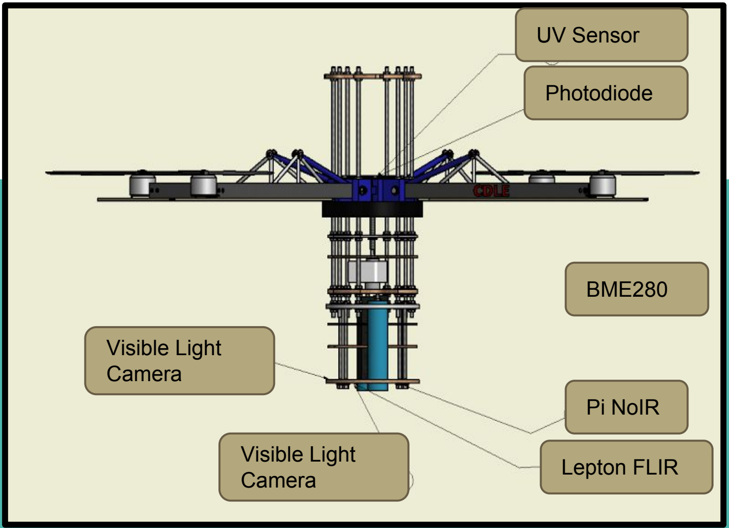
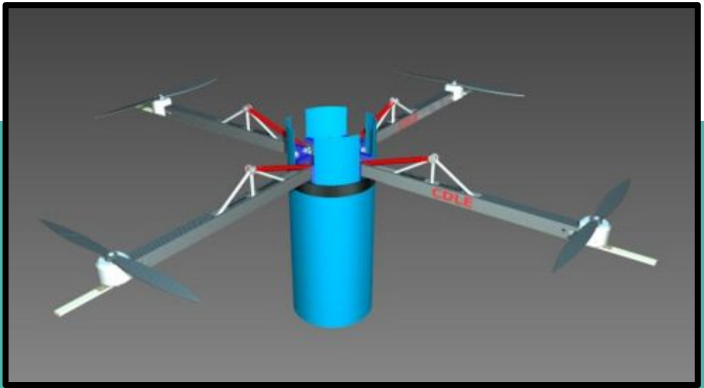
NUSPACE

Northeastern University Scientific Payloads: Atmospheric-Measurement and Controlled-Descent Experiment

