CanSat 2023
Post Flight Review (PFR)
Version 1.0

Team 1079

Team Afterburner

Presentation Outline

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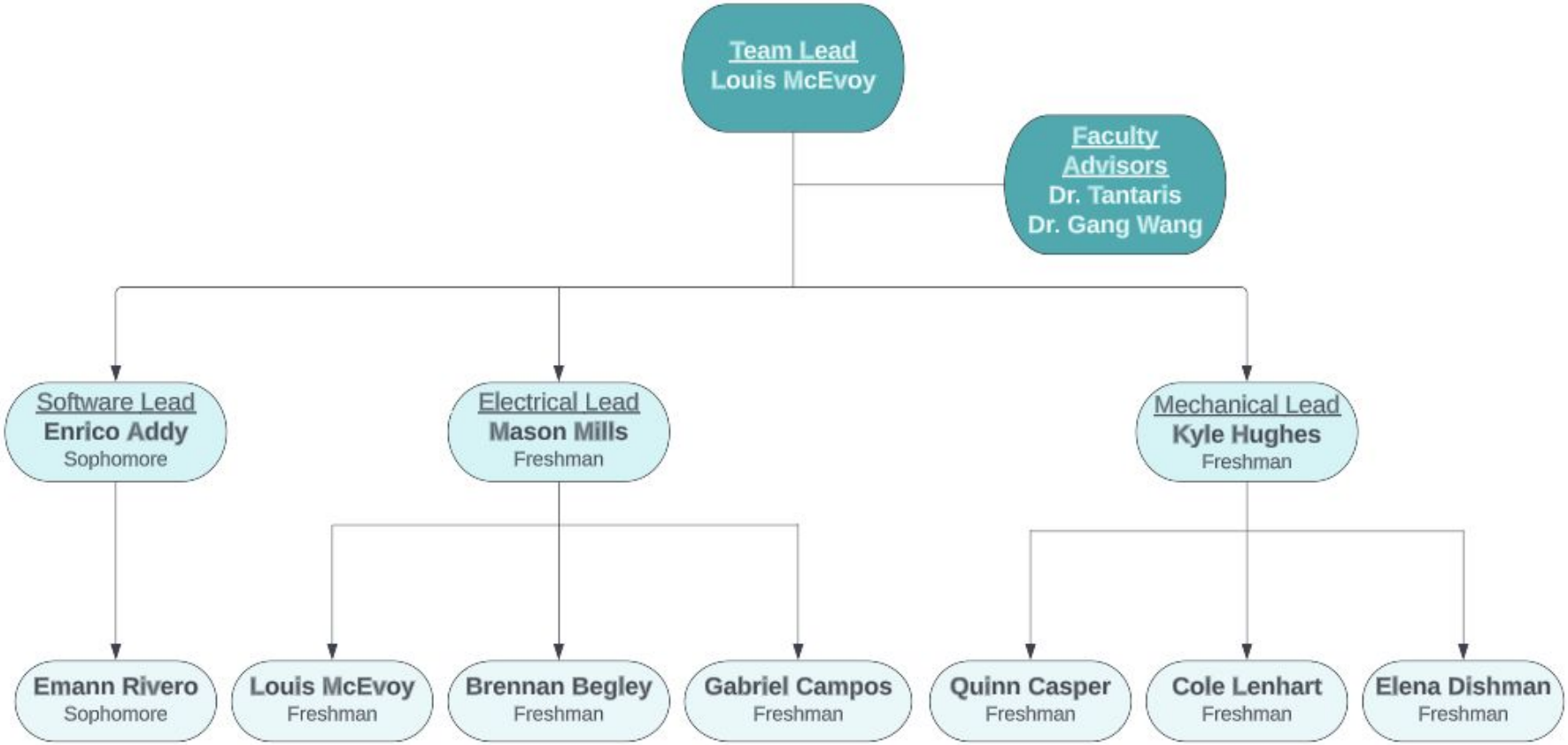
Team Organization



