Designing and Flying an Experimental Sounding Rocket

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ESRA Rocket Engineering Competition

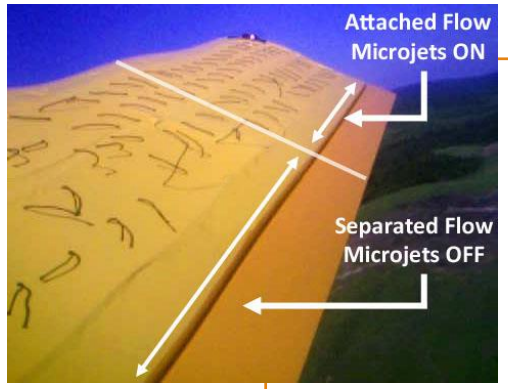
- **Category:** 10,000 ft using COTS solid or hybrid propulsion
- **Location:** Truth or Consequences, New Mexico
- **Date:** June 20-24, 2017
- **Purpose:** To promote further experimentation in the field of sounding rocketry.

Figure 1: Spaceport America[1]

Why build a rocket?

The commercial launch sector is rapidly growing with billions of dollars in investments and thousands of jobs

Rocket reusability will require novel approaches to landing and recovery



Leverage research specialty in active flow control at the AME

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

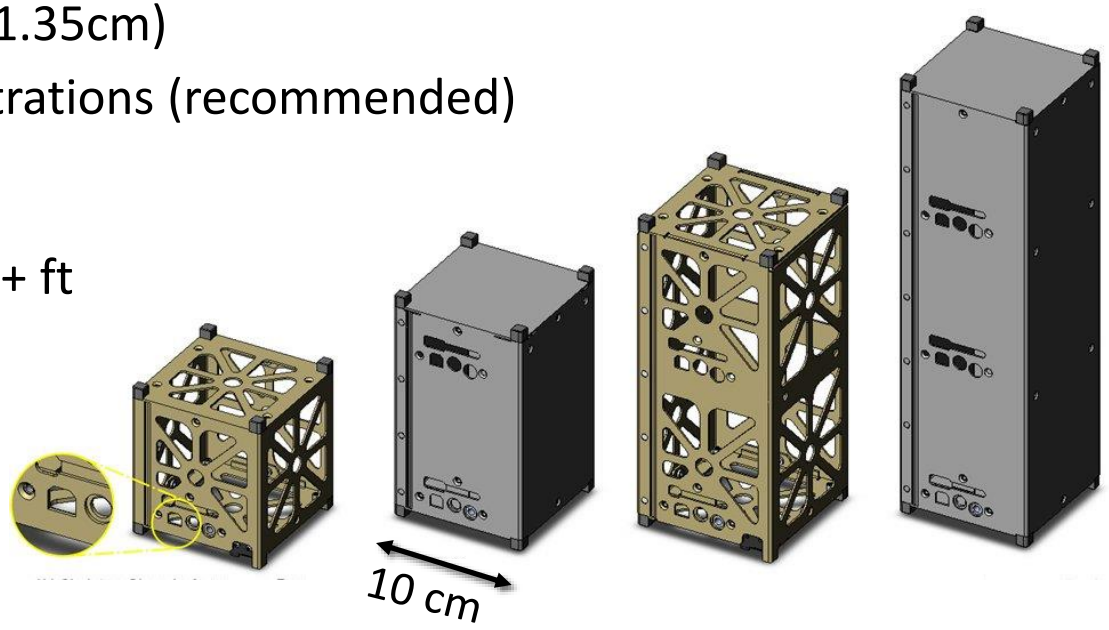


Figure 2: CubeSat Sizes[2]

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 3: Competition rules document coverpage [3]

Design Overview

- Length: 102.5 in
- Mass: 56.3 lb
- Rocket ID: 6 in
- Rocket OD: 6.14 in
- 4 segments
- Fiberglass Body

