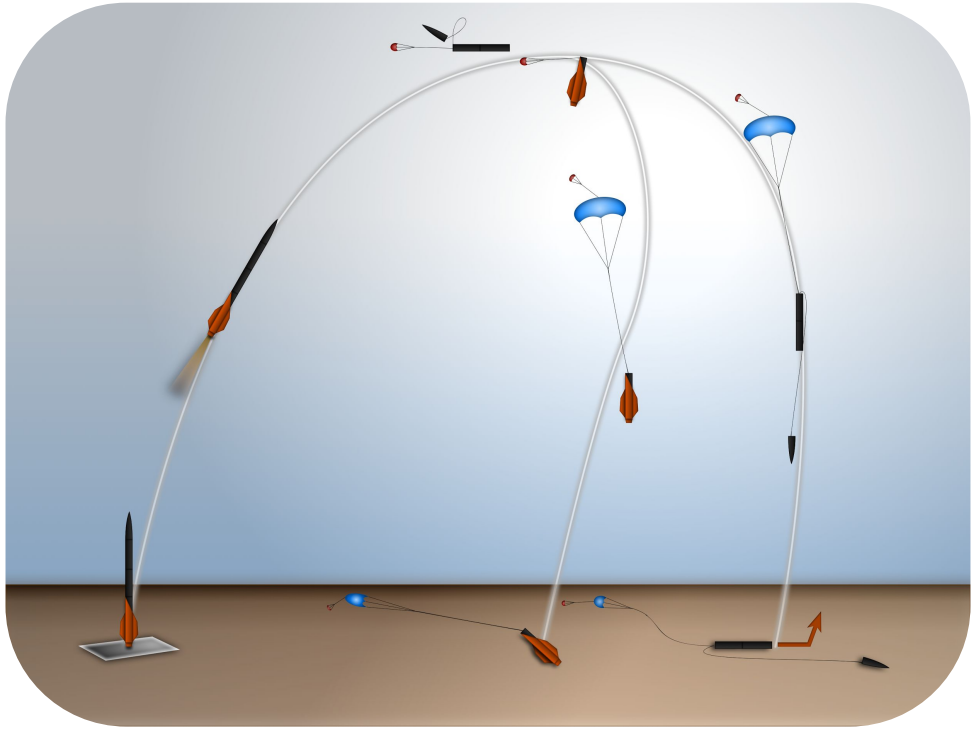
Oregon State University NASA USLI PDR

11/17/2017

Mission Overview

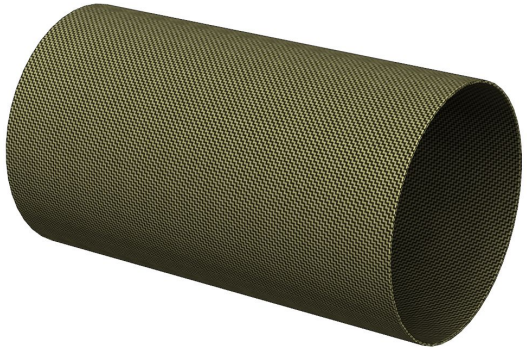


Structural Overview

- 45.2 lbs at launch
- 5” diameter
- 116” length

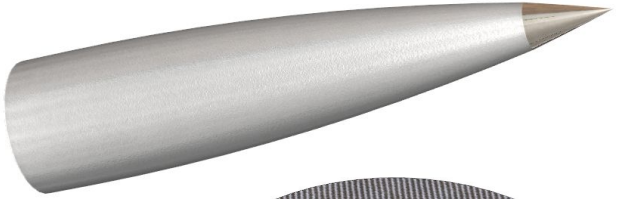
Body Materials

- Carbon Fiber Airframe
  - 2 sections, 50” and 46”
- Fiberglass Coupler Tubes
  - 2 coupler sections, 8” each

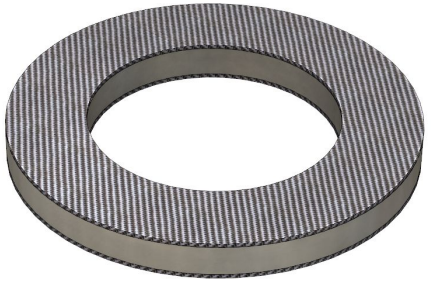


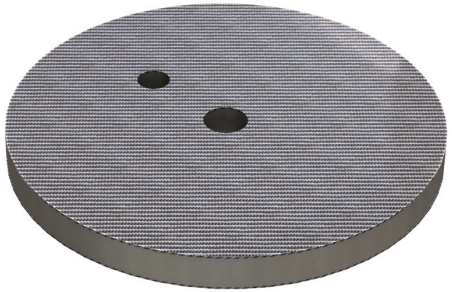
Nosecone and Bulkheads

- Nosecone:
  - Fiberglass with aluminum tip



- 5 Bulkheads, 2 Centering Rings
  - Carbon fiber and Nomex
  - 0.38” Nomex
  - 0.024” carbon fiber





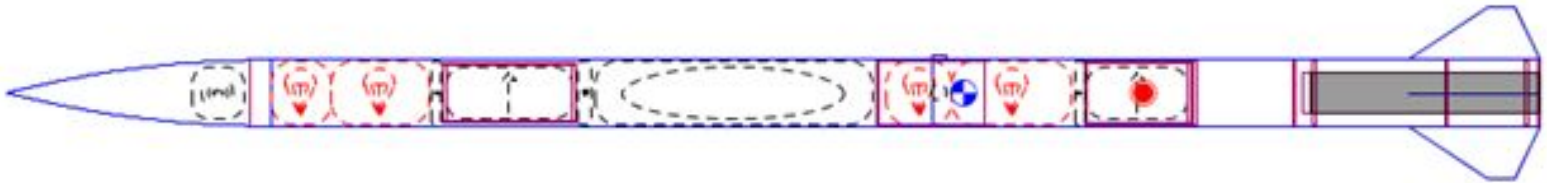
Motor Selection and Justification

- Requirements:
  - APCP motor
  - Plugged motor
- **Aerotech L1420R**
  - Total impulse: 4616 N-s
  - Mounting diameter: 75 mm
  - Thrust-to-weight ratio: 6.74
  - Rail exit velocity: 68 ft/s