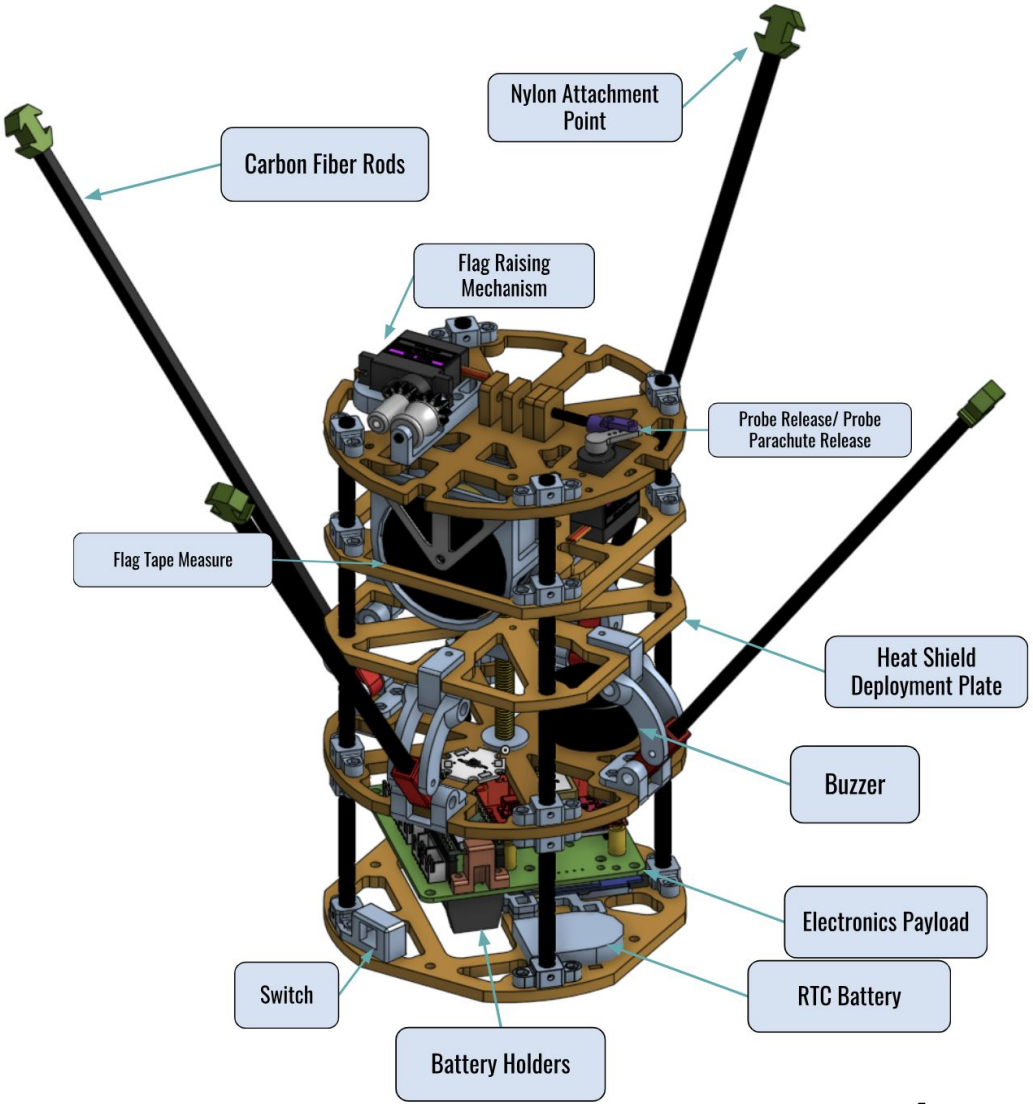
Team Objectives

Main Objective	
Design a CanSat consisting of a container and probe that simulates the landing sequence of a planetary probe.	
Secondary Objectives	
1	Compete in 2023 Cansat Challenge and follow all mission requirements
2	Design and fly a heat shield that shields a majority of the CanSat from oncoming air
3	Learn sandwich composite and fiberglass layup manufacturing methods
4	Learn PCB design techniques including KiCad software
5	Implement software design techniques and version control
6	Learn Python and Arduino development for live processes
7	Gain leadership experience in a fast-paced engineering environment

Systems Overview

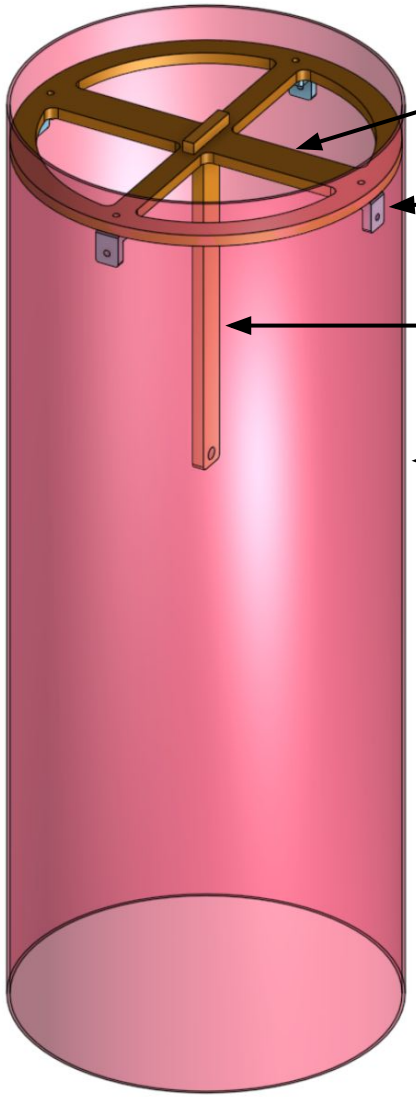
Presented by
Kyle Hughes

Payload Design Description

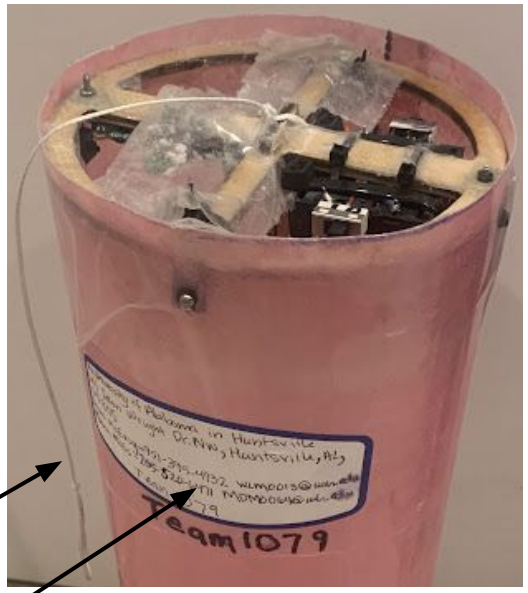


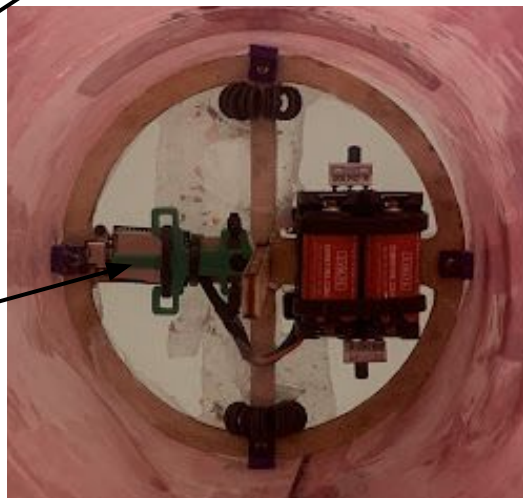
Probe Flight Day Hardware

Container Design Description



- Wood-Fiberglass Composite Structural Plate
- 3D Printed Plate-Shell Mounts
- Probe Release Mount
- Fiberglass Shell
- Parachute Connection Line
- Sticker Labeling Required Team Information
- Electronics Package including batteries wired to two switches: one that powers on the camera and another that flash the camera using logic





Concept of Operations and Sequence of Events

Presented by
Mason Mills

Comparison of Planned and Actual Concept of Operations

Planned Concept of Operations						
1	2	3	4	5	6	7
CanSat is loaded into launch vehicle	CanSat deploys at an altitude of 670 m - 725 m	Descent is slowed via parachute to a rate of 15 m/s	Probe is released at 500 m	Probe opens a heat shield and descends at 20 m/s	Probe deploys parachute at 200 m, slowing descent to 5 m/s	Probe lands, uprights, and raises a flag 500 mm above the probe

Actual Concept of Operations							
1	2	3	4	5	6	7	8
CanSat is loaded into launch vehicle	CanSat deploys at an altitude of 616 m	Container parachute tangles in rocket shock cord	Container detaches from tangled parachute and descends to the ground	Container release mechanism actuates at 497 m	Parachute release mechanism actuates at 179 m	Probe hits ground at 11.2 m/s and ejects from container upon impact	Probe uprights itself and raises flag 540 mm above its base

Comparison of Planned and Actual SOE (1 of 4)

Actual Event	Description and Planned Objectives	Team
Arrival	Arrive at Launch Location with CanSat and Ground Station Hardware	All
Pre-launch	Assemble CanSat and Test Integrity of Mech. Systems	CanSat
	Assemble Antenna and Ground Station	Ground Station
	Power CanSat On	CanSat
	Validate Signal Acquisition and Calibrate/Test Electrical Systems	Ground Station
	CanSat Integration into Rocket	CanSat
Launch	Initiate CanSat Launch	Mission Control Officer
	Validate Flight State Changes	Ground Station
	Monitor Data Reception and Integrity	Ground Station
	Prepare Recovery Operations	Recovery

Comparison of Planned and Actual SOE (2 of 4)

Actual Event	Description and Planned Objectives	Team
Recovery	Track CanSat Using GPS and Audio-Visual Indicators	Recovery
	Recover Probe and Container	Recovery
	Return CanSat to the Launch Site	Recovery
↓	Recover SD Cards.	Recovery
Data Analysis	Submit Transmitted Data and SD Cards to Judges for Scoring	Ground Station Recovery

