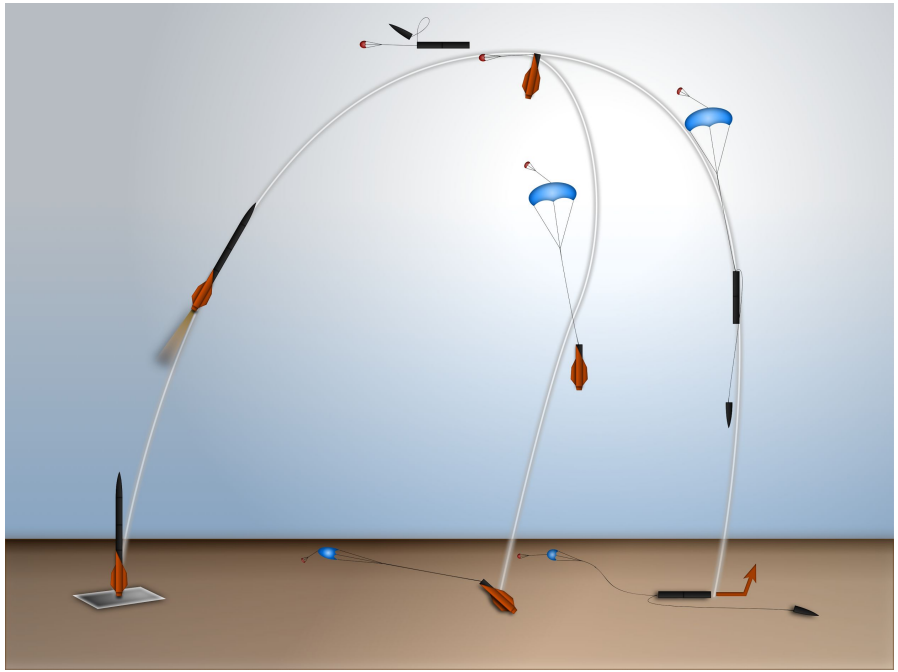
Oregon State University NASA USLI CDR

01/12/2018

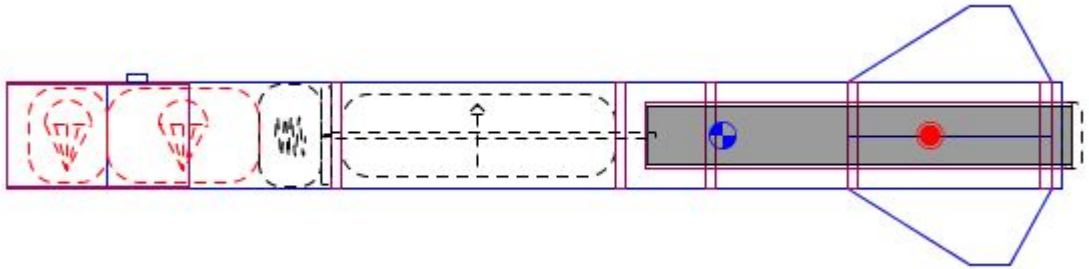
Mission Overview



- Projected altitude of 5199 ft.
- 2 section separation at apogee
- Main deployment at 800 ft.
- Autonomous rover ejection
- Solar panel deployment

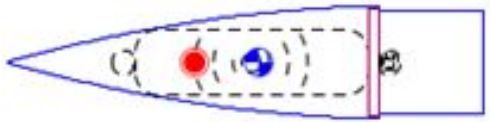
Motor Section

- Section: 47 in.
  - Motor
  - Lower avionics telemetry unit (ATU)
  - Lower recovery controller (ReCo)
  - Lower recovery harness



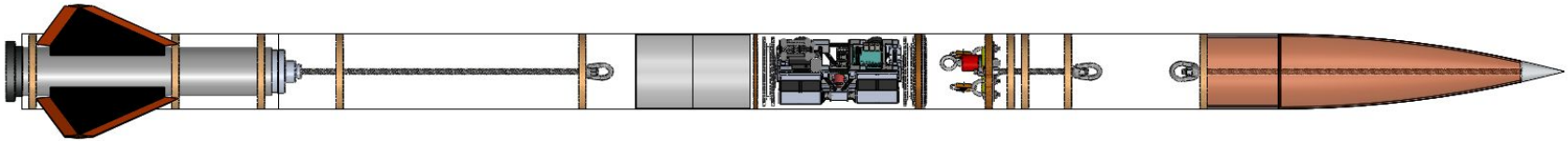
Payload Section

- Nose Cone: 17.5 in.
  - Aluminum tip
  - Upper ATU
  - Recovered with payload section
- Payload Section: 43 in.
  - Payload
  - Payload ejection controller (PLEC)
  - Upper ReCo
  - Upper recovery harness



Structural Overview

- Weight at Launch: 37.5 lb.
- Inner Diameter: 5.2 in.
- Length: 118 in.



Airframe

- Upper Section
  - Material: Carbon fiber
  - Length: 43 in.
  - Inner Diameter: 5.2 in.
- Lower Section
  - Material: Carbon fiber/fiberglass
  - Length: 47 in.
  - Inner Diameter: 5.2 in.

Nose Cone

- Design: 4:1 Ogive nose cone
- Nose Cone Material: Fiberglass
- Tip Material: Aluminum as anchoring point

Mounting Overview

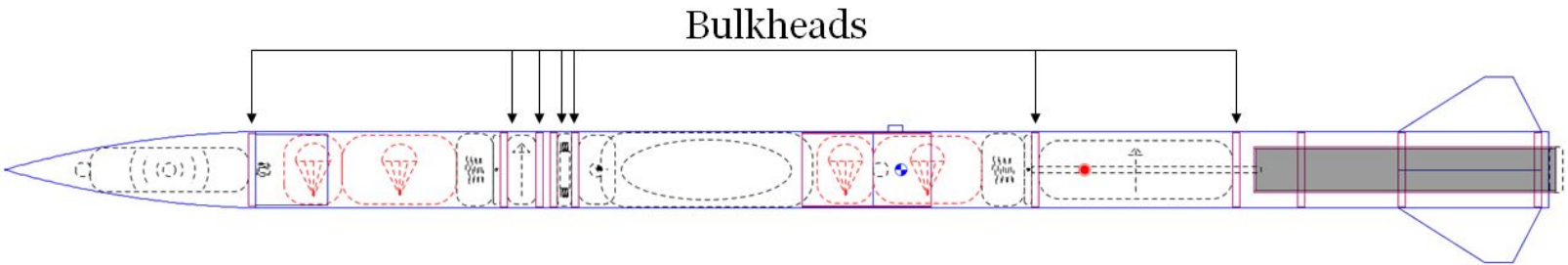
- Seven ½ in. thick plywood bulkheads (9-ply)
- Three threaded rods

Bulkheads

- Three bulkheads epoxied to body
  - Structural mounting
  - Sealed to body
- Four bulkheads for mounting
  - Cap sections
  - Provide pressure seal
  - Through holes for wiring
  - Removable for internal access

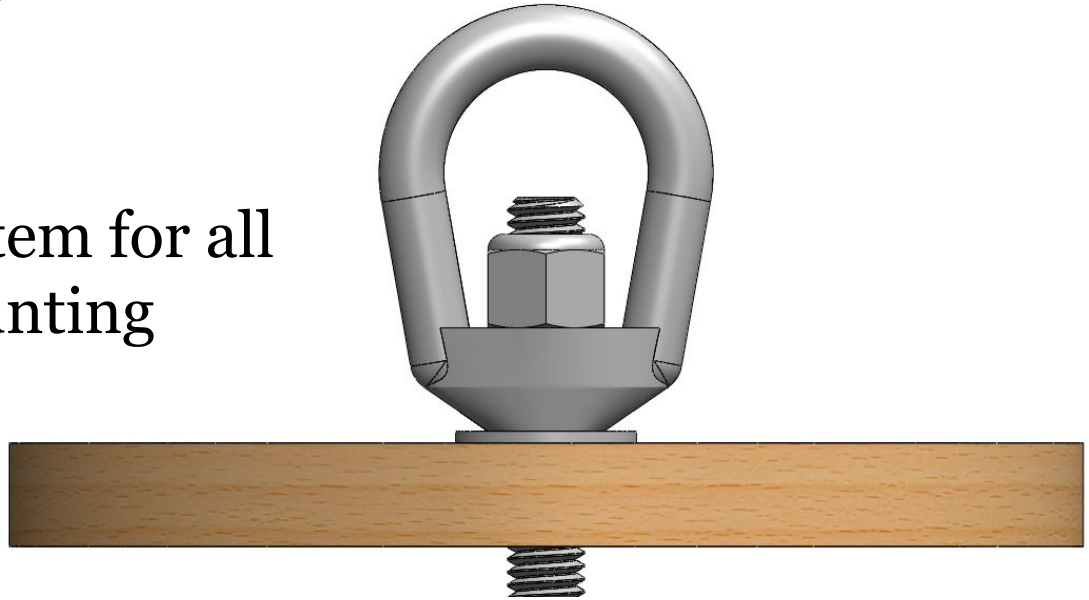
Bulkheads: Locations

- Nose Cone: 1 bulkhead
- Upper Section: 4 bulkheads
- Lower Section: 2 bulkheads



