CRITICAL DESIGN REVIEW

BYU ROCKETRY EXPERIMENTAL HIGH-POWER TEAM

2020-2021

Team Lead:	Dallin Cordon
Structures:	Brennen Dover, Jayson Davis, Josh Halliday
GNC:	Brayden Smith, Derrick Walker, Greg Hill
Payload:	Brandon Sutherland, Dunstan Chi

TABLE OF CONTENTS

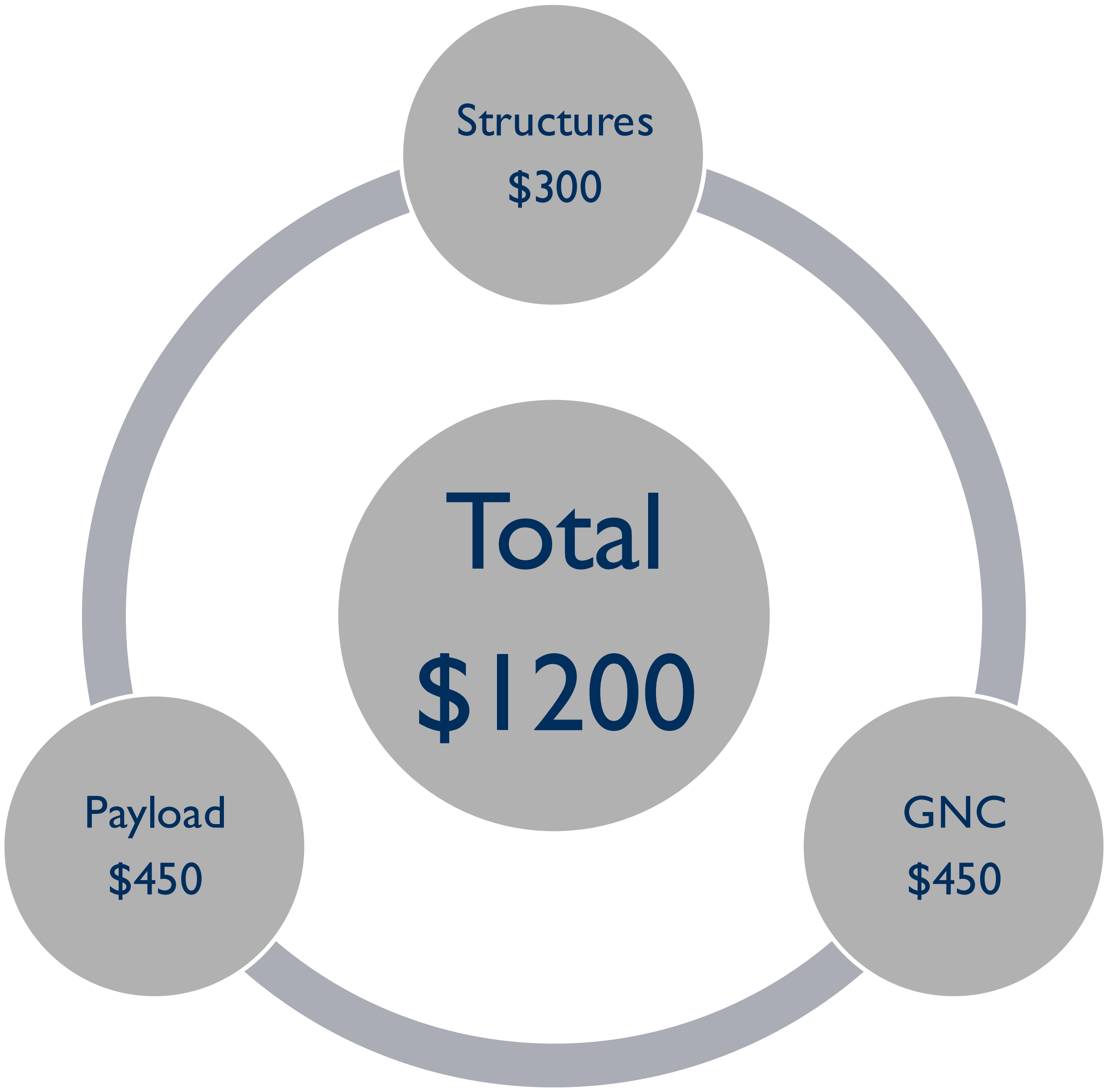
PROJECT OVERVIEW

MISSION OBJECTIVE

Develop and launch a high-power rocket following similar procedures and guidelines as required by the Spaceport America Intercollegiate Rocket Engineering Competition. Included in this purpose are several goals:

- Develop a professional rocket capable of launching an eight-pound payload to a target apogee of 10,000 feet by March 30, 2021.
- Complete the minimal systems for base operation no later than February 27, 2021.
- Maintain high levels of professionalism and communication.
- Provide team members with real world engineering team-based work experience that can be referenced in internship and job interviews.