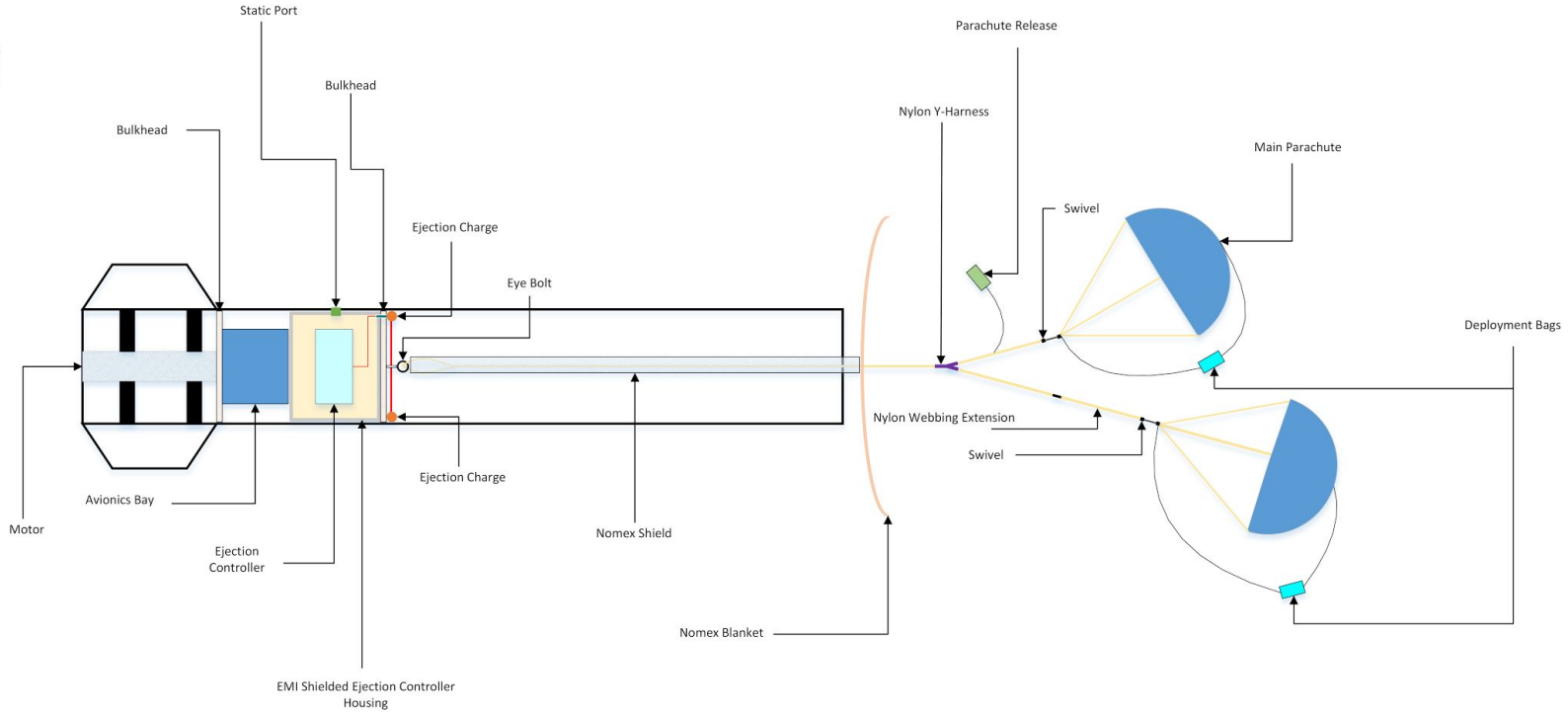
Aerodynamics/Recovery Overview

Aerodynamic System:

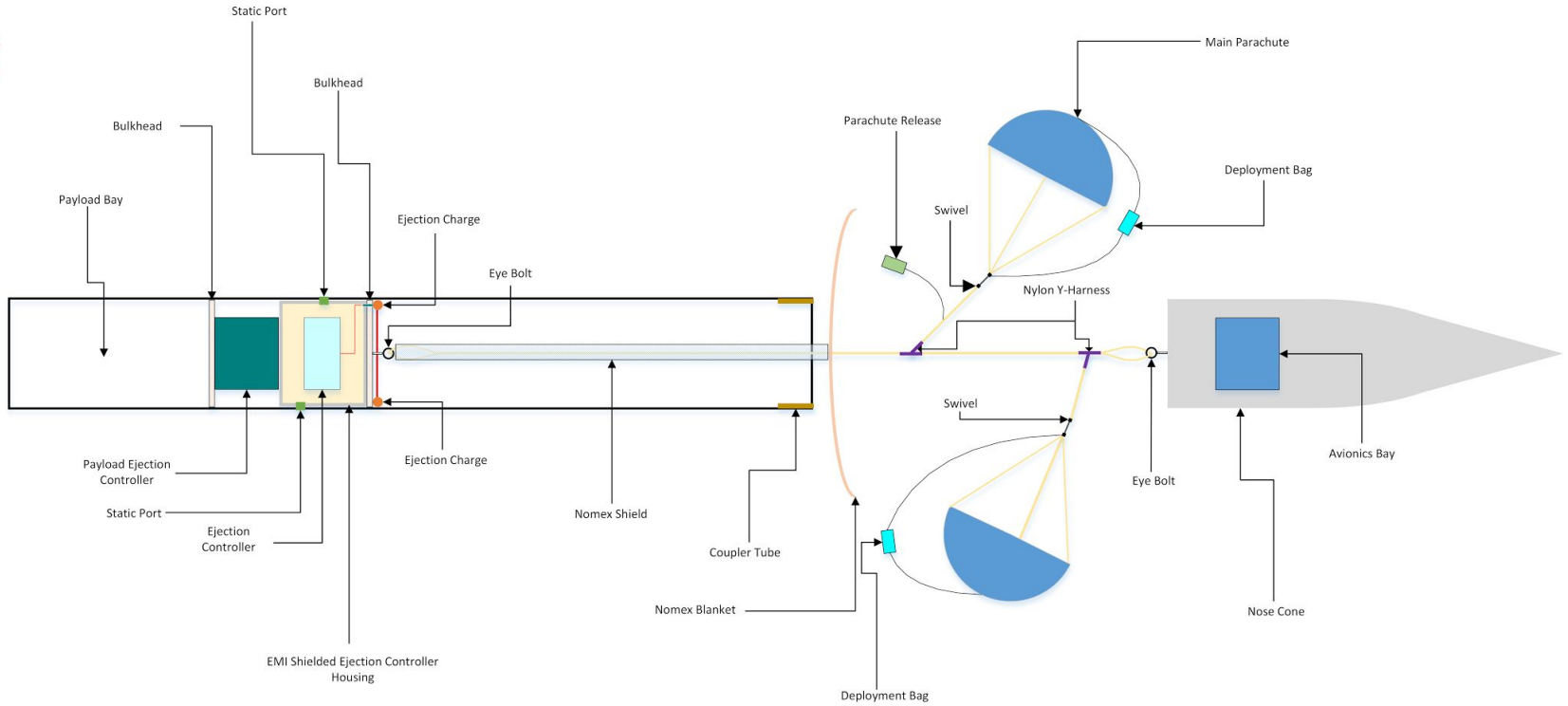
- CG is 72.4 inches, CP is 86.0 inches aft of tip
- Stability: 2.87 calipers
- Estimated Altitude: 5900 feet
- Ogive nosecone and clipped delta fins



Recovery Overview: Aft Section

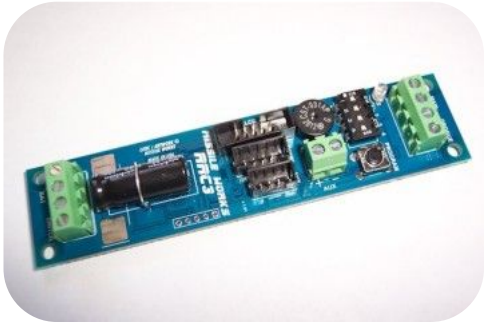


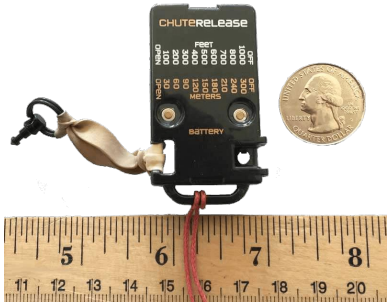
Recovery Overview: Fore Section



Aerodynamics/Recovery: Ejection

- Black Powder Ejection Charges
- Separation: Missile Works RRC3
- Parachute Release: Jolly Logic Chute Release



