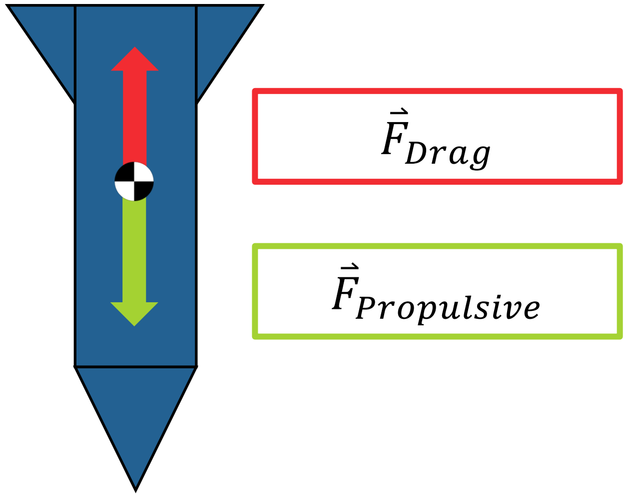
What does an accelerometer measure?



Samuel Duval

Achieving Freefall

$$\vec{F}_{Specific} = \frac{\vec{F}_{Propulsive} - \vec{F}_{Drag}}{m} \approx 0\,\frac{m}{s^2}$$



Samuel Duval

Key Goals

Microgravity

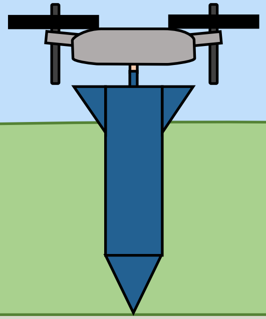
Recoverable

Meet weight requirements

Reproduceable

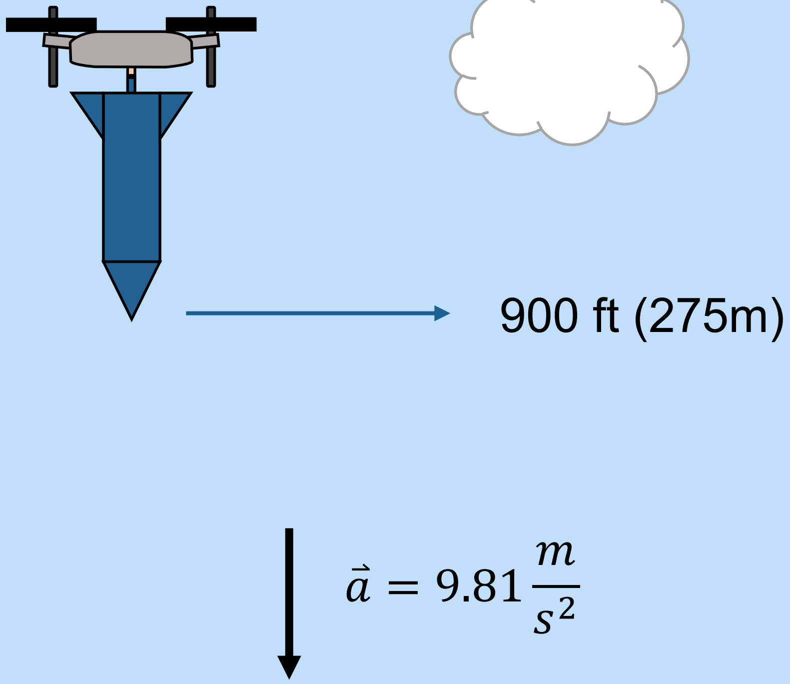
Pedro Siman

Competition Day



Pedro Siman

Competition Day



Metric	Target
Time to Detect Disconnection	0.1s
Degrees of Freedom	1
Acceleration	$9.81\frac{m}{s^2}$
Final Velocity	$5\frac{m}{s}$

Pedro Siman

Competition Day

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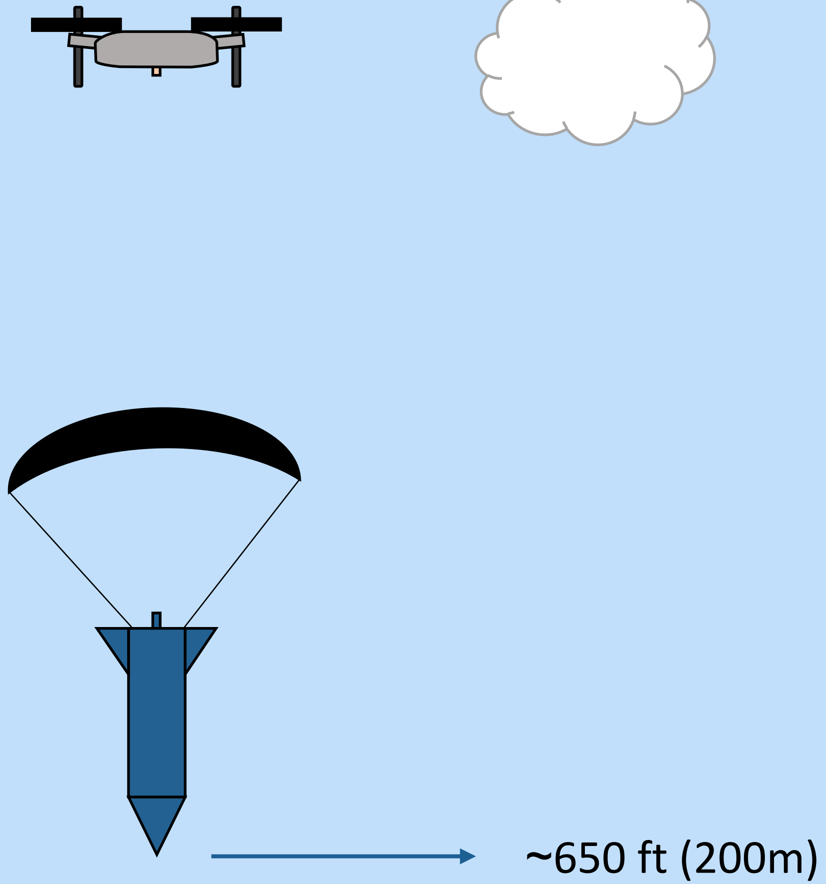

Pedro Siman

Competition Day

Metric	Target
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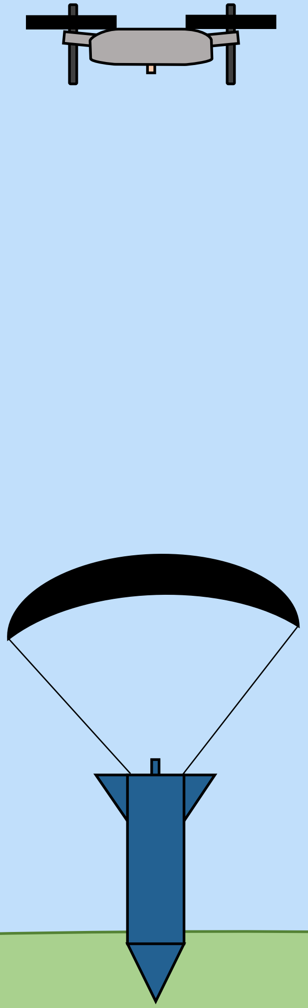
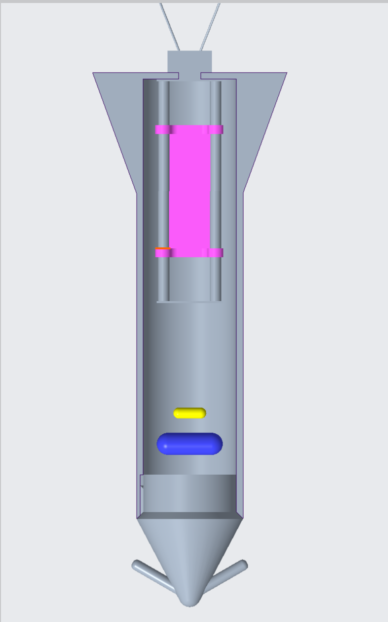
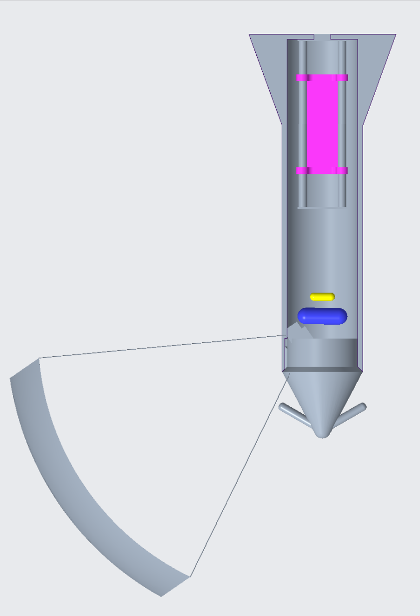


$$\vec{V_f} = 5\,\frac{m}{s}$$

Pedro Siman

Concept Generation





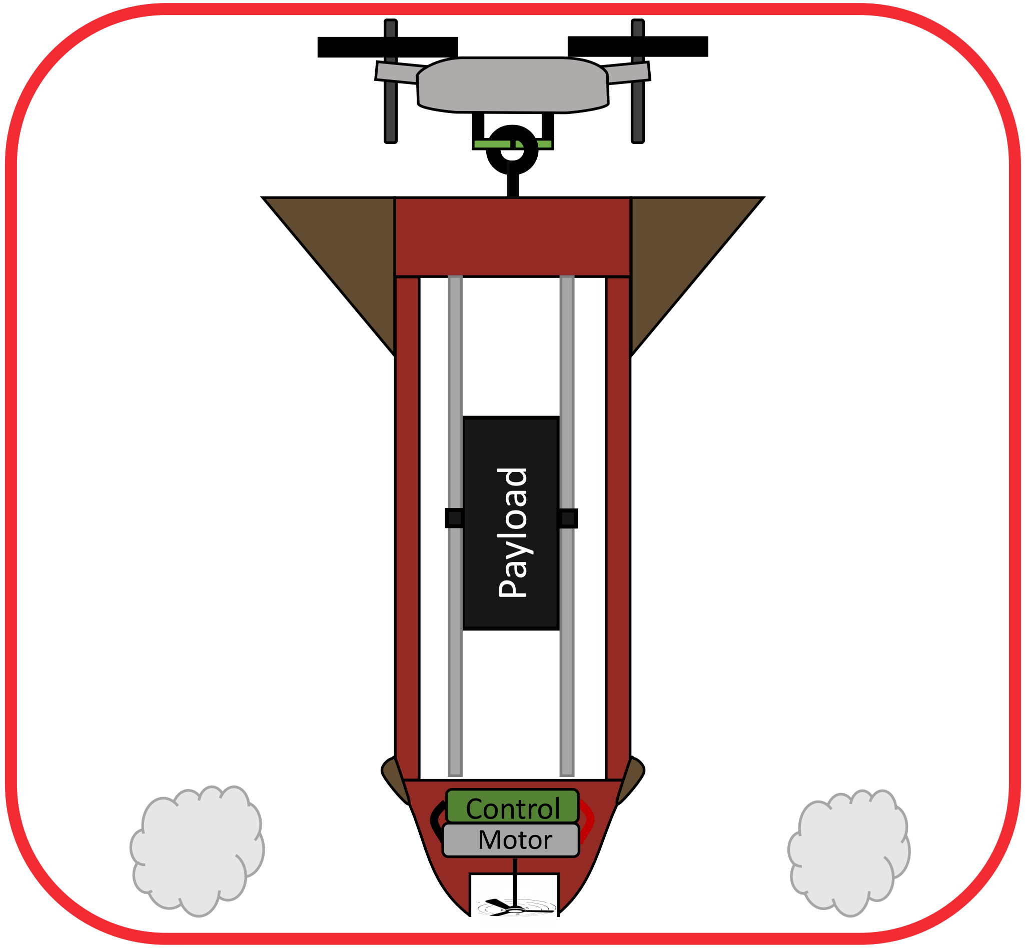
Pedro Siman

Concept Generation

ICARUS

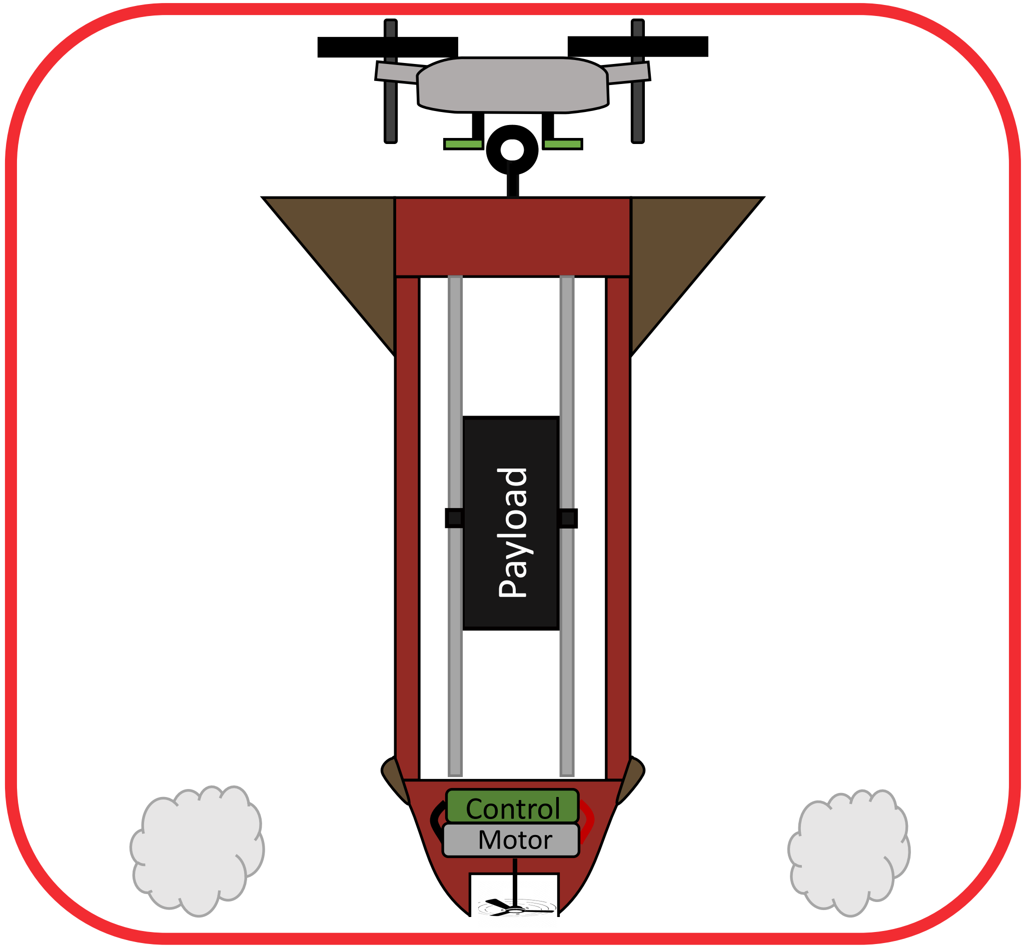
Pedro Siman

Selected Design: ICARUS



Collin Gainer

Selected Design: ICARUS



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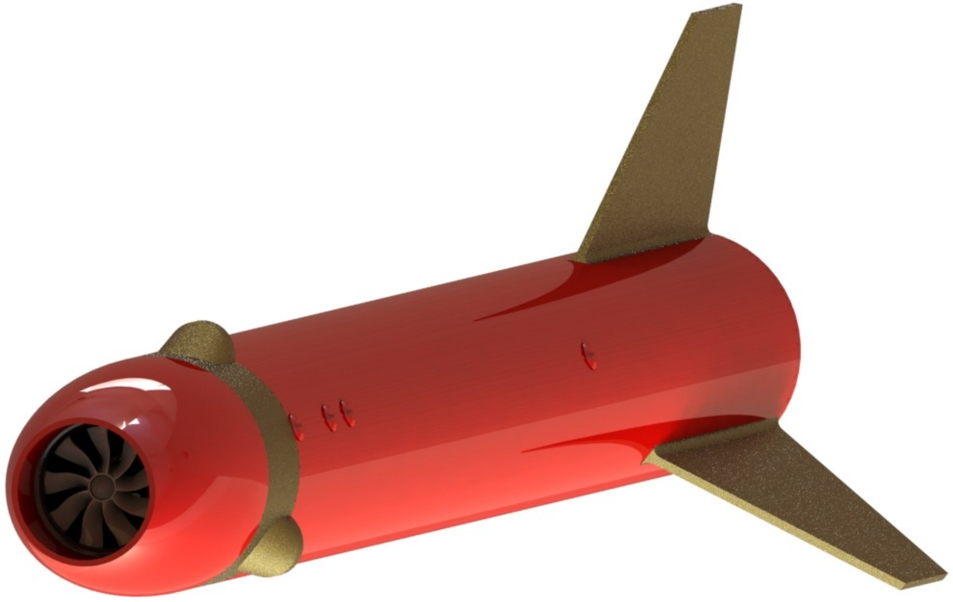

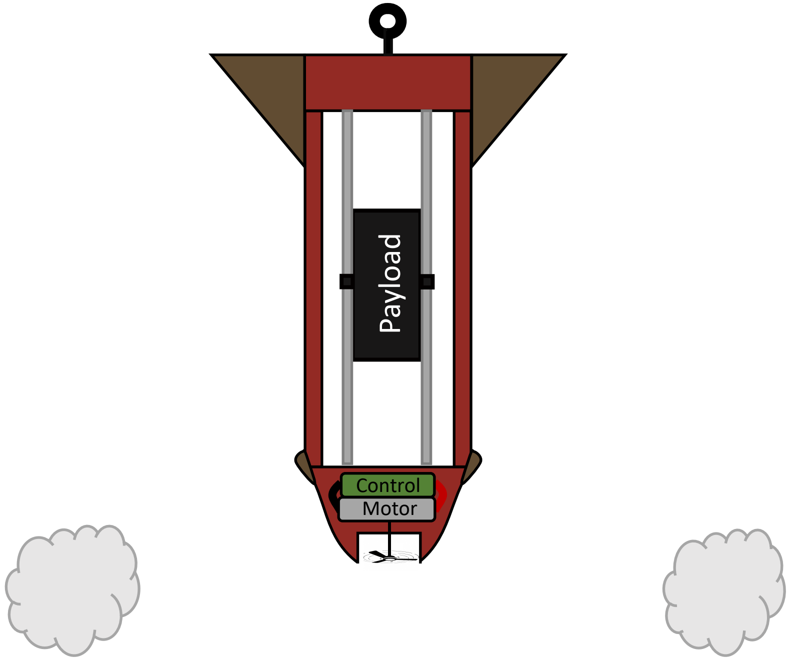

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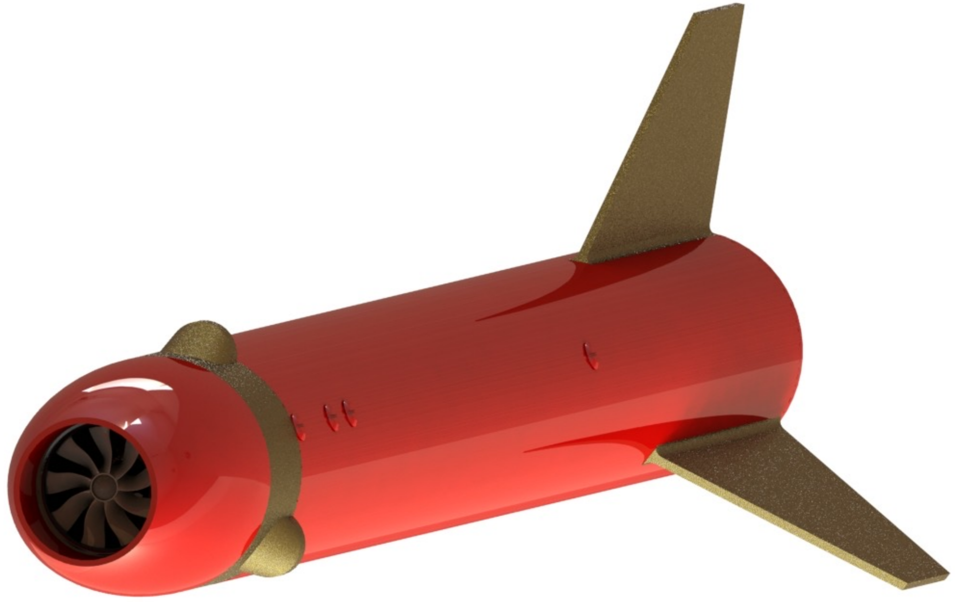

