Designing and Flying an Experimental Sounding Rocket

TEAM 24

ALEX MIRE

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SPONSOR: FAMU-FSU COLLEGE OF ENGINEERING

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Problem Statement & Scope

Design and construct a rocket capable of carrying an experimental payload to be launched and safely recovered within the parameters of the 2017 Intercollegiate Rocket Engineering Competition hosted by the Experimental Sounding Rocket Association.

Figure 1: 2015-2016 Intercollegiate Rocket Engineering Competition [1]

The Competition

- **Category:** 10,000 ft using COTS solid or hybrid propulsion
- **Location:** Truth or Consequences, New Mexico
- **Date:** June 20-24, 2017
- **Purpose:** To promote further experimentation in the field of sounding rocketry.

Figure 2: Spaceport America[2]

Competition Requirements

- Payload
  - 8.8 lbs
  - CubeSat outer dimensions (10cm x 10cm x 11.35cm)
  - Scientific experiment or technology demonstrations (recommended)
- Recovery
  - Dual Deployment required for vehicles 1,500+ ft
- Electronics
  - 1 COTS altimeter
  - Redundant electronics
  - Radio beacon

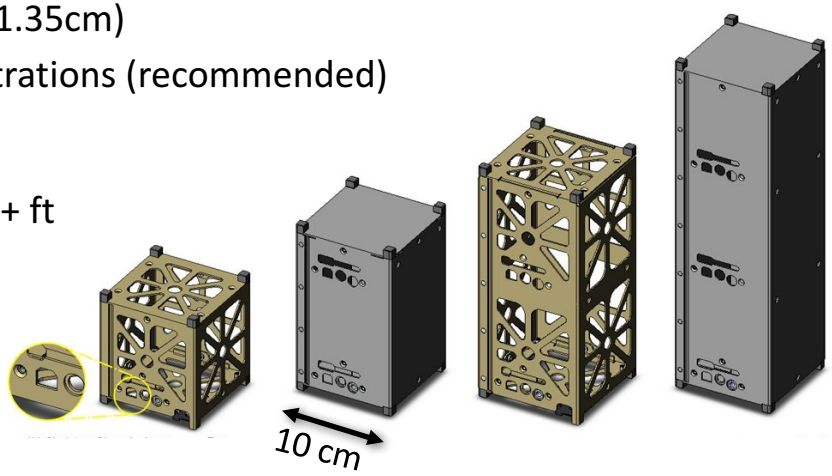


Figure 2: CubeSat Sizes[3]

Point Breakdown (1,000 Points Total)

- Entry Form and 3 Progress Updates **(100)**
- Project Technical Report **(200)**
  - Analysis
- Design Implementation **(200)**
  - Competency of Design and Construction
  - Degree of SRAD
- Flight Performance **(500)**
  - Apogee
  - Successful Recovery
- Unsafe or Unsportsmanlike Conduct **(-20)**

Spaceport America Cup

Intercollegiate Rocket Engineering Competition
Rules & Requirements Document

Figure 4: Competition rules document coverpage [4]

Design Overview

- Length: 8 ft
- Mass: 30.26 kg
- Rocket ID: 152 mm
- Rocket OD: 156 mm
- 5 segments
- Fiberglass Body

