UC Berkeley Space Technologies and Rocketry
Flight Readiness Review Presentation

01

Airframe

Propulsion

Recovery

Payload

Safety

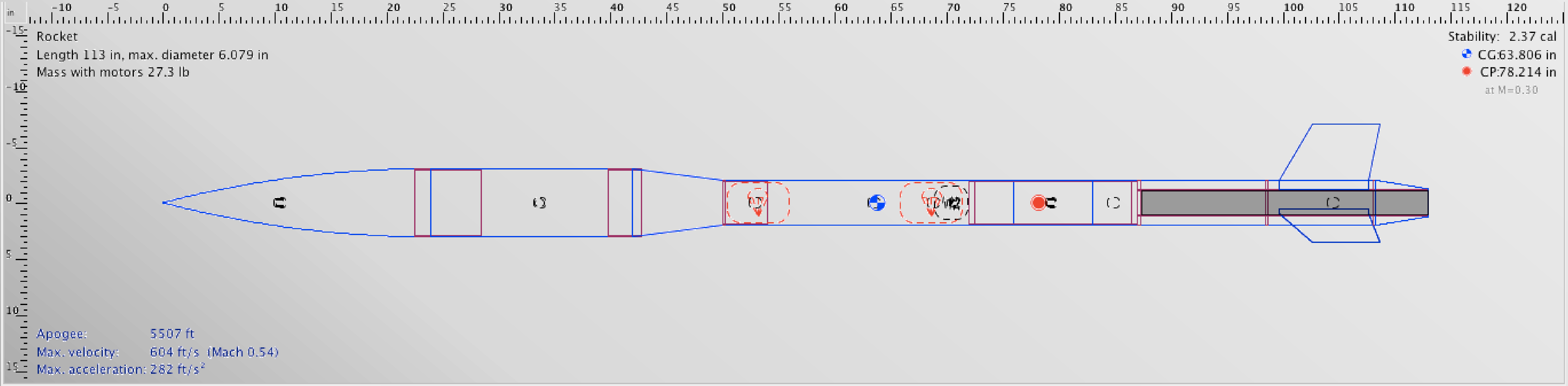
Outreach

Airframe Macros

Simulated Macros:

Apogee: 5507 ft **Max. Vel**: Mach 0.54 **Max Accel**: 8.75 g

Stability: 2.37 **Length:** 9.42 ft **Weight (wet):** 27.31 lb.



Airframe Design

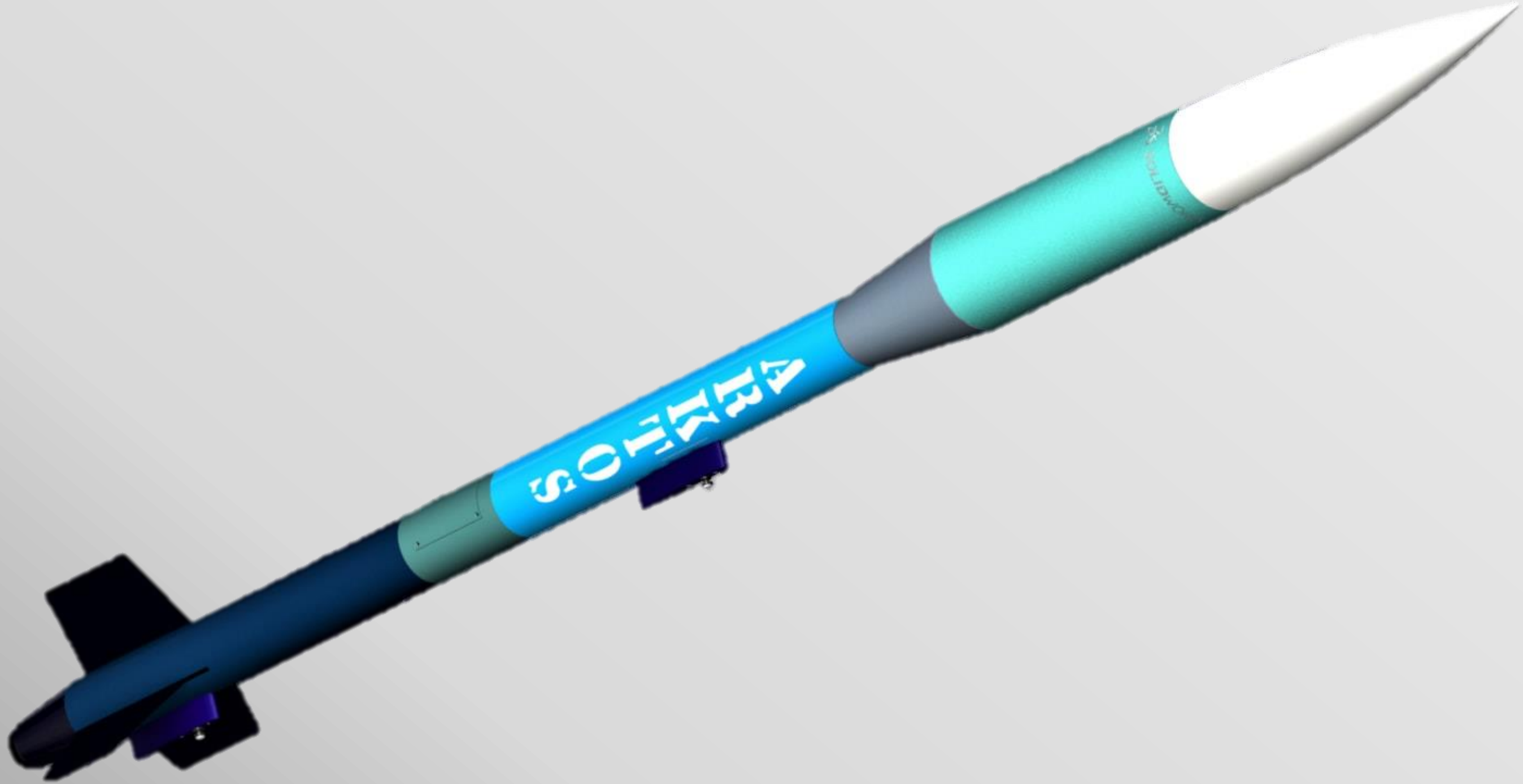
- Weights (Wet Total: 27.31 lbs. Dry Total: 22.38 lbs.)
  - Electrical - 2 lbs. (allocated) Nose Cone
  - Payload - 6 lbs. (allocated) Payload Tube
  - Recovery -
    - Recovery Tube
      - 0.811 lbs. Main Parachute
      - 0.134 lbs. Drogue Parachute
      - 0.623 lbs. Shock Cord
      - + ~ ⅓ lb. misc
    - Booster +
      - 2 lbs Avionics
  - Propulsion - 4.9 lbs. (Wet only) Booster Section
  - Airframe - Rest of the weight, throughout the launch vehicle

Airframe Design

- Lengths (Total: 9.42 ft)
  - Nose Cone - 24 in. (4:1 Length:Diameter)
    - Payload/Electronics can use
  - Payload Tube - 18 in.
  - Payload - Transition Coupler - 3 in.
  - Transition - 8 in.
    - 6 - 4 in. change.
  - Transition - Recovery coupler - 4 in.
  - Recovery Tube - 26 in.
  - Recovery - Av Bay Coupler - 15 in. (Runs through the entire Av Bay tube)
  - Av Bay Tube - 7 in.
  - Booster - 26 in.
  - Boat Tail - 4.7 in.

Airframe Renders

Airframe Renders



Airframe Test Plans

- The only non-flight proven components of the rocket were the transition piece and boattail
- Crash landing from Feb 3rd test flight serves to verify robustness of both parts in place of the previously designed formal test

Airframe Integration

- Integration issues from Feb. 3 test flight
  - Non blue tube coupler fits were too tight:
    - The nose cone shoulder and transition couplers were sanded
  - Launch Standoffs and their tubes had to be aligned:
    - Alignment was done with a spare piece of 1515 rail prior to launch
  - Ejection’s scissor lift centering ring was not level:
    - A spacer was laser cut and epoxied to correct the error
  - Ejection’s payload posts were not long enough to keep the scissor lift stable:
    - They were redesigned and will be integrated into the Arktos rebuild

Airframe Manufacturing

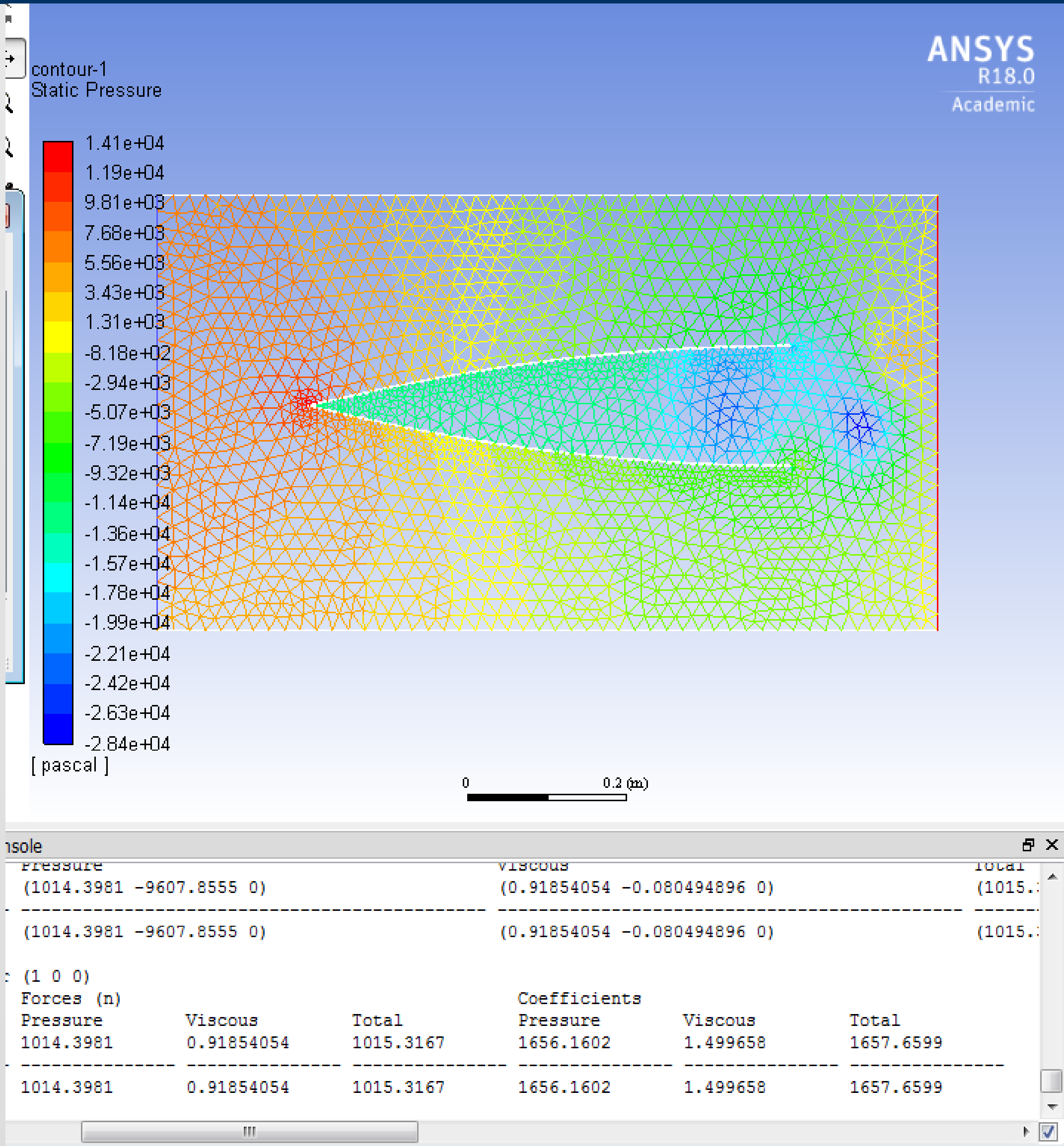
- Transition Piece
  - 3D Printed with PETG
  - Reinforced with fiberglass
    - 8 strips of 1.5” width and 15” long
    - Layup with West System Epoxy
- Boat Tail
  - 3D Printed with PETG
  - No fiberglass reinforcement needed
    - Non structural component
    - Low thermal exposure

Airframe Simulation

- Software
  - ANSYS Fluent
  - OpenRocket

- Goals
  - Accurately simulate pressure and drag on rocket components
  - Use data to predict flights
  - Optimize rocket cost and design by simulating parts before manufacture

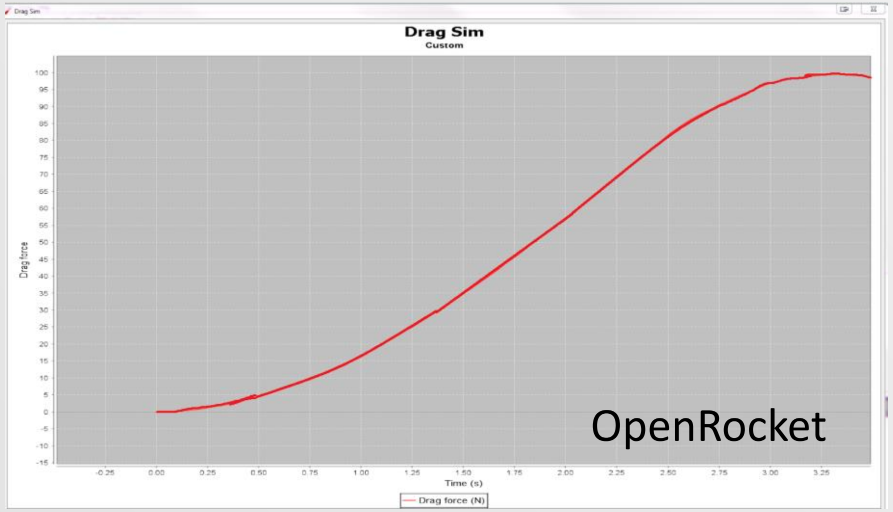
- The simulation pictured here was a test of pressure and drag across our tangent ogive nose cone.

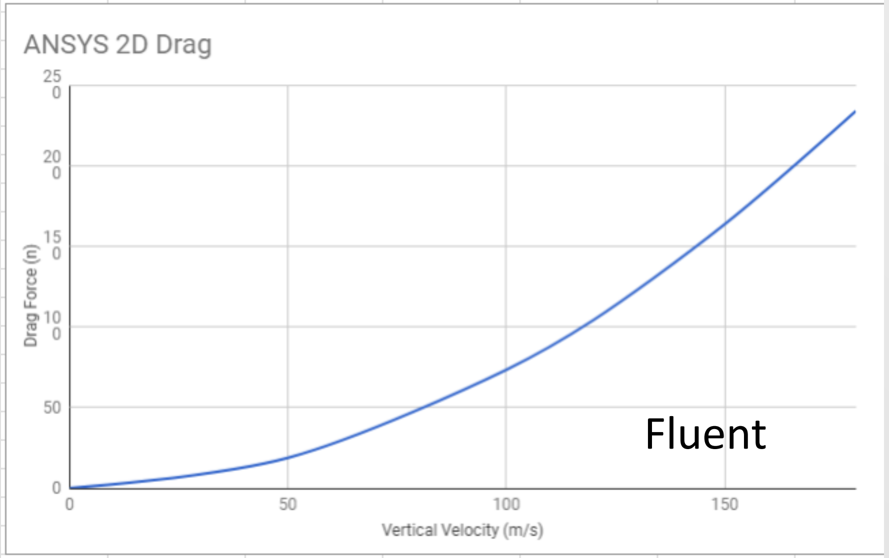


Airframe Simulation

- Goals that we have accomplished
  - Apogee prediction
  - Drag prediction
  - Stress Analysis

- The simulations pictured here are our comparison of OpenRocket and Fluent's drag analyses. We used OpenRocket to get drag vs time and Fluent to get a graph of drag at specific vertical velocities. By comparing data across multiple simulations, we hope to get a better understanding of our rocket's aerodynamics.