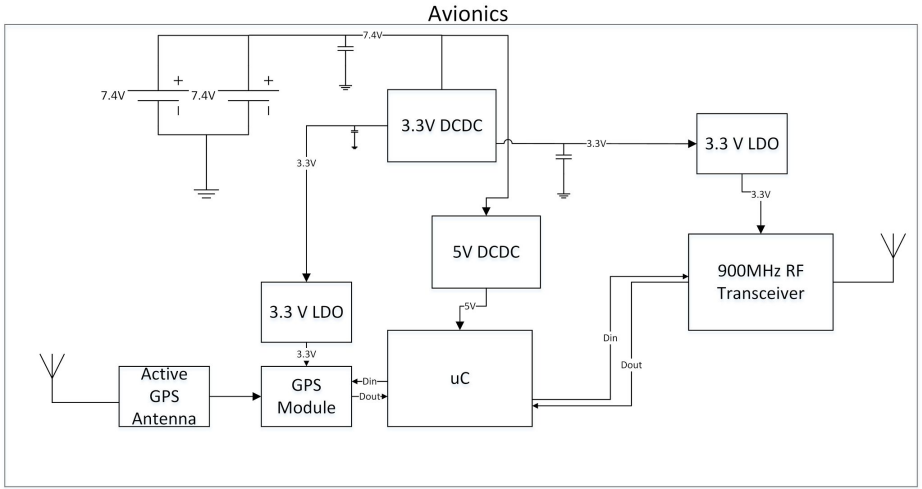


Aerodynamics/Recovery: Parachutes

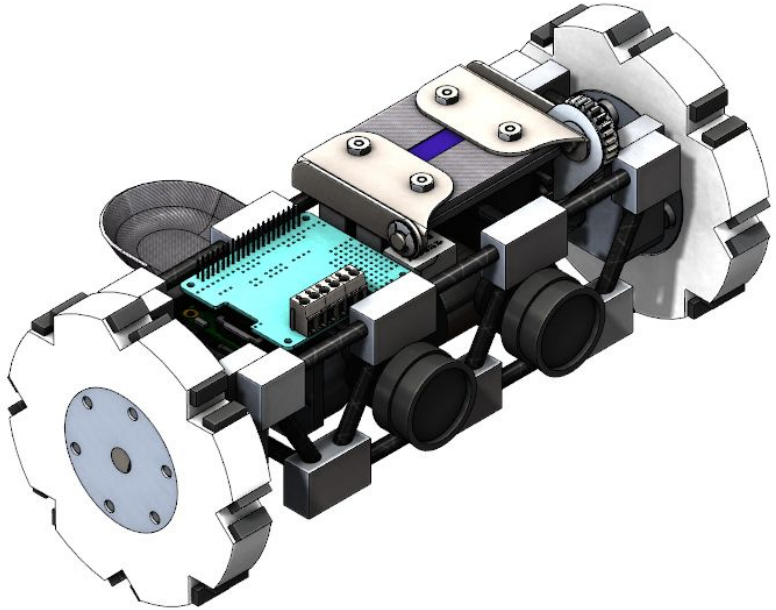
- Main Parachutes: Fruity Chutes Iris Standard
- Drogue Chutes: Fruity Chutes Classic Elliptical
- Drogue Velocities: ~130 ft/s
- Main Velocities: ~13 ft/s
- Landing KE: 55.0 ft-lbf, 51.1 ft-lbf

Aerodynamics/Recovery: Avionics

Component	Specs
RF Transceiver	900 MHz, 1 W
GPS	65 Channel, 30s TTFF, -166dBm Rx Sensitivity
Power Supply	5000mAh, 2 Cell, 20C LiPo Batteries
GPS Antenna	30dB active antenna
RF Antenna	Whip monopole
Micro Controller	Teensy 3.6, ARM Cortex M4, 32 bit



Rover Payload: Overview

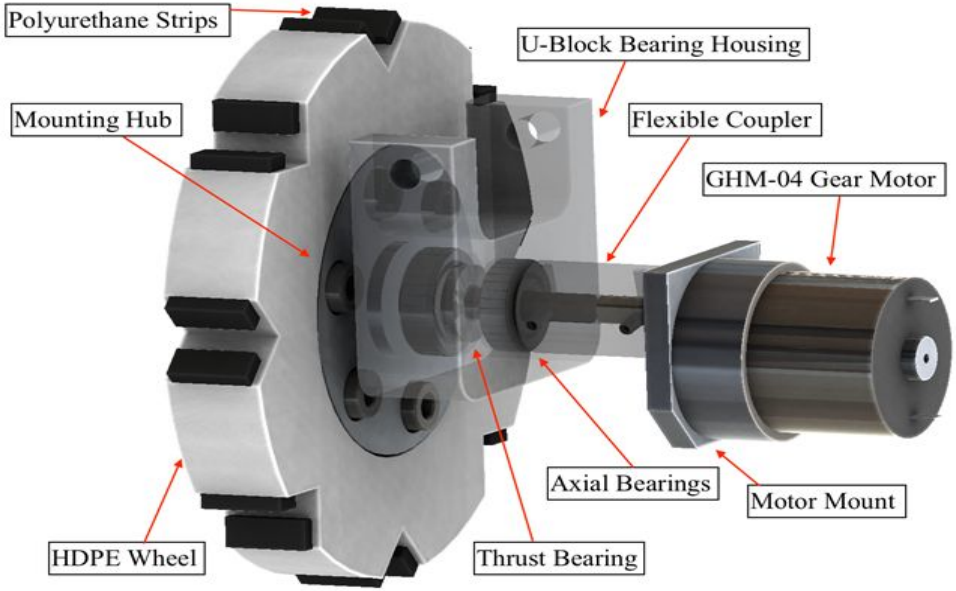


Technical Specifications

- 5.05 pounds
- 4.5 inches in diameter
- 5 ft/s top speed
- 10.625 inches long

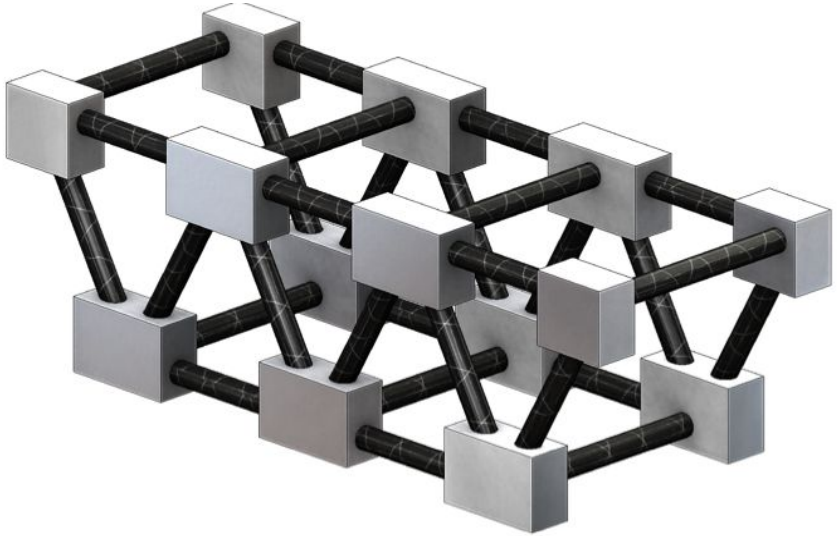
Rover Payload: Drive Train

- 7.81 lbs.-in. max torque
- Carbon fiber axle
- ¾” thick HDPE wheel
- Load dissipation from wheel through U-block