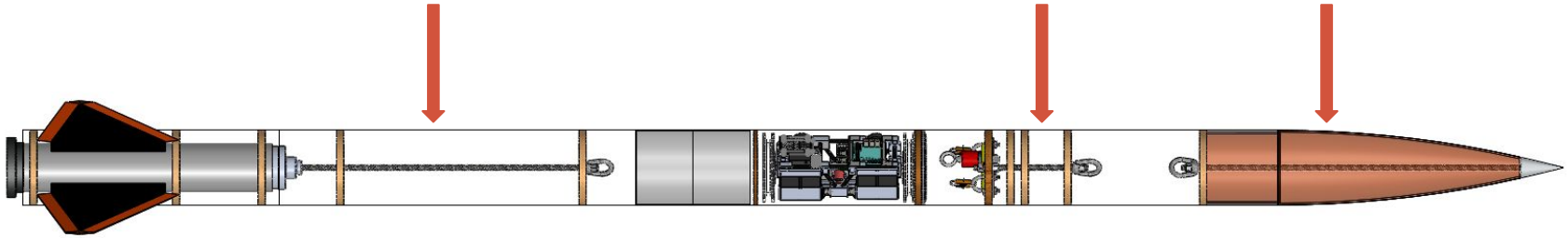
Bulkhead: Recovery Mounting

- Three piece system
  - Nut
  - Eye
  - Washer
- Standard system for all recovery mounting



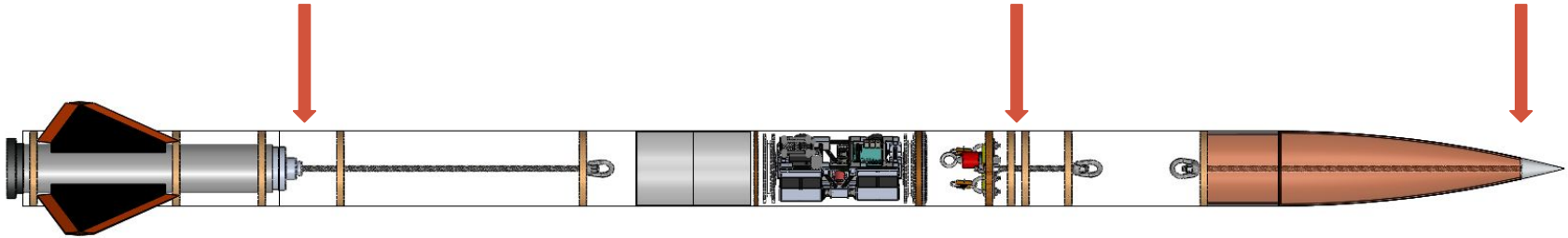
Threaded Rods

- 3 Threaded rods
  - Motor to aft recovery eye-nut assembly
  - Payload ejection bulkhead to forward eye-nut
  - Nose-cone bulkhead to nose-cone tip



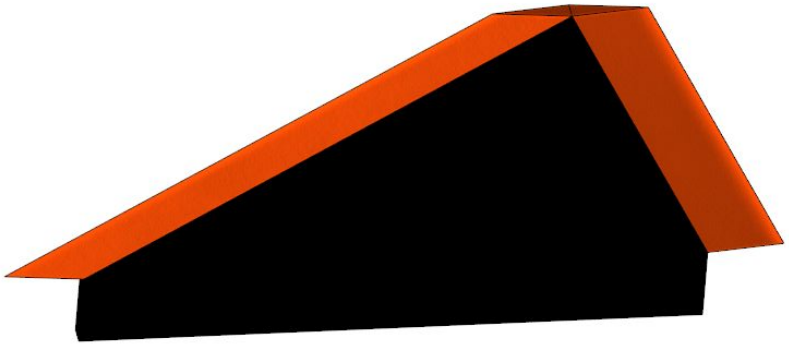
Threaded Rods

- 3 Hardpoints
  - Nose cone
  - Paired bulkhead
  - Forward retainer
- Hardpoints to mount each rod
- One hardpoint per section



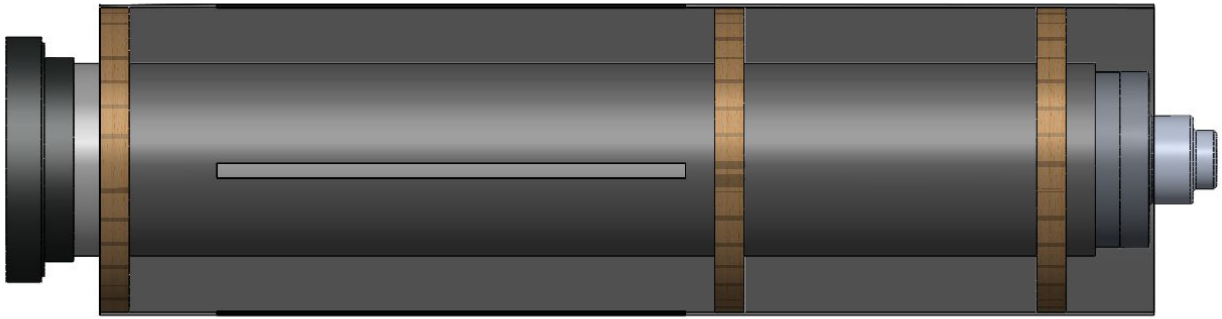
Fins

- Trapezoidal fin shape
- Fin thickness of 0.25 in.
- Carbon fiber/Nomex honeycomb sandwich



Motor Retainment

- 3 Centering rings
- 3 in. motor mount tube
- Aluminum retainer

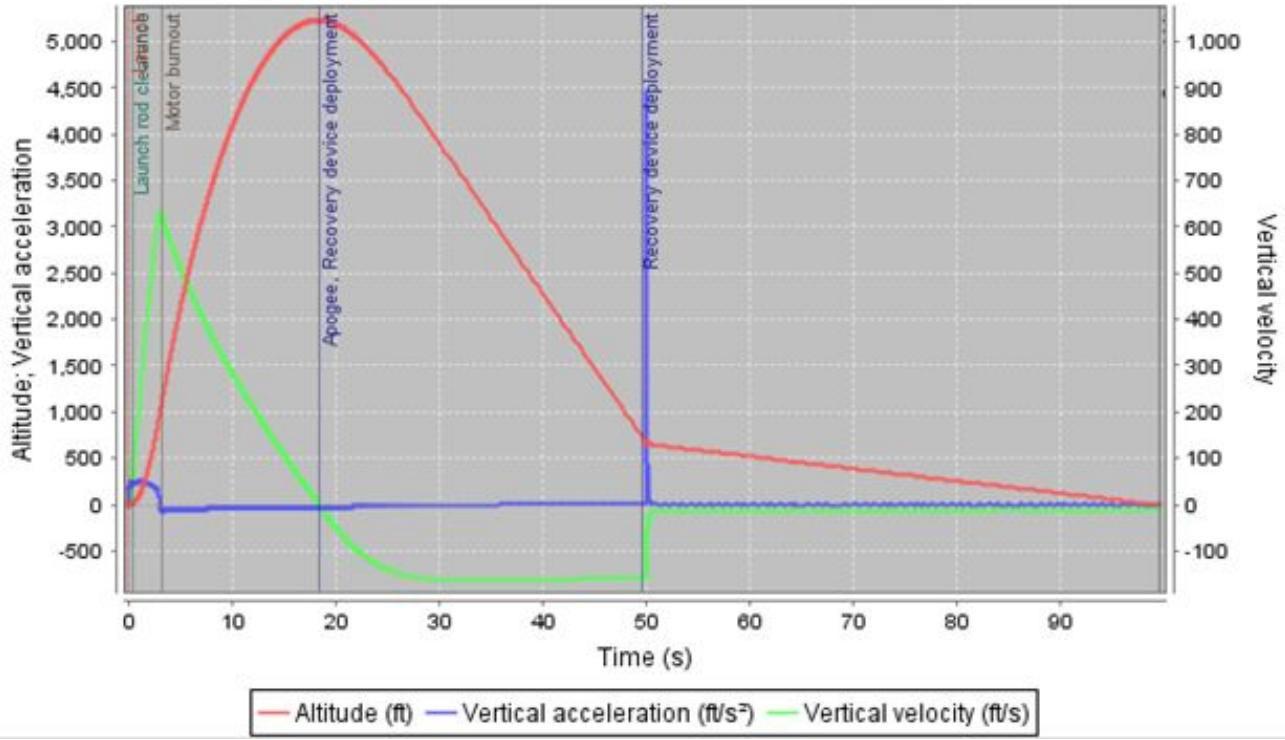


Final Motor Choice

- Motor: Aerotech L850W
  - Total Impulse: 830.7 lbf.-s.
  - Mounting Diameter: 75 mm
  - Liftoff Thrust: 227.0 lb.
  - Plugged Motor