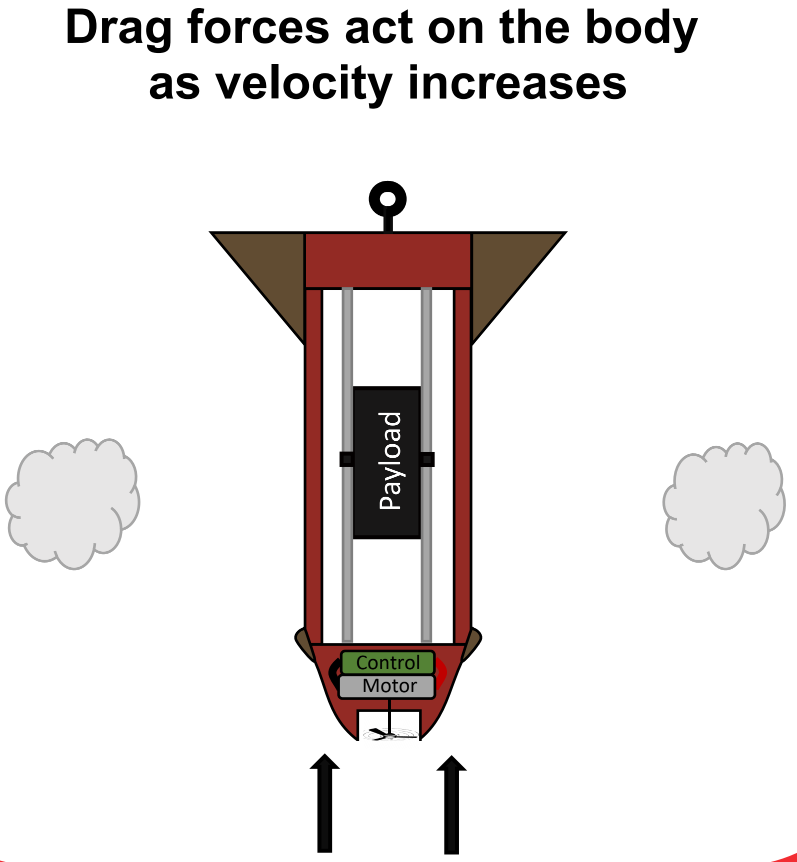

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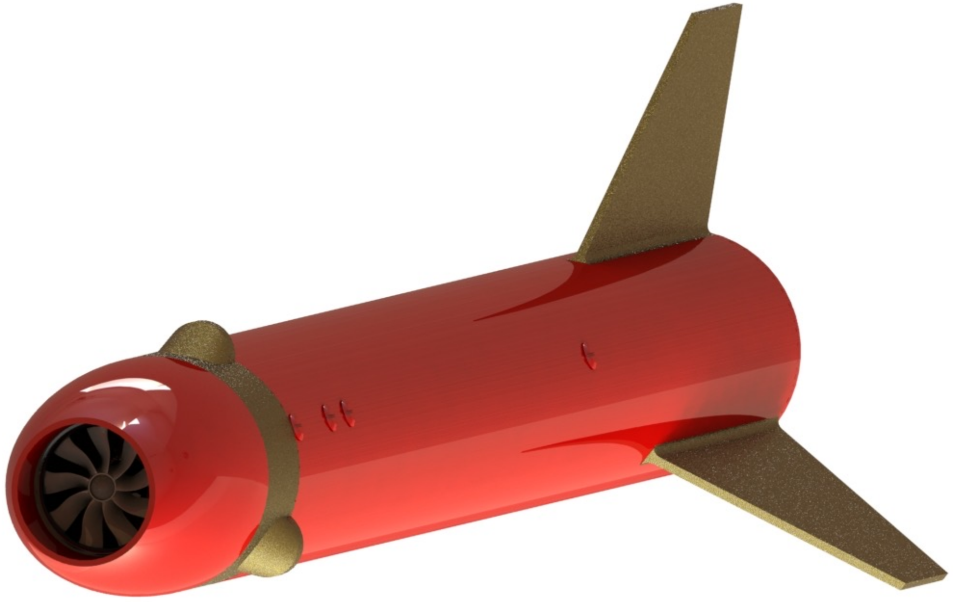
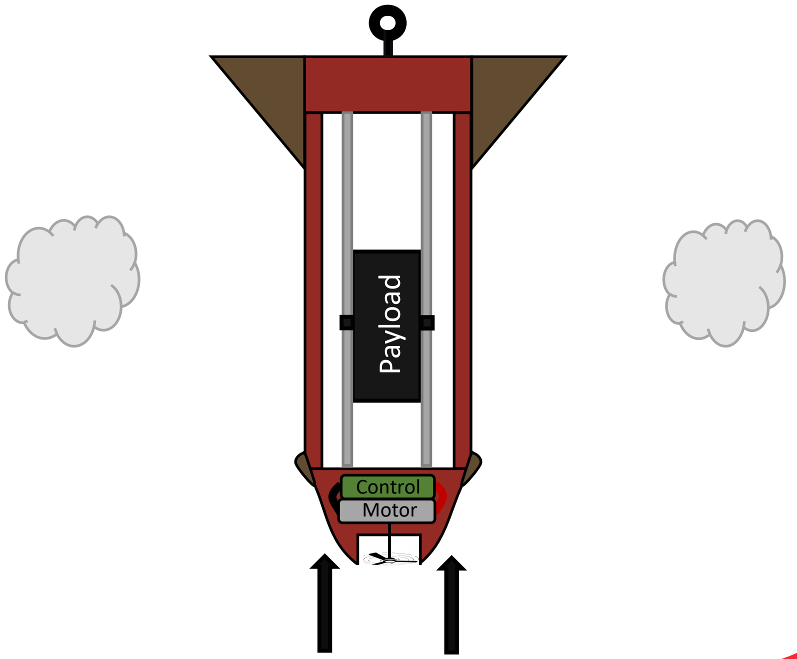


Payload slides along rails in the body



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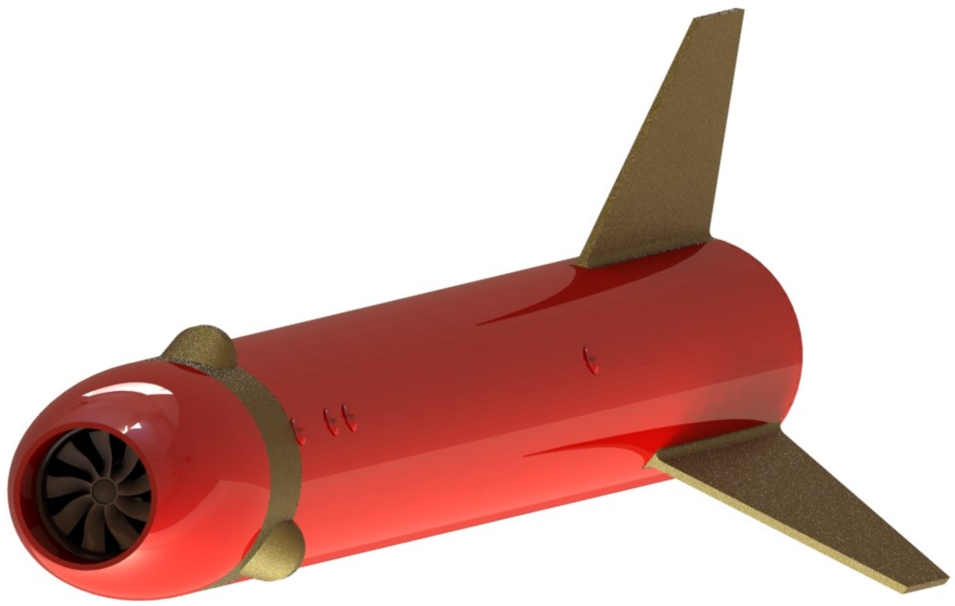

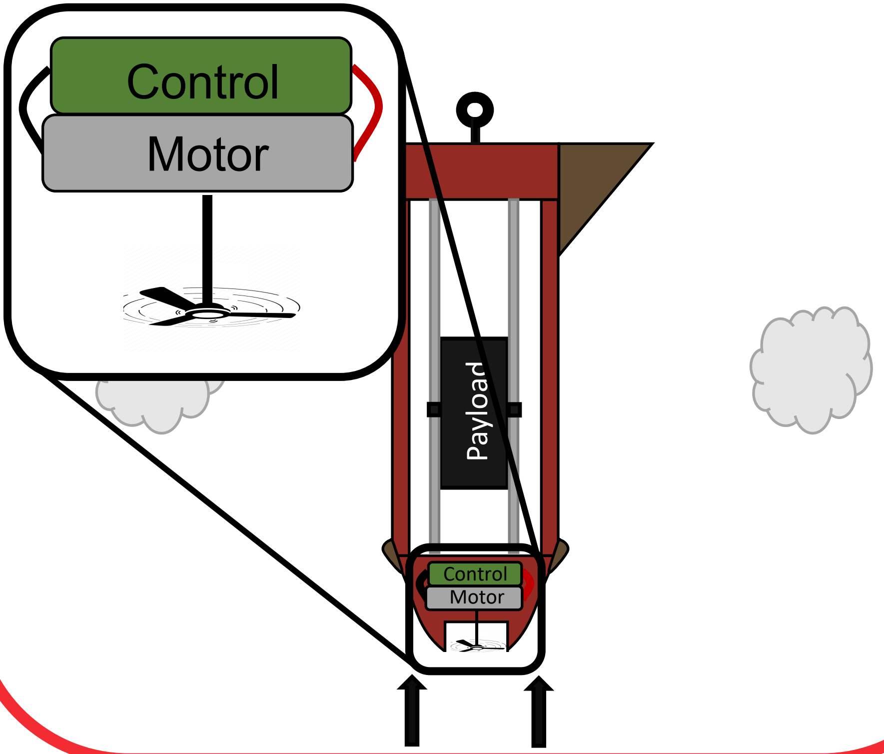

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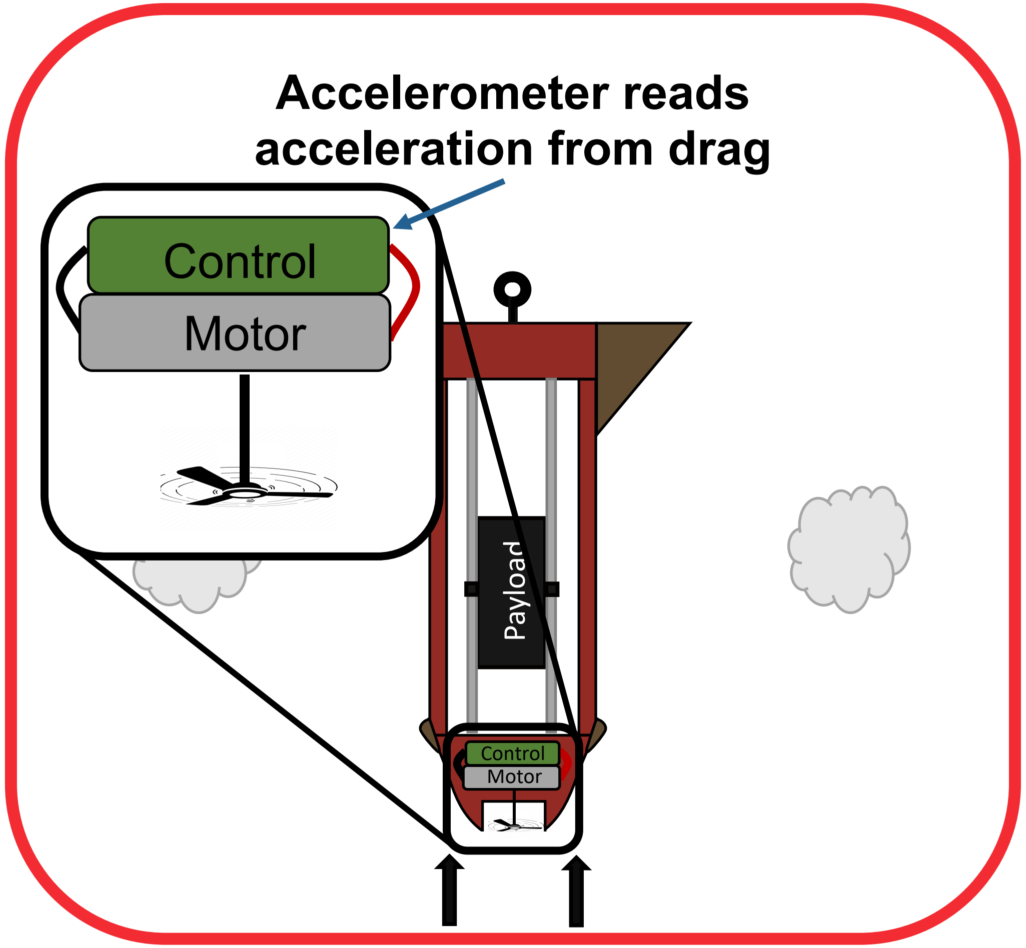

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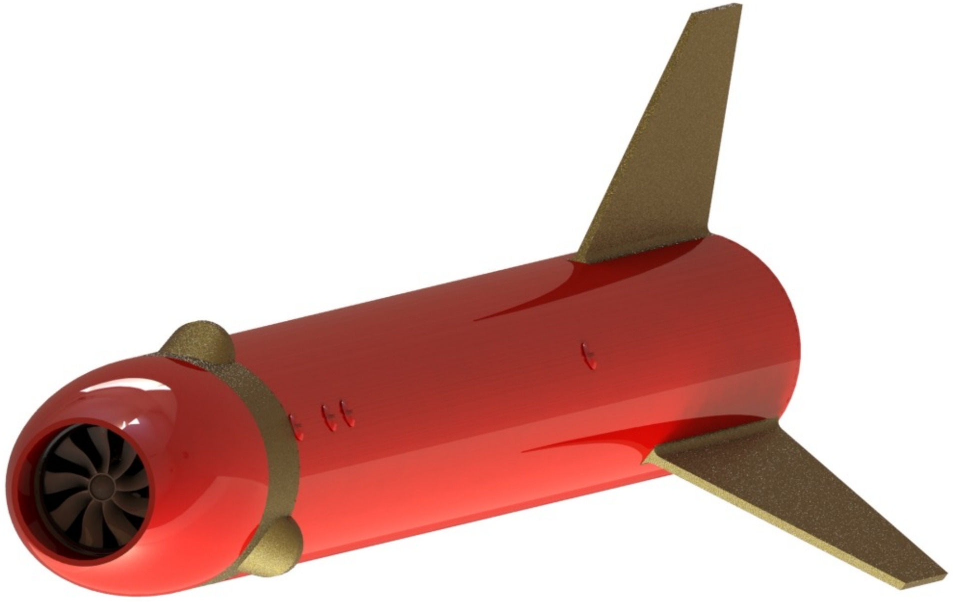
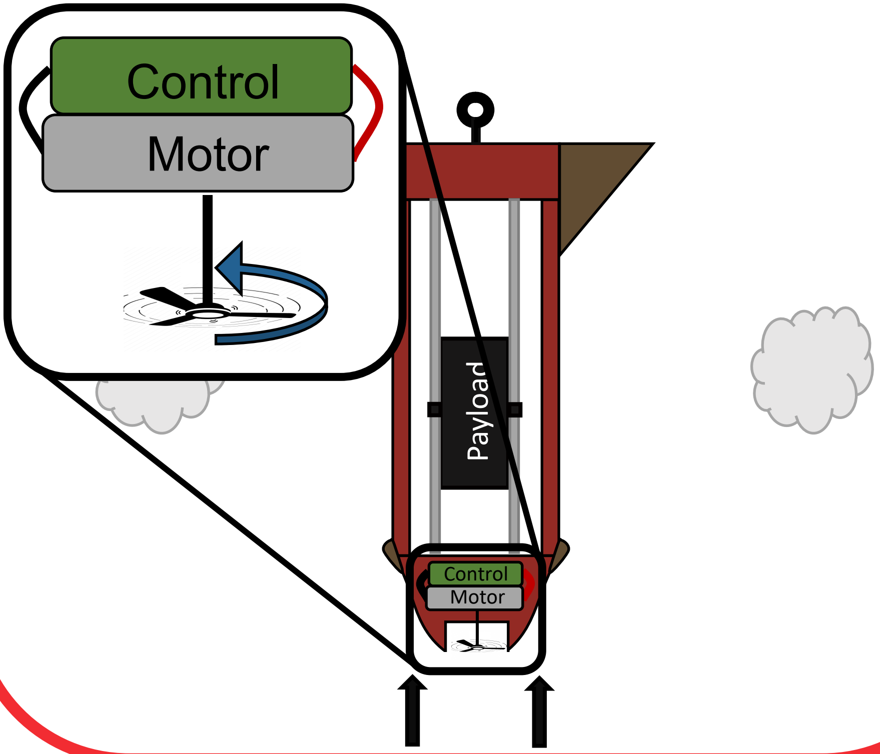