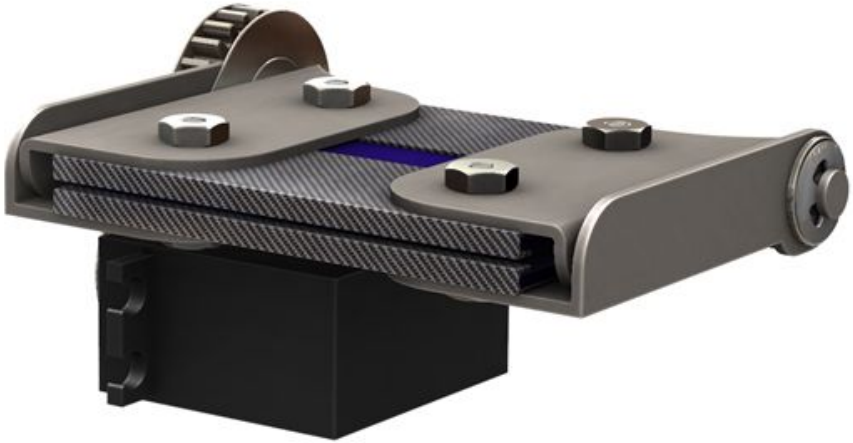


Rover Payload: Chassis

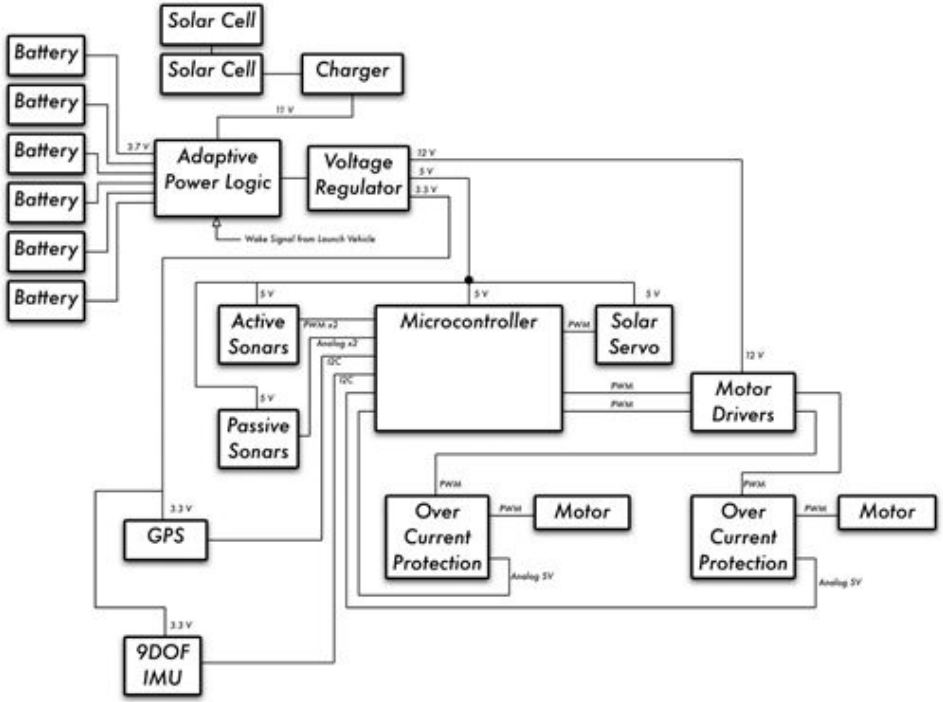
- 0.25” carbon-fiber rods
- Aluminum joints
- Drivetrain and electronics attached inside
- High compressive strength



Rover Payload: Solar Deployment



Rover Payload: Electronics



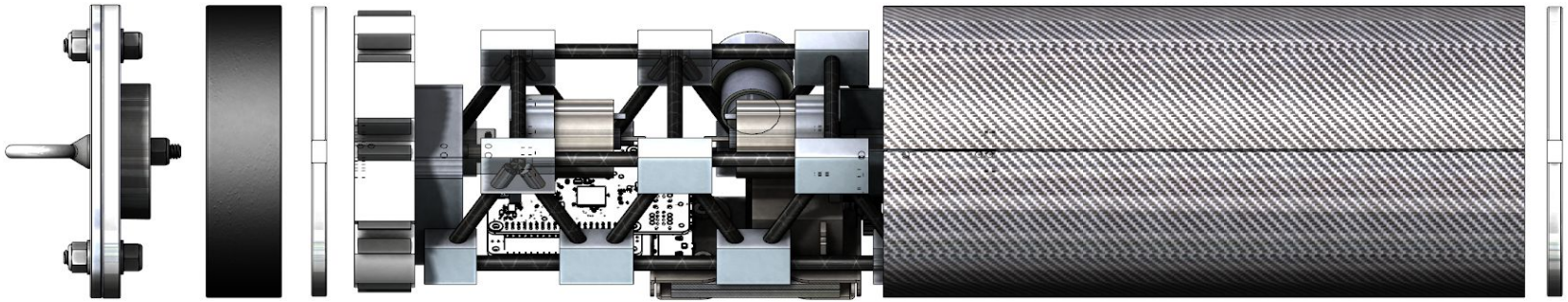
Rover Payload: Retention

Rattworks Advanced Retention Release Device

- Proof load tested to 2,000 lbs
- Activated by air pressure or Pyrodex
- Fixed to nose cone bulkhead and rover housing

Rover Payload: Ejection

- Black powder ejection upon landing



Requirement Compliance Plan

- Ejection testing
  - 5” mockup airframe currently being designed
  - Will determine final black powder loads/reliability
- Subscale testing
  - Before Critical Design Review
  - 4” diameter launch vehicle
- Full scale testing
  - Before Flight Readiness Review

Educational Outreach:

First Outreach Event: October 27th, 2017

Silver Crest School (K8) - Built and launched model rockets (A-motors) on the OSU campus after a presentation about rocketry. Provided a tour of the local AIAA chapter lab space.

