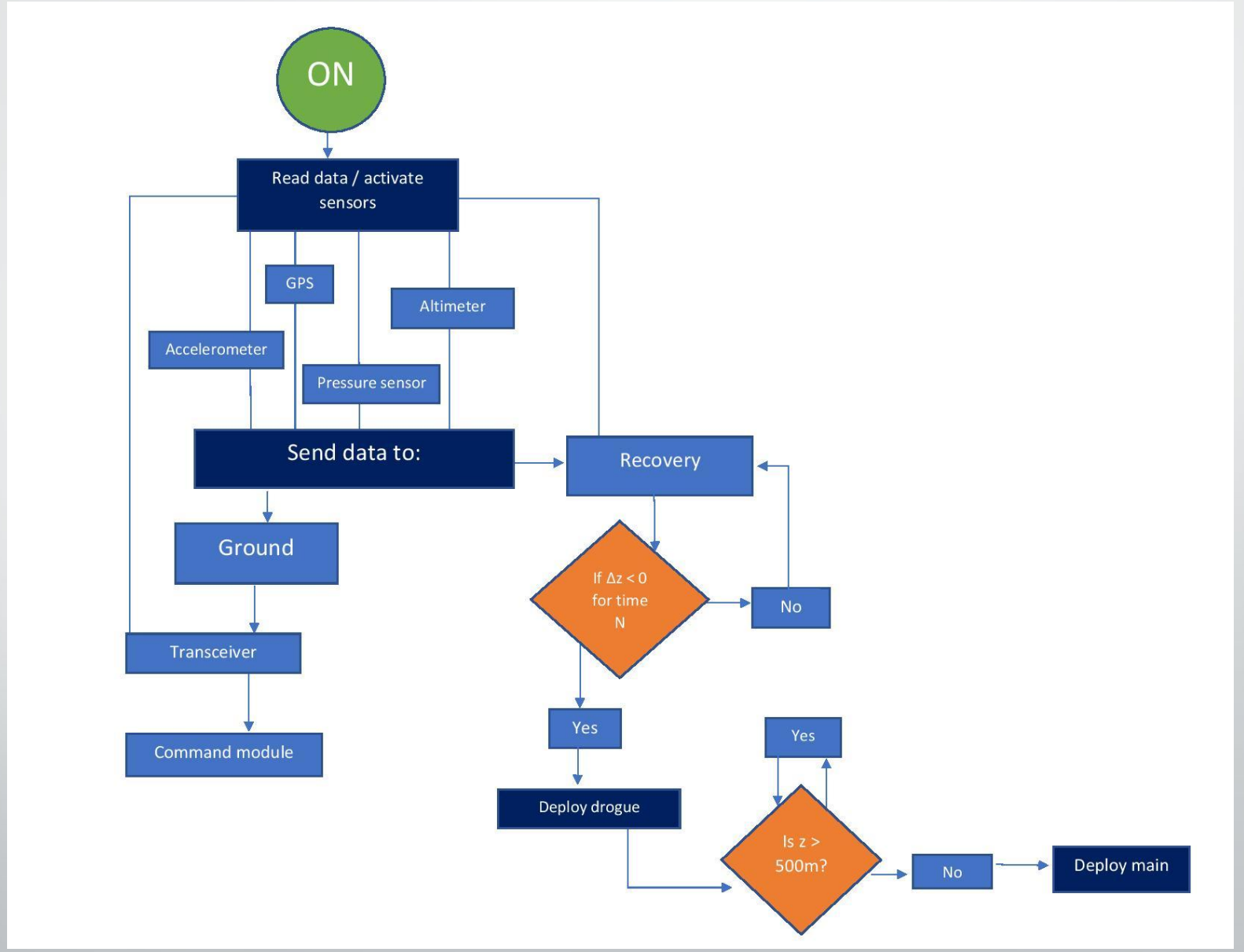
Presentation:

Reusable Stage Separation

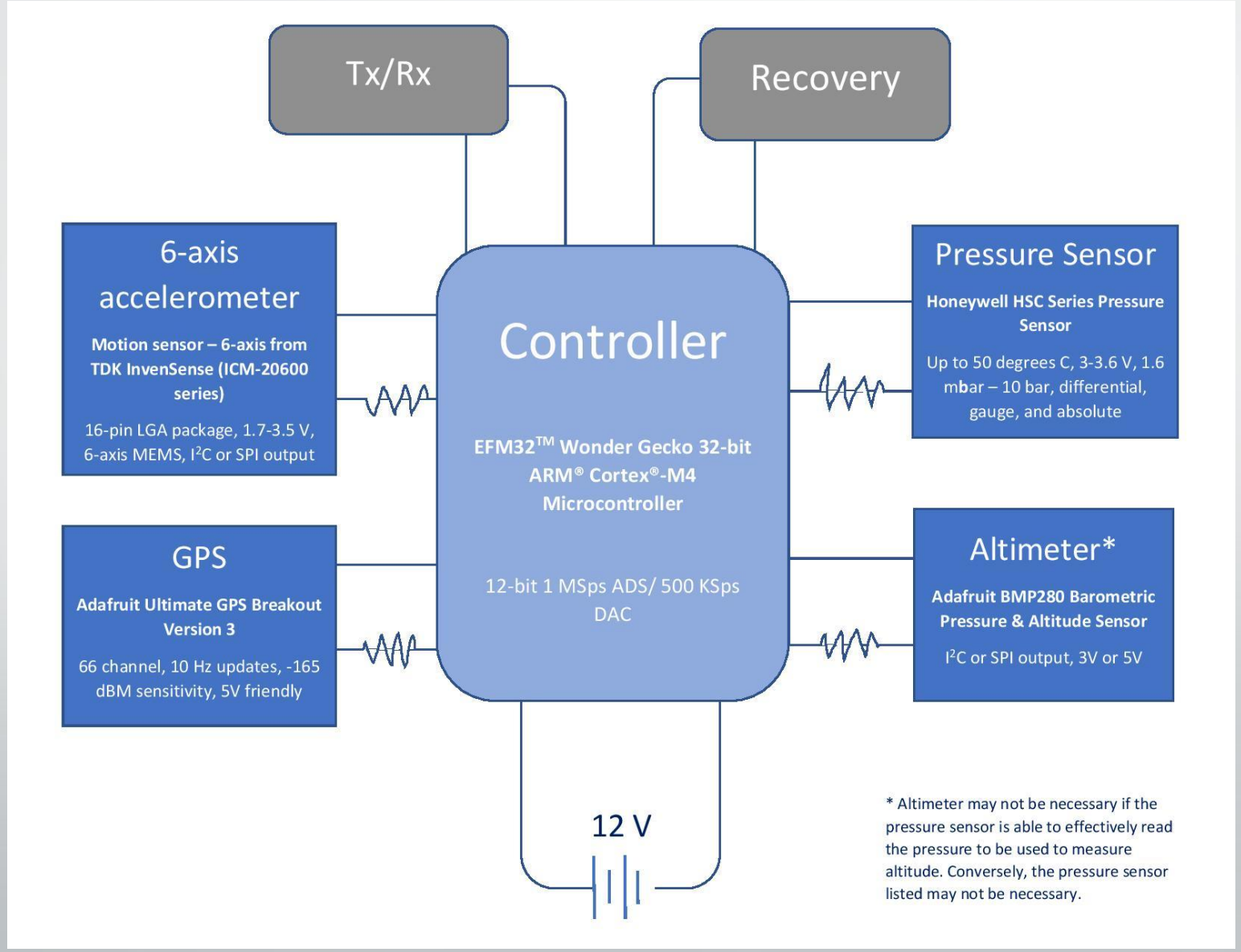
OTHER SUBSYSTEMS

Detail other subsystems affecting
the primary focus/innovation in the rocket (recovery)