http://www.rocketryforum.com/attachment.php?attachmentid=134470&d=1371596603

Rocket Flight Profile

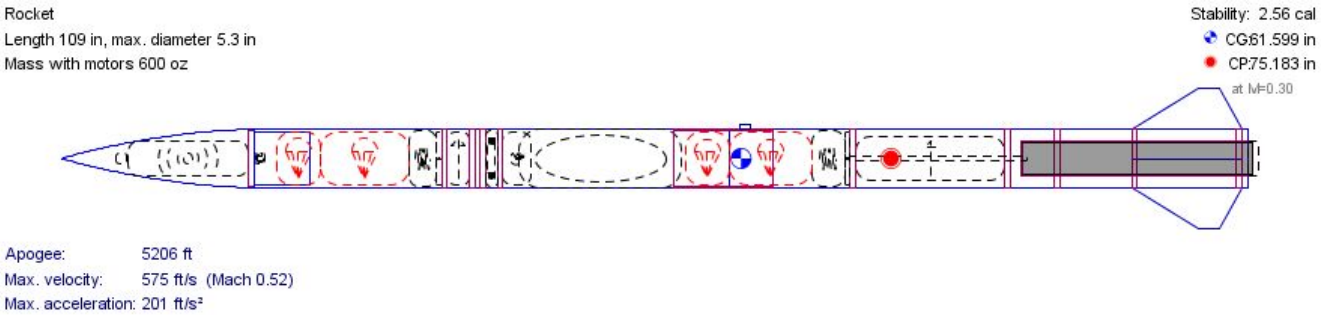


Flight Profile Continued

- Apogee: 5199 ft.
- Thrust to Weight Ratio: 6.05
- Maximum Velocity: 576 ft./s
- Rail Exit Velocity: 65 ft./s

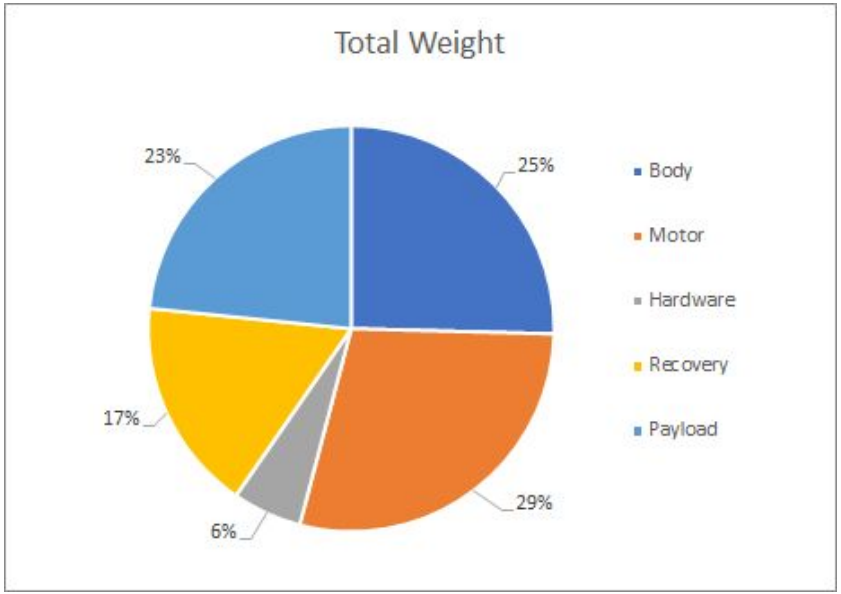
Aerodynamics/Recovery Overview

- Aerodynamic System:
  - CG is 61.6 in., CP is 75.2 in. aft of tip
  - Stability: 2.56 calibers
  - Estimated Altitude: 5199 ft.
  - Ogive nose cone and clipped delta fins



Mass Statement and Margin

Section	Weight (lb.)
Body	9.94
Motor	10.54
Hardware	2.031
Recovery	6.24
Payload	8.6
Total	**37.50**



Mass Statement and Margin

Section	Weight (lb.)
Body	9.94
Motor	10.54
Hardware	2.031
Recovery	6.24
Payload	8.6
Total	**37.50**

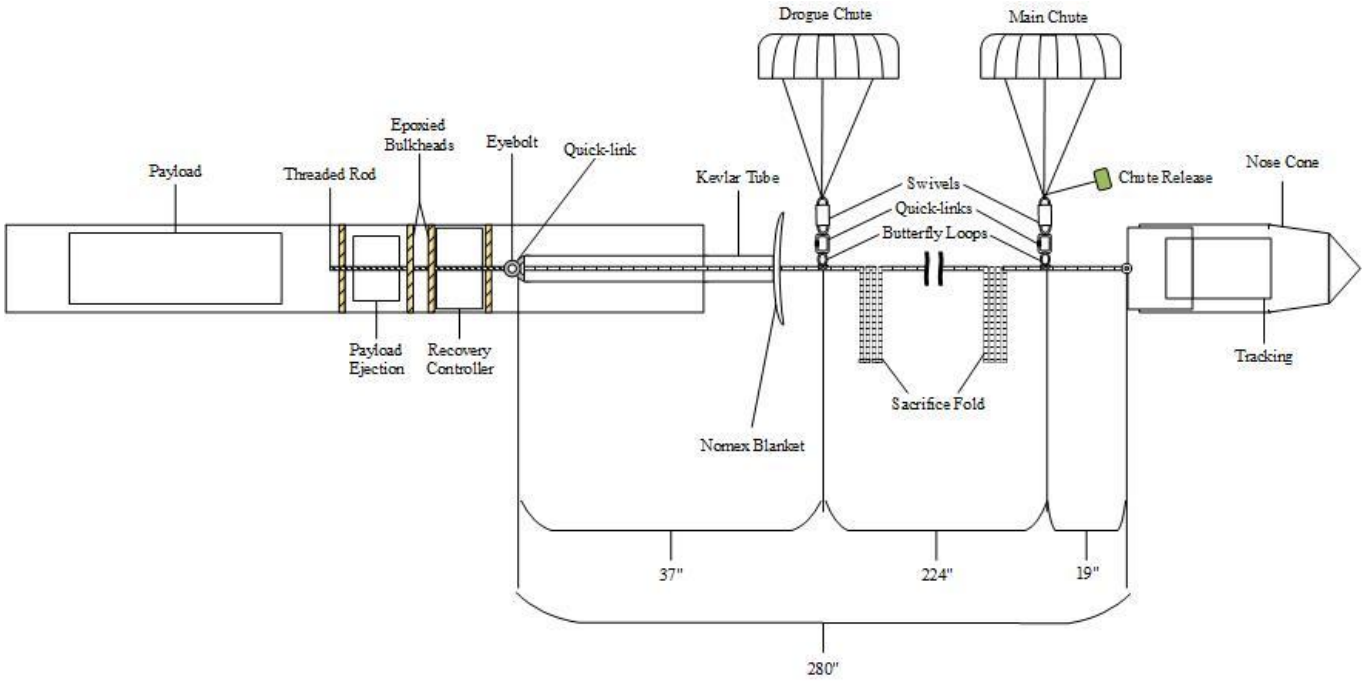
Section	Current Weight (lb.)	Margin	Max Weight (lb.)
Fore	19	2.4	21.4
Aft	18.5	5	23.5