Change in thrust is calculated from accelerometer reading



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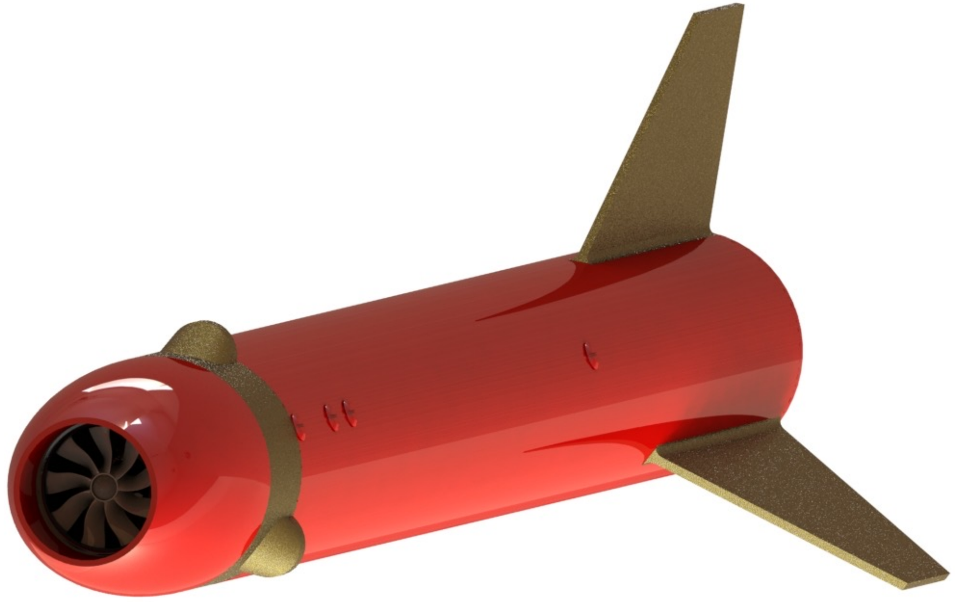
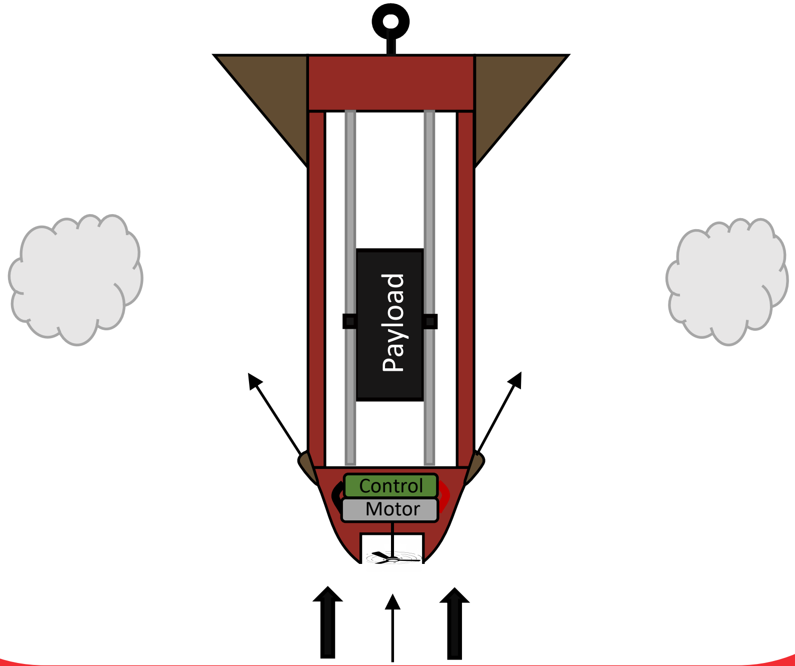


Air is pulled in by the fan and expelled from nozzles



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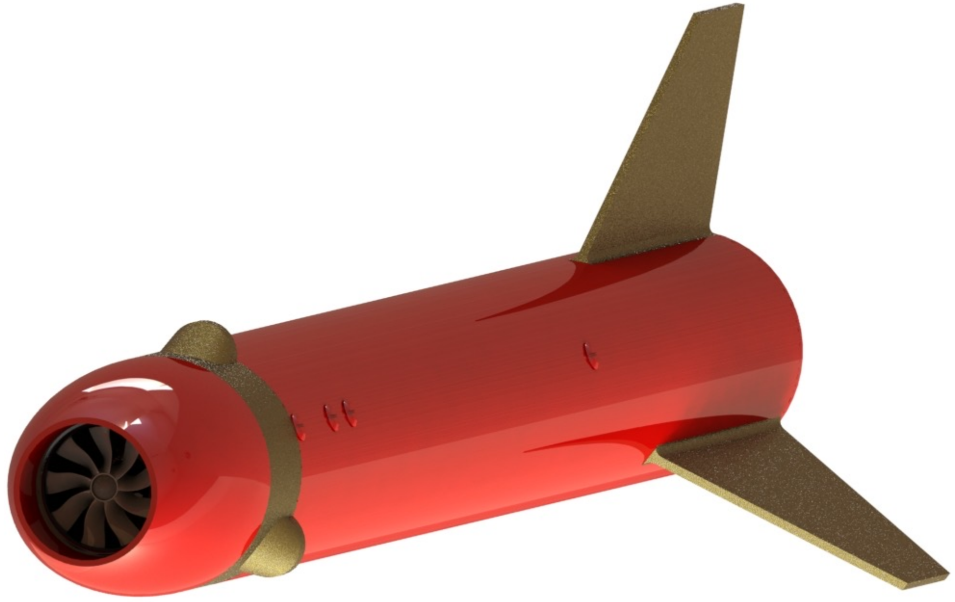
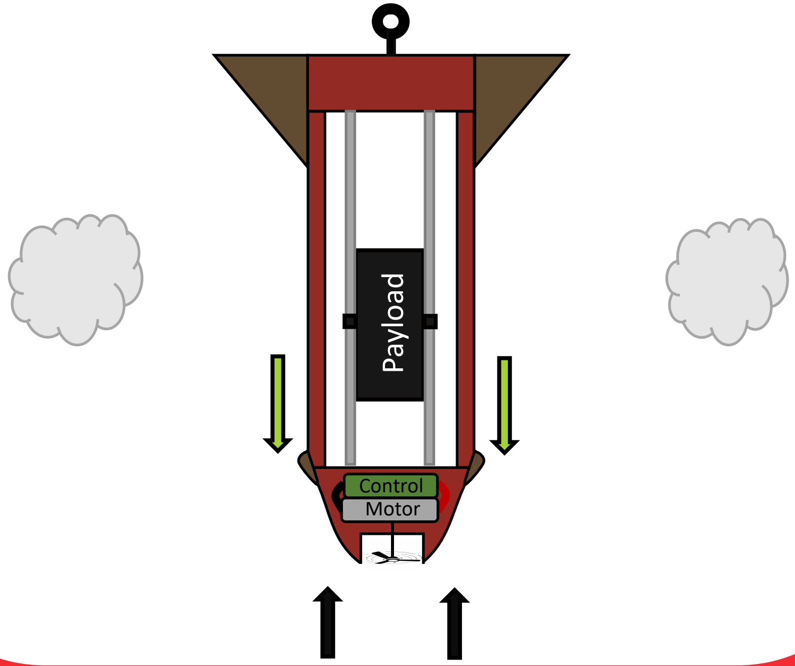


Propulsive forces cancel out drag forces



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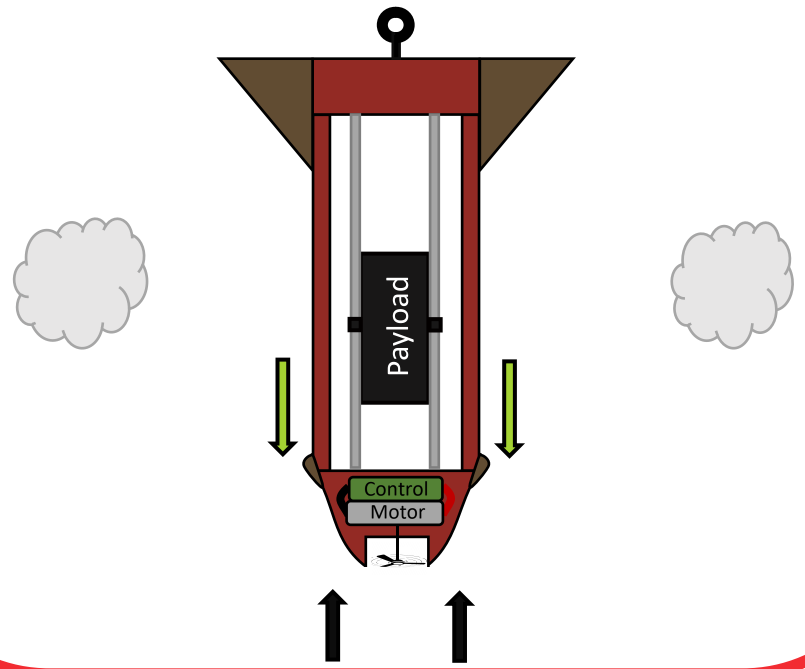

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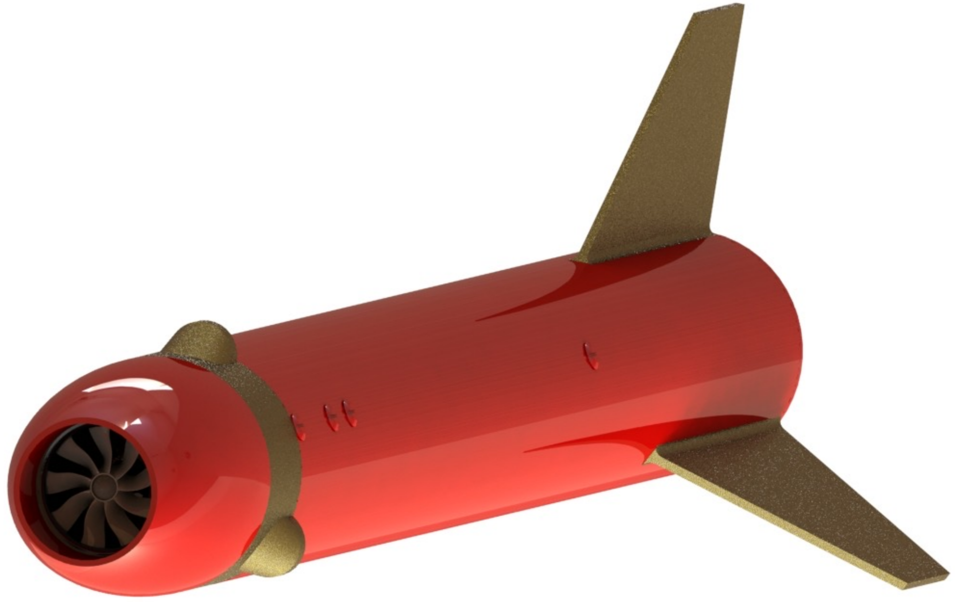
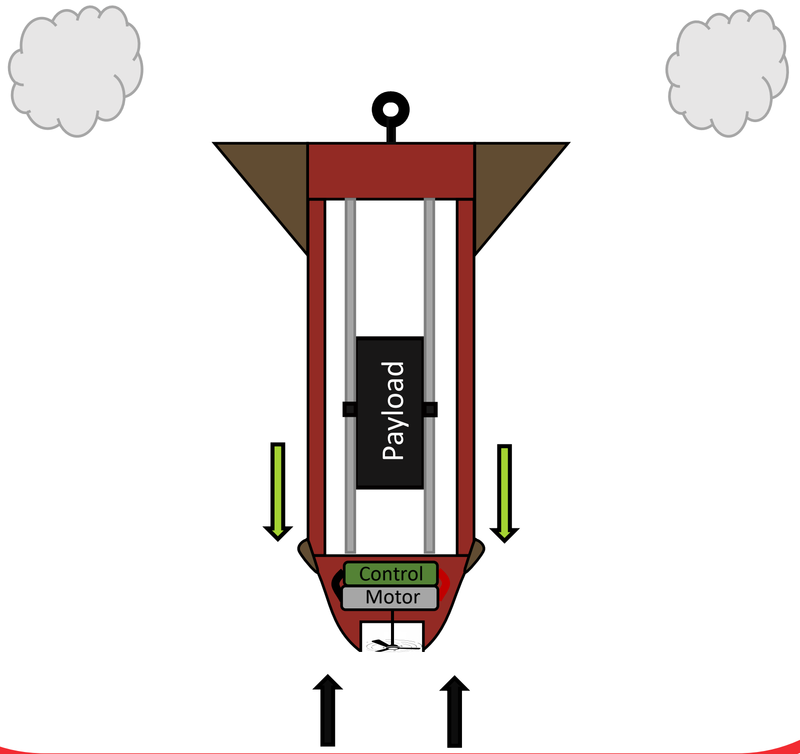


Controller continuously revaluates thrust for 4 seconds



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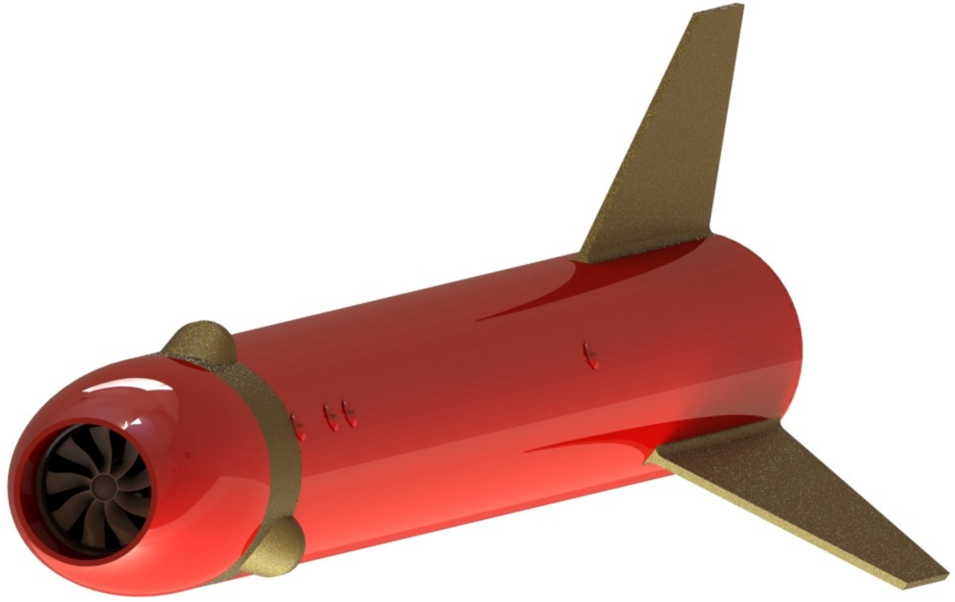

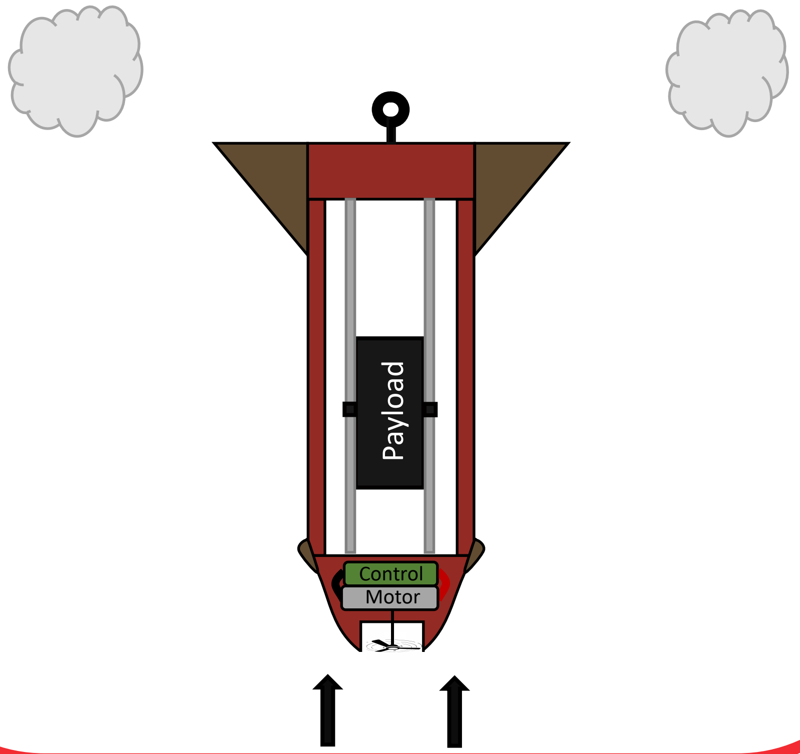

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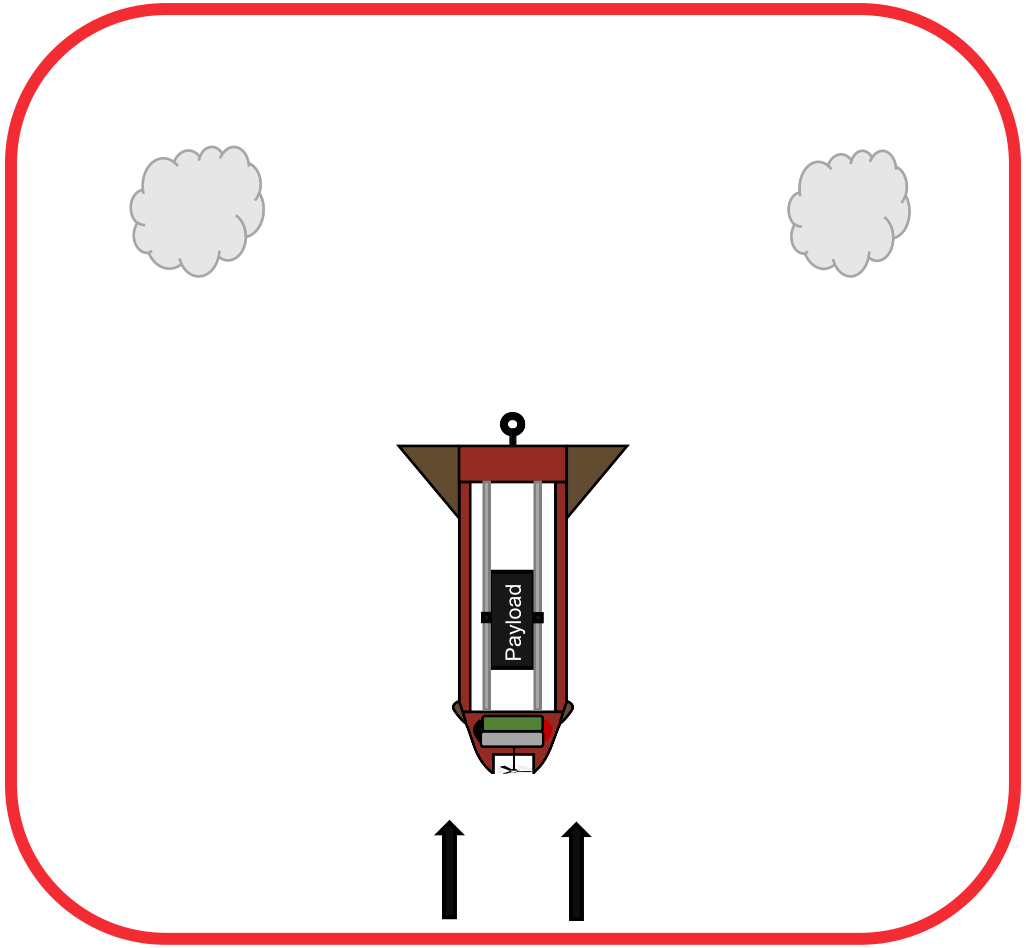