Avionics Status Flow

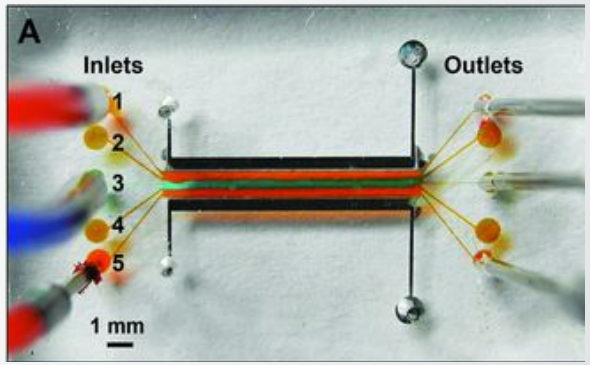


Avionics Control Module

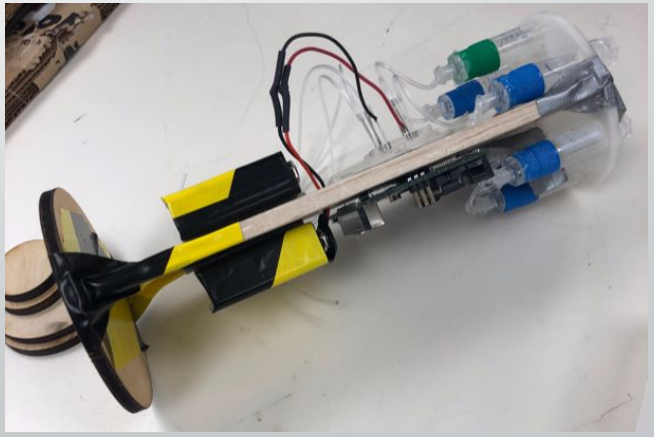


Payload

- Microgravity Experiment
- Simplifies monitoring/testing for the effects of space on the human body
- Separate proteins from plasma
- Capable of surviving extreme conditions



Microfluidics Device



Previous Payload Module

Carbon Fiber Structure

- Benefits of Carbon Fiber
  - High Strength/Weight Ratio
  - High Rigidity
  - Allows for any dimension body tube as it is produced in house
- Goals:
  - Streamline and expand carbon fiber capabilities for future years
    - Less costly than contracting someone else
    - Good learning experience

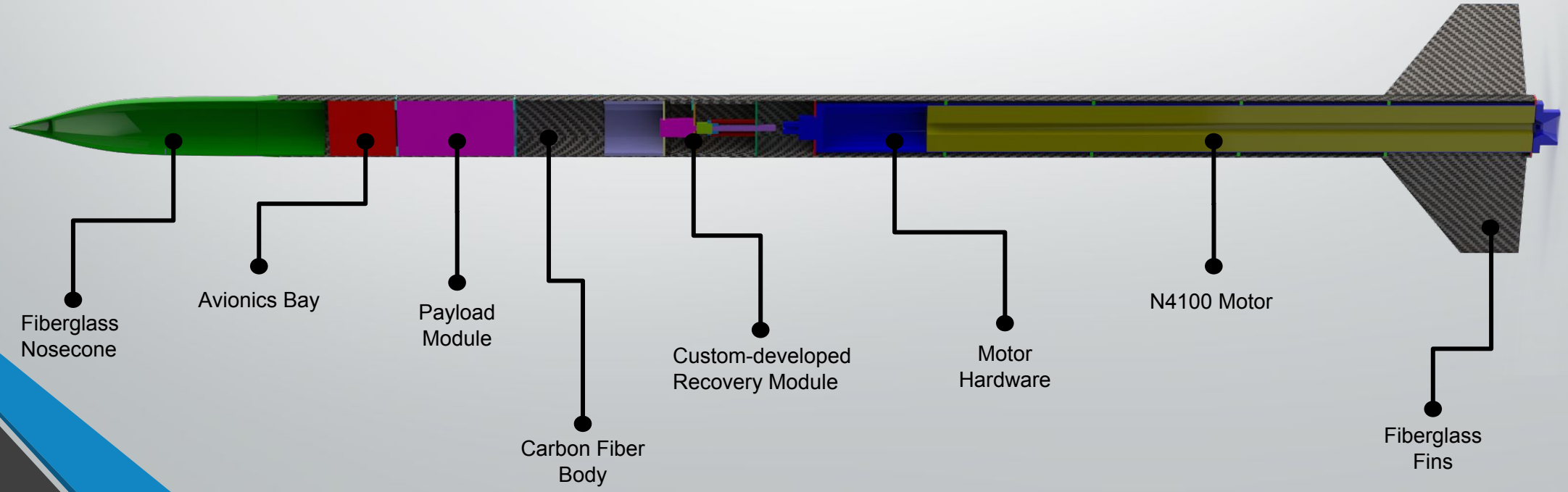
Concept

Traditional Stage Separation:

- Black powder
- Reliable
- Non-reusable

Non-Pyro Mechanism Requirements:

- Reliable
- Ease of reusability
- Fits with future vision

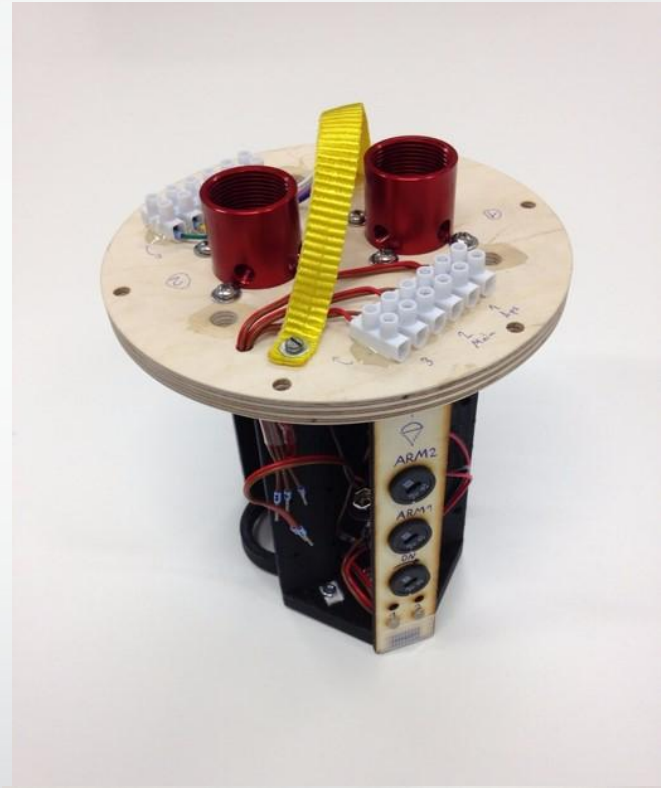


REUSABLE RECOVERY SYSTEM

Design and adaptation of reusable recovery system

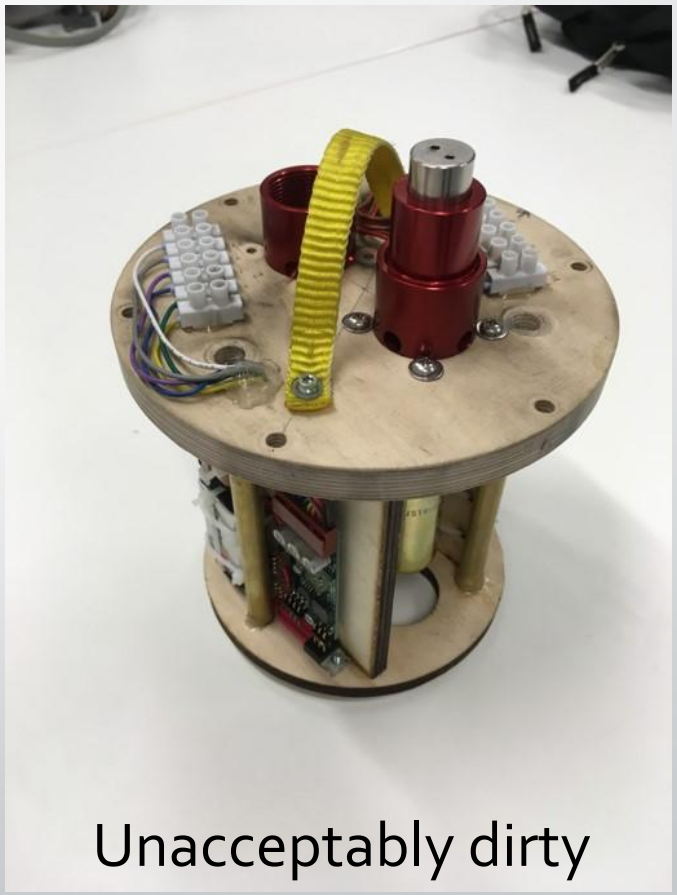
Initial Stage Separation Mechanism

- Gunpowder
  - Single use
  - Simplest design
  - Pyrotechnic event
- CO_2 canisters (right)
  - Single Use
  - Controllable
  - Modular build



Why Reusable?

After 1 use:



Unacceptably dirty

To prepare for next launch, would need to clean inside of rocket to ensure smooth operation/separation.

