7.390 - VTVL Model Rocket

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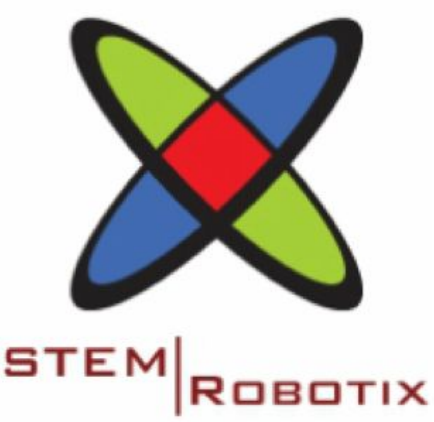
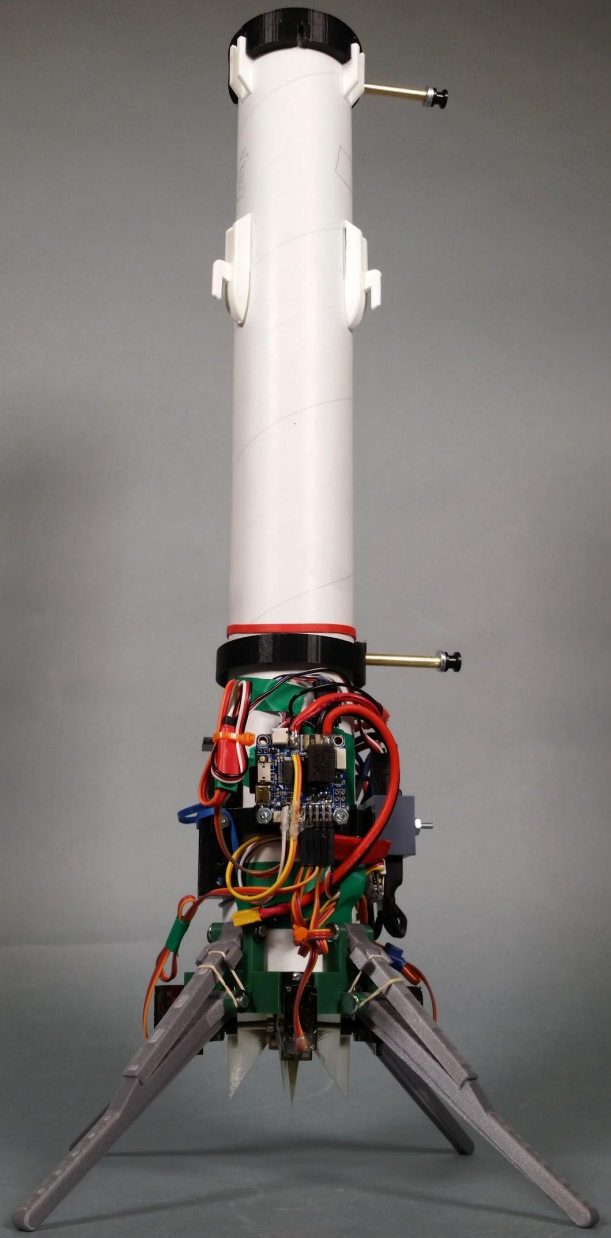