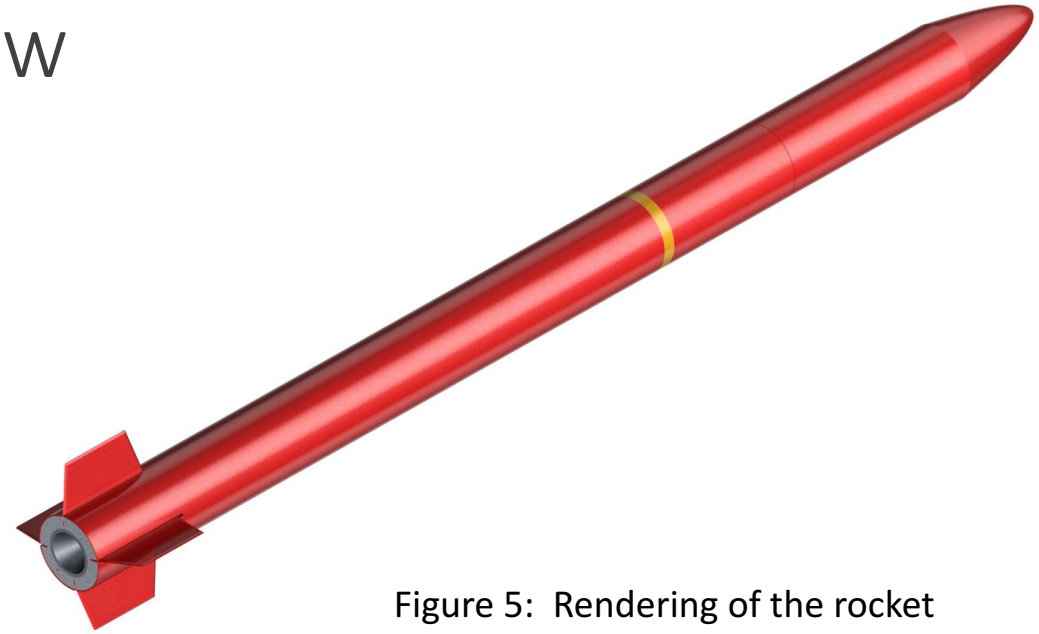
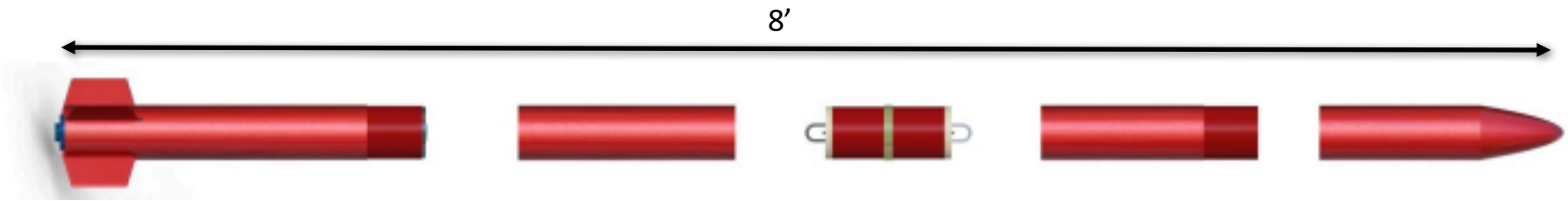


Figure 5: Rendering of the rocket



Booster Segment

- M Class Motor
- Motor mount adapter
- Aluminum centering rings
- Fins mount to centering rings

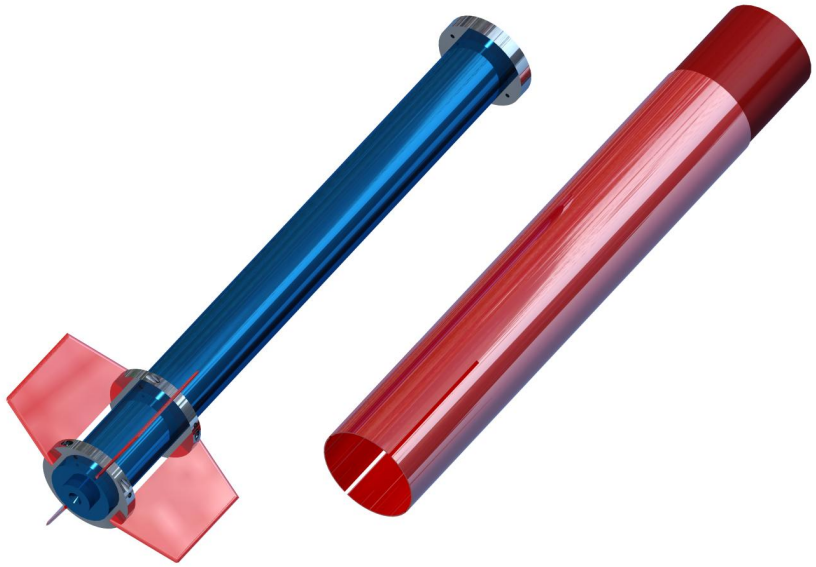
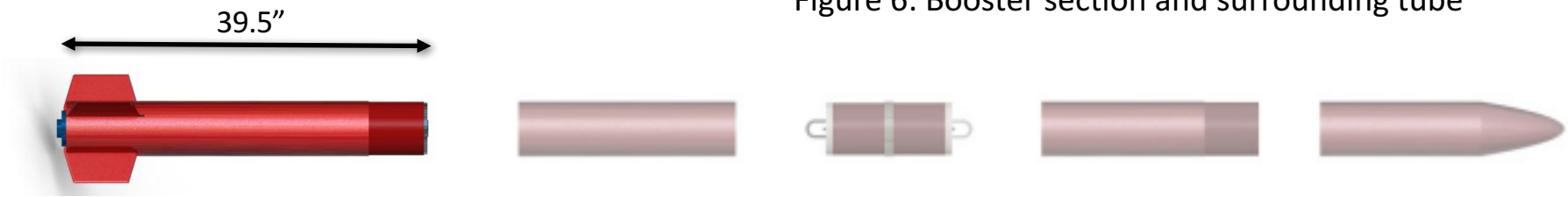


