Team 511

MICROGRAVITY MACHINE

Design Review 5

TEAM 511

Samuel Duval

Propulsion Engineer

Pedro Siman

Recovery Engineer

Thomas Lenz

Test & Systems Engineer

Collin Gainer

Aero Design Engineer

John Tietsworth

Controls Engineer

Thomas Lenz

Sponsor and Advisor

Dr. Mohd Yousuf Ali

FAMU-FSU College of Engineering
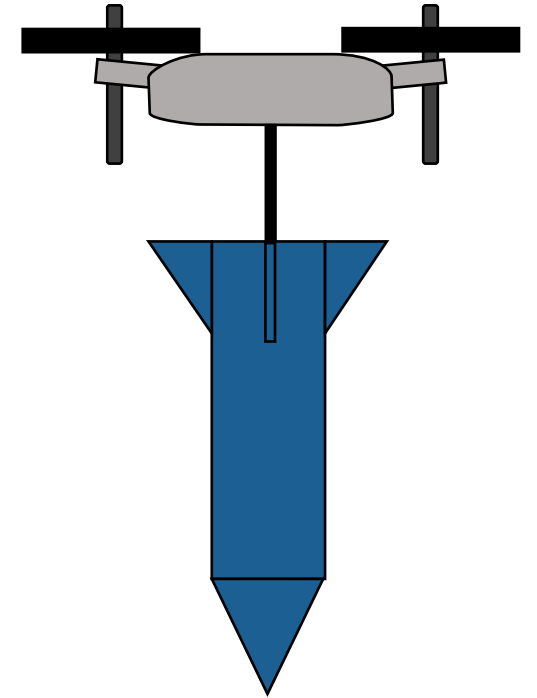
Mike Conroy

Florida Space Grant Consortium

Dr. Shayne McConomy

FAMU-FSU College of Engineering

Thomas Lenz

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.
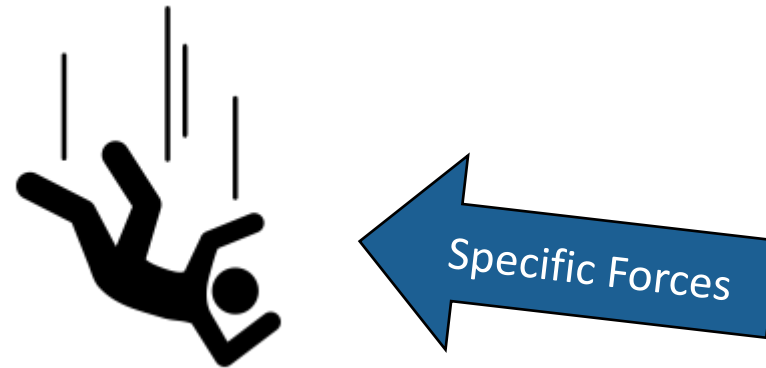
Thomas Lenz

What is Microgravity?

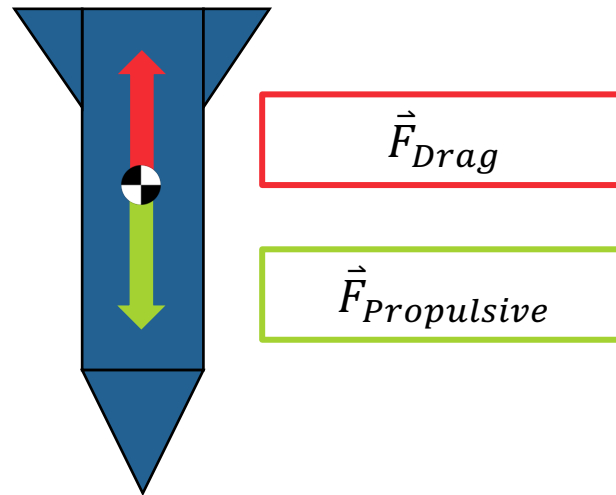$$\vec{F}_{Specific} = \frac{\sum \vec{F}_{nongravitational}}{m} \approx 0 \, \frac{m}{s^2}$$

What does an accelerometer measure?

Specific Forces

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FAMU-FSU Engineering

Achieving Freefall

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

$\vec{F}_{Drag}$

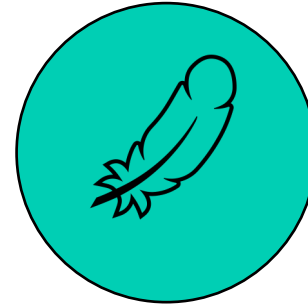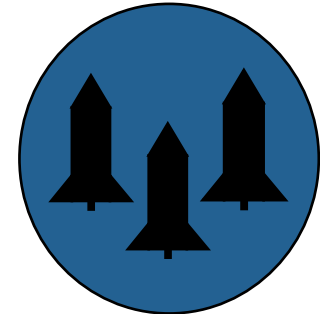$\vec{F}_{Propulsive}$

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Key Goals

Microgravity

Recoverable

Meet weight requirements
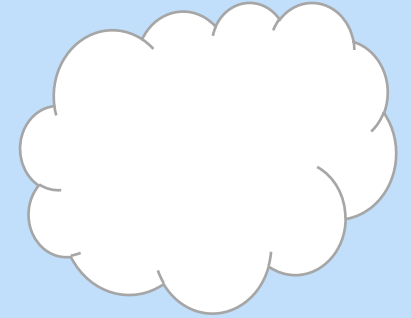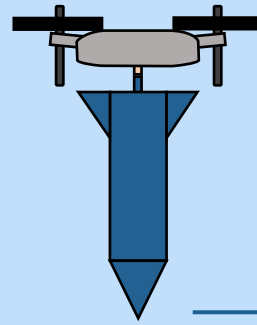
Reproduceable

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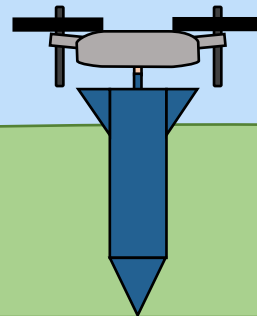
Competition Day

Thomas Lenz

Competition Day

900 ft (275m)

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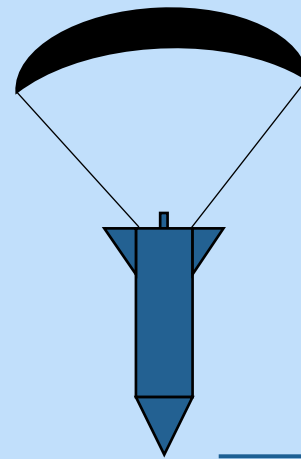
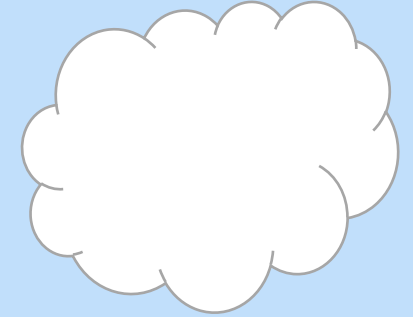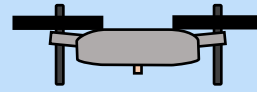| Metric	Target
Time to Detect Disconnection	0.1s
Degrees of Freedom	1
Acceleration	$9.81 \frac{m}{s^2}$
Final Velocity	$5 \frac{m}{s}$

Thomas Lenz

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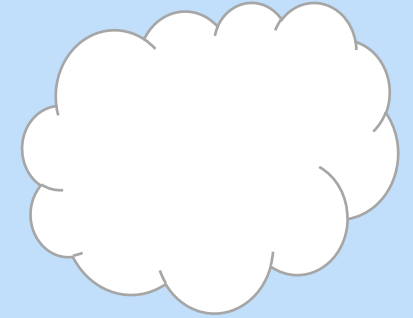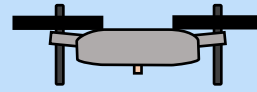
Metric	Target
Time to Detect Disconnection	0.1s
Degrees of Freedom	1
Acceleration	$9.81 \frac{m}{s^2}$
Final Velocity	$5 \frac{m}{s}$

~650 ft (200m)

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Competition Day

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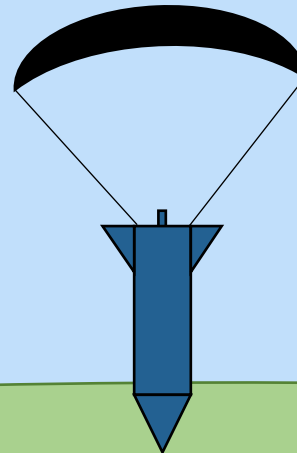
$$\overrightarrow{V_f} = 5 \frac{m}{s}$$

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Concept Generation

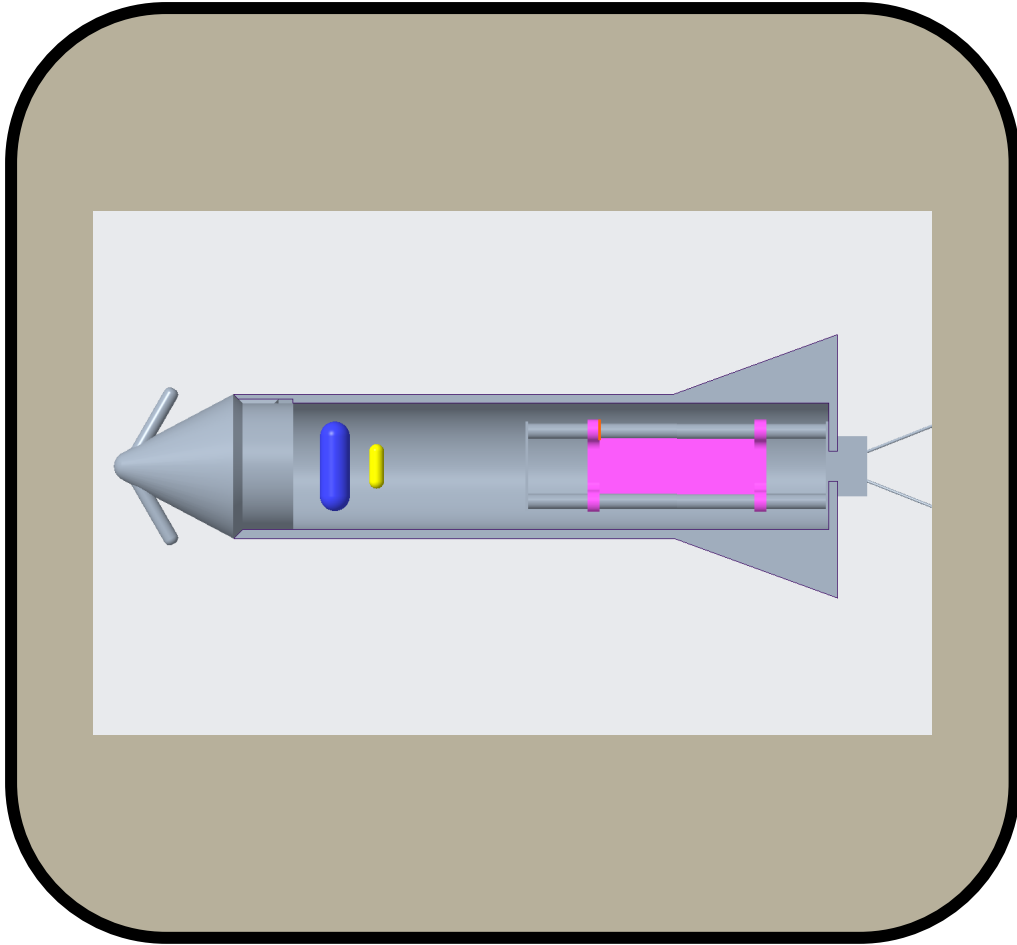| Propulsion	Recovery	Body	Stabilize
Expel propellant from nose of vehicle	Rear deployed parachute	Pointed front, blunt back	Fins
Expel propellant from sides of vehicle	Airbrakes	Football shape	Use water to spin the body
Electric motor propeller at the rear of the device	Airbag	Rubbery Skin	Use airbrakes to make it spin
Electric motor propeller at the front of the device	Side deployed parachute	Needle like, long and skinny	Thrust vectoring
No propulsion			

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Design #1: Nose Fluid Propulsion

1

2

3

4

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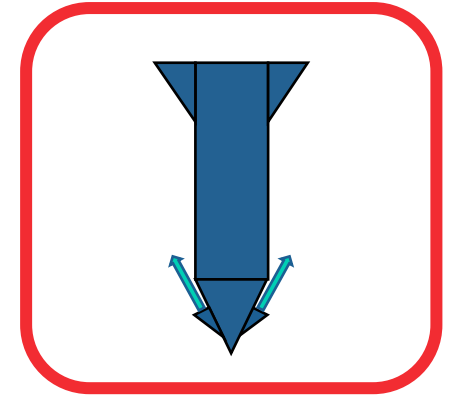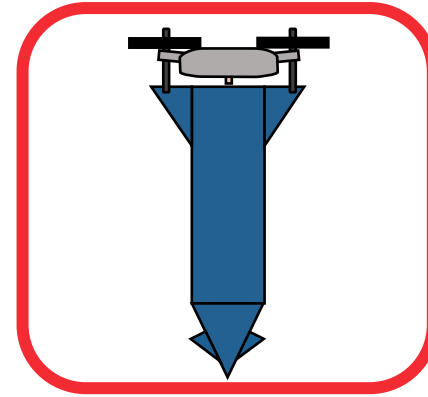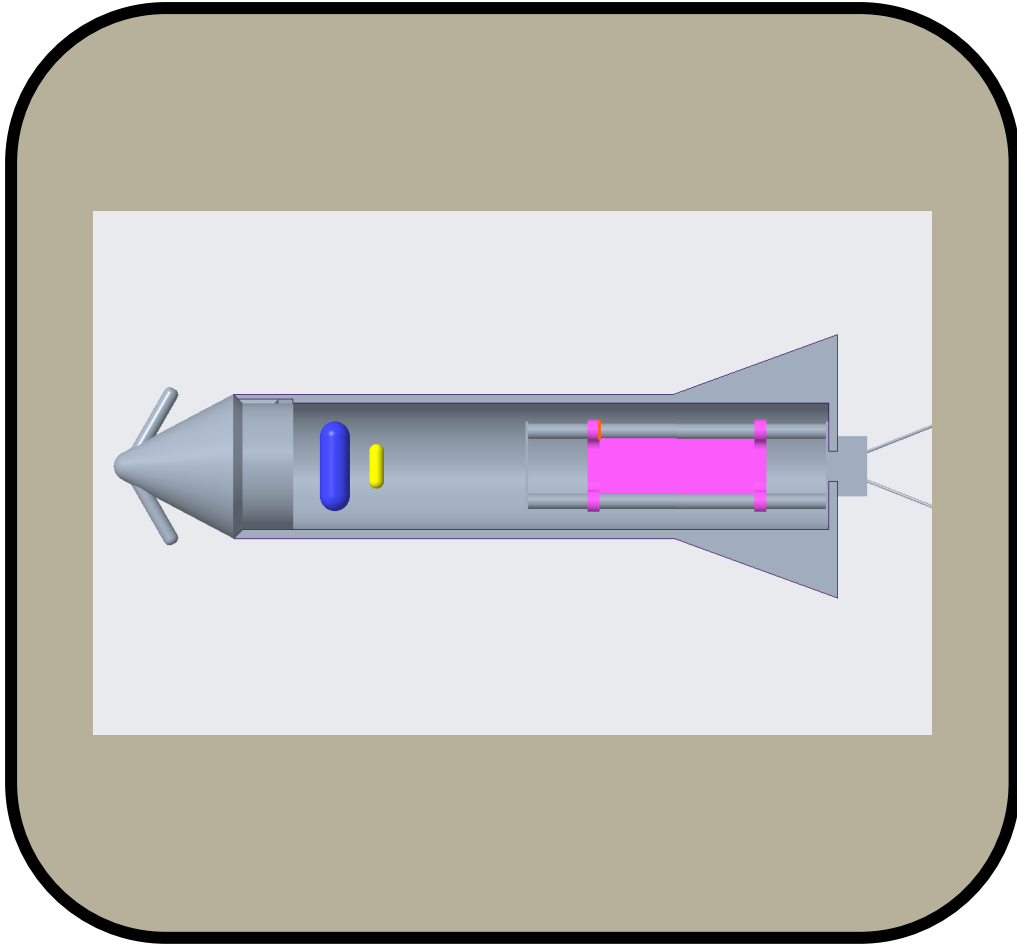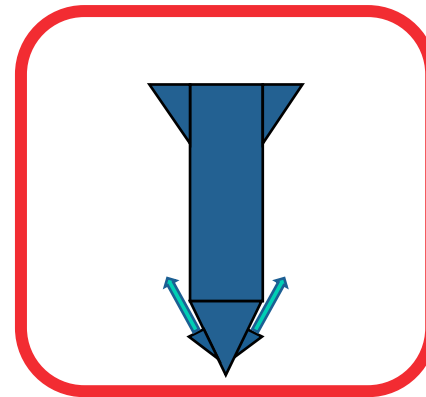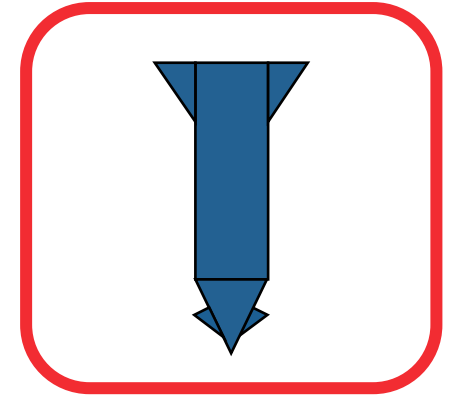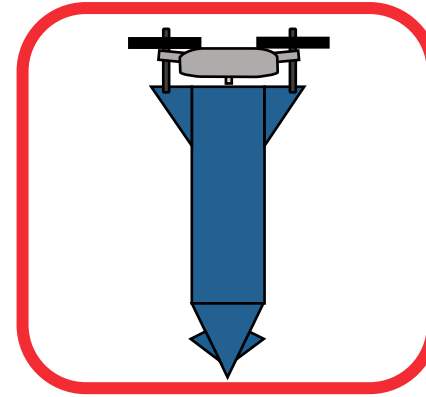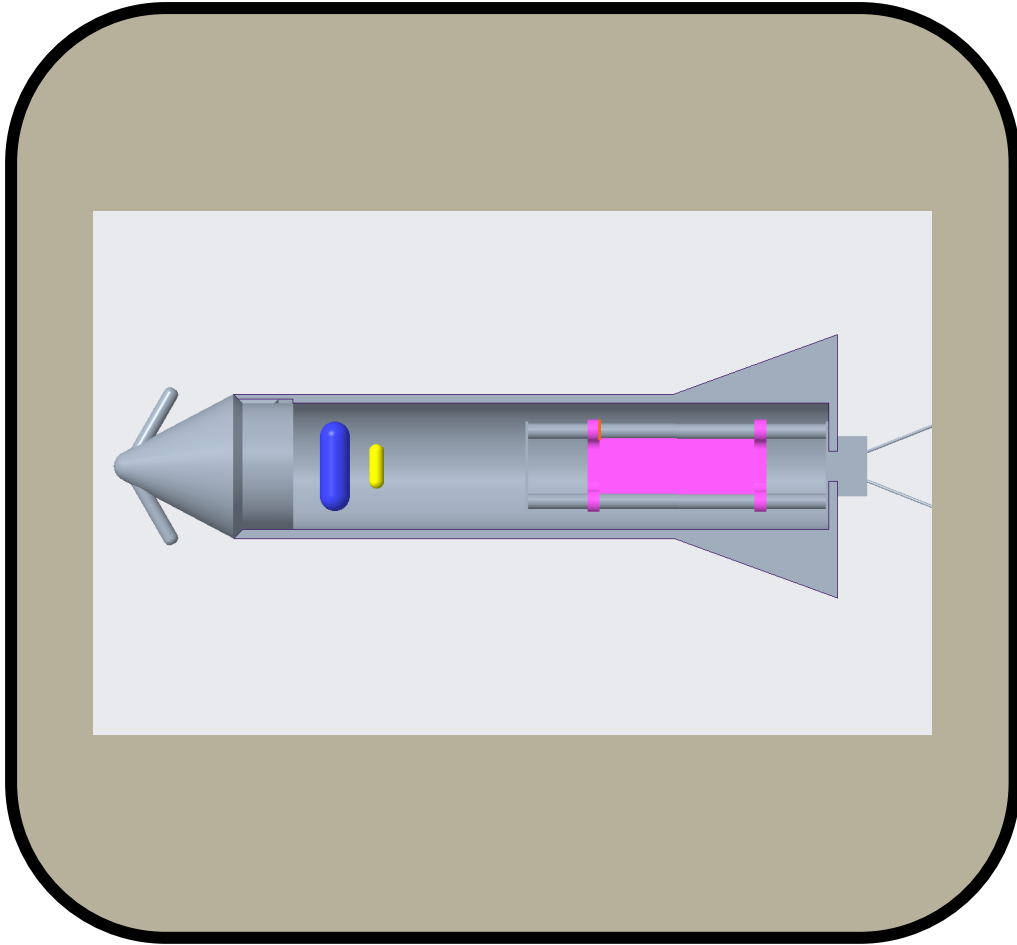
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Engineering