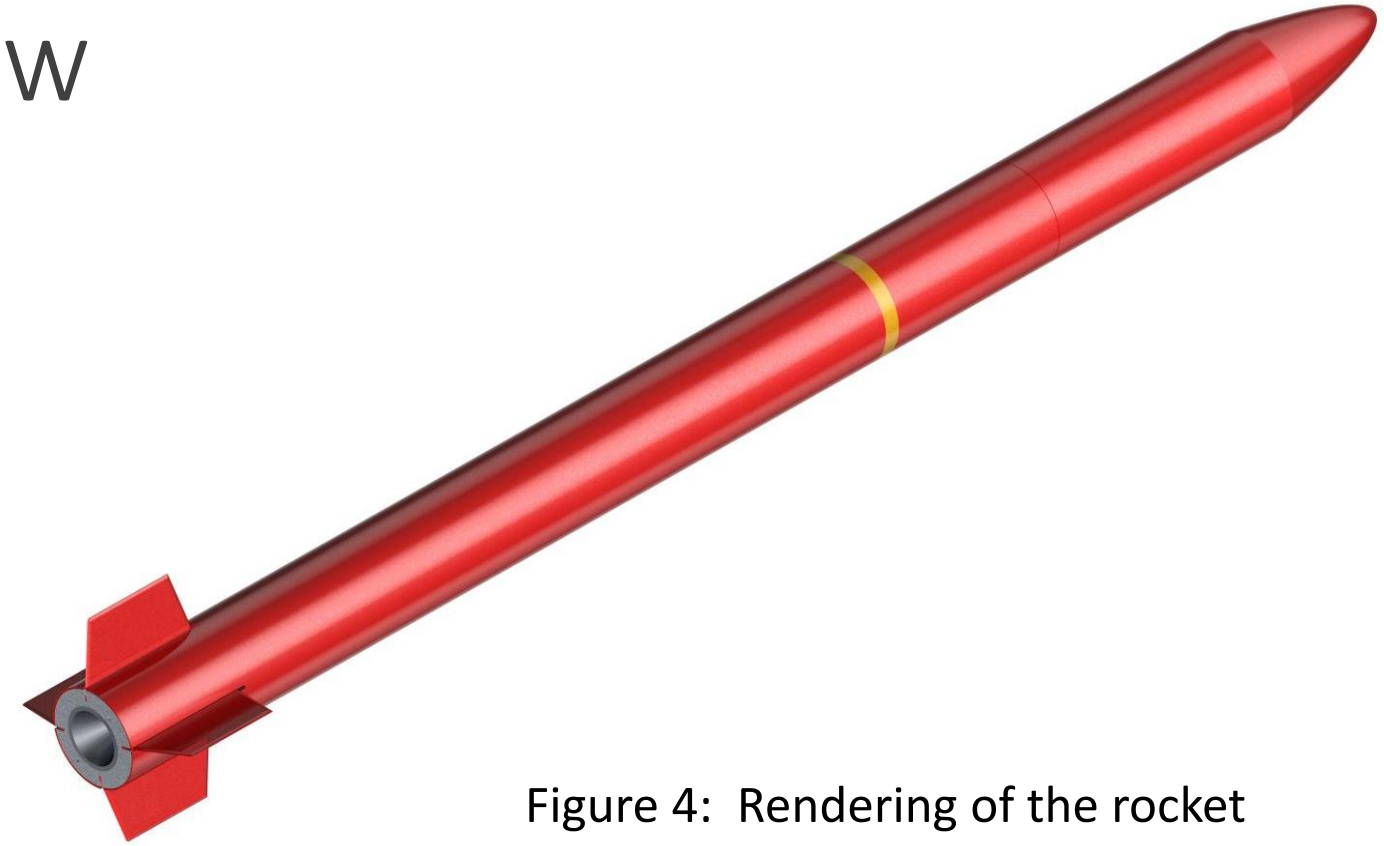


Figure 4: Rendering of the rocket

Booster Segment

- Skidmark M1790 motor (98mm)
  - 4.53 second burn
  - Rocket will experience 7.5 G's
- Wooden centering rings
- Fiberglass fins