Figure 6: Booster section and surrounding tube



Propulsion Selection

- Cesaroni Technology Incorporated M1450-P motor (98mm)
- 6.87 second second burn time
- Rocket will experience 6.6 G's

Figure 7: Motor casing [5]

Drogue Parachute Bay

- Houses a 3ft drogue parachute by The Rocketman
  - Decent rate of 90 ft/s
  - Shock chord attachment
- "Zipper-less" design
- Easily replaceable if damaged during flight

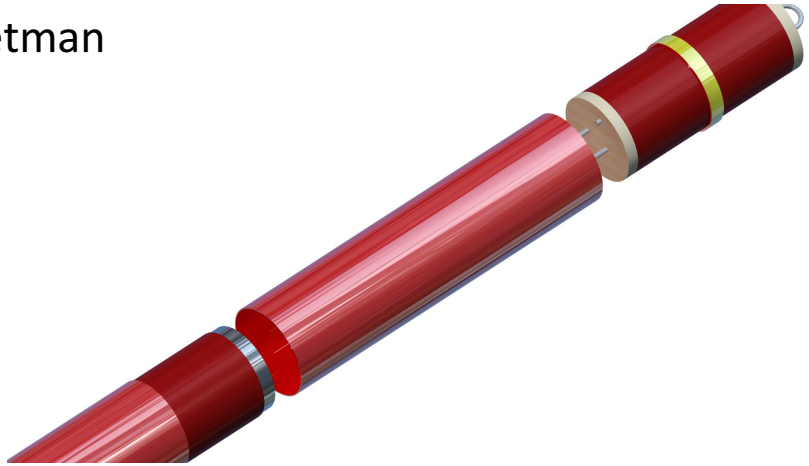
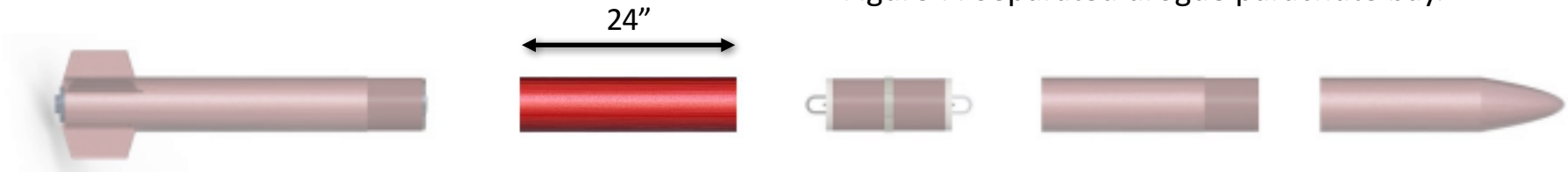


Figure 7: Separated drogue parachute bay.