Mass margin defined by current parachute selection

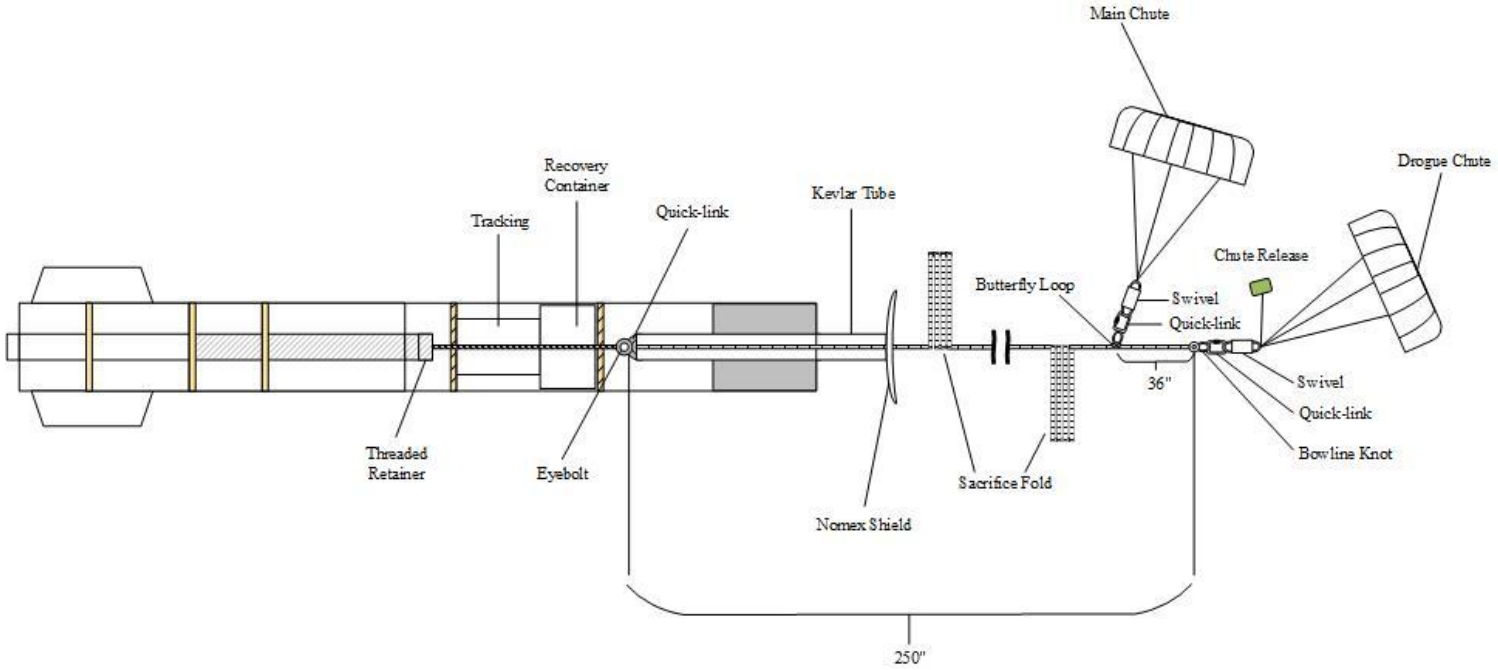
Recovery: Parachutes

- Main Parachutes: Fruity Chutes Iris Standard
- Drogue Chutes: Top Flight X-Type
- Drogue Velocities: 76.9 - 80.4 ft./s
- Main Velocities: 14.5 - 14.9 ft./s
- Landing KE: 55.0 ft.-lbf., 51.1 ft.-lbf.
- 1 in. Tubular Nylon Harness,
  - Fore 23 ft., Aft 20 ft.

Fore Recovery Section



Aft Recovery Section



Kinetic Energy During Mission

- Predicted kinetic energy on landing
- Based on estimated land velocity

Section	Weight (lb.)	Main Size (ft.)	Drogue Size (ft.)	Main Velocity (ft./s)	Drogue Velocity (ft./s)	Landing Velocity (ft./s)	Drogue Kinetic Energy (ft.-lbf.)	Landing Kinetic Energy (ft.-lbf.)
Nosecone	4.4	7	2	14.50	76.88	14.14	403	13.66
Payload	15.0						1,376	46.57
Aft	14.9	6	1.5	14.93	80.40	14.61	1,495	49.38

Predicted Drift

- Predictions based on wind velocity * descent time

Simulation	Cross Wind Velocity (ft./s)						
Section	Program	Descent Time (s)	0	5	10	15	20
Fore	MATLAB	115.7	0	579	1,157	1,735	2,314
	OpenRocket	100.2	0	501	1002	1503	2004
Aft	MATLAB	111.5	0	558	1115	1672	2230
	OpenRocket	100	0	501	1002	1503	2004

Ejection Charges

- Estimated charge for sub-scale: 0.0367 oz.
- Required five times estimated
- Rerun calculation for full scale
- Secondary charges 150% primary

Sub-Scale Test Results	
Charge size (oz.)	Pass/Fail
0.052911	fail
0.070548	fail
0.088185	fail
0.141096	pass

Subscale Launch

Sub-Scale Launch Vehicle

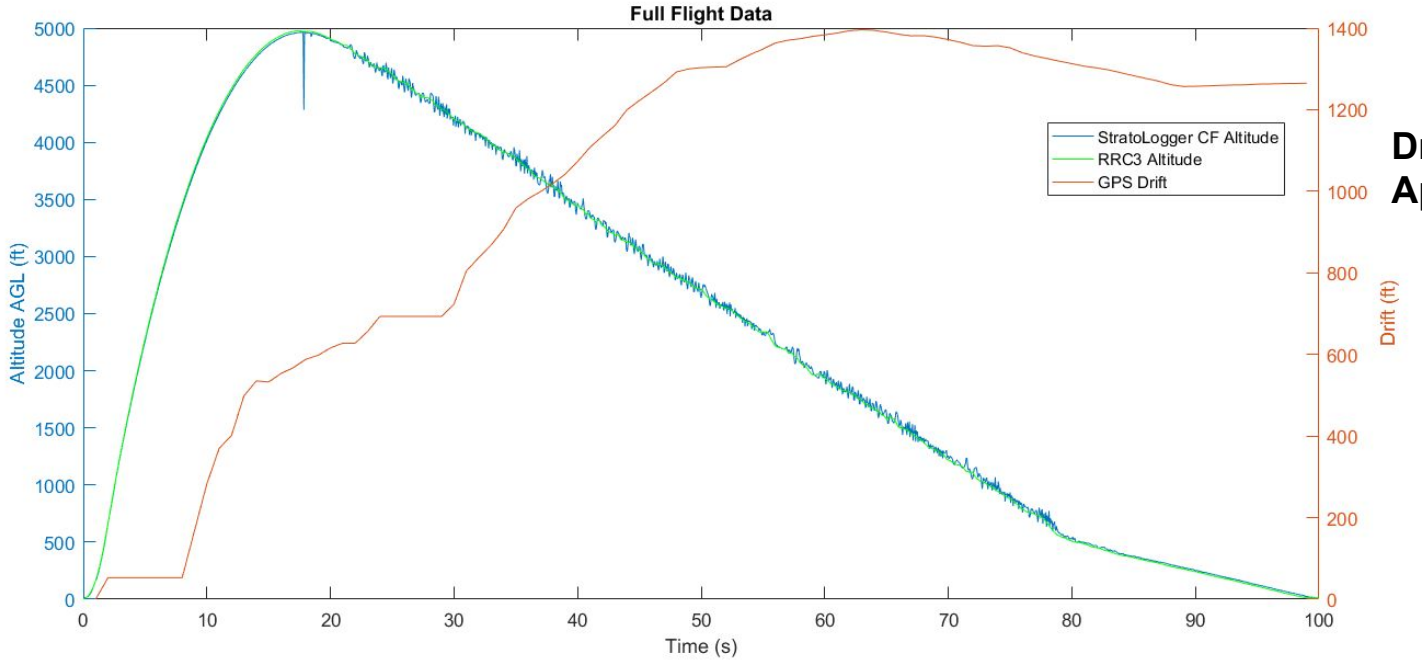
- Sub-scale parameters:
  - 4 in. Mad Dog DD rocket
  - ⅘ size of full-scale rocket
  - 16.5 lb. at launch - 44% of full-scale
  - K1103x motor

Sub-Scale Launch

- Launch took place on January 6th, 2018 in Brothers, Oregon
- Results:

	Apogree	Max Velocity	Rail-Exit Velocity	Tumbling Descent Velocity	Landing Velocity
StratoLoggerCF	4,976 ft.	660.0 ft./s	80-120 ft./s	73.9 ft./s	25.2 ft./s
AltimeterThree	4,977 ft.	629.9 ft./s	85 ft./s	74.6 ft./s	25.9 ft./s
OpenRocket Sim	5,332 ft.	736.0 ft./s	118 ft./s	132.0 ft./s	14.8 ft./s

Sub-Scale Launch



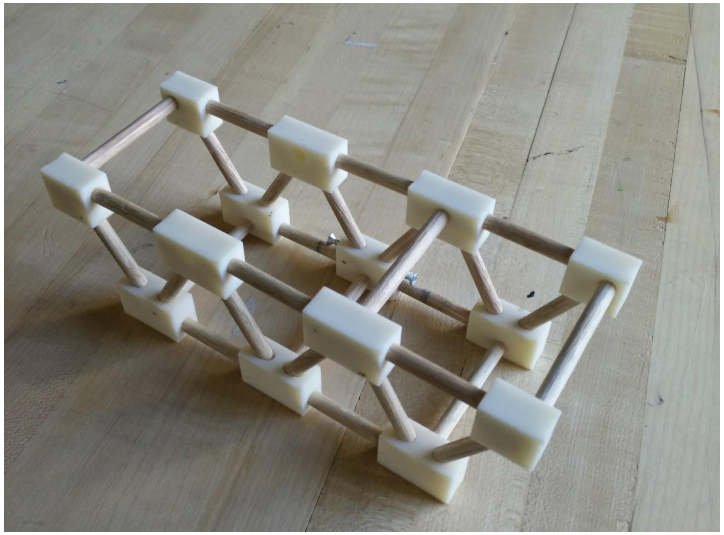
Drift: 1265 ft.
Apogee: 4977 ft.

