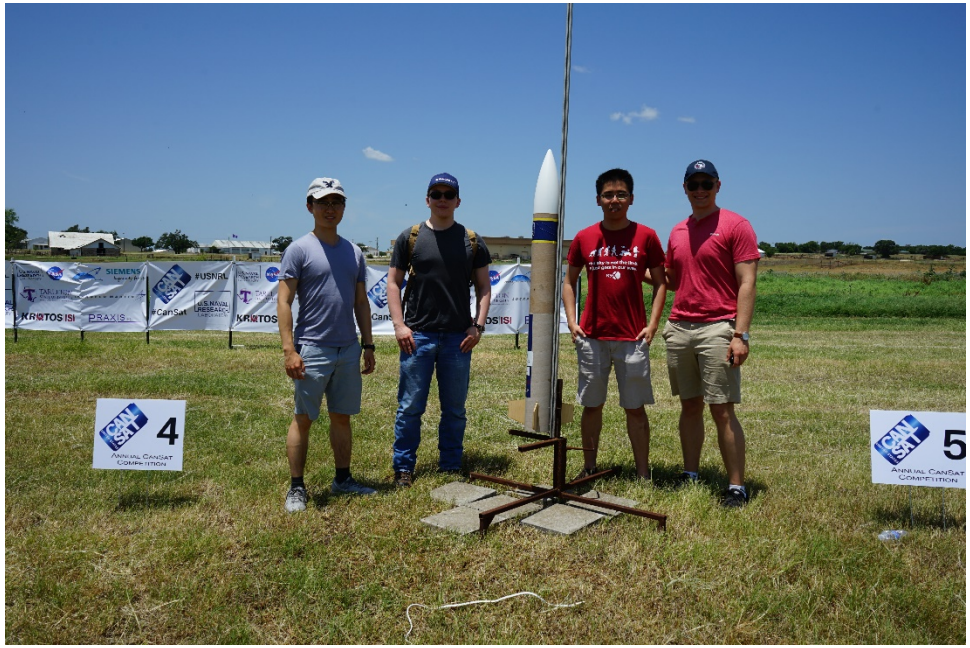
CanSat 2018
Post Flight Review



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Robotics for Space Exploration

10 June 2018

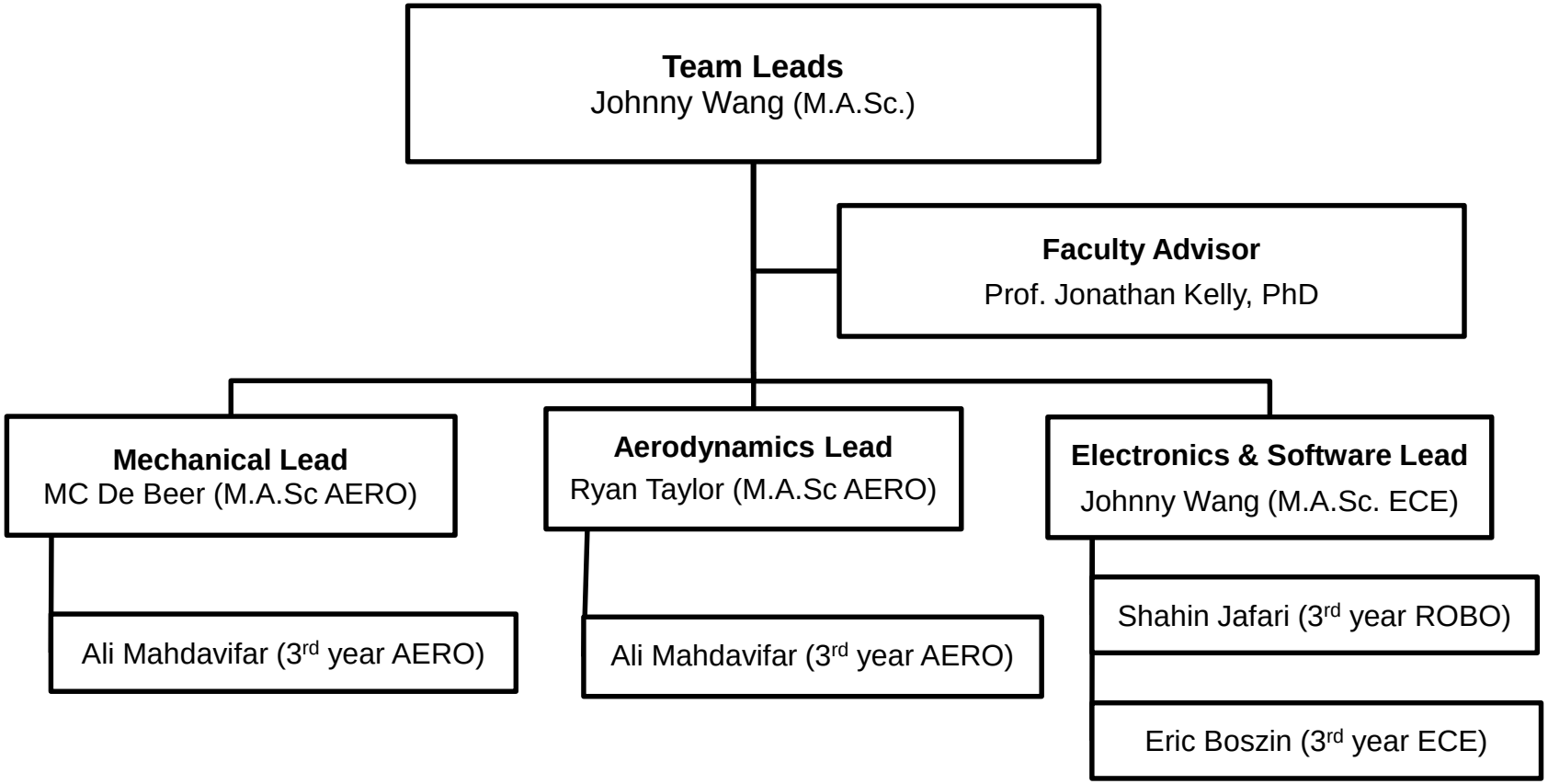
Presentation Outline

- **Introduction**
  - Presentation outline
  - Team organization
- **Systems Overview**
  - CanSat design overview
  - Cost of CanSat
  - Physical layout
- **Concept of Operations and Sequence of Events**
  - Comparison of planned and actual Con-ops
  - Comparison of planned and actual Sequence of Events

Presentation Outline

- **Flight Data Analysis**
  - Heatshield separation altitude
  - Payload pressure sensor data plot
  - Payload altitude plot
  - Payload temperature sensor plot
  - Payload GPS plot
  - Payload battery voltage plot
  - Tilt Sensor plot
  - Wind and camera bonus
- **Failure Analysis**
- **Lessons Learned**
- **Conclusions**

Team Organization



Systems Overview

MC De Beer

Mission Summary

- **Overview of the mission objectives**
  - The CanSat shall:
    - Upon release from the rocket, deploy a heat shield which shall:
      - Reduce the velocity of the CanSat to 10-30 m/s
      - Stabilize the CanSat to prevent tumbling
    - At an altitude of 300 m, the heat shield shall be ejected and a parachute deployed to slow the vehicle to 5 m/s
    - The CanSat shall collect and broadcast atmosphereic data throughout the flight and protect one egg from damage during descent
- **Bonus objectives are not attempted**
  - In order to maintain simplicity in the design
- **External objectives are not attempted**

CanSat Overview

Probe & Heat Shield:

1. Probe:

   Cylindrical frame that houses all of the sensors, electrical components, the parachute and the egg.