Design #1: Nose Fluid Propulsion
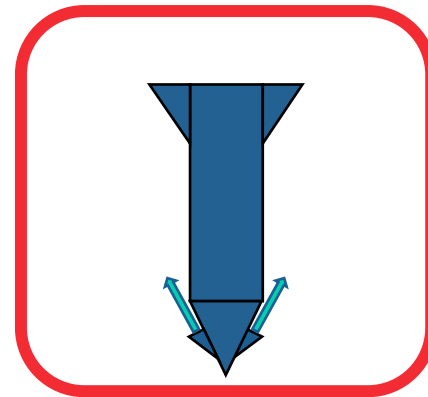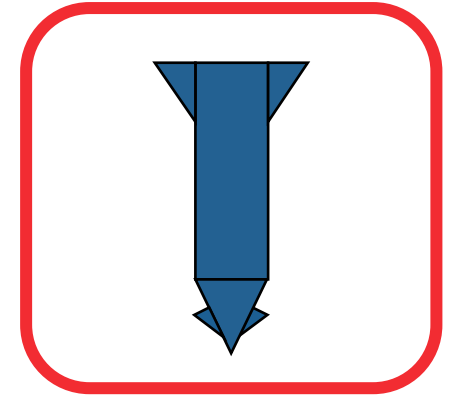

2

3

4

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Design #1: Nose Fluid Propulsion

3

4

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Design #1: Nose Fluid Propulsion

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Design #1: Nose Fluid Propulsion

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Design #2: Parachute at Nose

1

2

3

4

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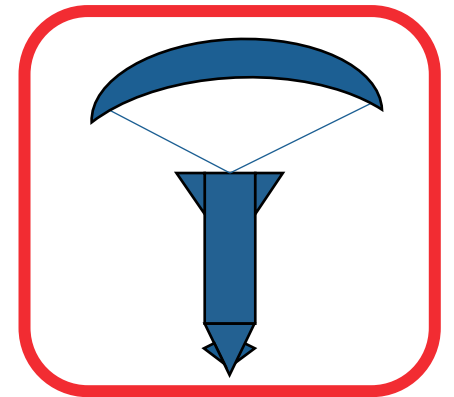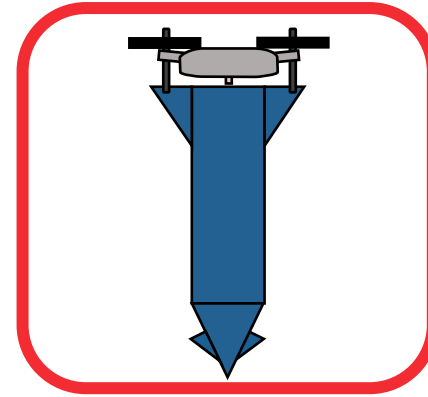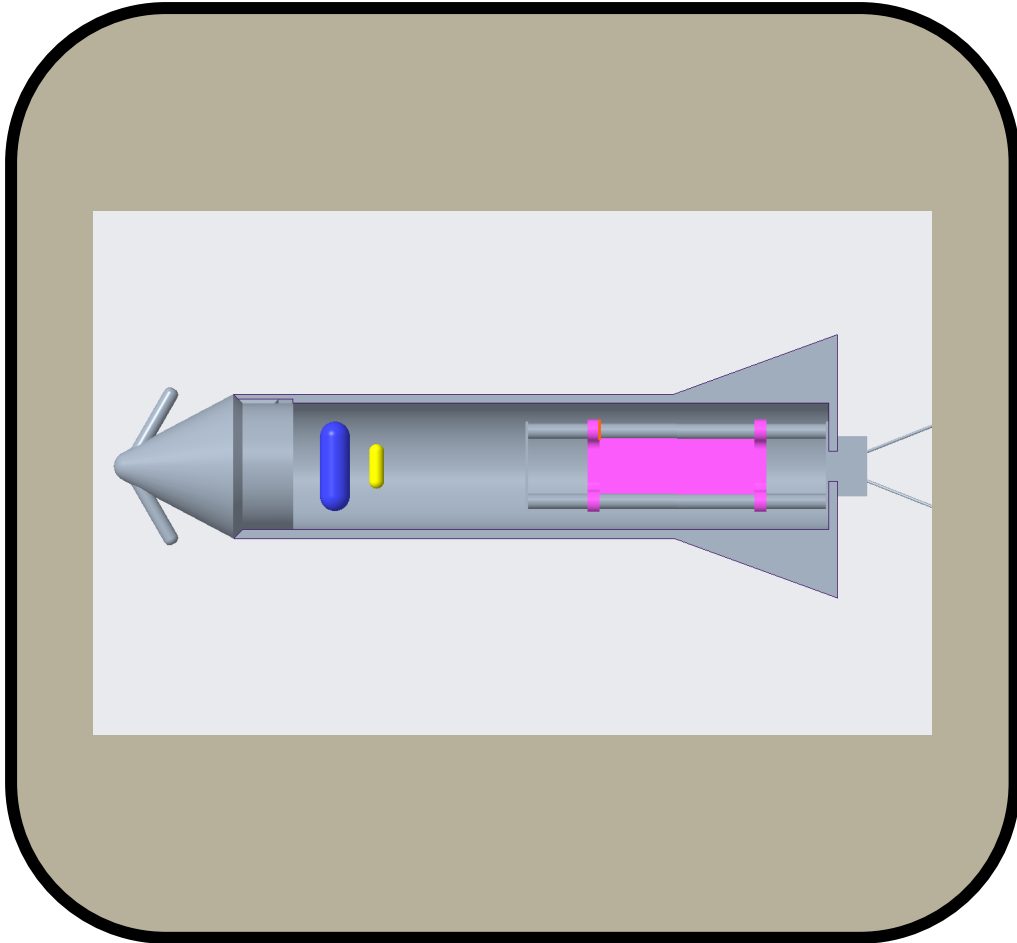
Design #2: Parachute at Nose
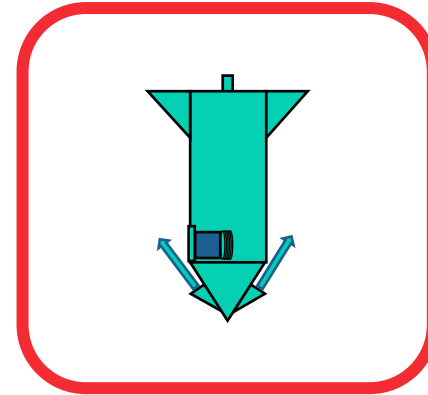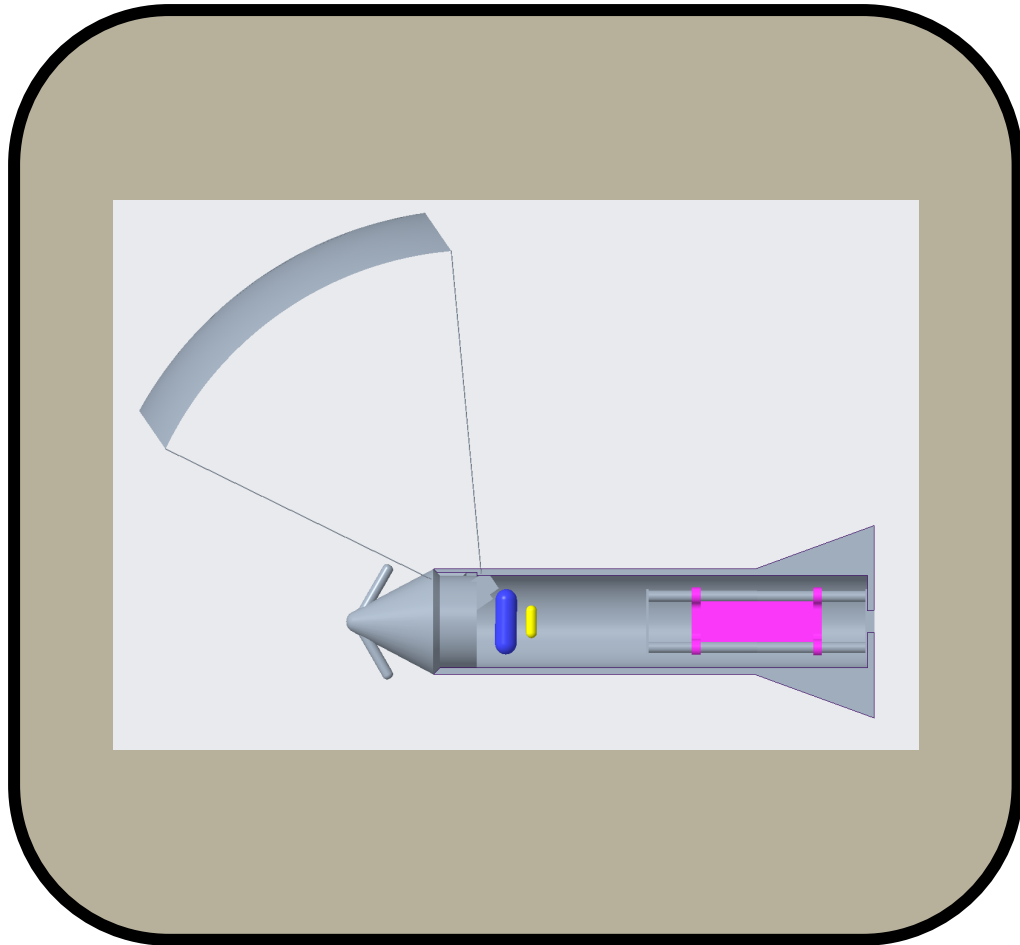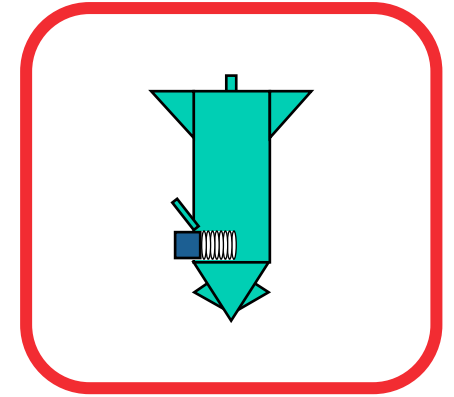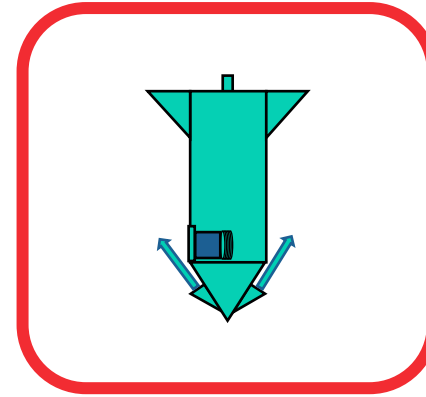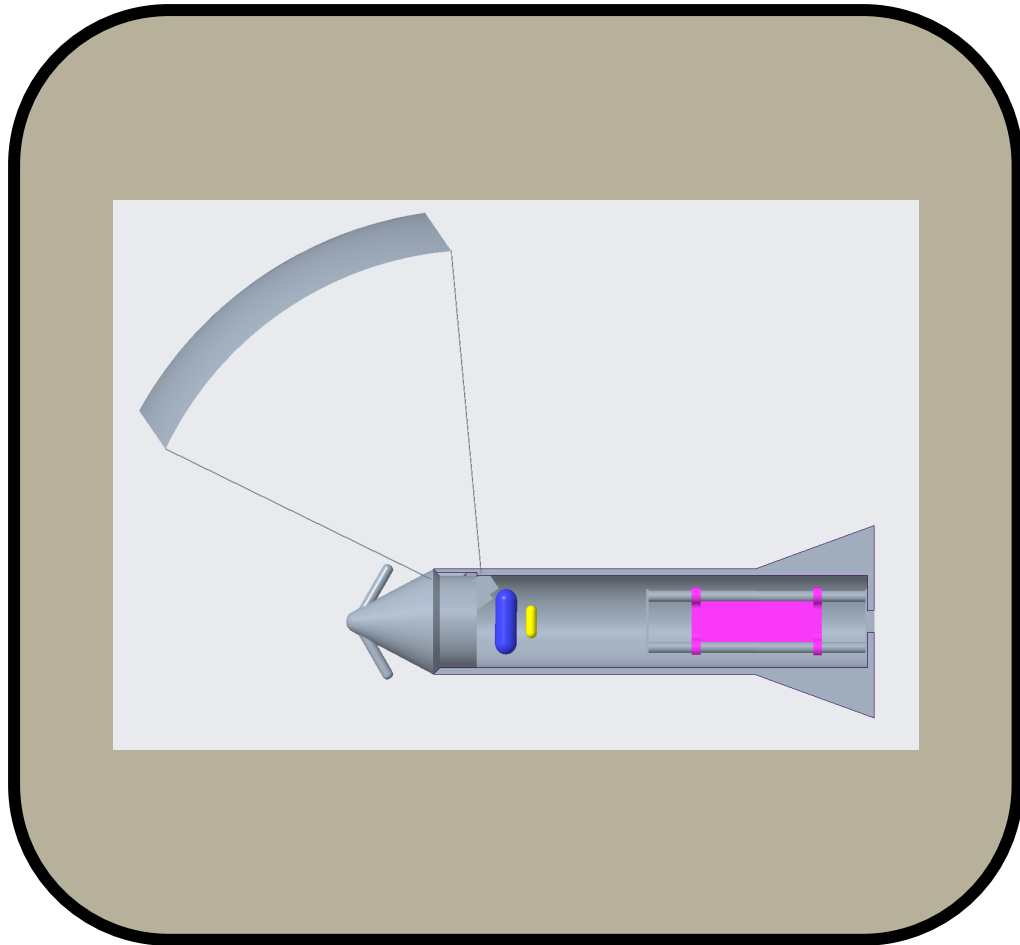
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Design #2: Parachute at Nose