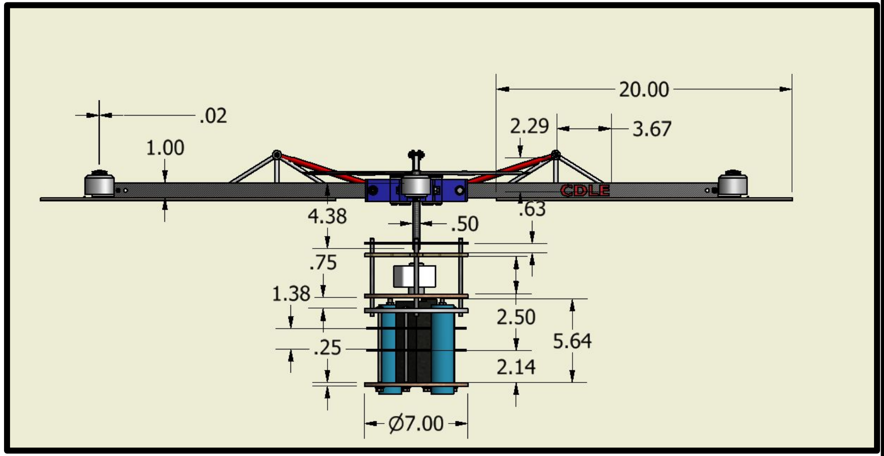
Critical Design Review

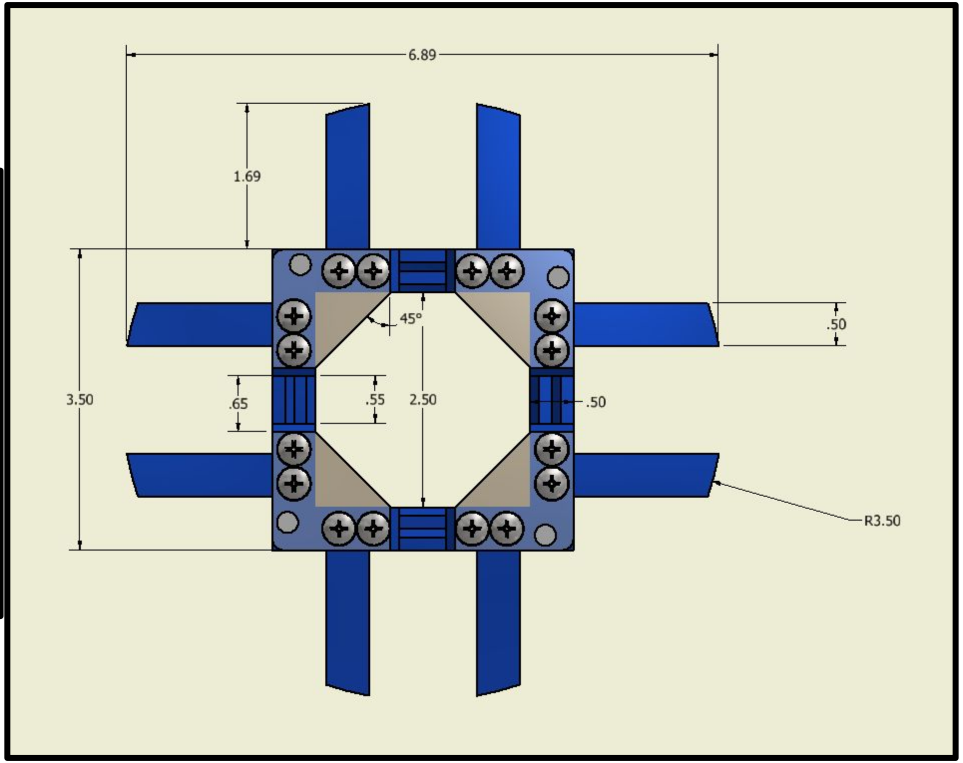
PAYLOAD DIMENSIONS



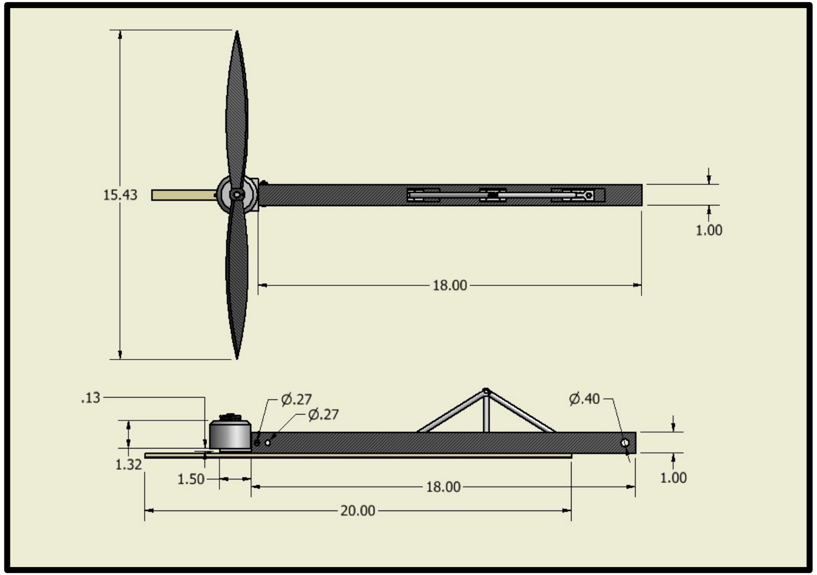


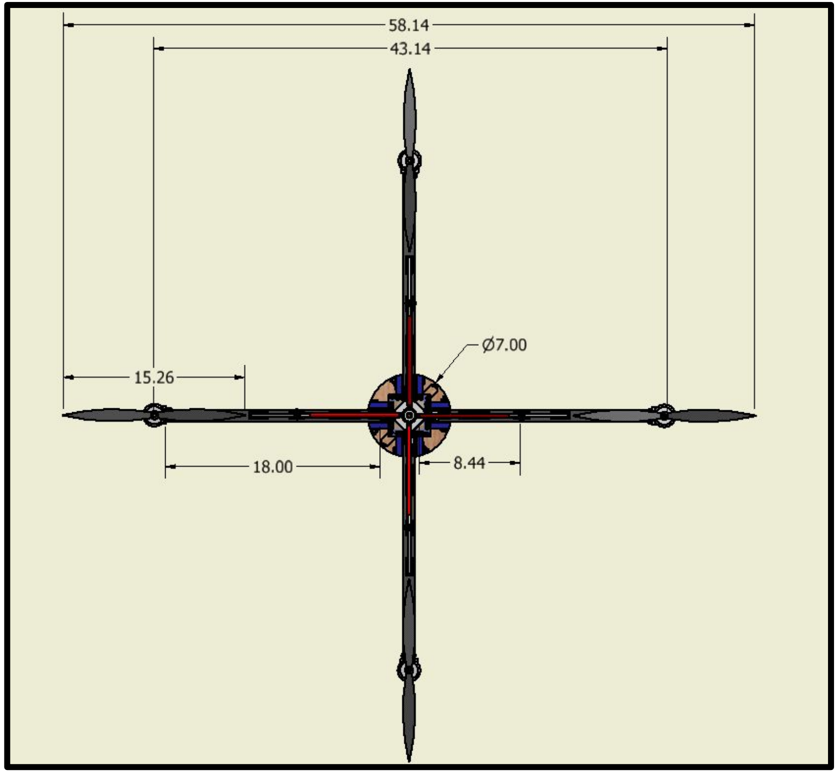
CDLE Payload Dimensions