BUDGET



Feb. 27, 2021

Manufacturing Completed

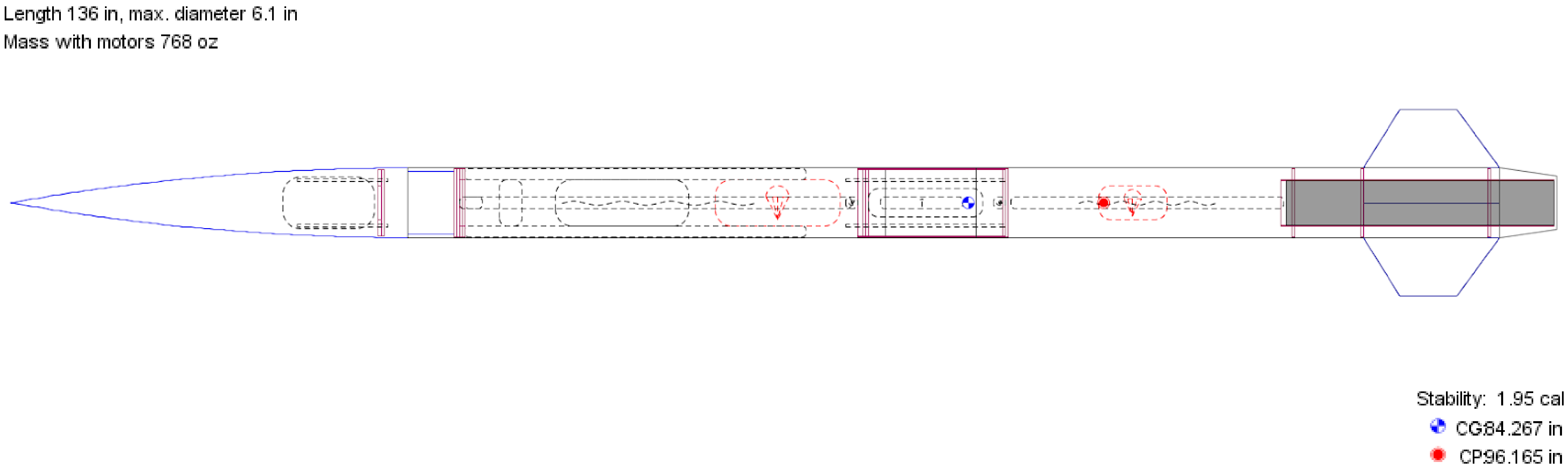
Mar. 30, 2021

Launch Day

MAJOR MILESTONES

STRUCTURES

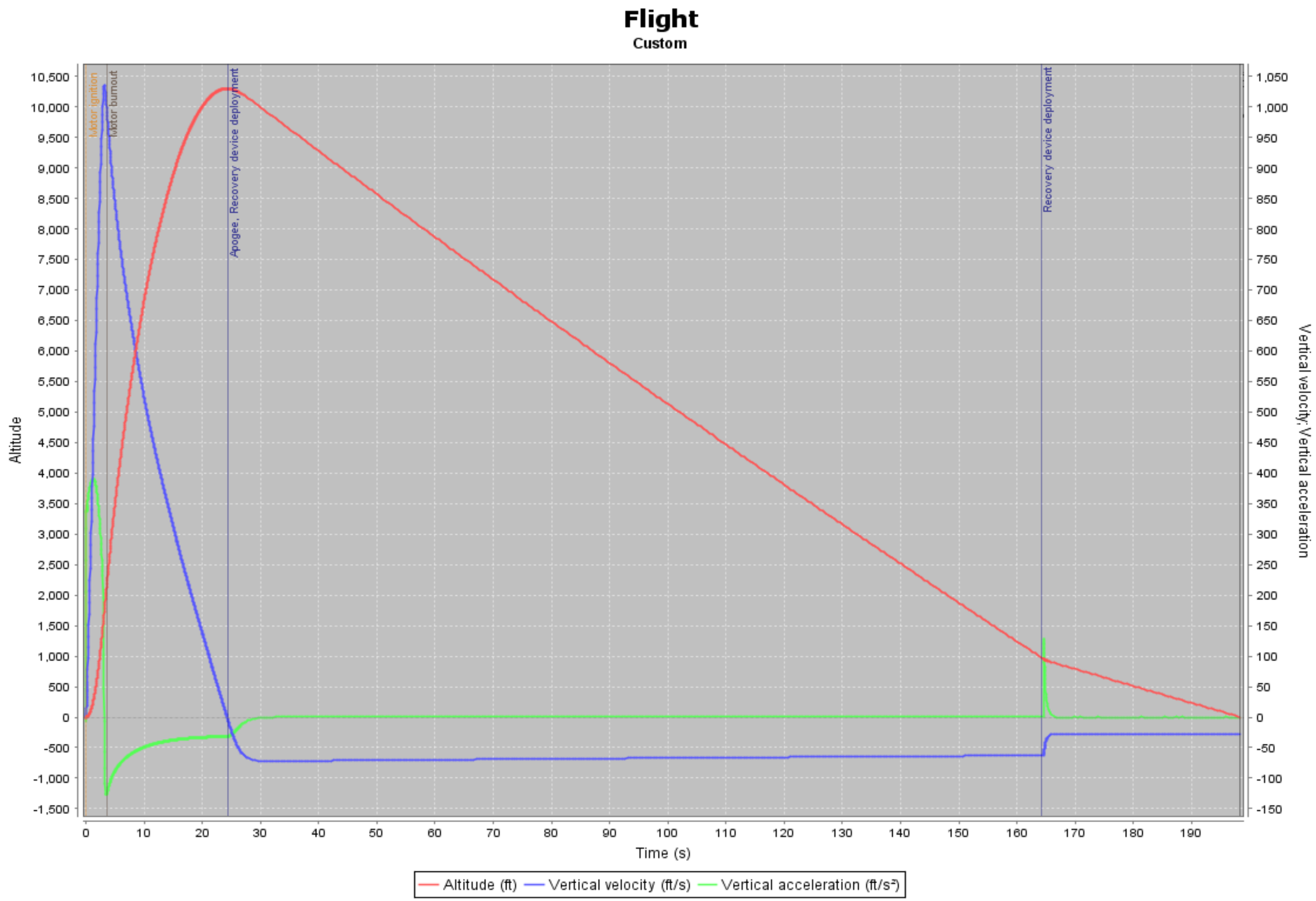
BRENNEN DOVER ● JAYSON DAVIS ● JOSH HALLIDAY