3

4

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Design #2: Parachute at Nose

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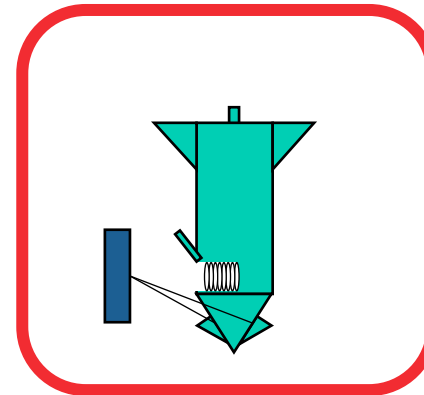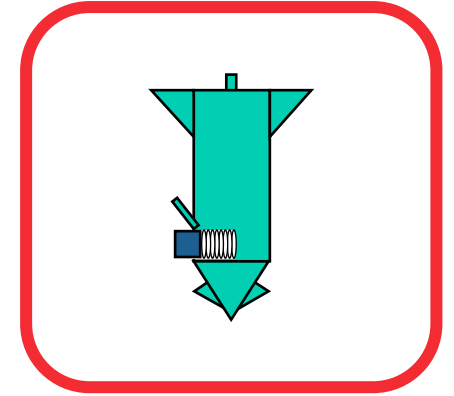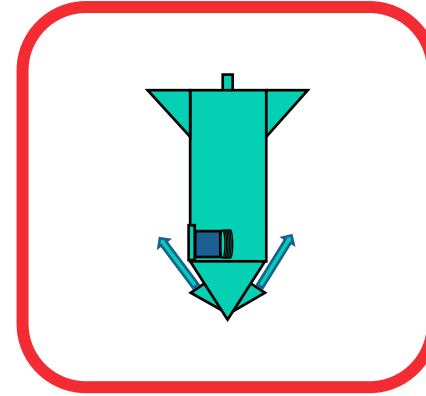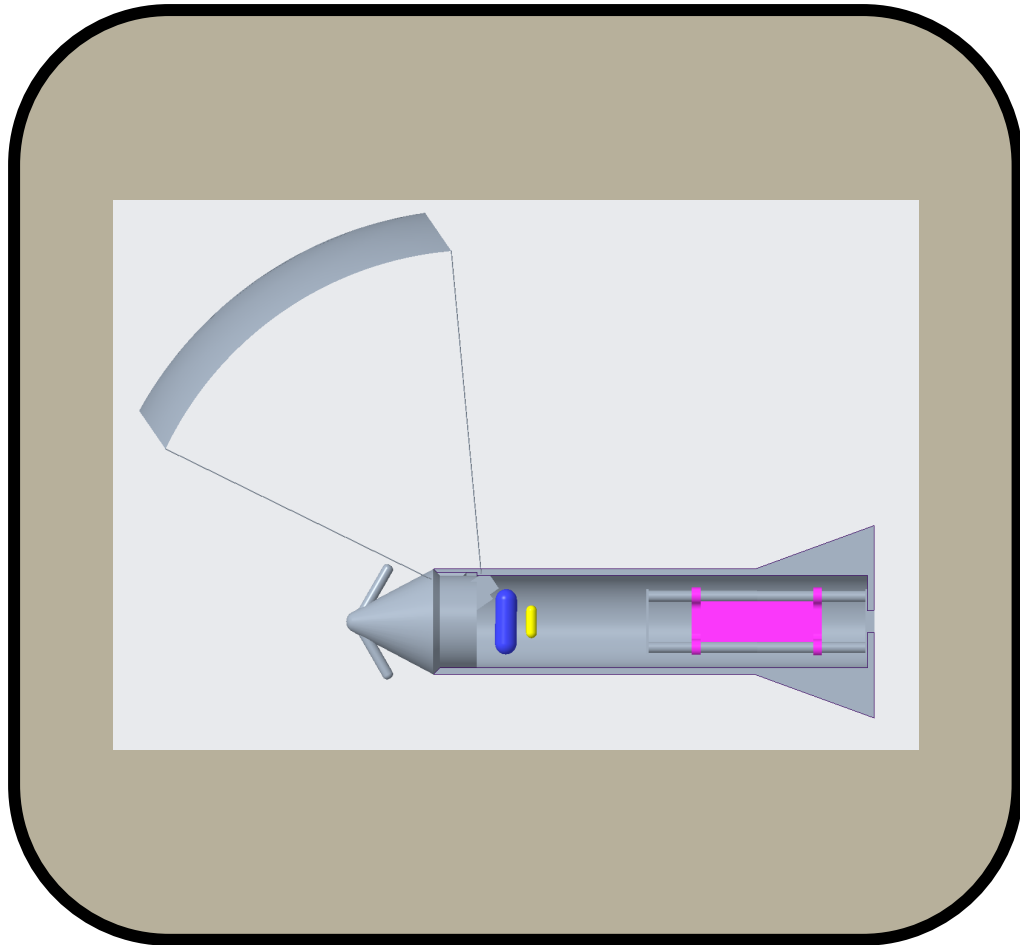
Design #2: Parachute at Nose
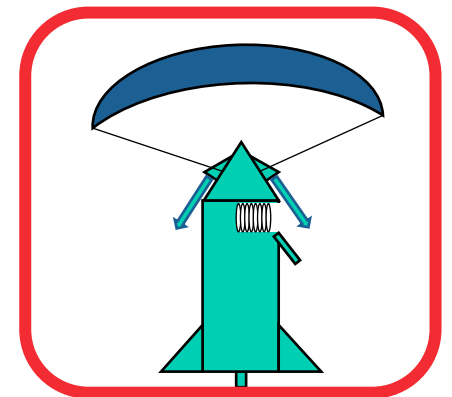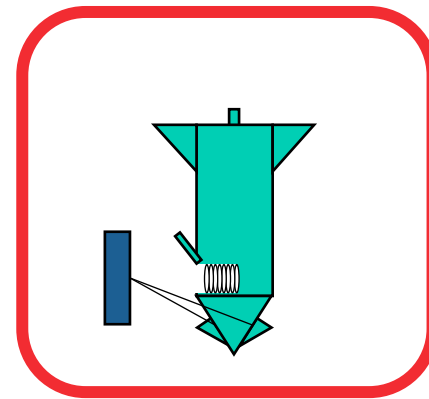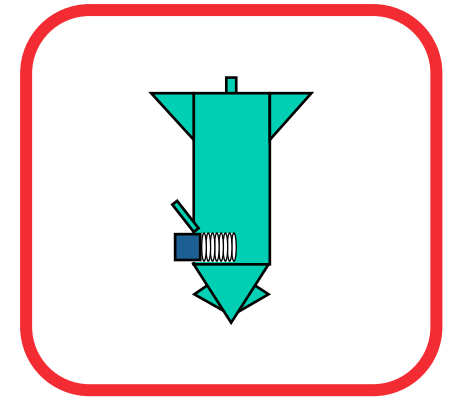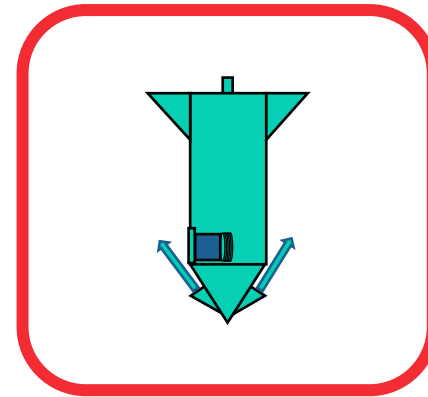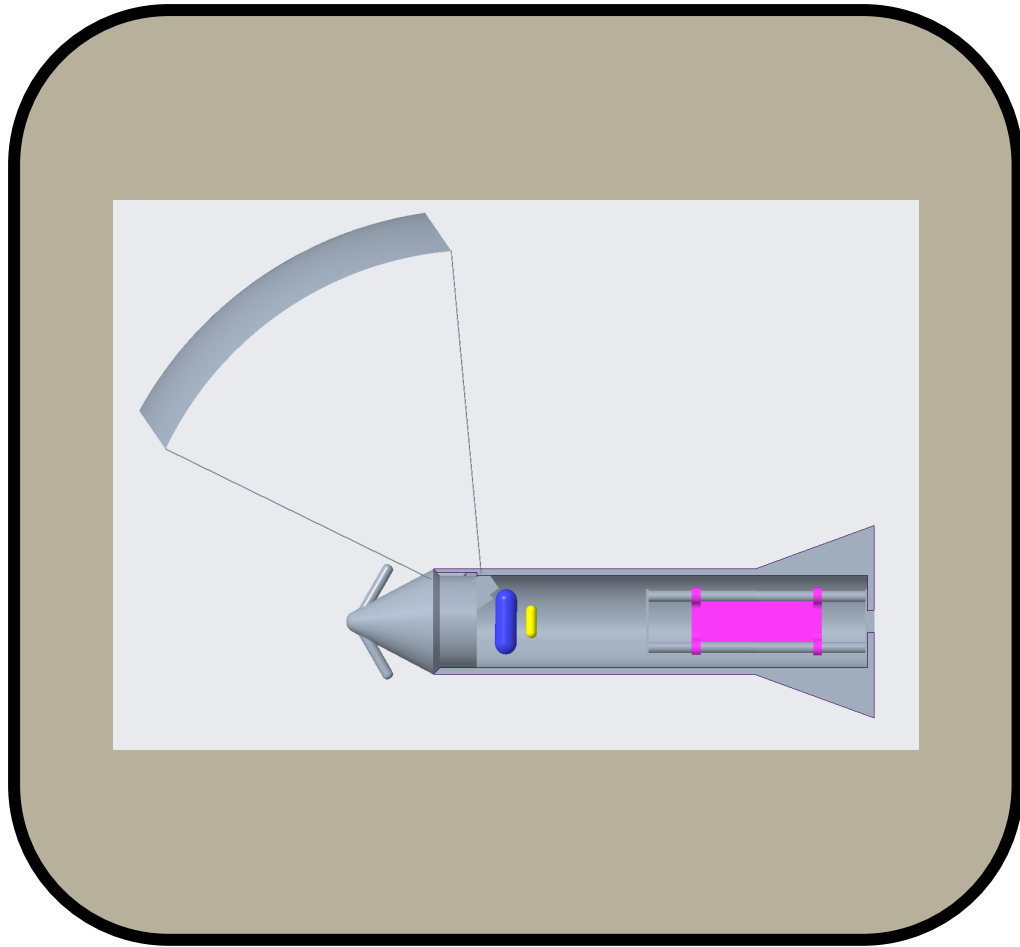
Thomas Lenz

Selected Design: Ducted Fan
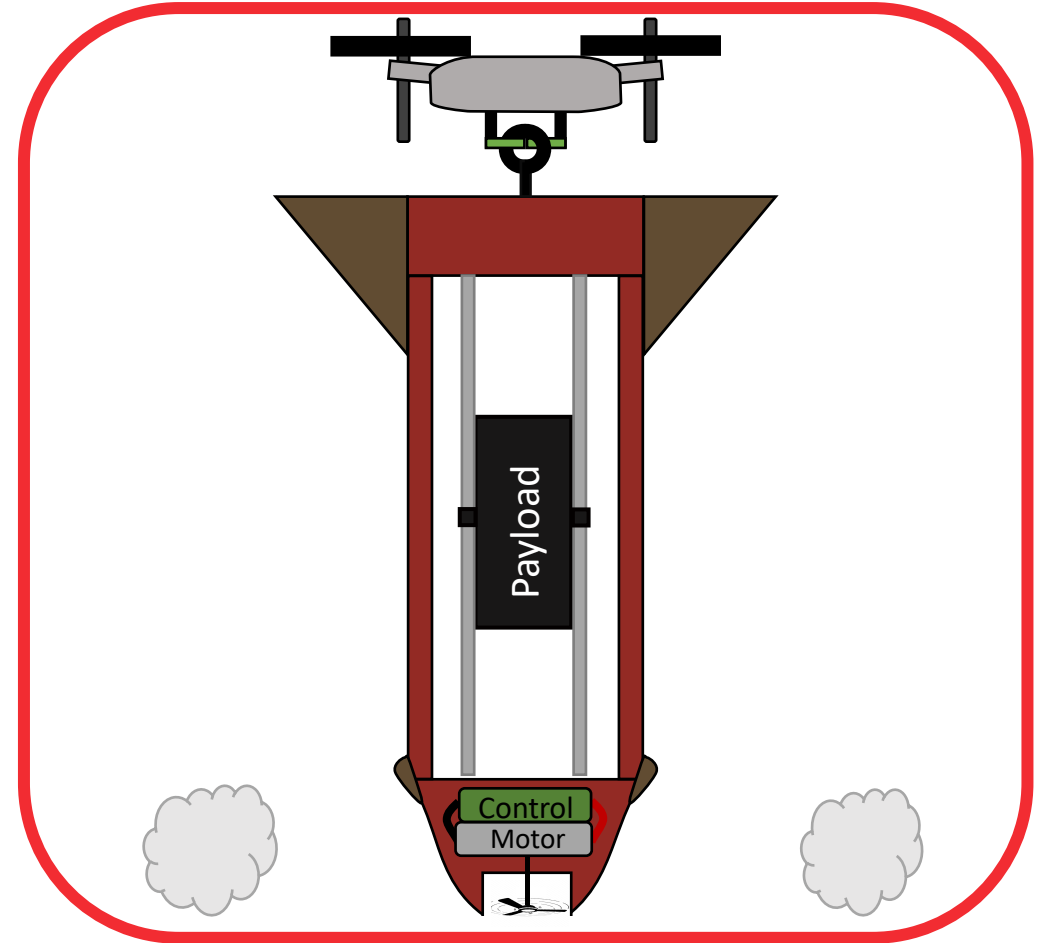
Payload

Control
Motor

Collin Gainer

Selected Design: Ducted Fan

Collin Gainer

FAMU-FSU Engineering

Selected Design: Ducted Fan

Collin Gainer

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Engineering
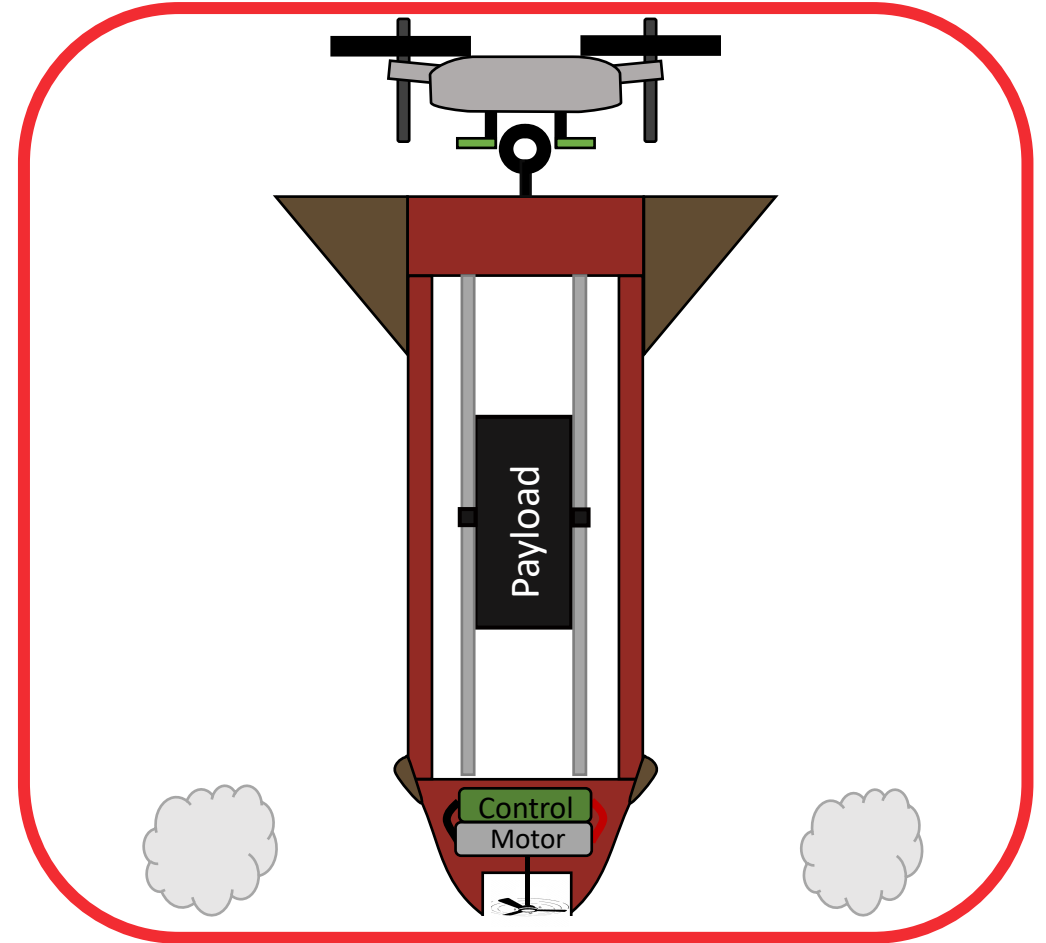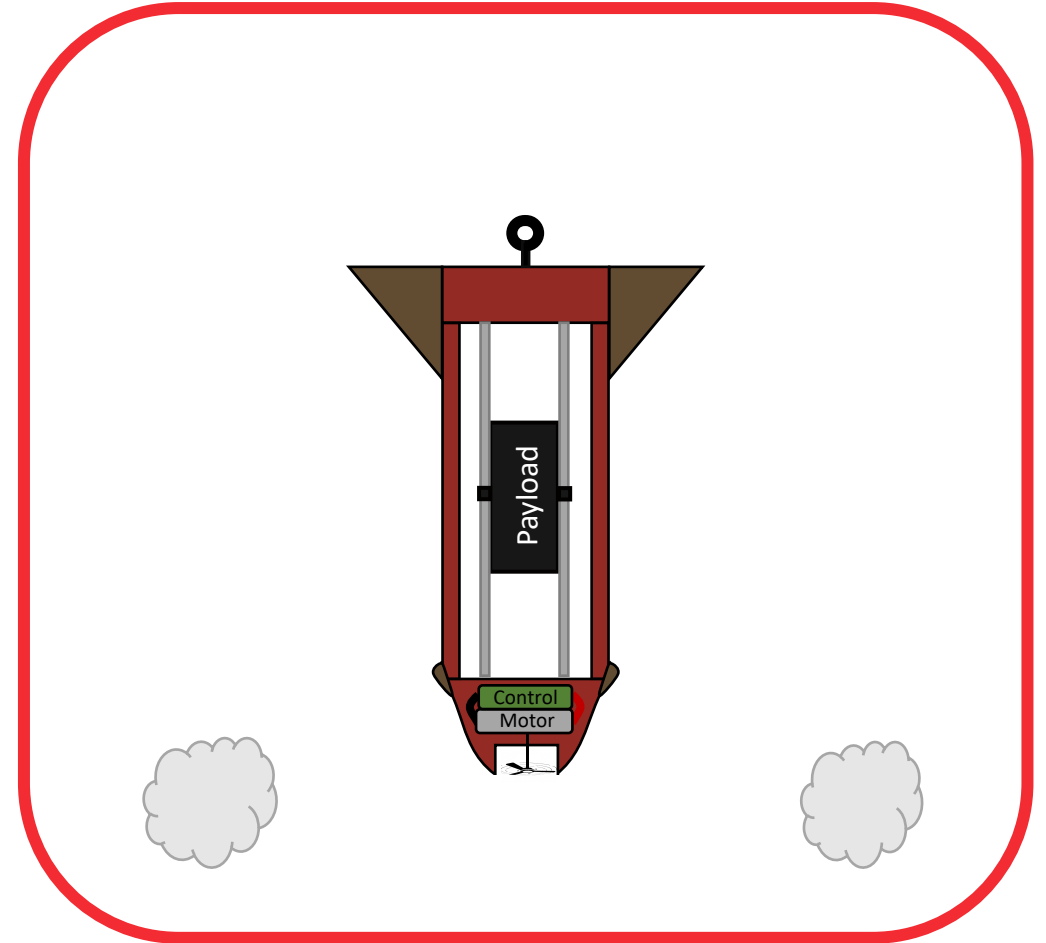
Selected Design: Ducted Fan