Payload Overview

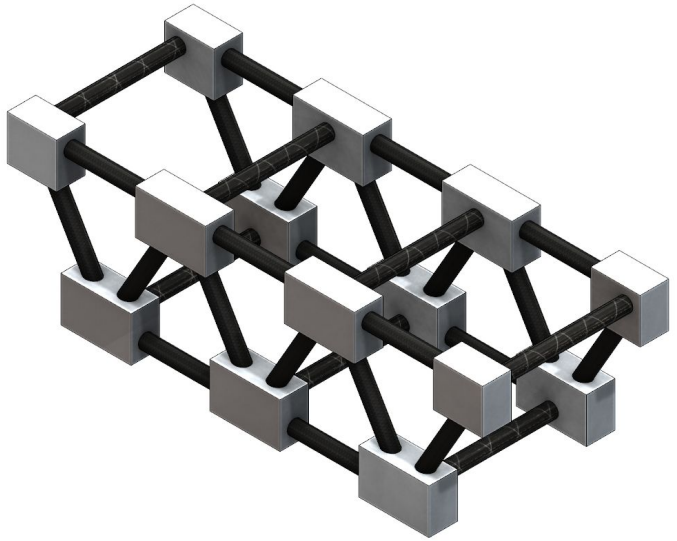
- Compressed Wheel Diameter: 4.8 in.
- Expanded Wheel Diameter: 6.05 in.
- Rover Length: 10.625 in.
- Rover Mass: 4.53 lb.
- Ejection Mass: 4.07 lbs.

Payload: Rover Chassis

Aluminum and Carbon Fiber Truss



Oak and ABS Prototype

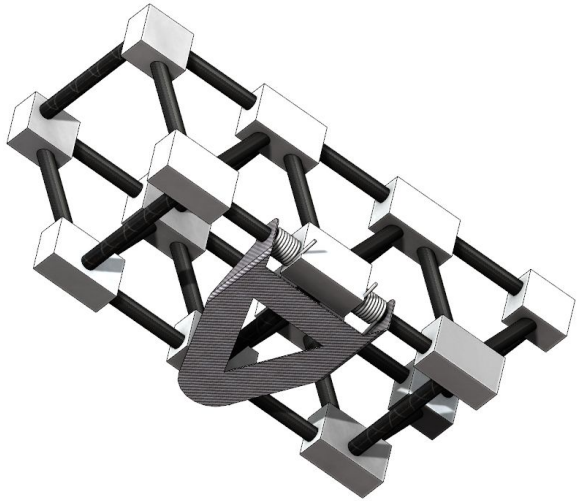


Final Design

Payload: Rover Stabilizer

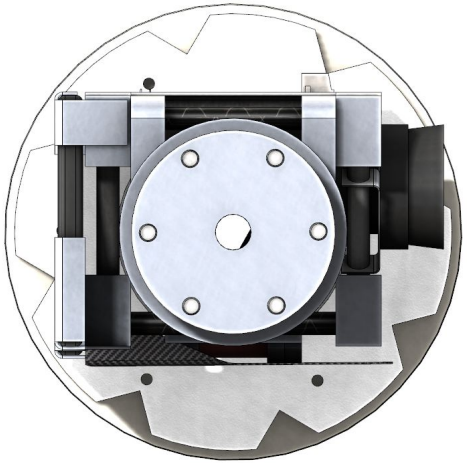
Spring-Loaded Carbon Fiber Stabilizer

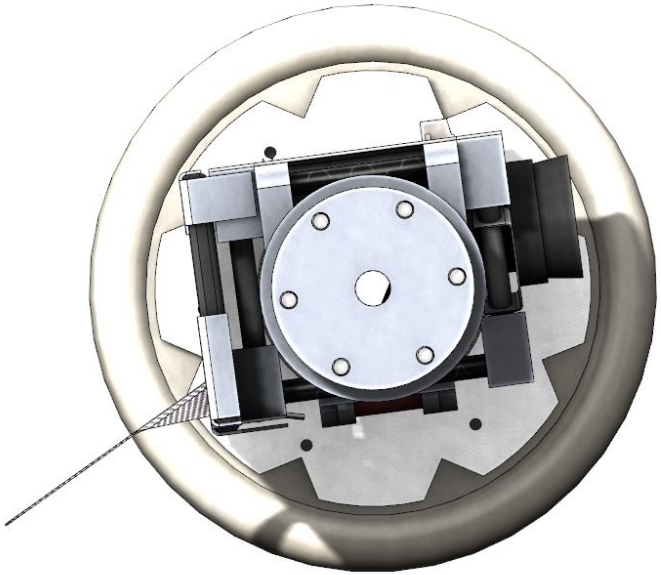
Sheet Metal Prototype



Final Design

Payload: Deployment



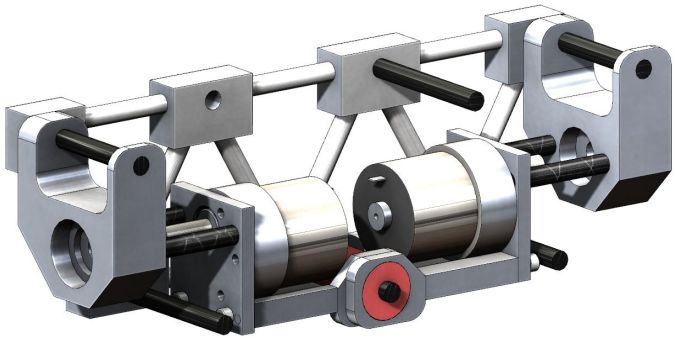


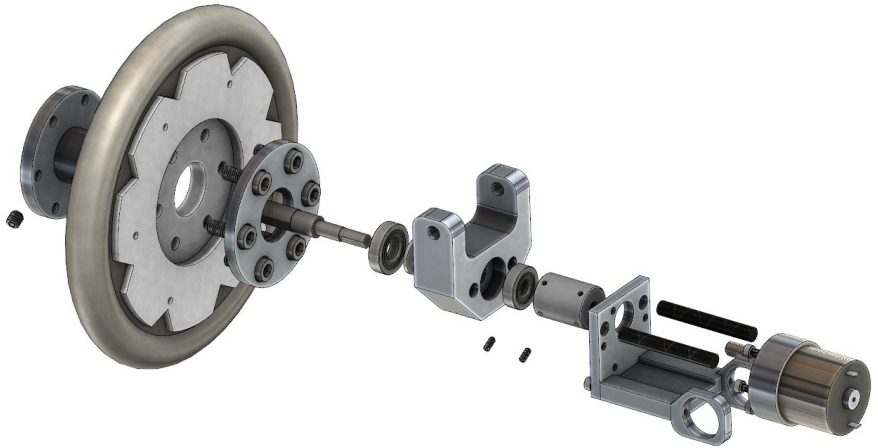
- Compressed to 4.8 in.
- Stabilizer folded