New Recovery Concepts Required

Brainstorm:

- Separation
  - EMF/Railgun deployment
  - Hydraulic Actuators
  - Linear Actuators
  - Screw-on
- Locking
  - Rotational motion
  - Translational motion
- Power
  - Capacitor Bank
  - Disposable Batteries (9V)
  - Lithium Ion Polymer Batteries

Second generation prototype for stage separation before it underwent testing

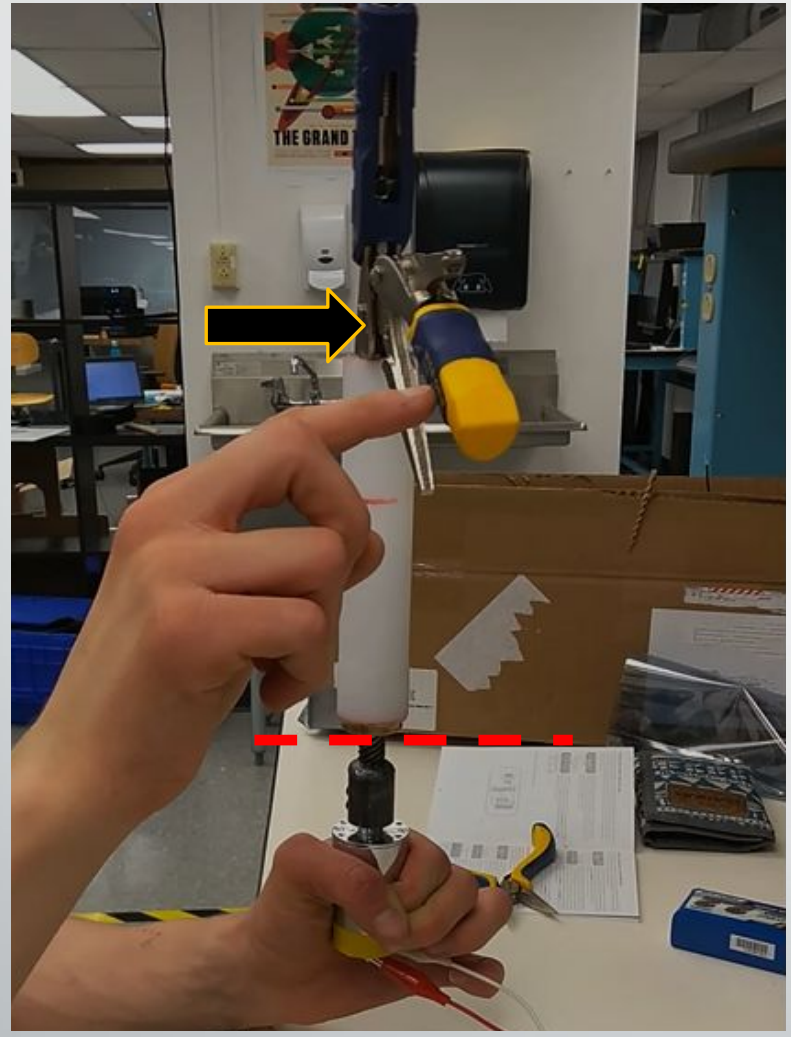
Reusable Stage Separation

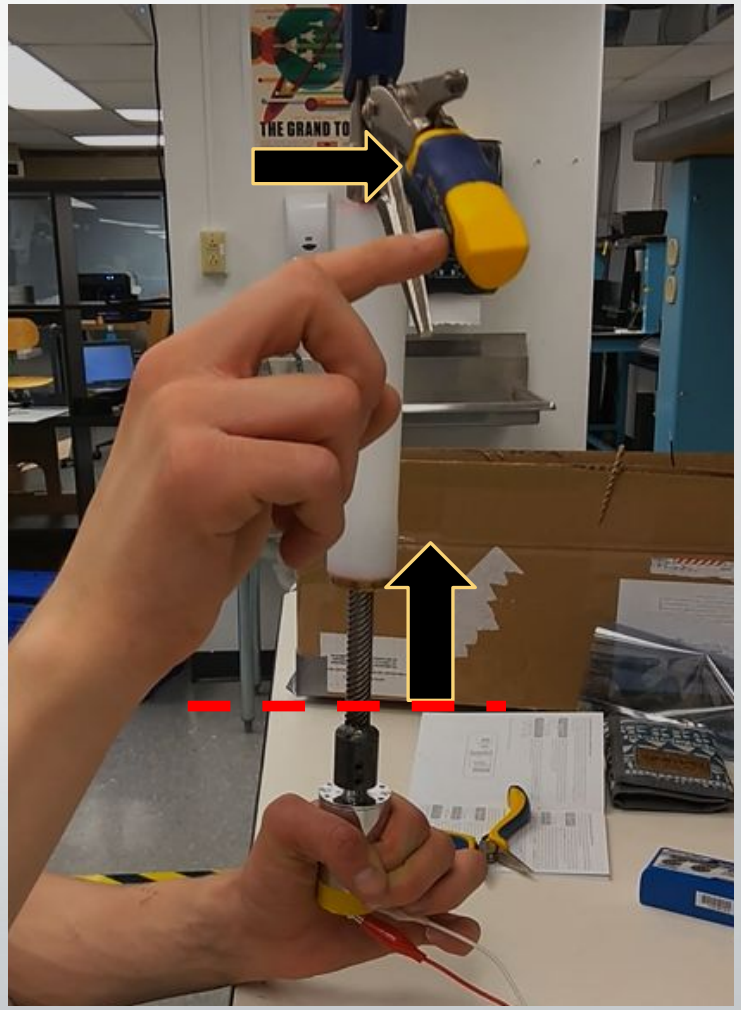
Project demonstrates:

- Iterative Design
- Design Analysis
- In-depth Development
- System Overview
- Rigorous Testing
- Integration

The core assembly of the stage separation module

Revised Reusable Stage Separation

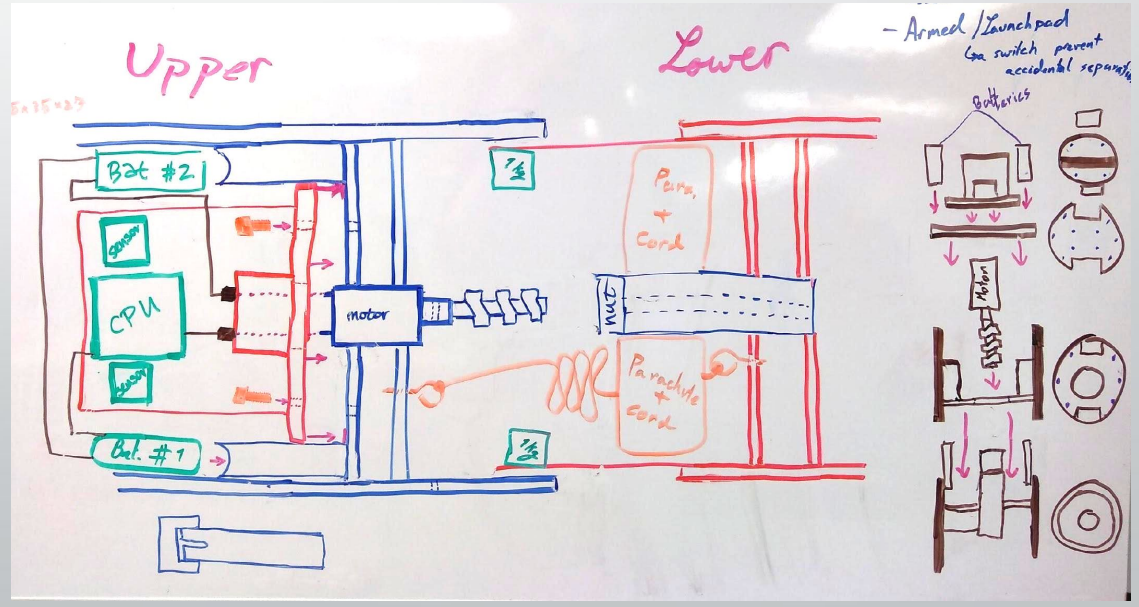




Full Video: https://youtu.be/E2N8dM2k_2A

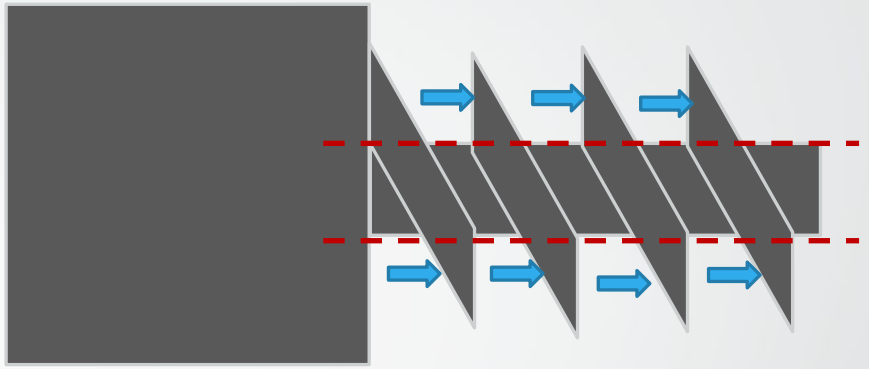
Revised Reusable Stage Separation Mechanism