ROCKET DESIGN

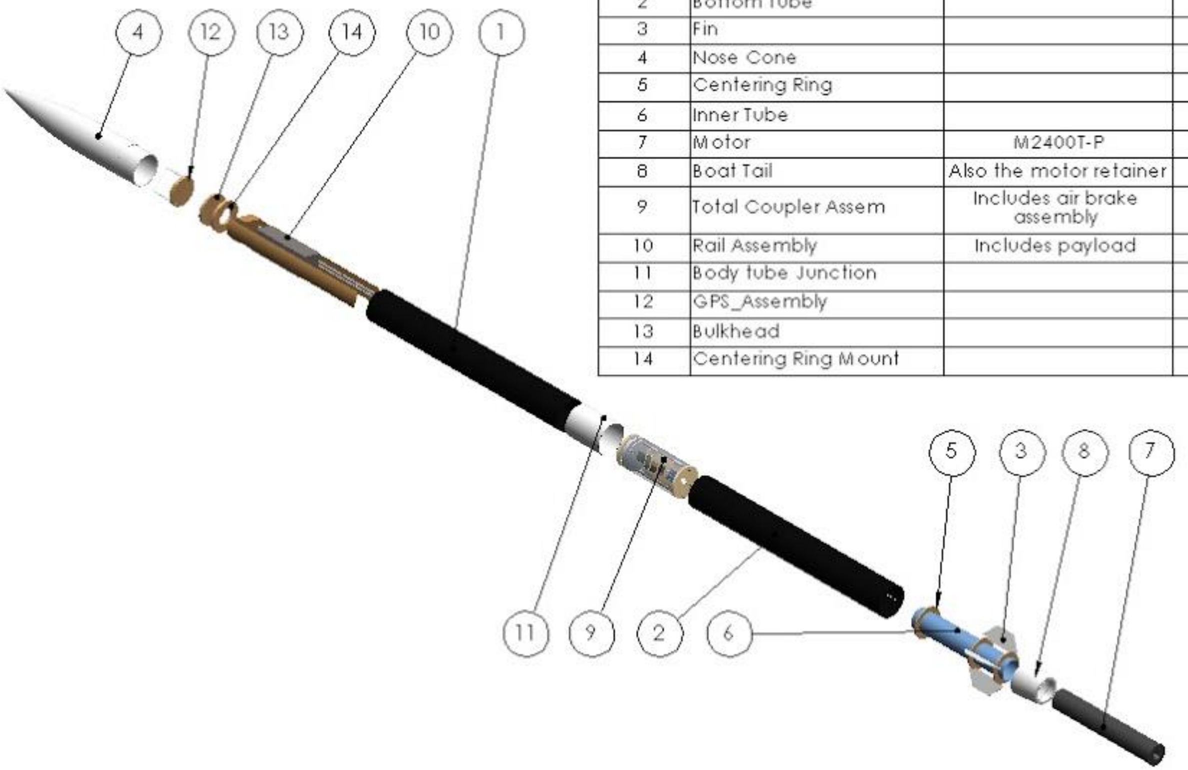
ROCKET FLIGHT SIMULATION

Velocity Off Rod:	48.5 ft/s
Max Velocity:	1037 ft/s
Max Acceleration:	390 ft/s^2
Apogee:	10304 ft
Time to Apogee:	25.2 s
Optimum Delay:	20.7 s
Flight Time:	198 s
Ground Hit Velocity:	27.6 ft/s
Motor Configuration:	M2400T