Future Outreach Events:

- November
  - Sprague & Sunset High Schools
- All Later Months
  - Coordinating schools with alumni information and availability.

Questions?

Decision Matrices

Structures/Propulsion: Main Body

Main Body Material Alternatives							
Design		Fiberglass		**Carbon Fiber**		Aluminum 6061-T6	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Weight	10	8	80	10	100	6	60
Thermal Conductivity	3	10	30	8	24	6	18
Cost	3	8	24	4	12	10	30
Strength	8	8	64	10	80	4	32
Ability to Modify	8	7	56	6	48	10	80
Total		**254**		**264**		**220**	

Structures/Propulsion: Nose Cone

Nose Cone Material Alternatives					
Design		**Fiberglass**		Carbon Fiber	
Requirement	Weight	Value	Score	Value	Score
Weight	7	8	56	10	70
Cost	4	6	24	2	8
Strength	8	7	56	10	80
Ease of Manufacture	9	7	63	7	63
RF Transparent	10	8	80	0	0
Total		**279**		**221**	

Structures/Propulsion: Nose Cone

Nose Cone Tip Alternatives							
Design		None		**Aluminum**		Steel	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Weight	8	10	80	7	42	4	32
Cost	5	5	25	5	25	5	25
Strength	8	5	40	7	56	9	72
Ease of Manufacture	10	4	40	10	100	8	80
Total		**185**		**223**		**209**	

Structures/Propulsion: Motor

Motor (75mm) Alternatives							
Design		L1420R		**L1390**		L850W	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Length	4	4	16	7	28	7	28
Weight	8	4	32	7	56	8	64
Thrust	6	9	56	7	42	4	24
Acceleration	3	4	12	4	12	6	18
Total		**116**		**138**		**134**	

Aerodynamics/Recovery: Nosecone

Nosecone Alternatives							
Design		**Ogive (4:1)**		Elliptical		Cone	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Coefficient of drag	10	9	90	8	80	6	60
Ease of manufacturing	7	5	35	4	28	8	56
Ease of purchasing	3	8	24	2	6	2	6
Total		**149**		**114**		**122**	

Aerodynamics/Recovery: Fins

Tail Fins Alternatives							
Design		Elliptical		Trapezoidal		Delta	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Lift to drag ratio	10	10	60	8	80	8	80
ease of manufacturing	8	4	32	8	64	6	48
Total		**92**		**144**		**128**	

Aerodynamics/Recovery: Configuration

Recovered Sections Alternatives							
Design		Single Section		**Two Sections**		Three Sections	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Landing Kinetic Energy	10	6	60	10	100	10	100
Recovery Radius	7	6	42	8	56	5	49
Ease of Integration (Structures)	3	10	30	7	21	4	12
Ease of Integration (Recovery)	6	9	54	5	30	2	12
Ease of Integration (Payload)	5	5	25	7	35	7	35
Total		**211**		**242**		**194**	

Aerodynamics/Recovery: Configuration

Number of Ejection Events per Section Alternatives					
Design		**Single Event**		Dual Event	
Requirement	Weight	Value	Score	Value	Score
Inflation Reliability	8	9	72	8	64
Entanglement Susceptibility	8	9	72	8	64
Descent Stability	2	9	18	8	16
Ease of Integration (Structures)	4	8	32	8	32
Ease of Integration (Recovery)	6	9	54	7	42
Total		**248**		**218**	

Aerodynamics/Recovery: Ejection

Parachute Ejection System Alternatives					
Design		Black Powder		CO2	
Requirement	Weight	Value	Score	Value	Score
Pressure Created	3	3	9	2.5	7.5
Reliability	3	4	12	1	3
Possible Damage	1	1	1	4	4
Cost	1	4	4	2	2
volume required	2	5	10	2	4
Total		**36**		**20.5**	

Aerodynamics/Recovery: Parachutes

Canopy Shape Alternatives							
Design		Elliptical		Semi-Elliptical		**Toroidal**	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Coefficient of Drag	10	5	50	6	60	9	90
Entanglement Susceptibility	8	9	72	9	72	6	48
Pack Volume	10	3	30	6	60	9	90
Cost	4	9	36	6	24	3	12
Total		**188**		**216**		**240**	

Aerodynamics/Recovery: Parachutes

Packing Method Alternatives							
Design		Fold and Wrap		**Deployment Bag**		Pressure Pack	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Packing Volume	10	3	30	6	60	9	90
Deployment Reliability	10	5	50	8	80	10	100
Packing Time	4	9	36	7	28	1	4
Ease of Integration	8	9	72	7	56	1	8
Cost	4	10	40	7	28	3	12
Total		**228**		**252**		**214**	

Aerodynamics/Recovery: Ejection Control

Ejection Altimeter Alternatives							
Design		**MissleWorks RRC3**		Raven3		Stratologger CF	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Deployment Reliability	10	10	100	8	80	7	70
Scale and Sensitivity	8	9	72	8	64	7	56
Programmability	6	7	42	9	54	6	36
Cost	4	6	24	6	24	8	32
Total		**238**		**222**		**194**	

Aerodynamics/Recovery: Ejection Control

Parachute Retainer Alternatives							
Design		Jolly Logic Chute Release		Tender Descender		**Defy Grav Tether**	
Controllability	7	7	49	9	63	9	63
Available Redundancy	10	5	30	8	80	8	80
Ease of Integration (Recovery)	5	9	50	6	30	6	30
Durability	5	7	35	7	35	9	45
Total		**179**		**208**		**218**	