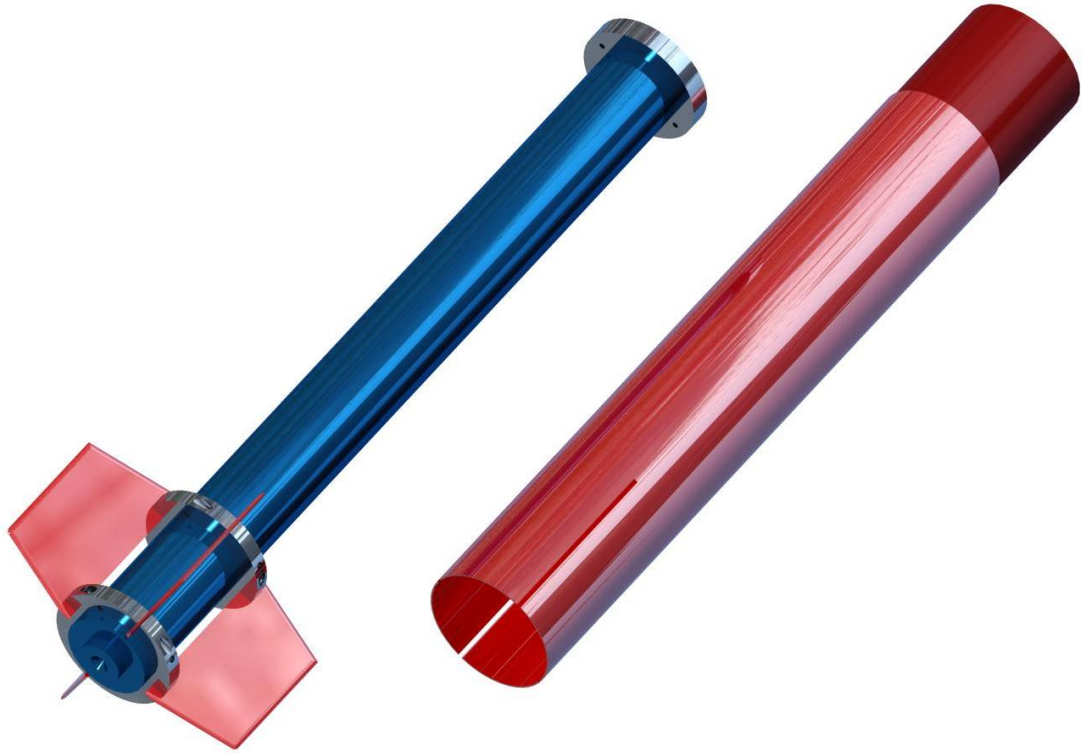


Figure 5: Booster section and surrounding tube

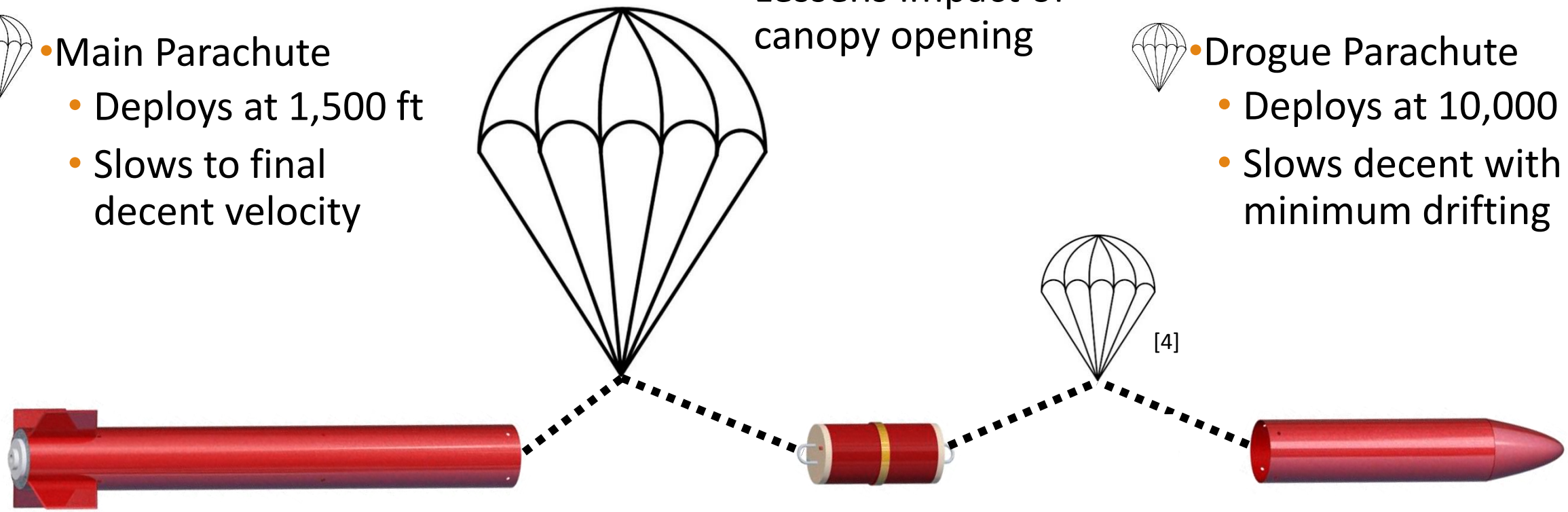
Dual Deployment

Shock Chord

- Keeps segments together in decent
- Lessens impact of canopy opening

- Main Parachute
  - Deploys at 1,500 ft
  - Slows to final decent velocity

- Drogue Parachute
  - Deploys at 10,000 ft
  - Slows decent with minimum drifting

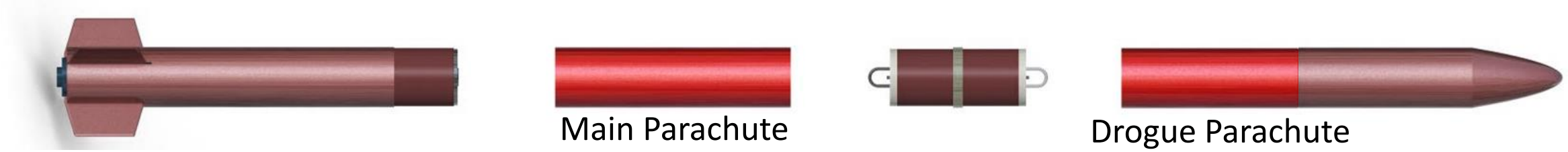


[4]

Parachute Bays

- Drogue parachute: Rocketman 3ft parachute
  - Decent rate of 90 ft/s
- Main parachute: XL B2 parachute
  - Decent rate of < 17 ft/s
- “Zipper-less” design

Figure 6: Separated drogue parachute bay.



Avionics Bay

- Fiberglass outer body
- Ejection charges
- Exposed ring for Altimeters
- Parachute Mounting U-bolts
- Redundant electronics
  - Commercial Flight Controller
  - Student Designed Flight Controller

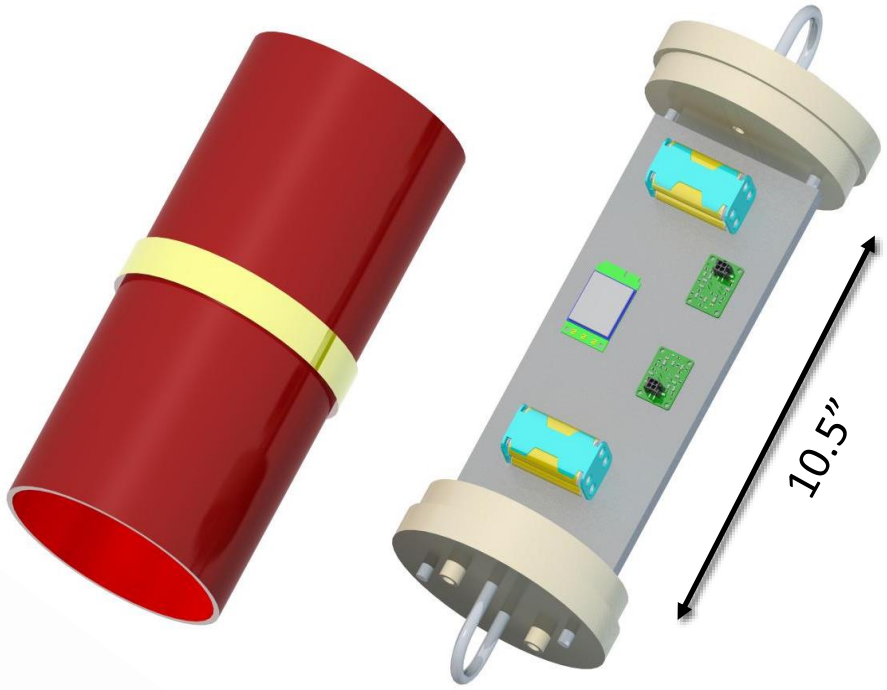


Figure 7: Avionics sled and bay body section[5] [6] [7]