- Expanded to 6.05 in.
- Stabilizer extended

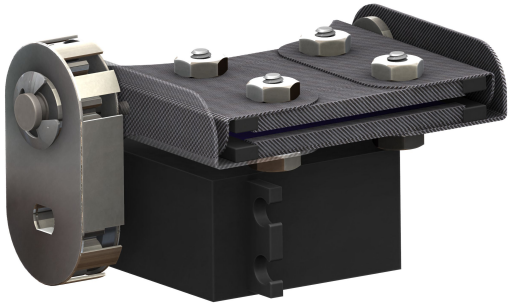
Payload: Rover Drivetrain

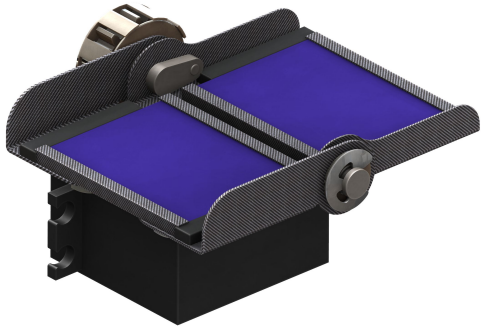
- Compressed Wheel Diameter: 4.8 in.
- Expanded Wheel Diameter: 6.05 in.
- Max Motor Torque: 7.81 lb.-in.
- Max rpm: 146 rpm





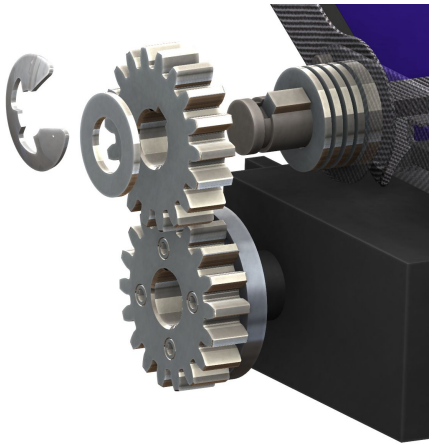
Payload: Rover Solar

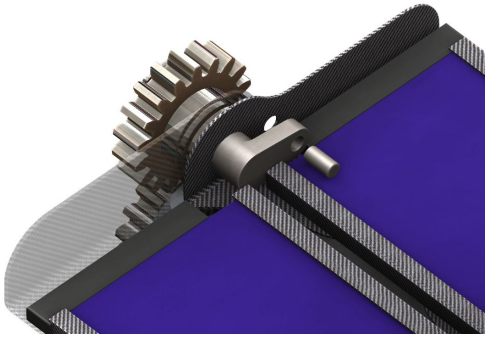


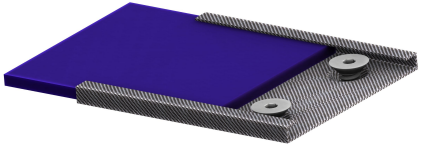


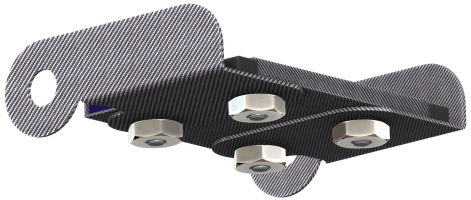
- Fully enclosed panels
- Carbon fiber shield
- Foam padding
- Enclosed gears
-
- 1800 expansion
- 188.9 oz.-in. servo
- 8.0 lb. end-panel actuation

Payload: Rover Solar





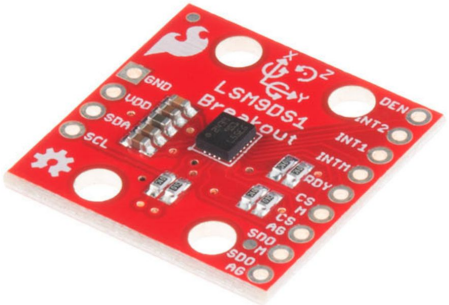




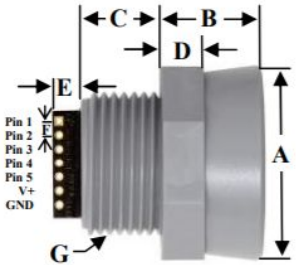
- Steel Gears
- Spring Retaining Clips
- Keyed Shaft
- Sliding Panel
- Threaded Fasteners

Payload: Rover Electronics

- Object Detection Sensors (Sonar)
- Inertial Localization (IMU)
- Light Detection Sensor



Compact Housing

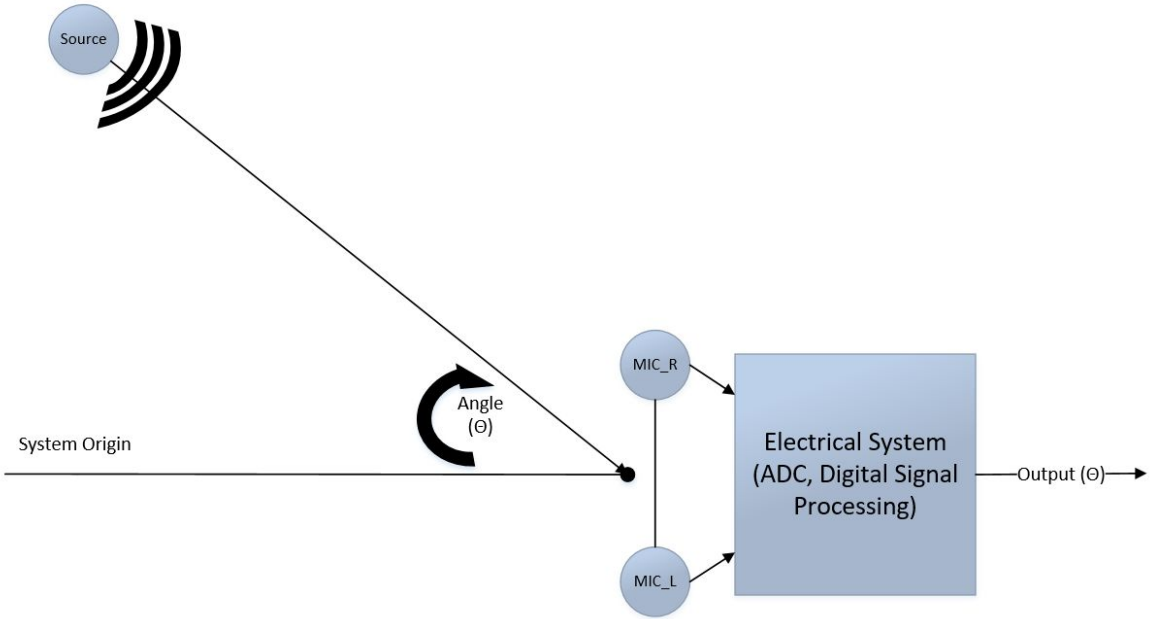


A	1.37” dia.	34.7 mm dia.
B	0.70”	17.9 mm
C	0.57”	14.4 mm
D	0.31”	7.9 mm
E	0.23”	5.8 mm
F	0.1”	2.54 mm
G	3/4”-14 NPS	
H	1.032” dia.	26.2 mm dia.
I	1.37”	34.8 mm
Weight, 1.23 oz., 32 grams		