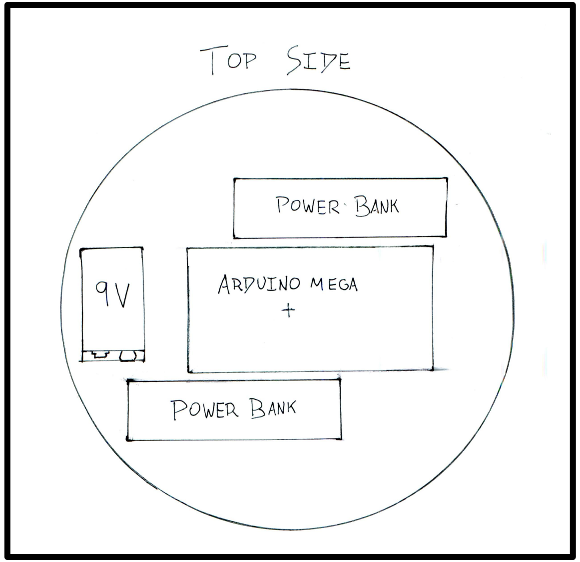


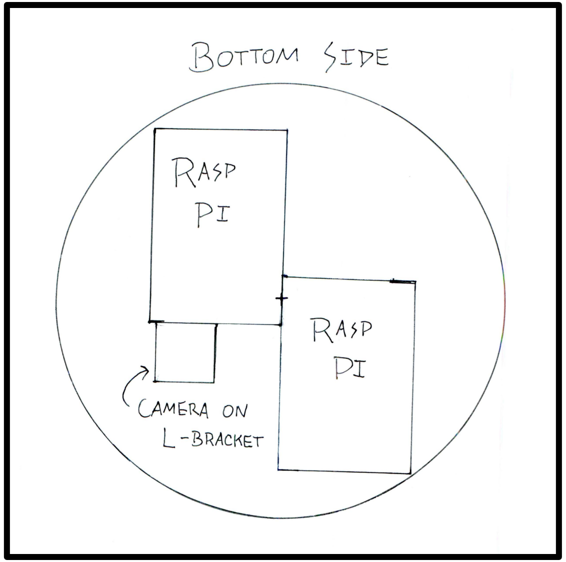
Payload Dimensions





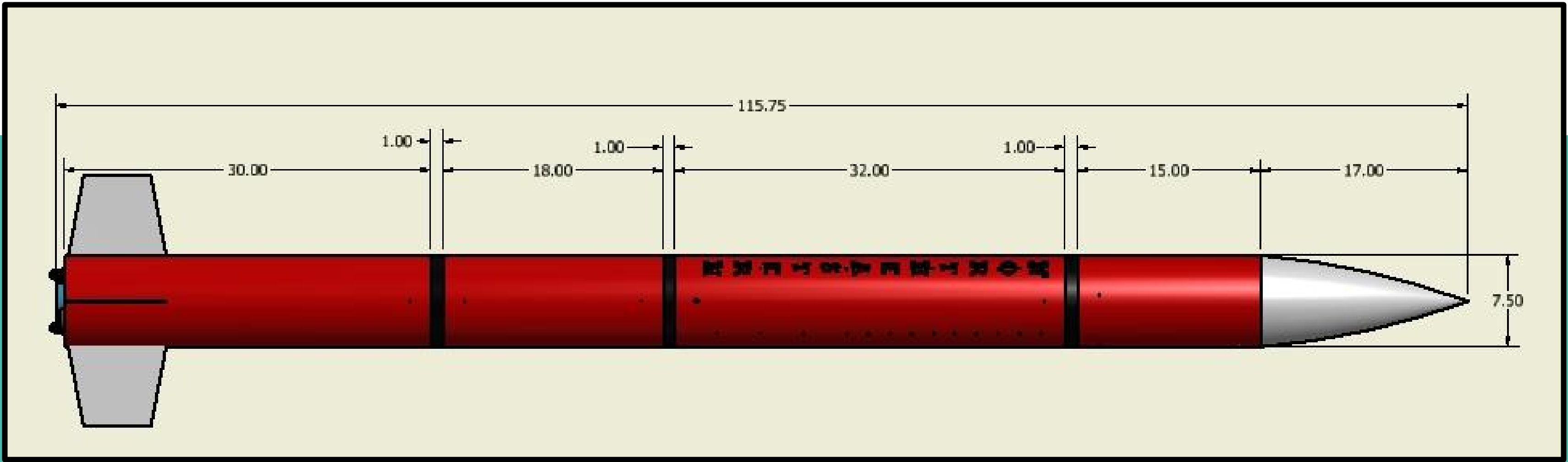
ATMOS Payload Dimensions





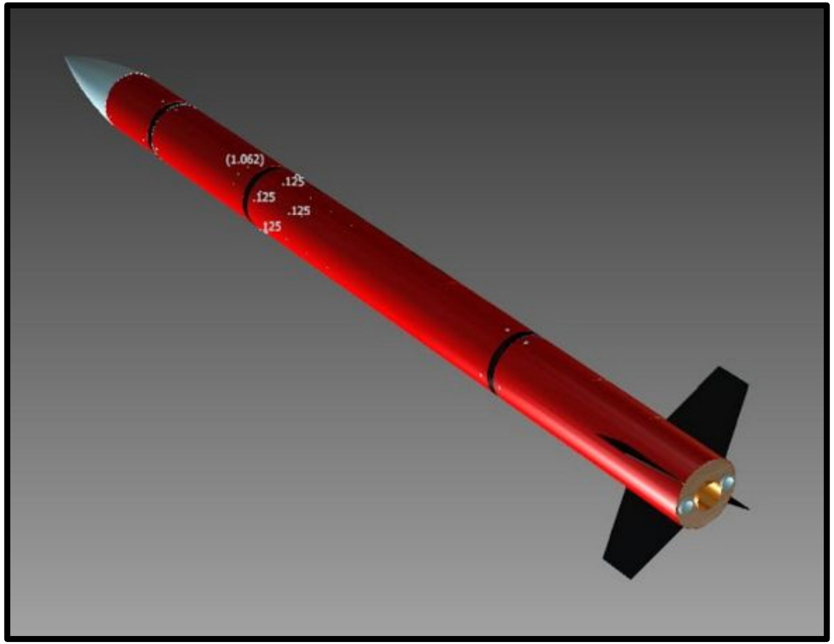
ATMOS components drawn to scale on a 7.5” bulk head