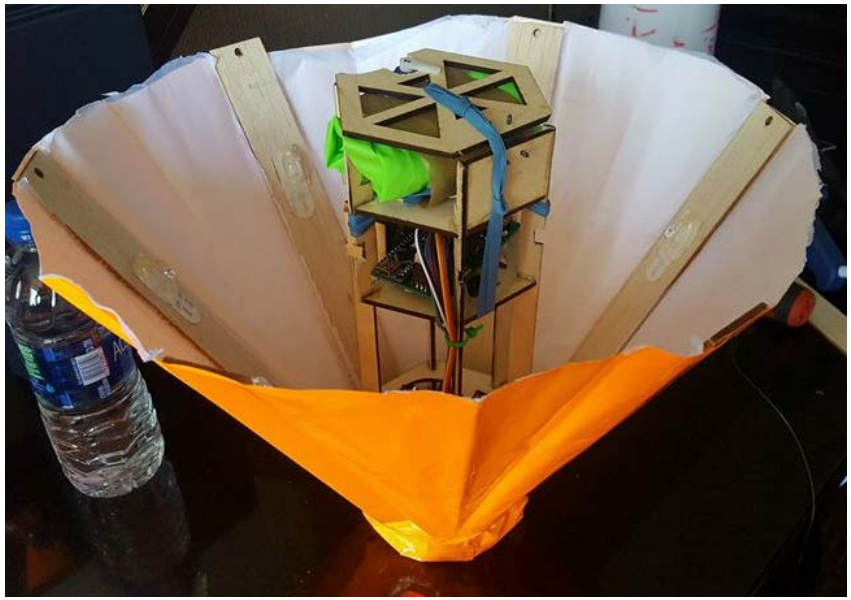
2. Heat Shield:

   Deployed after ejection from the rocket to stabilize and slow down the CanSat. Attached to the probe and is ejected at 300 m.

CanSat Overview

Probe and Heat Shield:

1. Probe stowed inside of heat shield
2. Heat shield deployed using a string and servo mechanism
3. Heat shield ejected using a screw and servo mechanism
4. Parachute deployed using a spring and cap system



Heat shield and probe design

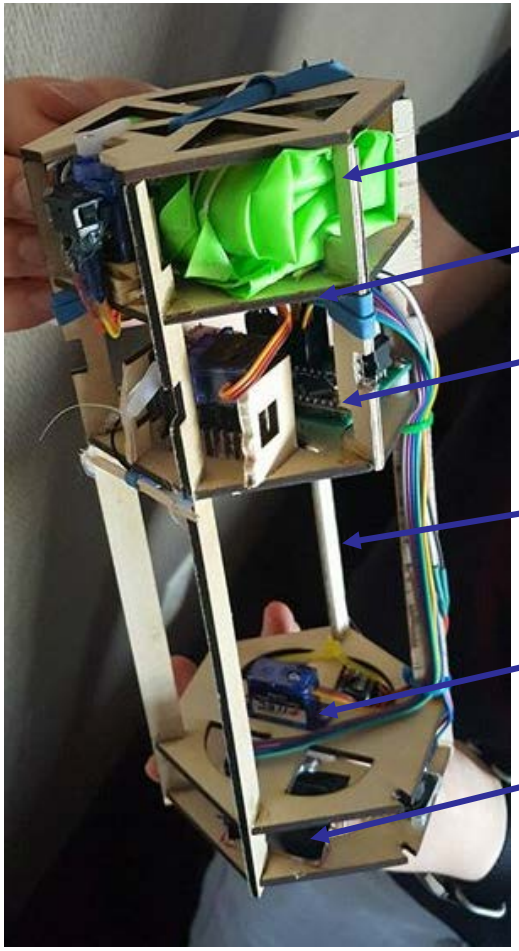
Cost of CanSat

Subsystem	Component	Quantity	Unit Price (USD)	Total Price (USD)	Source
CDH	Arduino Nano	1	24.00	24.00	Newark
CDH	DS3231 RTC Module	1	5.99	5.99	Amazon.com
CDH	Taoglas FXP290 Antenna	1	19.00	19.00	Digikey.ca
CDH	RTC coin battery	1	4.00	4.00	Amazon.ca
CDH	XBEE Pro 900HP	1	55.00	55.00	Sparkfun
Sensor	MPU-9250 Magnemometer	1	14.95	14.95	Sparkfun
Sensor	Bosch BMP180	1	9.00	9.00	Ebay
Sensor	NEO-7M-C	1	20.99	20.99	RobotShop
Sensor	10kΩ resistor	2	0.20	0.40	Home Hardware
EPS	Buzzer	1	2.50	2.50	Digikey
Power	9V Battery	1	3.00	3.00	Canadian Tire

Cost of CanSat

Subsystem	Component	Quantity	Unit Price (USD)	Total Price (USD)	Source
Mech	PAR-24 24” Parachute	1	11.05	11.05	Top Flight Recovery
Mech	Plywood 12” x 12”	1	15.00	11.59	A&J Hobby
Mech	Balsa Wood 9” x 36”	1	6.18	6.18	A&J Hobby
Mech	Insulation Foam	1	4.07	4.07	Hobby shop
Mech	Feetech FS90R Servos	3	7.22	21.66	Canada Robotix
Mech	Hinges	1	4.83	4.83	Home Depot
Mech	Misc (Elastics, screws etc.)	1	7.73	7.73	Dollarama & Home Depot
Mech	Monocoat	1	15.46	15.46	Dollarama
Mech	Adhesives	1	7.73	7.73	Dollarama
	Subtotal			**246.88**	