Avionics Bay

- Fiberglass outer body
- Ejection charges
- Redundant electronics
- Exposed ring for Altimeters
- Parachute Mounting U-bolts

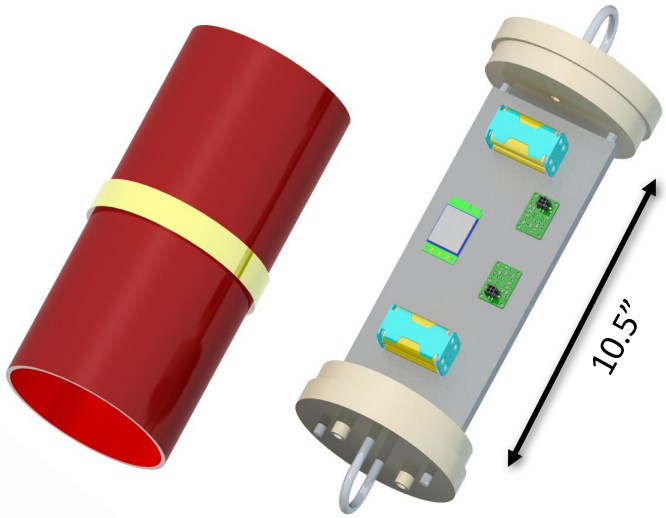
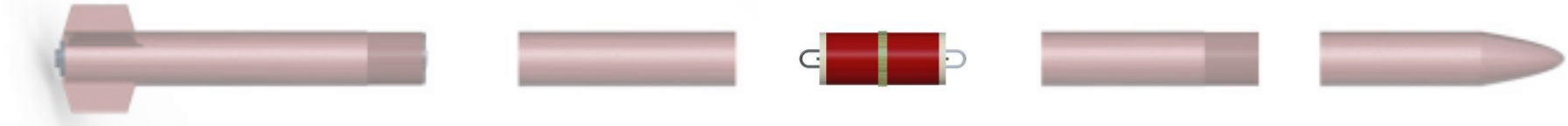


Figure 7: Avionics sled and bay body section[6] [7] [8]



Main Parachute Bay

- Houses a XXL B2 parachute
  - Decent rate of < 17 ft/s
- One end has coupler pinned to nosecone
- “Zipper-less”
- Easily Replaceable.

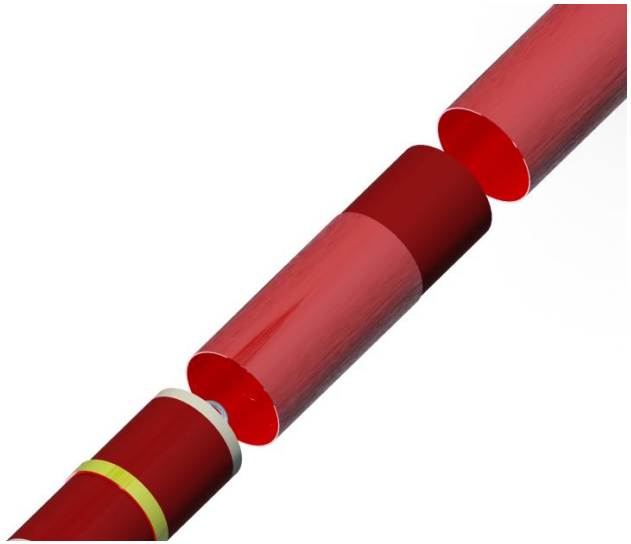
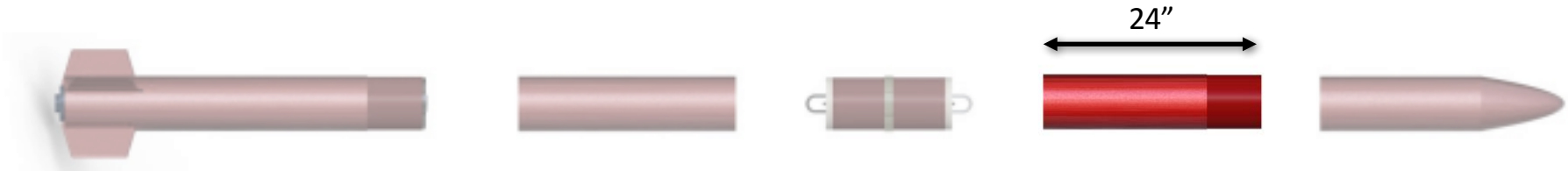