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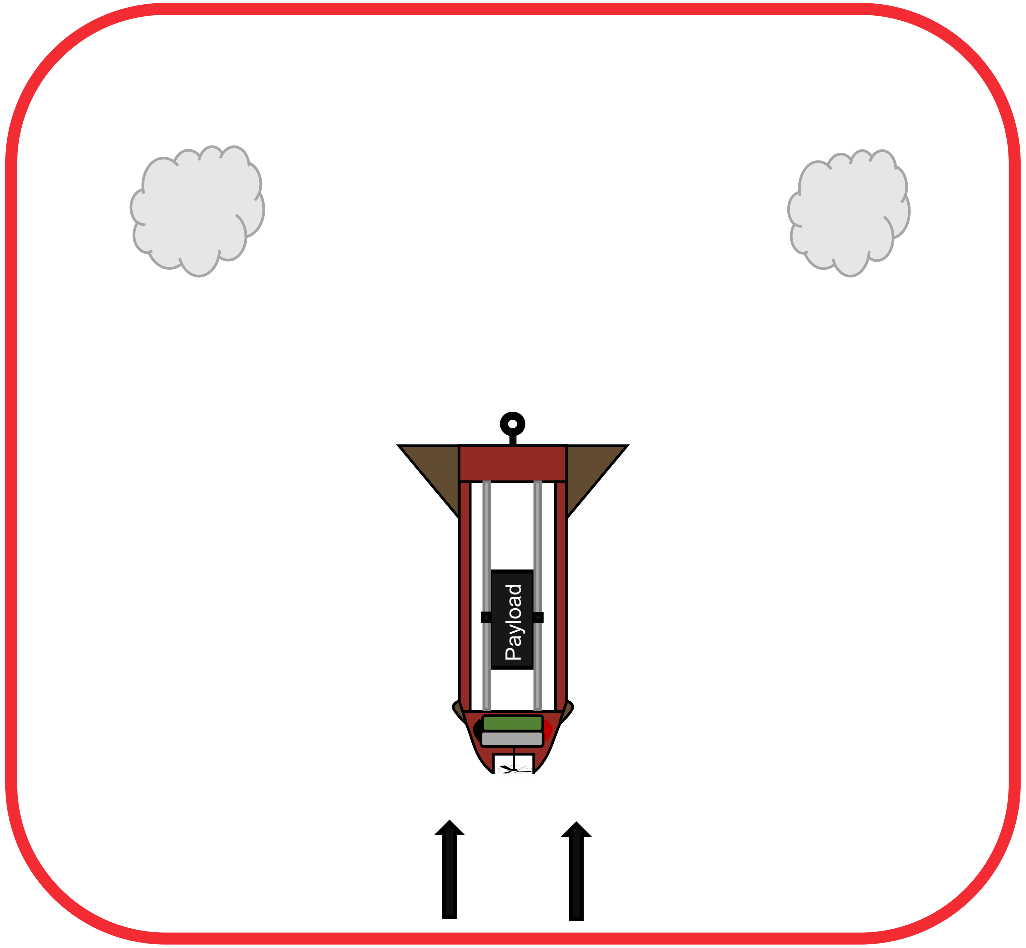

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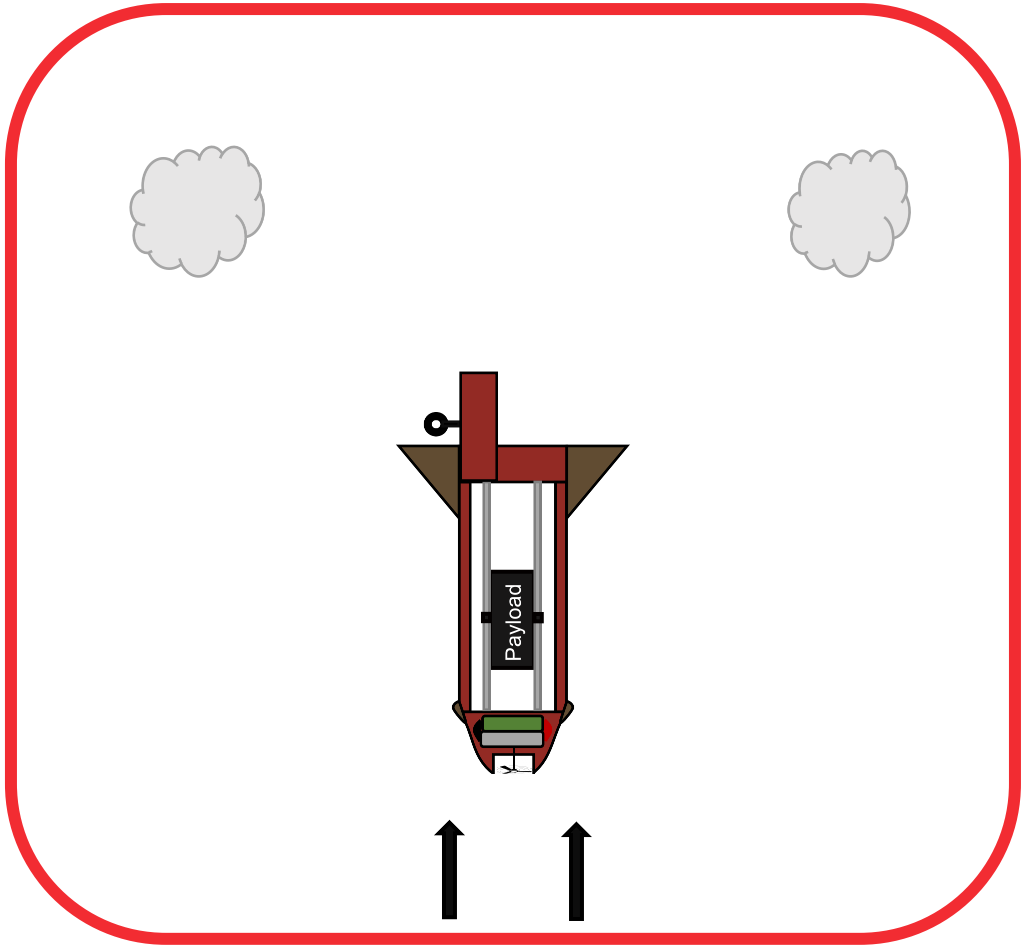

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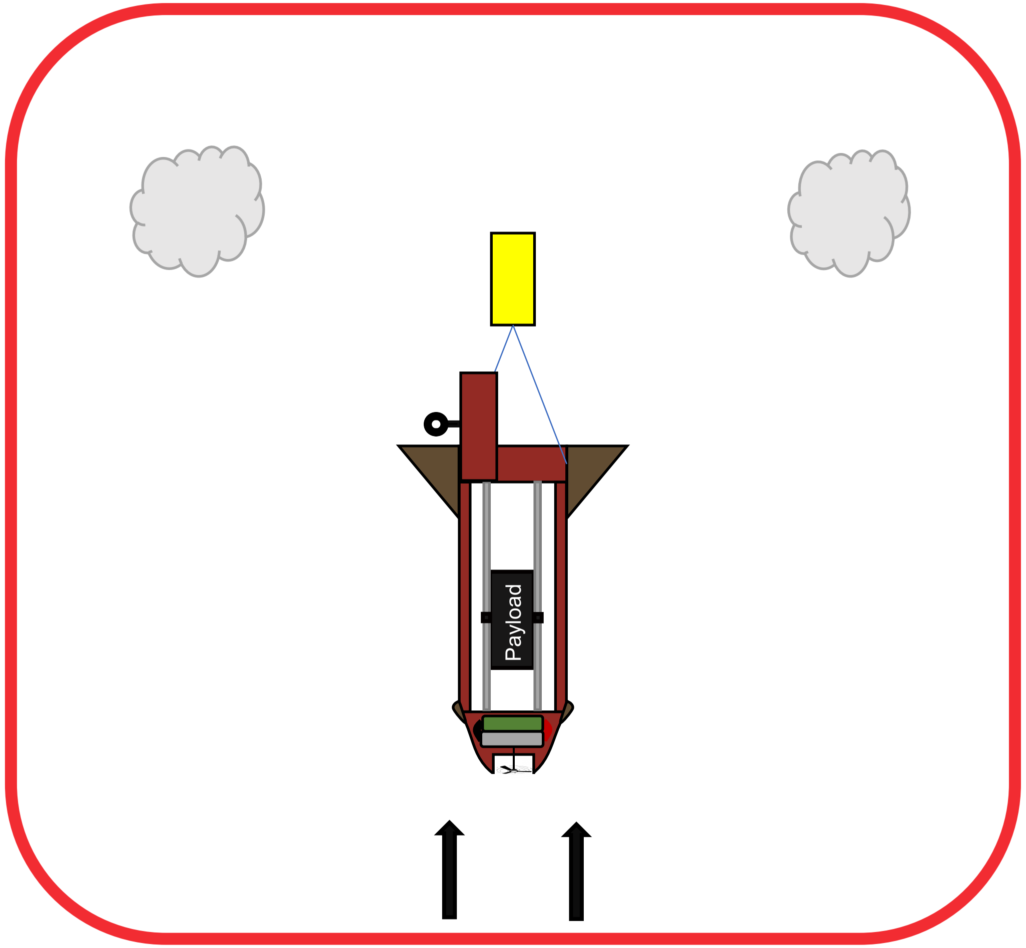

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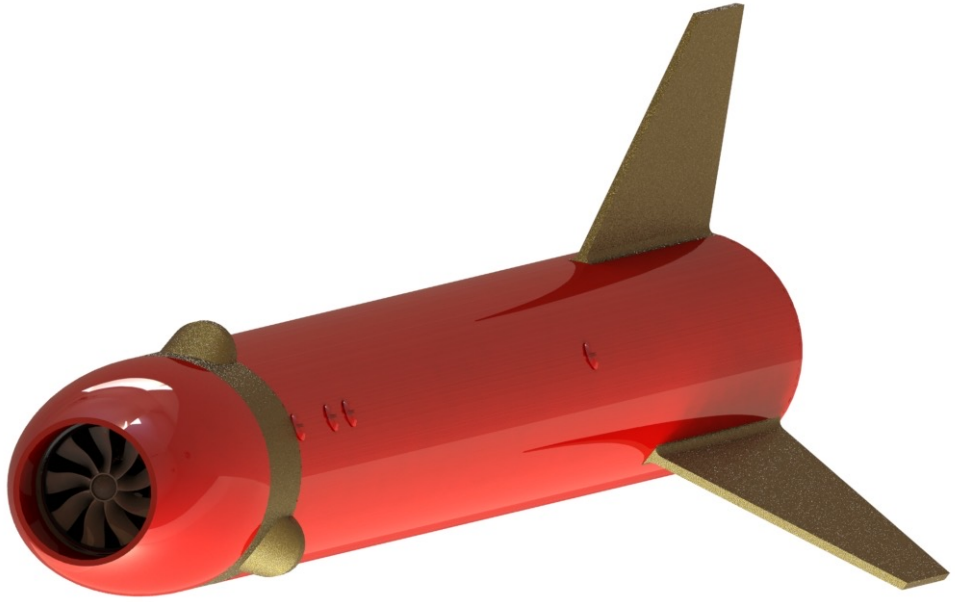
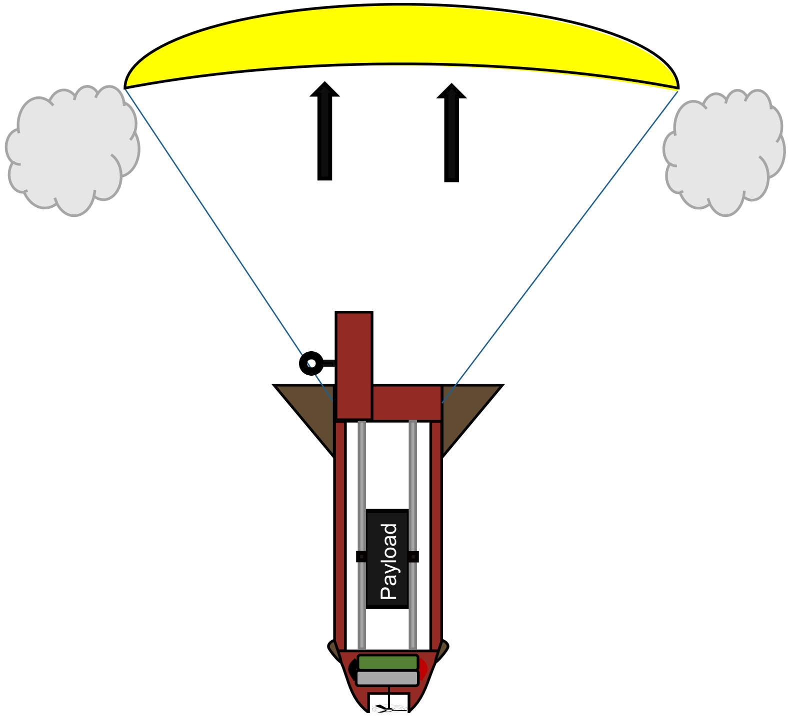
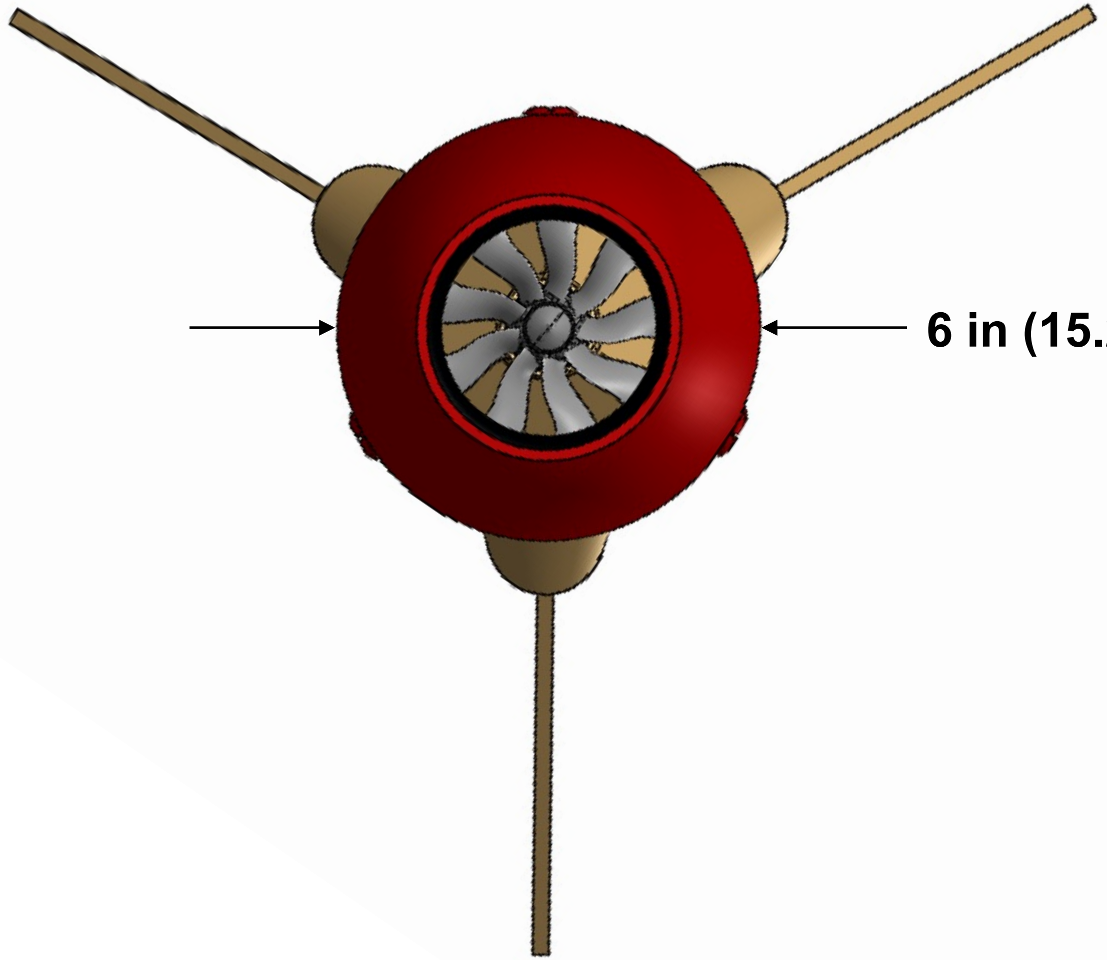