Drag forces act on the body as velocity increases
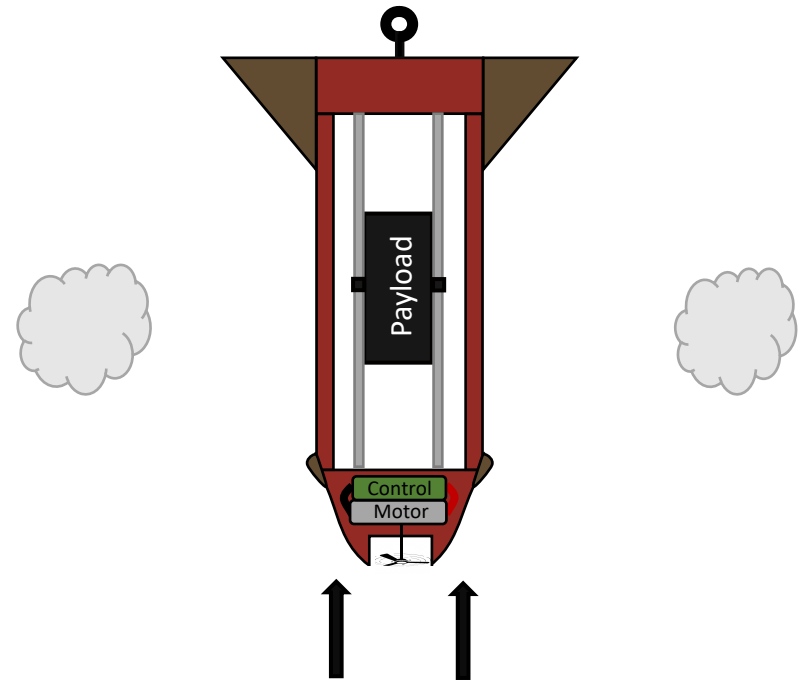
Collin Gainer

Selected Design: Ducted Fan

Payload slides along rails in the body
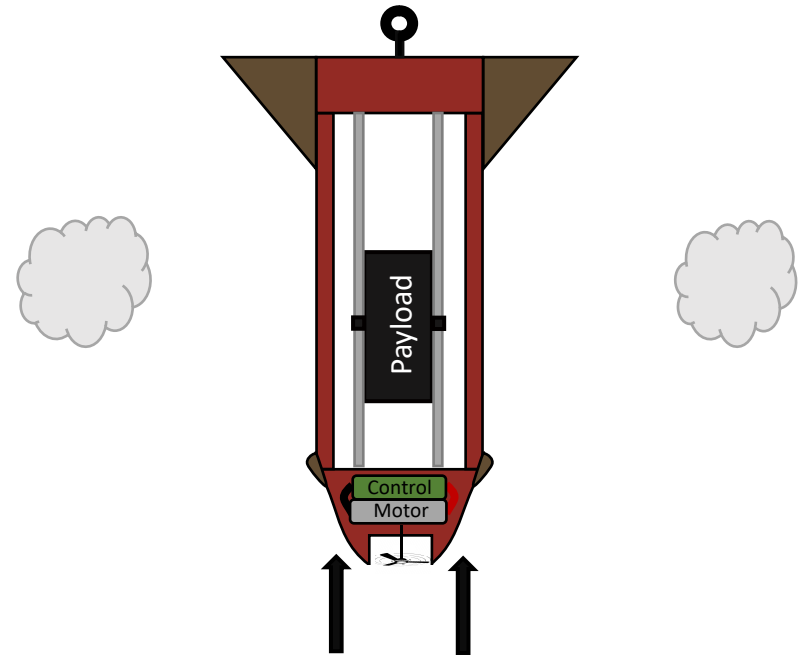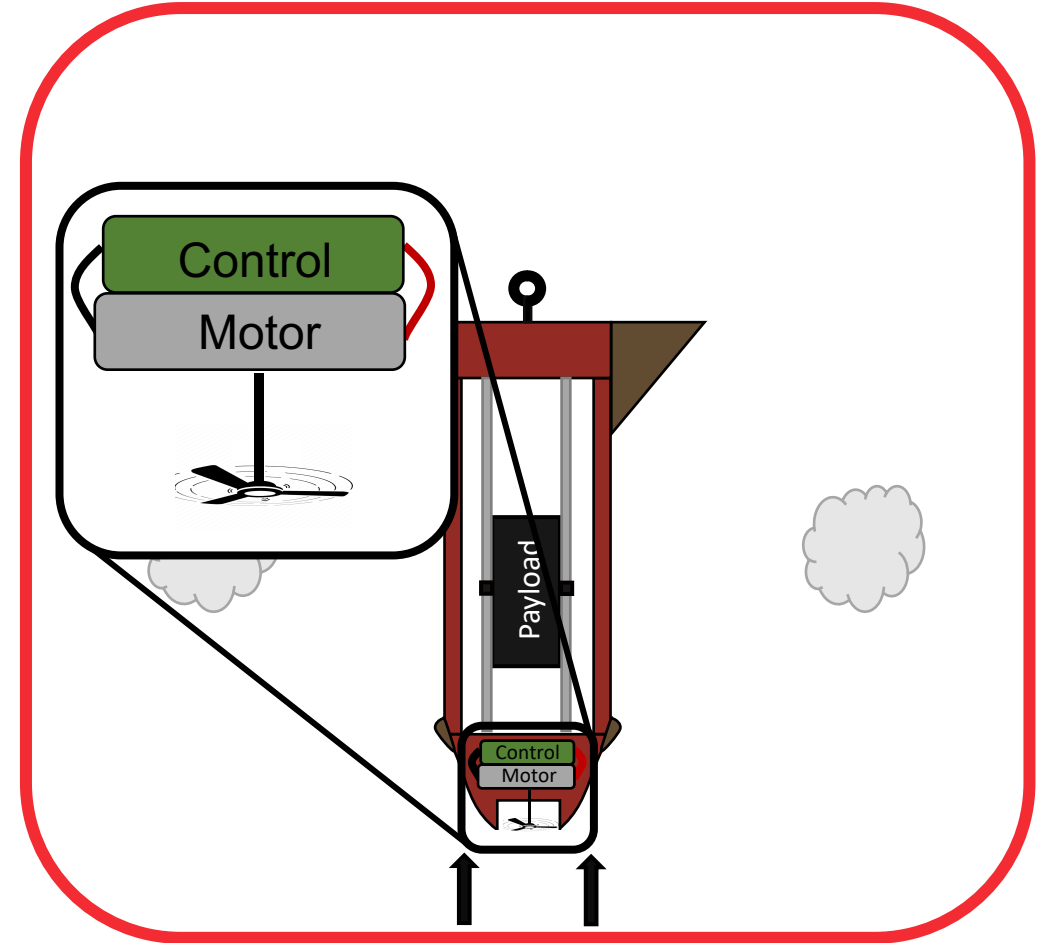
Payload