Figure 8: Main parachute bay



Nose Cone and Payload

- 3D printed nose epoxied to fiberglass tube
- Centering Rings hold CubeSat
- CubeSat contains 8.8lb payload

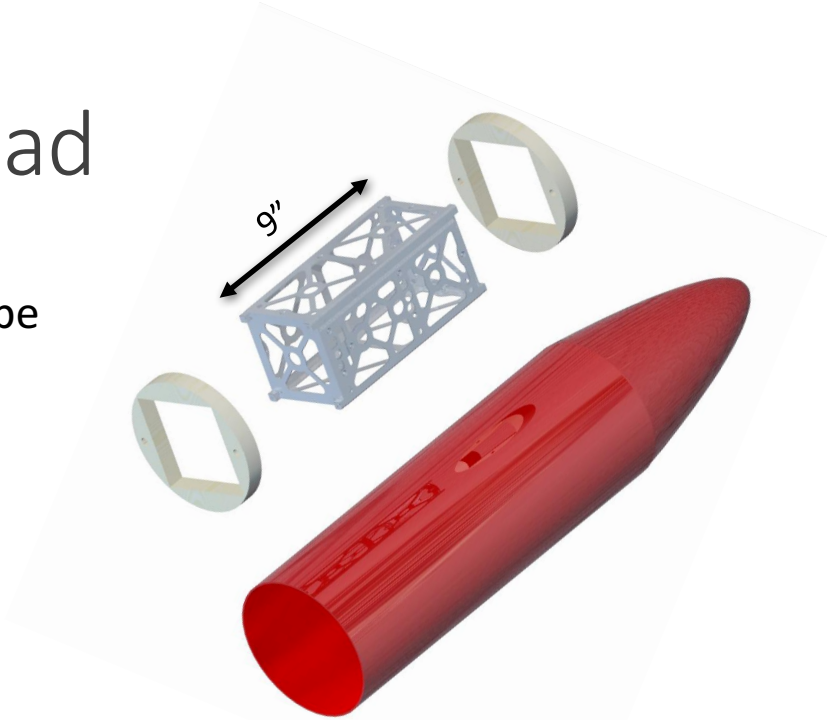
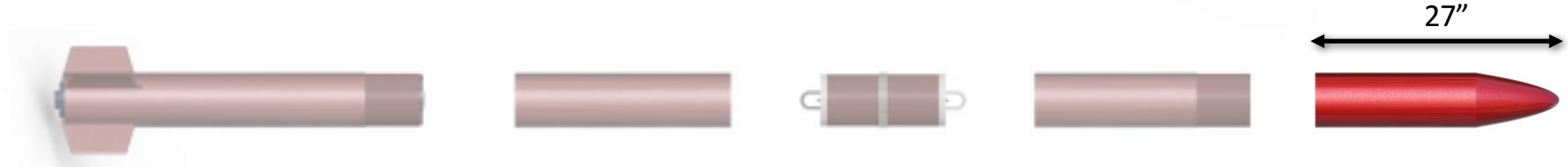


Figure 9: Experimental housing section



Weight and Cost

Section	Cost	Mass
Booster	$1570.01	16.9 kg
Drogue Parachute	$117.77	2.13 kg
Avionics Coupler	$636.57	2.06 kg
Main Parachute	$332.00	3.22 kg
Nosecone and Payload	$75.98	5.93 kg
TOTAL	**$2732.32**	**30.26 kg**

- Total only includes flight hardware.
- Competition fees are $900.
- Flight hardware and competition fees subtotal **$3632.32**

Flight Calculations

M1450-P motor achieves target altitude with an approximately 30.26 kg. vehicle at liftoff