Physical Layout



Parachute

Antenna

Electronics Hub & HS release mech

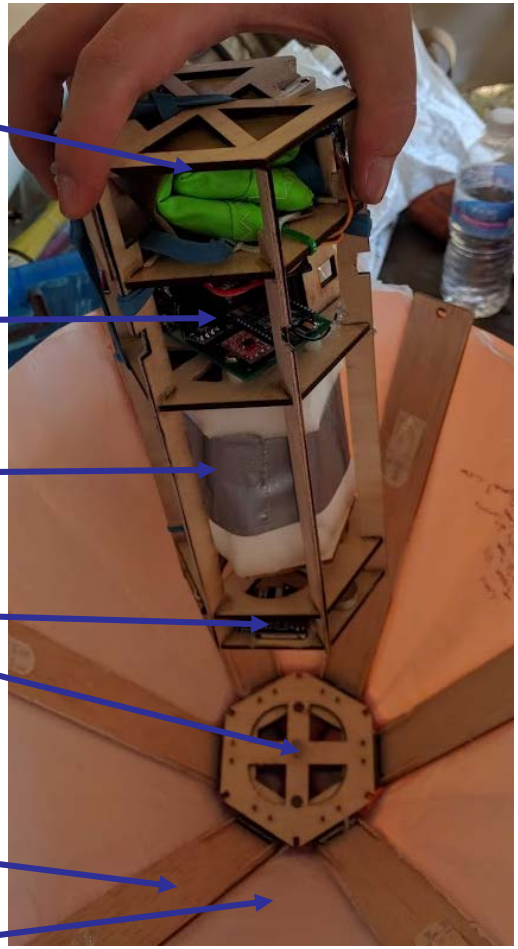
Egg compartment

HS Ejection

Battery

HS Slats

HS Monocoat

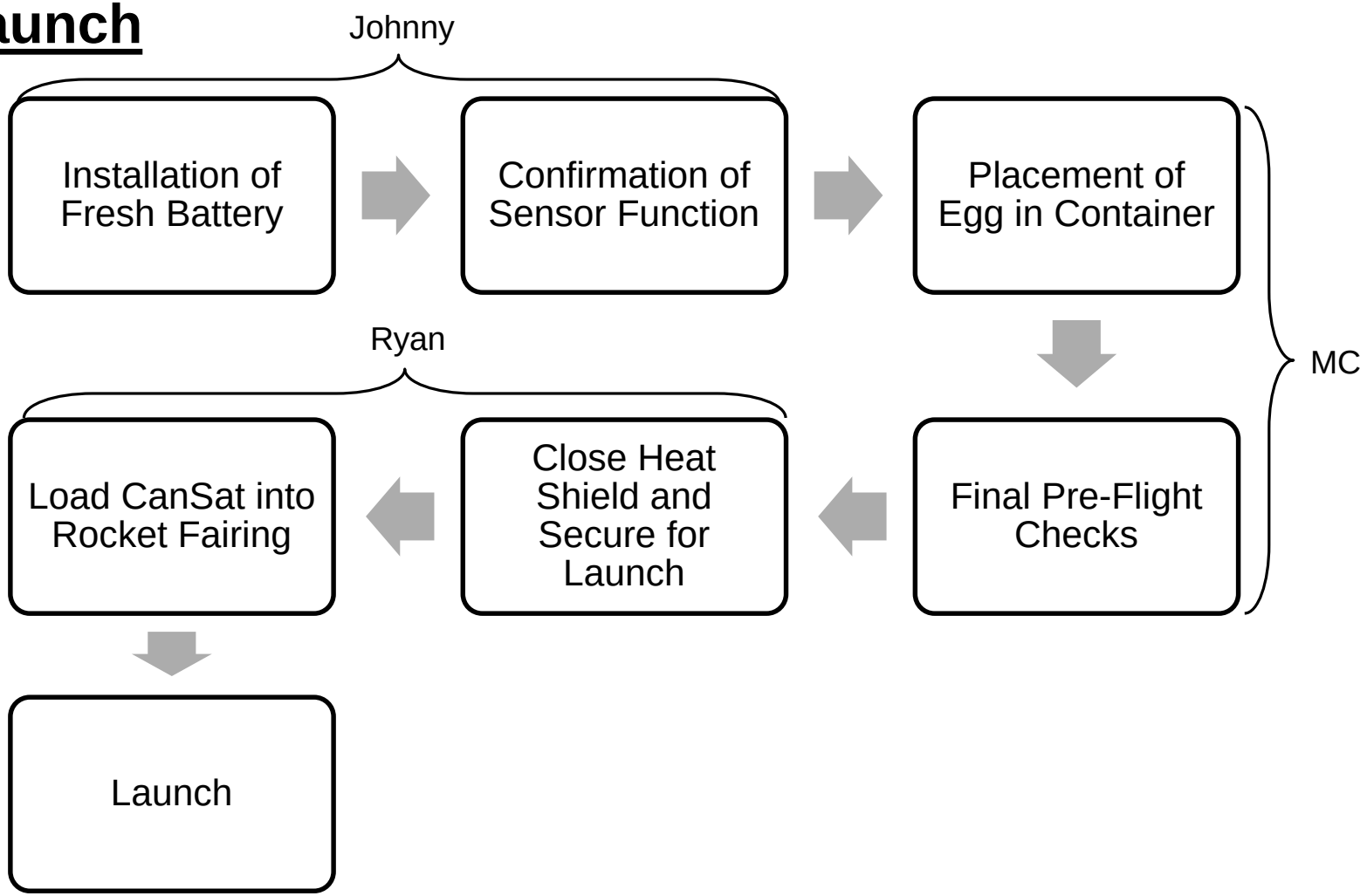


Concept of Operations and Sequence of Events

MC De Beer