Control
Motor

Collin Gainer

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Selected Design: Ducted Fan

Control

Motor

Control
Motor

Payload

Collin Gainer

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Selected Design: Ducted Fan

Accelerometer reads acceleration from drag

Control

Motor

Payload

Control
Motor

Collin Gainer

Selected Design: Ducted Fan

Change in thrust is calculated from accelerometer reading

Control

Motor

Payload

Control
Motor

Collin Gainer

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Selected Design: Ducted Fan

Air is pulled in by the fan and expelled from nozzles

Payload

Control
Motor

Collin Gainer

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Selected Design: Ducted Fan

Propulsive forces cancel out drag forces

Payload

Control
Motor

Collin Gainer

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Selected Design: Ducted Fan

Controller continuously revaluates thrust for 4 seconds

Payload

Control
Motor

Collin Gainer

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Engineering

Selected Design: Ducted Fan

Controller continuously revaluates thrust for 4 seconds

Payload

Control
Motor

Collin Gainer

Selected Design: Ducted Fan

Back door opens and parachute is released

Payload

Control
Motor

Collin Gainer

Selected Design: Ducted Fan

Collin Gainer

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Selected Design: Ducted Fan

Collin Gainer

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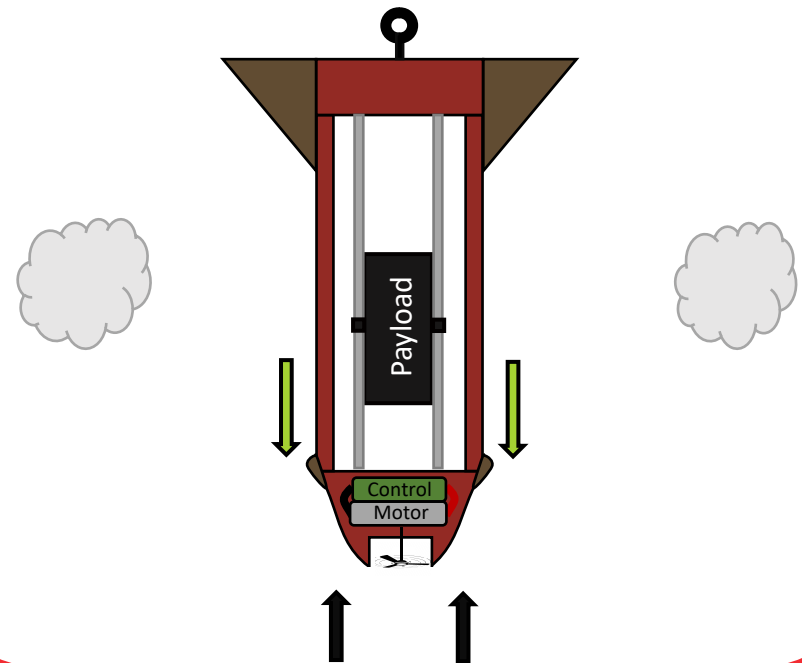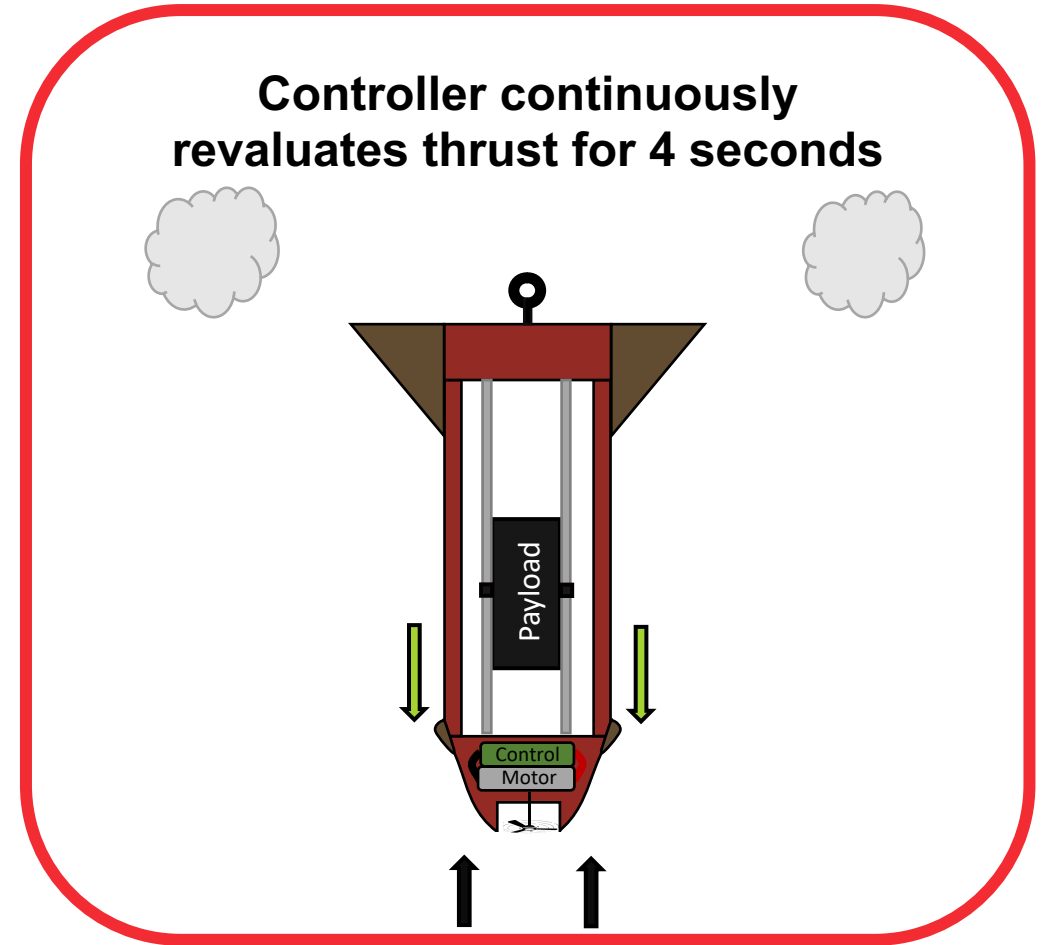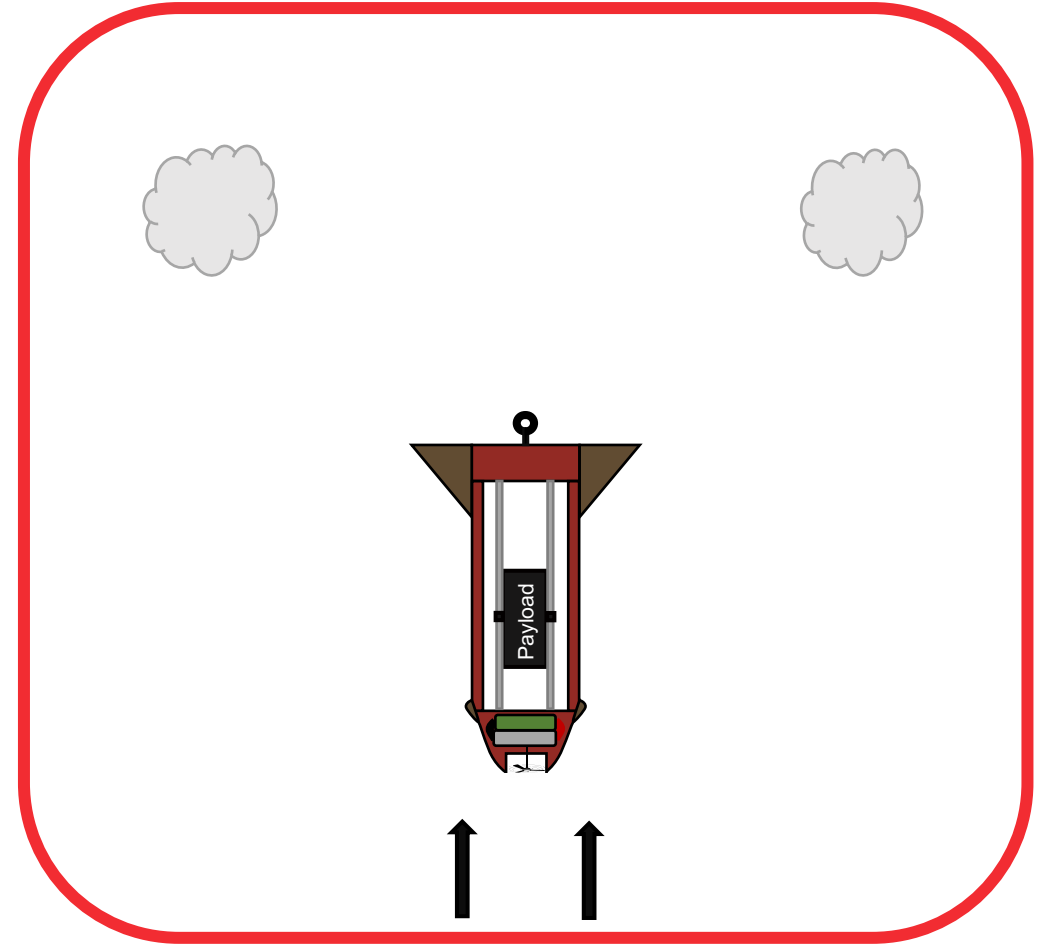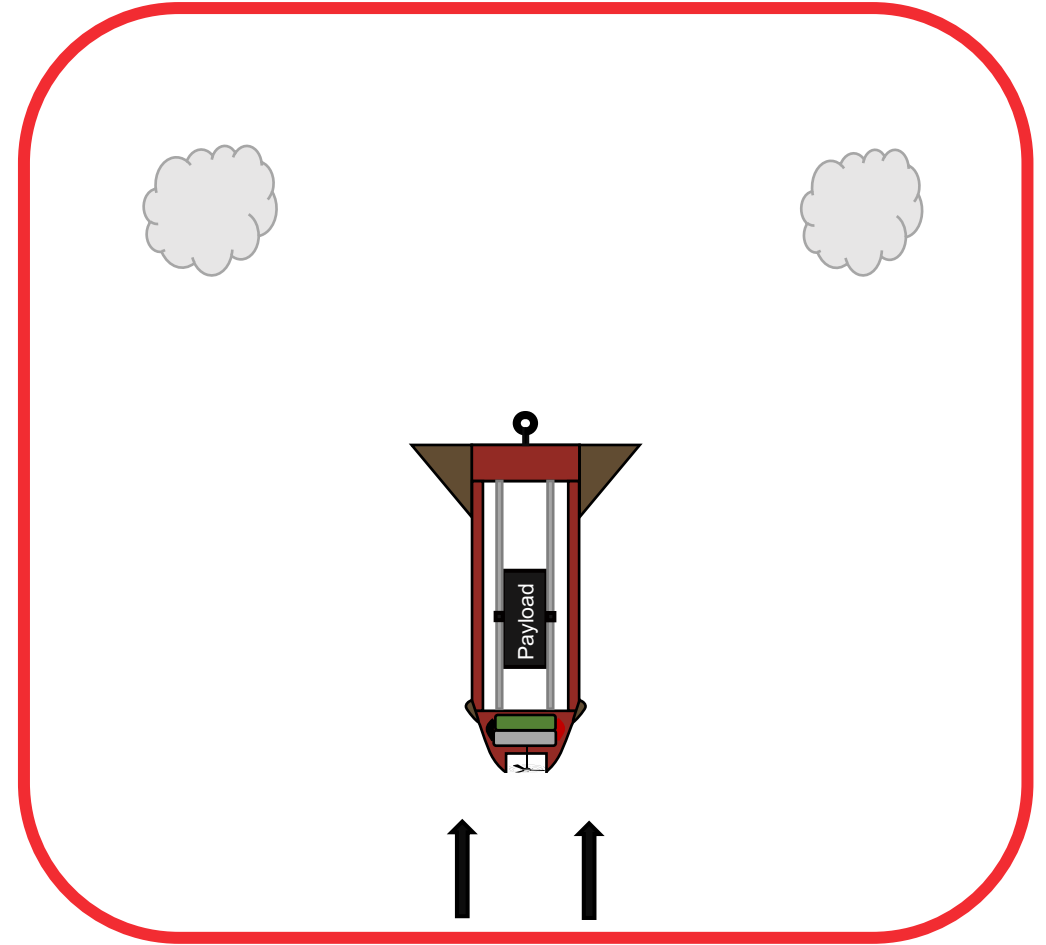
Selected Design: Ducted Fan
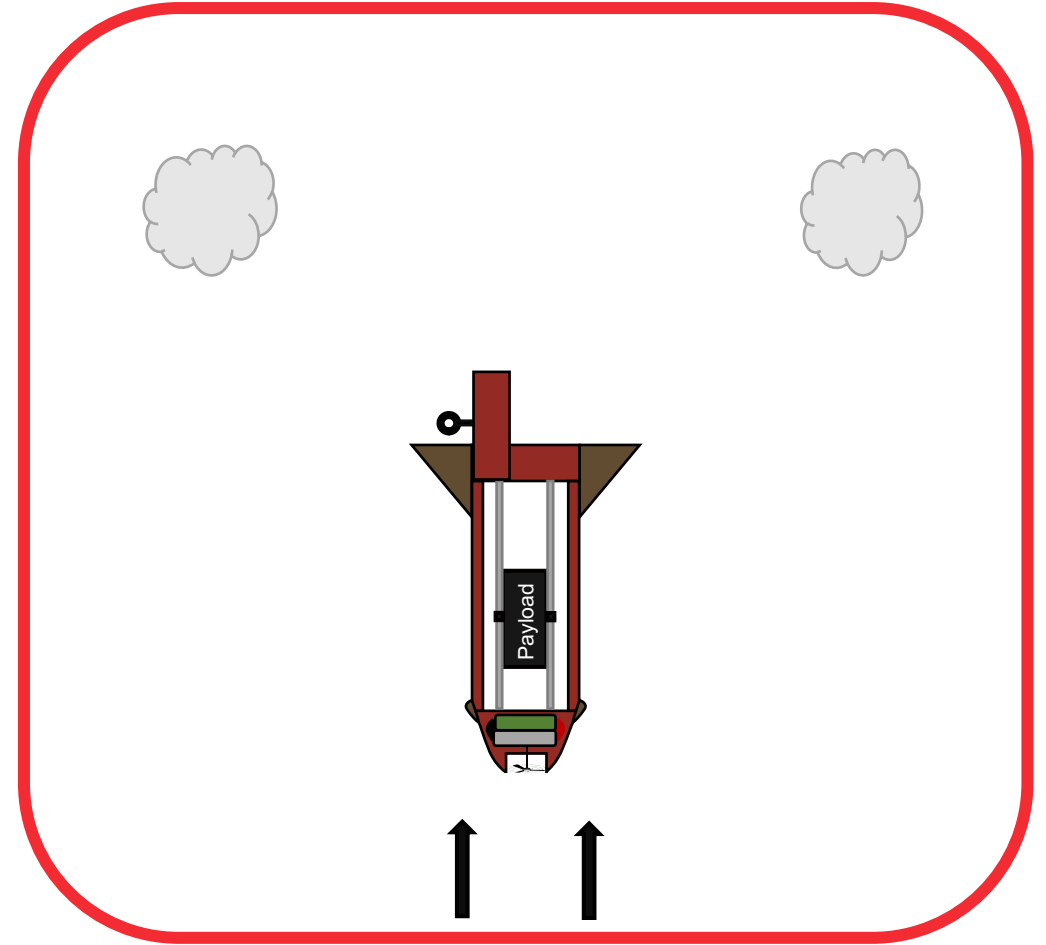
Collin Gainer

Selected Design: Ducted Fan
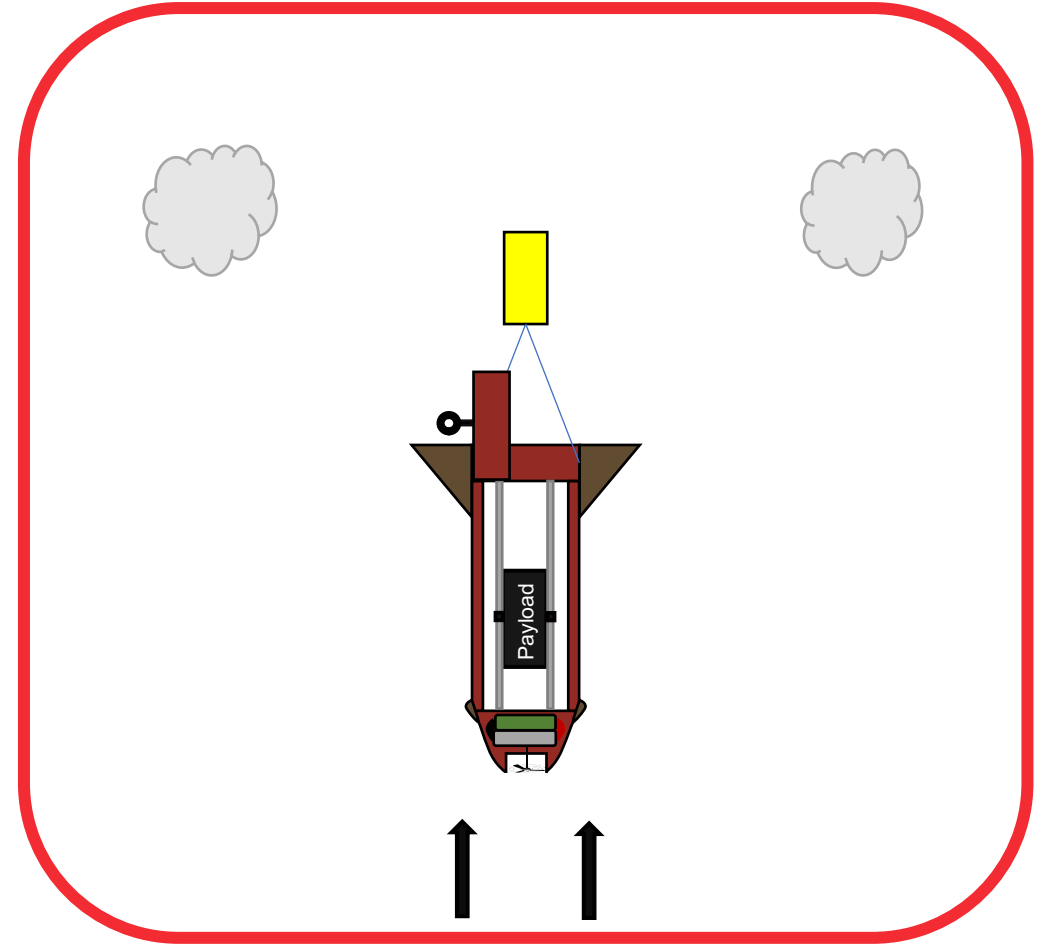
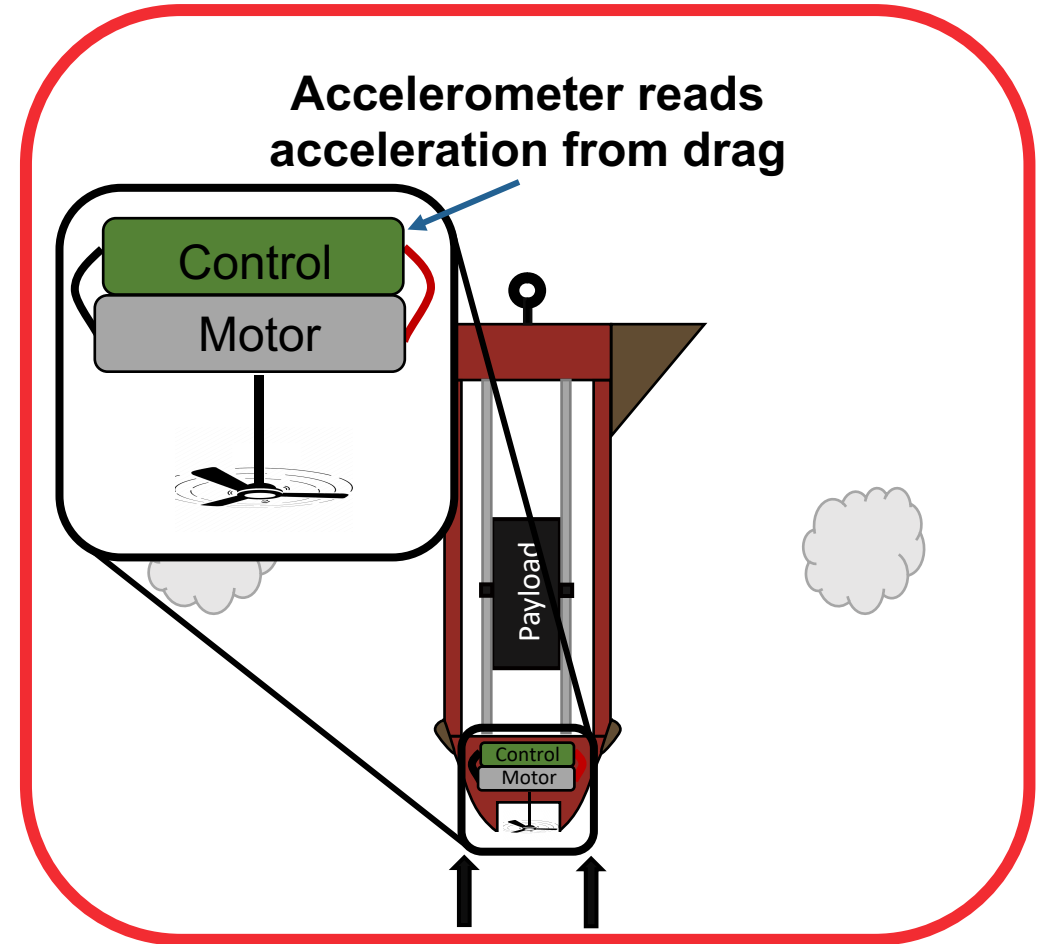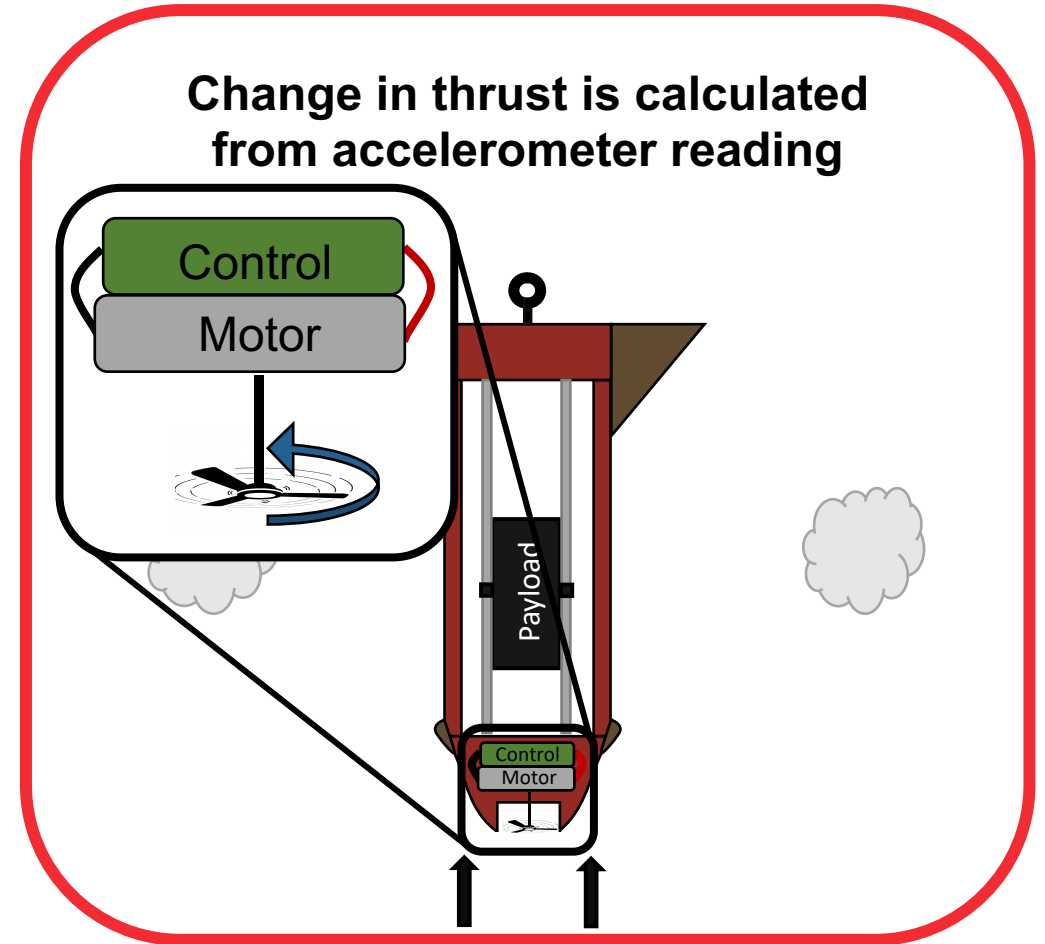Collin Gainer