02

Propulsion

Recovery

Payload

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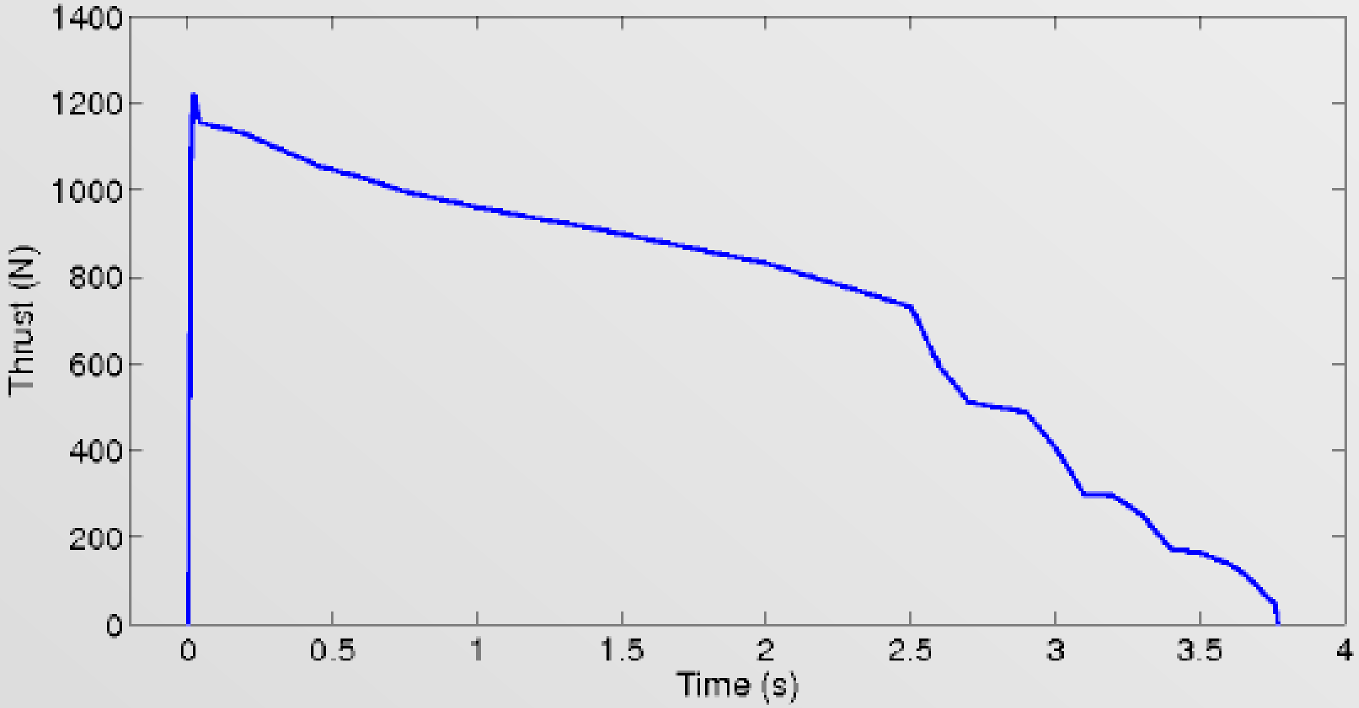
Outreach

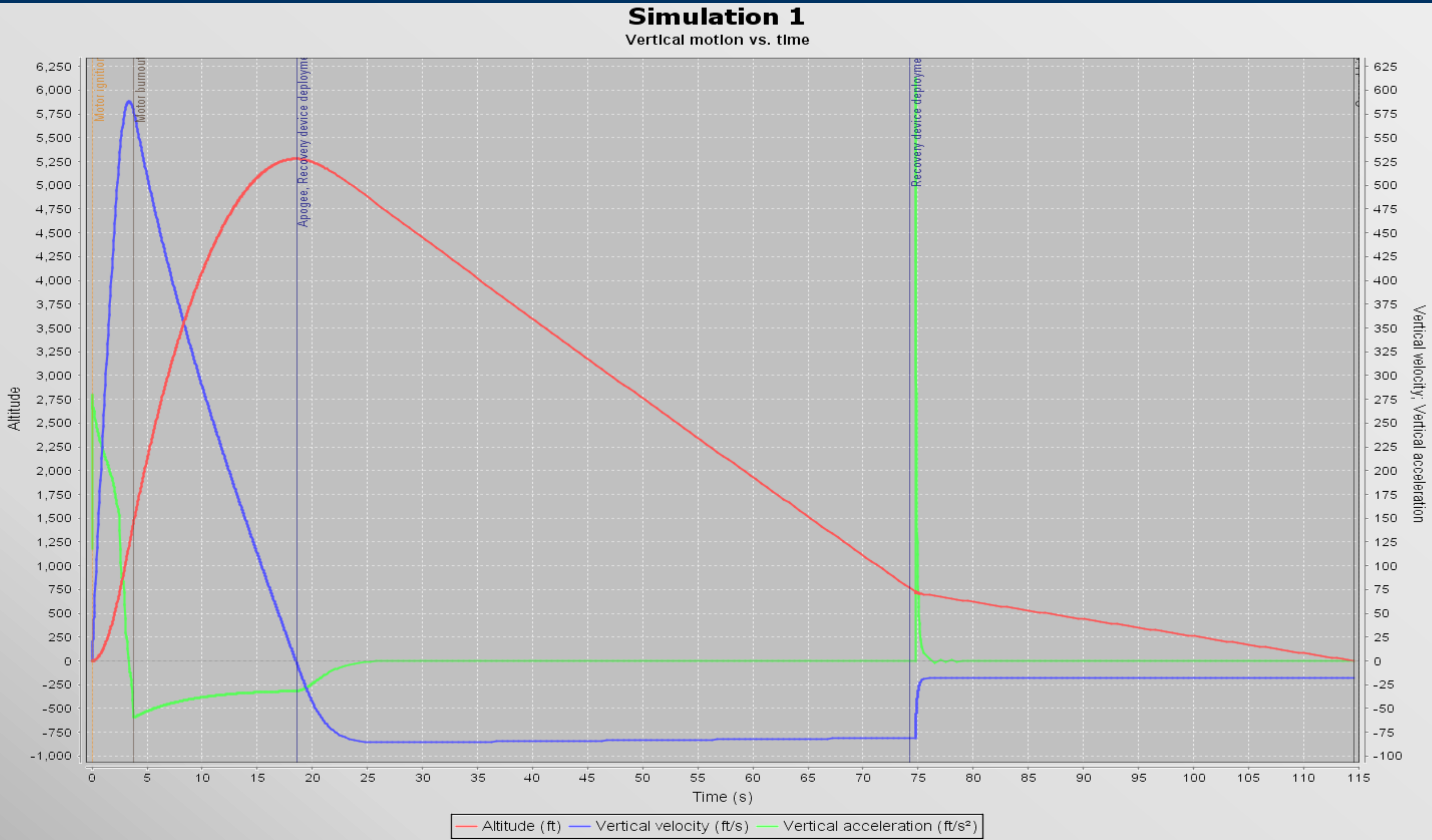
Project Plan

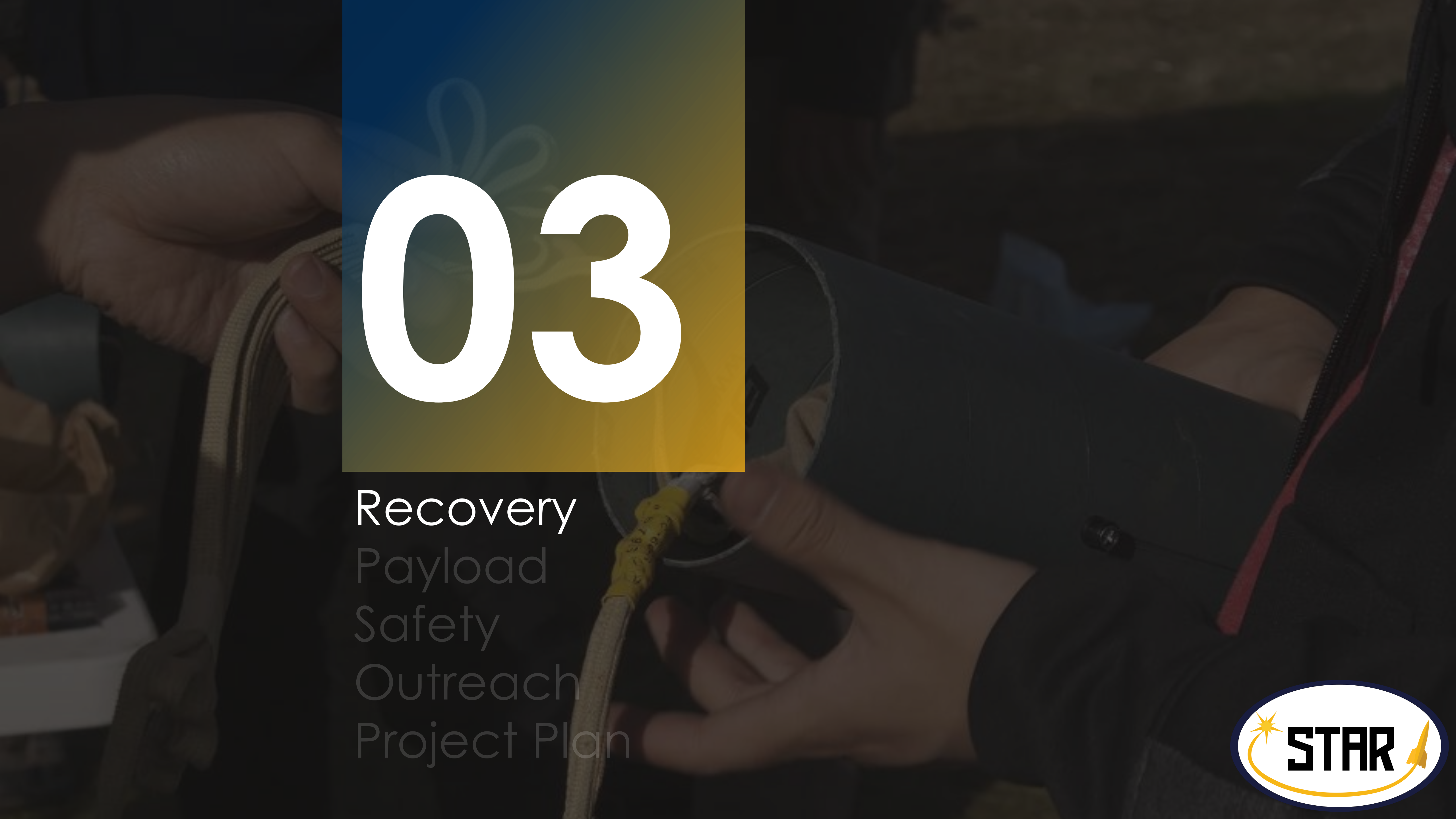
Motor Choice

- Final motor choice
  - Cesaroni L730
  - ~6 avg thrust to weight ratio



Flight Curve

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Recovery
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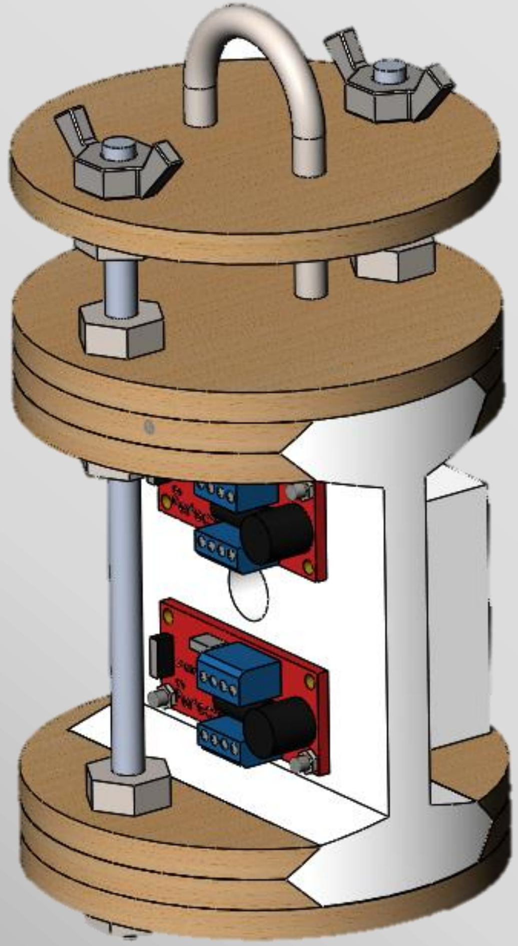
STAR

Avionics Bay and Deployment System



Recovery Specs

<u>Parachute Sizes</u>

Drogue Chute: 12” Elliptical parachute from Fruity Chutes; the red and white one

Main Chute: 72” Toroidal parachute from Fruity Chutes; the orange and black one

<u>Kinetic Energy Estimates</u>

After Drogue:

- Nosecone - 733ft-lbs
- Booster - 700ft-lbs

After Main:

- Nosecone - 54.51ft-lbs
- Booster - 52.01ft-lbs

Recovery Specs

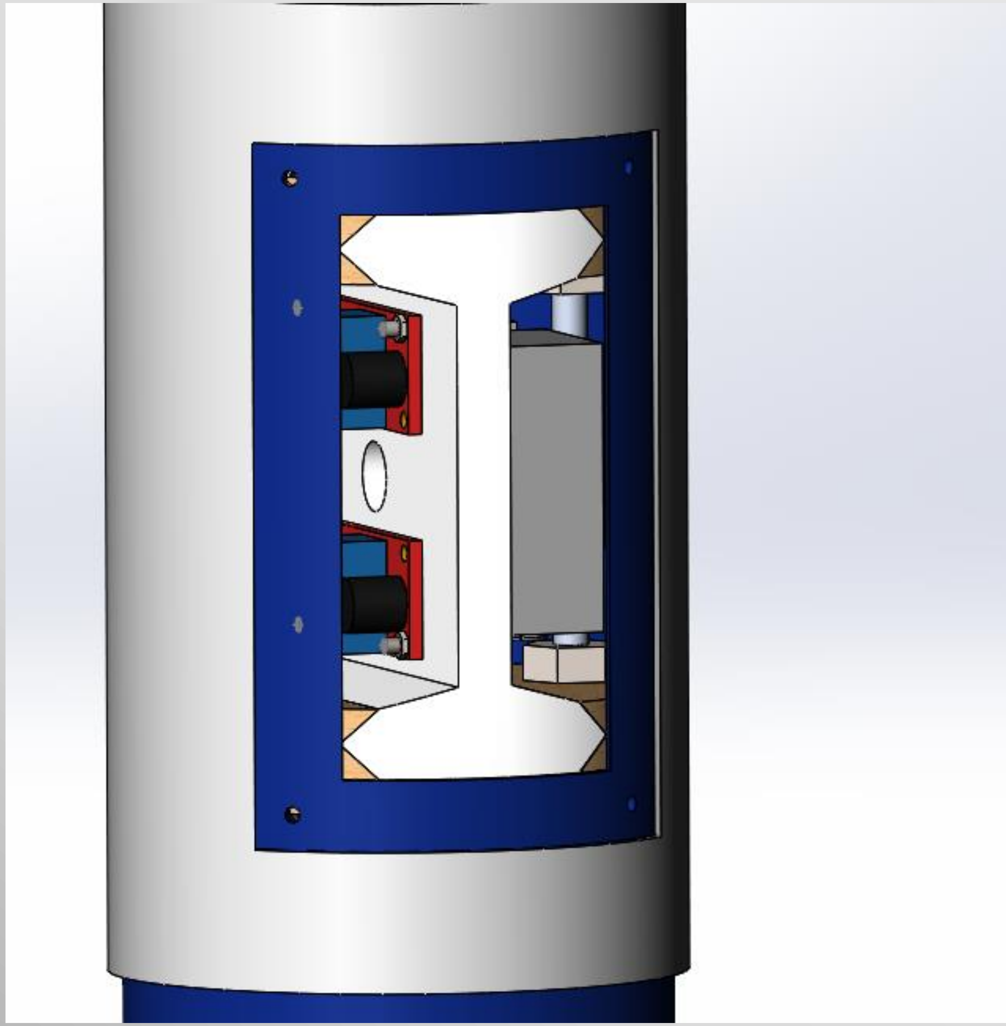
<u>Velocity Estimates</u>
At drogue deployment: 0ft/s
At main deployment: 130.27ft/s
Terminal after main: 17.76ft/s