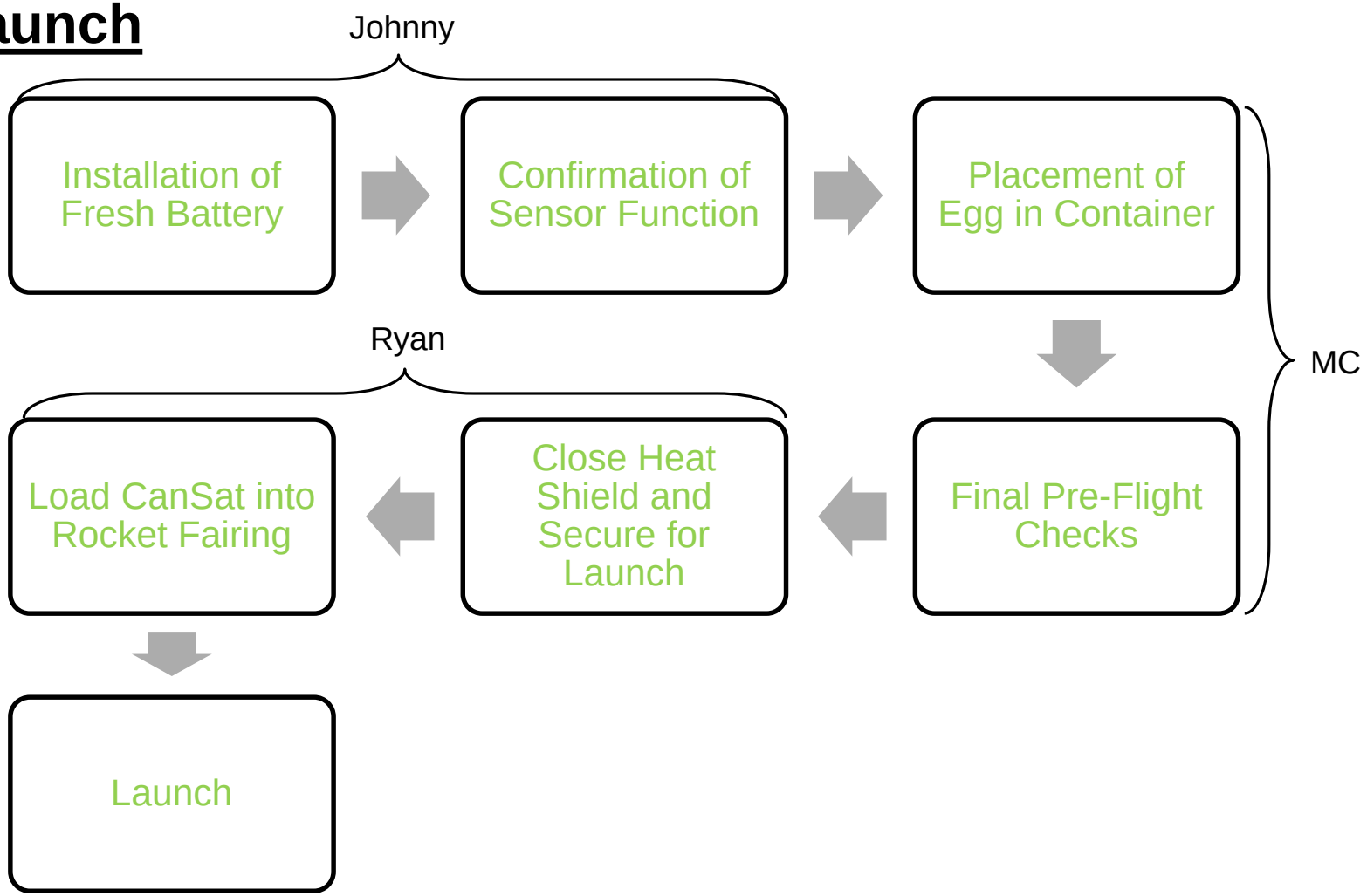
Planned Con-ops

Pre-Launch



Planned Con-ops

Pre-Launch



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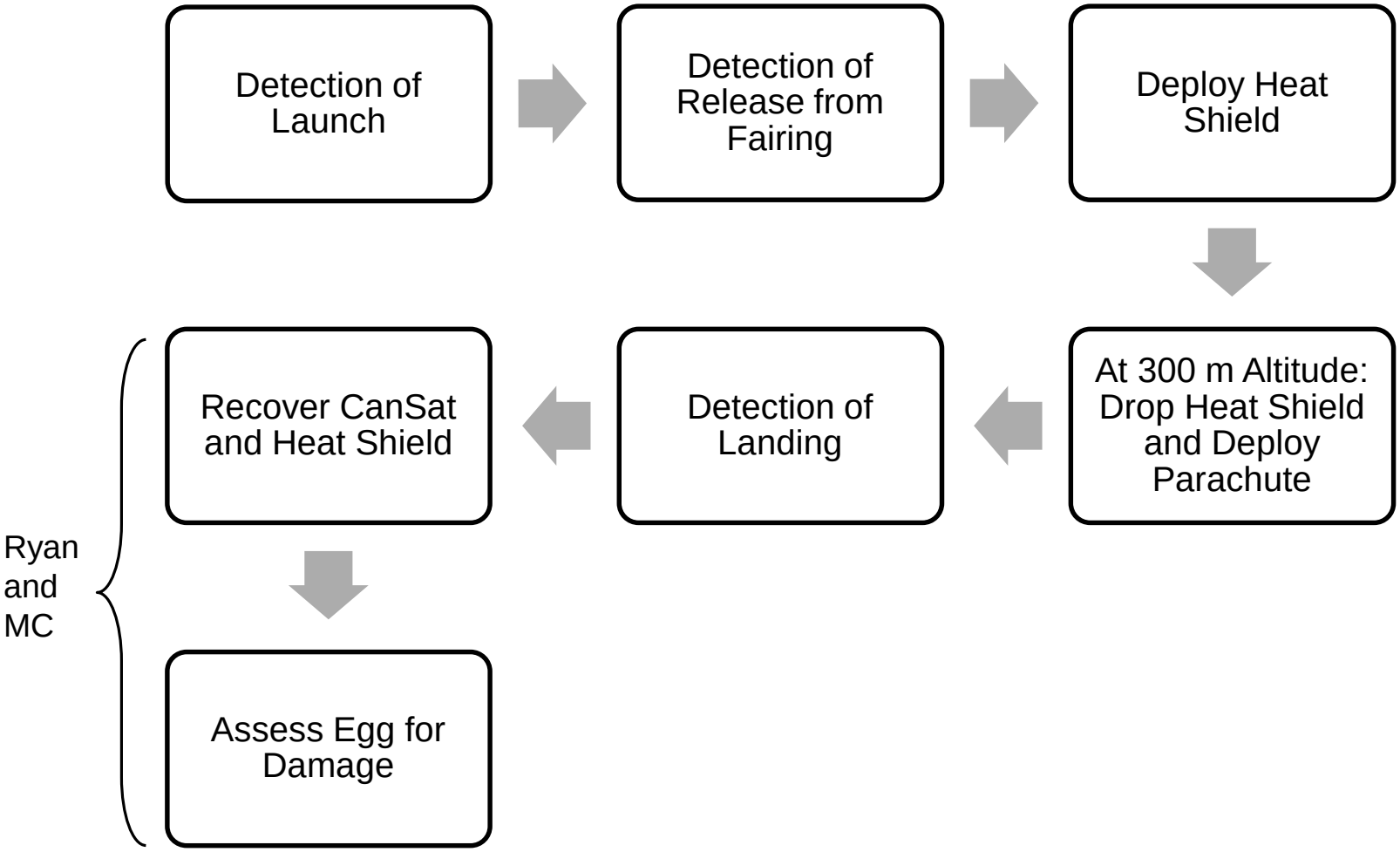
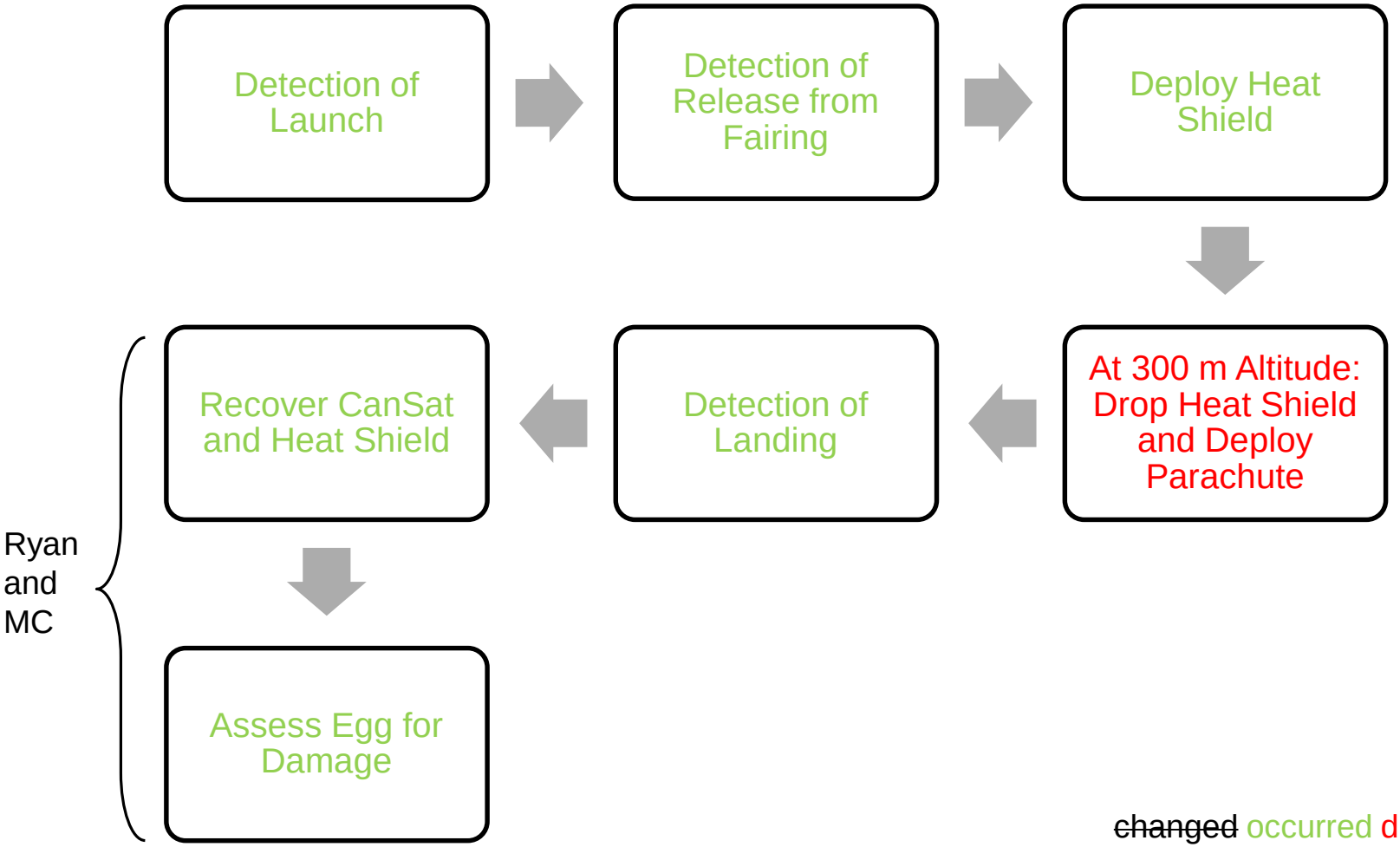
System Concept of Operations