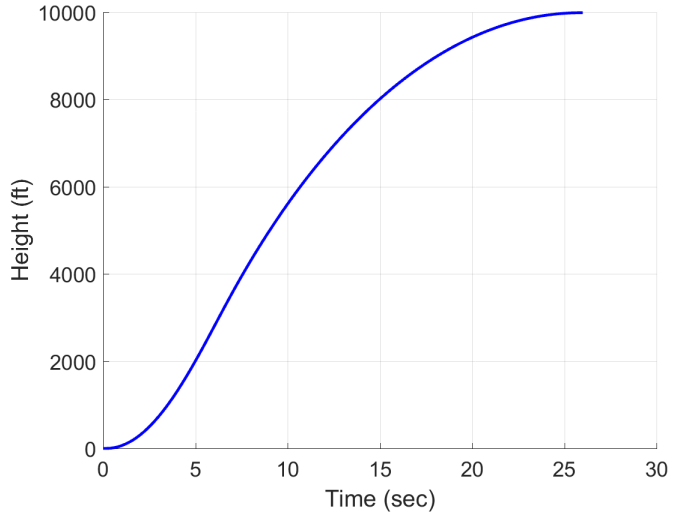


Figure 10: Altitude for calculated vehicle mass

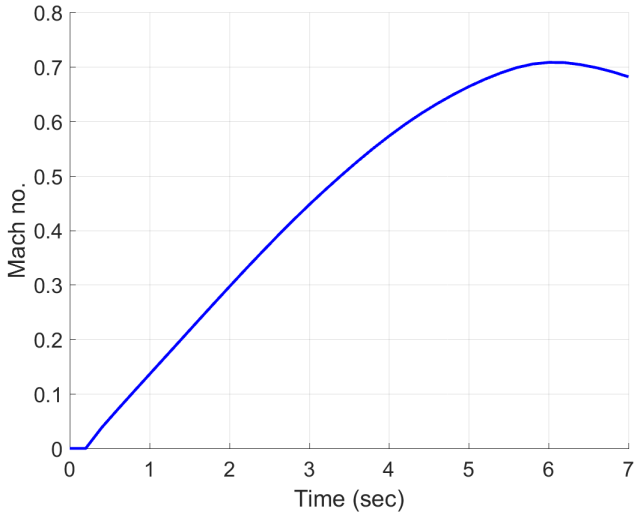


Figure 11: Velocity profile for calculated vehicle mass

OpenRocket Simulation Software

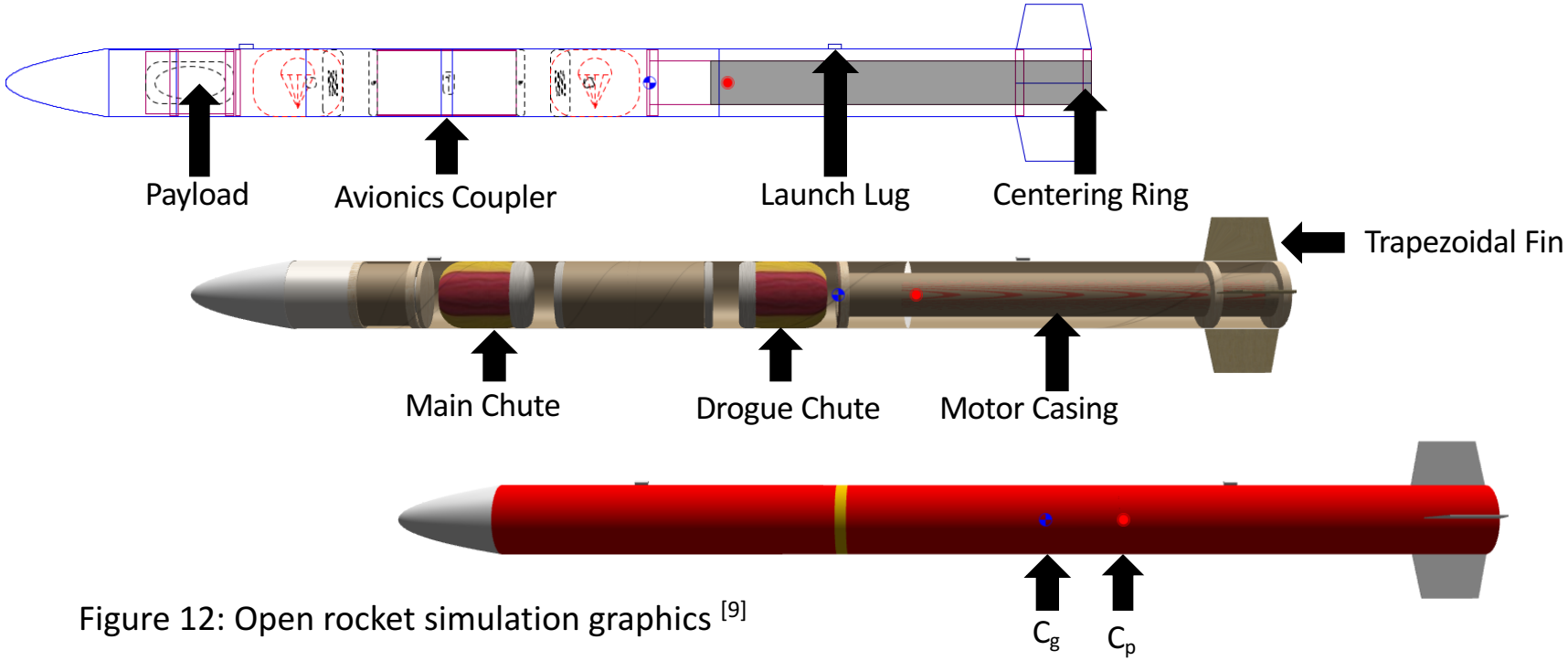


Figure 12: Open rocket simulation graphics [9]

OpenRocket Data

Data	Simulated Value
Apogee	3073 m (10,082 ft)
Max. Velocity	242 m/s (794 ft/s)
Max. Acceleration	65.3 m/s^2 (214.2 ft/s^2)
Center of Gravity	146 cm (57.5 in)
Center of Pressure	165 cm (65 in)