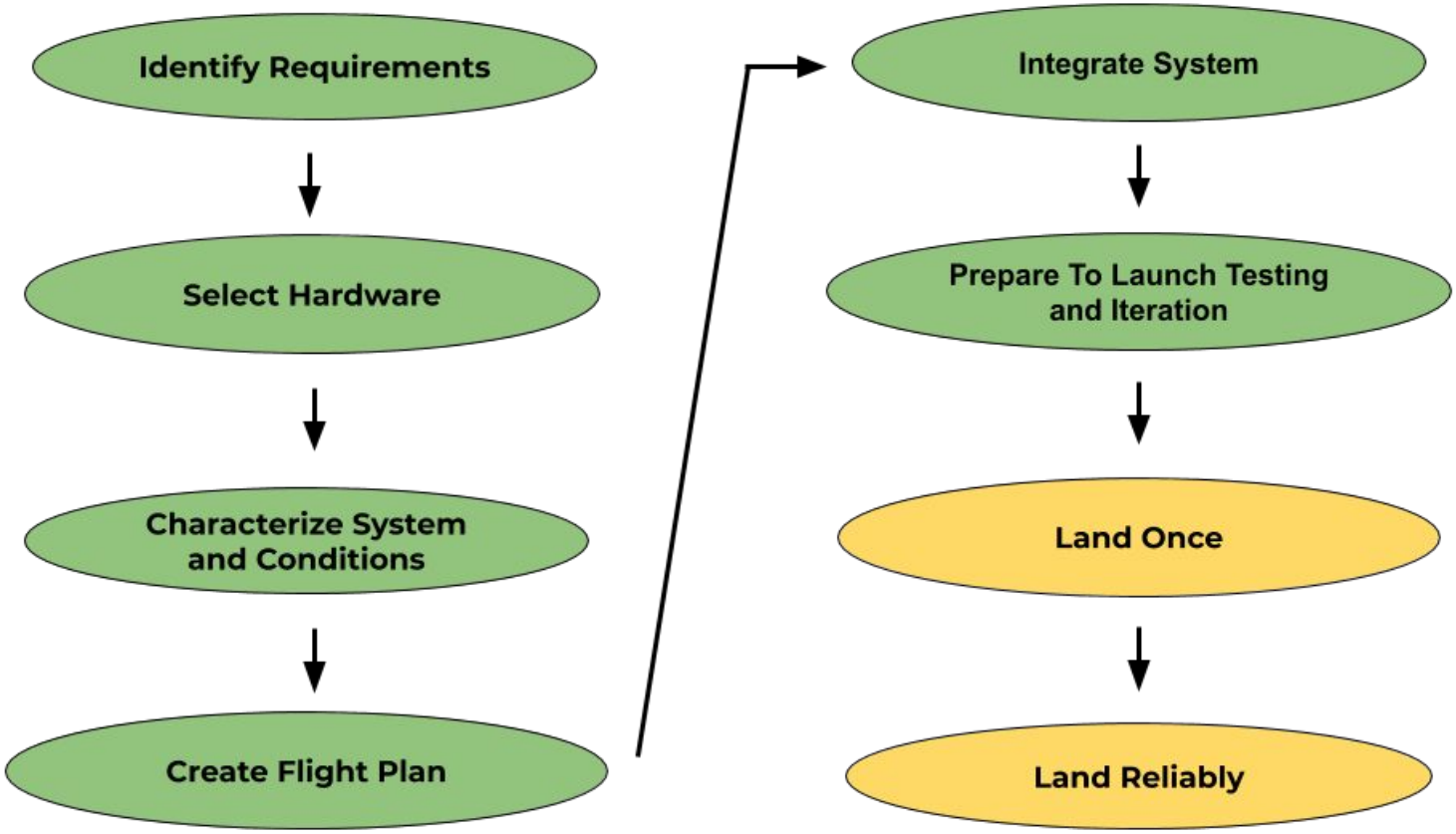
VTVL



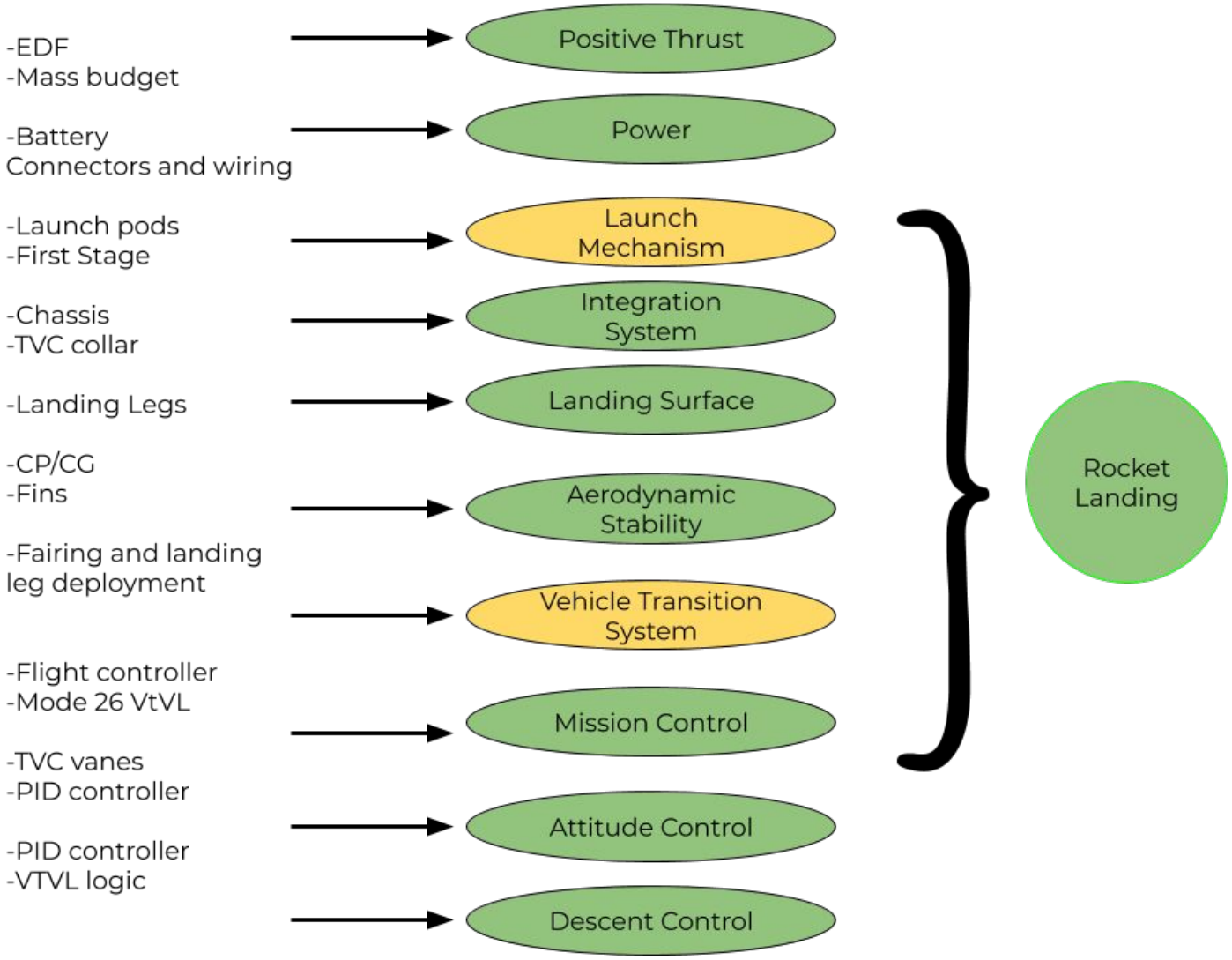
Problem Statement

Current model rocket technology lacks the physical mechanisms and electronic control design sophisticated enough to emulate full-sized VTVL rocket systems, preventing hobbyists and students from engaging in and appreciating the new heights of rocket science.

Methodology



Requirements



Ascent System

- Sized up the 3 motors
- Wider to accommodate new motors, shorter to fit under fairing
- Rail buttons, 80-20 T-slot launch rail
- January Test
  - All pods separated
  - Target altitude reached (~90m)

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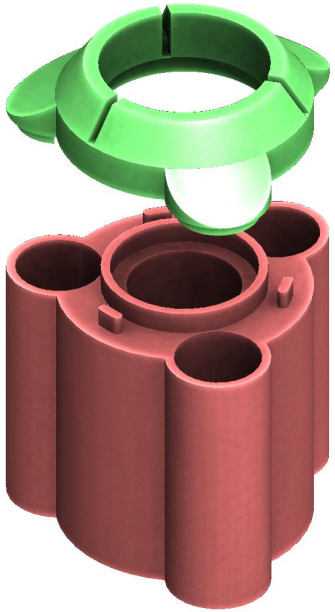
First Stage

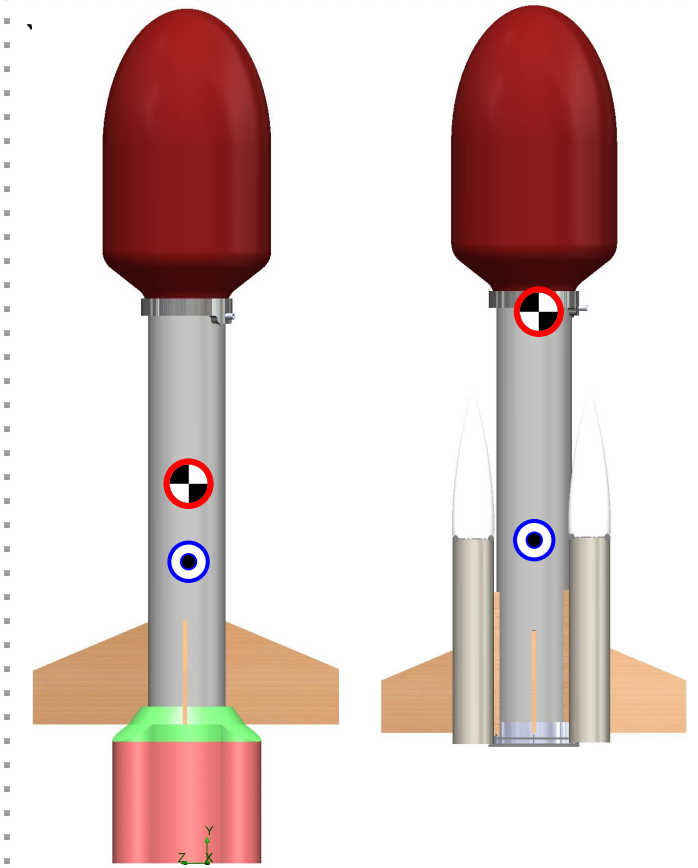
- System developed in parallel to side pods
- Single housing for all motors
- Collar can integrate fins and EDF inlet
- Test Launch
    - Parachute tangled with main body



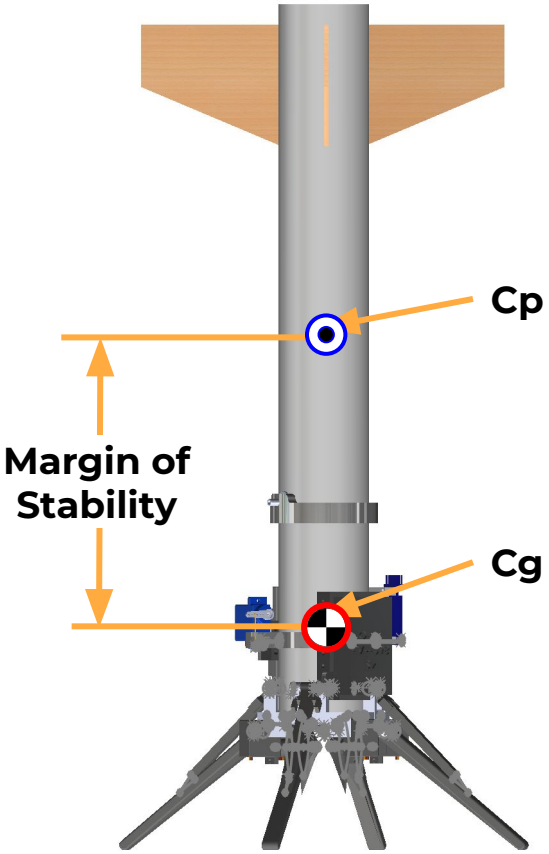
Cluster Ignition

- Reliability issues
- Multiple launches with 1 or 2 failed ignitions
- Area for future improvement