Nose Cone and Payload

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

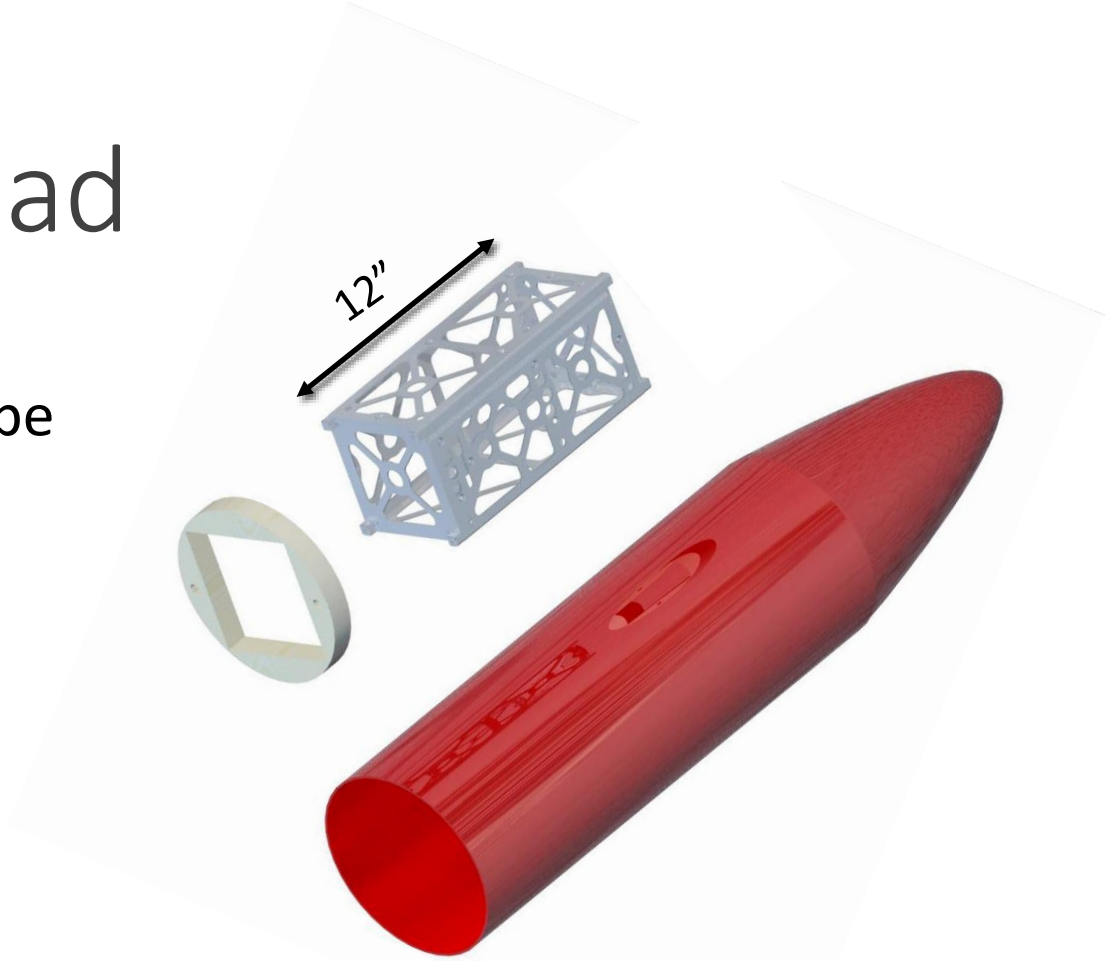
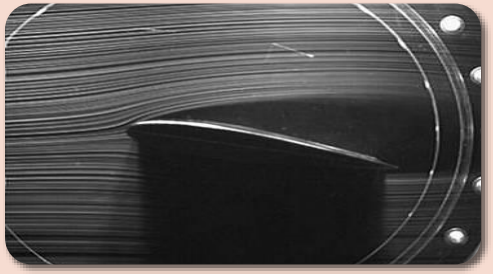
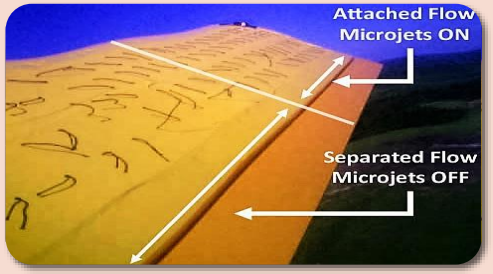