FINAL LAUNCH VEHICLE

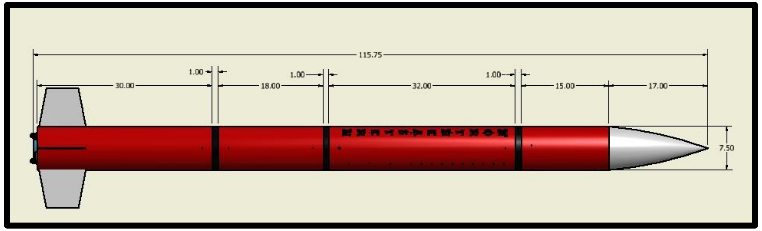


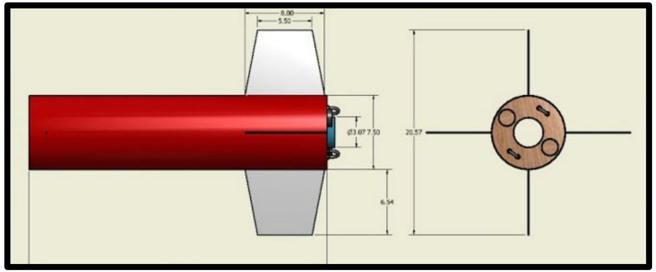
Launch Vehicle Specifications

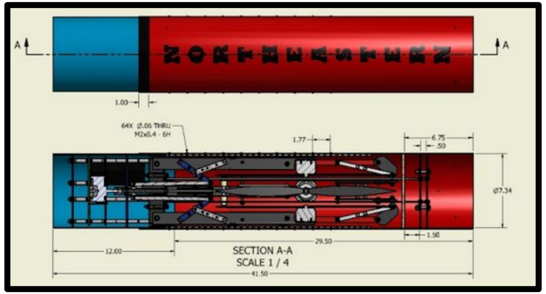
- Vehicle Dimensions
  - Length: 115/118 in.
  - Diameter: 7.5 in.
- Materials
  - Fins: G10 Fiberglass
  - Nose cone: Polypropylene
  - Launch Vehicle body: Blue tube
  - Recovery System: Carbon fiber
- Thrust-to-weight ratio: 12.3
- Rail Exit velocity: 42.2 ft/s



Launch Vehicle Specifications Cont.







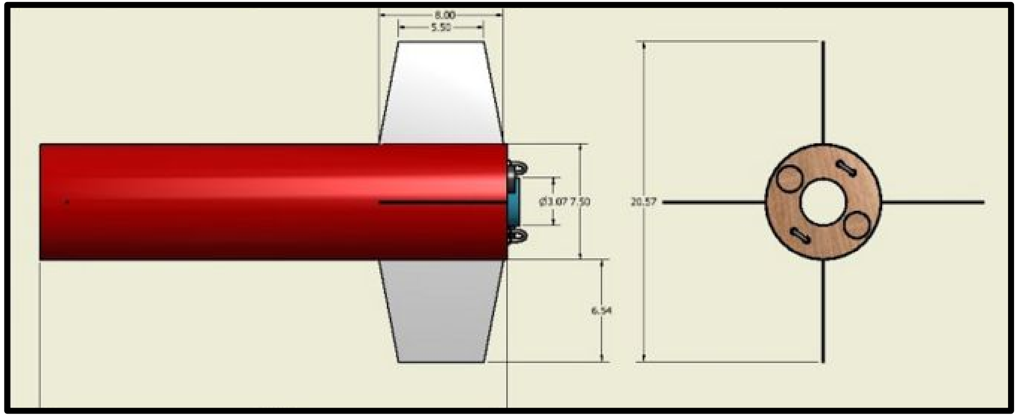
Independent Sections	Mass (lb)	Mass (kg)
The CDLE	11.09	5.03
Nose Cone Section	2.52	1.15
Motor Section + Sheath	18.6	8.47
Total	32.2/40.3*	14.6/18.3*

Mass margin: 1 kg

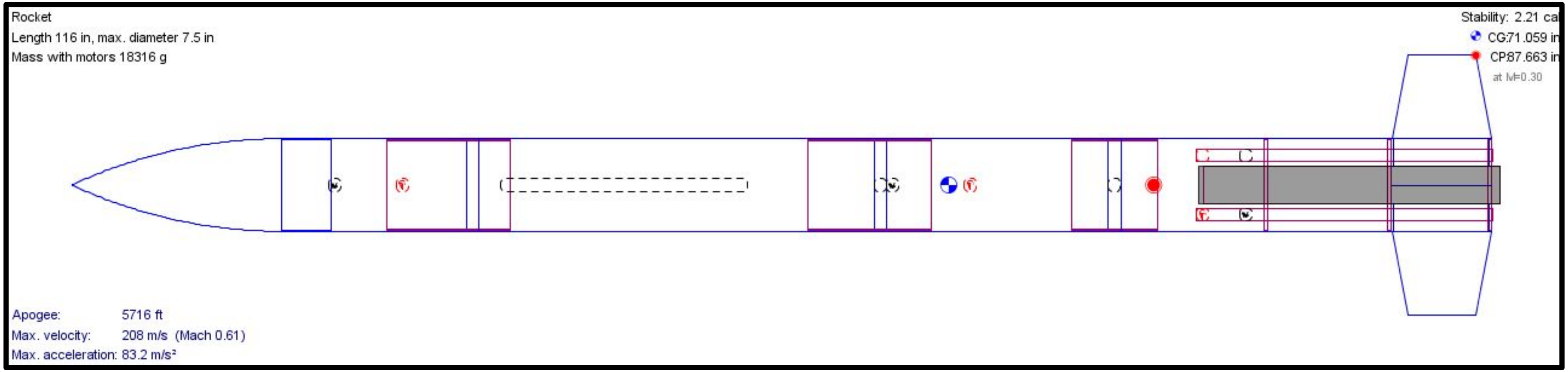
Motor Selection

Manufacturer	Cesaroni Technologies
Name	L1115
Diameter	2.95 in (75 mm)
Average Thrust	1119.0 N
Maximum Thrust	1713.3 N
Total Impulse	5015.0 Ns
Burn Time	4.5 s