Comparison of Planned and Actual SOE (3 of 4)

Planned Event	Description and Actual Objectives	Team
Arrival	Arrive at Launch Location with CanSat and Ground Station Hardware	All
Pre-launch	Assemble CanSat and Test Integrity of Mechanical Systems	CanSat
	Assemble Antenna and Ground Station	Ground Station
	Power CanSat On	CanSat
	Validate Signal Acquisition and Calibrate/Test Electrical Systems	Ground Station
	CanSat Integration into Rocket	CanSat
Launch	Initiate CanSat Launch	Mission Control Officer
	Validate Flight State Changes	Ground Station
	Verify Successful Packet Transmission	Ground Station
	Monitor Data Reception and Integrity	Ground Station
	Prepare Recovery Operations	Recovery

Comparison of Planned and Actual SOE (4 of 4)

Planned Event	Description and Actual Objectives	Team
Recovery	Wait for End of Volley	Recovery
	Locate CanSat Using GPS and Audio-Visual Indicators	Recovery
	Verify Status of CanSat with Field Judge	Recovery
	Recover Probe and Container	Recovery
	Toggle Cameras	Recovery
	Return CanSat to the Launch Site	Recovery
↓	Recover SD Cards.	Recovery
Data Analysis	Submit Transmitted Data and SD Cards to Judges for Scoring	Ground Station Recovery

Flight Data Analysis

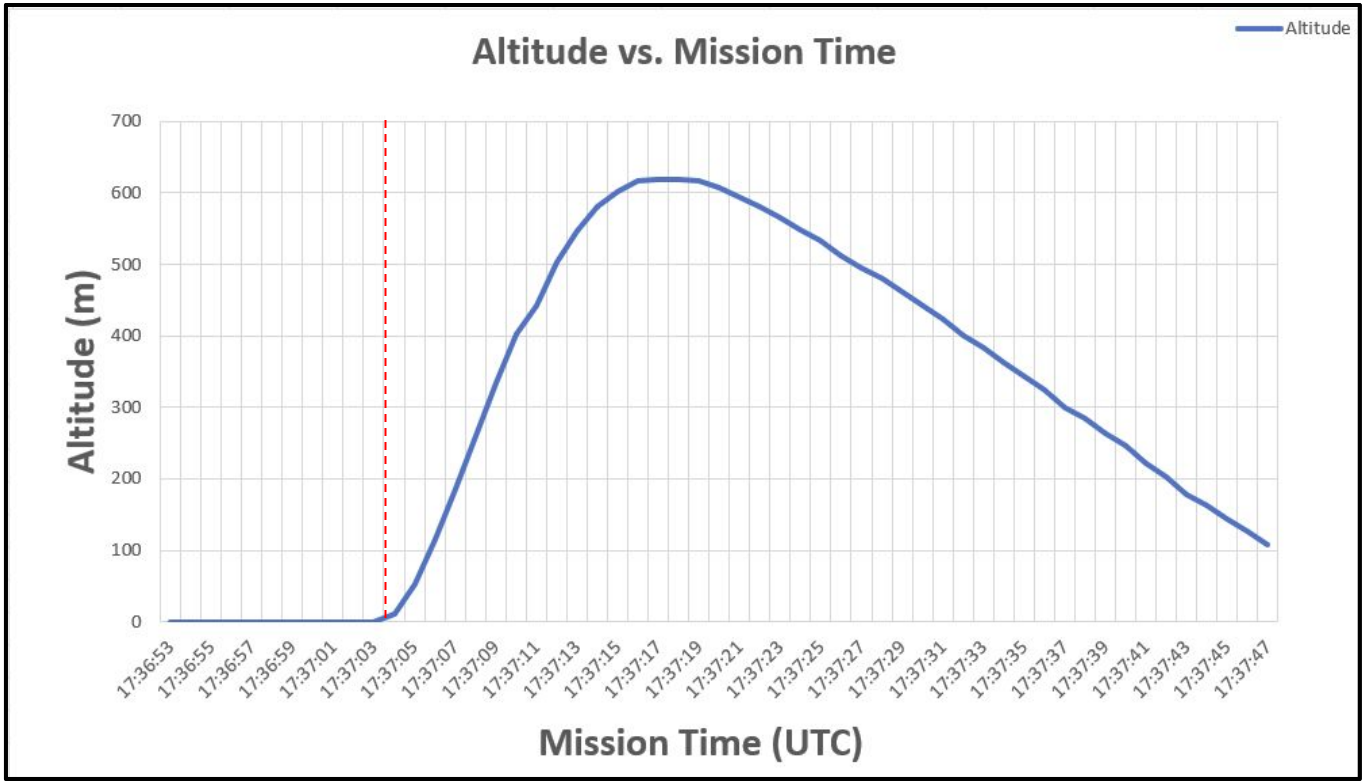
Presented by
Enrico Addy

Probe Deployment Systems

Deployment System	Deployment Condition	Proof of Deployment	Final Results
Probe Release	Deploys at 500 meters	1079 17:37:25 1049 F CANDOWN 1079 17:37:26 1050 F CANDOWN 1079 17:37:27 1051 F CANDOWN 1079 17:37:28 1052 F PROBEDOV 1079 17:37:29 1053 F PROBEDOV 1079 17:37:30 1054 F PROBEDOV	Successful Mechanism Release*
Heat Shield Deployment	Deploys immediately after Probe Release	1079 17:37:24 1048 F CANDOWN 549.39 N 1079 17:37:25 1049 F CANDOWN 533.11 N 1079 17:37:26 1050 F CANDOWN 513.23 N 1079 17:37:27 1051 F CANDOWN 496.37 P 1079 17:37:28 1052 F PROBEDOV 479.41 P 1079 17:37:29 1053 F PROBEDOV 461.08 P	Successful Deployment*
Parachute Release	Deploys at 200 meters	1079 17:37:40 1064 F PROBEDOV 245.87 P N 1079 17:37:41 1065 F PROBEDOV 221.28 P N 1079 17:37:42 1066 F PROBEDOV 203.21 P N 1079 17:37:43 1067 F PROBEDOV 178.59 P C 1079 17:37:44 1068 F PROBEDOV 162.12 P C 1079 17:37:45 1069 F PROBEDOV 142.92 P C	Successful Mechanism Release*

*** - Due launch vehicle interference our container was not in the proper orientation for separation with the probe, however video shows proper actuation and a loose fit within the container**