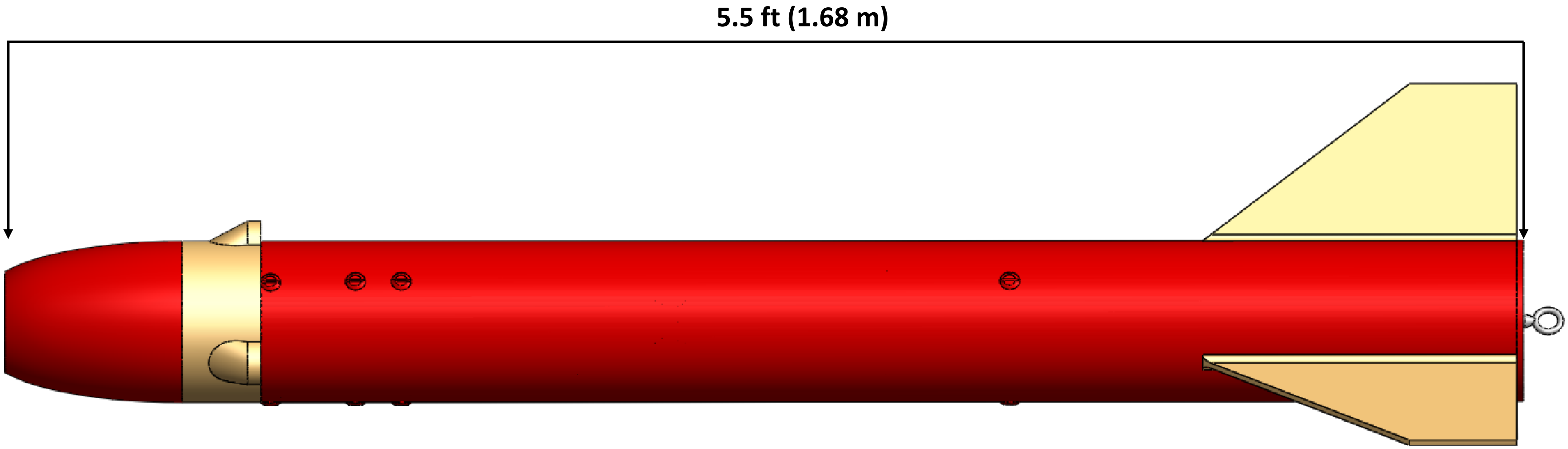
Collin Gainer

Front View



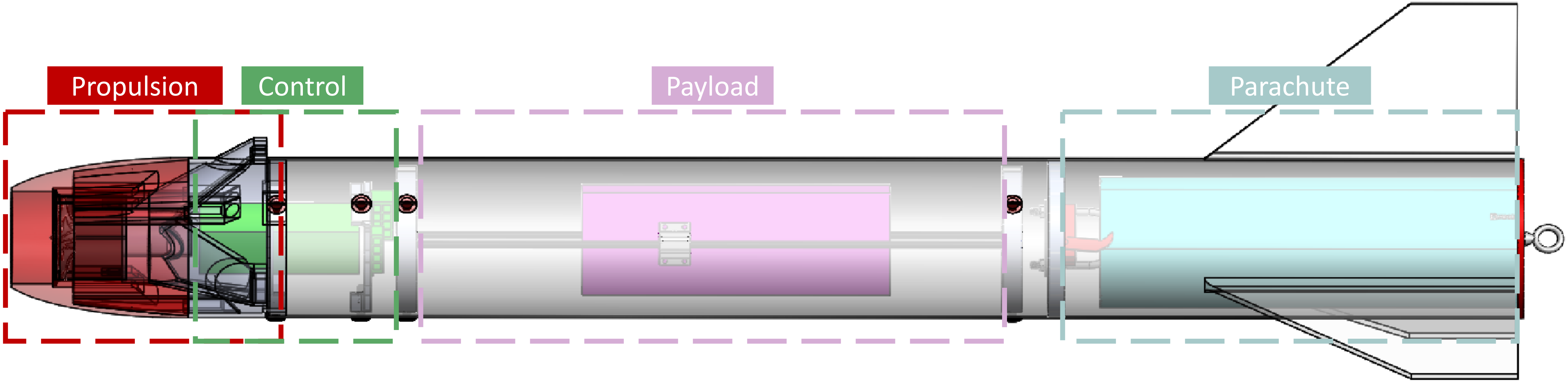
Collin Gainer

Side View



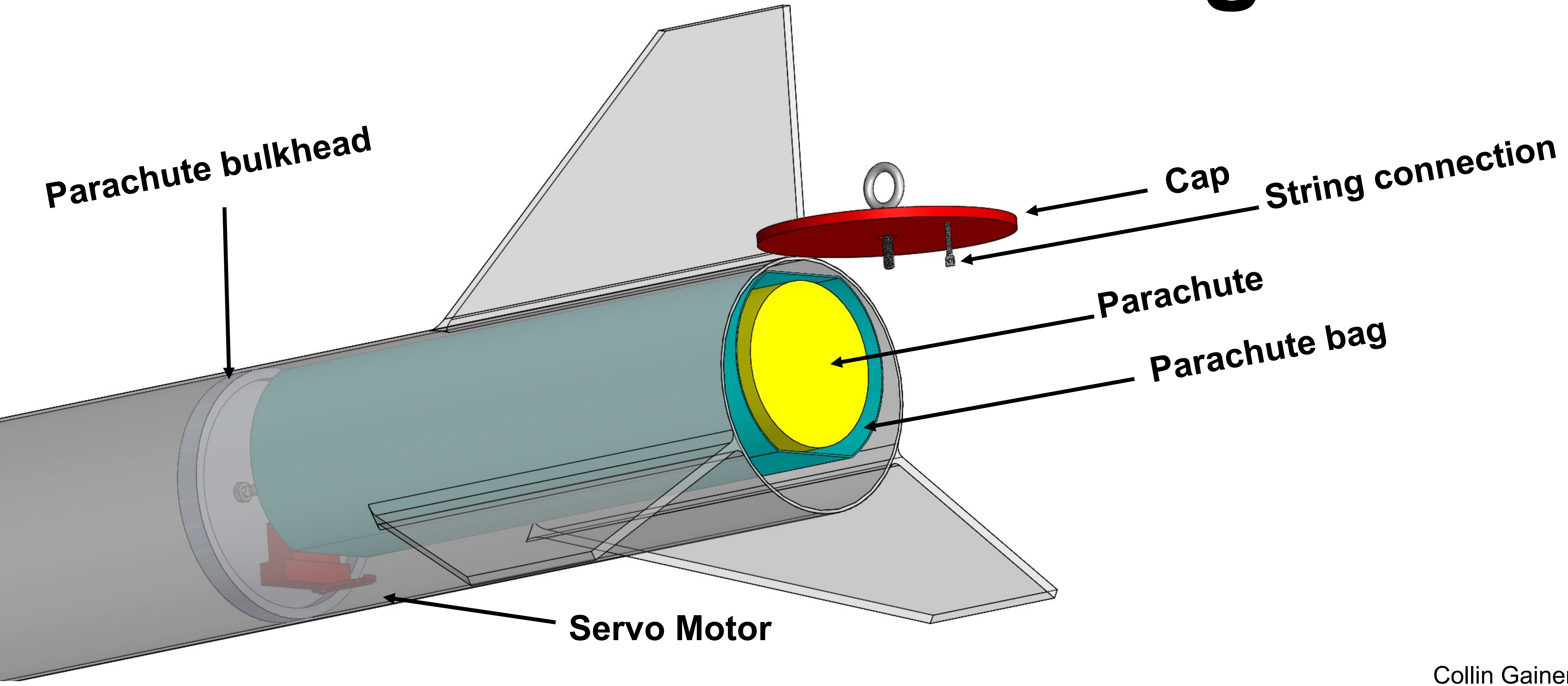
Collin Gainer

Side View



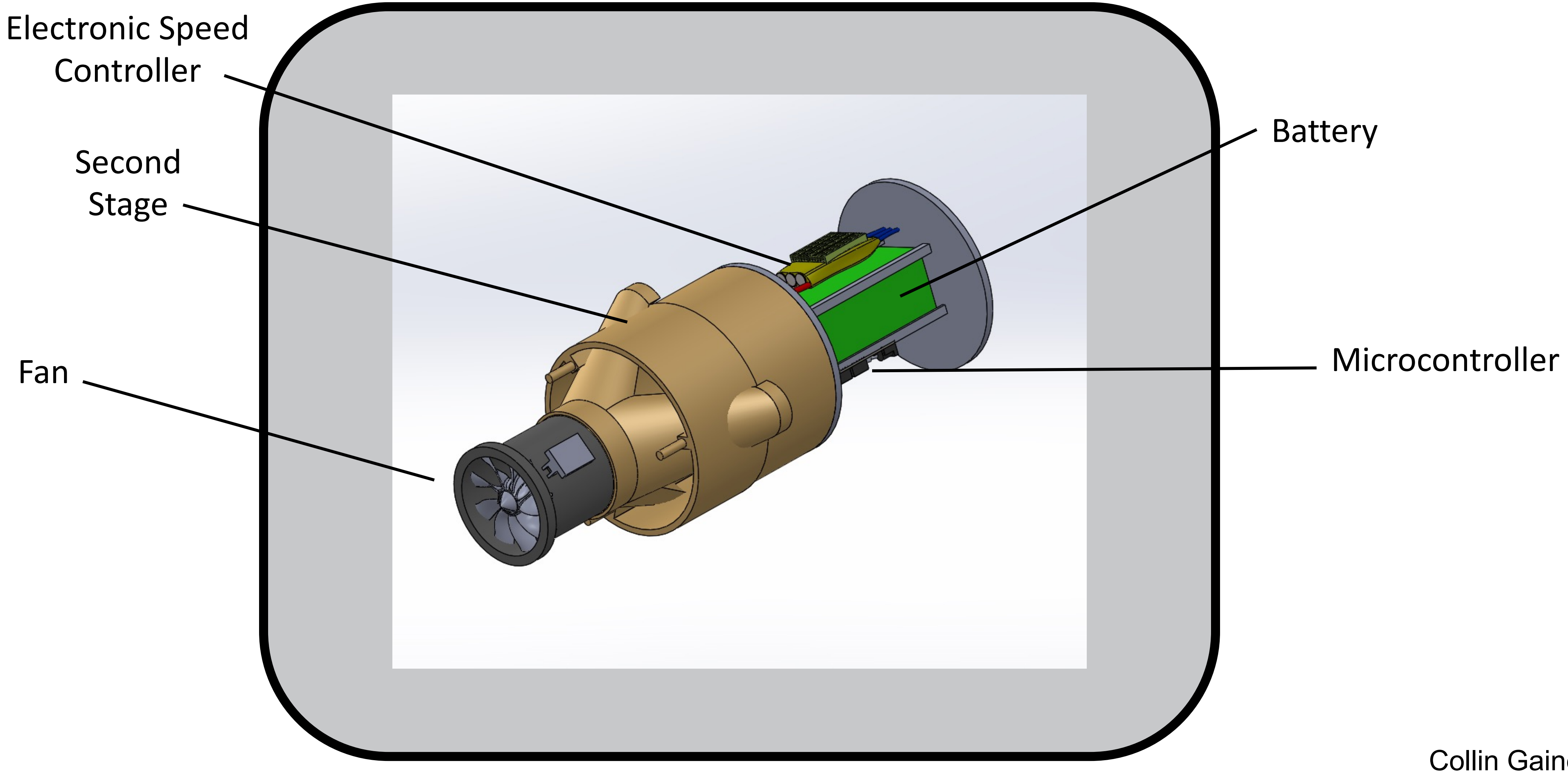
Collin Gainer

Parachute Storage



Collin Gainer

Propulsion System



Collin Gainer

Uncontrolled Simulation

1st portion: Vehicle falls under gravity with drag acting on it.

2nd portion: Vehicle slows after parachute is released

V ≈ 4 m/s 0.5 s after the parachute is opened

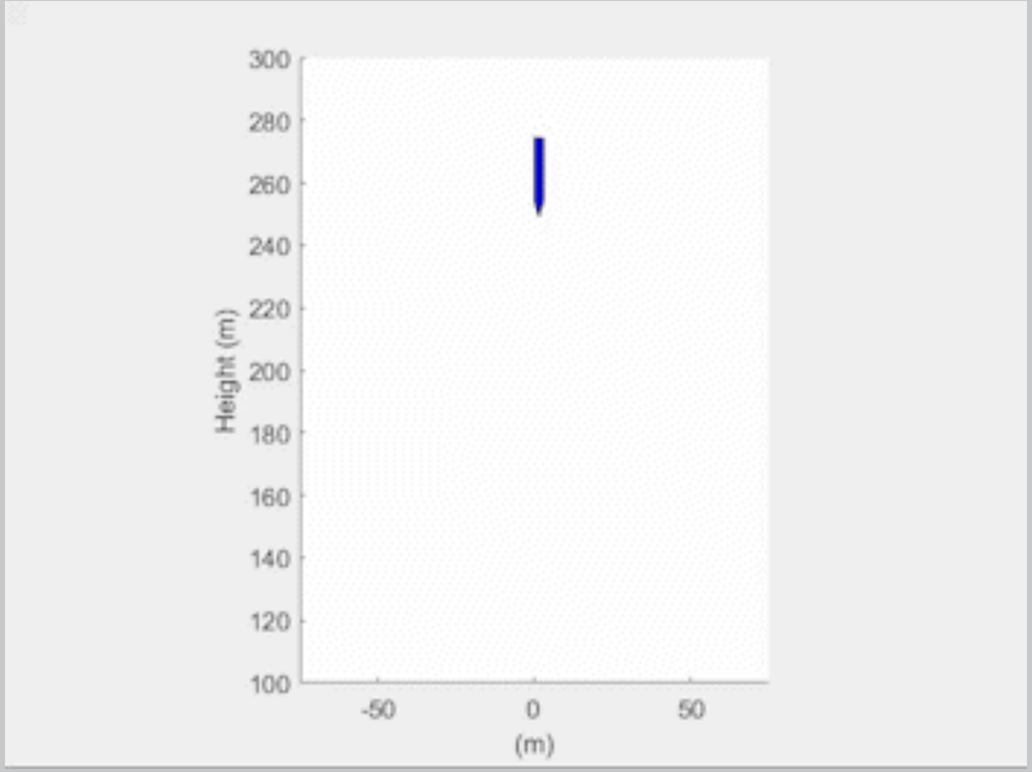
John Tietsworth

Uncontrolled Simulation

1^{st} portion: Vehicle falls under gravity with drag acting on it.

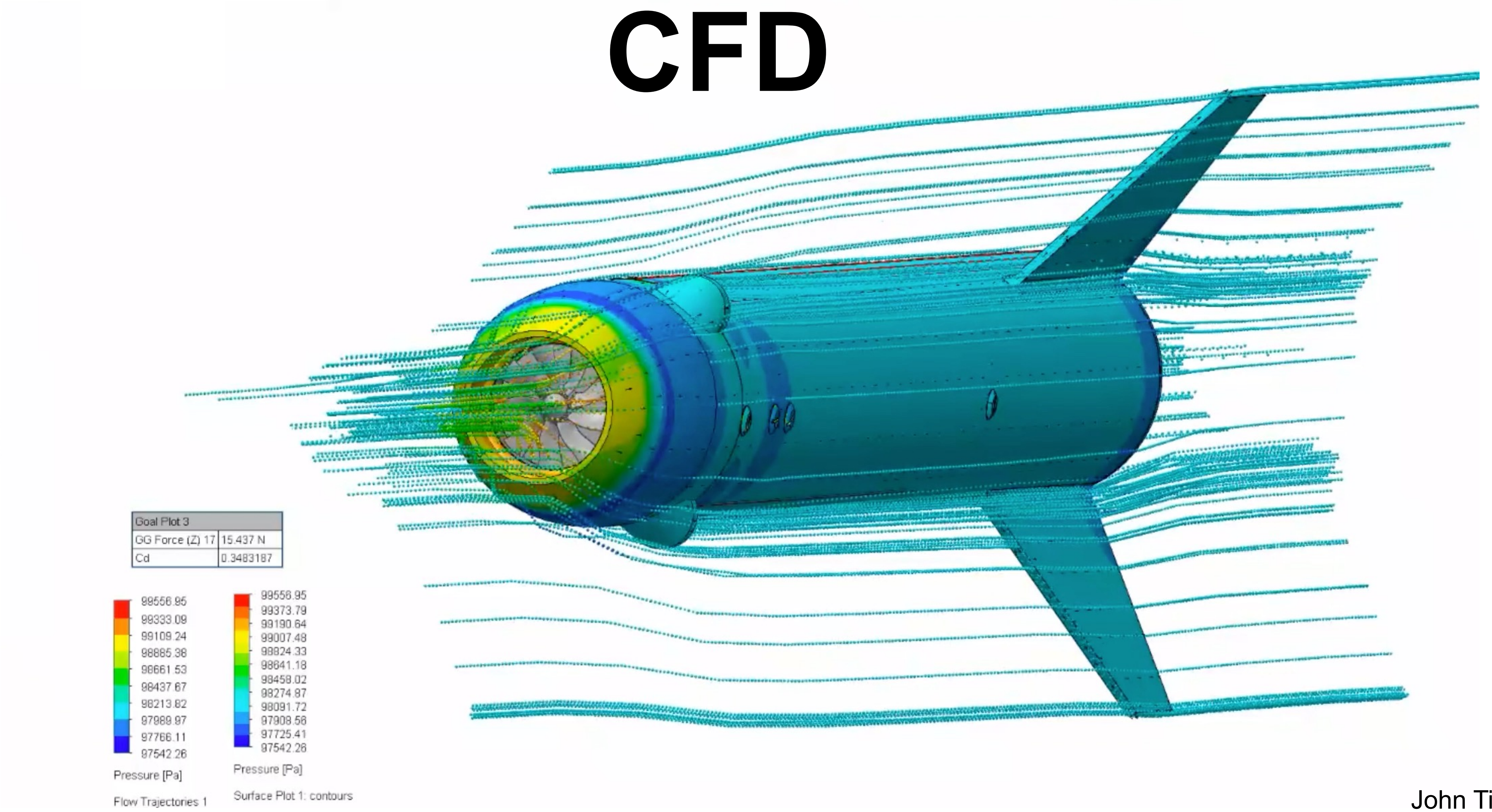
2^{nd} portion: Vehicle slows after parachute is released

V ≈ 4 m/s 0.5 s after the parachute is opened



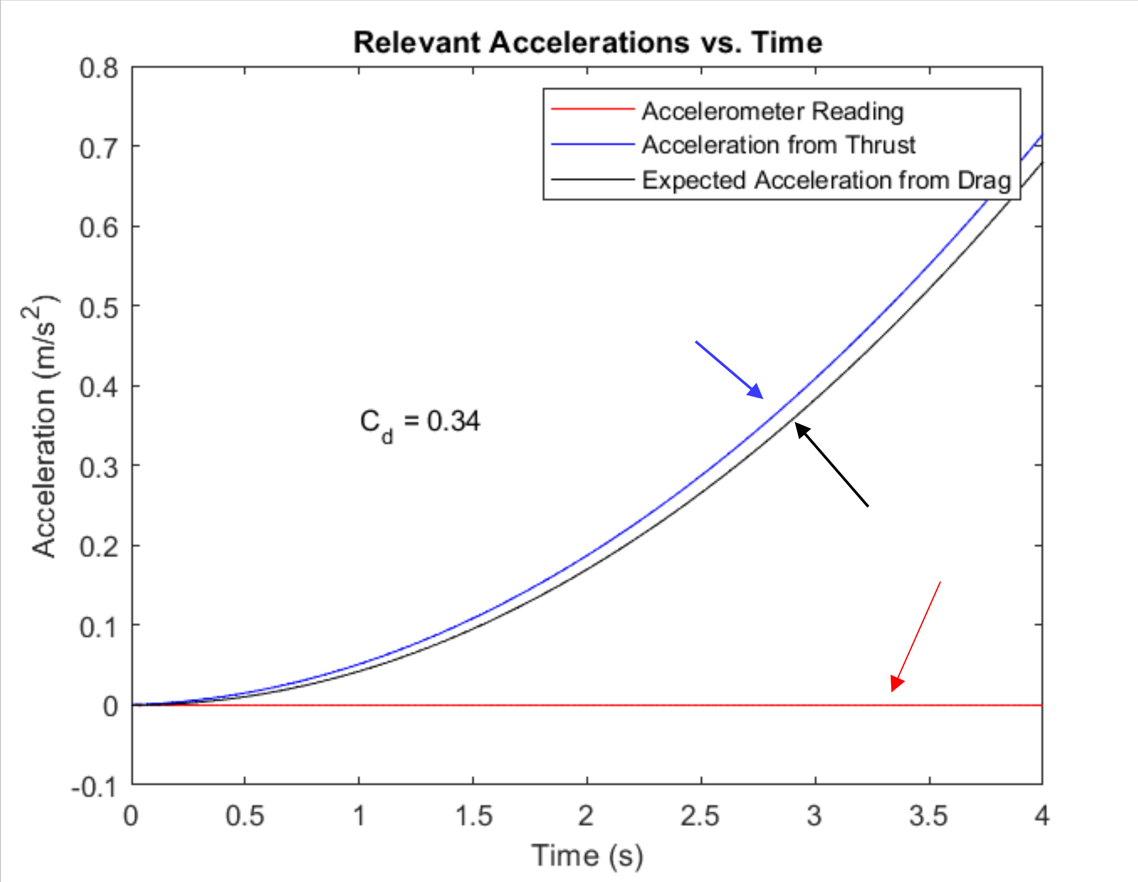
John Tietsworth

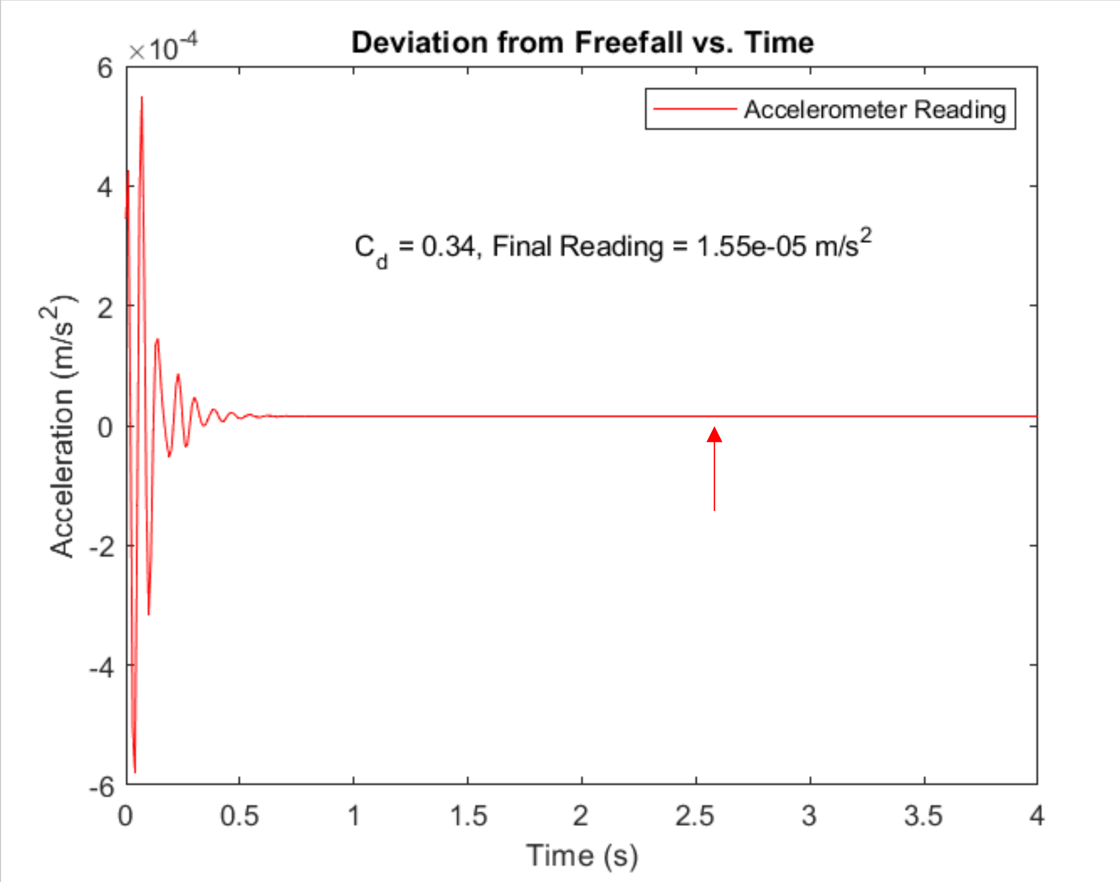
CFD



John Tietsworth

Controlled Simulation (PID)