Post-Launch



System Concept of Operations

Post-Launch



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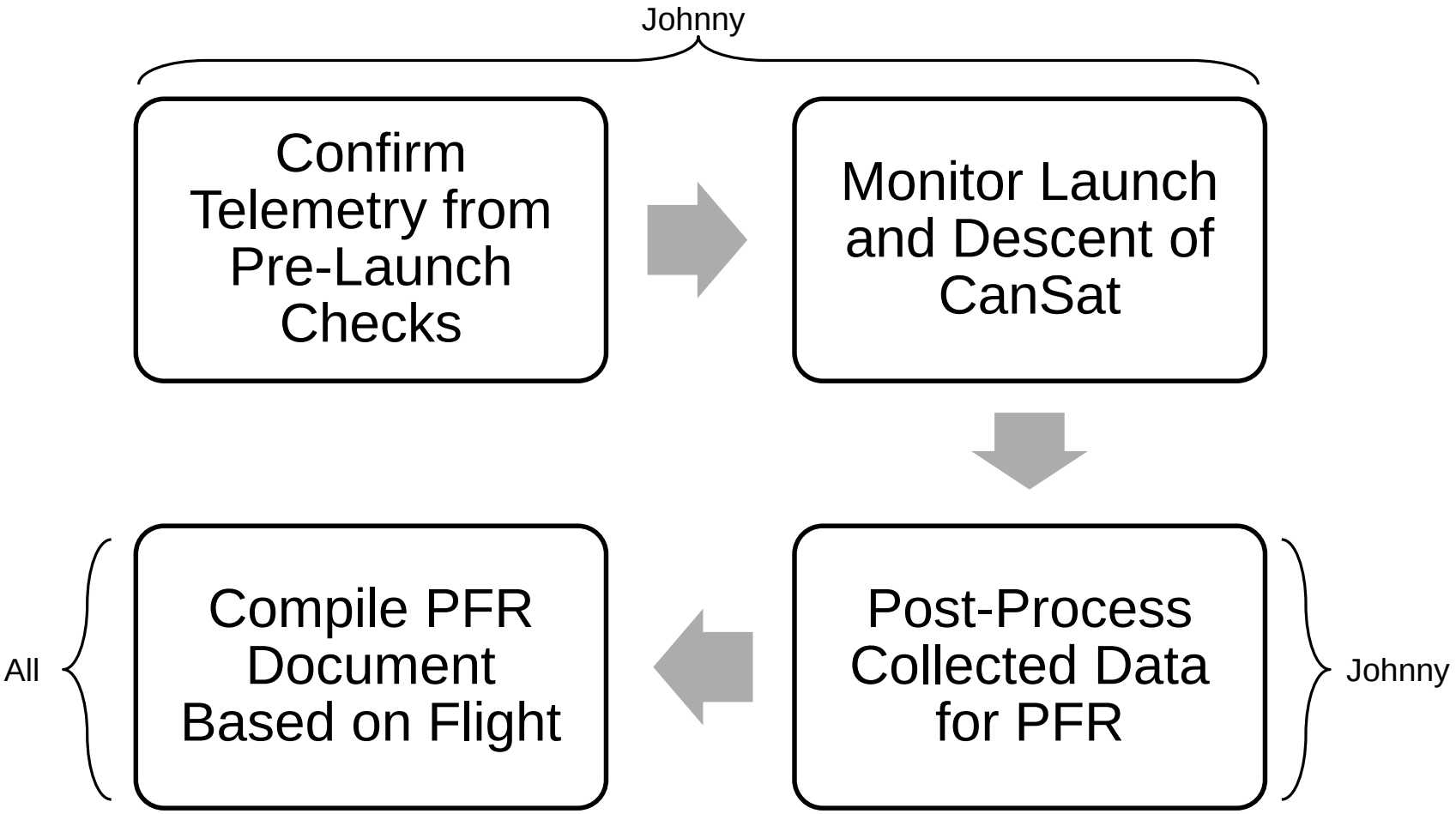
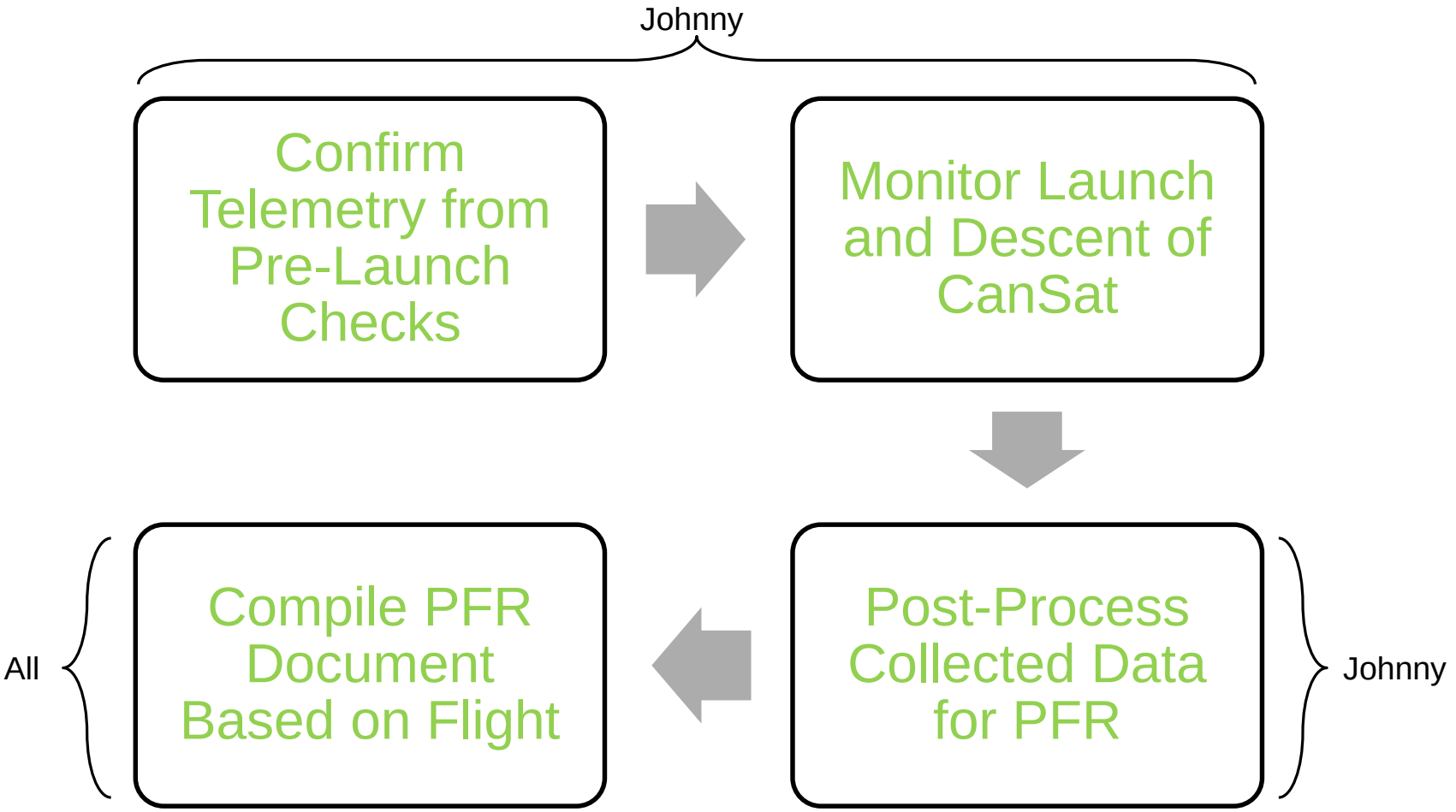
System Concept of Operations