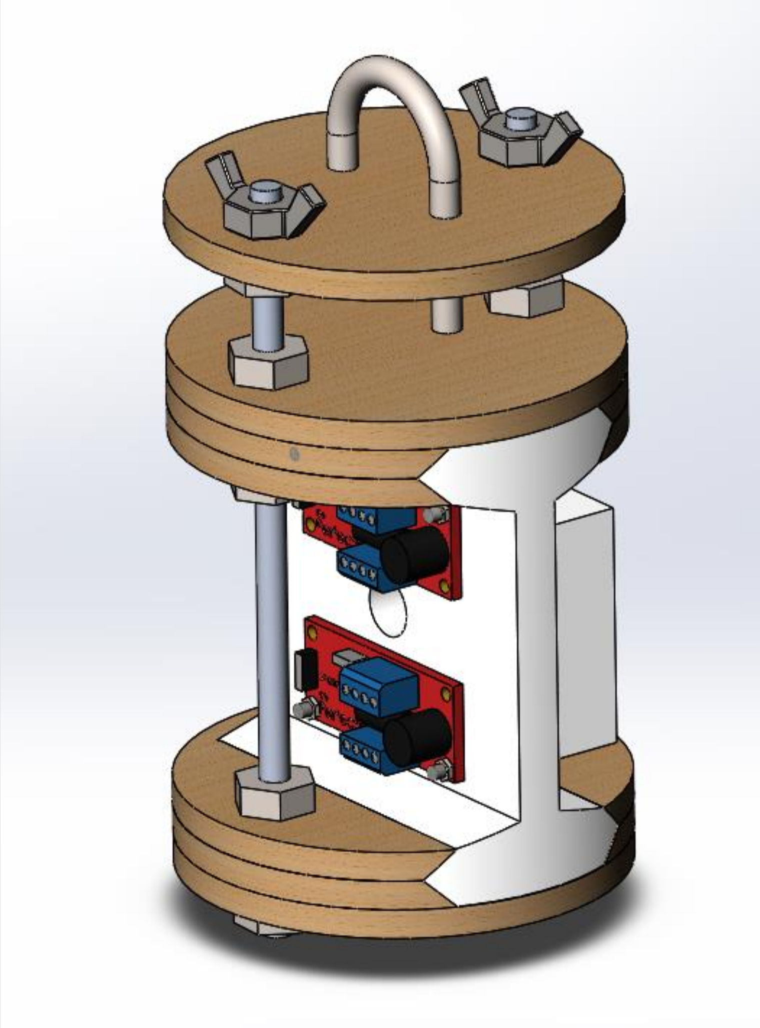
<u>Deployment System</u>
Dual Side Dual Deployment
Black Powder

Recovery Sled Design

Design focus on accessibility and compactness
Went through several iterations
Altimeters and batteries mounted on either side
Houses 2 PerfectFlite Stratologger CFs & 2 9V batteries
Sled slot fits into pre-cut rails in bulkhead
Made of 3D printed plastic

Airframe Integration





Recovery Deployment

- No longer using single side dual deployment
  - Opted for dual side, dual deployment due to space issues
- Black Powder Ejection Charges w/ e-matches
- Redundancy

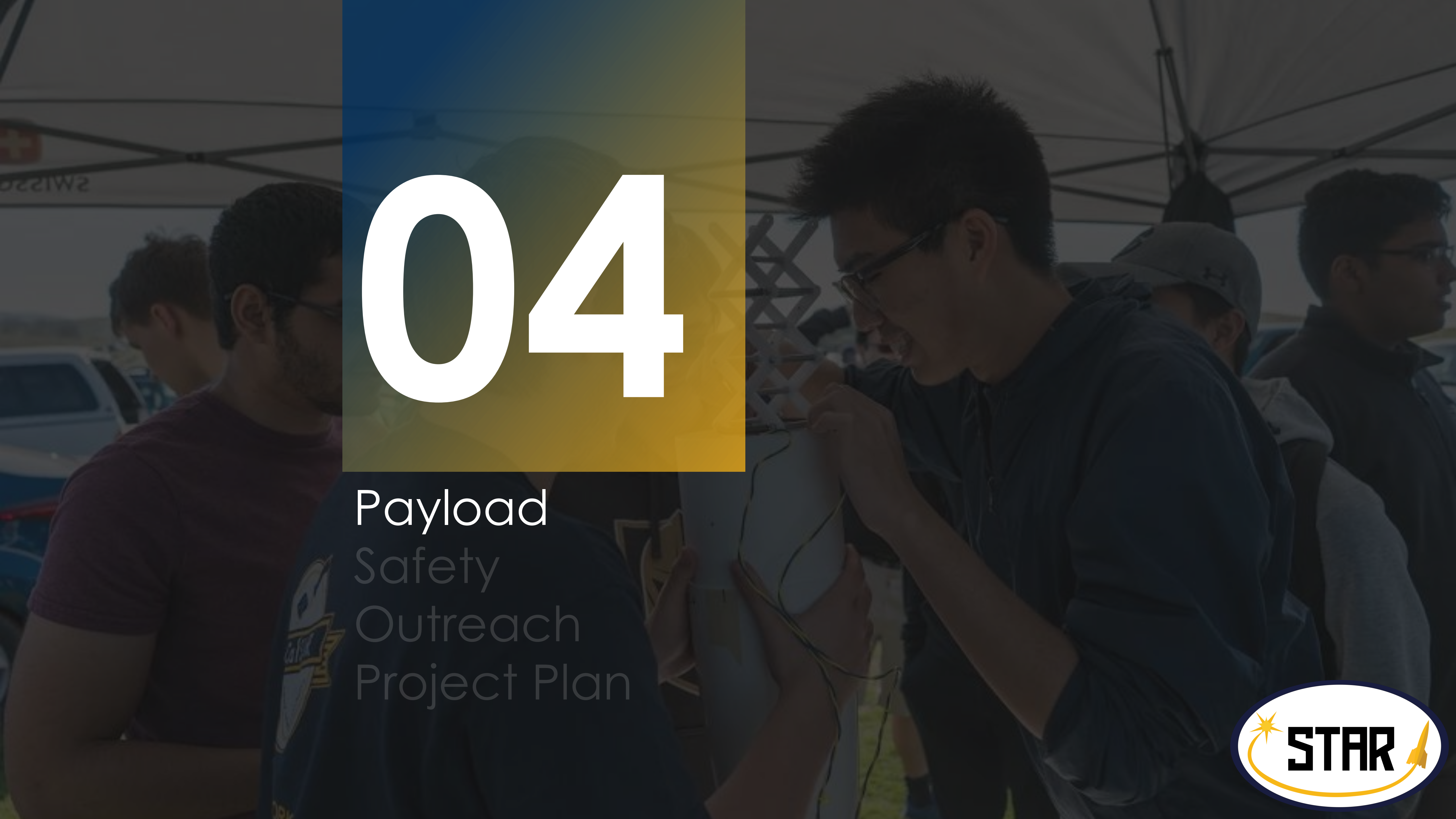
Recovery Drift Calculations

Current descent time: 117s

Wind Speed (mph)	Drift (ft)
5	609
10	1217
15	1826
20	2435

Recovery Tests

- Static Load Test
- Ground Deployment Test
- Electronics Test
  - To verify Handbook Req. 2.10



04

Payload

Safety

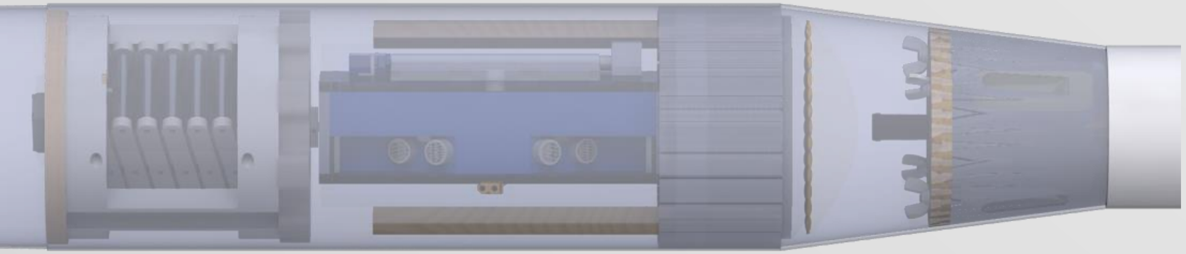
Outreach

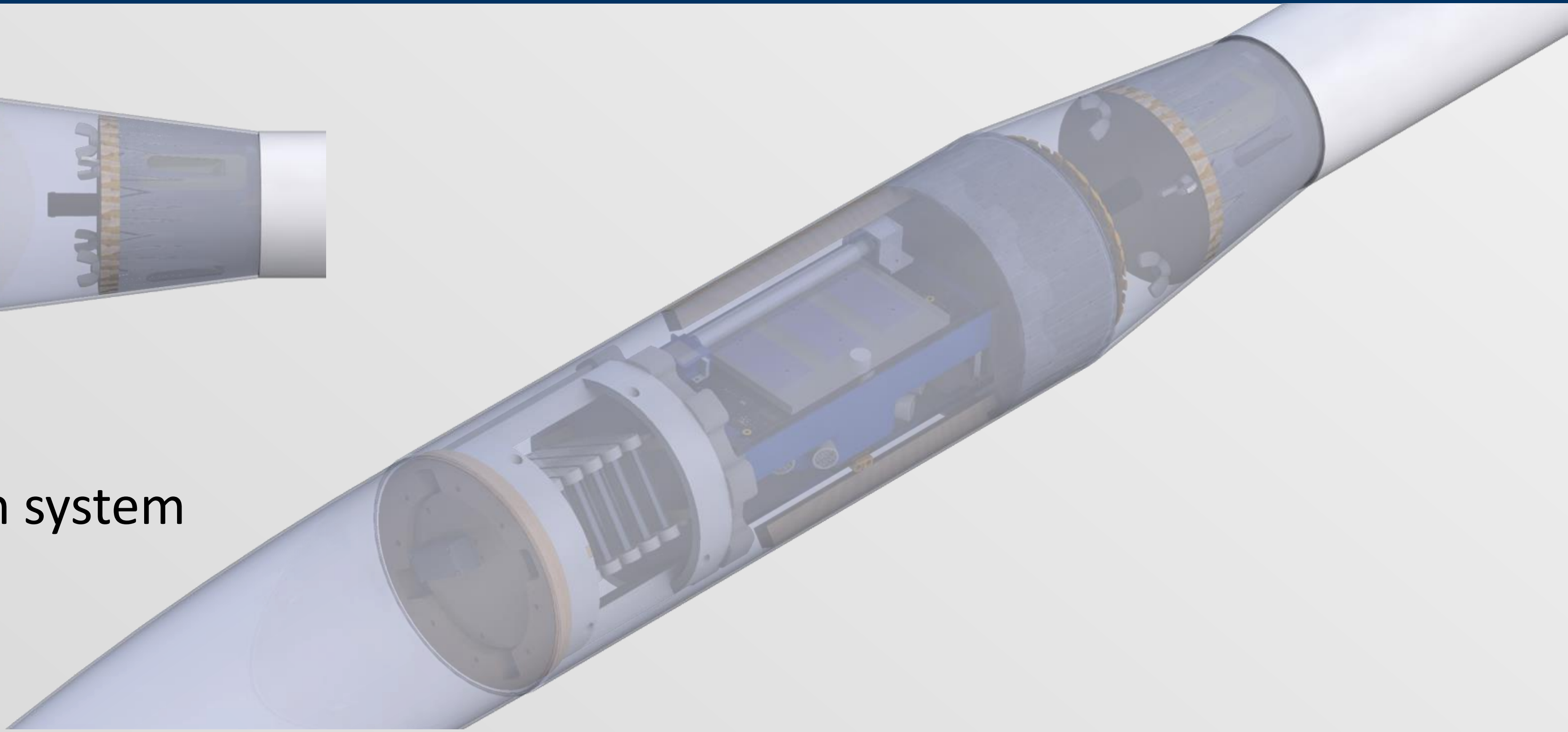
Project Plan

Payload Overview

- After vehicle lands, airframe is separated by a radio-triggered gas expansion deployment system (black powder)
- Rover is pushed out of airframe by a scissor-lift ejection system
- Rover detects ejection and drives away from airframe
  - Distance verification using encoders + inertial measurement unit (accelerometer + gyroscope) data

Payload Overview

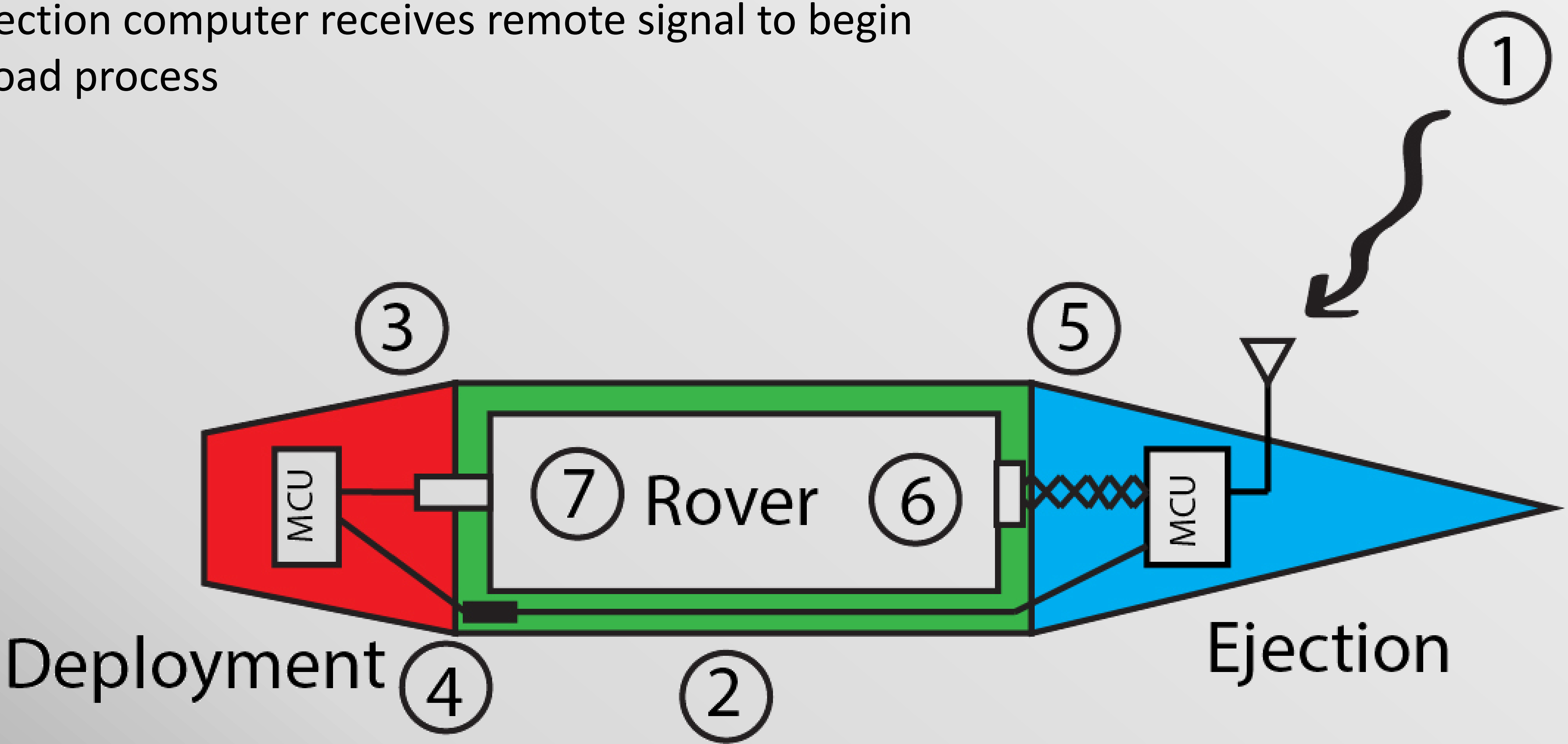




- Deployment
  - Black powder separation system
- Ejection
  - Scissor lift shove-out
- Movement
  - Rectangular two-wheeled rover capable of obstacle avoidance and traversing rough terrain
- Solar
  - Deployment system and panel functionality verification