John Tietsworth

Chosen Microcontroller

FireBeetle ESP32
- 240 MHz
- Dual core processing

Compared to Arduino Mega
- 15x faster computation

Samuel Duval

Testing Plans

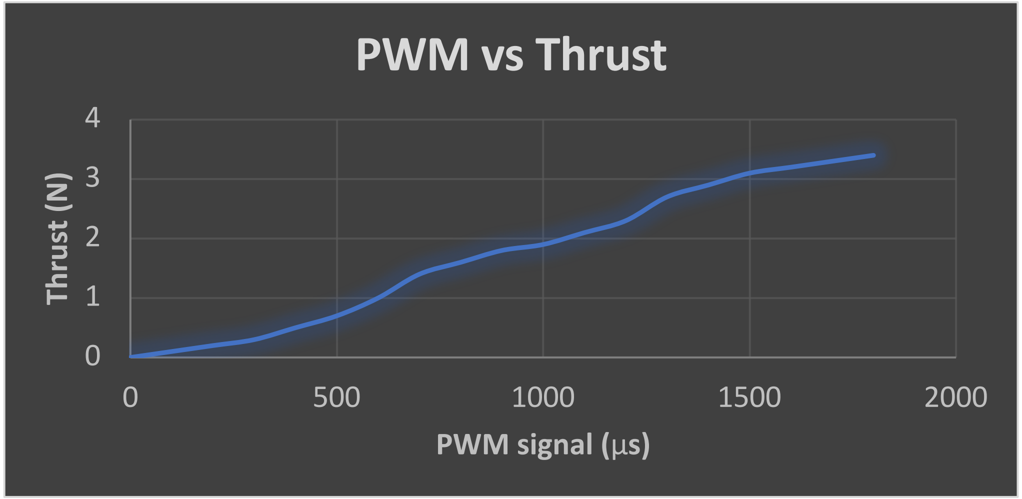
1. [redacted]
2. [redacted]
3. [redacted]
4. [redacted]
5. [redacted]

Samuel Duval

Testing Plans

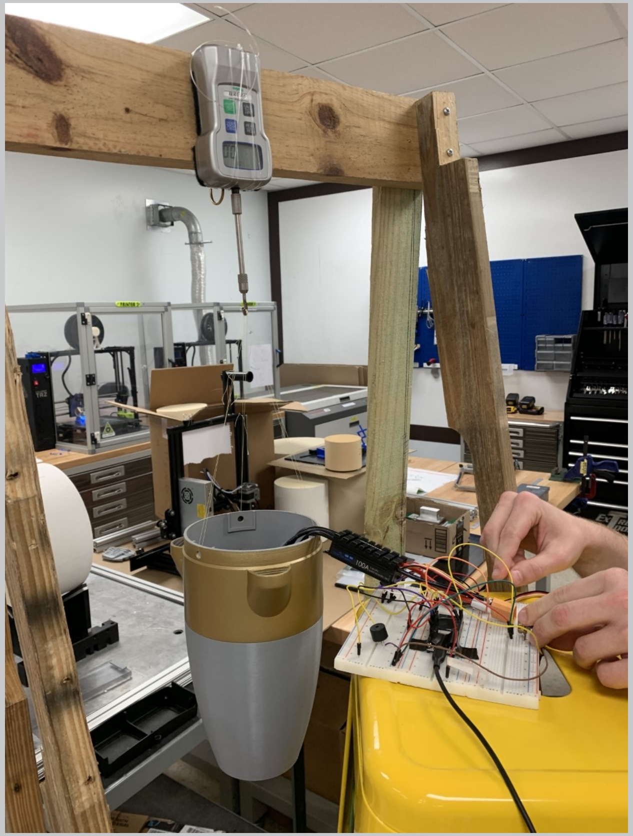
1. Thrust curve for the EDF

[redacted]