- Predicted Apogee: 5664 ft
- Rationale: most viable L2 motor to reach target altitude
- Armed Launch Vehicle Weight: 40.6 lbs



Rocket Flight Stability



The static margin of the full scale competition rocket

Recovery Subsystems

	Nose cone section	Motor section + sheath	Motor section (aft)	CDLE (backup)
Parachute size (in)	18	72	18 (two parachutes)	48
Shock cord length (ft)	20	40	15	30
Shock cord thickness (in)	0.23	0.23	.23	.23
Deployment speed (ft/s)	0	66.2	0	Varies (depends on reason for deployment)
Section ground impact velocity (ft/s)	35.1	14.9	14.9	Varies (max = 18.3)

Mission Performance

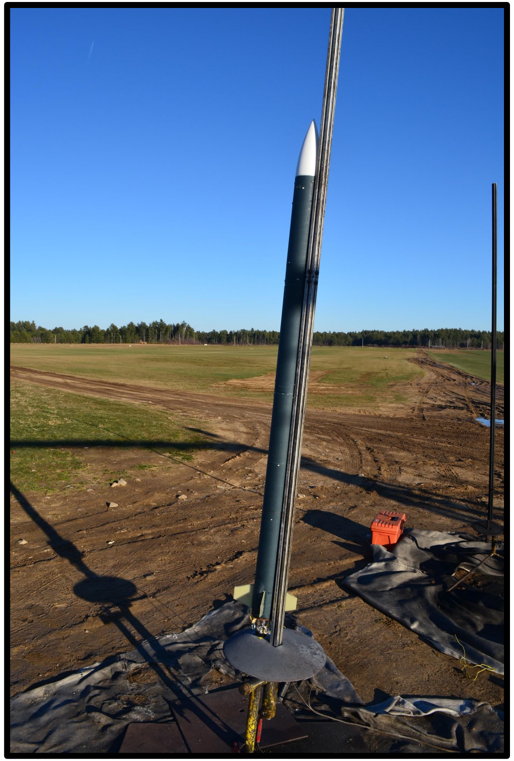
Section	Terminal Velocity (ft/s)	Kinetic Energy (J)	Kinetic Energy (Ft*lbs)
Nose Cone Section	35.1	65.6	48.4
Motor Section + Sheath	14.9	88.3	65.1
CDLE	18.4	79.0	58.3

Wind Speed (mph)	Wind Speed (ft/s)	Nose Cone Drift (ft)	Motor Section + Sheath (ft)	CDLE (ft)
0	0	0	0	0
5	7.333	1103.0	1206.7	2352.8
10	14.66	2205.2	2412.5	4703.7
15	22	3309.2	3620.4	7058.7
20	29.33	4411.8	4826.6	9410.6

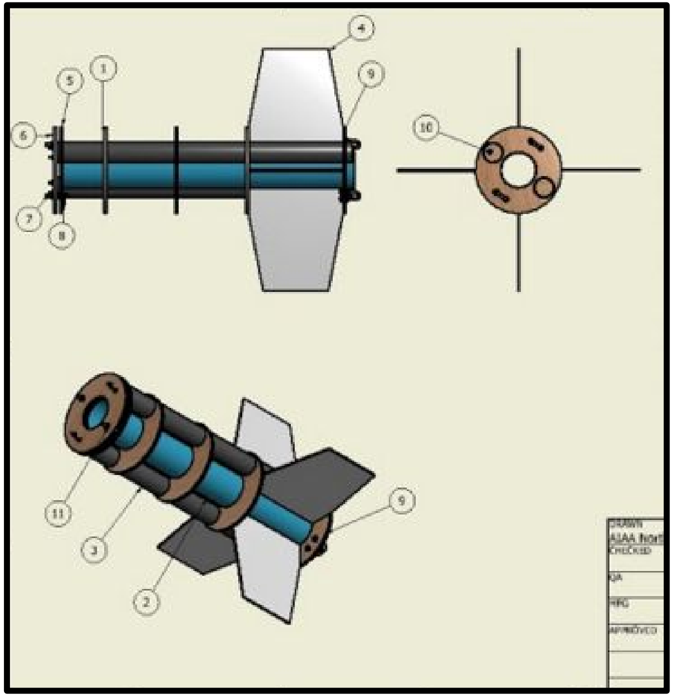
Test Plans and Procedures

- All portions of the rocket will the thoroughly tested before FRR
  - All launch avionics will be tested with a multimeter for continuity
  - All launch avionics will be tested on the ground
  - Static tests will be conducted for all parachutes and separations
- A full scale rocket will be launched before March 14th
  - The full scale will be launched multiple times to test systems
  - One launch will be without the CDLE systems to test separations in the air
  - One launch will contain the CDLE to test CDLE deployment during flight