Aerodynamic Stability

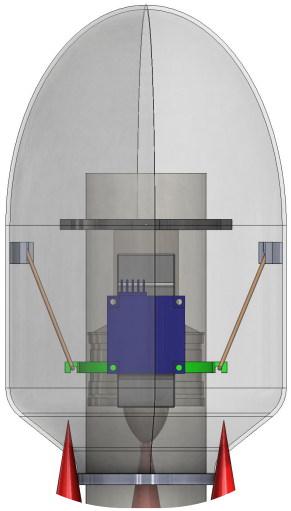


Ascent Stability

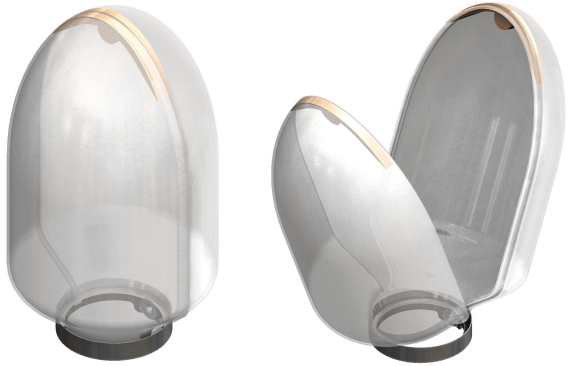


Descent Stability

Vehicle Transition System



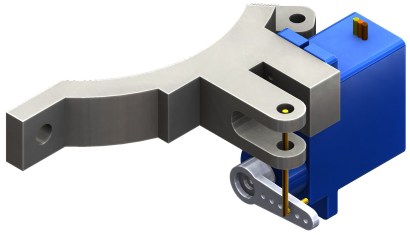
NiChrome
Wire System



Clamshell Fairing

Slip-On Fairing

Further
Development

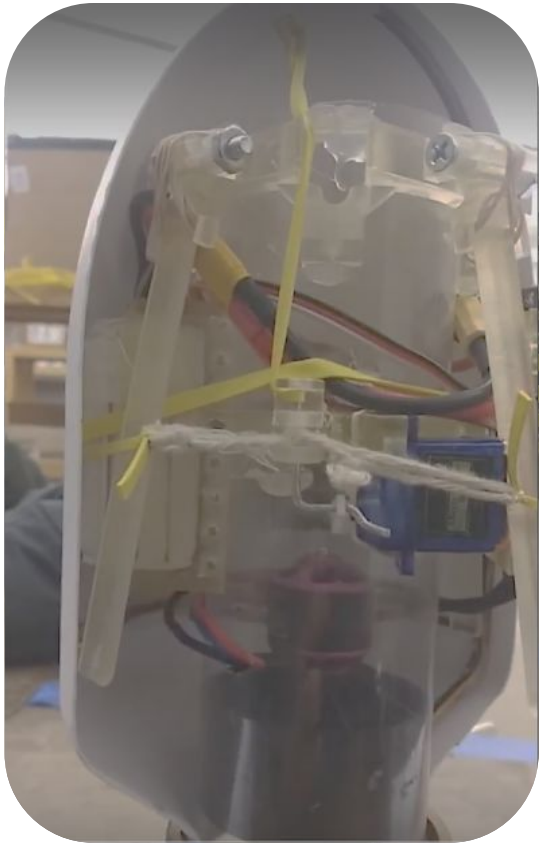


Landing Legs

Further
Development

Vehicle Transition System

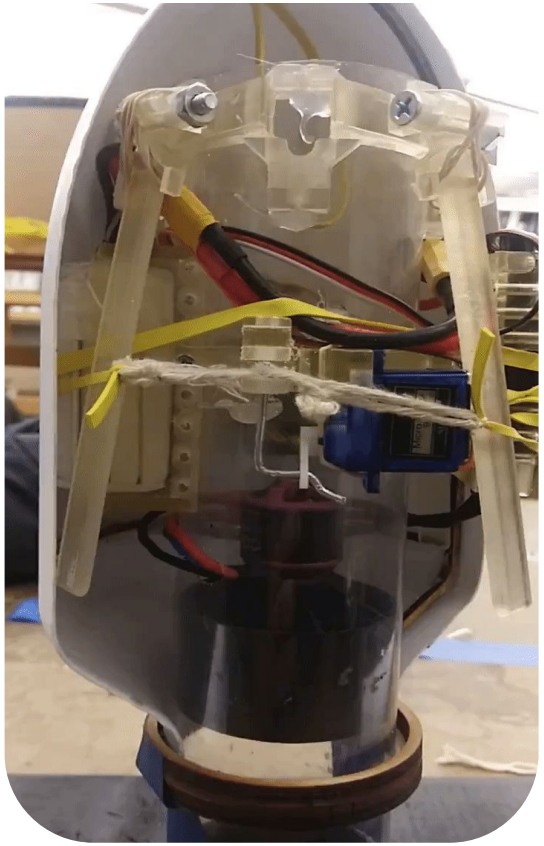
Fairing Deployment



Landing Leg Deployment

Vehicle Transition System

Fairing Deployment

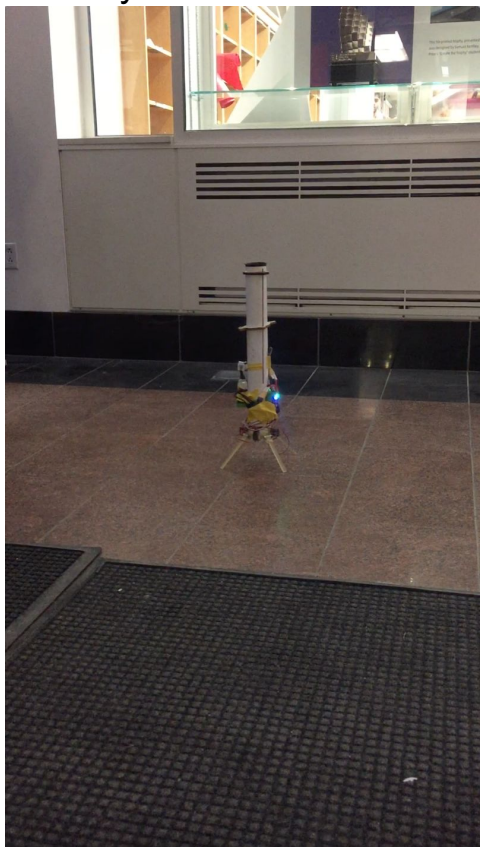


Landing Leg Deployment

Hover Stability

Indoor Hover testing -> Outdoor Hover testing -> Outdoor Descent Tests

January 13