Selected Design: Ducted Fan
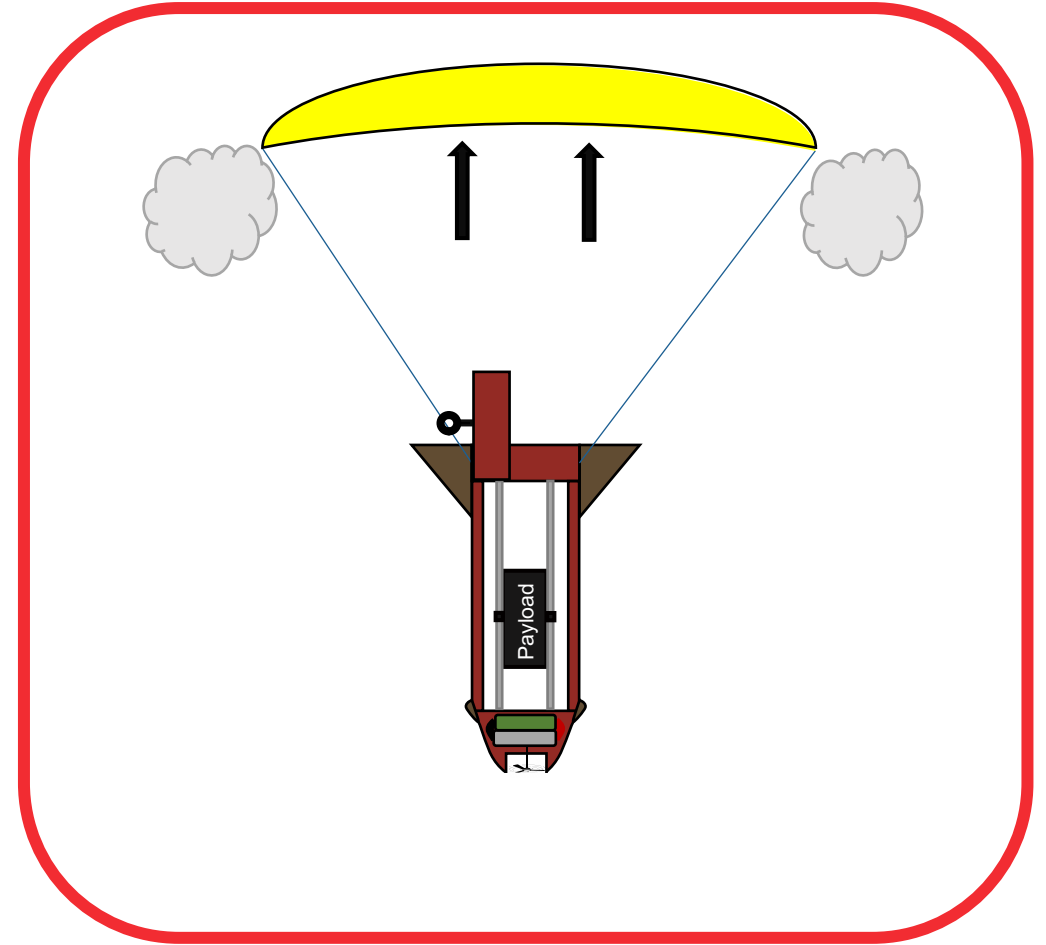
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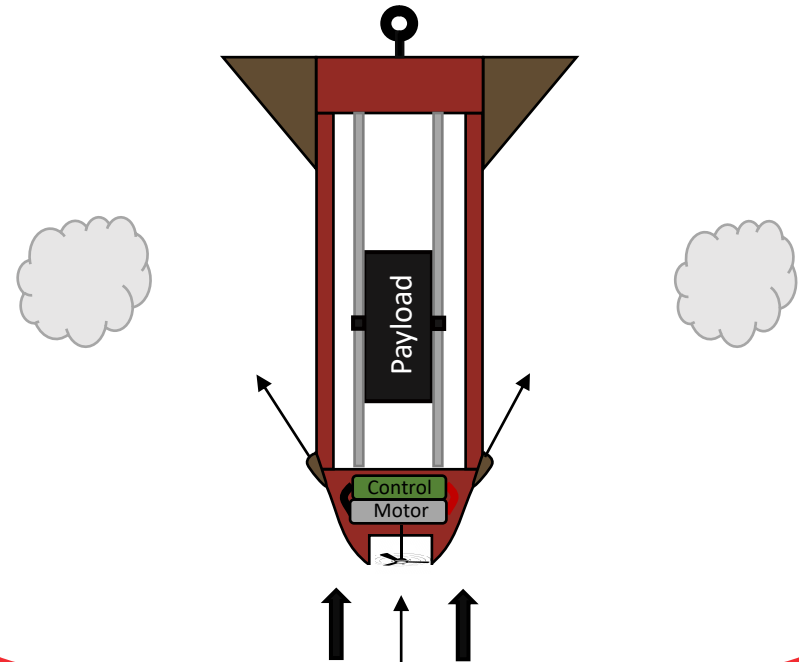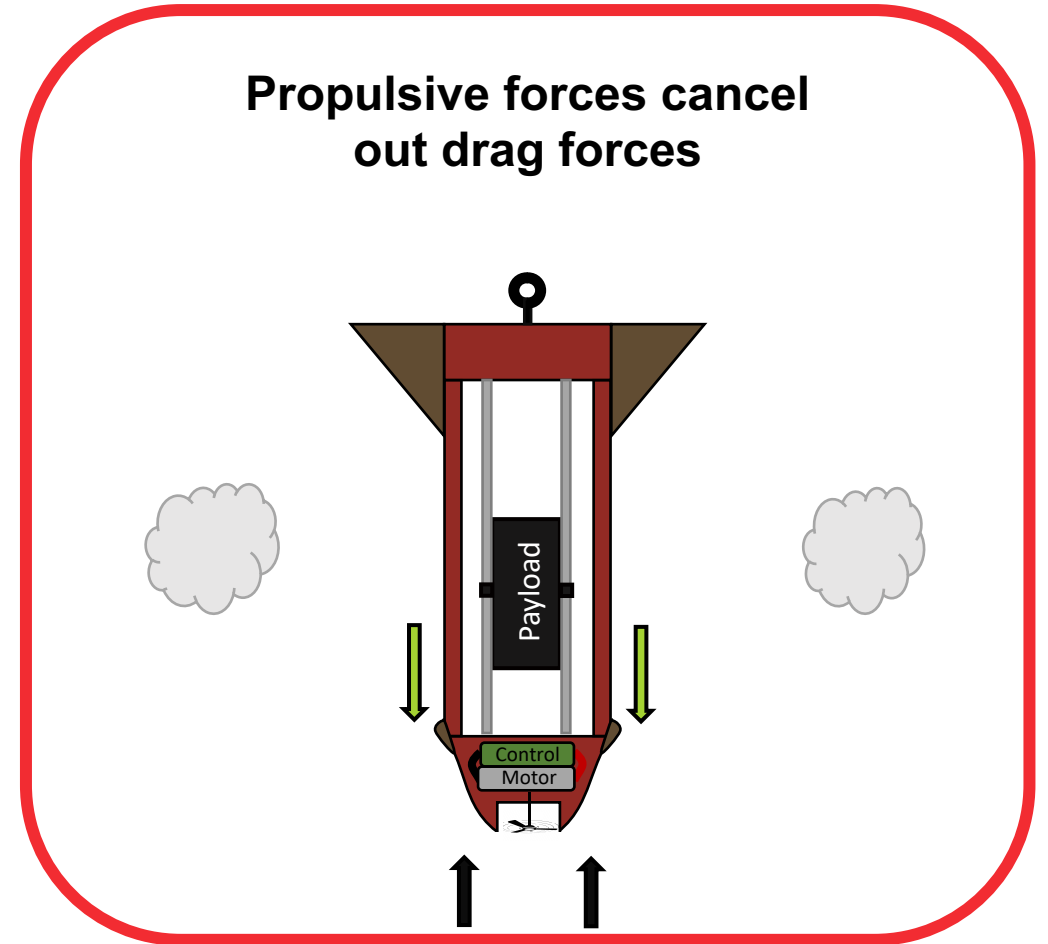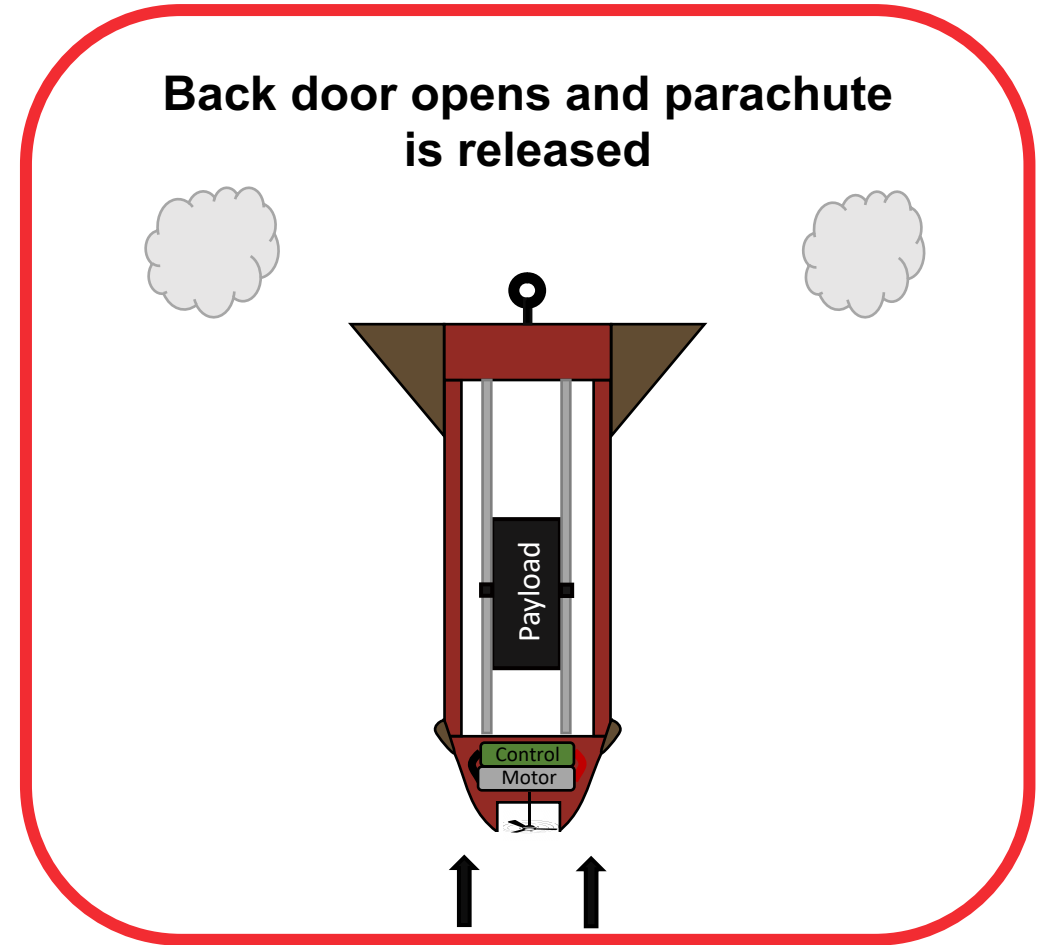
Front View

6 in (15.2 cm)
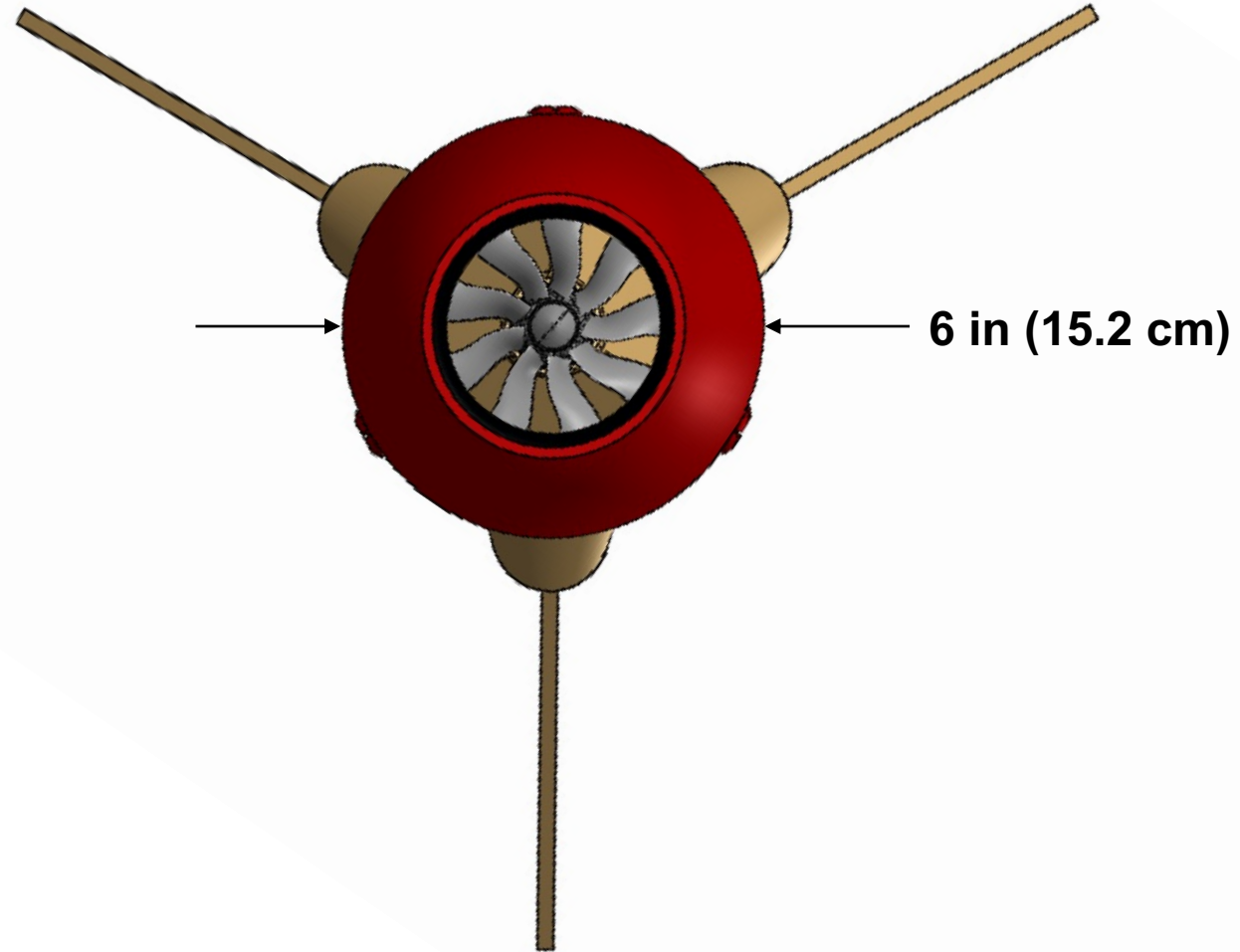
Collin Gainer

Side View

Collin Gainer

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Side View

Propulsion Control Payload Parachute

Collin Gainer

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Engineering

Parachute Storage

Parachute bulkhead

Cap

String connection

Parachute

Parachute bag

Servo Motor
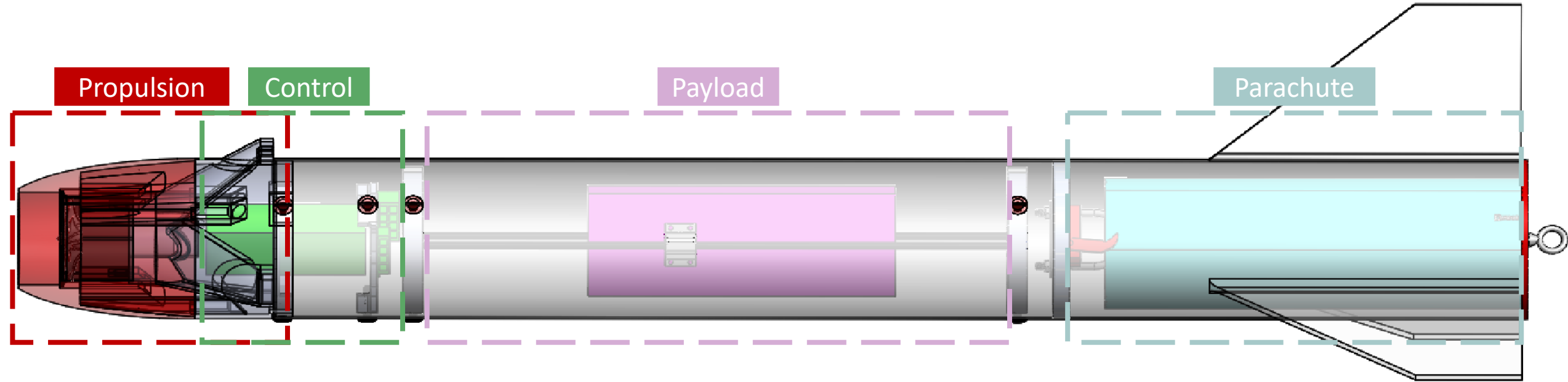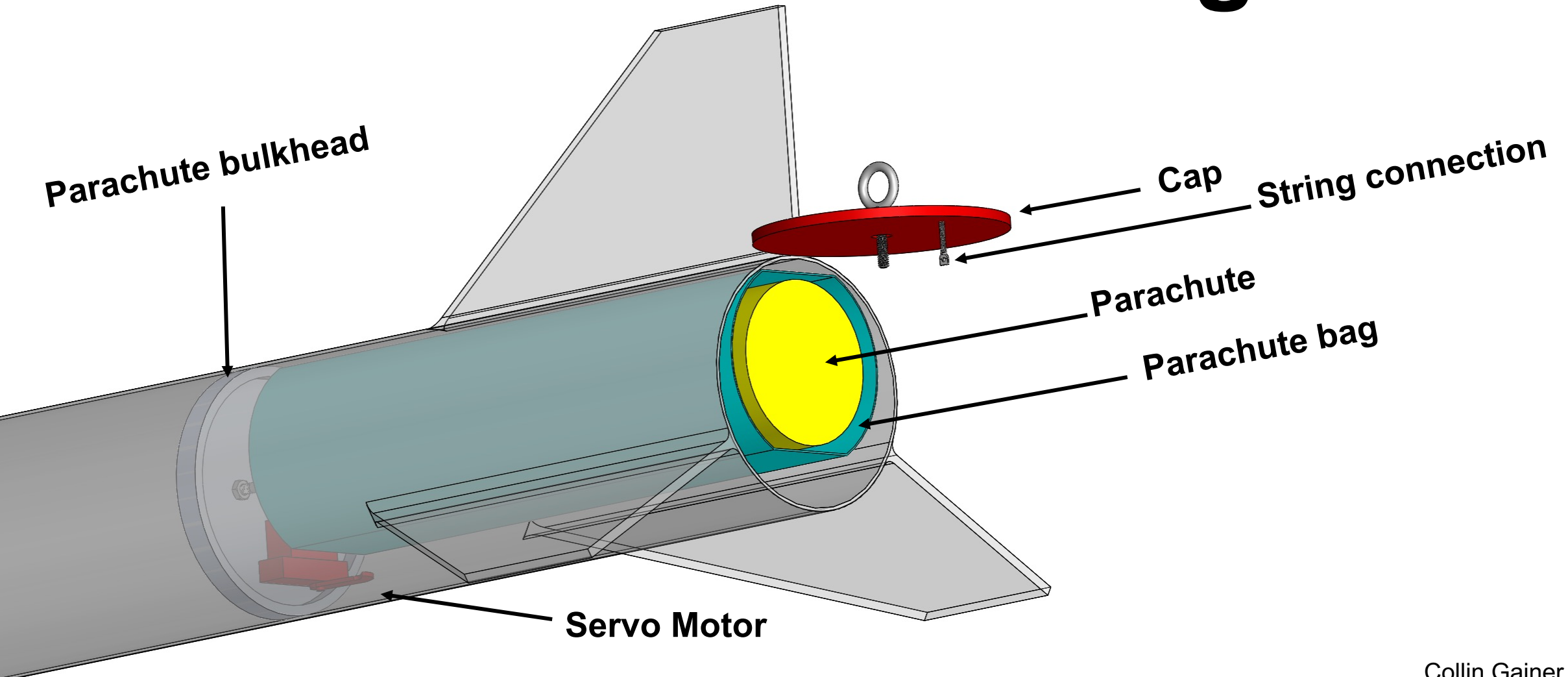
Collin Gainer