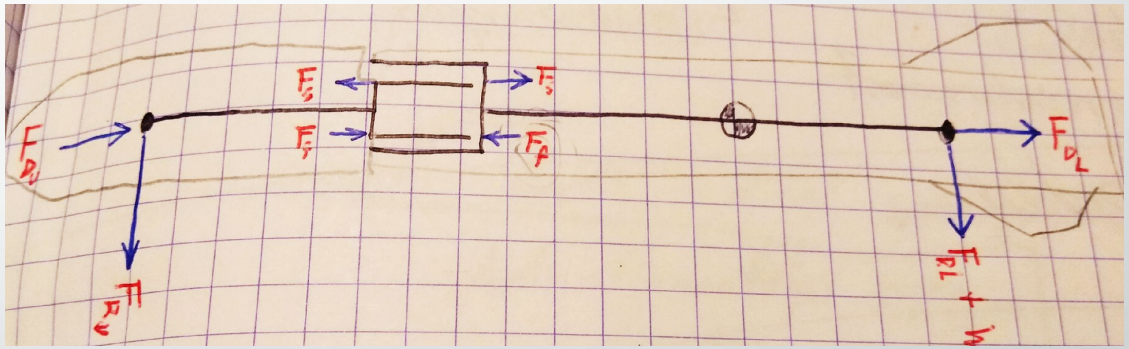
- Comprised of:
  - DC motor
  - ACME Screw
  - Adaptor
  - ACME Nut
  - 1” ID tubing
  - Base Plates



Stress Analysis

- Axial
  - Force distributed along acme screw teeth
    - Each tooth treated as separate entity
    - Determined stress required to shear a tooth
- Bending
  - Treated screw as a rod
    - Cantilever
  - Highly variable
    - Fluctuating conditions
    - Wrote script to calculate
    - Amassed a range of loads
  - Dictated by coupler tolerances
- Weld Area
  - Concentration
    - Assume simple column and flange
    - Large safety factor