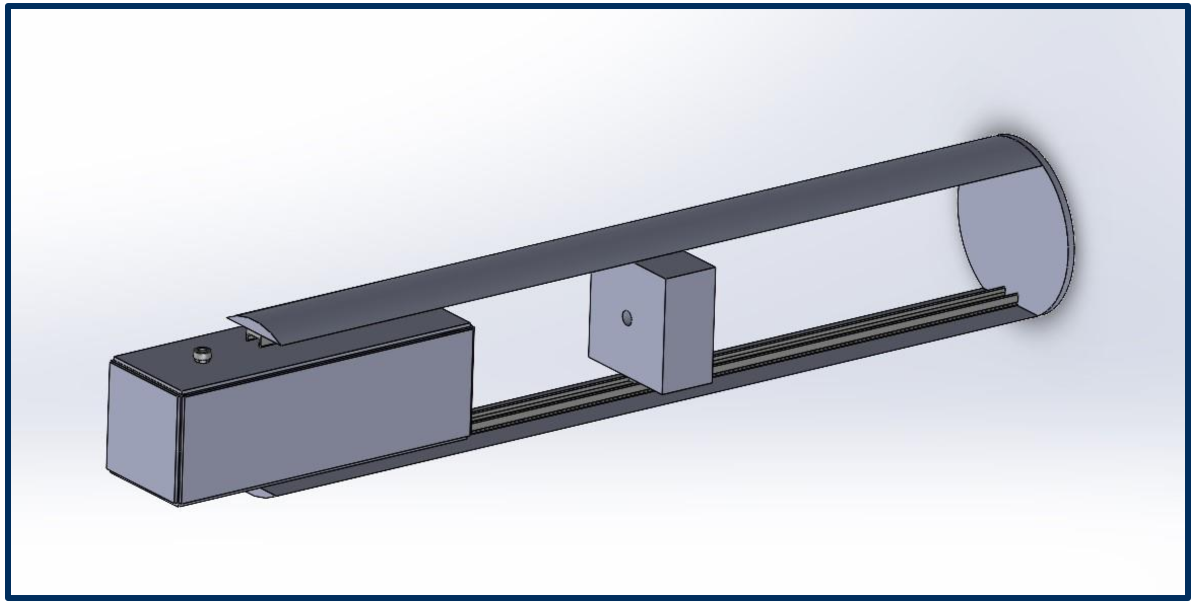


ROCKET LAYOUT

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Top Tube		1
2	Bottom Tube		1
3	Fin		4
4	Nose Cone		1
5	Centering Ring		3
6	Inner Tube		1
7	Motor	M2400T-P	1
8	Boat Tail	Also the motor retainer	1
9	Total Coupler Assem	Includes air brake assembly	1
10	Rail Assembly	Includes payload	1
11	Body tube Junction		1
12	GPS_Assembly		1
13	Bulkhead		2
14	Centering Ring Mount		2



PAYLOAD EJECTION



At 1000 ft avionics bay triggers main ejection charge. → Top tube and nose cone assembly detach from coupler.

→ Shock cord gains tension and pulls on the main chute. → The main chute pulls other end of shock cord.

→ Tension on shock cord pulls block on rail which also pushes payload out of rocket. → Main chute deploys and payload falls away from rocket.

Failure Modes and Effects Analysis

System Name: Junior High-Power Team Structures Subteam

Owner: Jayson Davis, Brennen Dover, Josh Halliday

Revision: 1

Date: 1/27/21

10 is most Severity | 10 most Likelihood | 10 least Detectability

Main System	Component	Functional Purpose	Failure Mode	Failure Effect	Cause	Current Situation S	Current Situation L	Current Situation D	Current Situation RPN	Assigned Action or Comments	Improved Situation S	Improved Situation L	Improved Situation D	Improved Situation RPN
	Fins	Adjusts CP and provides stability	Shearing off during flight	The rocket will lose guidance and cause possible missed altitude or lose of vehicle	Shearing forces on the fins overcome their attachment	8	2	8	128	Use fiberglass fins	8	1	8	64
			Breaking off	Vehicle will not be reusable aka the rocket will be broken	Landing too hard on the fin	5	2	10	100	epoxy fins to body tube and centering rings, ensure proper parechute sizing and	5	1	10	50
	GPS Mount	Secure GPS equipment	Comes off/loose	GPS may become displaced inside the nose cause, may cause loss of signal which may cause loss of vehicle	Shaking	6	2	4	48	Use foam for dampening	6	1	4	24
					Shock of landing	6	2	4	48	Effectively epoxy the rings	6	1	4	24
					Force of take off	6	2	8	96	Effectively epoxy the rings	6	1	8	48
					Shock of parachute deployments	6	2	7	84	Effectively epoxy the rings	6	1	7	42
	Rail buttons	Directed rocket on launch	Out of alignment	Rocket will not fly straight and could lead to missed target altitude	Poor manufacturing	4	1	1	4	Quality control	4	1	1	4
					Damage preflight	5	1	1	5	Careful handling	5	1	1	5
			Breaking on rail		Lunch rail breaks the buttons	4	1	10	40	Strong fastening methods	4	1	8	32
Airframe	Motor mount	Holds the motor and transfers force	Bulkheads failing	Parachutes will not deploy, some or all of the vehicle could be lost	Material not strong enough for the load	10	2	7	140	Use fiberglass, test material stregnth and compare to expected load	10	1	6	60
					poor manufacturing	8	1	1	8	Quality control	8	1	1	8
			Motor falling out	Motor falls out and may damage the motor or a toe	motor retainer poorly attached	4	1	1	4	Effectively epoxy the rings	4	1	1	4
			Motor going inside the rocket	The motor flies inside the rocket and destroys everything inside causing a lost of vehicle	bulkheads, inner tube, or motor casing lip failing	10	3	8	240	Effectively epoxy the rings	10	2	8	160
			Zippering	Cord rips through the side of the rocket, damaging the vehicle	shock cord too short	7	2	8	112	Ensure correct length	7	1	8	56
			Cracking	Forces on the rocket crack the body, damaging the vehicle	body tube not strong enough	10	1	10	100	Highly unlikely	10	1	10	100

Additional Structures FMEA found here

STRUCTURES PARTS AND EXPENDITURE LIST

Part Name	Material	Source	Quantity	Total Cost
Nose cone	Fiberglass w/ aluminum tip	Madcow Rocketry	1	$0.00
Body Tube (Top, Center, Bottom)	Carbon Fiber	Composites Lab	3	$0.00
Fins	Fiberglass	McMaster Carr	4	$50.00
Centering Rings/Bulkheads	Plywood	Hardware Store	3	$25.00
Inner Tube	Blue Tube	Apogee Rockets	1	$40.00
Rail Buttons	Aluminum	Machined	2	$3.00
Shear Pins	Nylon	Lab	TBD	$0.00
Boat Tail	Carbon Fiber Covered ABS	3D Printer/Composites Lab	1	$50.00
Coupler	Blue Tube	Apogee Rockets	1	$21.35
Epoxy	N/A	Hardware Store	N/A	$40.00
Epoxy Filler	N/A	Lab	N/A	$0.00
Spray Paint	N/A	Hardware Store	N/A	$20.00
TOTAL				$249.35

STRUCTURES SCHEDULE

30 Jan.
- Tail Cone Printed
- All Parts Ordered
- GPS mount ready to be cut

6 Feb.
- Centering rings cut
- Payload Deployment block cut
- GPS mount cut and epoxied in nose cone
- Tail cone reinforced with carbon fiber