Figure 8: Experimental housing section

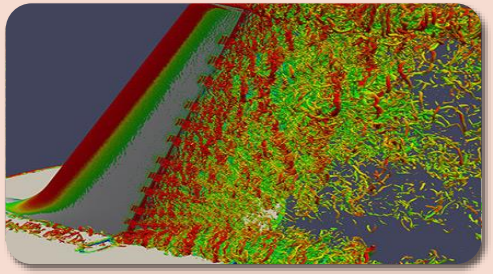
Research Payload – Active Flow Control



Active flow control studies the effects of injecting momentum into a flow field [13]



The injection of momentum can reattach flow to a surface [14]



Applications include lowering drag on aircraft, missile, and launch vehicle designs [15]

Research Payload – Sequence of Events

-After apogee, begin injecting fluidic jets in surrounding air

-Alter flow physics around vehicle

-Orient the vehicle in optimal direction to deploy parachutes

Research Payload – Parts

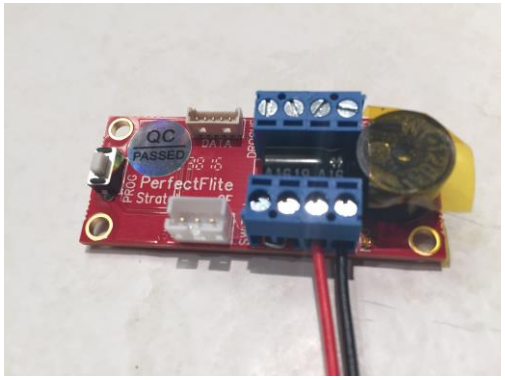
- Payload must follow competition's pressure vessel requirements
- Compressed gas (9oz HPA tank)
- Adapters
- Solenoid valve
- Splitter and nylon tubing

Build Status – Fiberglass Body

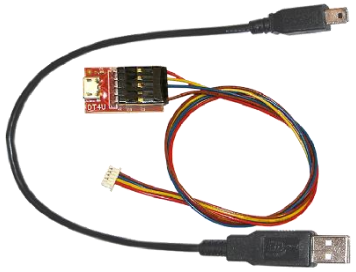
- What has been done:
  - All tubes produced
  - Sanded body
  - Squared and leveled ends
  - Checked sizing and fits
- Still to do:
  - Paint tubes
  - Drill holes
  - Cut fins

Build Status - COTS Avionics

- Received and assembled
- Functional build
  - Speaker
  - Barometric sensor
  - Data cable and software
- Intended Dual-Deployment test
  - Timing e-matches
  - Black powder test



StratologgerCF



DT4U Cable

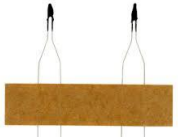
SRAD Avionics

- Determine altitude and orientation
- Log flight data
- Activate experiment
- Deploy parachutes
- Transmit GPS coordinates