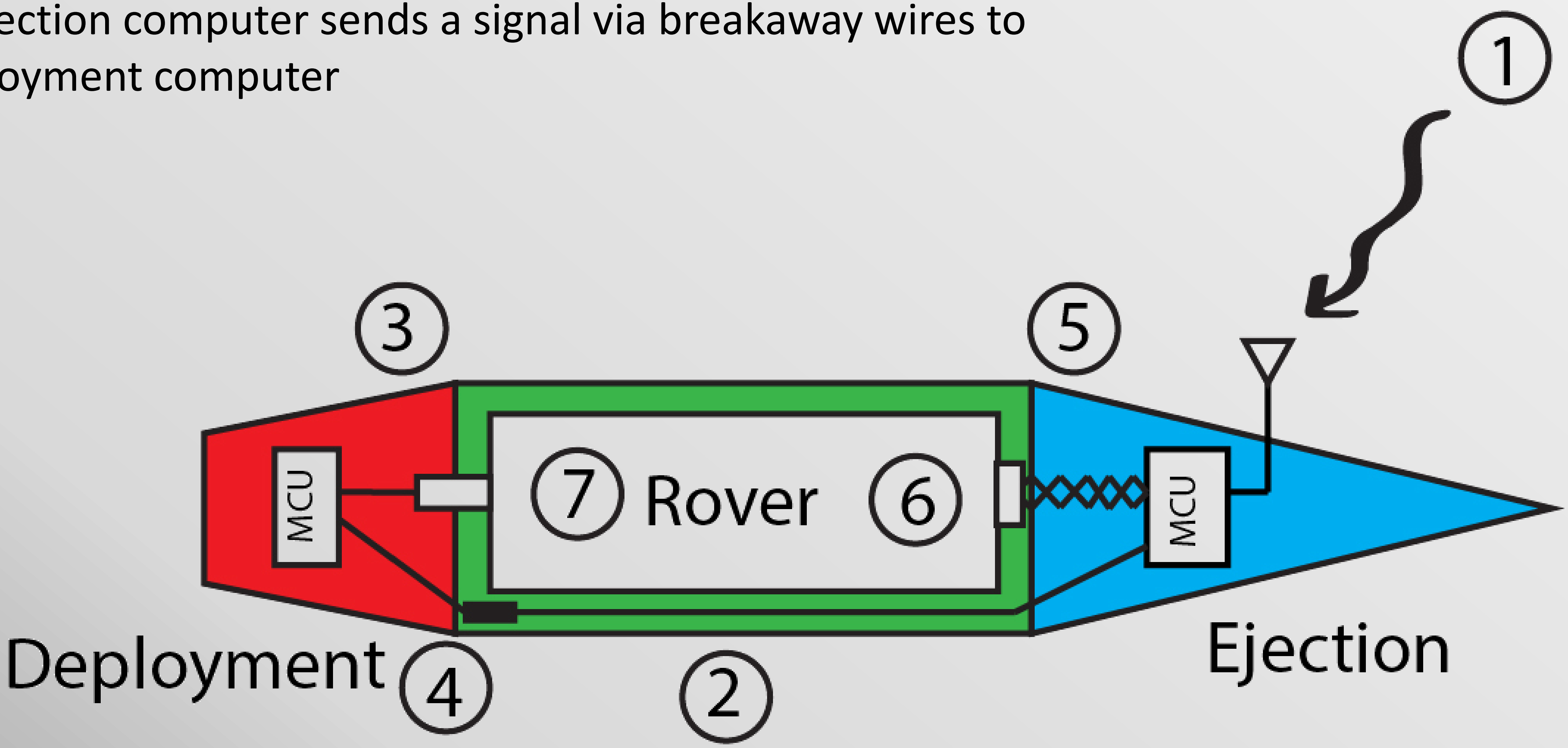
Payload Overview

- 1. Ejection computer receives remote signal to begin payload process



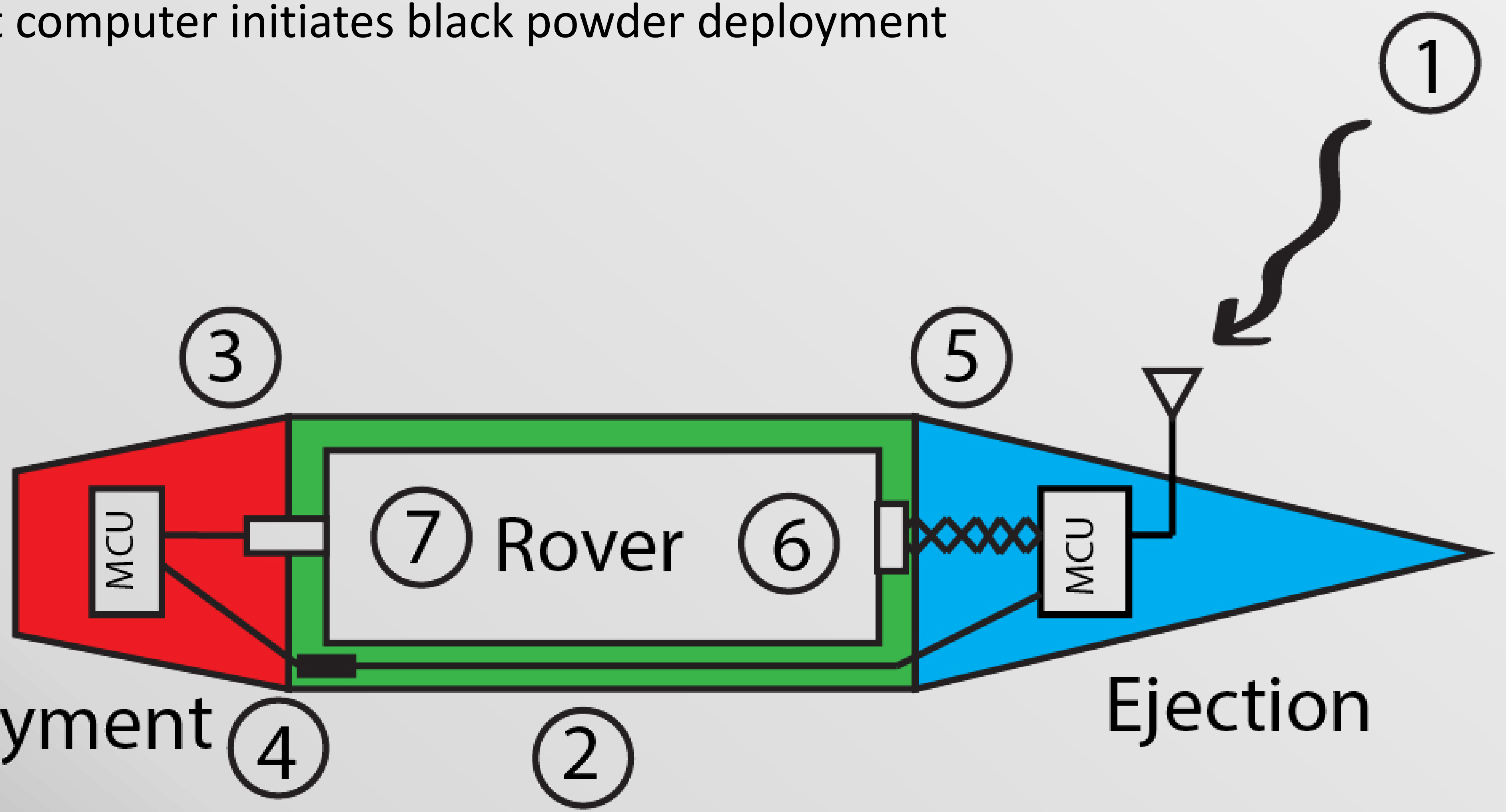
Payload Overview

- 2. Ejection computer sends a signal via breakaway wires to deployment computer



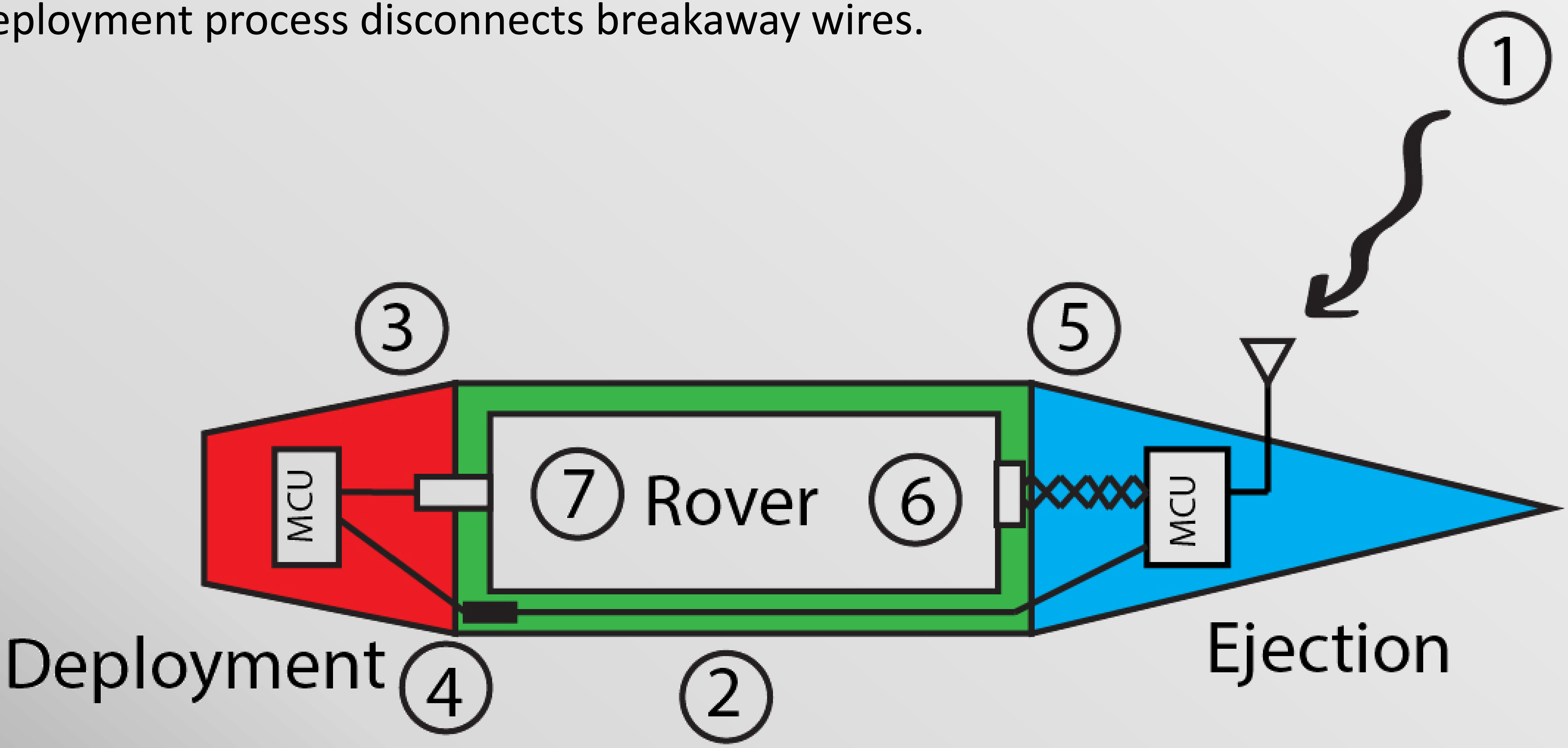
Payload Overview

- 3. Deployment computer initiates black powder deployment



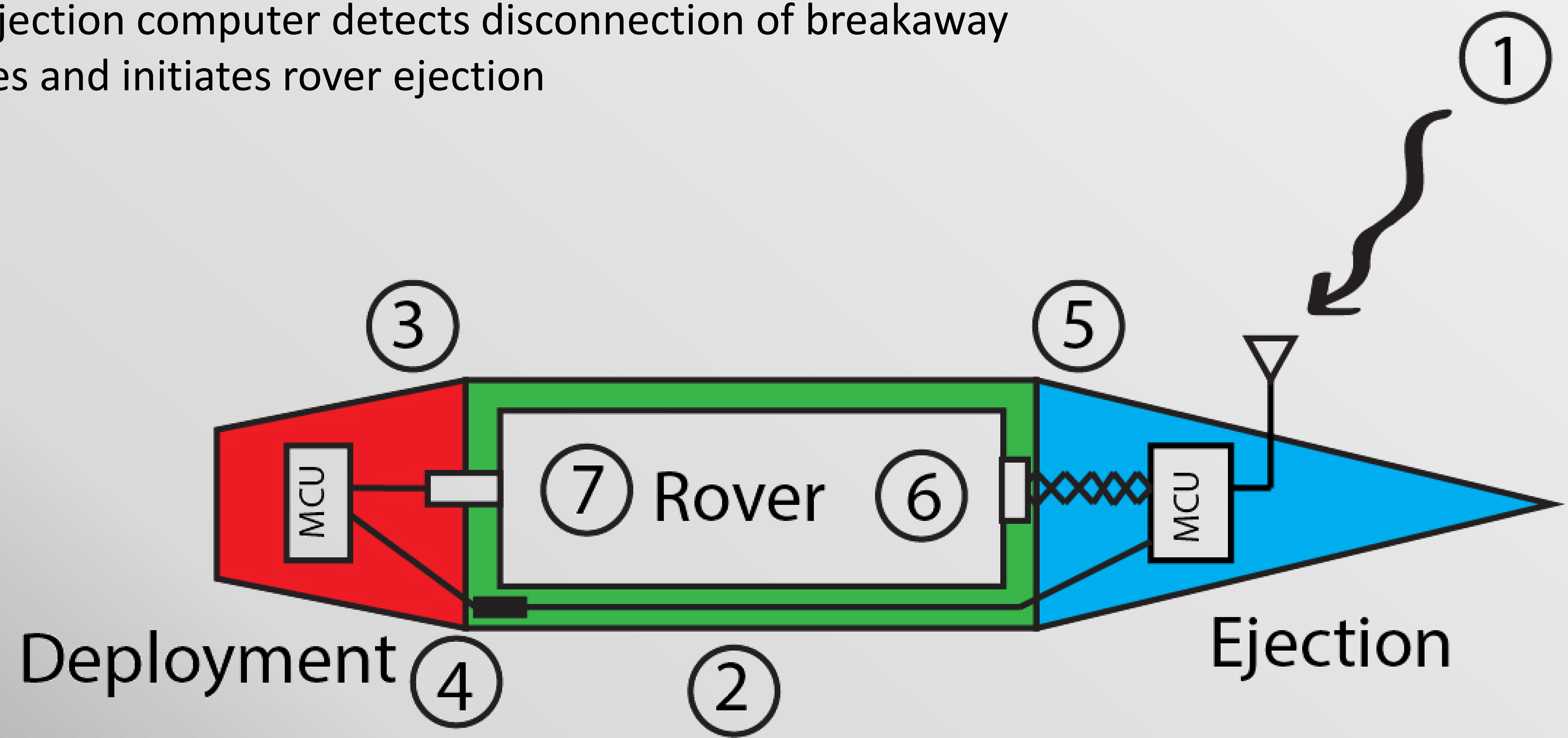
Payload Overview

- 4. Deployment process disconnects breakaway wires.