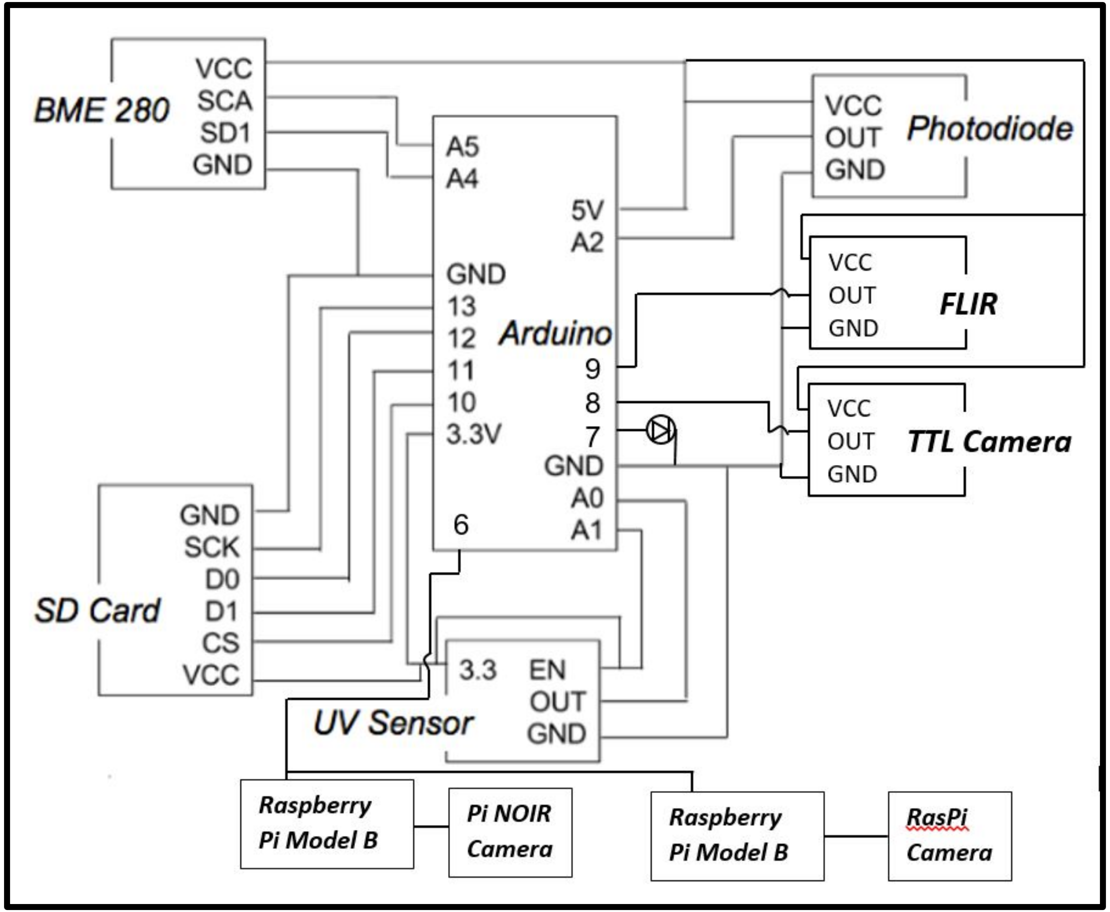
Subscale Tests and Results



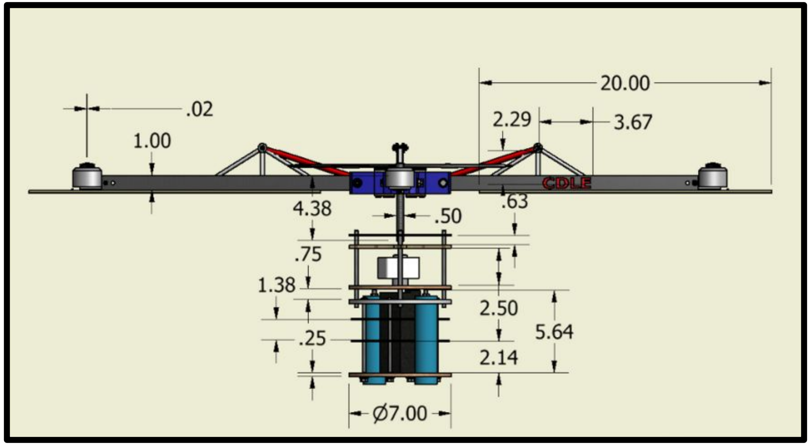
Tests of the Staged Recovery System

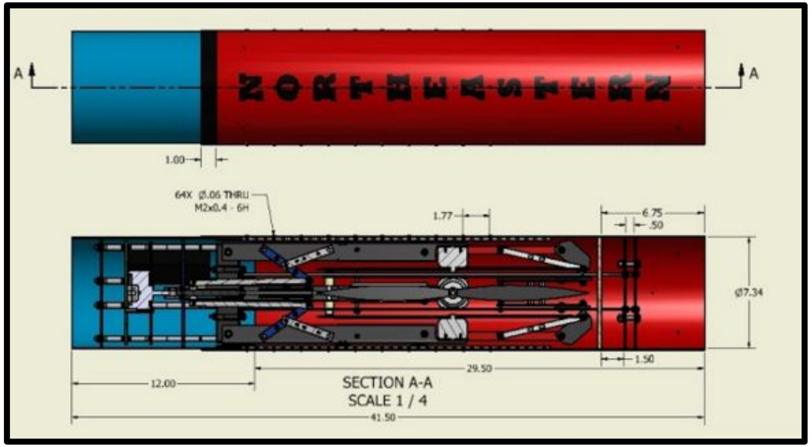


Final ATMOS Design Overview

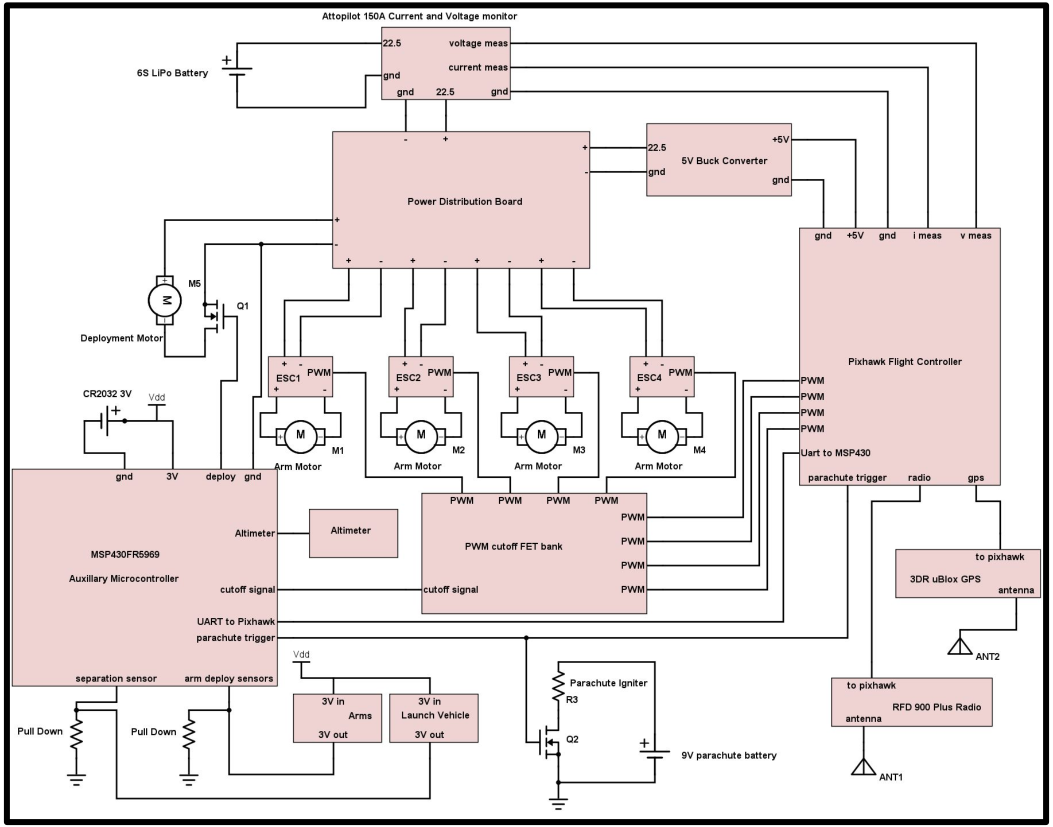


Final CDLE Design Overview

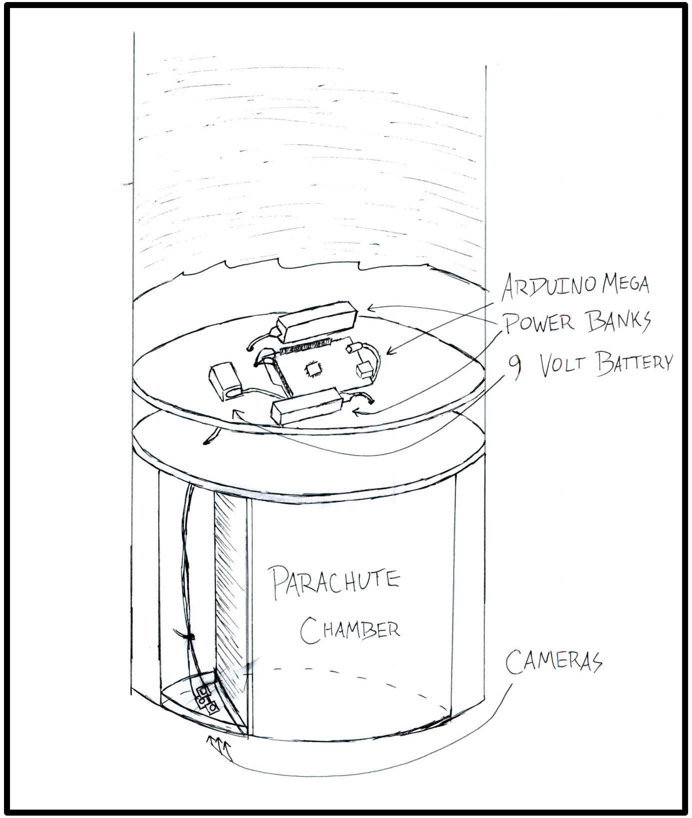


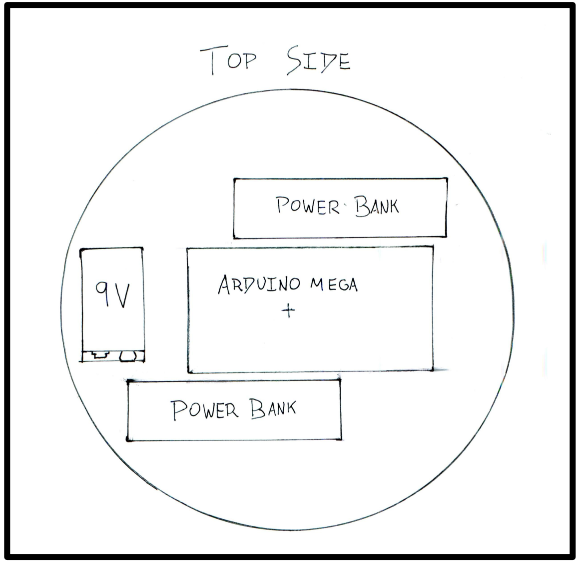


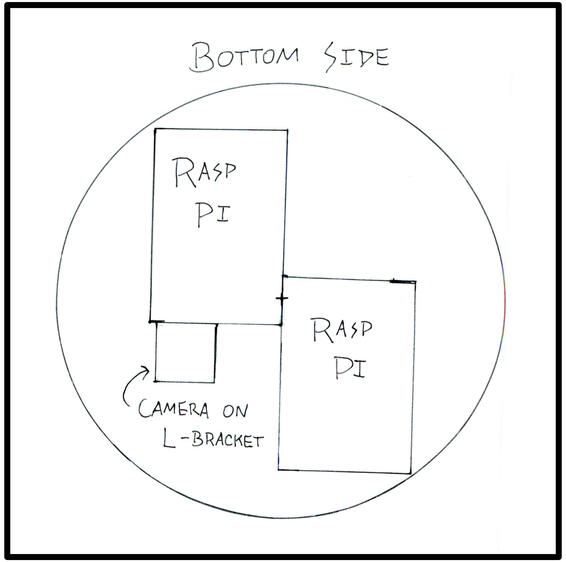
CDLE Electronics: Block Diagram



Payload Integration







Interfaces (Internal and to Ground)

- RFD 900 plus radio (915 MHz, 1W max)
    - ground link
- Internal serial data connections
    - Pixhawk to Radio
    - Pixhawk to GPS
    - MSP430 (auxiliary electronics) to Pixhawk (UART)
    - Altimeter to MSP430 (auxiliary electronics) (I2C)
- PWM to motors
    - from Pixhawk

Status of Launch Vehicle Requirements Verification

Launch Vehicle Requirement	Verification Procedure
The launch vehicle will reach an apogee of 5,280 feet.	The full scale will be launched at least twice to ensure that it can reach the target altitude.
The launch vehicle will be intact, reusable, and relaunchable.	The full scale will be launched at least twice in order to ensure that it is reusable and relaunchable. Upon recovery, all components will be inspected for damage and the design will be reassessed as necessary.
The launch vehicle will be able to sit on the launch pad for one hour with full functionality of all launch components.	Upon recovery the team will inspect each section to ensure that all systems functioned properly.
The launch vehicle can be prepped for launch within two hours.	The launch vehicle team will become familiar with the preparation of the launch vehicle and practice preparation before the competition.