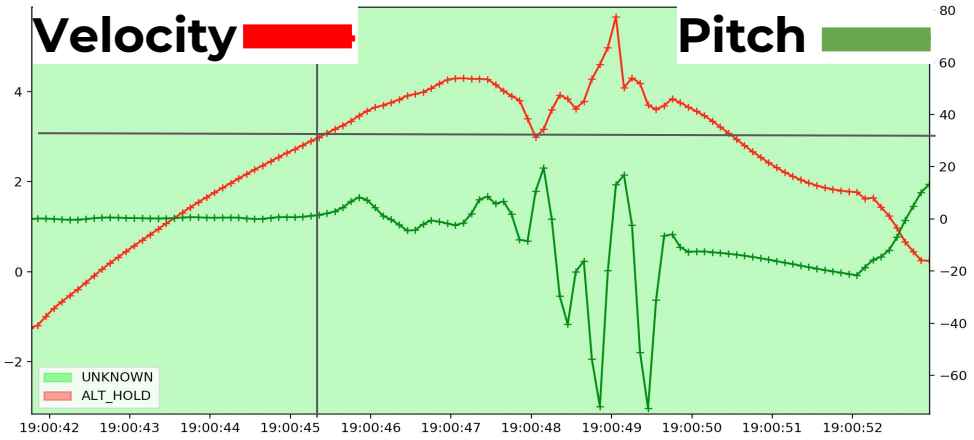


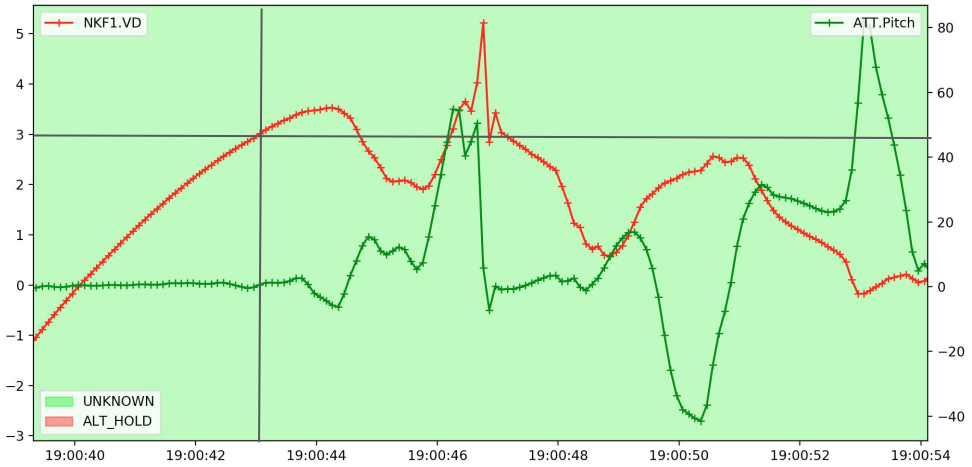
January 24

date	Video no:	Video no	timestamp	Pitch an	I	D	Yaw P	I	D	Precessio	result	adjustment	note
1/14/20	9943	1	5:34	0.15	0.135	0.0036	0.1	0.01	0	1	quickly unstable	decrease precession correction	
1/14/20	9944	2	5:45	0.15	0.135	0.0036	0.1	0.01	0	0.5	quickly unstable	decrease precession correction	
1/14/20	9945	3	5:46	0.15	0.135	0.0036	0.1	0.01	0	0.25	quickly unstable	increase P gain on pitch/roll axes	

Initial Hover Testing

Initial Descent Testing





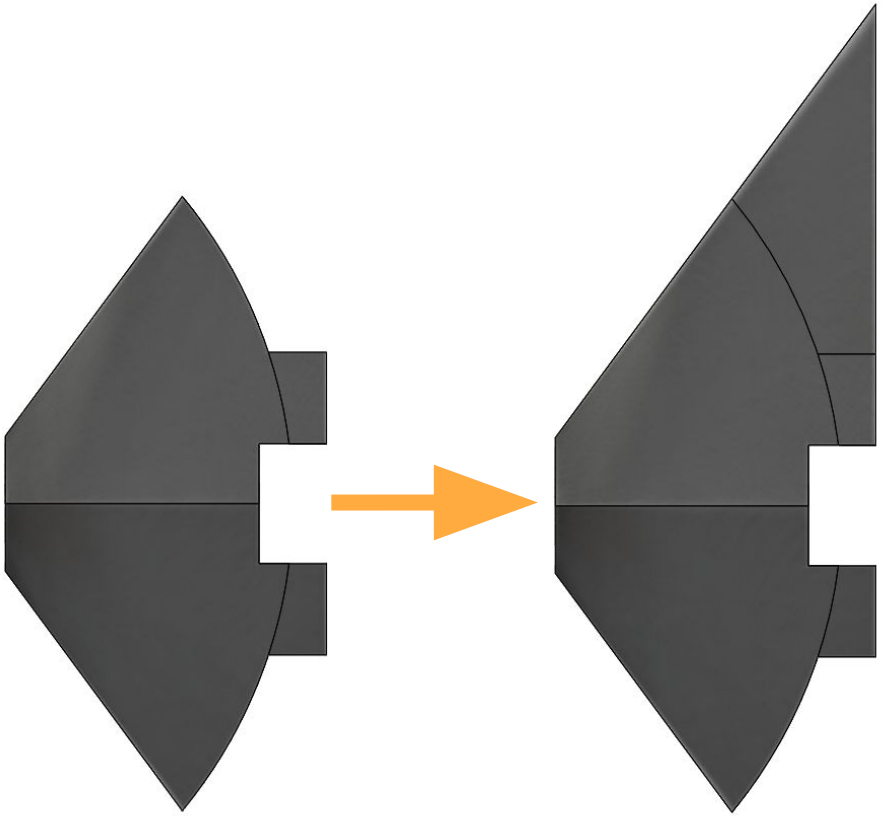
Conclusion:

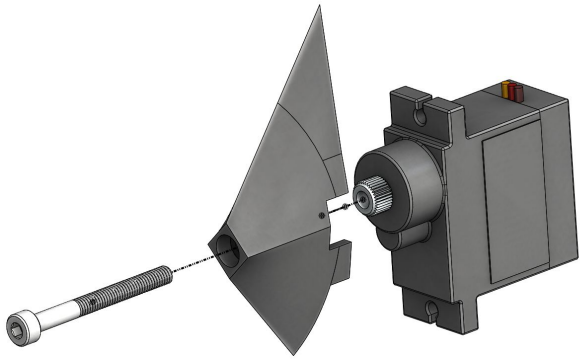
- Not Enough Control

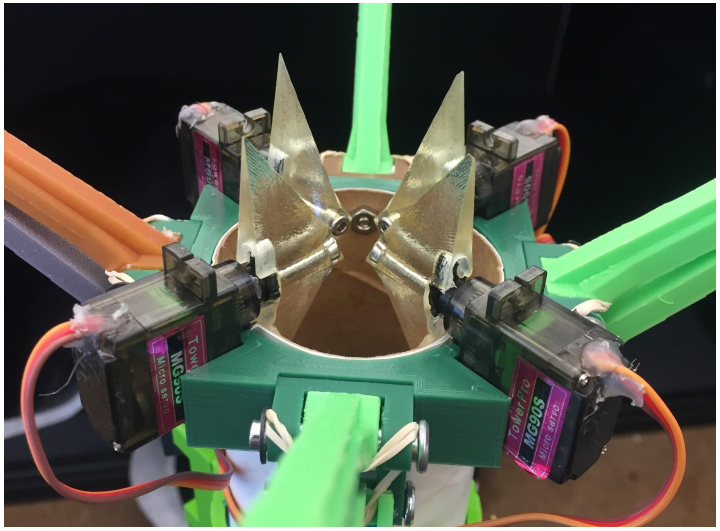
Next Steps:

- Change TVC vane design
- Change TVC vane position
- Return to hover testing

TVC Vane Improvements

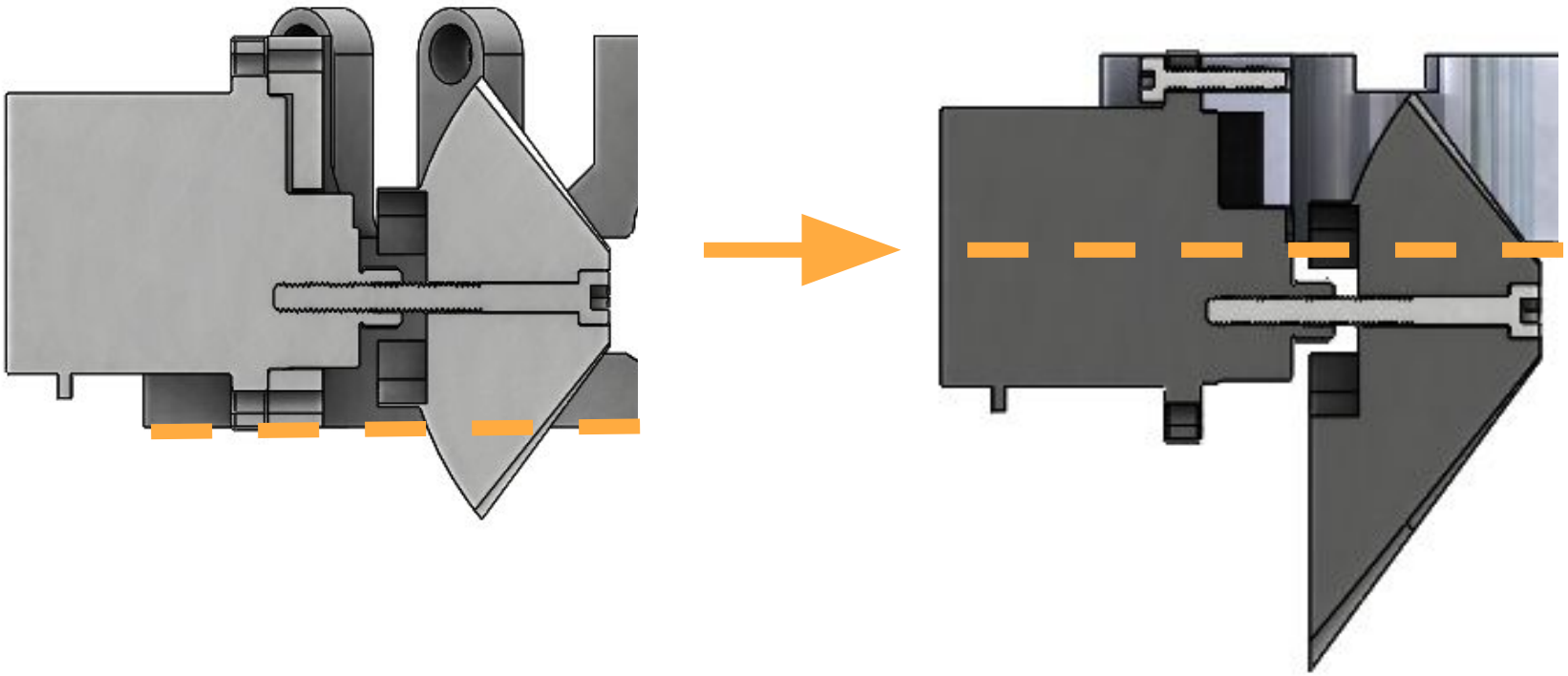






TVC Vane Improvements

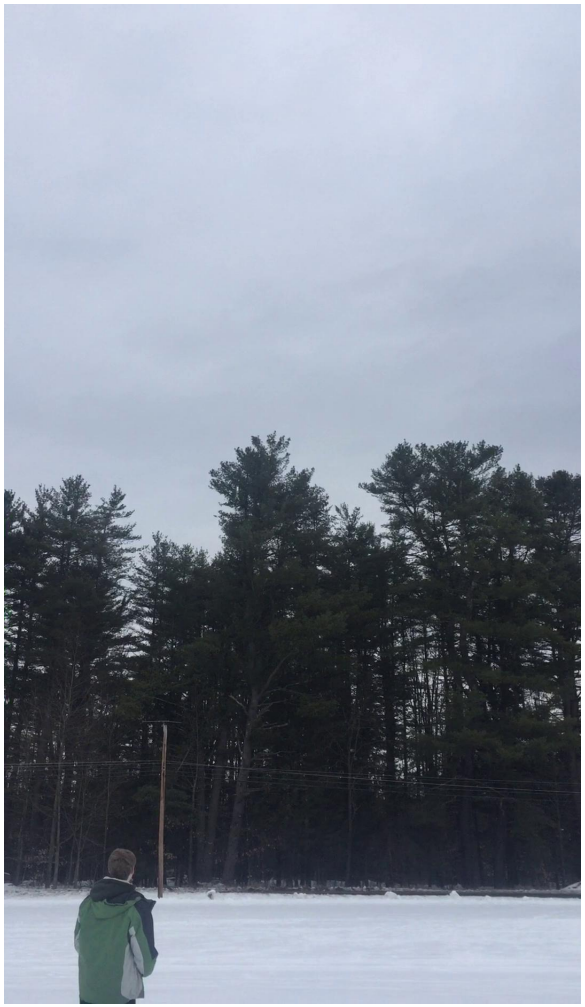
- Increase size
- Shift axis of rotation



Descent Sequence

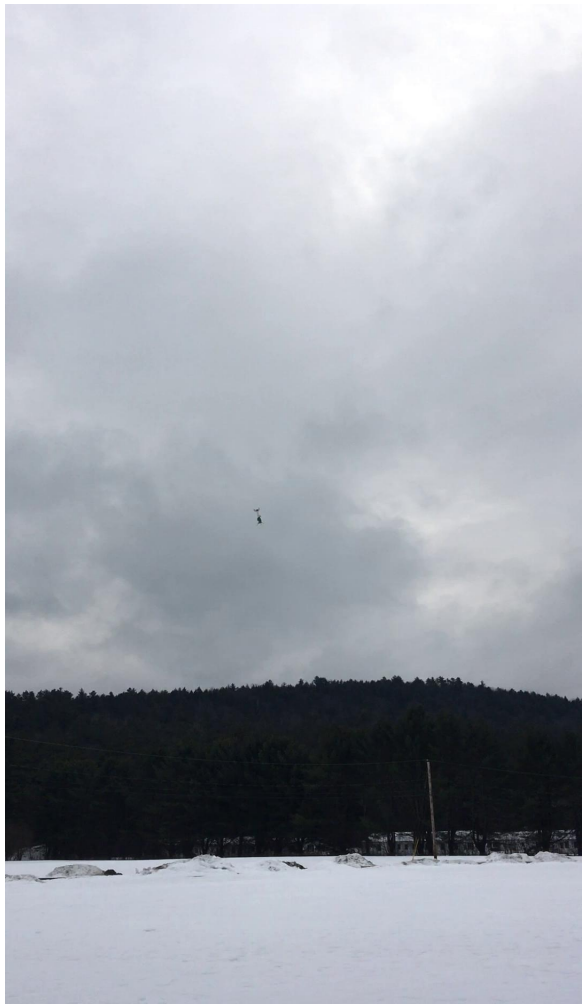
1. At apogee: deploy fairing and landing legs
2. At **velocity threshold**: constant acceleration to reach 1 m/s at 5 meters altitude
3. At 5 meters altitude: descend at 1 m/s
4. At 2 meters altitude: descend at 0.5 m/s until contact with ground