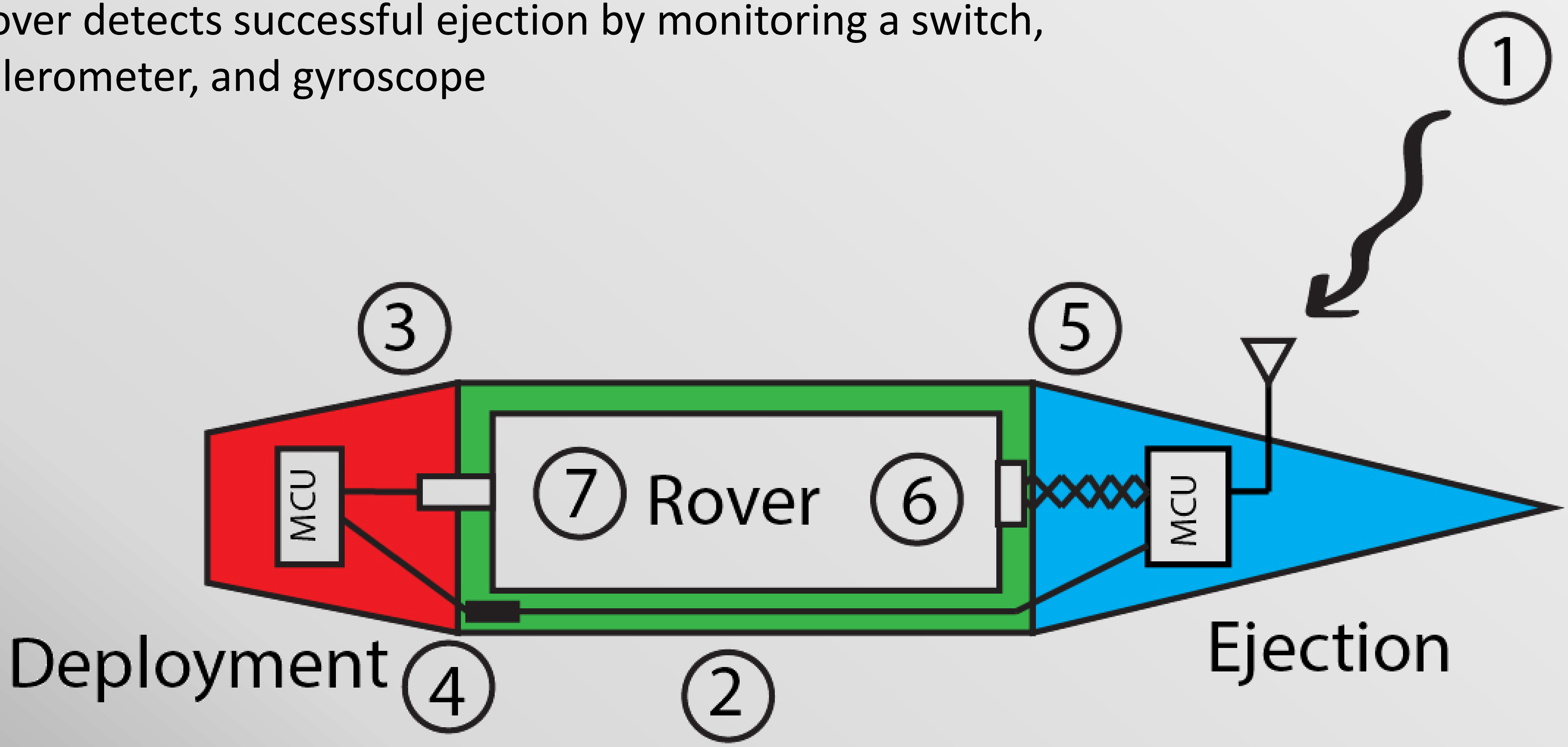
Payload Overview

- 5. Ejection computer detects disconnection of breakaway wires and initiates rover ejection



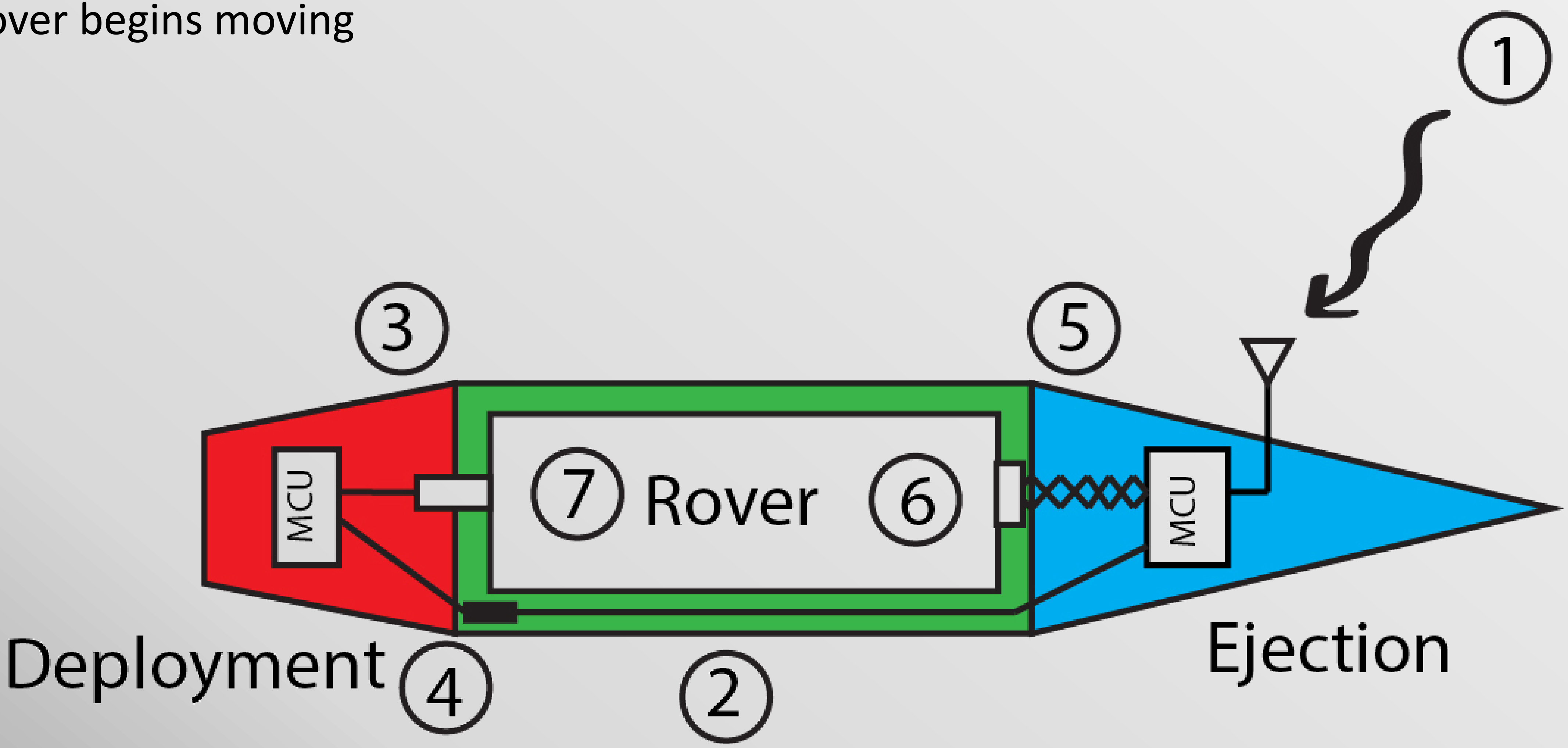
Payload Overview

- 6. Rover detects successful ejection by monitoring a switch, accelerometer, and gyroscope



Payload Overview

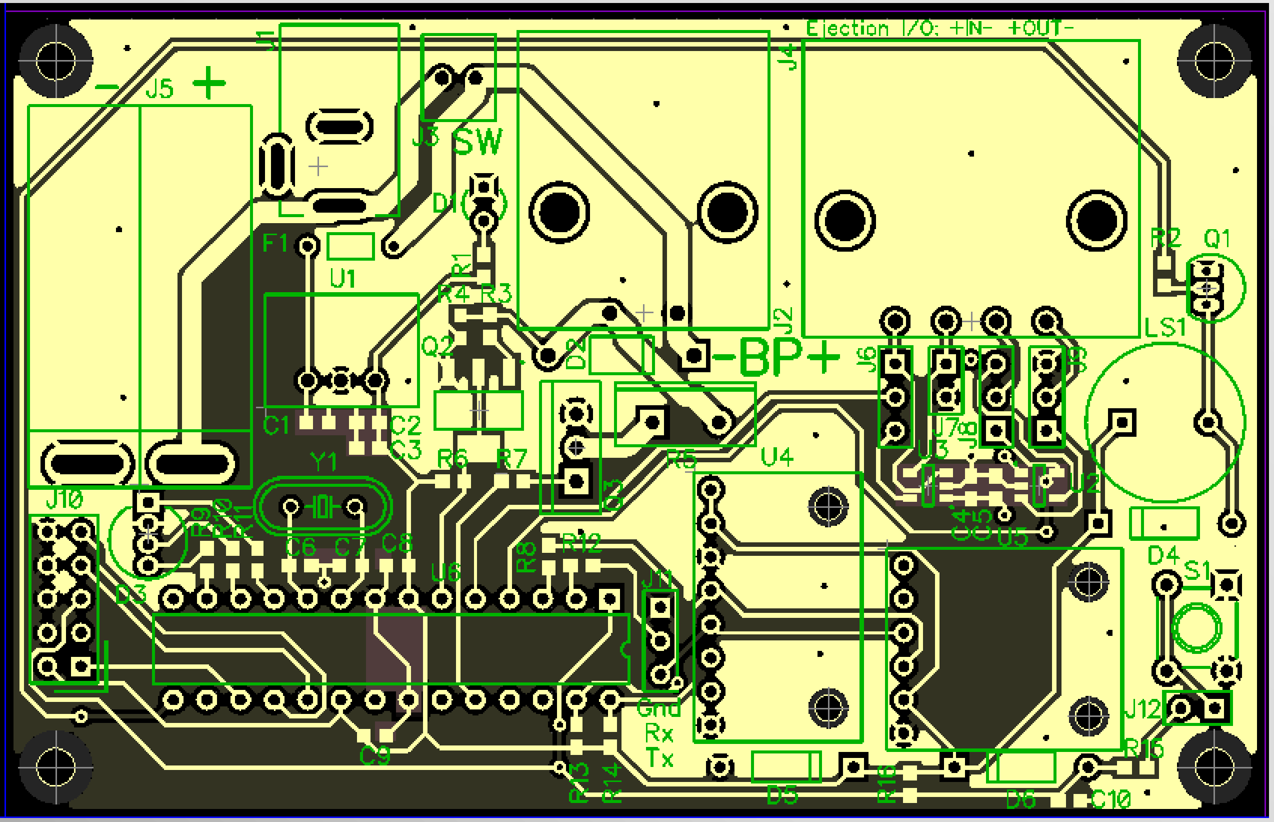
- 6. Rover begins moving

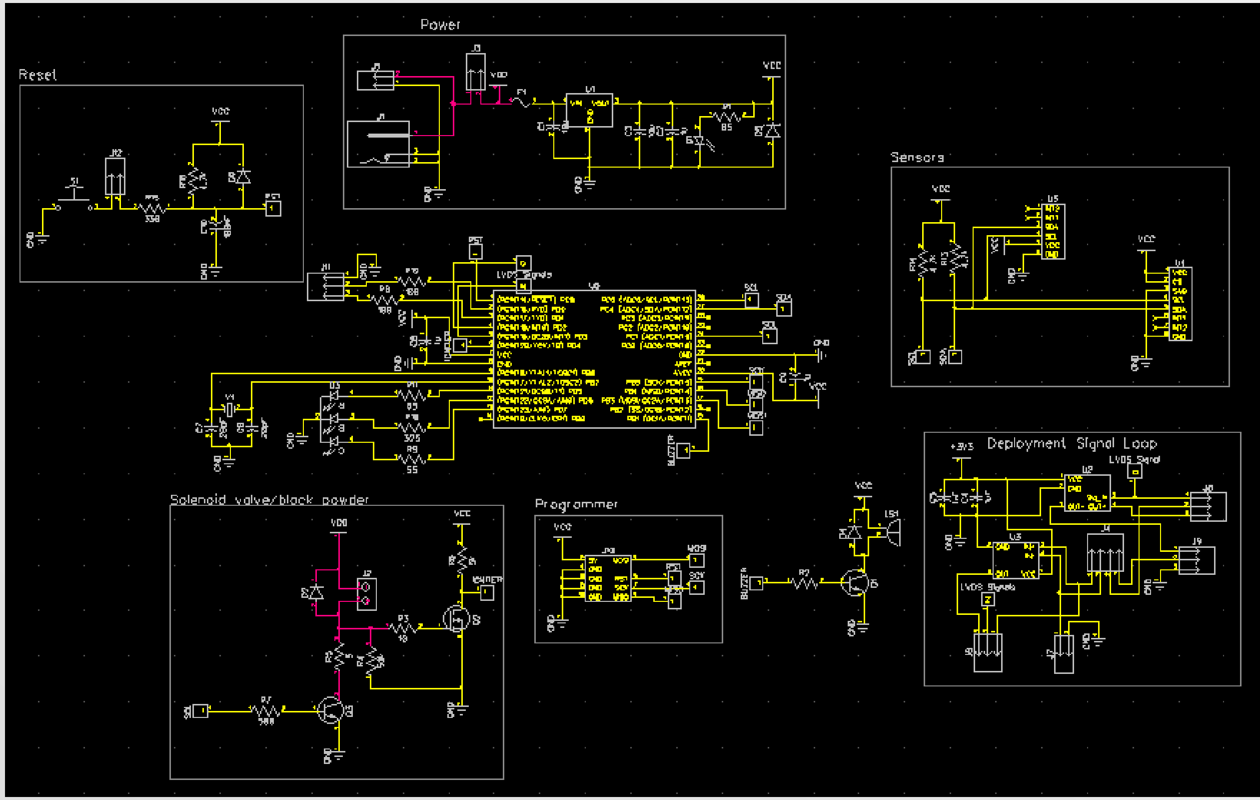


Payload – Deployment Overview

- Black powder ejection system
  - 6g Powder Charges
- Nomex Shielding for heat protection
- Elect. Bay separate from Ignition Chamber with electronics mounted to sled
- Breakaway wire connector from ejection electronics
- Weight estimate:
  - Currently ~1.4 lb

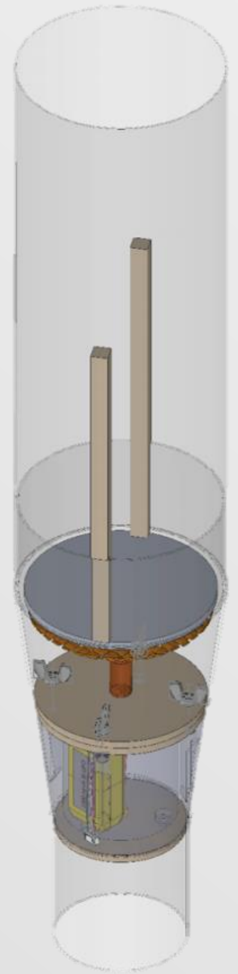
Payload – Deployment Board





Payload – Deployment Integration

- Centering ring glued into transition section
- Permanent bulkhead bolted to centering ring
- Electronics sled mounted to aft end of permanent bulkhead without interference with recovery bulkhead
- Black powder charge secured into position on fore end of permanent bulkhead
- Nomex shielding and loose bulkhead placed into position
- Within assembled airframe, loose bulkhead coincident with posts
- Three shear pins connecting transition and payload tubing



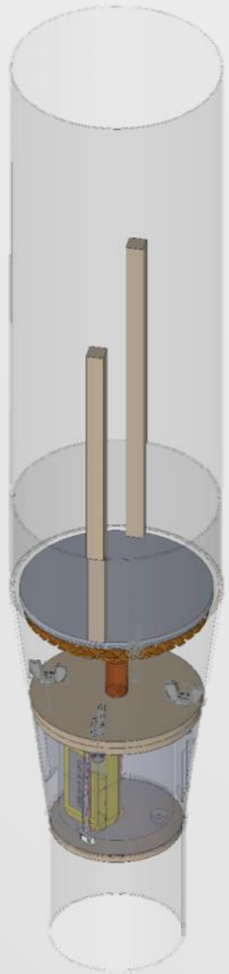
Payload – Deployment Tests

Detonation Test - Completed: Success

Remote Radio Trigger Test - Completed: Success

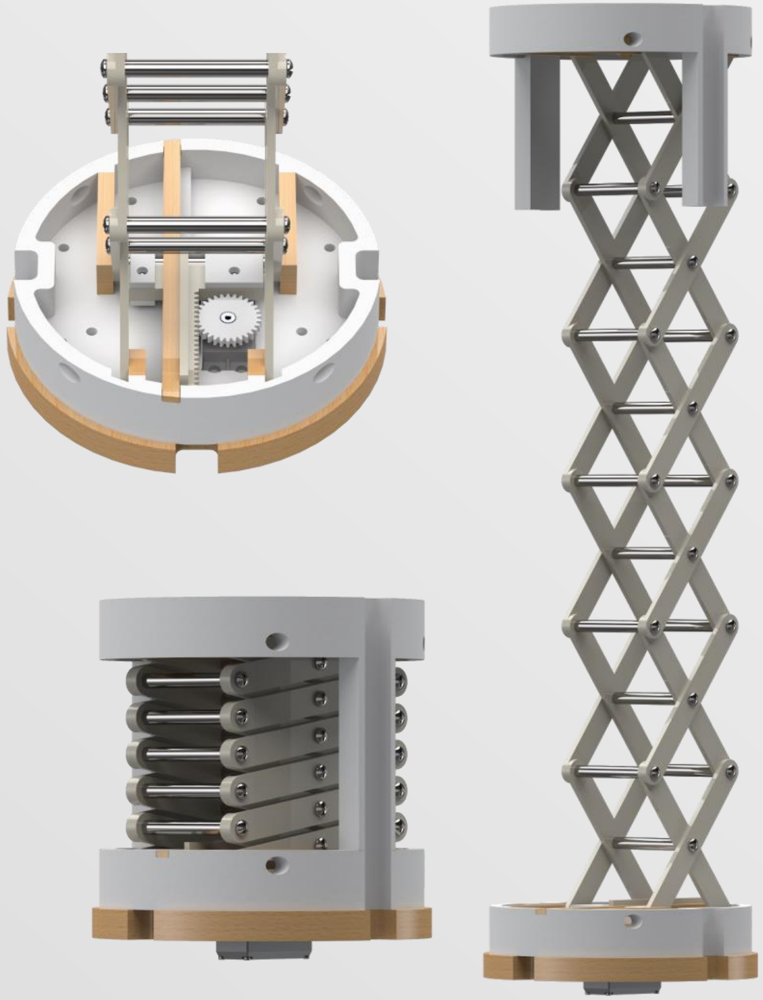
Separation Distance Test - Completed: Success