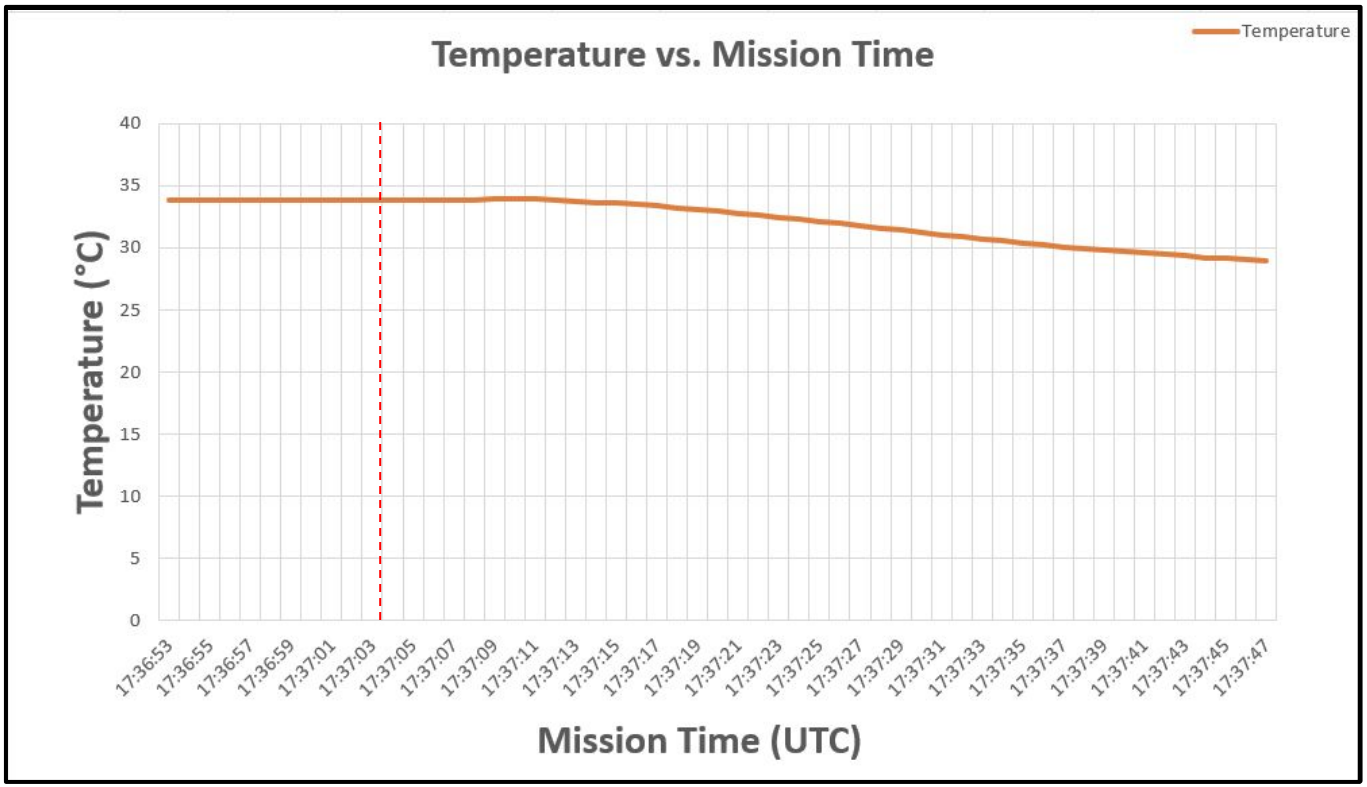
Probe Data Plots: Payload Altitude Plot



Engine Ignition
17:37:04 UTC

Maximum Altitude
619.79 m
17:37:17 UTC

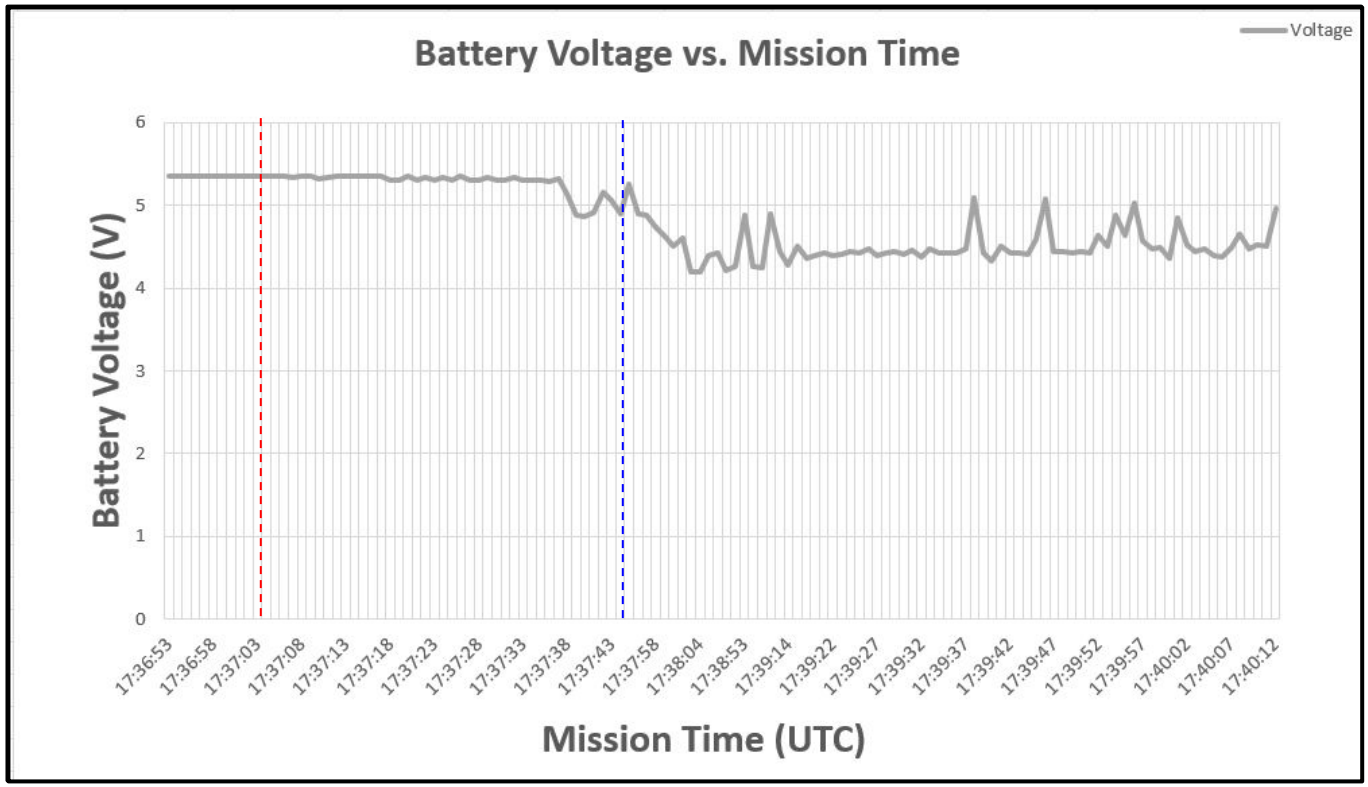
Probe Data Plots: Payload Temperature Plot