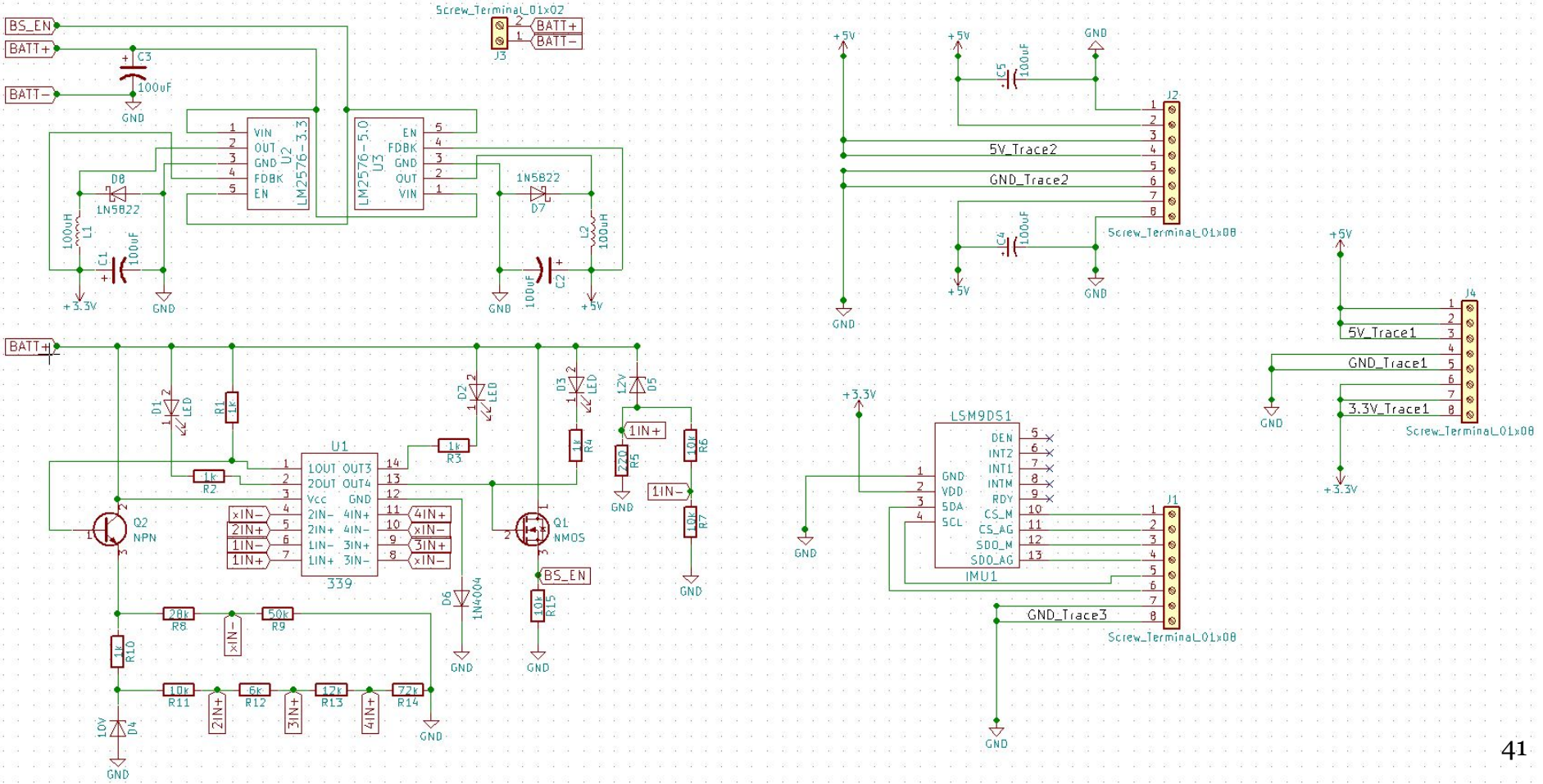
Values Are Nominal

Payload: Rover Electronics

Waypoint Localization System

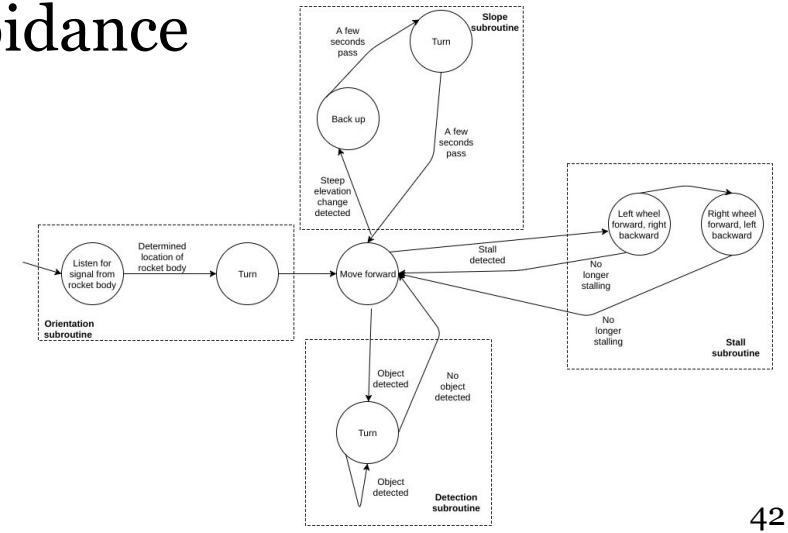


Payload: Rover Electronics

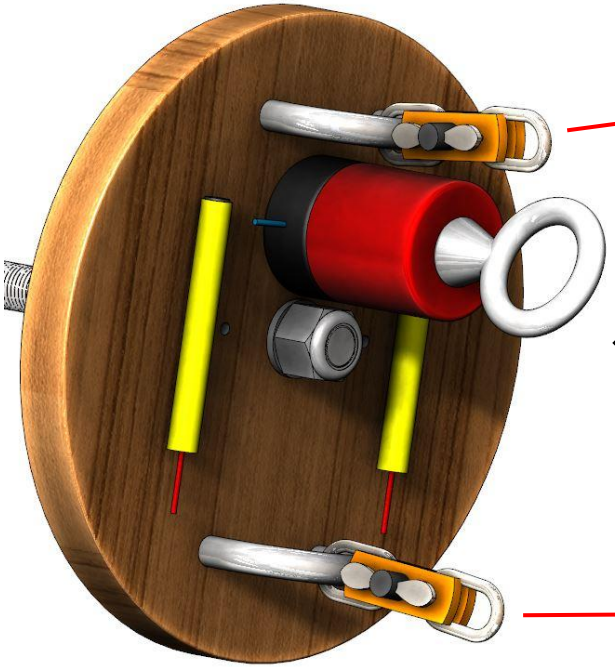


Payload: Rover Software

- ROS on the Raspberry Pi - algorithm hierarchy
  - Simultaneous location and mapping
  - Sensor-based object avoidance
  - Basic movement