BMP183

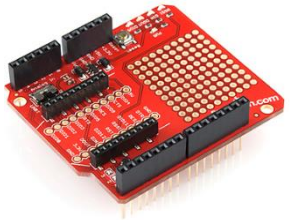
9-DOF IMU

MircoSD Card Reader



Igniters

Arduino Uno

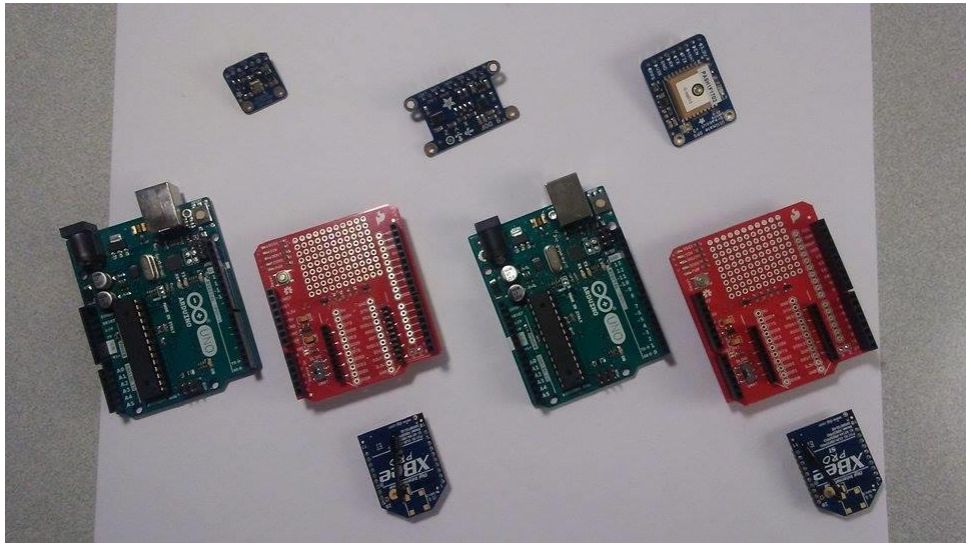


Xbee Shield

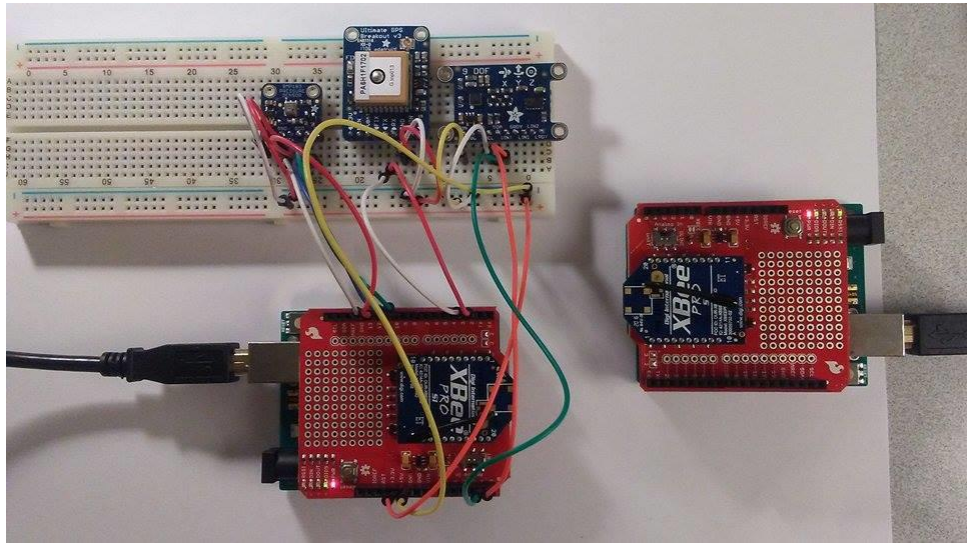
Ultimate GPS

Xbee Pro 60 mW

Build Status – SRAD Avionics



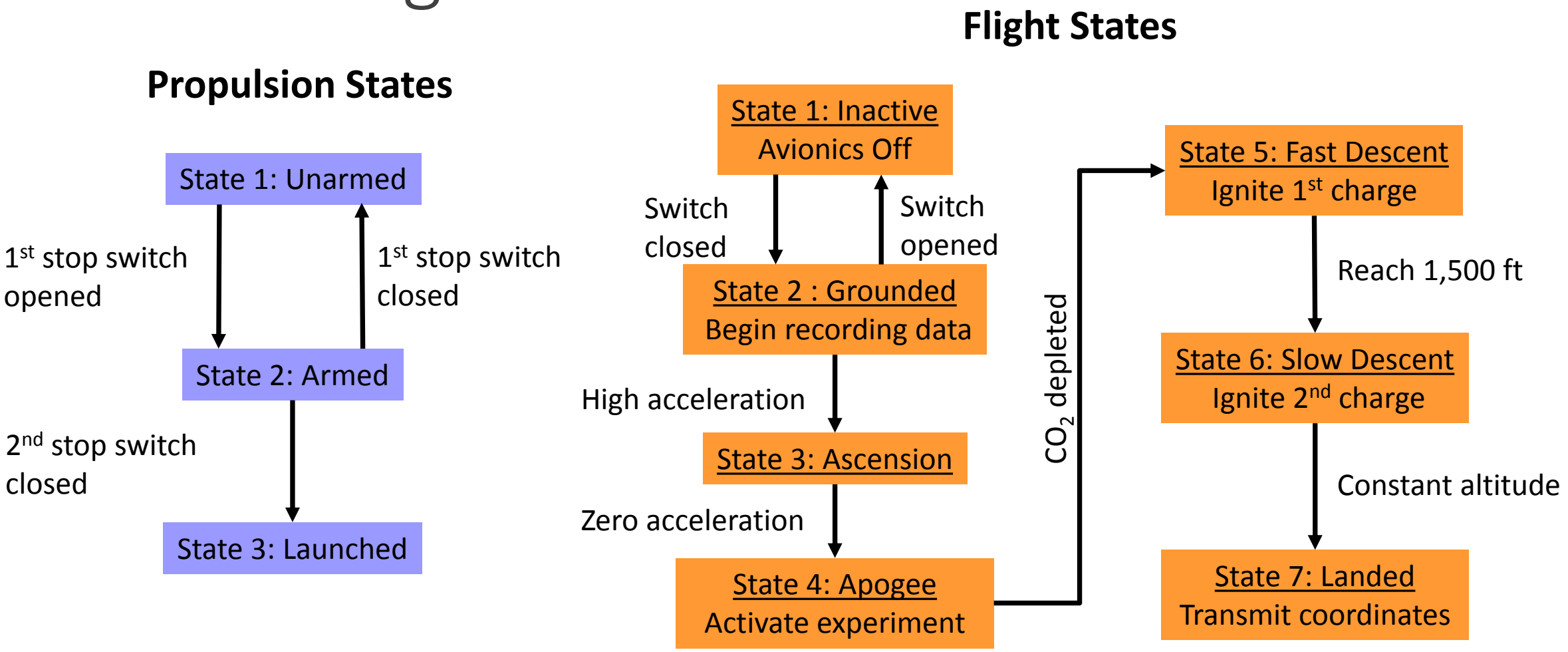
Avionics components



Testing setup

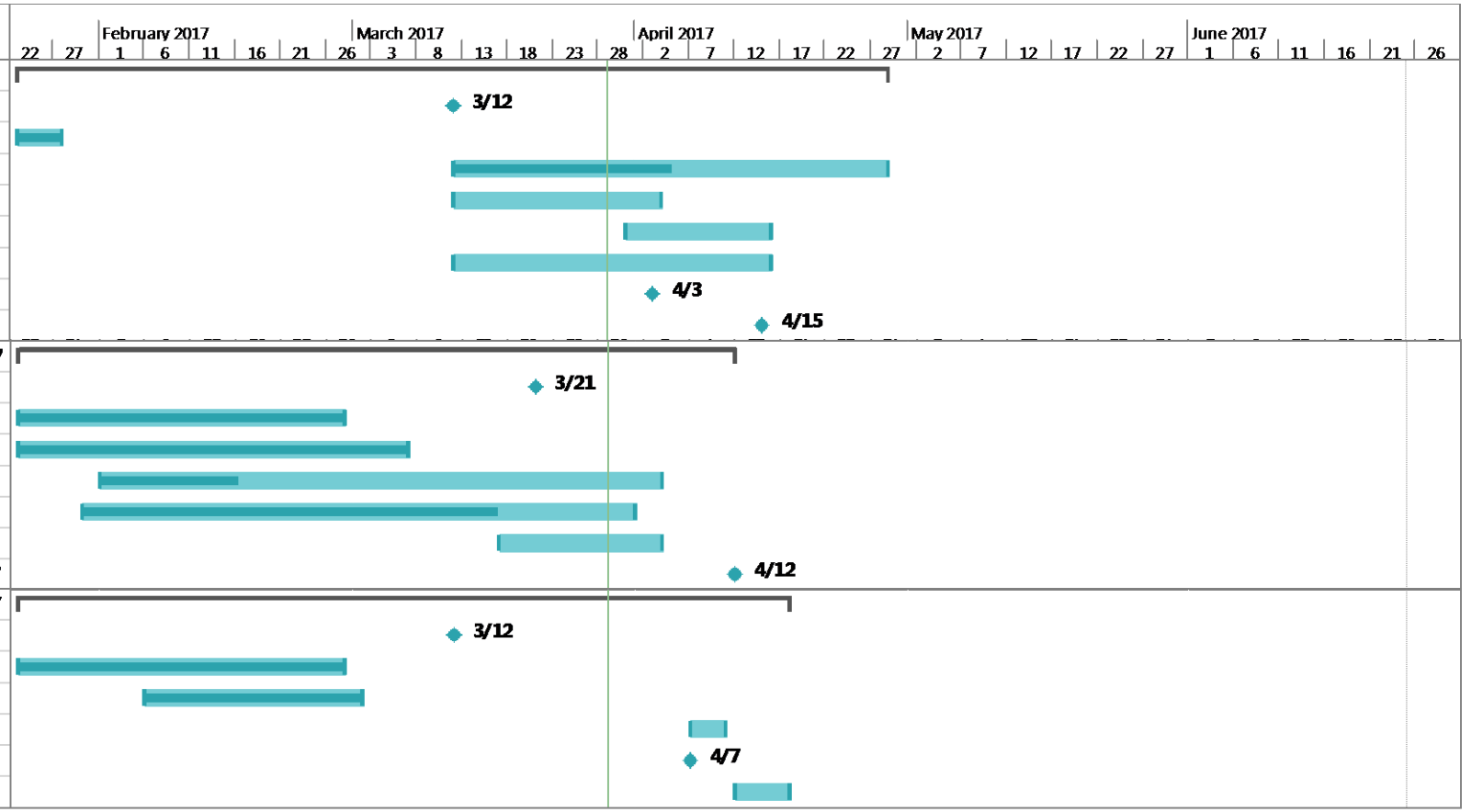
Igniter Test

State Diagram



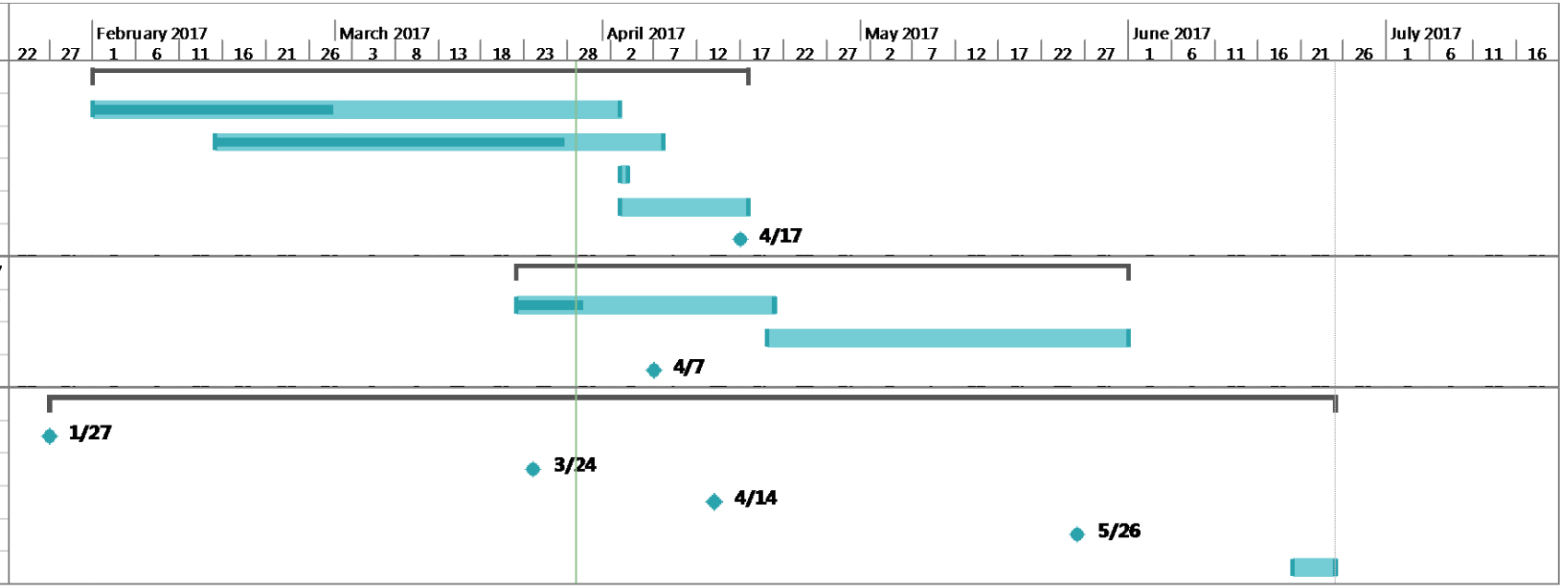
Gantt Chart

ID	Task Name	Duration	Start	Finish
11	**Booster**	**70 days?**	**Mon 1/23/17**	**Fri 4/28/17**
12	Complete fiberglass (booster)	0 days	Sun 3/12/17	Sun 3/12/17
13	Order centering rings and hardware	5 days	Mon 1/23/17	Fri 1/27/17
14	Build/Machine centering rings	36 days	Sun 3/12/17	Fri 4/28/17
15	Install rail button	17 days	Sun 3/12/17	Mon 4/3/17
16	Build fins	12 days	Fri 3/31/17	Sat 4/15/17
17	Install centering rings/fins	27 days	Sun 3/12/17	Sat 4/15/17
18	Order motor grains	0 days	Mon 4/3/17	Mon 4/3/17
19	Complete booster segment	0 days	Sat 4/15/17	Sat 4/15/17
21	**Avionics**	**57 days**	**Mon 1/23/17**	**Wed 4/12/17**
22	Complete fiberglass (avionics)	0 days	Tue 3/21/17	Tue 3/21/17
23	Order altimeters and radio beacon	26 days	Mon 1/23/17	Mon 2/27/17
24	Order parts for inner avionics	31 days	Mon 1/23/17	Mon 3/6/17
25	Build/Machine endcaps	44 days	Wed 2/1/17	Mon 4/3/17
26	Program altimeters and beacons	45 days	Mon 1/30/17	Fri 3/31/17