Engine Ignition
17:37:04 UTC

Maximum Altitude
619.79 m
17:37:17 UTC

Probe Data Plots: Payload Voltage Plot



Engine Ignition 17:37:04 UTC

Probe Landed 17:37:48 UTC

Probe Data Plots: Tilt Sensor Plots

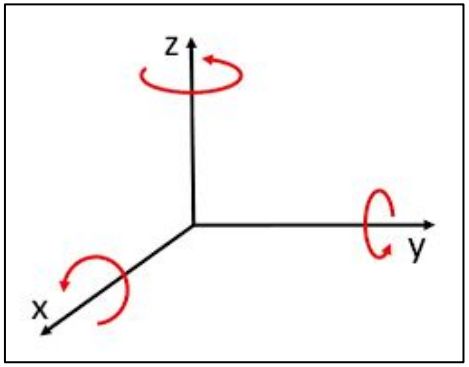
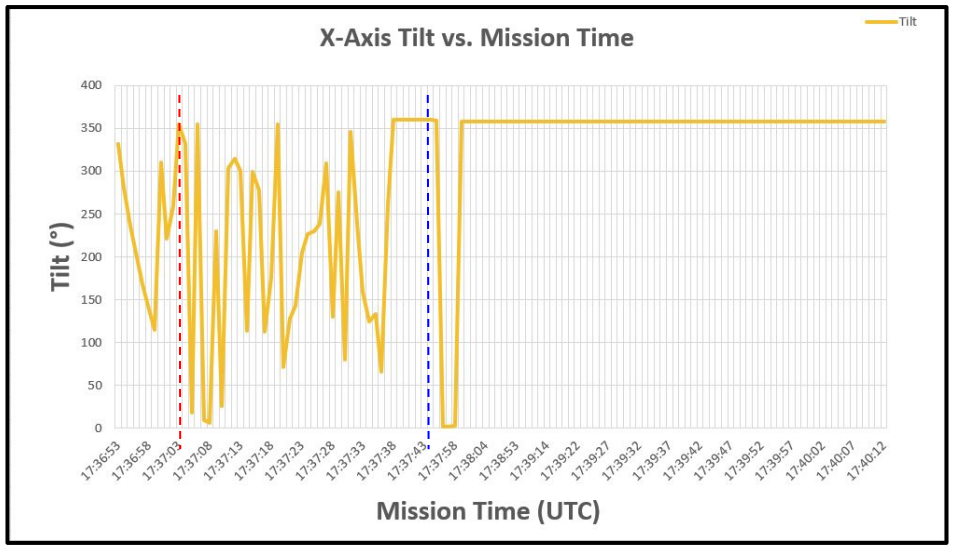
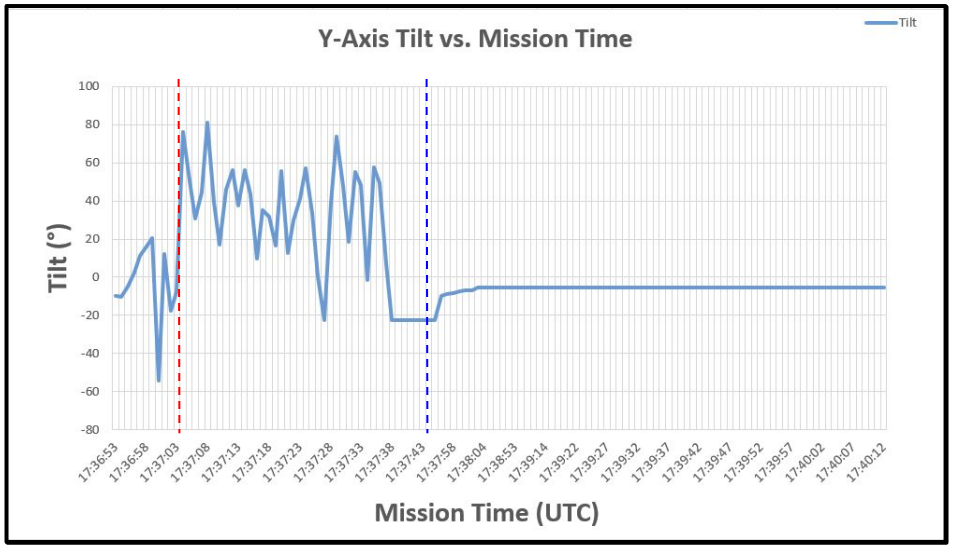