Rover Shield Test - Completed: Success

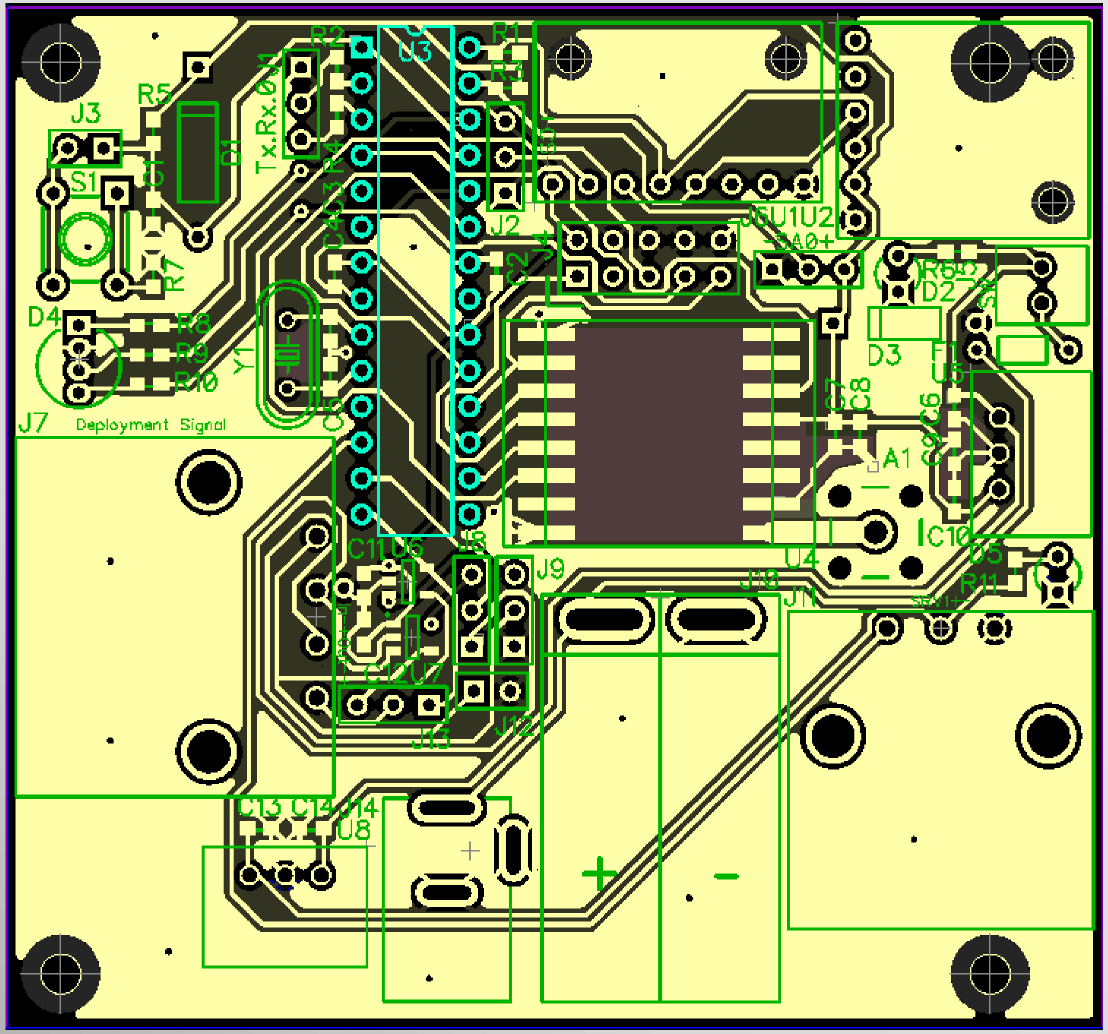


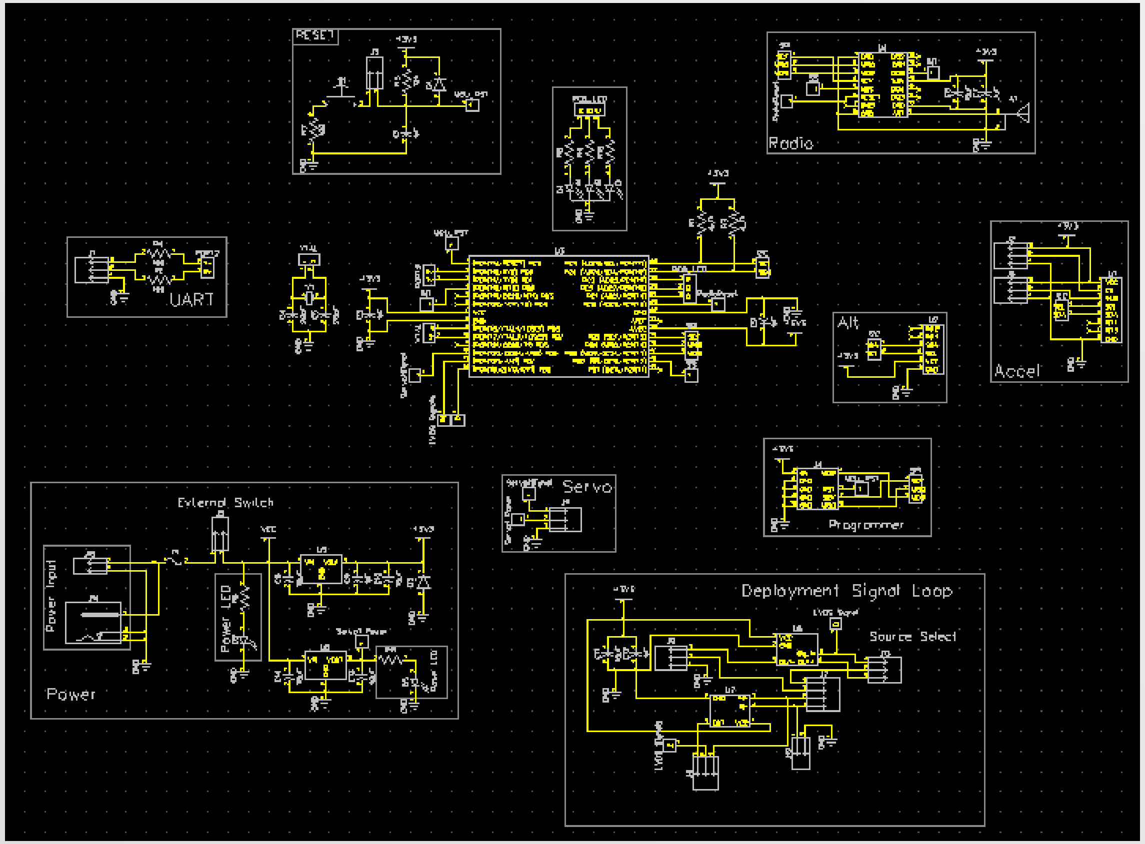
Payload – Ejection Overview

- Horizontal scissor lift used to eject rover out of the payload section and onto the ground.
- Electrical components are mounted on a sled attached to nose cone side of scissor lift.
- Compressed length: 6 inches
- Extended length: 19.5 inches
    - Scissor lift extends the length of the rover plus a 3.5 in. margin of safety.
- Weight estimate:
    - Currently ~1.6 lb



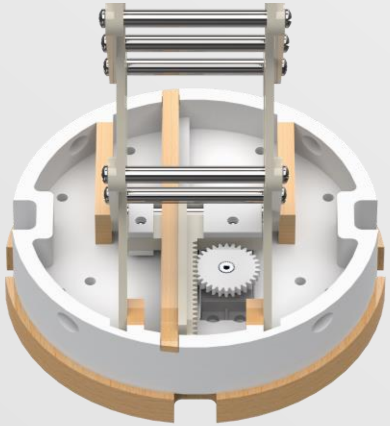
Payload – Ejection Board





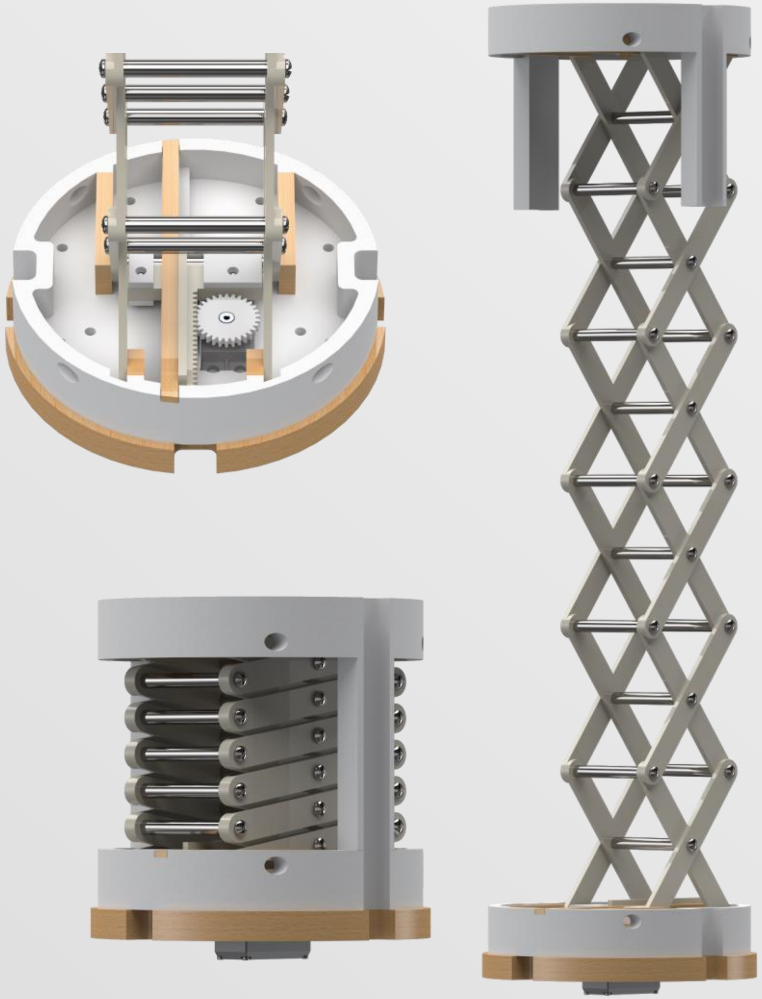
Payload – Ejection Integration

- Centering ring glued into nose cone
- Electronics sled mounts on fore end of bottom plate
- Bottom plate screws into centering rings
- Top plate oriented with respect to the posts
  - Ensured during installation of posts
- Breakaway wire runs along length of payload section, connecting ejection and deployment electronics



Payload – Ejection Tests

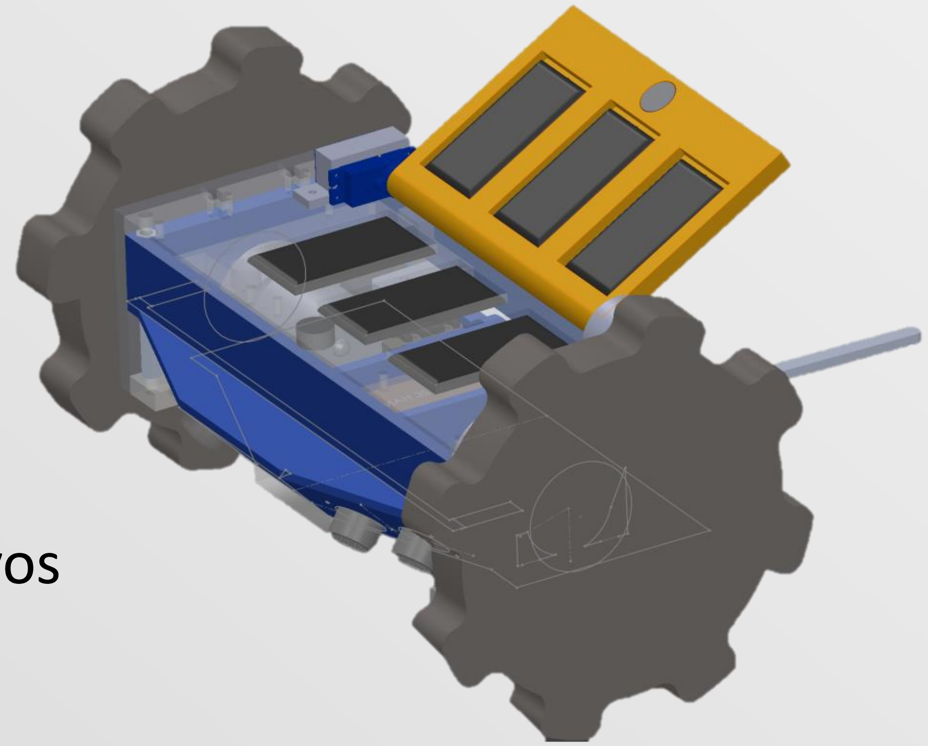
- Frame Load-bearing Capacity: Incomplete due to loss of primary frame
- Lift Actuation Force: Complete - Success
- Linkage Lateral Flex: Complete - Success
- Linkage Vertical Flex: Complete - Success
- Lift Range of Motion: Complete - Success