27	Wire buttons and drill holes	12 days	Fri 3/17/17	Mon 4/3/17
28	Complete avionics segment	0 days	Wed 4/12/17	Wed 4/12/17
30	**Recovery**	**61 days**	**Mon 1/23/17**	**Mon 4/17/17**
31	Complete fiberglass (recovery)	0 days	Sun 3/12/17	Sun 3/12/17
32	Order shock chord and hardware	26 days	Mon 1/23/17	Mon 2/27/17
33	Order parachutes	18 days	Mon 2/6/17	Wed 3/1/17
34	Install mounting hardware	2 days	Fri 4/7/17	Mon 4/10/17
35	Schedule testing date with FSU/CoE	0 days	Fri 4/7/17	Fri 4/7/17
36	Test deployment of recovery system	4 days	Wed 4/12/17	Mon 4/17/17



Gantt Chart

ID	Task Name	Duration	Start
38	**Payload and Nosecone**	**54 days**	**Wed 2/1/17**
39	Determine/design payload	44 days	Wed 2/1/17
40	Build nosecone	38 days	Wed 2/15/17
41	Order any payload parts	1 day	Mon 4/3/17
42	Weigh/ Integrate payload	11 days	Mon 4/3/17
43	Complete payload/nosecone section	0 days	Mon 4/17/17
45	**Test Launch**	**51 days**	**Wed 3/22/17**
46	Schedule test launch	22 days	Wed 3/22/17
47	Test launch	30 days	Thu 4/20/17
48	Complete safety and operations manual	0 days	Fri 4/7/17
50	**ESRA Dates**	**106 days**	**Fri 1/27/17**
51	1st Progress Reports	0 days	Fri 1/27/17
52	2nd Progress Reports	0 days	Fri 3/24/17
53	Payments	0 days	Fri 4/14/17
54	All remaining paperwork	0 days	Fri 5/26/17
55	Competition	5 days	Tue 6/20/17



Budget ($7,000)

Component	Cost
Body & Fiberglass	$400
Nosecone & Payload	$200
Recovery	$385
Avionics	$260