Image Credit:
Meccanismo Complesso



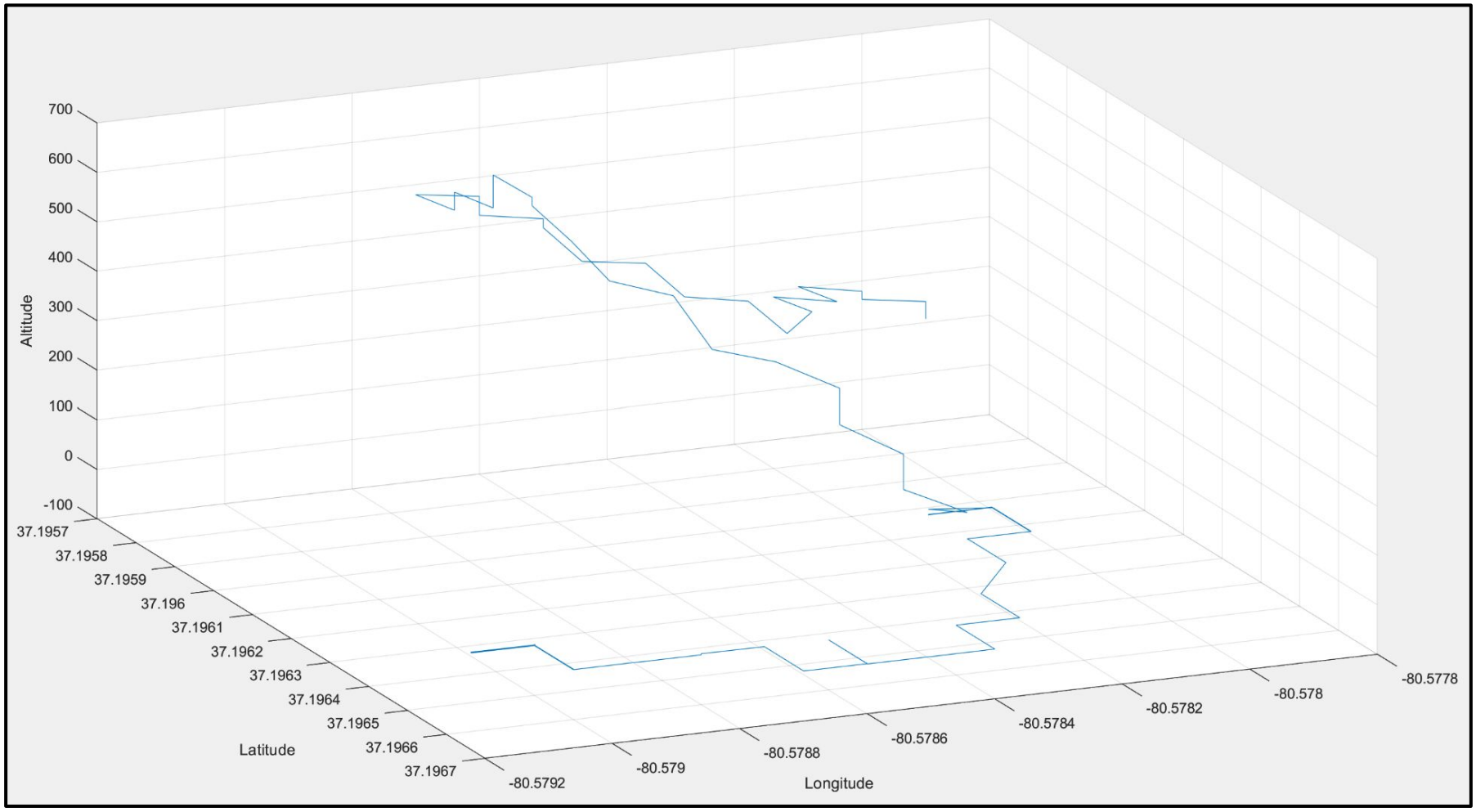


Engine Ignition
17:37:04 UTC

Landed
17:37:48 UTC

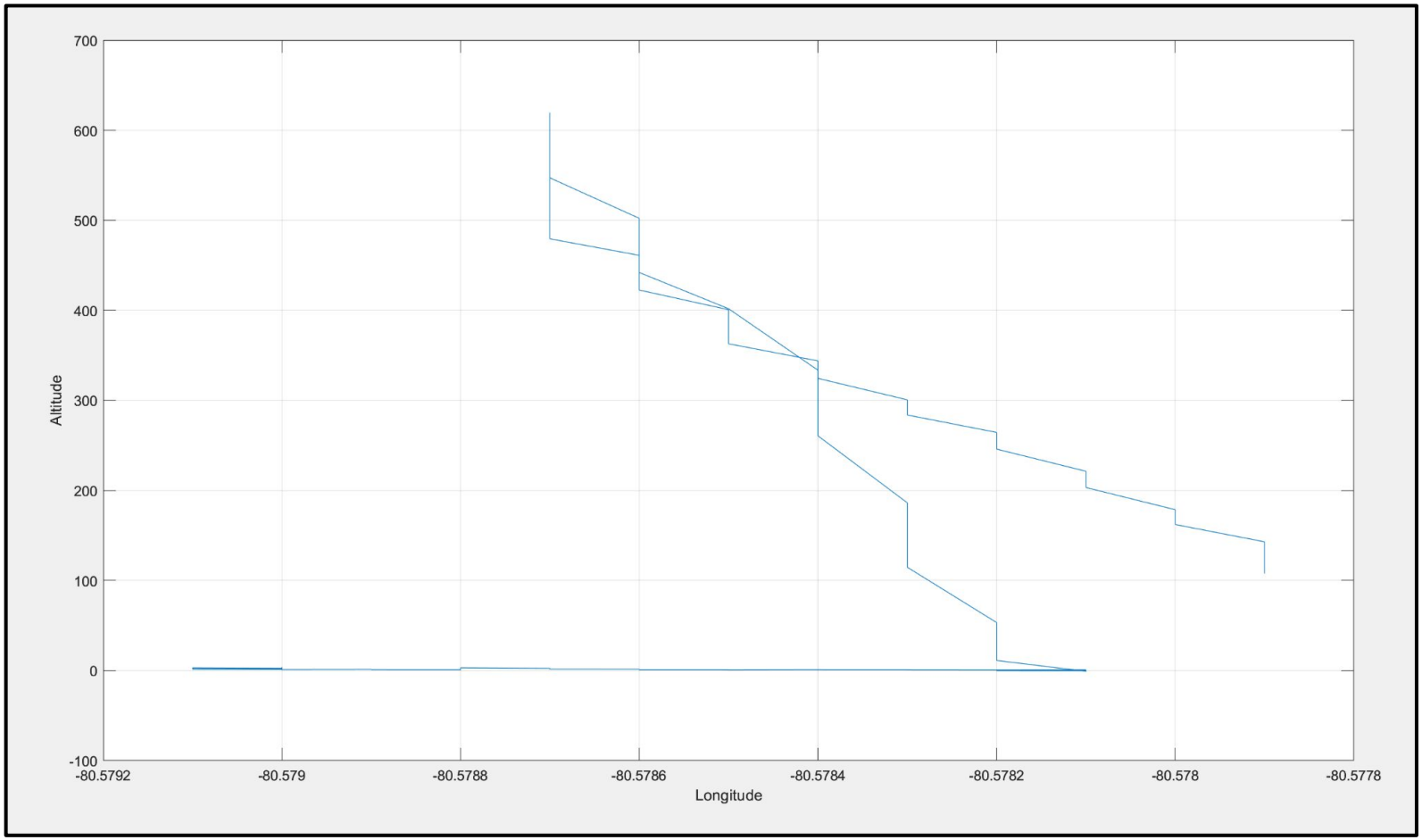
Probe Data Plots: GPS Position Plots (1 of 3)

GPS 3D Plot using MatLab



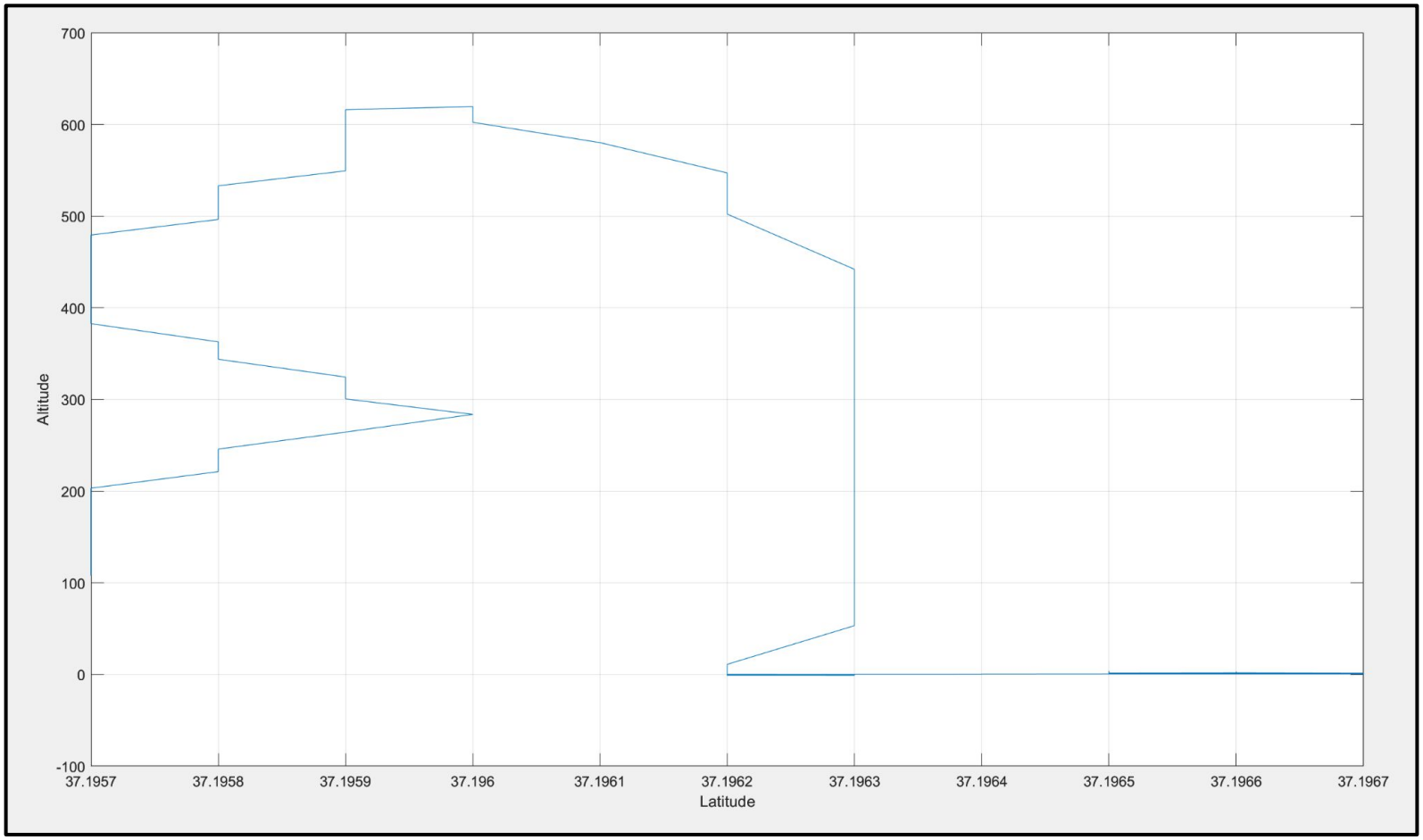
Probe Data Plots: GPS Position Plots (2 of 3)