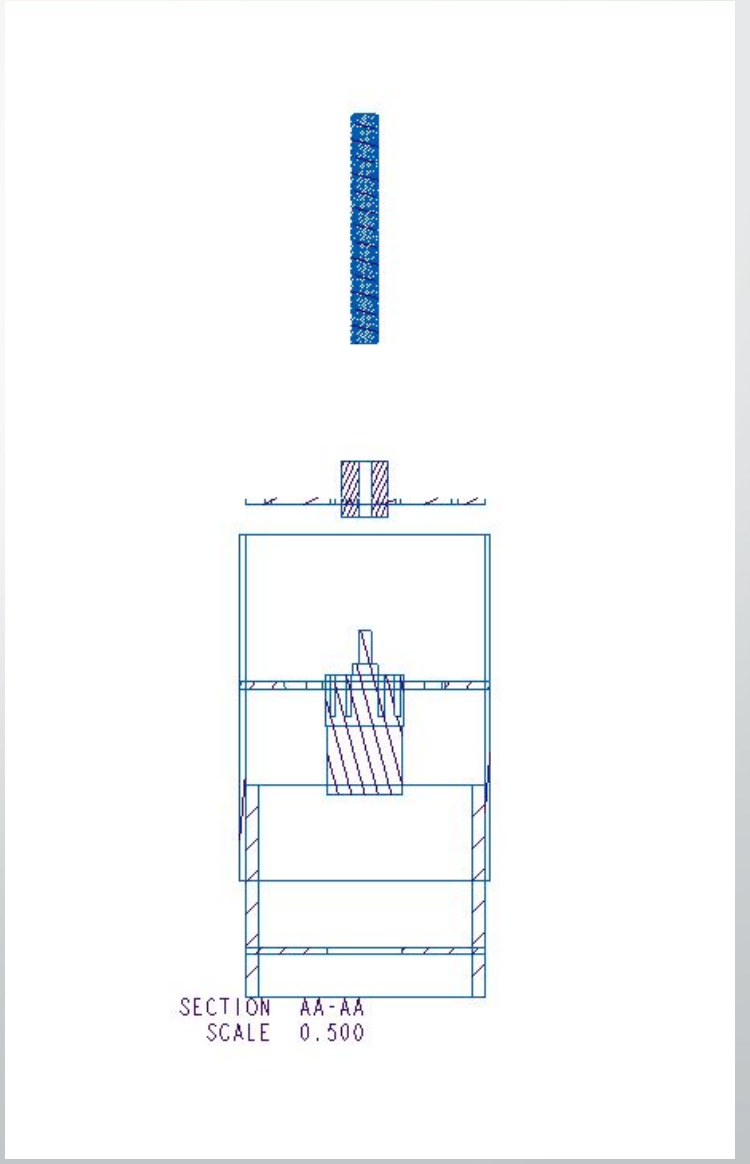


Manufacturing

- Specific component requirements
  - Defined from stress analyses
- Material Selection
  - Material Requirements
  - Available processes
  - Cost
- Machining
  - Tools
    - Lathe, welding, etc.
  - Tolerances
    - Individual parts
    - Assembly
  - Surface finish

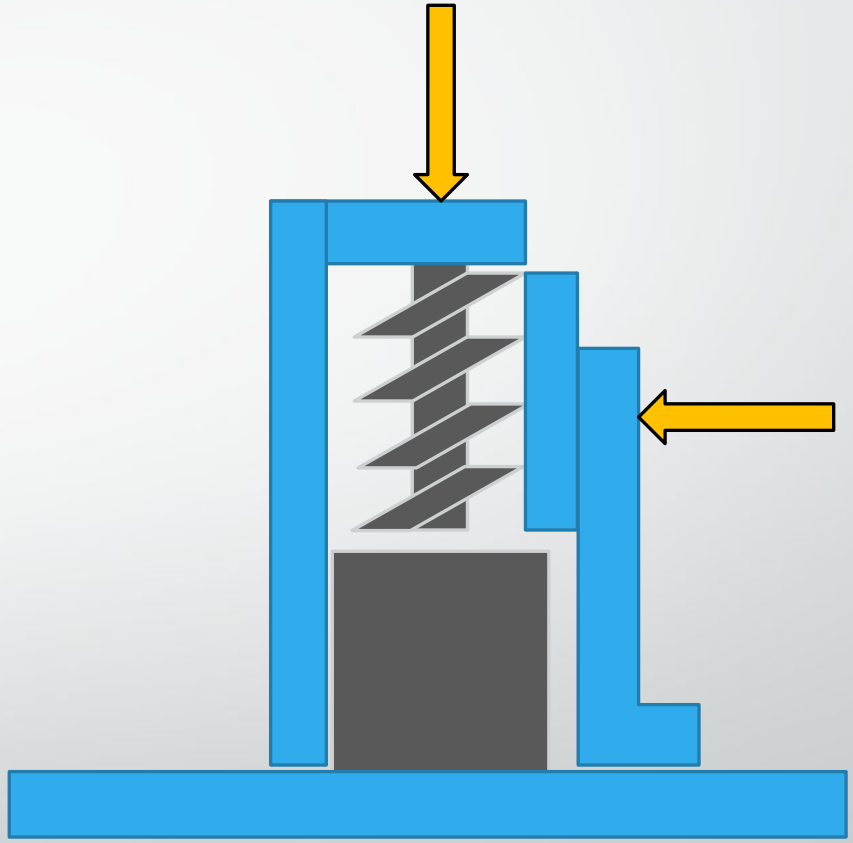
Testing Results

- Free
  - Requires a rotation lock to separate properly
- Loaded (16kg)
  - Motor stayed within expected range of conditions
    - Bending more concerning of two loading modes
    - Nutations induce bending
- Electronically controlled (via MOSFET)
  - DC Motor must be completely insulated
    - May arc across metal casing
  - Determine limitations of each motor
    - Speed vs. force required
  - Expected electro-mechanical loads matched measurements
- Ejection/Separation
  - No spring needed
  - Parachute Folding
    - Traditional method too cumbersome
    - Developed, tested new parachute folding method



Future Vision and Improvements

- Vertical Alignments
  - Aligning all components to be perfectly vertical
    - Decreases nutations, increased maximum load
    - Load tolerances significantly improve
- Design Change
  - Decrease
    - lead screw length
    - DC motor Size
  - Several motors to distribute loads
- Modularize Design
  - Easily assembled, standardize
  - Standardize Reusable stage separation



Future welding rig setup

Questions?

ASTROJAYS
ROCKETRY TEAM