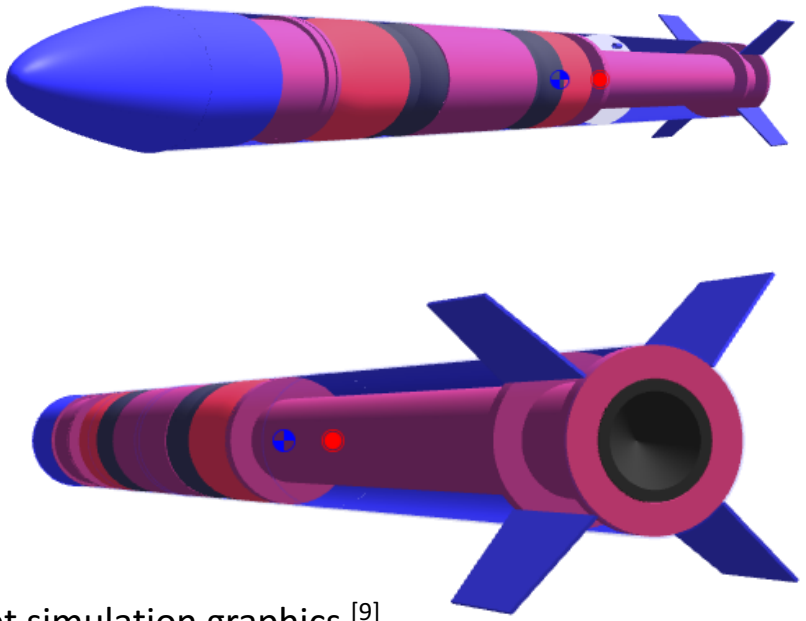


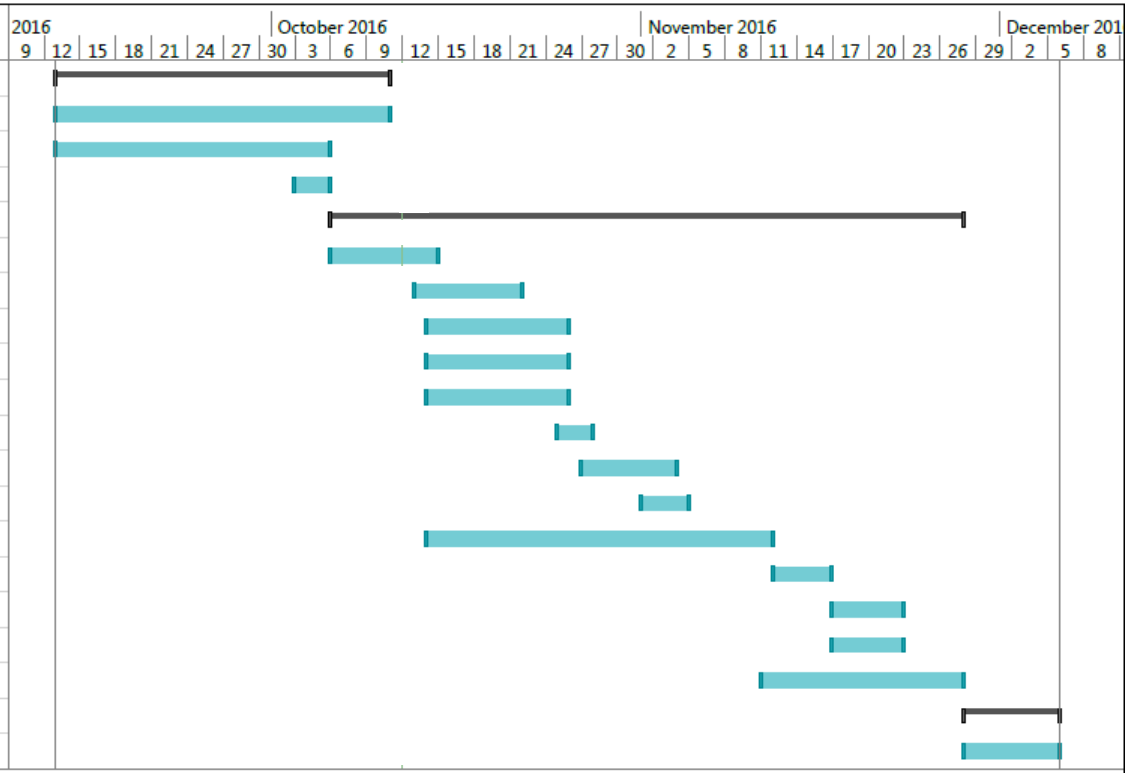
Figure 13: Open rocket simulation graphics [9]

Failure Mode Analysis

Process Function	Part	Potential Failure Mode	Mechanism(s) of Failure	Potential Effects(s) of Failure	Recommended Action(s)
Avionics package sensing	Avionics bay	Disruption due to flight forces	Intensive loading	Loss of altitude data acquisition, and of parachute deploy capability	Ensure tight fit of the altimeter into the avionics bay / all wires have slack
Launch sequence	Control box	Failure to send command	Faulty circuit board / power disconnect	Failure to launch	Redundant systems already in place

Gantt Chart

ID	Task Name
1	**<Research and Concept Generation>**
2	Background Research
3	Brainstorming
4	Concept Generation
5	**<Detailed Design/Analysis>**
6	Initial Concept Selection
7	Raw Material Selection
8	Initial CAD Model
9	Develop Flight Controler
10	Develop Recovery System
11	Initial Payload Selection
12	Payload Integration
13	Body and Fin Analysis
14	Tenative Final Design
15	FMEA and H-FMEA
16	Final Design
17	Bill of Materials
18	Cost Analysis
19	**<Design Implementation>**
20	Placing Orders



Changes and Current Issues

Changes

- No backup recovery system
- Store-bought altimeter
- 3D printed nose cone
- Storage & transportation
- “Zipper-less” design
- No bay doors

Current Issues

- Undeveloped payload
- Overall cost of design and competition
- Test launch uncertain

References

[1] http://www.soundingrocket.org/latest-news

[2] http://www.americaspace.com/?p=72686

[3] Vyonyx ltd

[4] http://www.soundingrocket.org/sac-documents--forms.html

[5] https://grabcad.com/library/quectel-uc20-pci-e-module-1

[6] https://grabcad.com/library/battery-pack-2

[7] https://grabcad.com/library/printed-circuit-board-4

[8] http://www.pro38.com/products/pro24/pro24.php#

[9] http://openrocket.sourceforge.net/

Thank you!
Questions?