Payload: Retention Mechanism



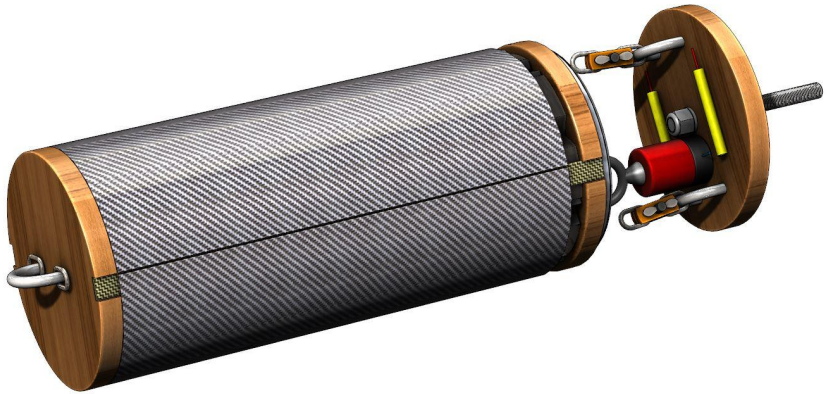
PRIMARY

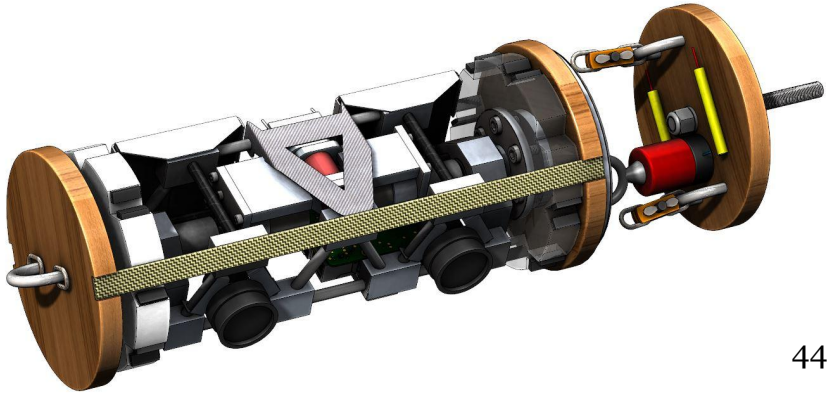
SECONDARY

- Secondary: 300 lb. kevlar cord
- Figure-eight follow through knot

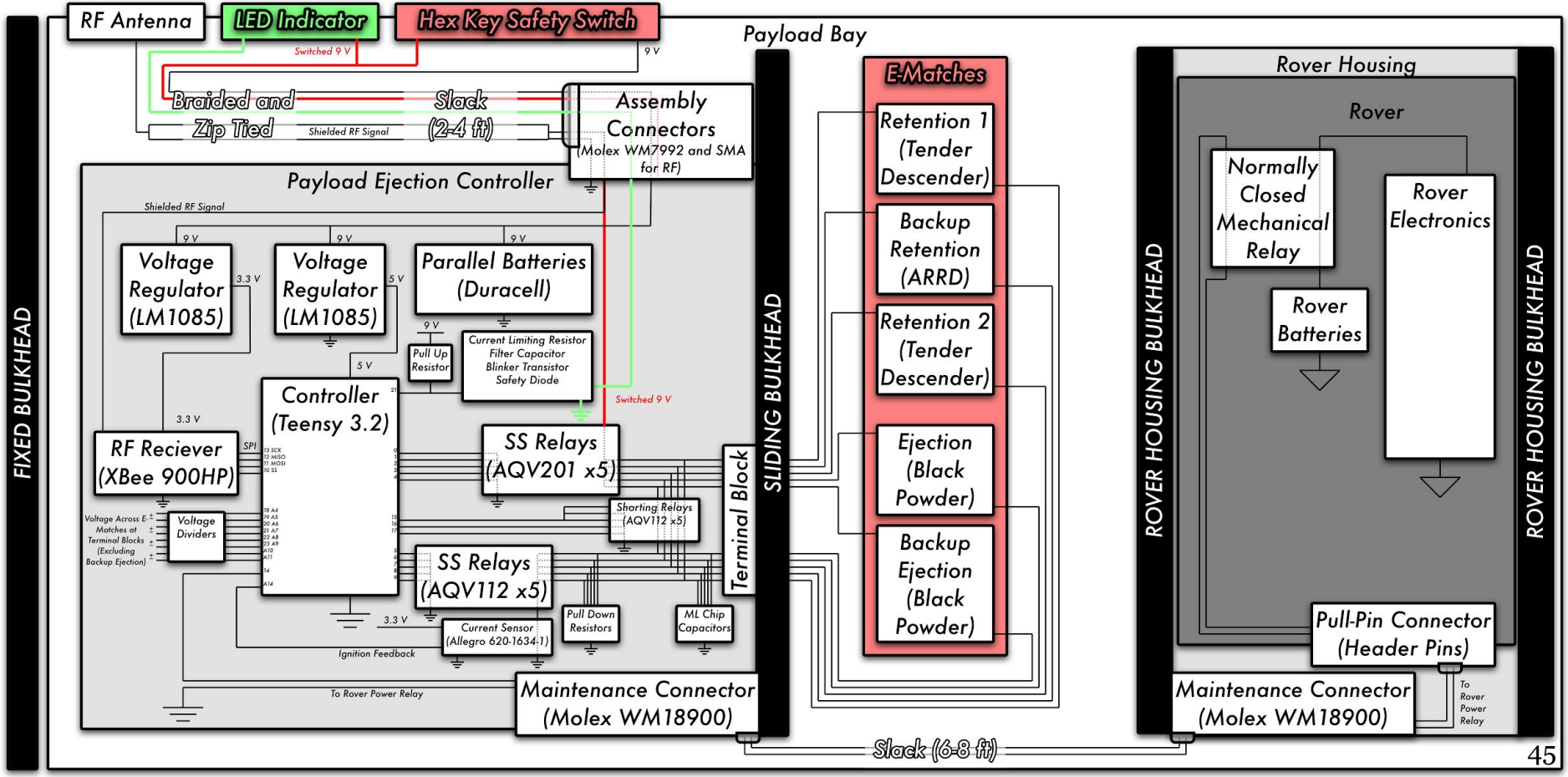
Payload: Ejection Mechanism

- Carbon fiber wrap, Kevlar straps, Plywood bulkheads
- Black powder charges: 6 g
- Mechanisms: 3.63 lb.
- Controllers: 0.44 lb.





Payload: Ejection Controller



Test Plans

- Major testing procedures include:
  - Separation Ejection Testing
  - Launch Vehicle Assembly Testing
  - Payload Ejection Testing
  - Payload Performance Testing:
    - Hill Climb
    - Maximum Velocity
    - Obstacle Detection
    - Solar Deployment

Test Plans: Separation Ejection

- Passing Conditions:
  - Success: separation of sections and parachute ejection from packing; tether fully extended
  - Types of Failures: Strength, Ejection, and Partial Separation
- Test Materials Required:
  - Black powder
  - Pressure sensor
  - Ejection interface
- Test Procedure:
  - Attach charges to bulkhead
  - Attach pressure sensor
  - Close body tubes/insert shear pins
  - Perform safety protocols
  - Initiate test
  - Record results test
  - Record pressure data
  - Repeat as necessary

Test Plans: Separation Ejection

- Status - *Incomplete*
  - Failed for subscale - only one test complete
  - Scheduled to be done during January and February 2018 testing

Test Plans: Launch Vehicle Assembly

- Passing Conditions:
  - Total weight < 45 lbs.
  - Time required < 2.5 hrs.
  - Internal volume > 4500 $in.^3$
  - Component number < 40
- Test Materials Required:
  - Precise scale
  - Timer
  - Measuring tape
- Test Procedures:
  - Measure interior space
  - Start timer
  - Assemble the launch vehicle
  - Stop timer
  - Place vehicle on scale
  - Count components

Test Plans: Launch Vehicle Assembly

- Status - *Incomplete*
  - Scheduled to be done during January and February 2018 testing

Test Plans: Payload Ejection

- Passing Conditions:
  - Rover clears airframe
  - Avoid entanglement
  - Successful 5 ft. travel
- Test Materials Required:
  - Test apparatus
  - Payload ejection housing
  - Rover payload
  - E-matches
  - Black powder
- Test Procedures:
  - Secure airframe
  - Place black powder charge
  - Insert dummy payload
  - Secure the payload housing
  - Activate charges
  - Retrieve rover

Test Plans: Payload Ejection

- Status - *Incomplete*
  - Scheduled to be tested in January

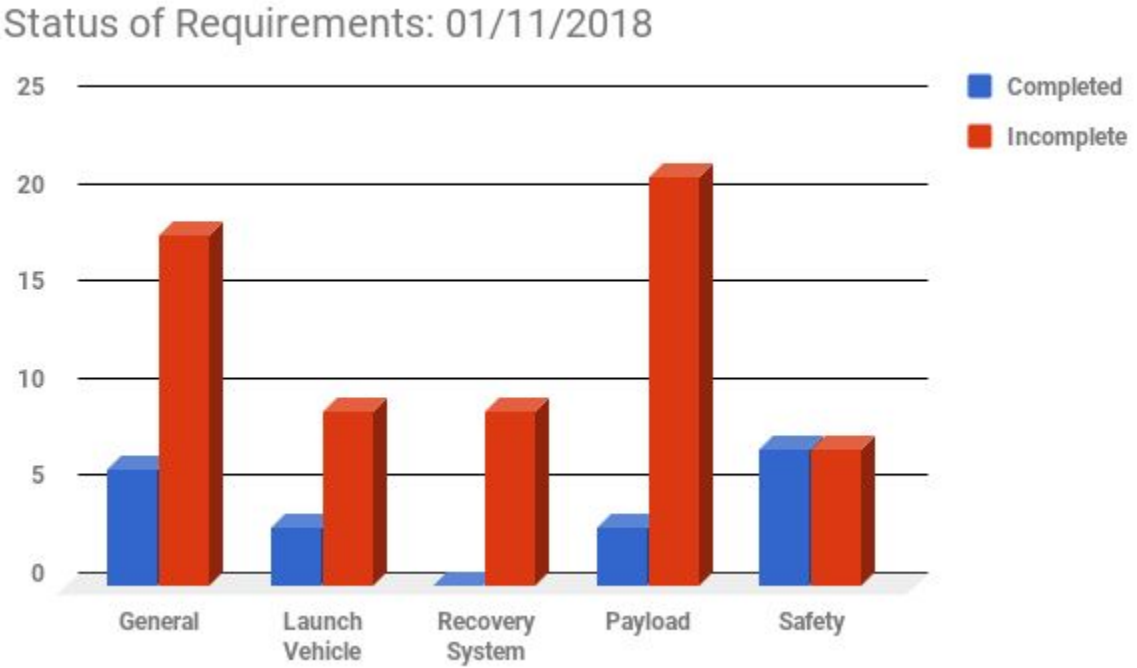
Test Plans: Payload Performance

- Hill Climb:
  - Success: Target hillclimb of 30° hill for fully assembled rover
- Maximum Velocity:
  - Success: Target velocity of 5 ft./s on a tiled, level field
- Object Detection:
  - Success: Ensure 90% pass rate for static assembly
- Solar Deployment:
  - Success: Ratio of successful tests is above 90%

Test Plans: Payload Performance

- Status - *Incomplete*
  - Scheduled to be done during January and February 2018 testing

Requirement Verification



Educational Outreach

- Four Outreach Events Completed
  - Silver Crest Middle School - 19 students
    - Model Rocket Launch
  - Philomath Middle School - 21 students
    - Model Rocket Launch
  - Sprague High School - 191 students
    - Aerodynamics, Matchstick Rockets, & Electromagnetism
  - Walker Middle School - 191 students
    - Electromagnetism & Mousetrap Cars
  - 422 students reached!

Educational Outreach

- Future Events
  - West Salem High School
  - Corvallis High School
- Future Planning
  - Connections with STEM district managers for events next year i.e. Science fairs, events, and guest presentations
  - Writing up all lesson plans generated during group “think tanks”

Questions?