Samuel Duval

Thrust Testing - BUILD



Samuel Duval

Thrust Testing - Adaptation

Samuel Duval

Thrust Testing Results

Max Drag	15.4 N
Max Fan Thrust	28 N

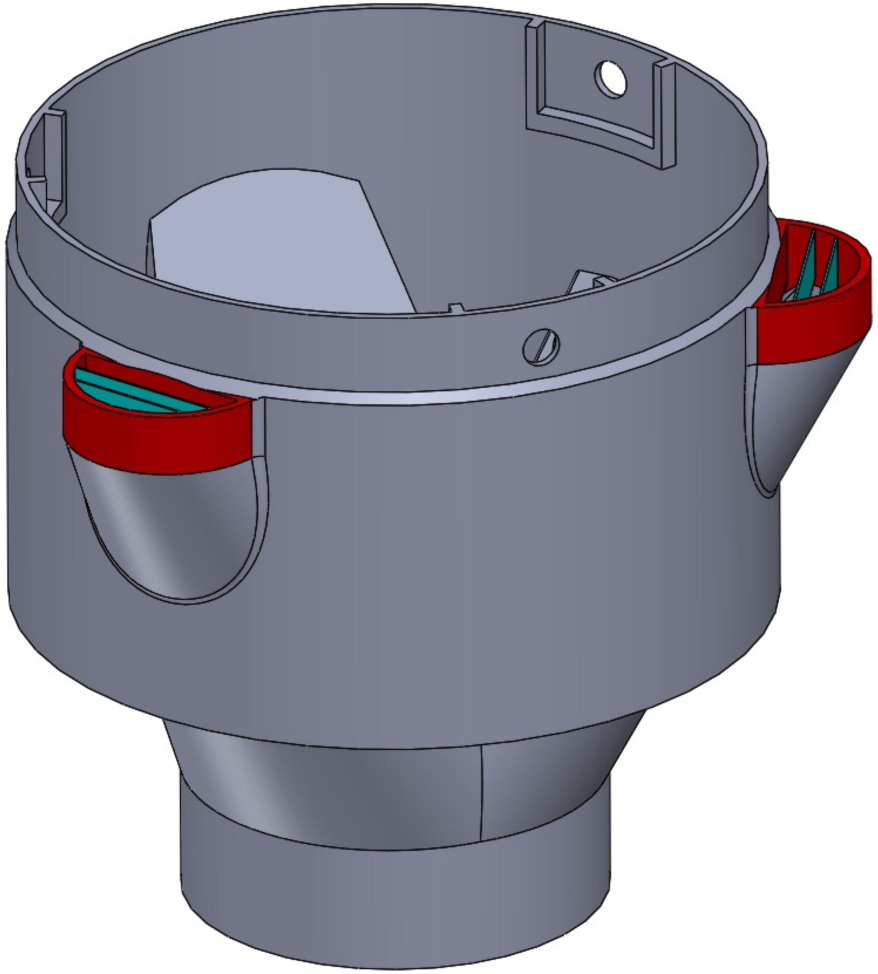
Duct Iteration	Maximum Trust

John Tietsworth

Thrust Testing Results

Max Drag	15.4 N
Max Fan Thrust	28 N

Duct Iteration	Maximum Trust
1	7 N

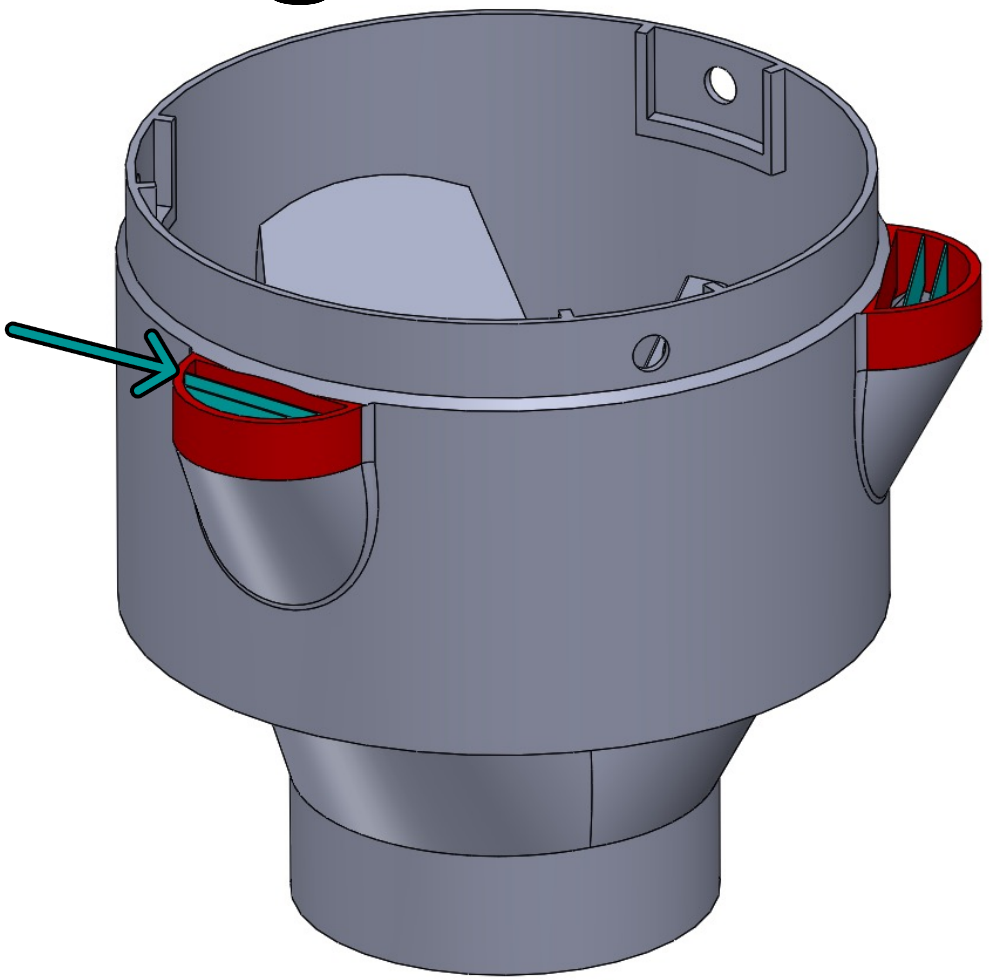


John Tietsworth

Thrust Testing Results

Max Drag	15.4 N
Max Fan Thrust	28 N

Duct Iteration	Maximum Trust
1	7 N
2	8.2 N

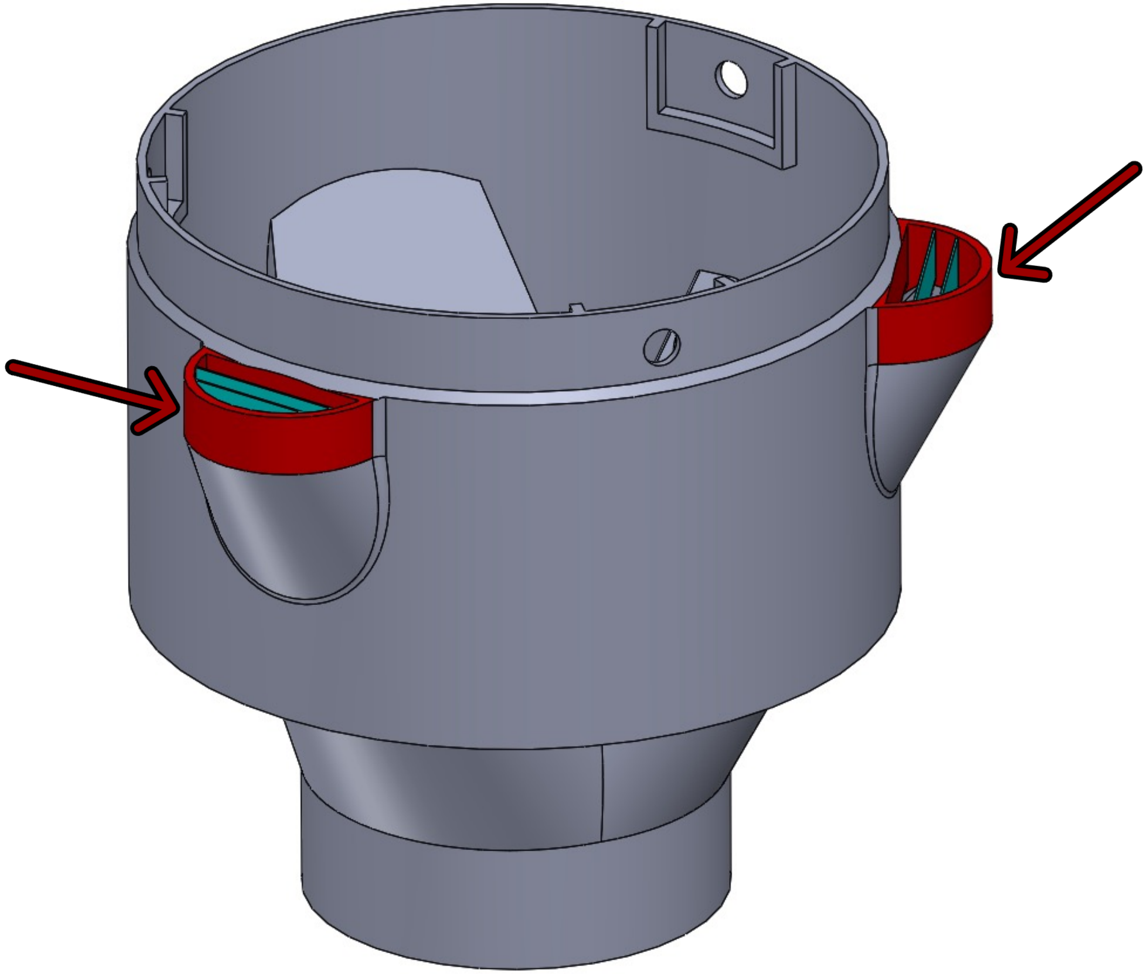


John Tietsworth

Thrust Testing Results

Max Drag	15.4 N
Max Fan Thrust	28 N

Duct Iteration	Maximum Trust
1	7 N
2	8.2 N
3	8.6 N

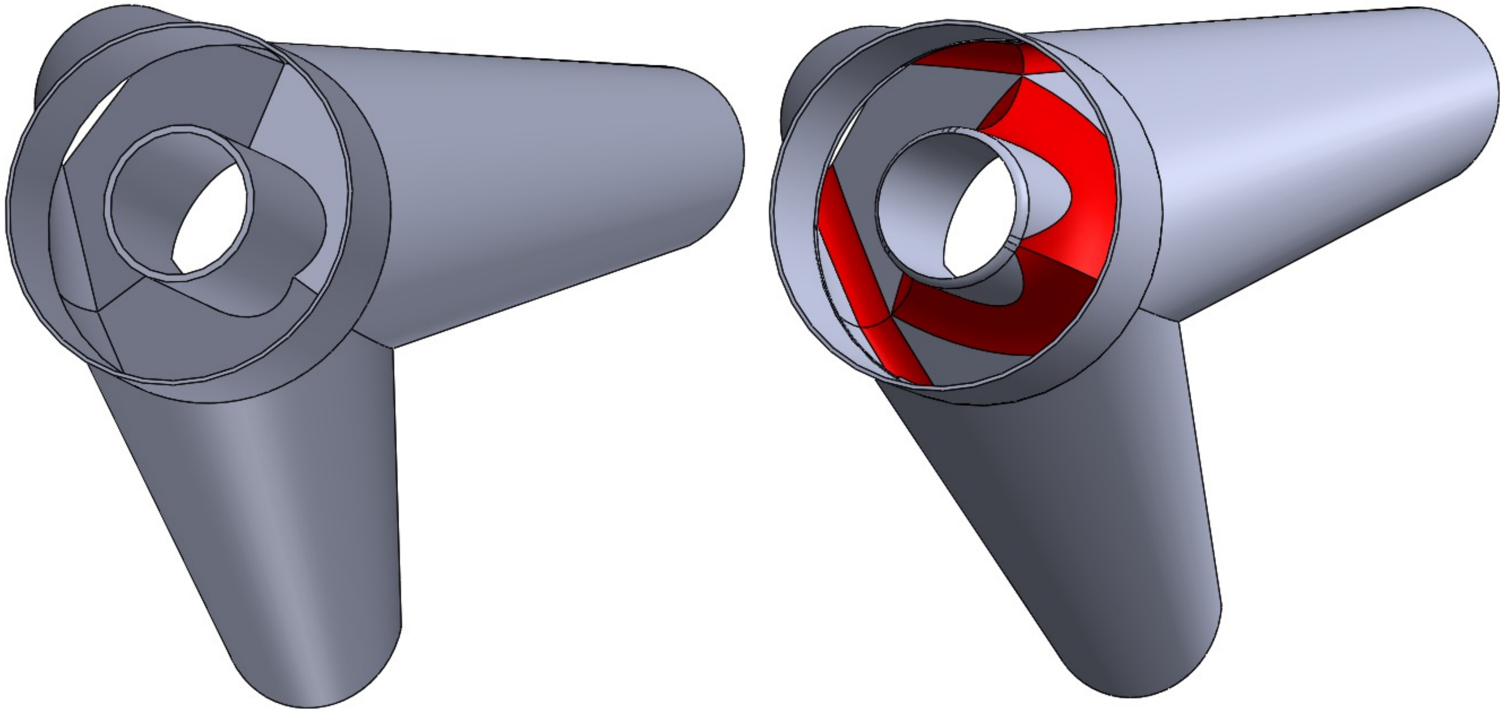


John Tietsworth

Thrust Testing Results

Max Drag	15.4 N
Max Fan Thrust	28 N

Duct Iteration	Maximum Trust
1	7 N
2	8.2 N
3	8.6 N
4	11 N

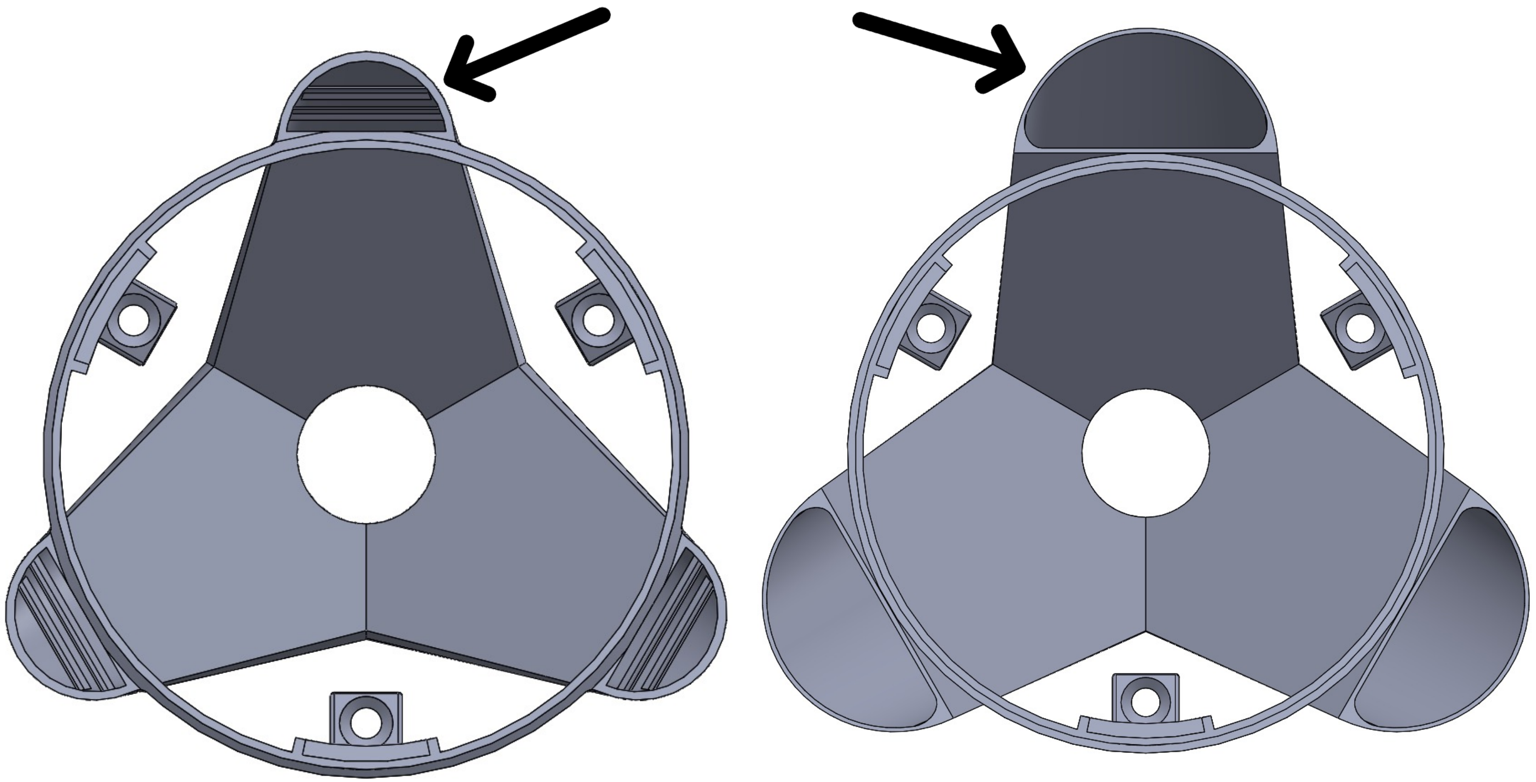


John Tietsworth

Thrust Testing Results

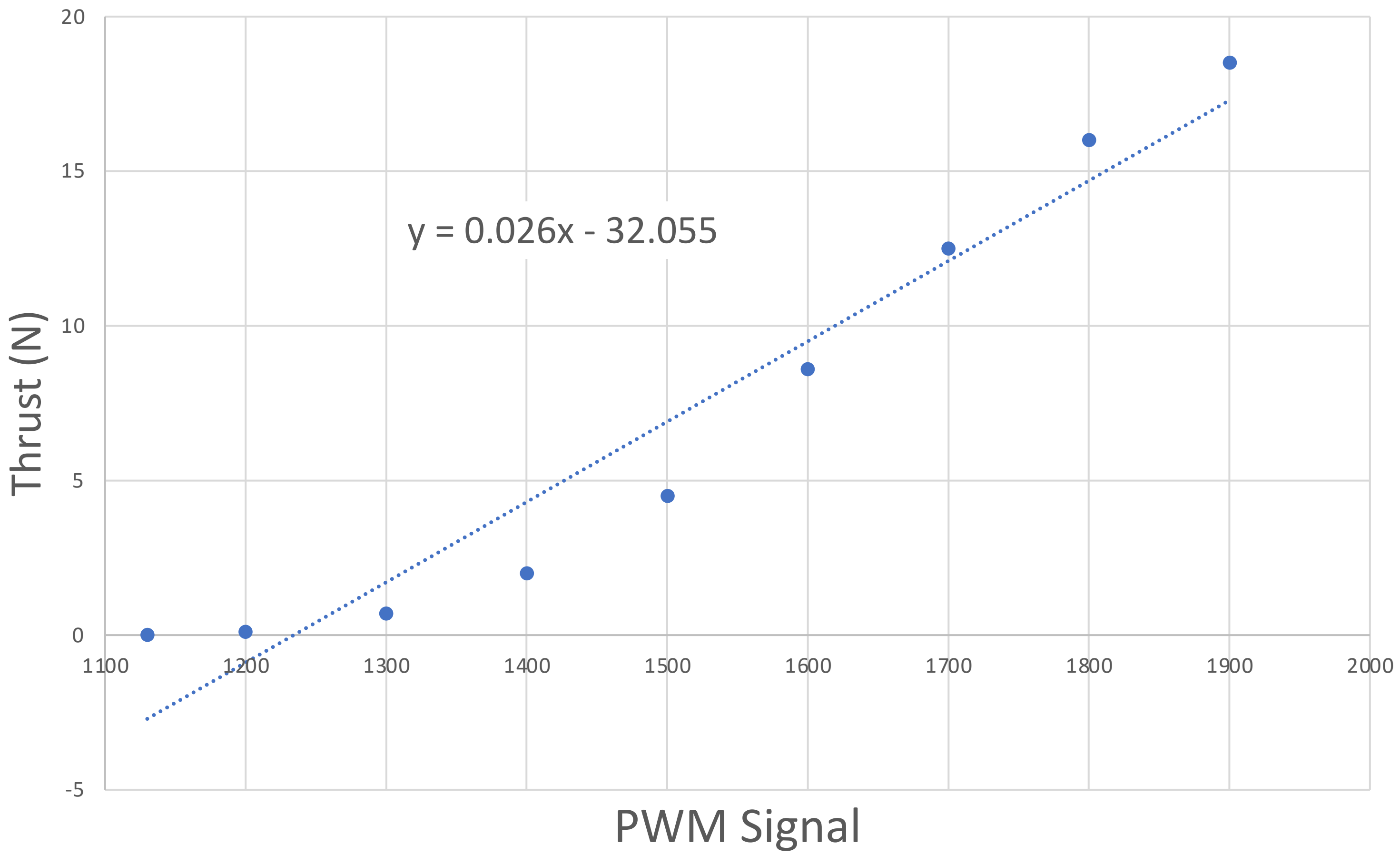
Max Drag	15.4 N
Max Fan Thrust	28 N

Duct Iteration	Maximum Trust
1	7 N
2	8.2 N
3	8.6 N
4	11 N
5	18.5 N



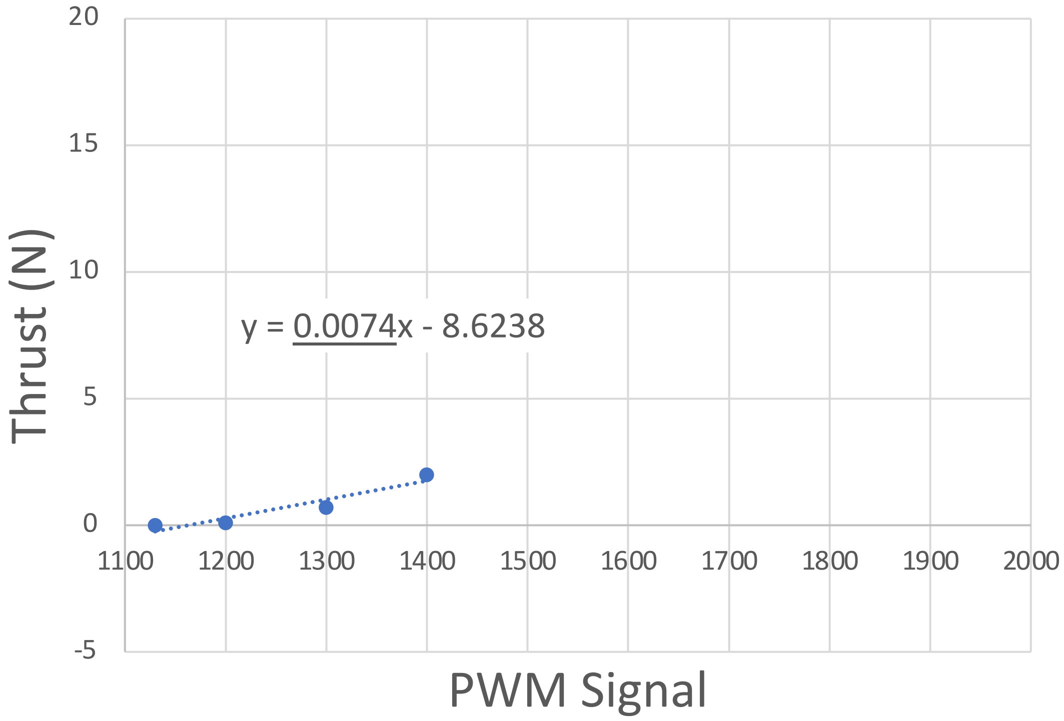
John Tietsworth

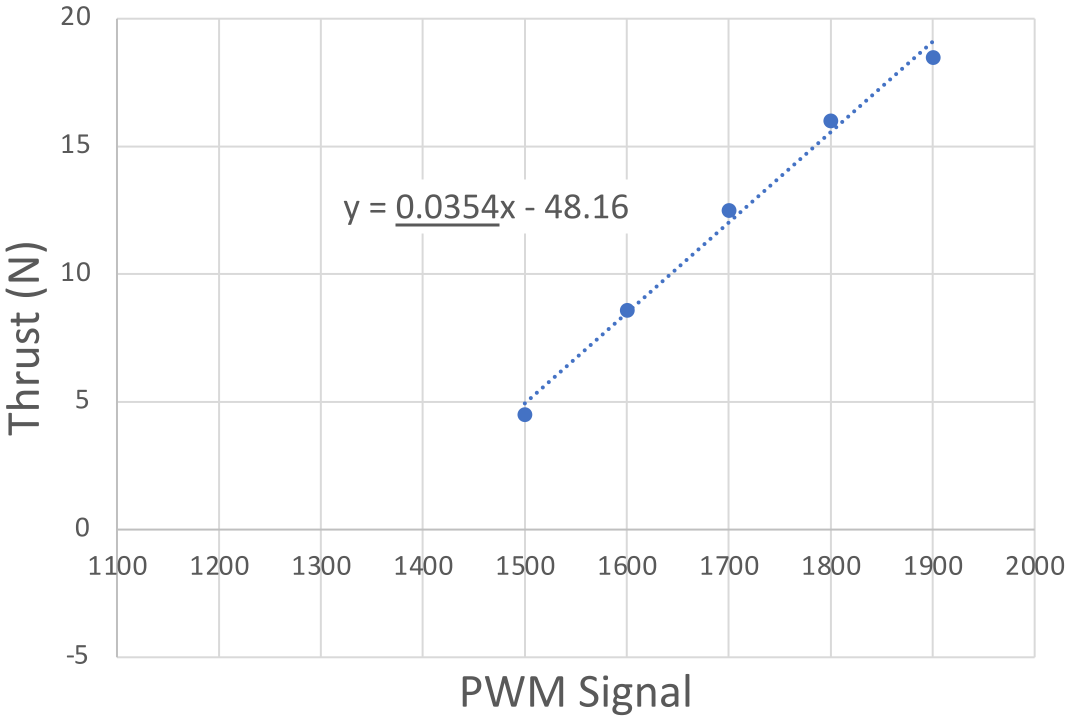
PWM Signal vs. Thrust



John Tietsworth

PWM Signal vs. Thrust

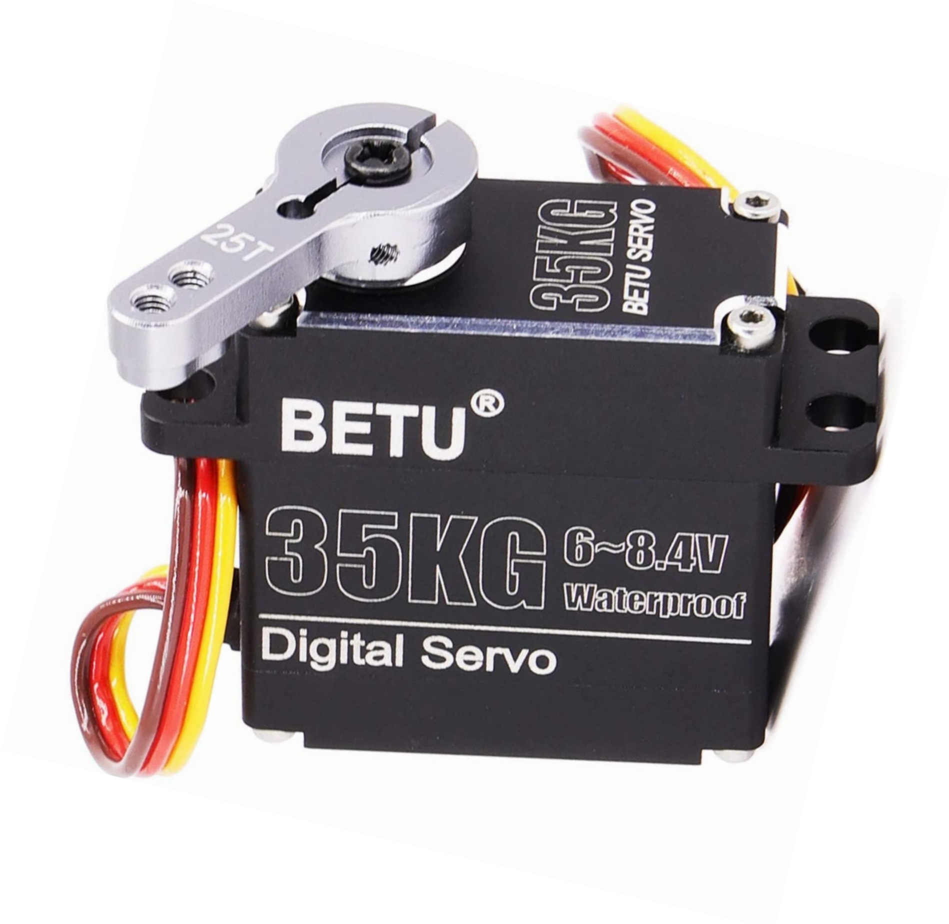




John Tietsworth

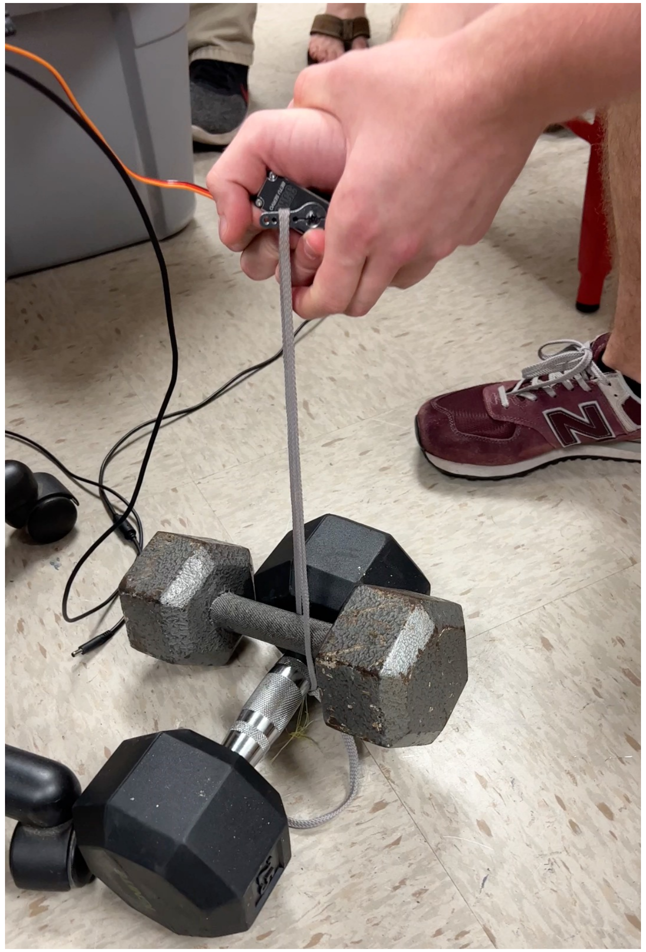
Testing Plans

1. Thrust curve for the EDF
2. Servo stall torque
3. [redacted]
4. [redacted]
5. [redacted]



Thomas Lenz

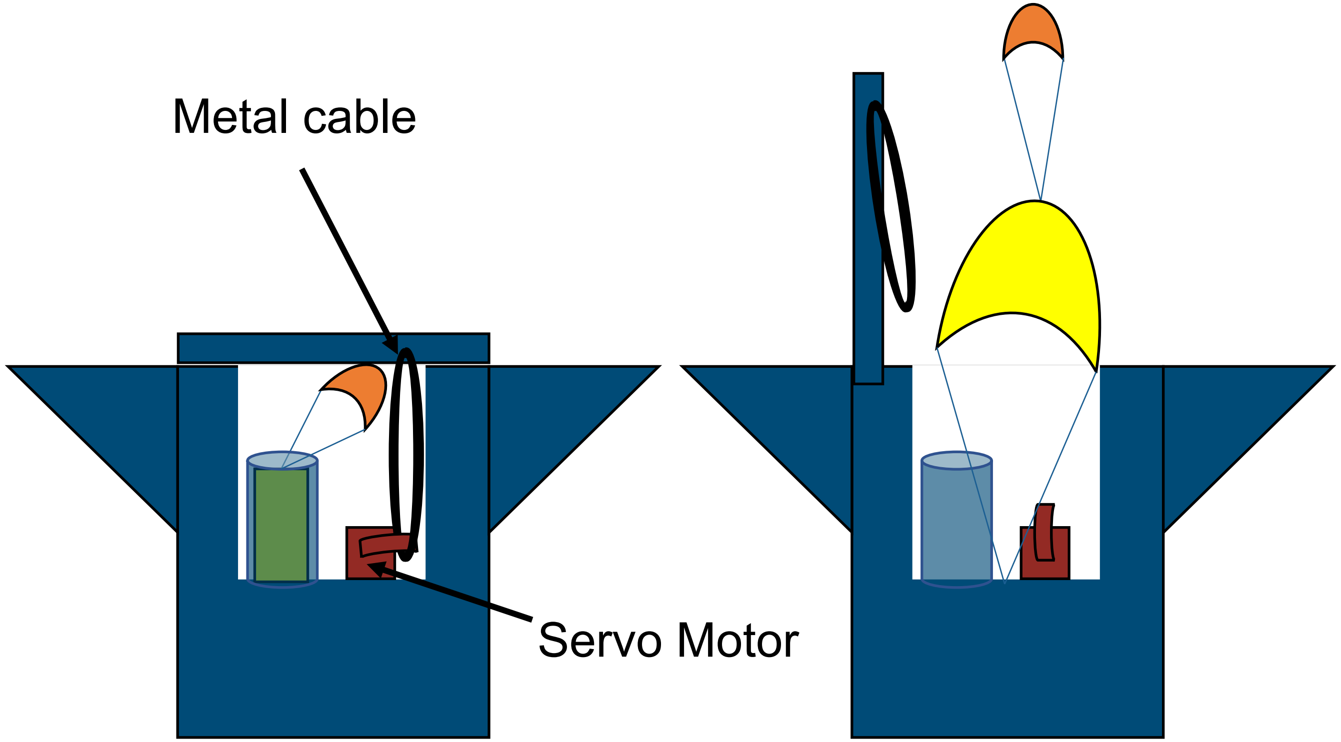
Servo Testing Results



Thomas Lenz

Testing Plans

1. Thrust curve for the EDF
2. Servo stall torque
3. Parachute release
4. [redacted]
5. [redacted]



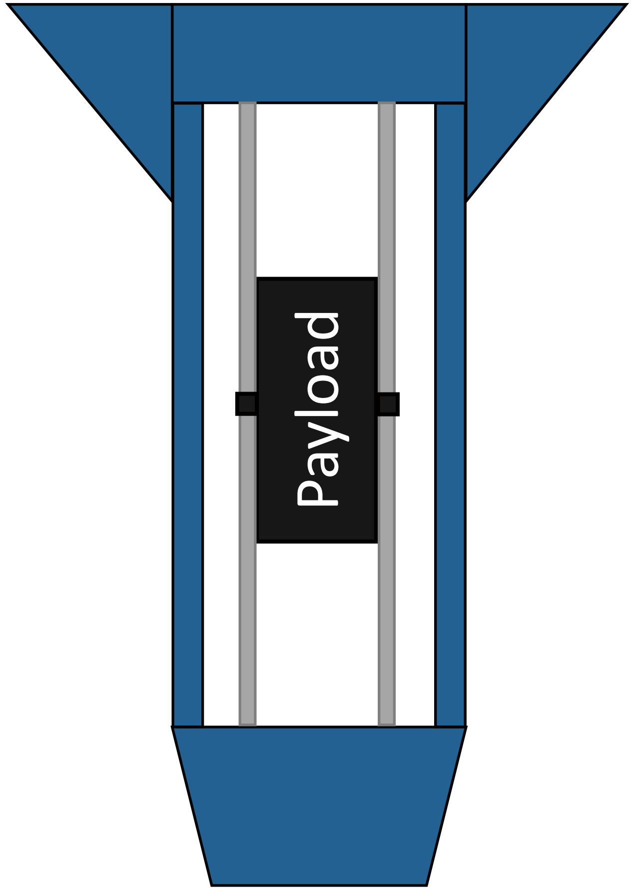
Thomas Lenz

Parachute Testing Results

Thomas Lenz

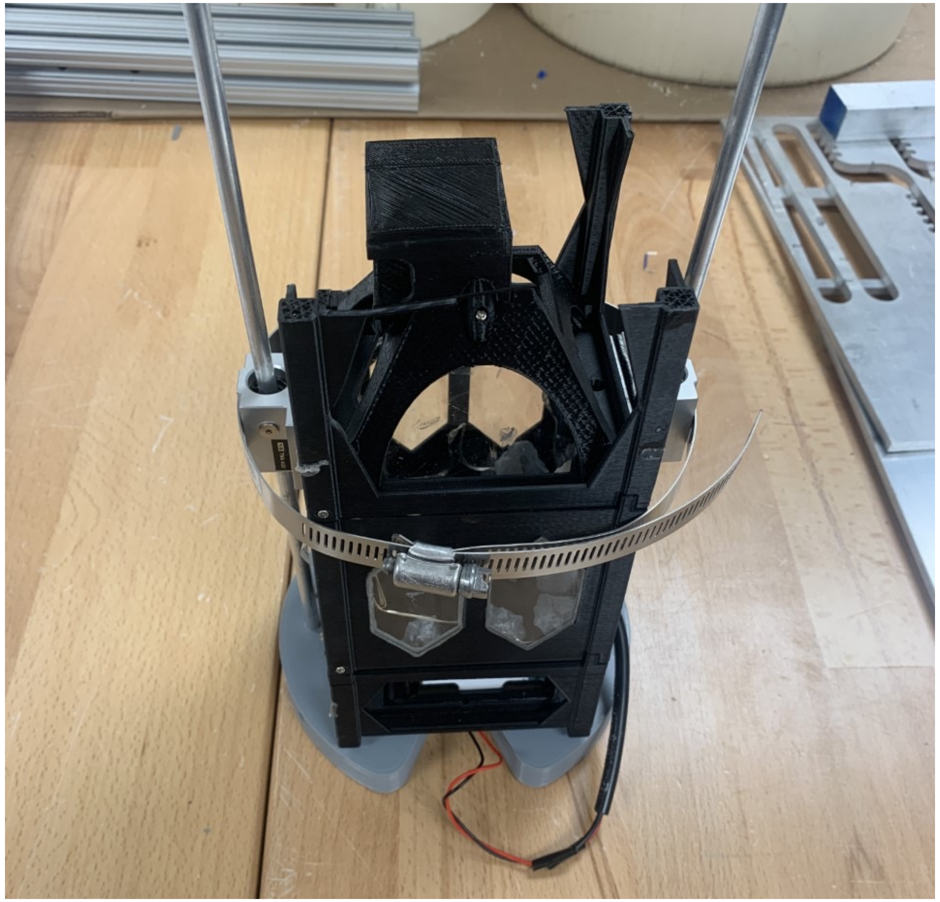
Testing Plans

1. Thrust curve for the EDF
2. Servo stall torque
3. Parachute release
4. Payload movement
5. [redacted]



Thomas Lenz

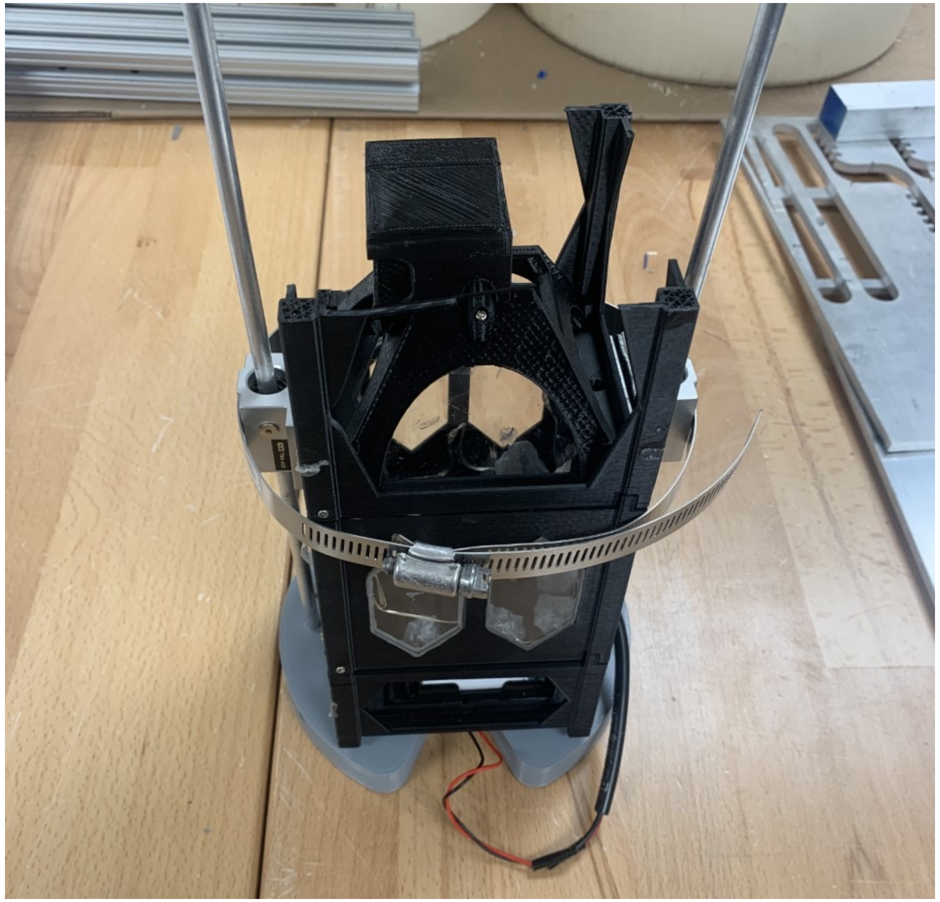
Payload Testing Results



✓ Bearings and Payload Caps Aligned

Thomas Lenz

Payload Testing Results



✓ Bearings and Payload Caps Aligned

✗ Carbon Fiber Rods