13 Feb.
- Fins cut and sanded
- Fin and airbrake slots cut into body tubes
- All holes drilled in body tubes

20 Feb.
- Fins inserted and filleted with sensors in place
- Tail cone attached with thermal sensor
- Shear pins and rail buttons made and attached

27 Feb.
- Double check components
- Finish outstanding tasks
- Decide on rocket aesthetics

13 Mar.
- Rocket design completed

30 Mar.
- Launch Day

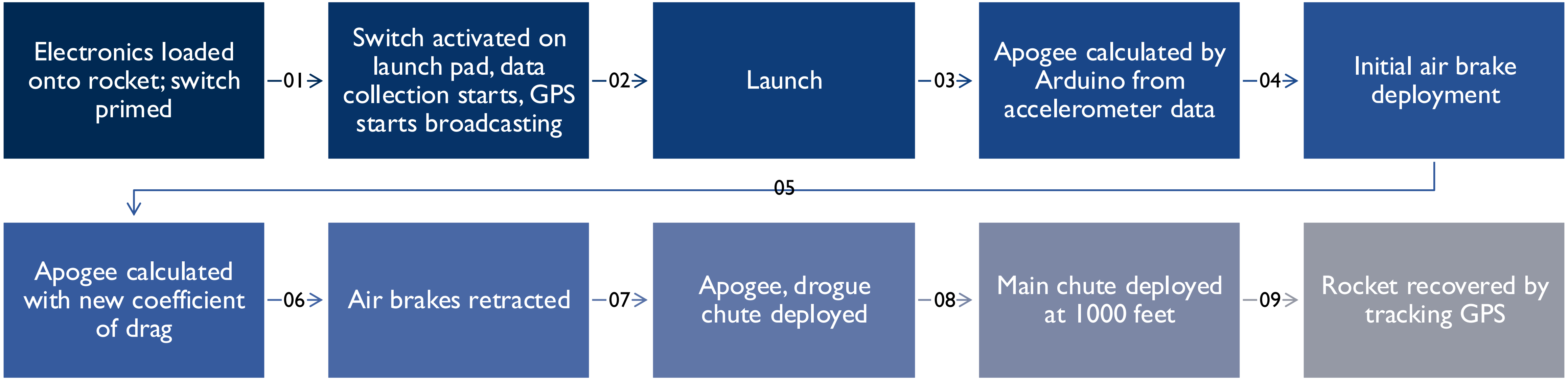
GNC

BRAYDEN SMITH ● DERRICK WALKER ● GREG HILL

GNC GOALS

- Recover the rocket safely
- Air brakes design and implementation
- Gain an understanding of:
  - Relationship between high-powered rockets, their materials and their environment
  - Physical anomalies (stress, strain, vibration, temperature, pressure, etc.) that occur during flight
  - How to better optimize a rocket for flight
  - How to reduce failure points