Status of ATMOS Requirements Verification

Payload Requirement	Verification
Pressure Readings taken every ten seconds during descent and then once every minute after landing	Analysis – Pressure readings will be compared to accepted pressure vs altitude data Test - sensor will be tested on the ground to verify that measurements are taken at the proper time increments.
Temperature Readings taken every ten seconds during descent and then once every minute after landing	Test- Put sensors in areas of known temperature and then compare the data to the accepted values.
Humidity Readings taken every ten seconds during descent and then once every minute after landing	Test- change humidity of environment and see if measurements change accordingly
Solar Irradiance Readings taken every ten seconds during descent and then once every minute after landing	Test- change the exposure to the sun and see if measurements changes accordingly. Also, compare readings to that of a pyranometer to quantify the accuracy.

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Ultraviolet Radiation (UV) Readings taken every ten seconds during descent and then once every minute after landing	Test- change the exposure to the sun and see if measurements changes accordingly.
At least two pictures during descent and three after landing.	Inspection- See if we get adequate images at appropriate times during test flight
All pictures must be of the horizon with the sky in the top of the frame and the ground in the bottom	Visual Inspection of photos taken during test flight
Store Data onboard	Inspection- verify data is on SD card
Transmit Data	Inspection- Successful if data is received
Vegetation Analysis	Analysis- receive images and compare visible light to IR light to place on NDVI scale
Atmospheric Transmittance Data	Inspection – receive images and analyze images to get reputable data

Status of CDLE Requirements Verification

Payload Requirements	Verification
The piston must be able to eject the quadcopter to a safe distance from the rocket at apogee	Static ground tests will be conducted to ensure that the quadcopter (a solid mass will be used in tests to prevent damage) reaches a safe distance from the rocket.
The arms must be able to unfold fast enough for the quadcopter to slow its descent to a controllable speed	Each arm will be bolted to the nut and will pivot around a stationary delrin core. When the arms reach the horizontal, the motor will stop, and the lead screw will by nature lock the driving nut and keep the arms in place.
The quadcopter will position itself using GPS and control its descent onto a designated landing zone	The electronics will be thoroughly tested before going aboard the quadcopter.
The CDLE must be able to collect data	The sensors will properly inform the failsafes and the data is stored on board.
The quadcopter must send data to the ground station at the appropriate time	The data will be transferred to the ground station after the mandatory ten minutes after landing.
The CDLE must do all of this in a safe manner which is dictated by the failsafes built in to the software	If any of the failsafes are triggered the parachute is deployed.

Questions?