Payload – Rover Overview

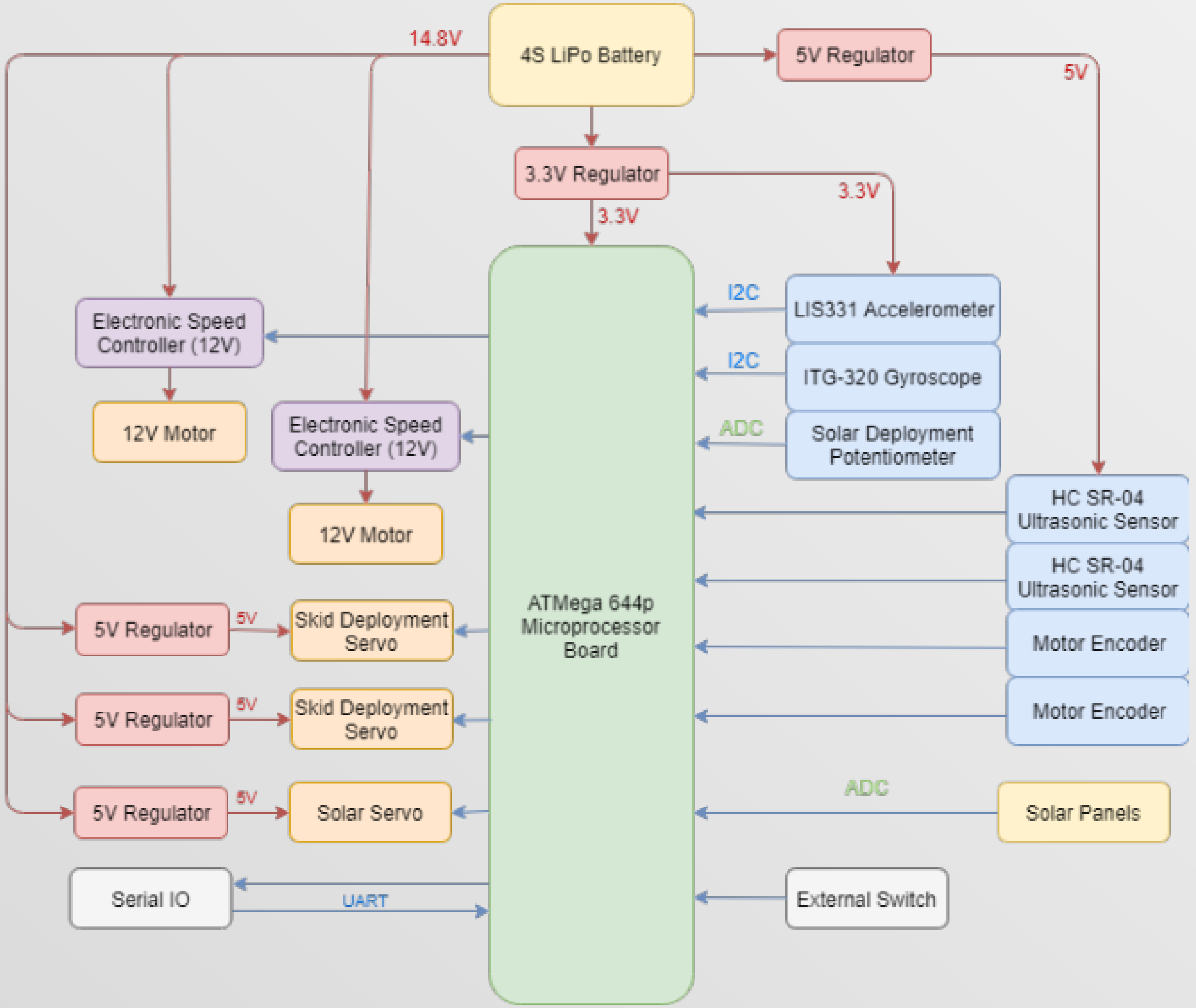
- Chassis Dimensions: 8.5” x 3.75” x 2.0”
-

  Rectangular frame with polycarbonate surfaces, PLA sidewall, and polycarbonate side plate supports.
- Solid toothed cross-linked polyethylene wheels.
  - Lightweight, deformable
  - Uniform material, Solid hub / soft treads
- Twin polycarbonate skids.
  - Stabilizing skids hold rover body in place
  - Simple design that takes mechanical load off of servos



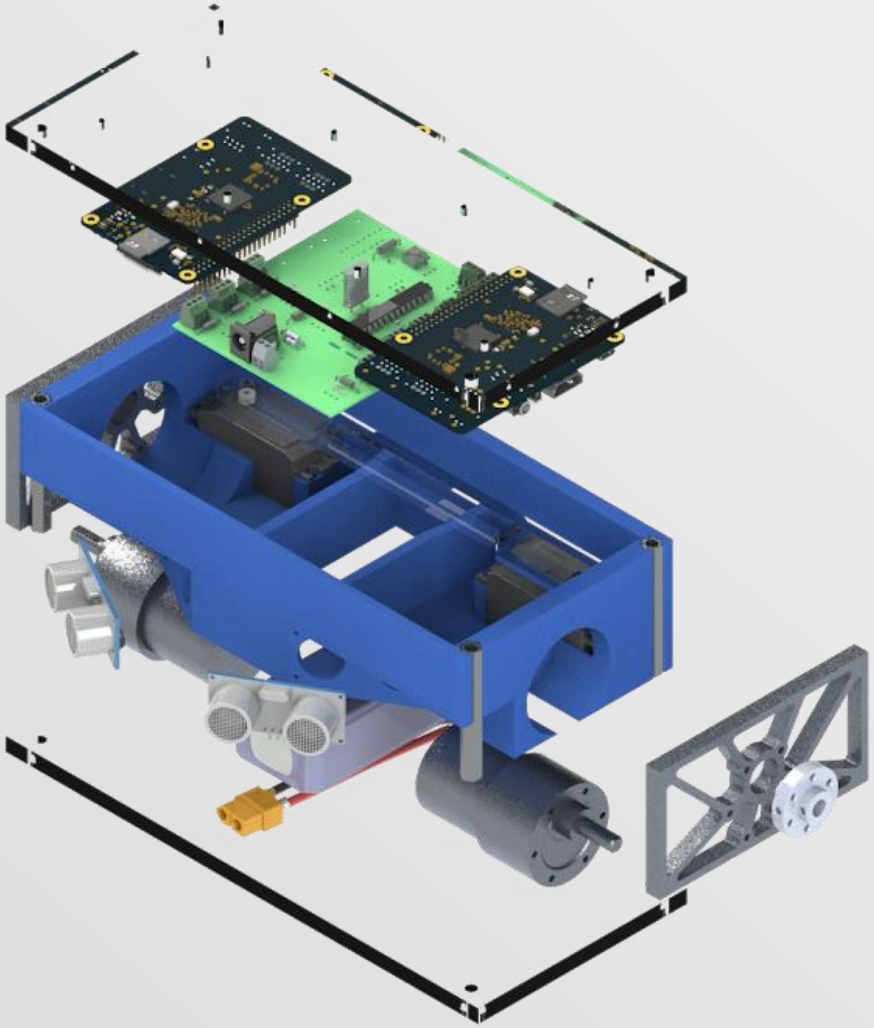
Payload – Rover Electronics Overview

- 4S LiPo Battery
- Microprocessor for custom code
- Tactile touch switch on wheel
- Accelerometer, gyroscope, ultrasonic sensors, and motor encoders
- Two motors with ESCs
- Two servos for skid deployment
- One servo for solar deployment
- Potentiometer and ADC for verification of solar deployment

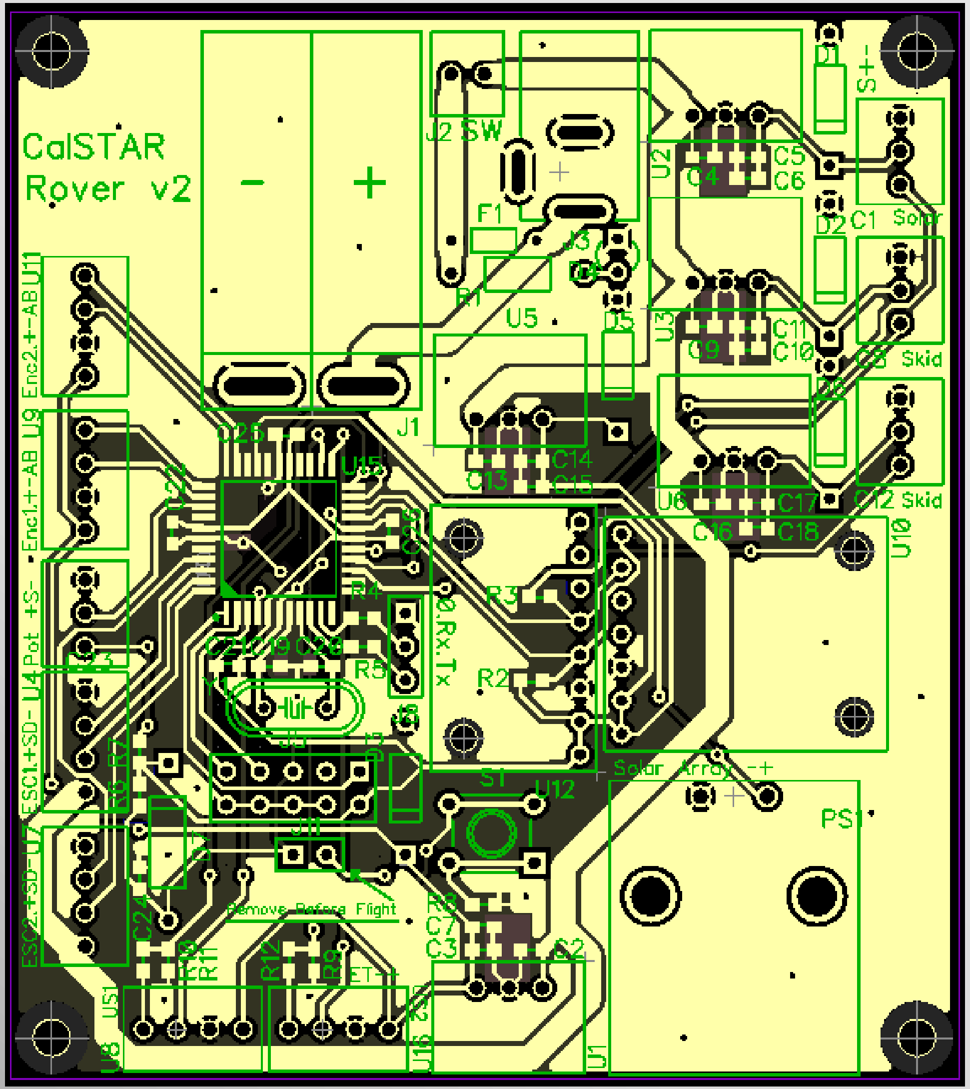


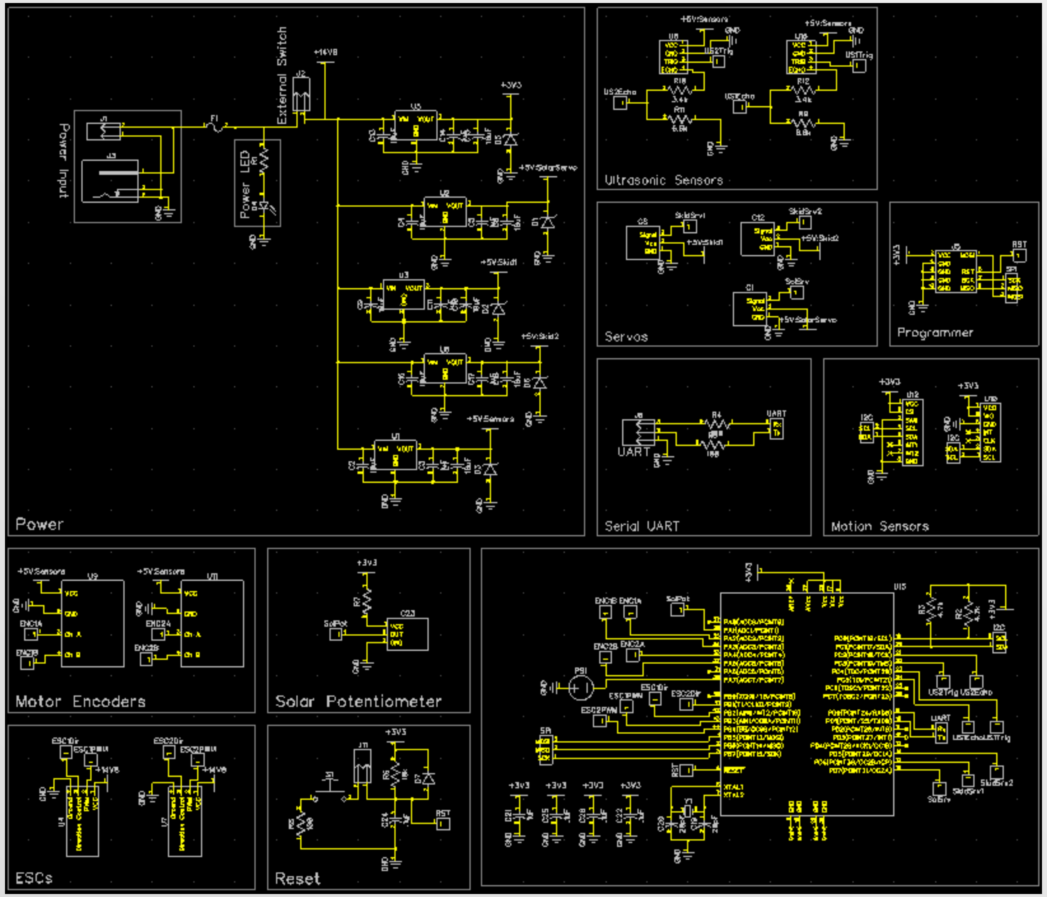
Payload – Rover Overview

- Motor Controller (x2)
- Rover Computer
- Servos (x2)
- Ultrasonic Sensors (x2)
- Motor (x2)



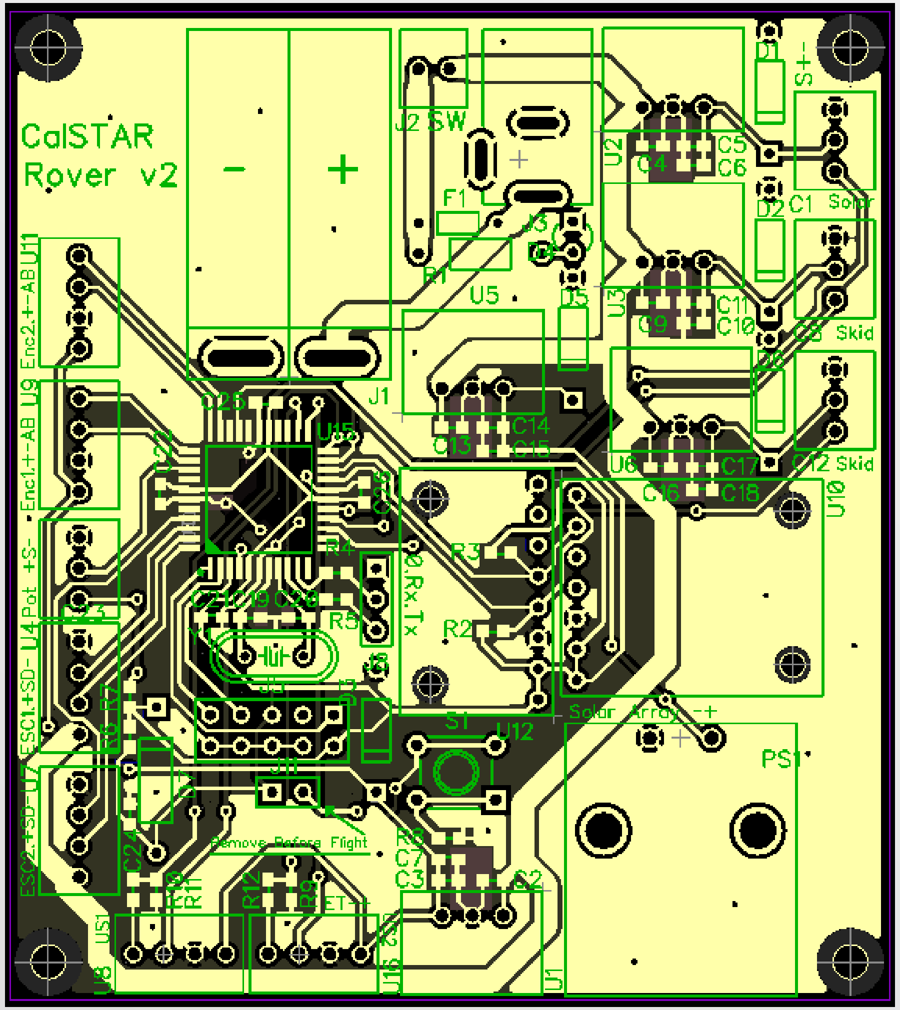
Payload – Rover Computer V2





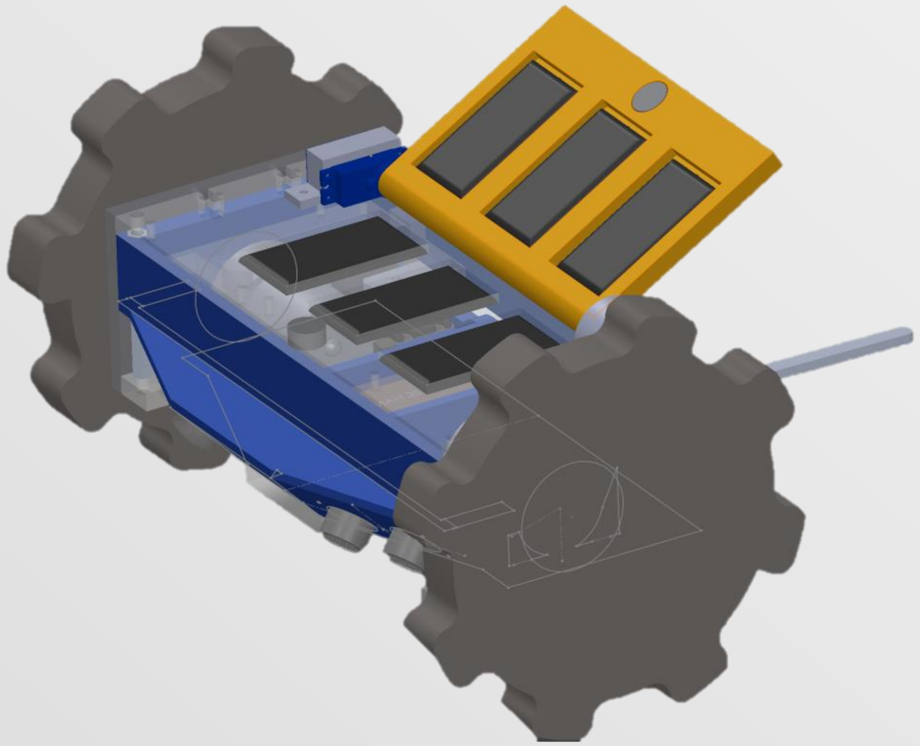
Payload – Rover Computer V2

- Upgraded to ATMega 644p to accommodate larger and more complex rover program.
- Optimized IO layout.
- Custom designed board offers superior customizability.
- Board manages all rover components