Booster & Test Motor	$2,160
Manufacturing Materials	$135
Competition Fees	$900
Travel	$1,300
TOTAL	**$5,740**
Amount Spent	**$1,700**

Work Still to Be Done

Booster

- Centering rings (glue and machine)
- Fins (design, build, and machine)
- Re-evaluate motor

Avionics Bay

- Build avionics mounting sled
- Build and machine end caps
- Additional programming/testing

Other Tasks:

- Ground testing

Payload and Nose Cone

- Print nose cone
- Design payload layout

Body

- Join body and couplers
- Drill holes
- Finish surface/paint

References

[1] Vyonyx ltd

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

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

[4] http://www.clipartbest.com/parachute-clip-art

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

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

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

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

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[10] http://www.mouser.com/ProductDetail/Digi-International/XBP9B-DMWT-012/?qs=NnxJOTDiCpOOEE6pVdOjDg%3D%3D&gclid=CLPj7J3T2dECFUkDhgodvHAEDw

[11] ttps://www.tinkerforge.com/en/doc/Hardware/Bricks/IMU_V2_Brick.html

[12] https://www.urbanwebsites.com/sabalan-enterprises/index.html

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[14] https://woodcraft-assets-weblinc.netdna-ssl.com/Images/products/600/152976.jpg

Thank you!
Questions?