GNC MISSION PROFILE

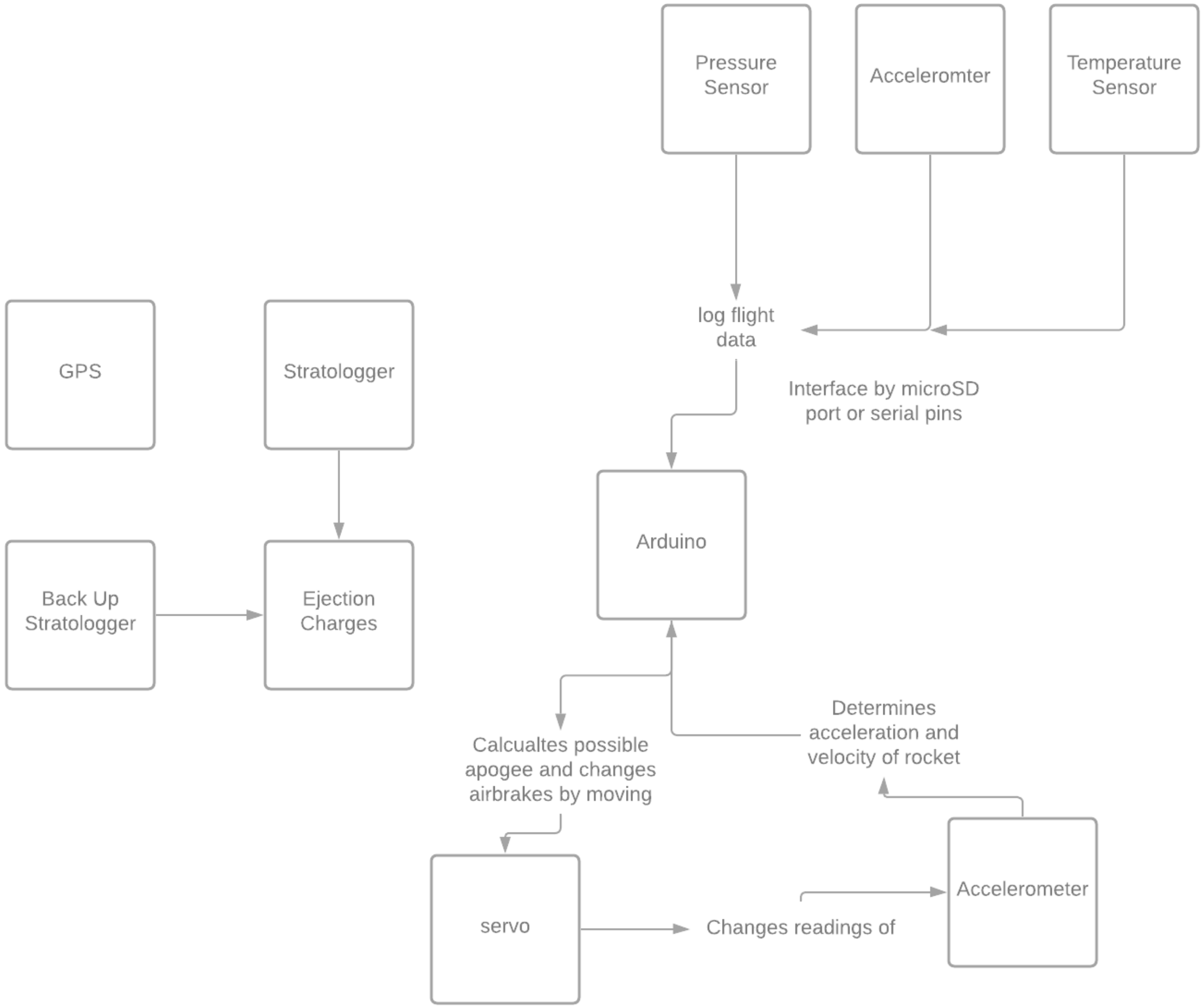


SYSTEMS OVERVIEW

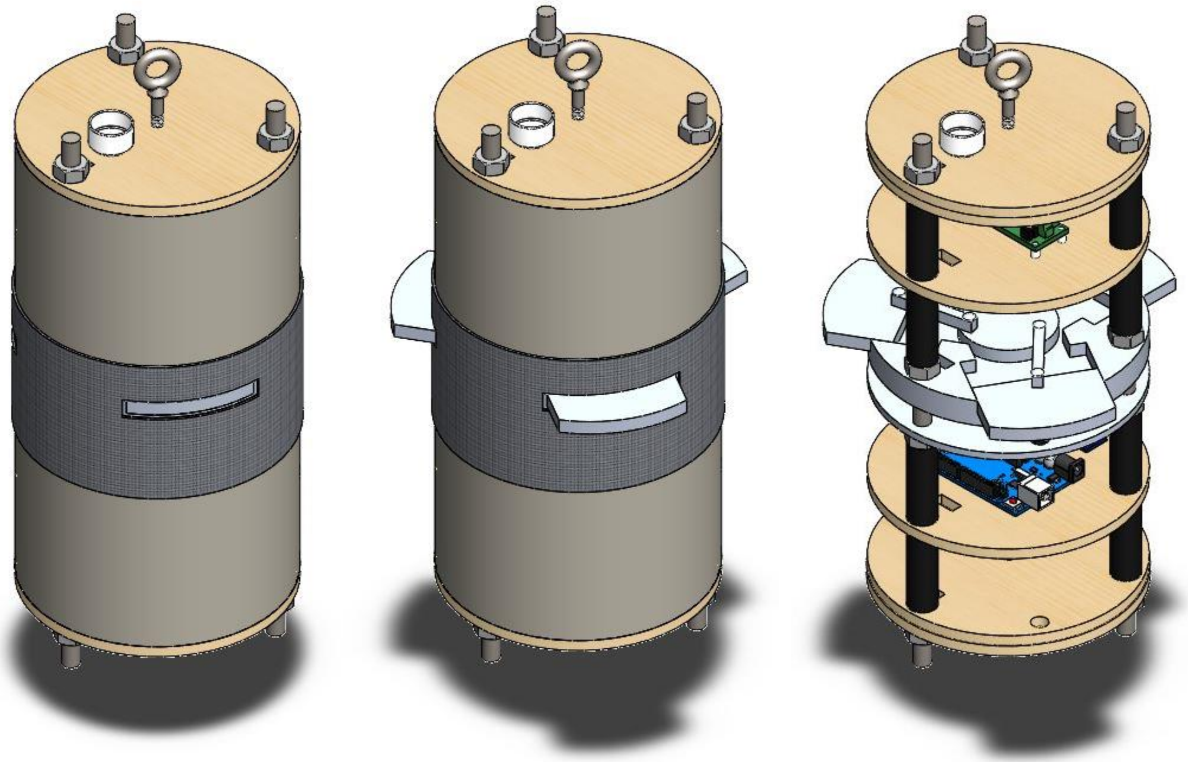
Separation of jobs

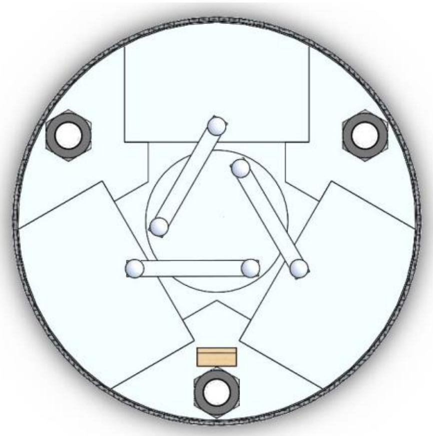
Arduino in charge of data collection

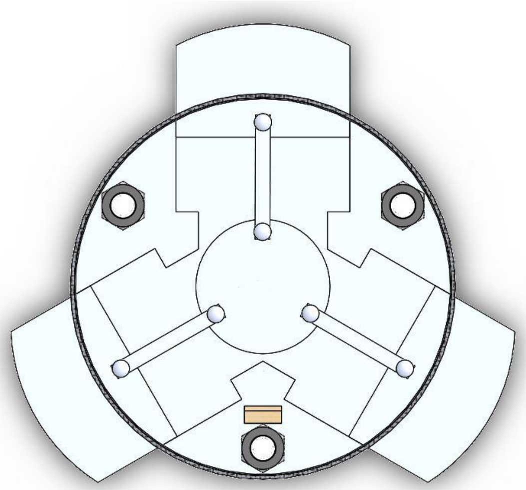
Stratologger or Eggtimer Quantum Altimeter