Aerodynamics/Recovery: Avionics

RF Transceiver Alternatives									
Design		**Xbee-PRO SX**		Digi Xtend vB 900MHz		Murata DNT90MCA		ADAFRUIT RFM96W	
Requirement	**Weight**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Tx Power	9	9	81	9	81	3	27	2	18
Current Consumption	3	3	9	5	15	9	27	9	27
Data Rate	4	8	32	7	28	5	20	9	36
Cost	2	6	12	2	4	8	16	9	18
Max Range	8	8	64	9	72	1	8	2	16
Documentation	2	8	16	8	16	8	16	8	16
Communication Protocol	2	8	16	7	14	8	16	7	14
Total		**230**		**230**		**130**		**145**	

Aerodynamics/Recovery: Avionics

RF Base Station Antenna Alternatives							
Design		Yagi		Dipole		Parabolic/Dish	
Requirement	**Weight**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Gain	8	9	72	8	64	10	80
Power Handling	4	5	20	5	20	5	20
Cost	2	4	8	8	16	2	4
Size	2	4	8	7	14	2	4
Bandwidth	3	5	15	5	15	5	15
Polarization	3	8	24	5	15	5	15
Directionalization	5	8	40	2	10	4	20
TOTAL		**187**		**154**		**158**	

Aerodynamics/Recovery: Avionics

RF Rocket Antenna Alternatives							
Design		**Whip**		PCB		Wire	
Requirement	**Weight**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Gain	8	9	72	9	72	3	24
Power Handling	4	7	28	4	16	6	24
Cost	2	5	10	6	12	7	14
Size	4	4	16	8	32	8	32
Bandwidth	3	8	24	8	24	8	24
Ease of Implementation	5	8	40	2	10	8	40
Directionalization	4	8	32	6	24	6	24
TOTAL		**222**		**190**		**182**	

Sources: http://1.bp.blogspot.com/-B_jOlbrTXc4/TfYn3rL24XI/AAAAAAAACN0/JOSGAyFXFa8/s1600/dipole-radiation-pattern.jpg

Aerodynamics/Recovery: Avionics

GPS Module Alternatives									
Design		GlobalTop PA6H		Trimble Copernicus II		UBlox MAX-M8Q-0		SparkFun Venus GPS	
Requirement	Weight	Value	Score	Value	Score	Value	Score	Value	Score
Rx Sensitivity	8	7	56	5	40	9	72	9	72
Current Consumption	2	7	14	3	6	8	16	5	10
Cost	2	5	10	5	10	5	10	3	6
Time To First Fix	9	7	63	4	36	8	72	8	72
Communication Protocol	3	7	21	7	21	7	21	7	21
Number Of Channels	6	6	36	2	12	8	48	7	42
Ease of Use	9	3	27	3	27	3	27	8	72
Max Acceleration Force	6	8	48	4	24	8	48	8	48
TOTAL		275		176		314		343	

Rover Payload: Solar Assembly

Solar Expansion Method Alternatives									
Design		Rolling		Sliding		**One Folding**		Two Folding	
Requirement	**Weight**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Rover Mass	5	8	40	7	35	5	25	3	15
Volume	7	7	49	5	35	7	49	4	28
Mechanical Complexity	4	3	12	6	24	5	20	8	32
Robustness	9	5	45	6	54	8	72	7	63
TOTAL		**146**		**148**		**166**		**138**	

Rover Payload: Sensors

Object Detection Alternatives							
Design		LIDAR		**SONAR**		RADAR	
Requirements	**Weight**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Rover Mass	10	2	20	8	80	8	80
Volume	10	1	10	6	60	6	60
Detection Range	4	9	36	6	24	5	20
Detection Reliability	7	8	56	7	49	5	35
Number of moving parts	8	2	16	9	72	9	72
Battery discharge time	3	3	9	9	27	7	21
Number of sensors needed	6	7	42	3	18	3	18
TOTAL		**189**		**330**		**306**	

Rover Payload: Sensors

Sonar Alternatives									
Design		MB1040 LV-MaxSonar-EZ4		MB1020 LV-MaxSonar-EZ2		**MB7360 HRXL (Compact/IP67)**		MB7062 XL-MaxSonar-WR1	
Requirements		**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Rover Mass	10	6	60	6	60	5	50	5	50
Volume	10	6	60	6	60	5	50	5	50
Detection Range	4	6	24	5	20	6	24	6	24
Detection Reliability	7	6	42	5	35	8	56	6	42
Durability	10	3	30	3	30	8	80	8	80
Battery discharge time	3	6	18	6	18	5	15	5	15
Number of sensors needed	6	3	18	3	18	3	18	3	18
TOTAL		**252**		**241**		**293**		**279**	

Rover Payload: Chassis

Chassis Alternatives							
Design		**Al Frame**		Al Sheet		Foam Composite	
Requirements	**Weight**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Rover mass	1	3	3	4	4	6	6
Internal Volume	6	7	42	6	36	2	12
Ground clearance	4	6	24	6	24	2	8
Robustness	10	8	80	6	60	7	70
TOTAL		**149**		**124**		**96**	

Rover Payload: Stabilizer

Stabilizer Alternatives							
Design		Orthogonal 2-hinge		**Orthogonal 1-hinge**		Parallel	
Requirement	**Weight**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
Rover mass	2	2	4	10	20	8	16
Climb Angle	4	7	28	3	12	6	24
Robustness	8	5	40	8	64	3	24
TOTAL		**72**		**96**		**64**	