Propulsion System

Electronic Speed Controller

Second Stage

Fan

Battery

Microcontroller

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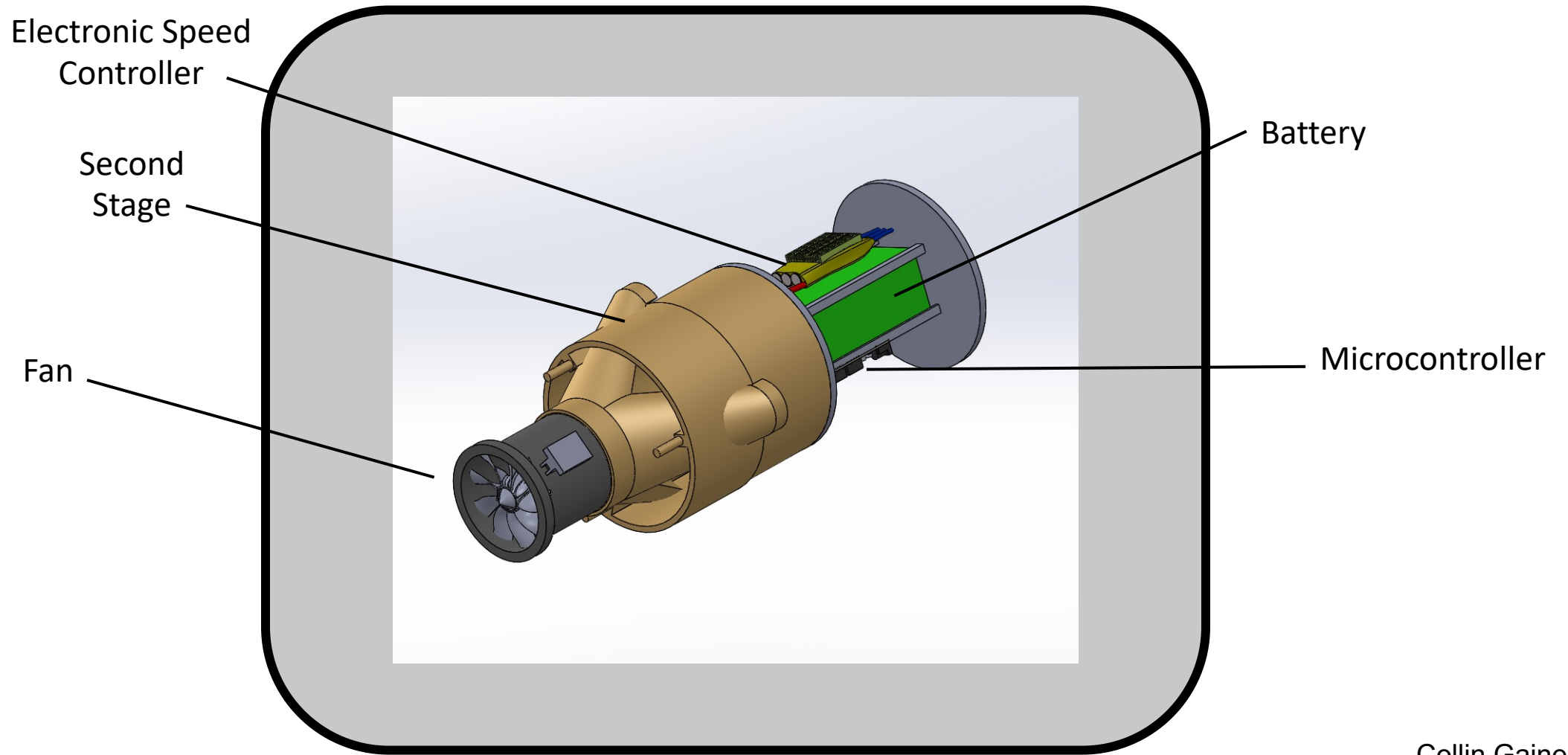
Current Work

Selected & Ordered Parts → Updated CAD → CFD Analysis → Controls Code
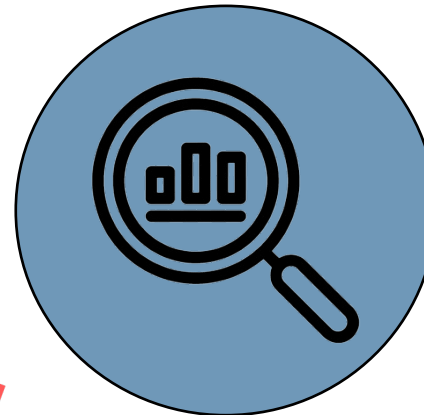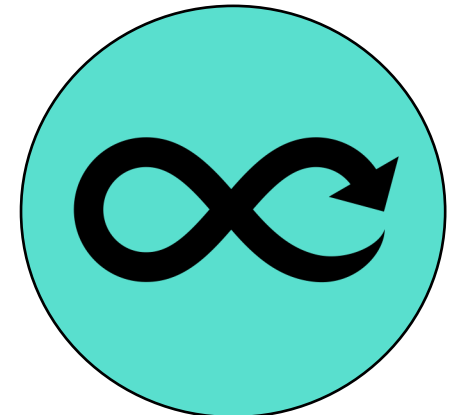
Collin Gainer

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

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

Department of Mechanical Engineering
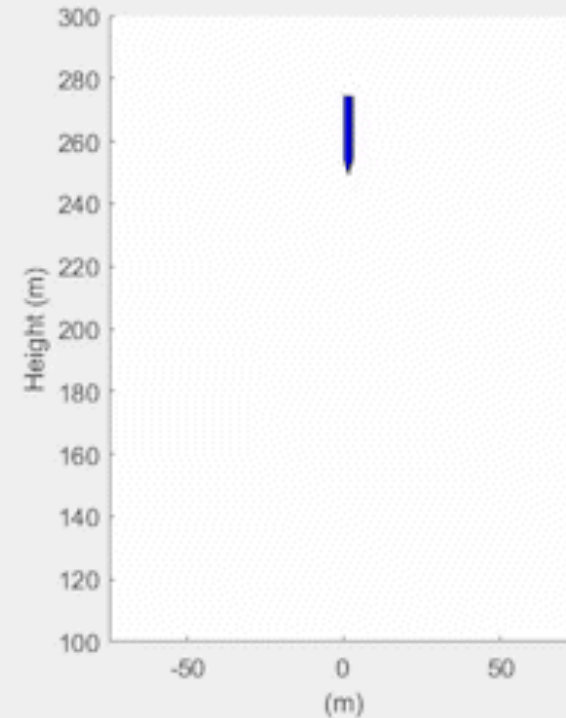
Controlled Simulation (PID)

John Tietsworth

Department of Mechanical Engineering

FAMU-FSU Engineering

49

Budget

Spent: $980
Left: $384

- 3D Printing Filament — 8%
- Body — 8%
- Shipping — 14%
- Electronics — 20%
- Structural Components — 50%
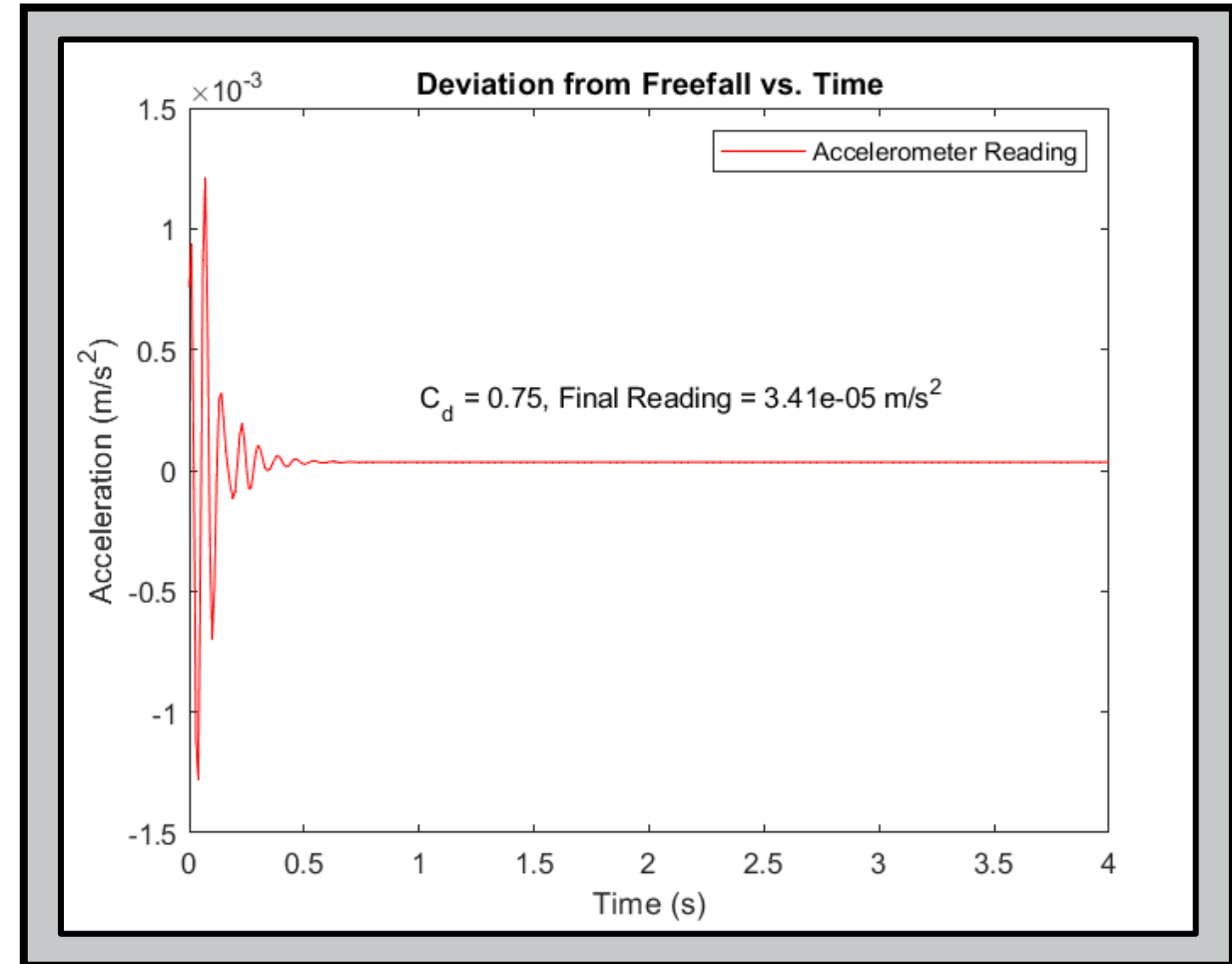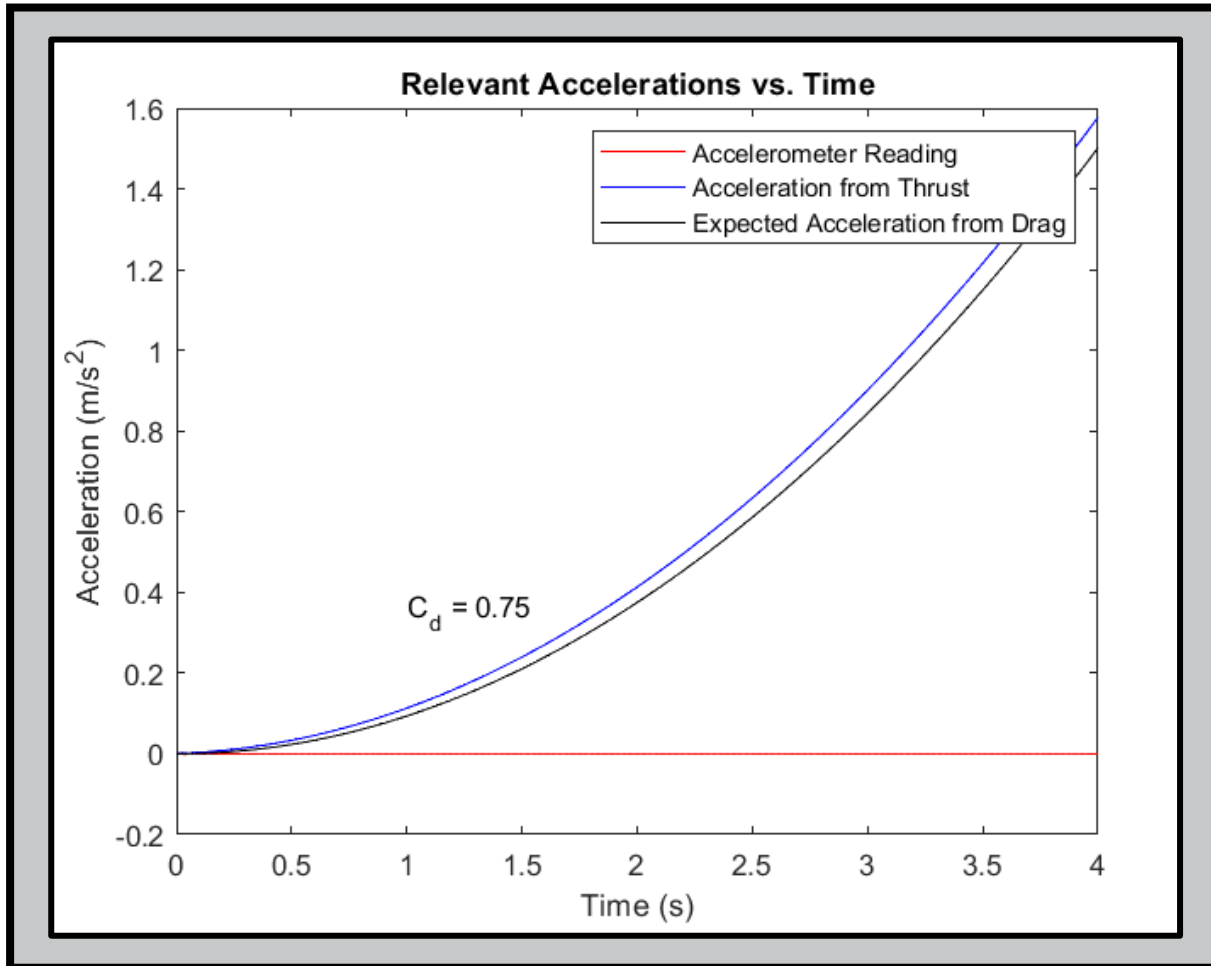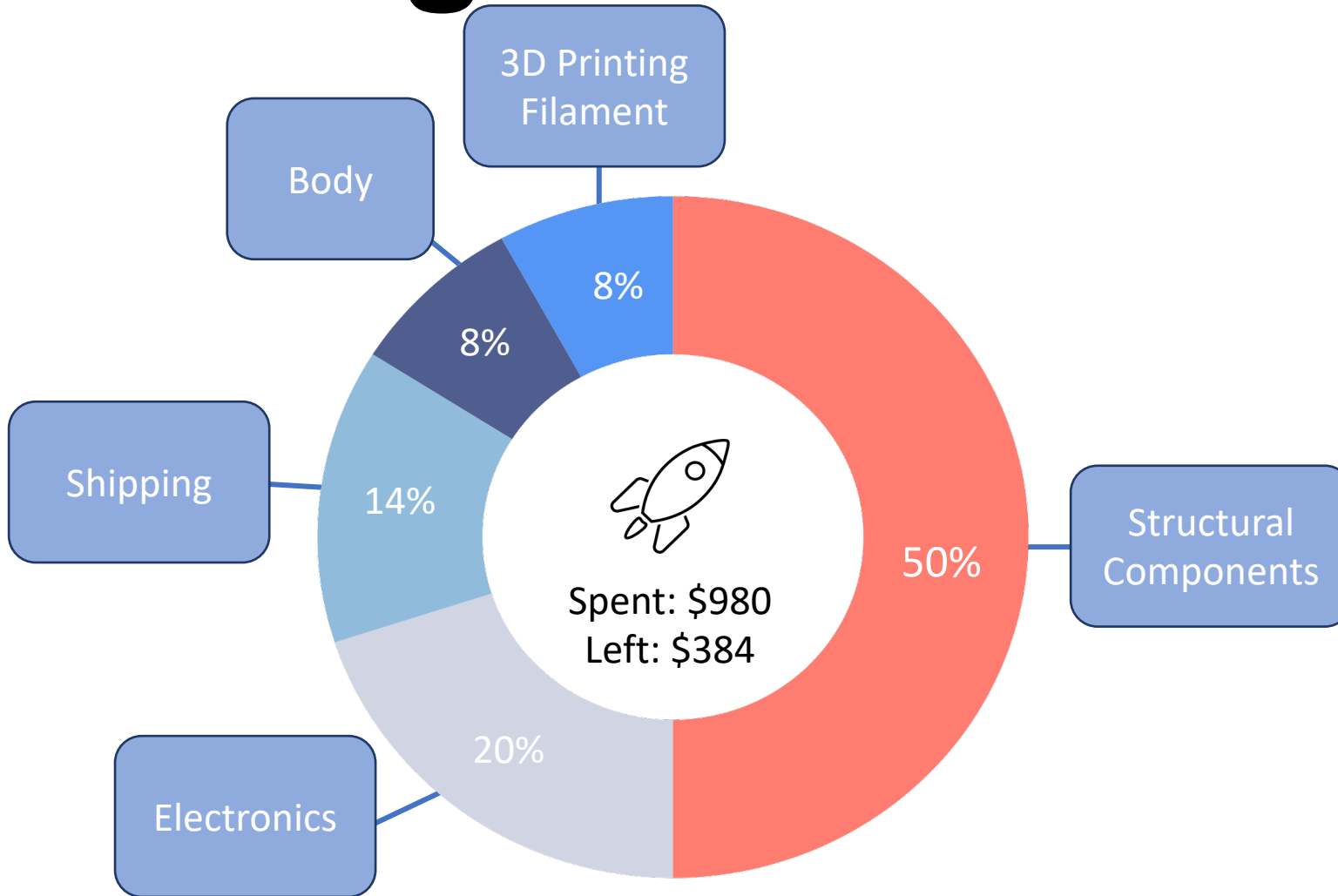
3D Printing Filament