Descent Testing with Improved Control



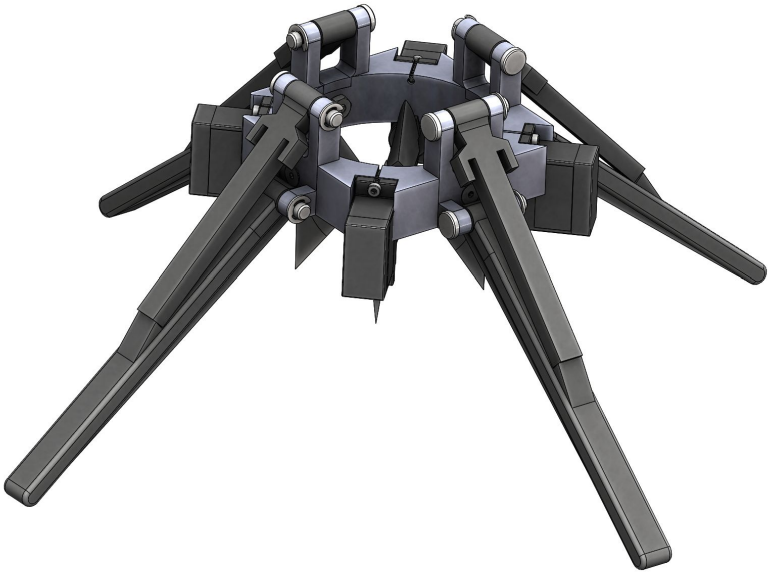
Fully controlled descent

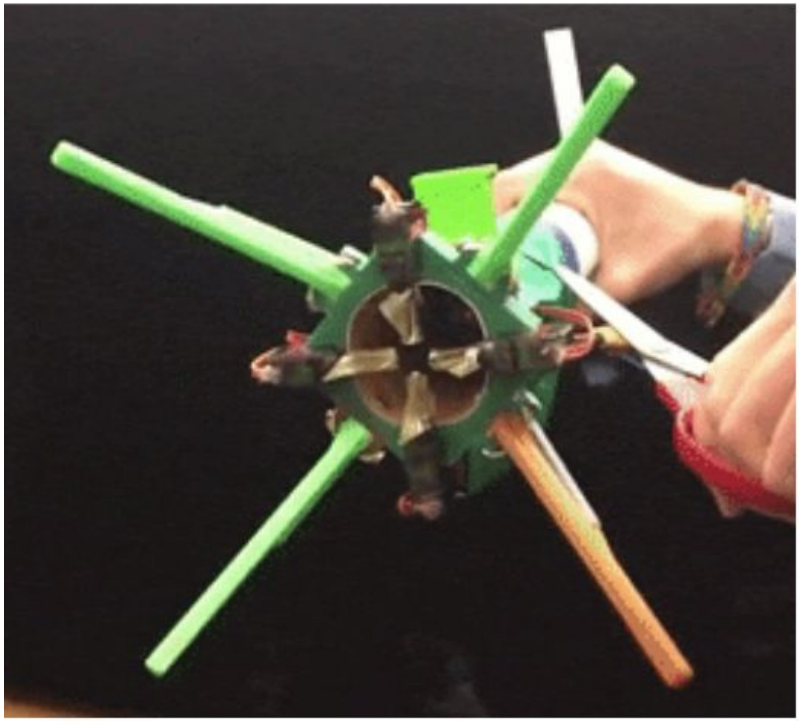
Tumble and control loss



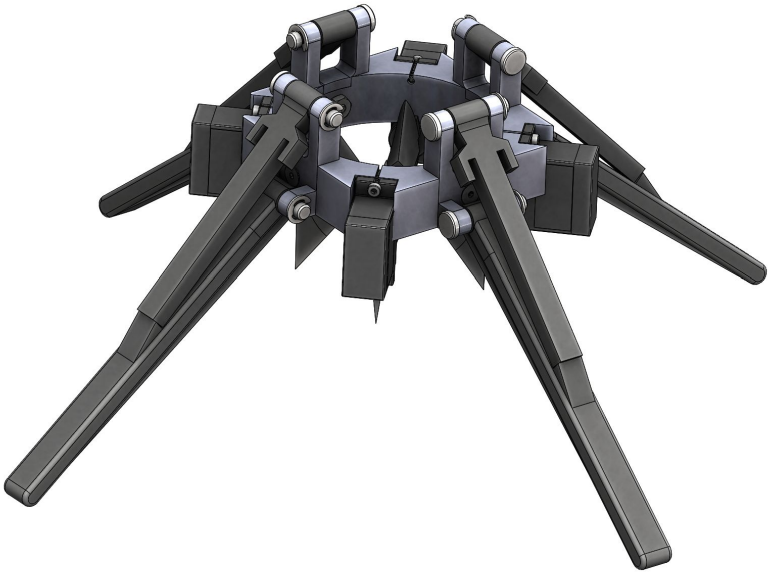
Tumble and wait for passive stability

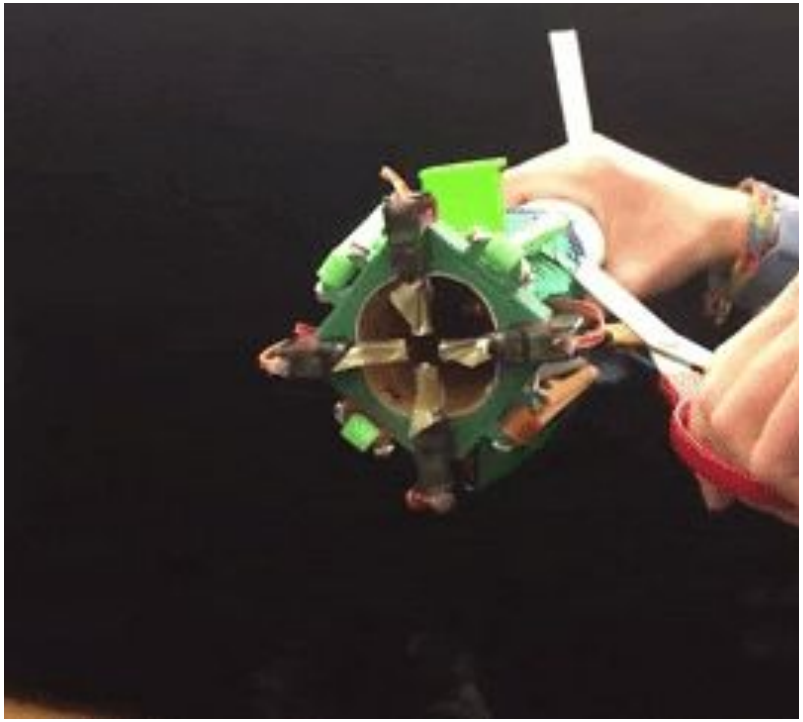
Landing Mechanism



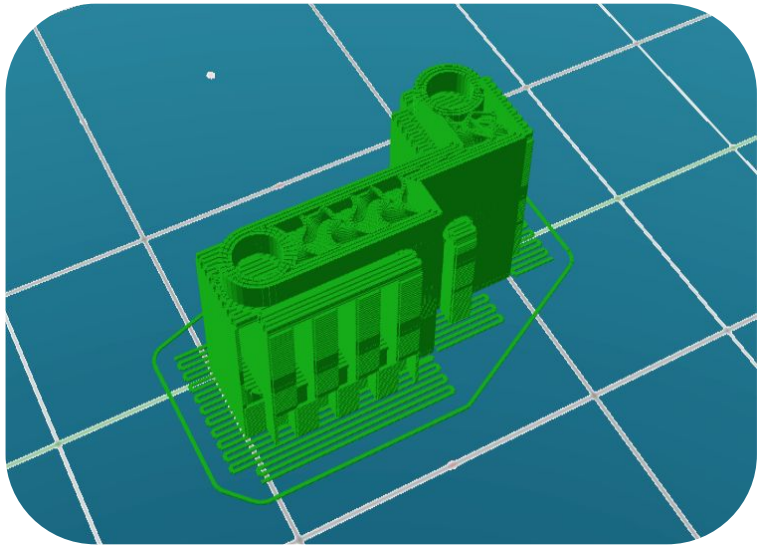