Rover Payload: Ejection

Ejection Methods Alternatives							
		Airframe clamshell		Out the end		Parachute assisted	
Criteria	Weight	Rating	Score	Rating	Score	Rating	Score
Mass	5	7	35	3	15	2	10
Ease of activation	2	3	6	5	10	3	6
Reliability	10	1	10	6	60	2	20
Durability	4	5	20	5	20	4	16
Repeatability	4	2	8	4	16	3	12
TOTAL			**71**		**105**		**52**

Rover Payload: Ejection

Ejection Design Alternatives							
Design		Linear actuator		Threaded rod		Black Powder	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Mass	5	3	15	2	10	6	30
Ease of activation	2	6	12	5	10	6	12
Reliability	10	5	50	6	60	5	50
Durability	4	6	24	6	24	5	20
Total		**101**		**104**		**112**	

Rover Payload: Power Systems

Battery Alternatives									
Design		**Samsung 26F 18650**		**UltraFire FLB 18650**		**LG HG2 18650**		**Samsung 30Q INR**	
Requirement	**Weight**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Capacity	6	5	30	7	42	7	42	7	42
Max Current	8	5	40	6	48	10	80	9	72
Protective IC	5	3	15	3	15	1	5	1	5
Charging Current	6	6	36	5	30	4	24	6	36
Brand Reliability	7	6	42	3	21	7	49	7	49
Totals		**163**		**156**		**200**		**204**	

Rover Payload: Power Systems

Voltage Regulator Alternatives									
Design		**LM1575-5.0 TI**		**LM2675N-5.0 TI**		**LM2592HV-5.0 TI**		**TPS54386PWP**	
Requirement	**Weight**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Output Current	8	6	48	6	48	8	64	10	80
Input Voltage Range	3	6	18	6	18	7	21	5	15
Voltage Variance	6	7	42	6	36	5	30	6	36
Number of Outputs	5	1	5	1	5	1	5	2	10
Totals		**108**		**102**		**115**		**141**	

Rover Payload: Drivetrain Motors

Motor Alternatives							
Design		**GHM-04 Spur Gear**		Pololu Metal Gearmotor		FIT 0441 Brushless DC Motor	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Rover Mass	1	6	6	3	3	3	3
Operates Within Temperature	2	3	6	3	6	7	14
Obstacle to Overcome	4	7	28	4	16	3	12
Motor Power	8	3	24	6	48	4	32
Maximum Velocity	3	4	12	8	24	4	12
Torque	6	8	48	5	30	3	18
Documentation	4	8	32	5	20	2	8
Volume	2	5	10	5	10	2	4
Total		**166**		**157**		**103**	

Rover Payload: Wheels

Wheel Alternatives							
Design		Open Structure		**Closed Structure**		Expandable Structure	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Rover Mass	1	10	10	2	2	5	5
Volume	4	5	20	5	20	10	40
Ground Clearance	6	3	18	9	54	10	60
Number of Moving Parts	5	9	45	10	50	2	10
Obstacle to Overcome	3	7	21	5	15	4	12
Coefficient of Friction	5	2	10	6	30	4	20
Ratio of Successful Tests	10	4	40	7	70	4	40
Totals		**164**		**241**		**187**	

Rover Payload: Motor Drivers

Motor Driver Alternatives									
Design		G2 24V13		Cytron Single Channel		Cytrol Dual Channel		**Dual MC33926 Motor Driver for Raspberry Pi**	
Requirement	Weight	Value	Score	Value	Score	Value	Score	Value	Score
Voltage Rating	10	10	100	10	100	10	100	10	100
Current Rating	10	6	60	6	60	8	80	10	100
Volume	5	10	50	4	20	8	40	6	30
Weight	2	8	16	5	10	6	12	5	10
Documentation	2	4	8	5	10	5	10	6	12
Total		**234**		**200**		**242**		**252**	

Rover Payload: Overcurrent Protection

Current Sensor Alternatives							
Design		**INA169 Current Sensor**		INA219 Current Sensor		Electronic Brick ±5A ACS712 Current Sensor	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Current Sense Range	10	8	80	6	60	8	80
Flexibility	8	10	80	6	48	7	56
Ease of Integration	5	8	40	8	40	5	25
Size	4	8	32	8	32	6	24
Weight	4	9	36	9	36	6	24
Documentation	2	6	12	6	12	5	10
Total		**280**		**228**		**219**	

Rover Payload: Operating System

Operating System Alternatives							
Design		Ubuntu		Raspian		Windows 10 IoT	
Requirement	Weight	Value	Score	Value	Score	Value	Score
Ease of Use	3	8	24	5	15	10	30
Software Support	10	7	70	10	100	3	30
Memory Overhead	7	3	21	6	42	1	7
Total		115		157		67	

Rover Payload: Framework

Framework Alternatives							
Design		**ROS**		**MRPT**		**MRDS**	
Requirement	**Weight**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Learning Curve	3	1	3	3	9	6	18
Language Support	6	10	60	1	6	2	12
OS Support	3	7	21	7	21	1	3
Functionality	10	10	100	6	60	6	60
Memory Overhead	6	4	24	7	42	1	6
Total		**208**		**138**		**99**	

Rover Payload: Language

Language Alternatives							
Design		**C++**		**Python**		**C#**	
Requirement	**Weight**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Team Familiarity	3	8	24	6	18	4	12
Memory Management	6	6	36	10	60	10	60
Multi-Processing	5	8	40	1	5	8	40
Ease of Debugging	7	5	35	10	70	6	42
Reflection	1	1	1	10	10	5	5
Readability	5	6	30	10	50	7	35
Memory Overhead	5	9	45	2	10	5	25
Performance	4	9	36	3	12	5	20
Total		**247**		**235**		**239**	