Body

Shipping

Electronics
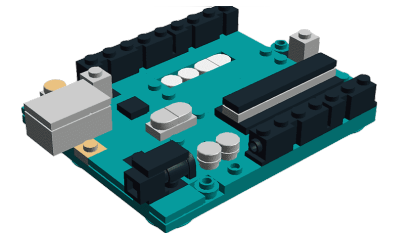
Structural Components

John Tietsworth

FAMU-FSU Engineering

Testing Plans

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

John Tietsworth

FAMU-FSU
Engineering

Testing Plans

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

PWM vs Thrust

John Tietsworth

FAMU-FSU
Engineering

Testing Plans

1. Thrust curve for the EDF
2. Servo stall torque
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4. Control system
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John Tietsworth

Testing Plans

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

Fishing line

Servo Motor

John Tietsworth

FAMU-FSU
Engineering

Testing Plans

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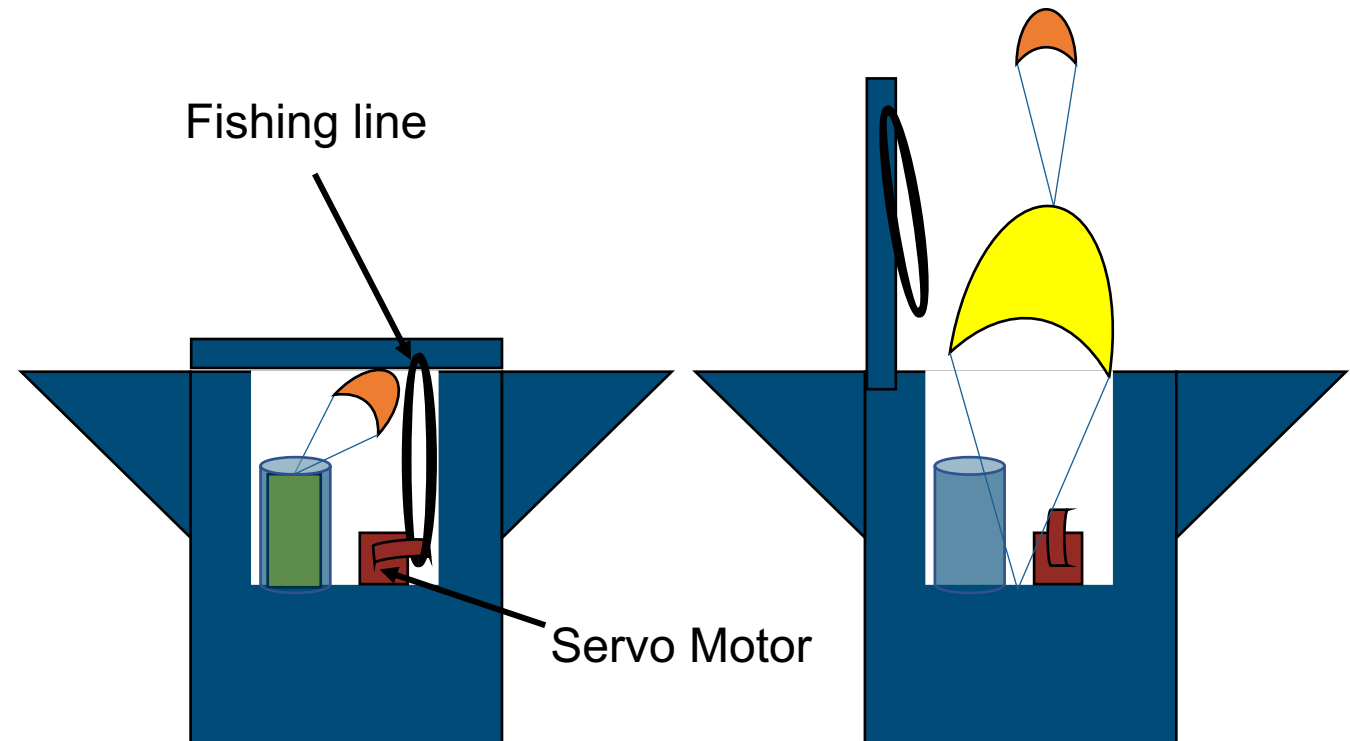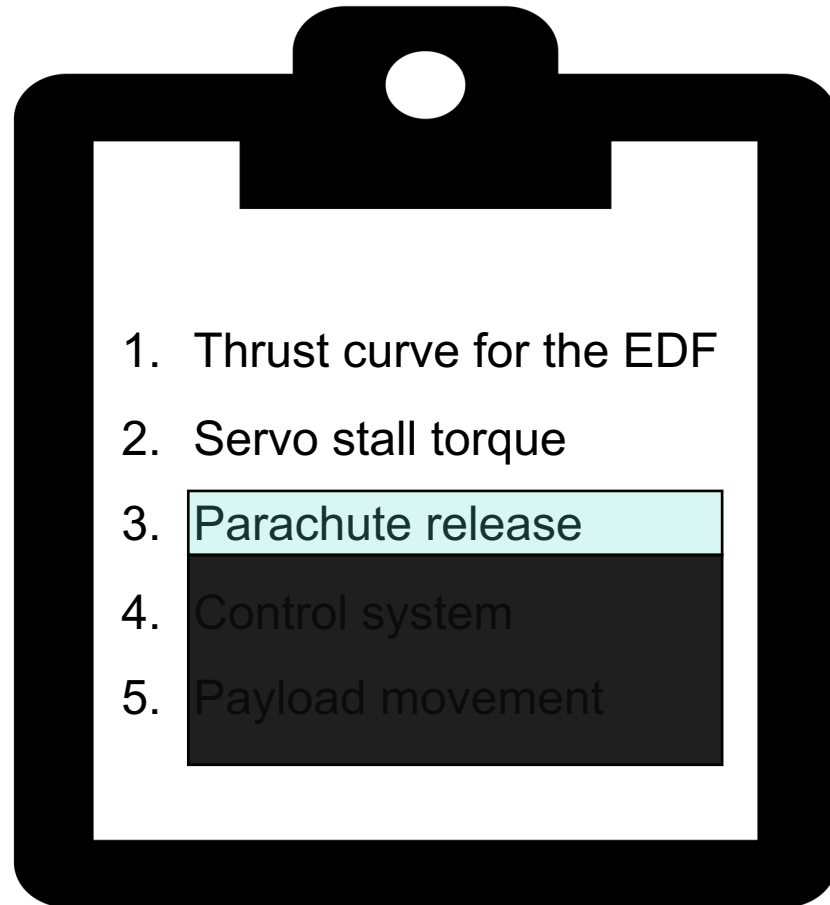3. Parachute release
4. Control system
5. Payload movement

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Testing Plans

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

Payload

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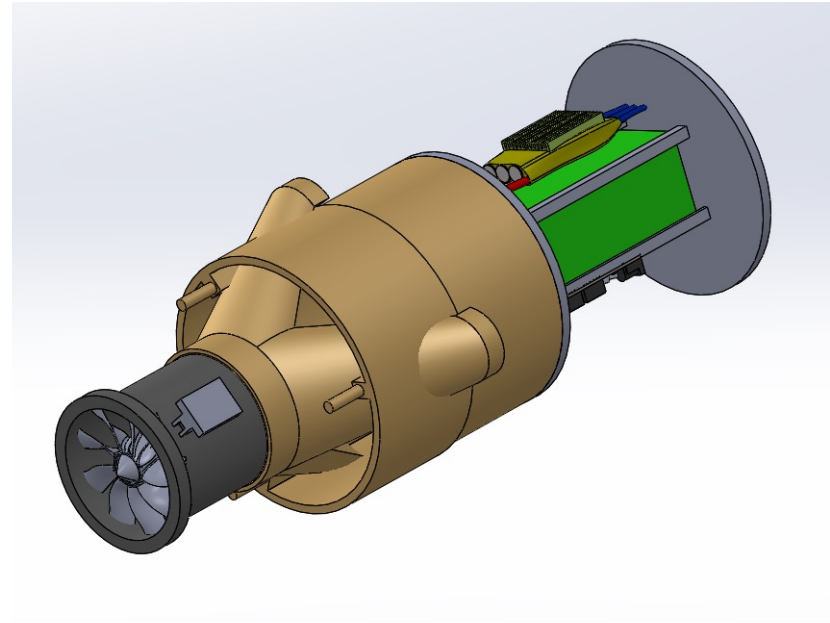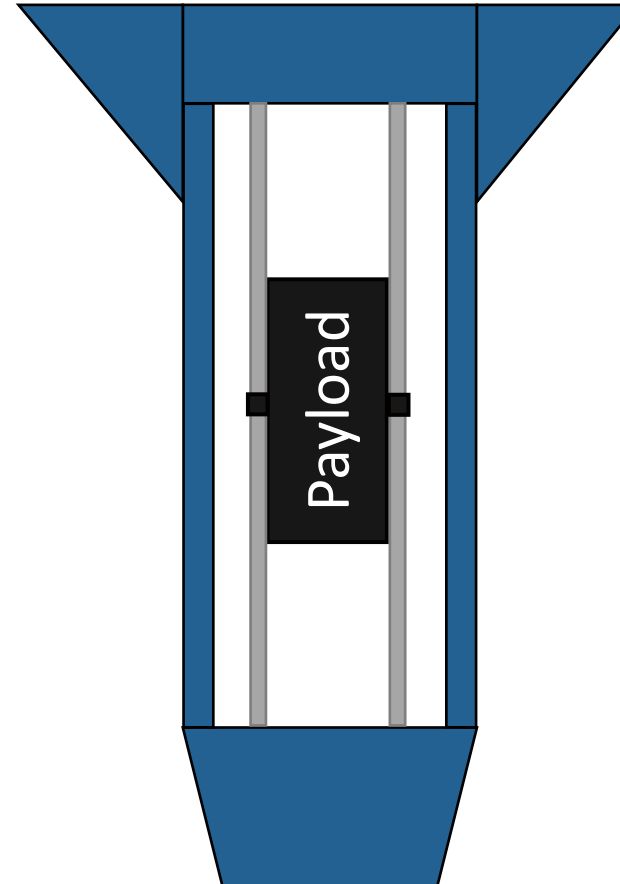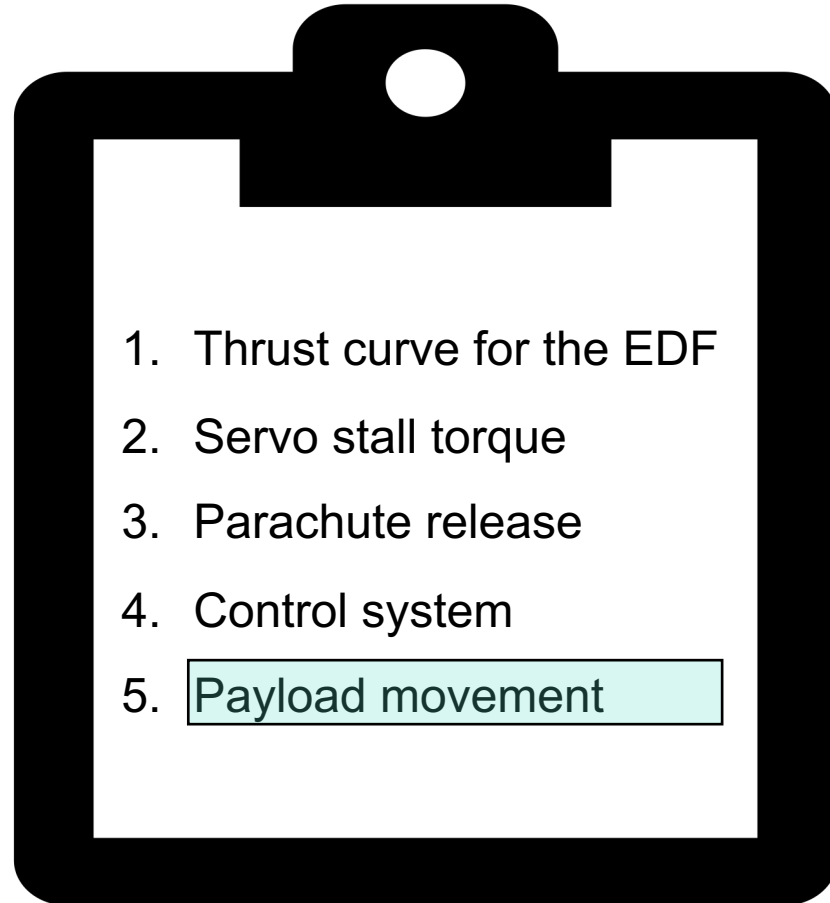
Future Work

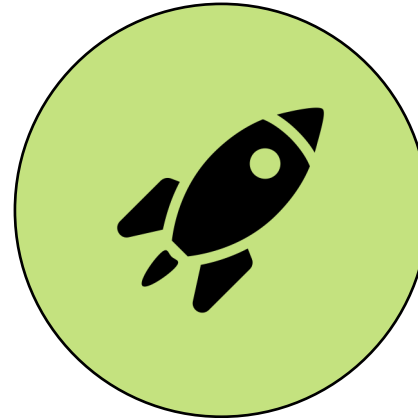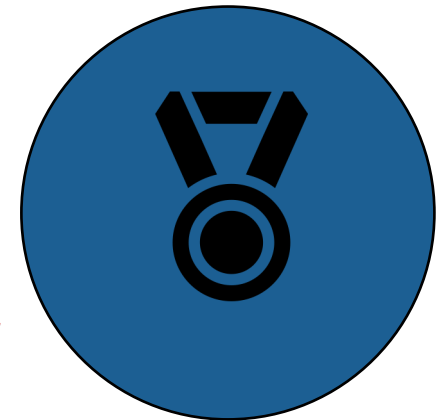SUBSYSTEM TESTING

ASSEMBLY

FULLSCALE TESTING

COMPETITION

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References

Images:

https://thekidshouldseethis.com/post/feathered-fighter-jets-peregrine-falcons

https://www.esa.int/ESA_Multimedia/Images/2007/11/Zero-G_Airbus_A300_for_parabolic_flights

https://en.wikipedia.org/wiki/Sounding_rocket

https://www.esa.int/ESA_Multimedia/Images/2017/03/ZARM_s_Drop_Tower_in_Bremen

https://www.hitec.uni-hannover.de/en/large-scale-equipment/einstein-elevator/

https://www.hitec.uni-hannover.de/en/large-scale-equipment/einstein-elevator/events-and-media/

Further Readings:

https://www.gozerog.com/

https://www.nasa.gov/mission_pages/sounding-rockets/missions/index.html

https://www.zarm.uni-bremen.de/en/drop-tower/general-information.html

https://www.hitec.uni-hannover.de/en/large-scale-equipment/einstein-elevator

https://www.youtube.com/watch?v=4aCMDQsx740&ab_channel=TomScott

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