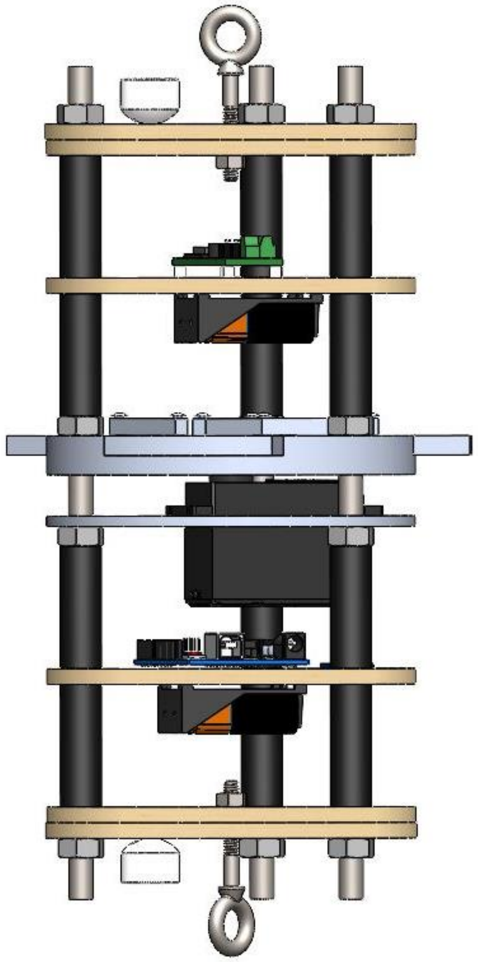


AVIONICS BAY









GNC MANUFACTURING AND TESTING PLAN

- **30 Jan.** – Begin machining aluminum parts
- **3 Feb.** – All parts purchased
- **10 Feb.** – All air brakes parts machined
- **27 Feb.** – AV bay and air brakes manufacturing complete
- **6 Mar.** – Air brakes coding finished and tested
- **13 Mar.** – Wind tunnel testing complete
- **30 Mar.** – Launch Day

GNC EXPENDITURE LIST

Part Name	Material	Source	Quantity	Total Cost
Main Parachute (96”)	Ripstop Nylon	Top Flight Recovery LLC	1	$150.00
Drogue Parachute (48”)	Ripstop Nylon	Top Flight Recovery LLC	1	$56.00
Main Shock Cord (30’)	2500 lb. 3 Loop Braided Kevlar	Rocketman Parachutes	1	$48.00
Drogue Shock Cord (20’)	1200 lb. 3 Loop Braided Kevlar	Rocketman Parachutes	1	$23.50
Servo Motor	N/A	ECEn Shop	1	$5.00
SEN0295 (pressure sensor)	N/A	Mouser	3	$20.70
Thermocouple Amplifier MAX31855	N/A	Adafruit	1	$15.00
Threaded Rod	Zinc Plated Steel	Home Depot	3	$6.78
Eyebolt	Zinc Plated Steel	Home Depot	2	$1.18
9V Battery	N/A	Home Depot	4	$14.00
Wood	Birch Plywood	Home Depot	N/A	$26.55
Pull Pin Kit	N/A	Lab Rat Rocketry	1	$12.00
TOTAL				$378.71

PAYLOAD

BRANDON SUTHERLAND ● DUNSTAN CHI

PAYLOAD GOAL AND MISSION PROFILE

Demonstrate the capabilities of a compact autonomous drone to fly and perform surveillance of surrounding terrain after transportation in a rocket.

01

Ground station containing drone is ejected from rocket with payload ejection system.

02

Ground station lands under personal parachute and opens, exposing and prepping drone for flight.

03

Drone awaits arm command after ground crew has established line of sight.

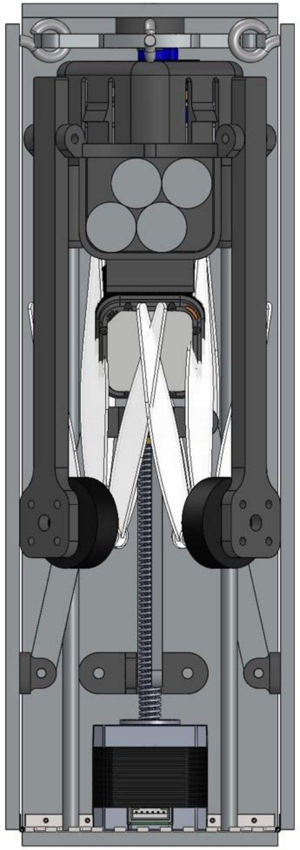
04

Once line of sight has been established, drone is armed remotely and begins autonomous survey of surrounding area with camera.

05

Once surveillance is complete, the drone will return to the ground station where the ground crew control will assume control of the drone and safely land it.