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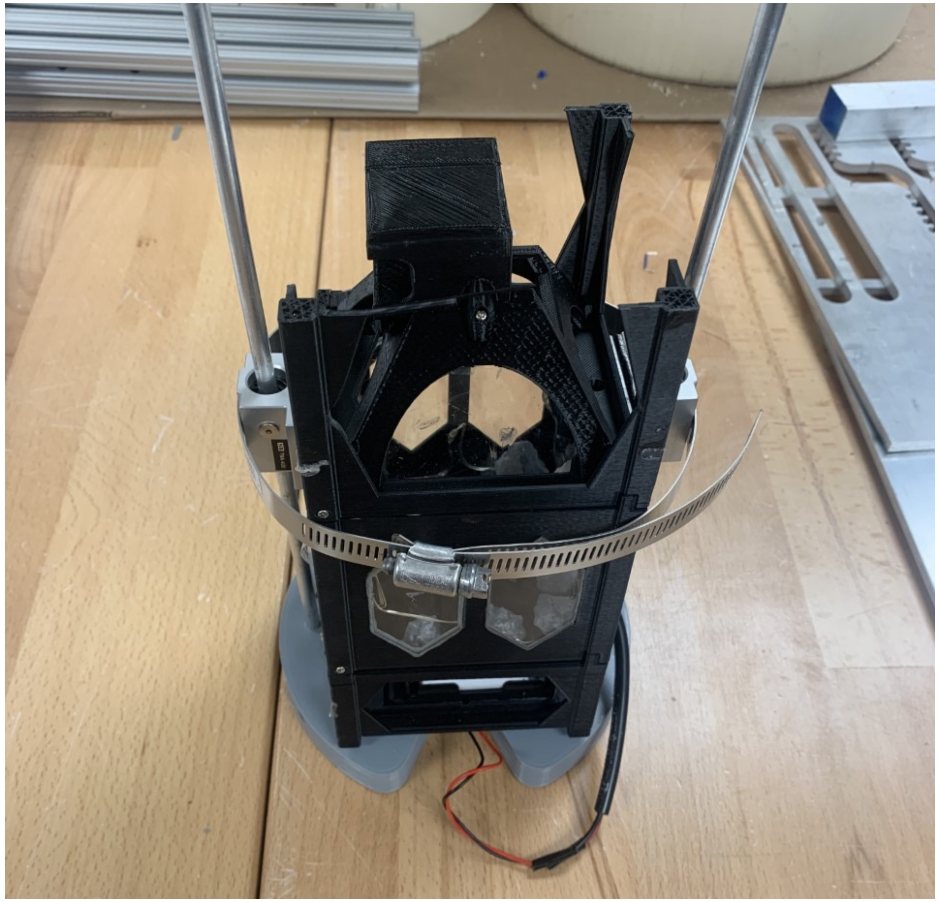
Payload Testing Results



✓ Bearings and Payload Caps Aligned

✗ Carbon Fiber Rods

✓ Aluminum Rods

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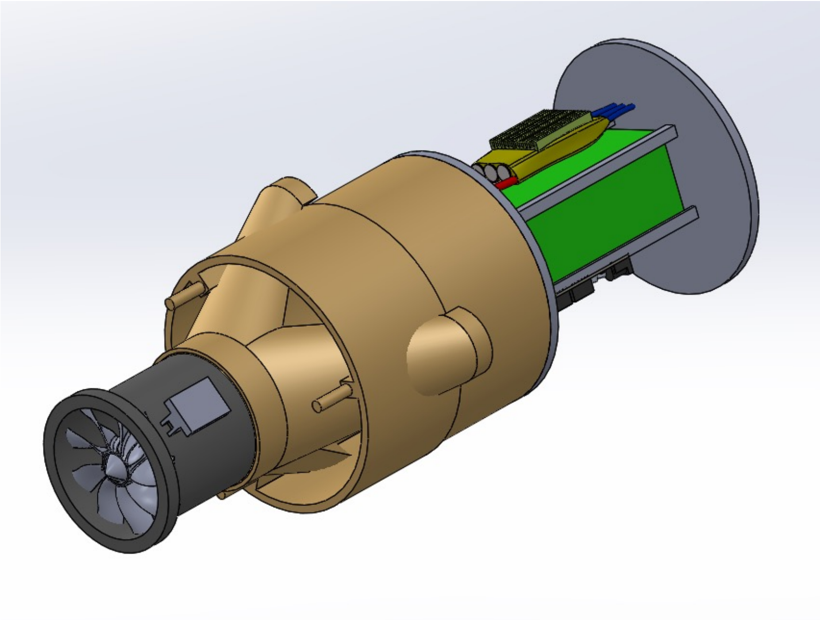
Testing Plans

1. Thrust curve for the EDF
2. Servo stall torque
3. Parachute release
4. Payload movement
5. Control system



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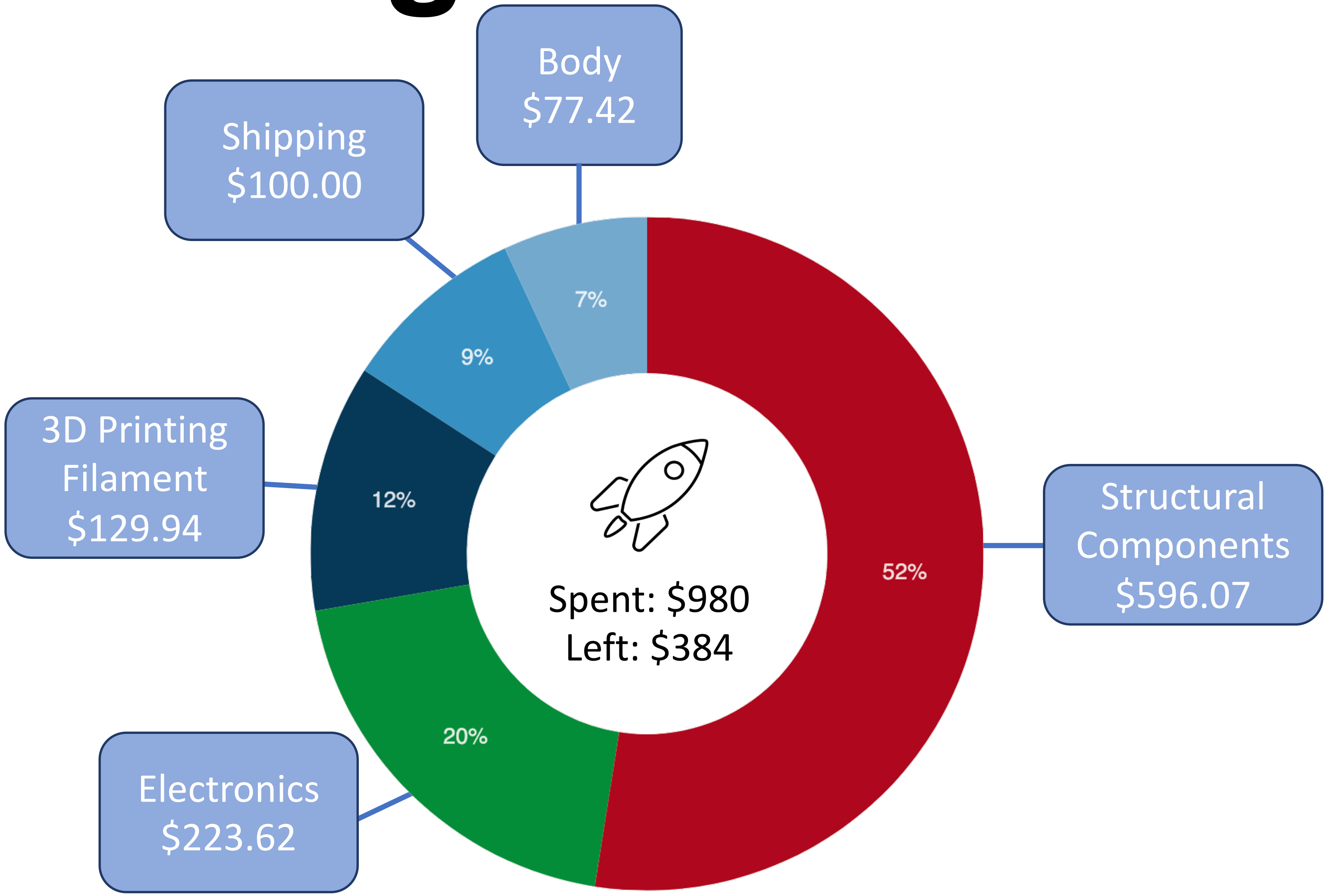
Budget

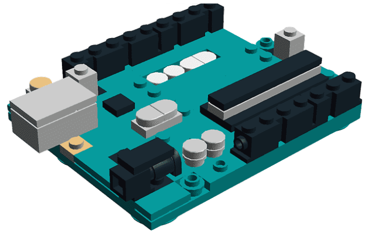


3D Printing Filament

Body

Shipping

Electronics



Structural Components

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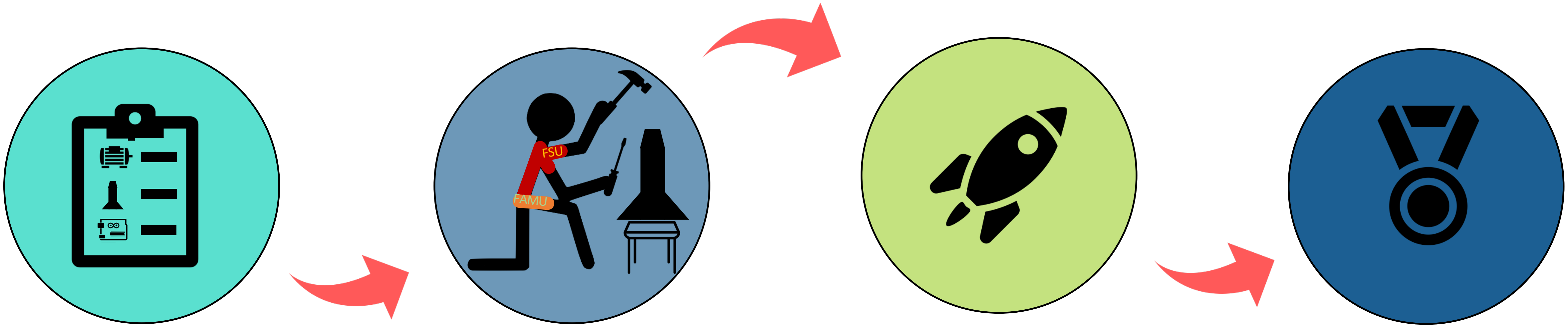
Future Work



CONTINUE TESTING — ASSEMBLY — FULLSCALE TESTS — COMPETITION

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Lessons Learned

Lesson 1

Lesson 2

Lesson 3

Lesson 4

Lesson 5

Lesson 6

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Lessons Learned

Double check test conditions before running test

Lesson 2

Lesson 3

Lesson 4

Lesson 5

Lesson 6

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Lessons Learned

Double check test conditions before running test	**Expect setbacks**
Lesson 3	**Lesson 4**
Lesson 5	**Lesson 6**

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Lessons Learned

Double check test conditions before running test

Expect setbacks

Acquire parts ASAP

Lesson 4

Lesson 5

Lesson 6

Thomas Lenz

Lessons Learned

Double check test conditions before running test

Expect setbacks

Acquire parts ASAP

Test parts when first acquired

Lesson 5

Lesson 6

Thomas Lenz

Lessons Learned

Double check test conditions before running test

Expect setbacks

Acquire parts ASAP

Test parts when first acquired

Double check tolerances before printing

Lesson 6

Thomas Lenz

Lessons Learned

Double check test conditions before running test

Expect setbacks

Acquire parts ASAP

Test parts when first acquired

Double check tolerances before printing

Research parts before purchasing

Thomas Lenz

References

Images:
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