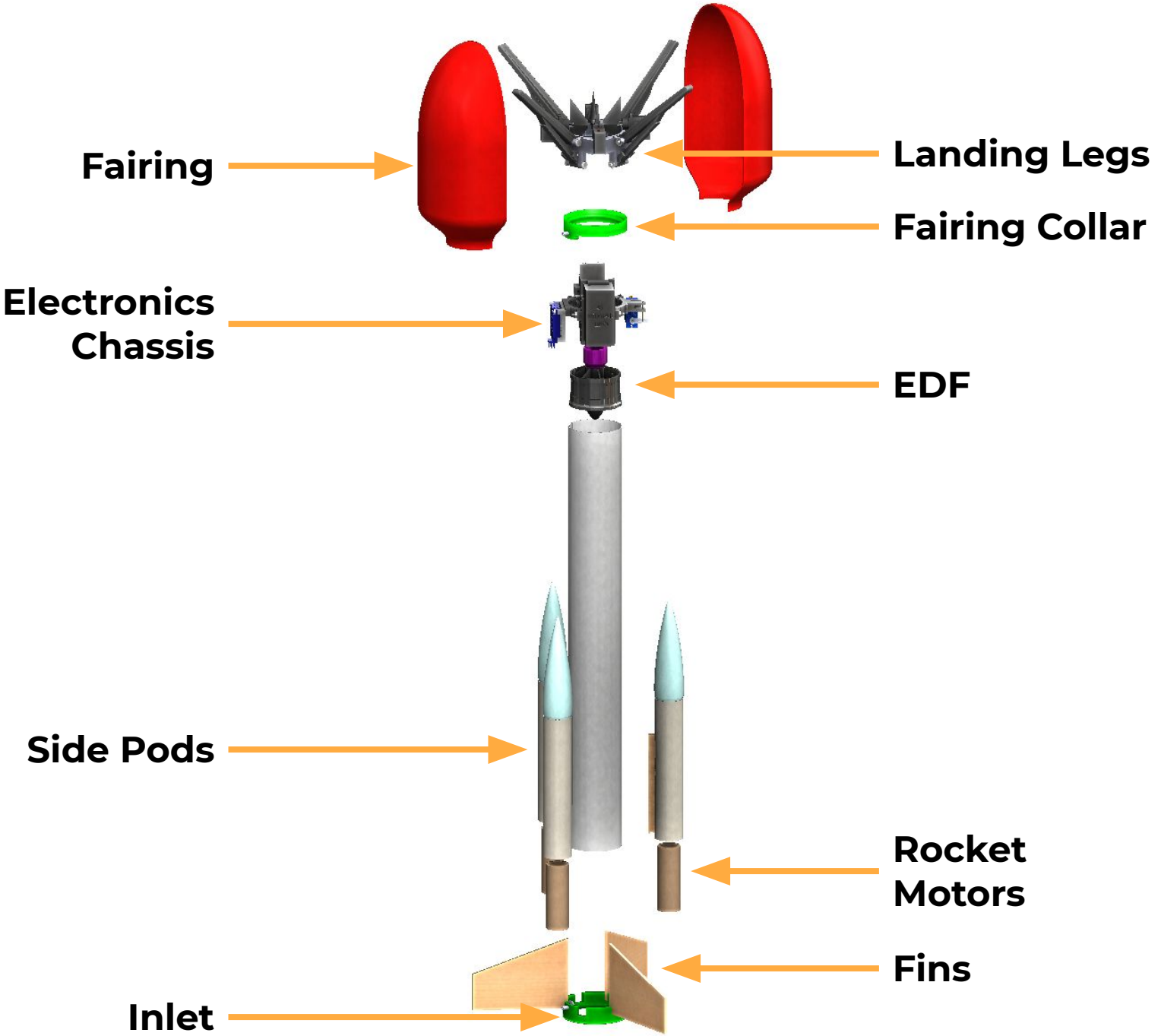
Landing Mechanism





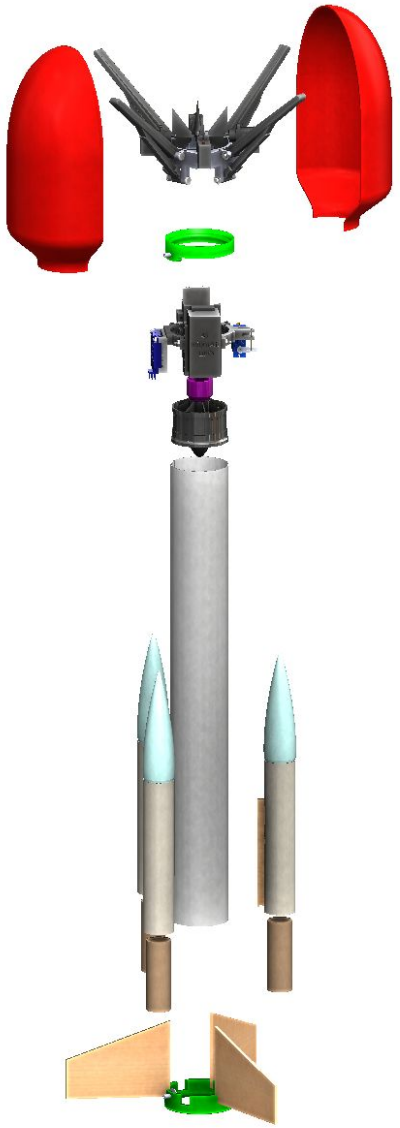
Landing Mechanism




Fairing
Landing Legs
Fairing Collar
Electronics Chassis
EDF
Side Pods
Rocket Motors
Fins
Inlet

Financial Plan

- Level 1 Kit
  - Fixed Cost: $120
  - Kit Price: $170
- Level 2 Kit:
  - Fixed Cost: $65
  - Kit Price: $120
- 1st year overhead - $24,000