DRONE AND GROUND STATION



- Drone is contained in deployable ground station
- Ground station is equipped with parachute and automated release
- Lead-screw driven joints push station upright during unfolding
- Drone unfolds and flies free of ground station

Failure Modes and Effects Analysis

System Name: Junior High-Power Team Payload Subteam

Owner: Brandon Sutherland, Dunstan Chi

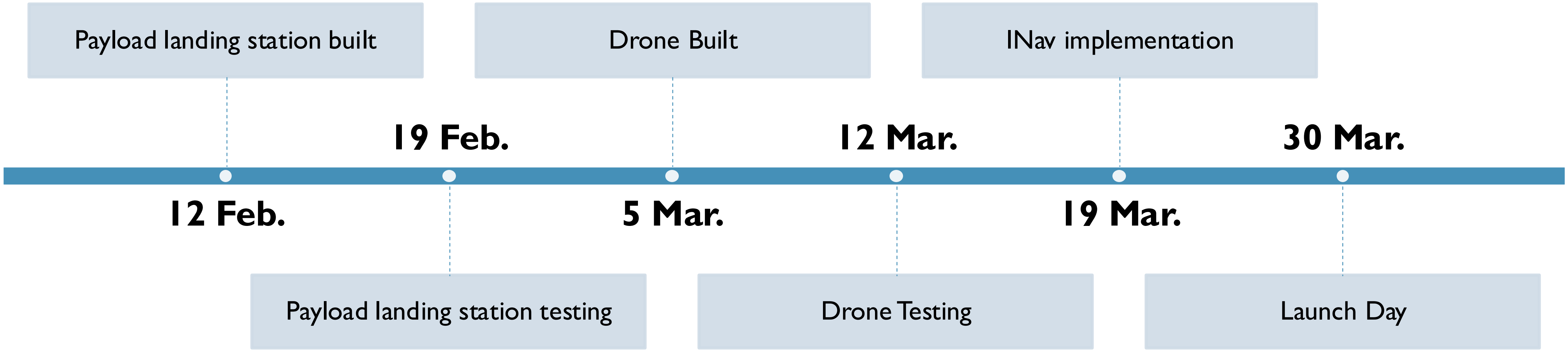
Revision: 2

Date: 1/26/21

Main System	Component	Functional Purpose	Failure Mode	Failure Effect	Cause	Current Situation S	Current Situation L	Current Situation D	Current Situation RPN	Assigned Action or Comments	Improved Situation S	Improved Situation L	Improved Situation D	Improved Situation RPN
Deployment System	Rail System	Provides runway for the payload to come out from the body tube.	Payload fails to eject from rocket.	Payload not deployed.	Parachute tangles with rocket.	5	6	7	210	Use chute release	5	2	7	70
					Shock cable tangles with payload.	5	4	8	160	Use chute release, keep shock cord well stored	5	2	7	70
Drone	Battery	Supplies power to the drone.	Battery is shorted or punctured and ignites.	Payload catches fire and is unable to fly and/or is destroyed.	A component of the drone punchtures the battery during some moment of the flight.	9	2	8	144	Use protective case for the battery	9	1	8	72
	Telemetry Communication	Gives information to the ground crew on the progress of the flight.	Fails to interface with flight controller.	No telemetry data transmitted or recieved, preventing flight.	Flight controller software refuses to connect or provide flight data.	7	5	6	210	Test enough to ensure smooth connection, and be prepared for possible software failure	7	2	6	84
			Fails to connect with ground crew laptop.	No telemetry data transmitted or recieved, preventing flight.	Wireless connection is lost due to too much range.	7	9	2	126	Figure out the max range for the telemetry system and create flight path well within it.	7	3	2	42
					Software does not cooperate and refuses the connection.	7	6	4	168	Test enough to ensure smooth connection, and be prepared for possible software failure	7	3	3	63
	Frame	Composes the majority of the drone, allows for proper flight.	Arms do not fold up during deployement.	Drone may not be able to take off.	Props get caught and prevent the arms from unfolding.	6	5	6	180	Use strong enough torsional springs to ensure the arms do not get caught	6	3	4	72
			Fails to control the propusion system for proper flight.	Drone cannot fly, or crashes during flight.	Malfunctioning electronics or software.	9	3	5	135	Use highly reliable hardware and software	9	2	3	54
	Software navigation systems	Controls the direction flying of the drone during atonomous flight. Dictates the path of the drone.	Stops directing the drone during flight.	Surveylance is not accomplished as wanted, and/or drone is lost entirely.	Software failsafes or cancels through other means.	7	3	7	147	Use highly reliable hardware/software, perform test runs beforehand	7	2	5	70

Additional Payload FMEA found here

System	Part Name	Model	Cost	Quantity	Total Cost
Drone	Propellers, two sets	Dalprop F7 Foldable Props	$4.99	2	$9.98
	Motors	iFlight XING Camo X2207 Motor	$22.99	4	$91.96
	Flight Controller & ESC	MAMBA F405 MK2 Betaflight Flight Controller	$45.99	1	$45.99
	Radio Telemetry & Transmitter	FPVDrone 3DR Radio Telemetry Kit	$28.59	1	$28.59
	Frame	Custom	$30.00	1	$30.00
	Battery	Custom Li-Ion 4s 1500 mAh battery	$40.00	1	$40.00
	GPS	Matek M8Q-5883 GPS Module	$29.99	1	$29.99
	Reciever	FrSky R-XSR	$0.00	1	$0.00
	HD Camera	Gopro Session 5	$0.00	1	$0.00
	Random Hardware		$15.00	1	$15.00
Deployment Station	Parachute	60" Parachute	$22.00	1	$22.00
	Servo	MG995 High Torgue Metal Gear Analog Servo	$5.59	1	$5.59
	Sheet Metal		$15.00	1	$15.00
	Microcontroller	Raspberry Pi Zero W	$10.00	1	$10.00
	Stepper Motor	NEMA 17	$14.00	1	$14.00
	Misc Hardware		$20.00	1	$20.00
	Trapozoidal Thread rod		$9.59	1	$9.59
Total					$387.69
Remaining out of $450					$62.31



PAYLOAD MANUFACTURING AND TESTING PLAN

BRIGHAM YOUNG UNIVERSITY

ROCKETRY ASSOCIATION

AD CAELUM

EST. 2016