GPS Longitude v Altitude Plot using MatLab



Probe Data Plots: GPS Position Plots (3 of 3)

GPS Latitude v Altitude Plot using MatLab



Camera Data (1 of 2)

Probe Video

Video Link: https://www.youtube.com/watch?v=iN317Itk3c8

Camera Data (2 of 2)

Bonus Container Video

Video Link: https://www.youtube.com/watch?v=lXijkq7Ps4E

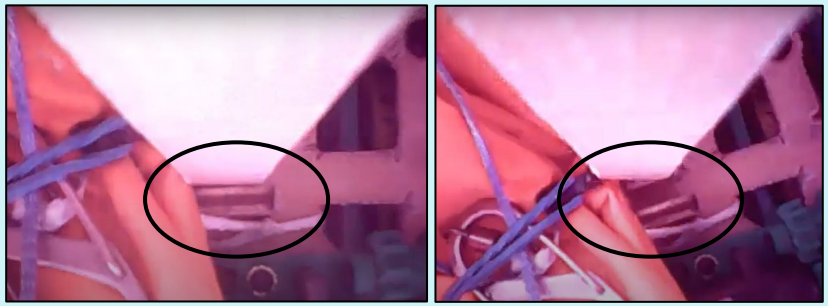
Failure Analysis

Presented by
Kyle Hughes

Launch Debrief (1 of 3)

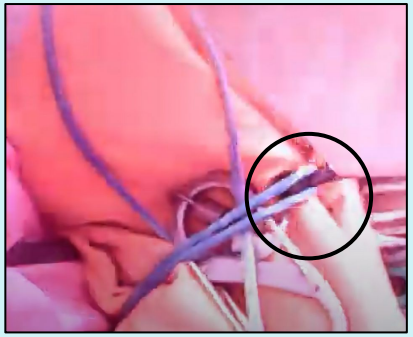
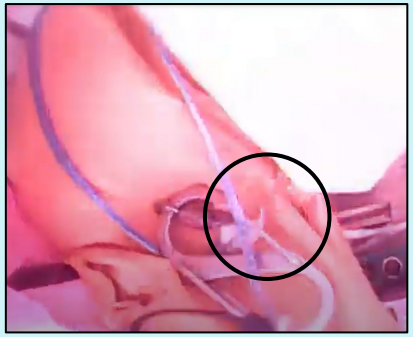
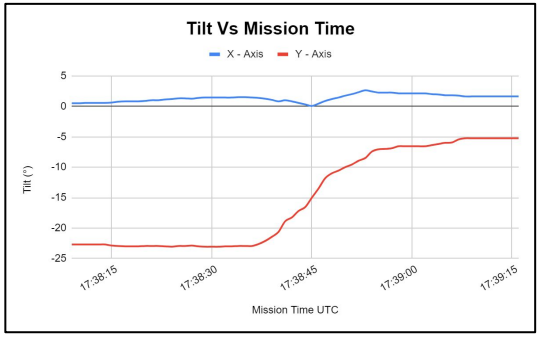
	Major Launch Events	Images
1	Container parachute was tangled in the rocket shock cord and separated from the container	 Tangled Line
2	Container ripped away from tangled container parachute. The probe and container fell together upside down, with the probe ejection hole facing upwards	 Bottom of Container (upside down)

Launch Debrief (2 of 3)

	Major Launch Events	Images
3	Probe release mechanism actuated, but due to the orientation of the payload and the lack of the container parachute, it did not separate from the container	Before Separation / After Separation 
4	Heatshield actuated inside the container, followed by the deployment of the probe parachute (Flight state PROBEDOWN)	

1079	17:37:16	1040	F	ASCENT
1079	17:37:17	1041	F	ASCENT
1079	17:37:18	1042	F	ASCENT
1079	17:37:19	1043	F	CANDOWN
1079	17:37:20	1044	F	CANDOWN
1079	17:37:21	1045	F	CANDOWN
1079	17:37:22	1046	F	CANDOWN
1079	17:37:23	1047	F	CANDOWN
1079	17:37:24	1048	F	CANDOWN
1079	17:37:25	1049	F	CANDOWN
1079	17:37:26	1050	F	CANDOWN
1079	17:37:27	1051	F	CANDOWN
1079	17:37:28	1052	F	PROBEDOWN
1079	17:37:29	1053	F	PROBEDOWN
1079	17:37:30	1054	F	PROBEDOWN

Launch Debrief (3 of 3)

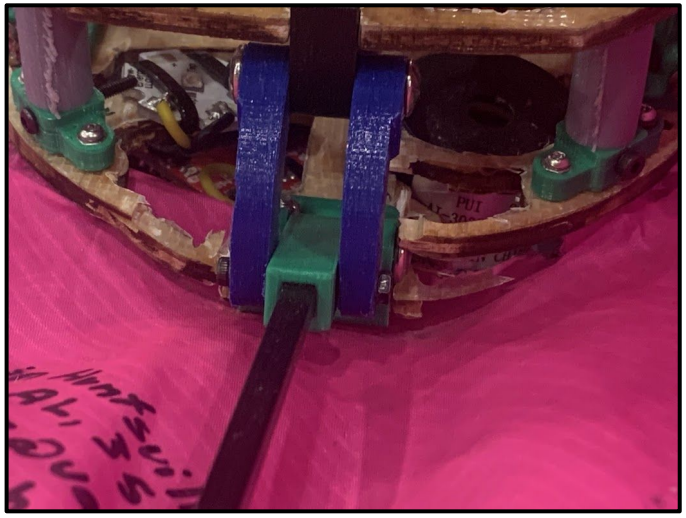
	Major Launch Events	Images
5	Probe parachute released, but was unable to unfurl due to lack of container separation	Parachute Attached  Parachute Detached 
6	After hitting the ground at 11.2 m/s, the probe was forcefully ejected from the container, successfully uprighted, and raised our flag 540mm above the base of the probe	 