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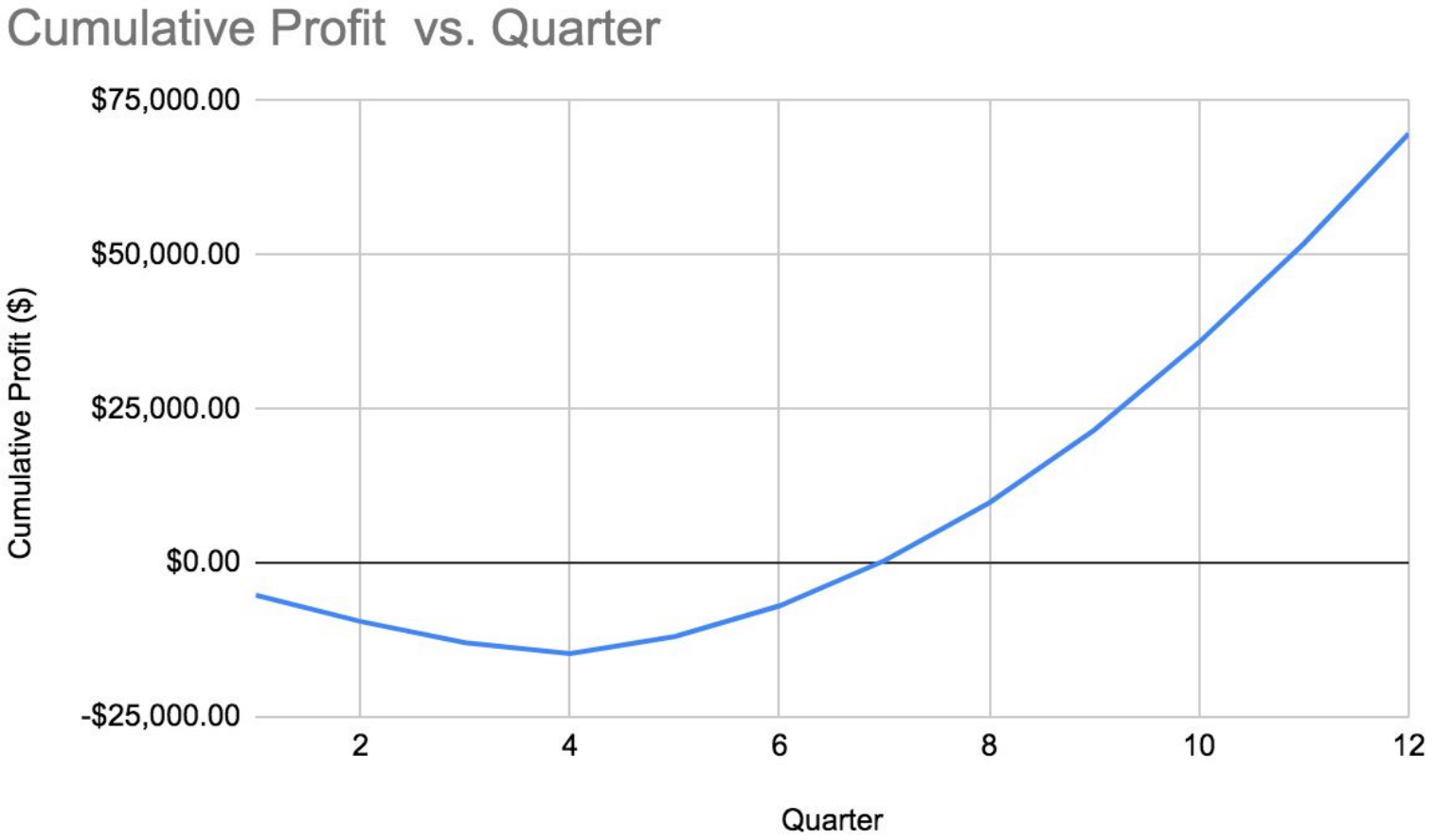


Goals

1. Refine an existing 56 mm VTVL concept rocket to achieve controlled landing
2. Develop TVC software, simulate and test (bench and field)
3. Design electronics package and create PCBs

4. Target BOM cost $100 (EDF, ESC, PCBs, LiPOs, IMU, controllers, sensors, servos)
5. Optional: Evaluate potential business models, open source licensing, kit pricing, supply sourcing

Deliverables

1. Development of a functional flight controller for a VTVL model rocket
2. Design files for all specific electronics/PCBs
3. Kit of parts BOM
4. Assembly documents/prints/media for a generic 56 mm airframe
5. Three camera video documentation of flight sequence (on ground, on rocket, in air)

6. Successful launch and controlled landing of a 56 mm VTVL prototype rocket

Onboard Camera

Ground Camera

Short Term Steps

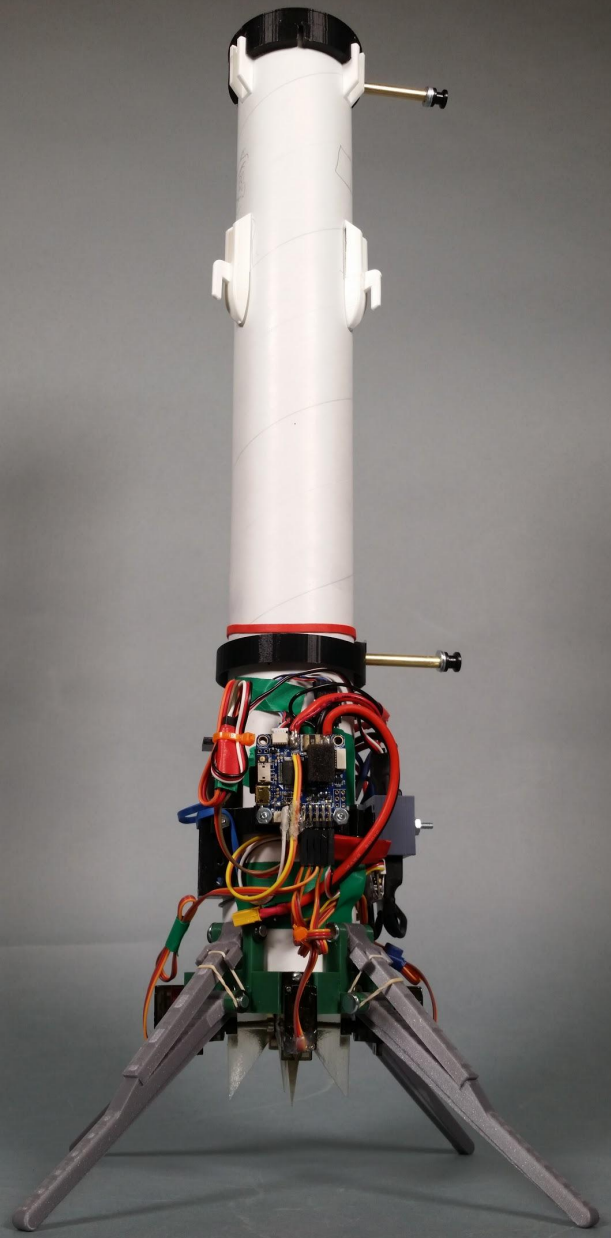
1. Improve vehicle transition system, in particular the fairing design
2. Ensure launch reliability

Long Term Steps

1. Address visible oscillations during descent
2. Address horizontal drift
3. Improve ease of assembly of the rocket
4. Make rocket easier for non-experts

VTVL

VTVL



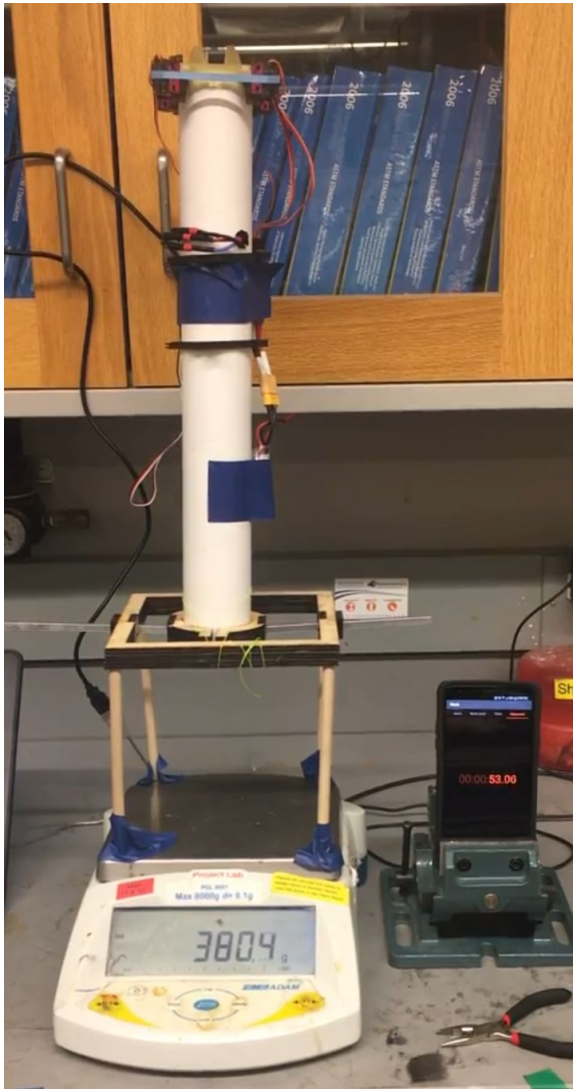
Onboard Camera

Ground Cam 2

Drone Camera

Ground Cam 1

Thrust and Power



Control Loops