Ground Station



Ground Station



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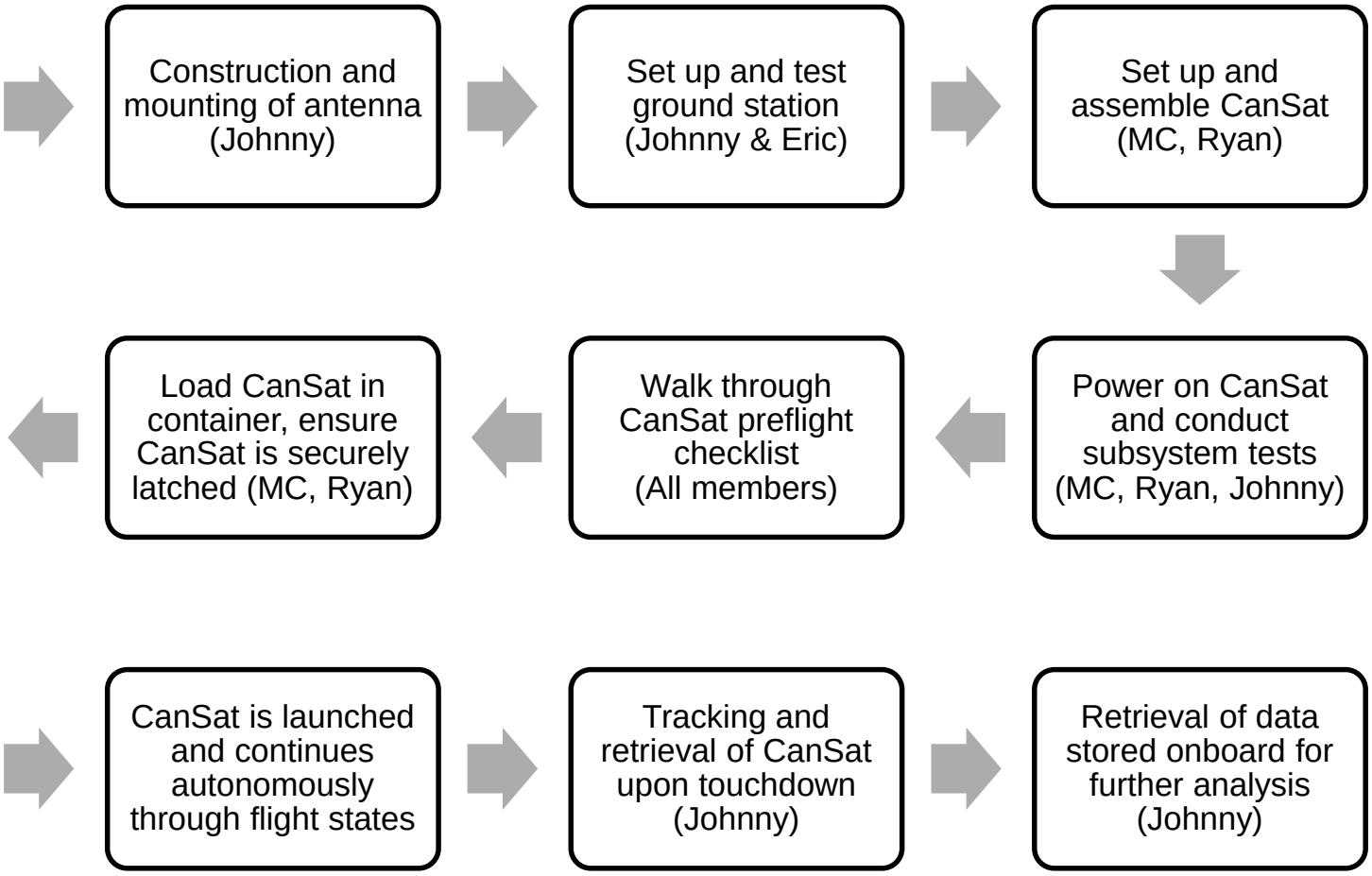
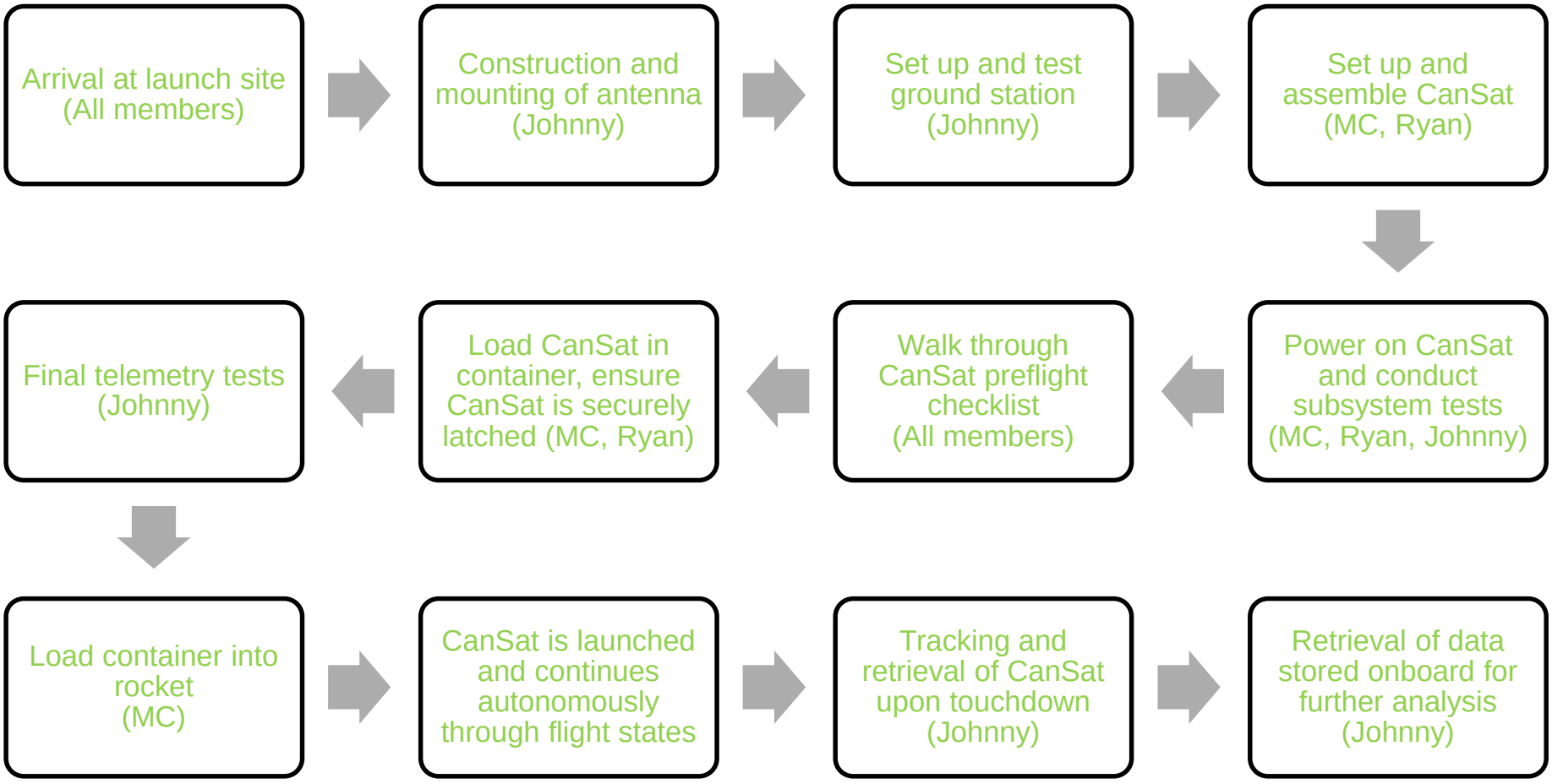
Overview of Mission Sequence of Events