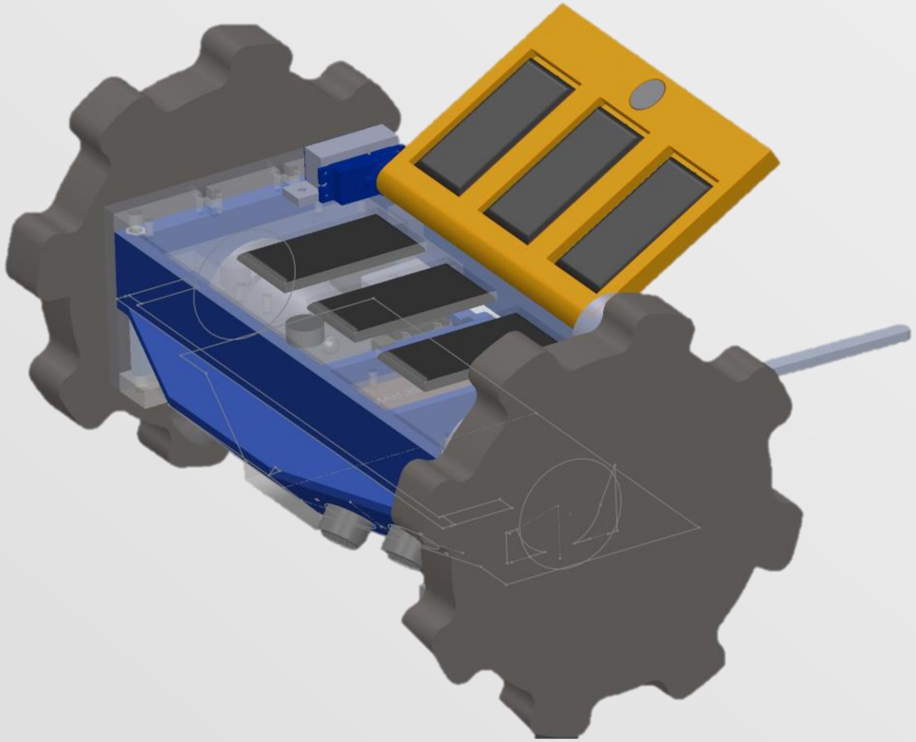
Payload – Rover Computer V2

- Manufacturing Testing: Completed - Success
- Electronics Resilience Test: Completed - Success
- Terrain Test: Incomplete
- Hill Climb Test: Incomplete
- Rover Actuation Test: Incomplete
- Distance Measurement Test: Incomplete
- Obstacle Avoidance Test: Incomplete



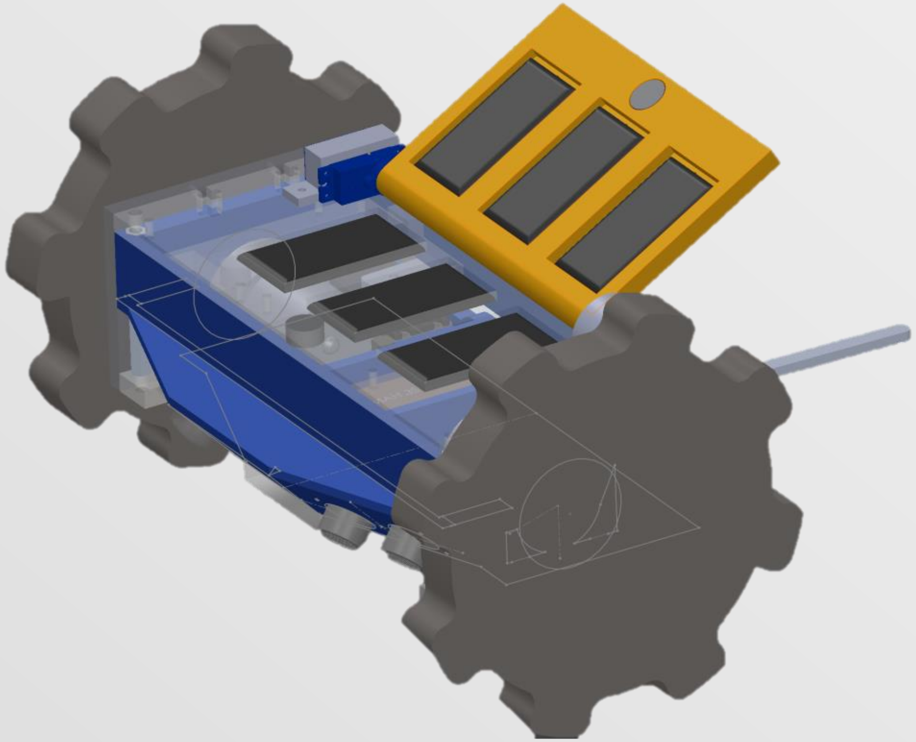
Payload – Solar Overview

- 2” x 1” solar cells chained together on two panels
  - 5V, 30mA, 0.15W each
- One panel mounted above rover electronics
- Second panel mounted on hood of rover body
- Hood attached to body with hinge
- Hinge actuated with servo whose fins are attached to rod to rotate hood
- Potentiometer shaft attached to hinge to verify deployment position
- Voltage output of solar panels passed to rover computer



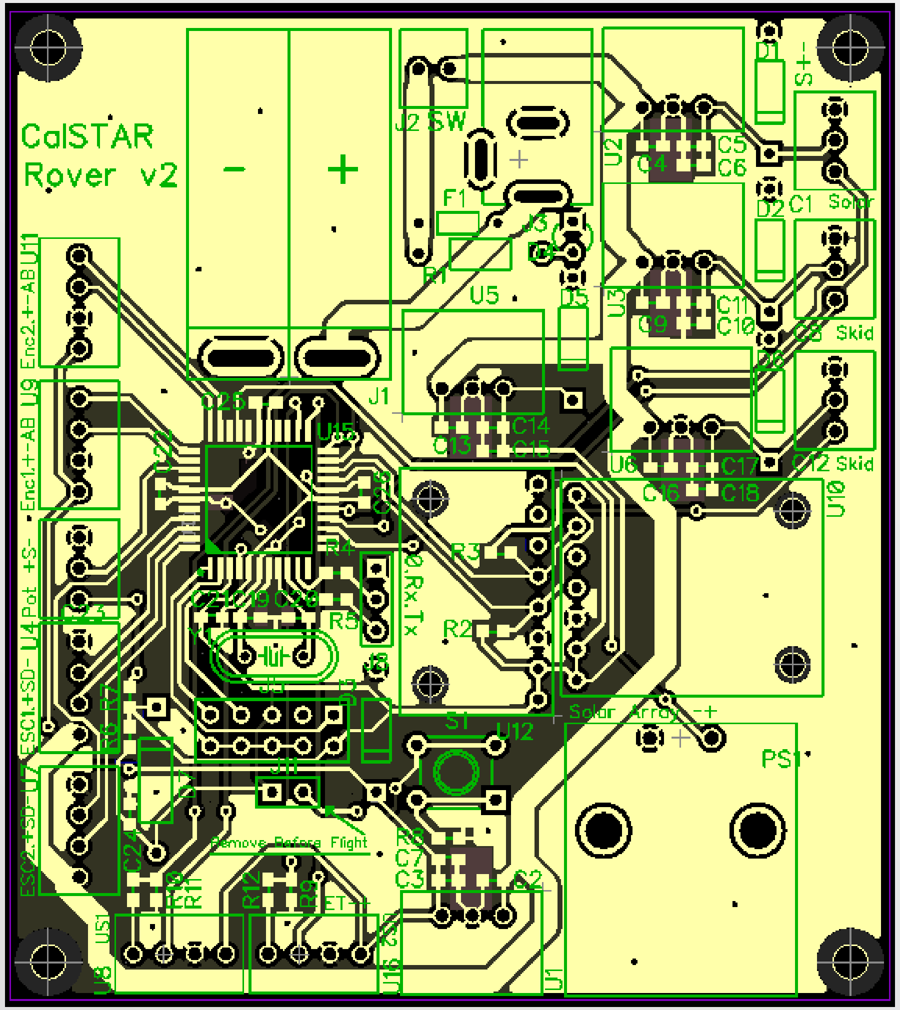
Payload – Solar Tests

- Solar Cell Integration: Completed - Success
- Servo Integration: Completed - Success
- Panel Deployment: Incomplete



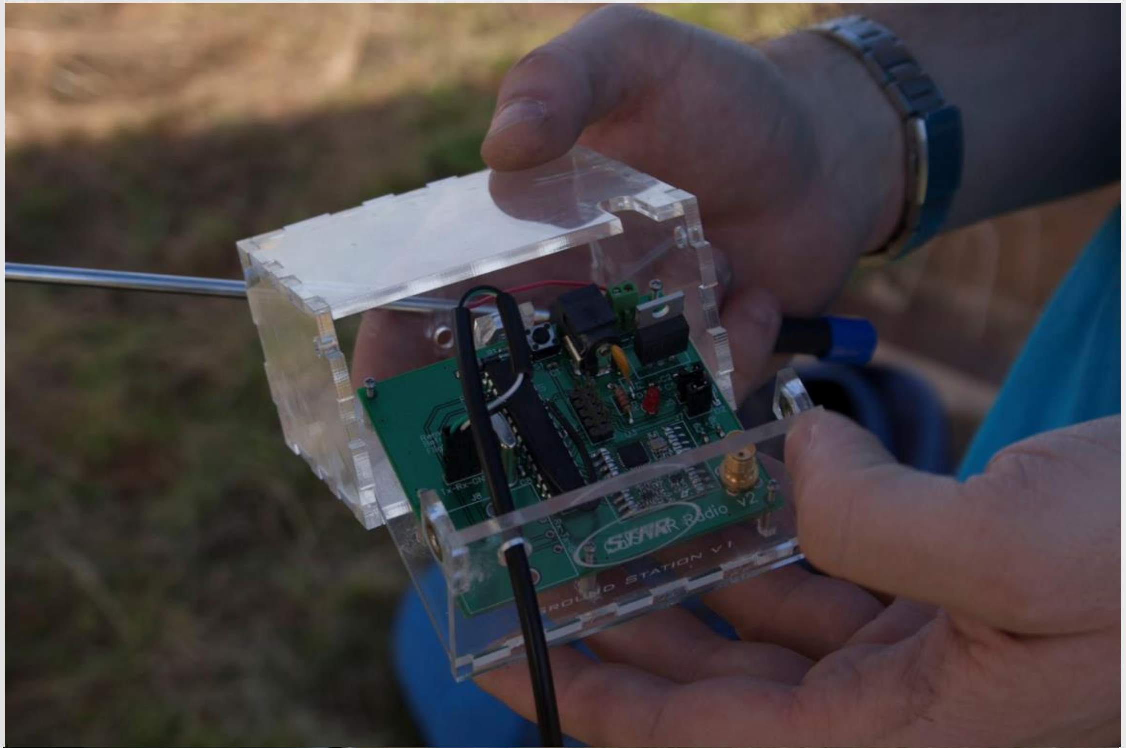
Payload – Electronics Tests

- Radio Link Test: Completed - Success
- Electronics Bench Test (deployment and ejection): Completed - Success
- Airframe Integration Test: Completed - Success
- Black Powder Test (deployment and ejection): Completed - Success



Payload Electrical – Ground Station

- 434MHz Radio, 500mW
- Antenna
  - 434MHz Yagi
  - 7 element
  - Handheld
- Communicates with Ejection Board
  - 434MHz Radio
  - Half-wave dipole antenna for remote signal reception
  - Sensor data + remote initiation of payload sequence



05

Safety

Outreach

Project Plan

Safety

- Safety improvements:
  - Last launch: recovery failure and inadvertent payload deployment
  - Improvements to design & procedures:
    - Updating recovery system to a standard dual-deploy system
    - Increasing number of shear pins connecting transition to payload tube
    - Considering nylon tether system
    - Updated procedure is to disarm payload if no ejection signal is received
- All members will have PPE and access to checklists at launch

06

Outreach

Project Plan

Outreach

- Completed Events:
  - Ohlone College Night of Science (Oct 7, 2017)
  - Parent Education Program (Oct 14, 2017)
  - High School Engineering Program (Oct 21, 2017)
  - Discovery Days, CSU East Bay (Oct 28, 2017)
  - Discovery Days, AT&T Park (November 11, 2017)
  - High School Engineering Program (Feb 11, 2017)
  - Splash! at Berkeley (March 4th, 2018)
- Current Outreach Numbers:
  - 1826 direct interactions with students
  - 1289 indirect interactions with community members (not including students above)
- Planned Events:
  - Currently have 9 outreach events planned this semester

07

Project Plan

Project Plan – Requirements Verification – Vehicle (Incomplete)

- The vehicle must be flown in its fully ballasted configuration during the full-scale test flight. Fully ballasted refers to the same amount of ballast that will be flown during the launch day flight. Additional ballast may not be added without a re-flight of the full-scale launch vehicle.
- All teams will successfully launch and recover their full-scale rocket prior to FRR in its final flight configuration. The rocket flown at FRR must be the same rocket to be flown on launch day.
- After successfully completing the full-scale demonstration flight, the launch vehicle or any of its components will not be modified without the concurrence of the NASA Range Safety Officer
- All other Launch Vehicle requirements complete

Project Plan – Requirements Verification – Recovery (Ongoing)

- Each team must perform a successful ground ejection test for both the drogue and main parachutes. This must be done prior to the initial subscale and full-scale launches.
- At landing, each independent sections of the launch vehicle will have a maximum kinetic energy of 75 ft-lbf.
- The electronic tracking device will be fully functional during the official flight on launch day
- The recovery system electronics will be shielded from any other onboard devices which may adversely affect the proper operation of the recovery system electronics.

Project Plan – Requirements Verification – Vehicle (Incomplete)

- All requirements are either complete or ongoing

Project Plan – Requirements Verification – Payload

- Complete:
- Each team will choose one design experiment from the list in section 4.3 of the handbook
- Ongoing:
- Teams will construct a custom rover that will deploy from the internal structure of the launch vehicle
- Incomplete:
- At landing, the team will remotely activate a trigger to deploy the rover from the rocket
- After deployment, the rover will autonomously move at least 5ft from the launch vehicle
- Once the rover has reached its final destination, it will deploy a set of foldable solar cell panels

Project Plan – Requirements Verification – Safety

- Complete:
- Each team must identify a student safety officer who will be responsible for all respective responsibilities listed in section 5.3 of the handbook
- Ongoing:
- During test flights, teams will abide by the rules and and guidance of the local rocketry club’s RSO (NAR)
- Teams will abide by all rules set forth by the FAA
- Each team will use a launch safety checklist. The final checklists will be included in the FRR reports and used during the Launch Readiness Review (LRR) and any launch day operations

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