Mechanical Failure Analysis (1 of 3)

Failure Description	Failure/Root Cause	Corrective Actions
Container parachute became tangled with rocket shock cord	External interference from launch vehicle	*External interference from launch vehicle*
Heat shield deployment failure	Heat shield deployment obstructed by container after separation failure	*External interference from launch vehicle*

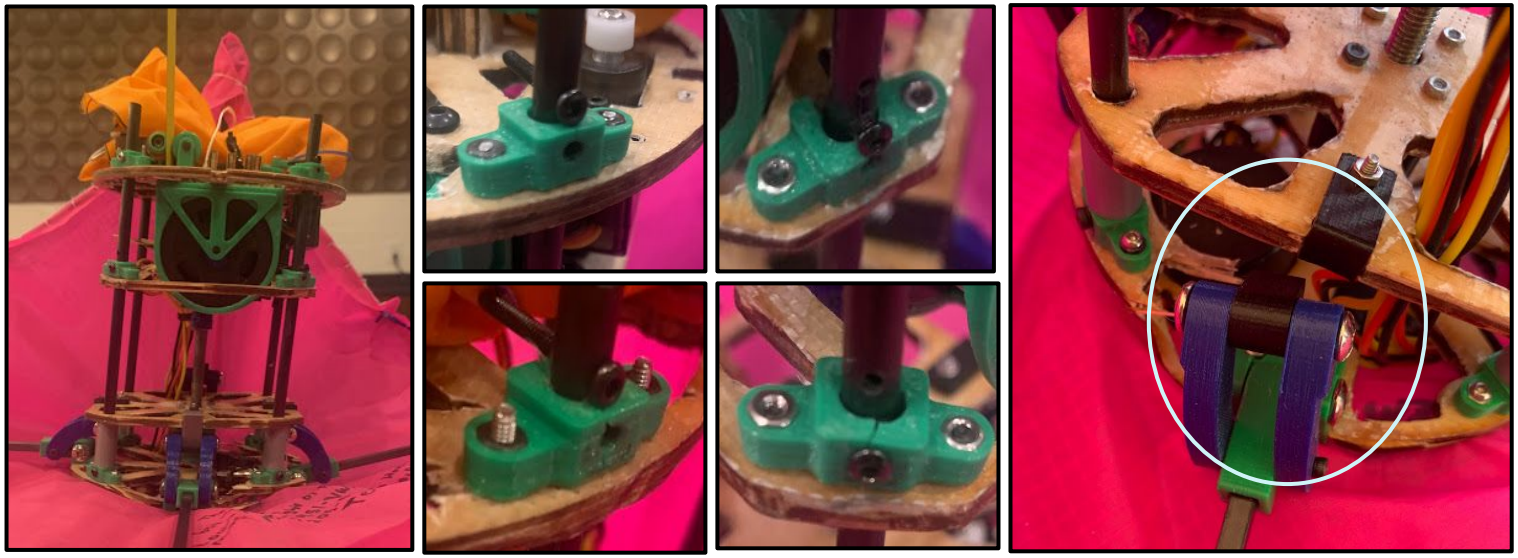
Mechanical Failure Analysis (2 of 3)

Failure Description	Failure/Root Cause	Corrective Actions
Several wood-fiberglass composite structural parts became warped/fractured	Probe and container fell at 11.2 m/s (6.2 m/s faster than expected)	*External interference from launch vehicle*
	Heatshield deployed while inside of container	*External interference from launch vehicle*



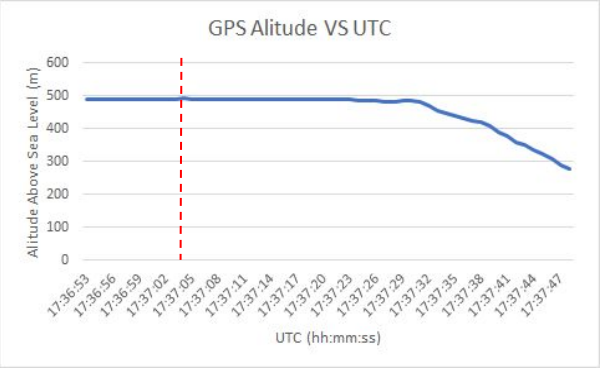
Mechanical Failure Analysis (3 of 3)

Failure Description	Failure/Root Cause	Corrective Actions
Main Structure Warped	3-D printed plate-rod mounts failed upon impact at 11.2 m/s (6.2m/s faster than expected)	Machine rod mounts or pursue stronger filament
3D printed heat shield deployment hinge broke	3D printed parts are too fragile to be structural components	Manufacture hinge arms out of wood-fiberglass composite



Electrical Failure Analysis

Failure Description	Failure/Root Cause	Corrective Actions
Momentary power loss upon impact with the ground	Large impact on probe electronics due to the probe falling at 11.2 m/s (6.2 m/s faster than expected)	*External interference from launch vehicle*
Probe camera did not record flight or landing	Momentary power loss caused the Adafruit Spy Camera to stop compiling video, which corrupted the video file	Source camera with live video storage to SD card
GPS Altitude incorrectly reporting	Insufficient testing of singular sensors lead to a inaccurate reading from the GPS altitude to be flown on flight day	Increase sensor testing, validation, and research



--- Engine Ignition

Software Failure Analysis

Failure Description	Failure Root Cause	Corrective Actions
Processor restart returned probe to initial conditions	The system for processor restart recovery was inoperable by time of launch	Create restart recovery system far in advance of launch day
	Unsuccessful deployment from container at intended height, despite attempt	*External interference from launch vehicle*
Premature ending of telemetry/flight operations	Lack of experience with accurate termination of flight operations	Verify transition through flight states with visual display
	Limited display of CanSat's physical state	Establish more visibility with CanSat and return position of actuators on Ground Station

Lessons Learned

Presented by

Louis McEvoy

Lessons Learned

Subsystem	Key Takeaways
Mechanical	Fiberglass-wood composite performed outstandingly in high force impacts
	Keep in mind ease of integration/de-integration with electronics package
Electrical	Research cameras that can write to SD card in real time
	Do more in depth sensor testing and validation before integration
Software	Prioritize an accurate, 3D display of CanSat to achieve a greater understanding of necessary flight operations
	Create and test all recovery systems far in advance of impending launch dates

Conclusions (1 of 2)

	Electrical	Software	Mechanical
Accomplishments	• Provided a stable power source for all sensors and Xbee transmissions • Performed nominally despite suboptimal conditions	• Sent and received 1072 packets successfully • Remotely operated and recorded duration of flight	• Successful actuation of container and parachute releases • Completed self righting and flag raising upon impact at 11.2 m/s

What's Next?

Team Afterburner appreciates the opportunity to compete in the International CanSat Competition, and will continue to use the skills and knowledge we've learned within our studies and our careers.

Conclusions (2 of 2)