Overview of Mission Sequence of Events



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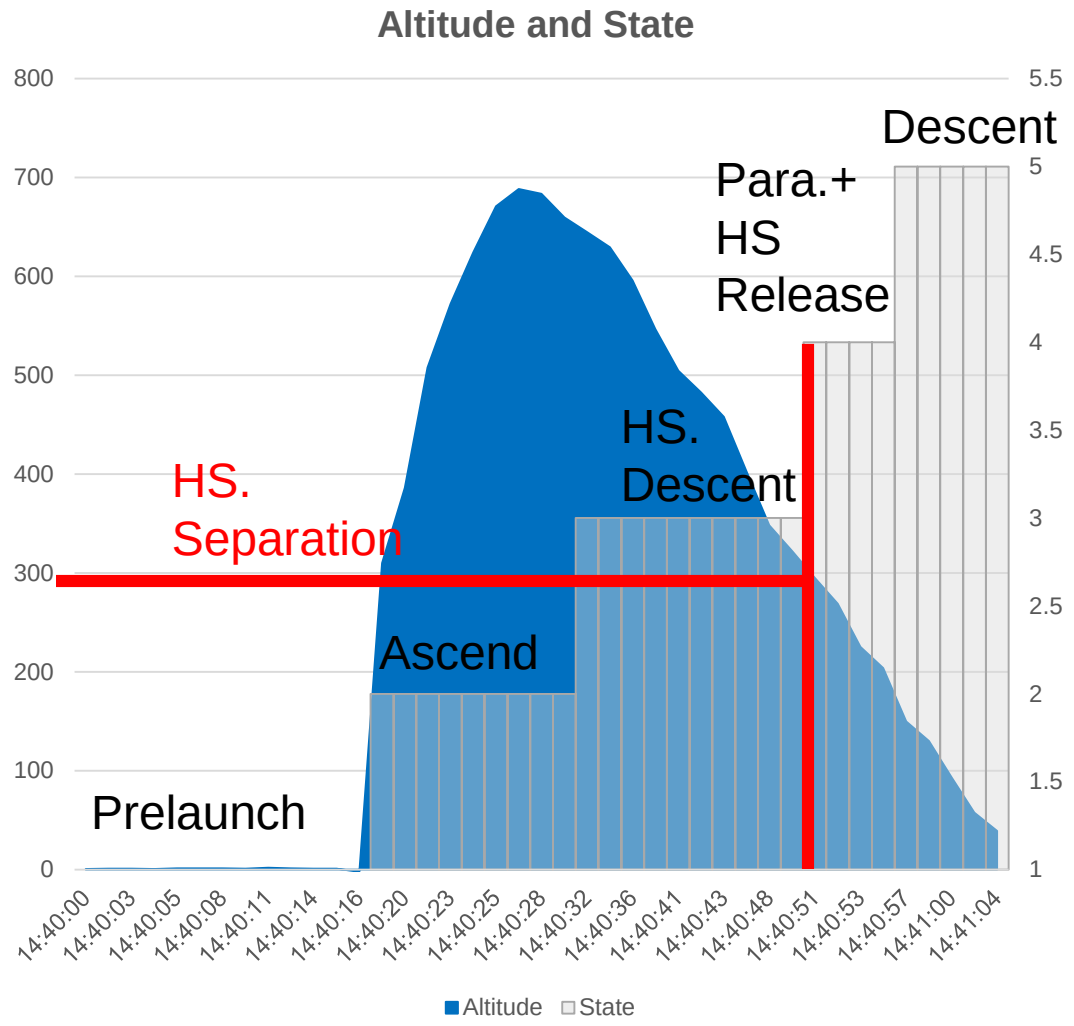
Flight Data Analysis

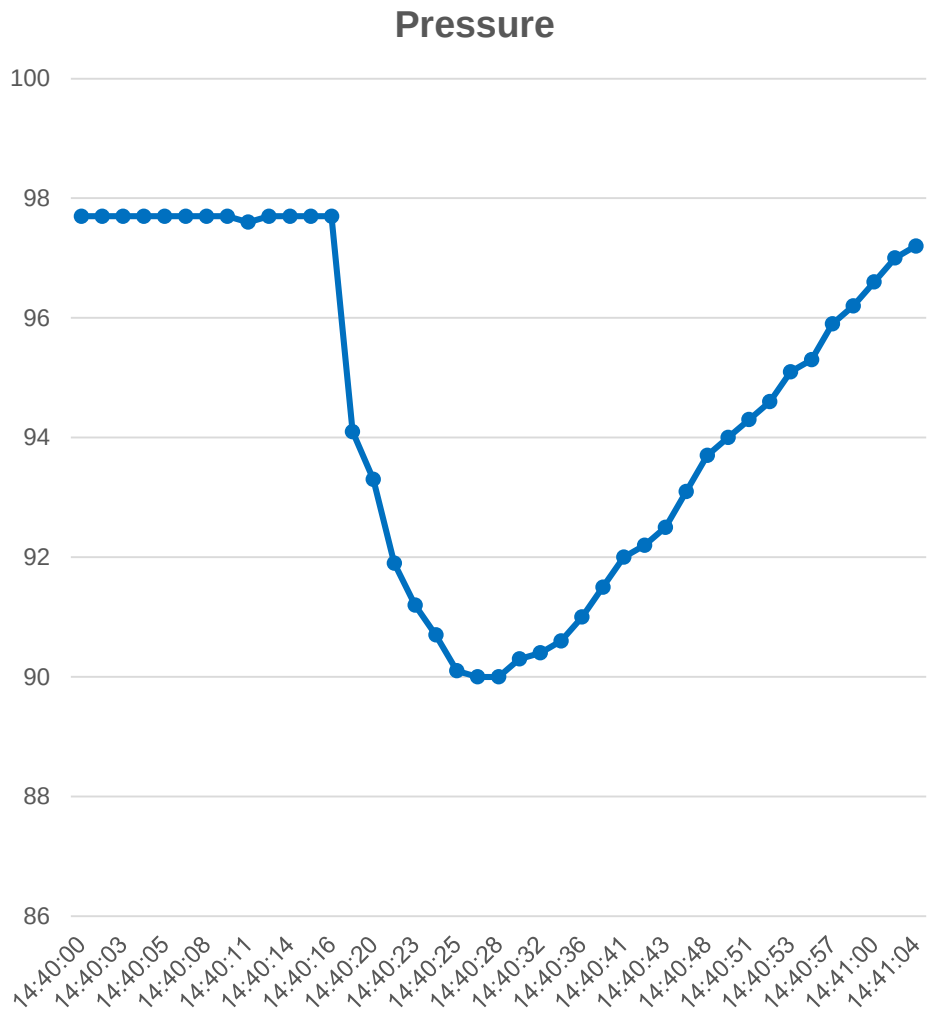
Johnny Wang

Heatshield Separation Altitude



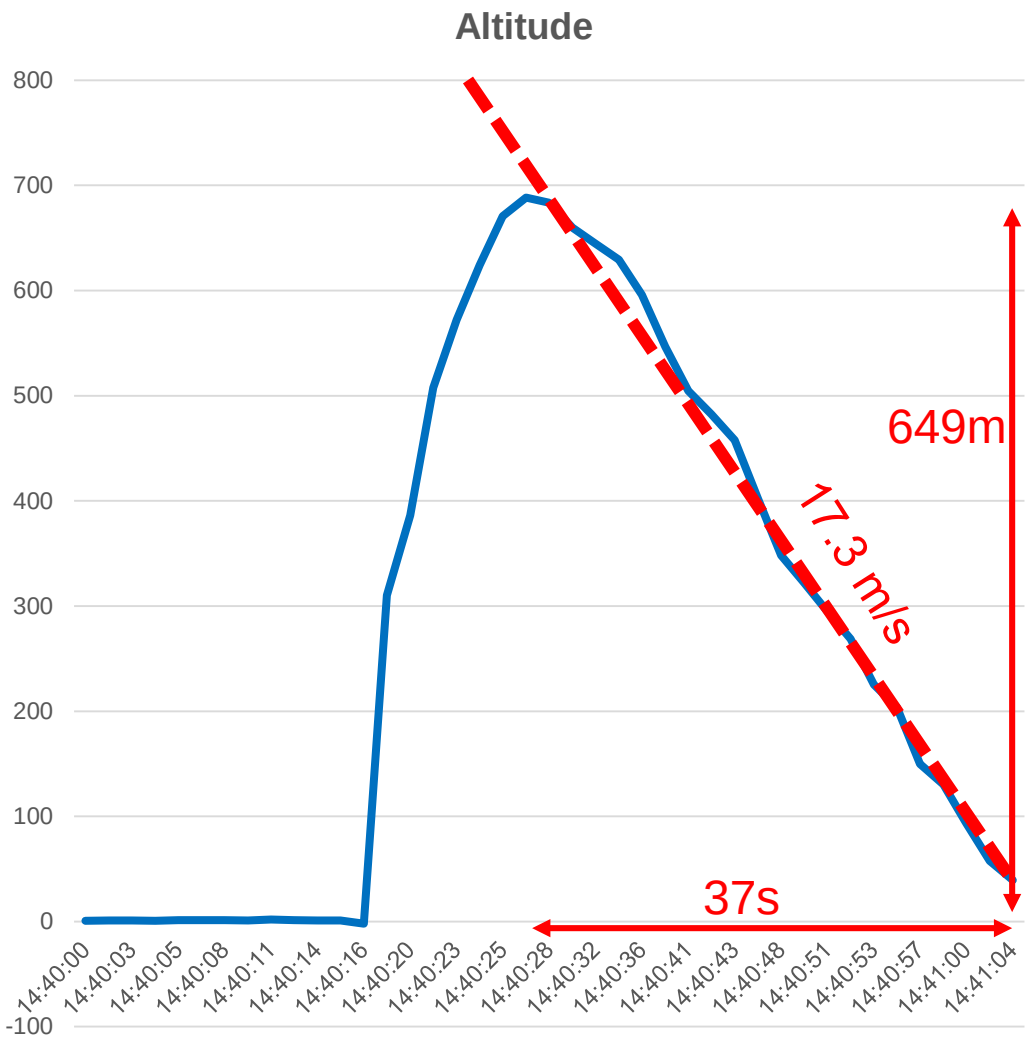
- **Heatshield separated at 294m altitude**
- **Failure of deployment of the parachute caused failure to pull the probe away from the heatshield**

Pressure Plot



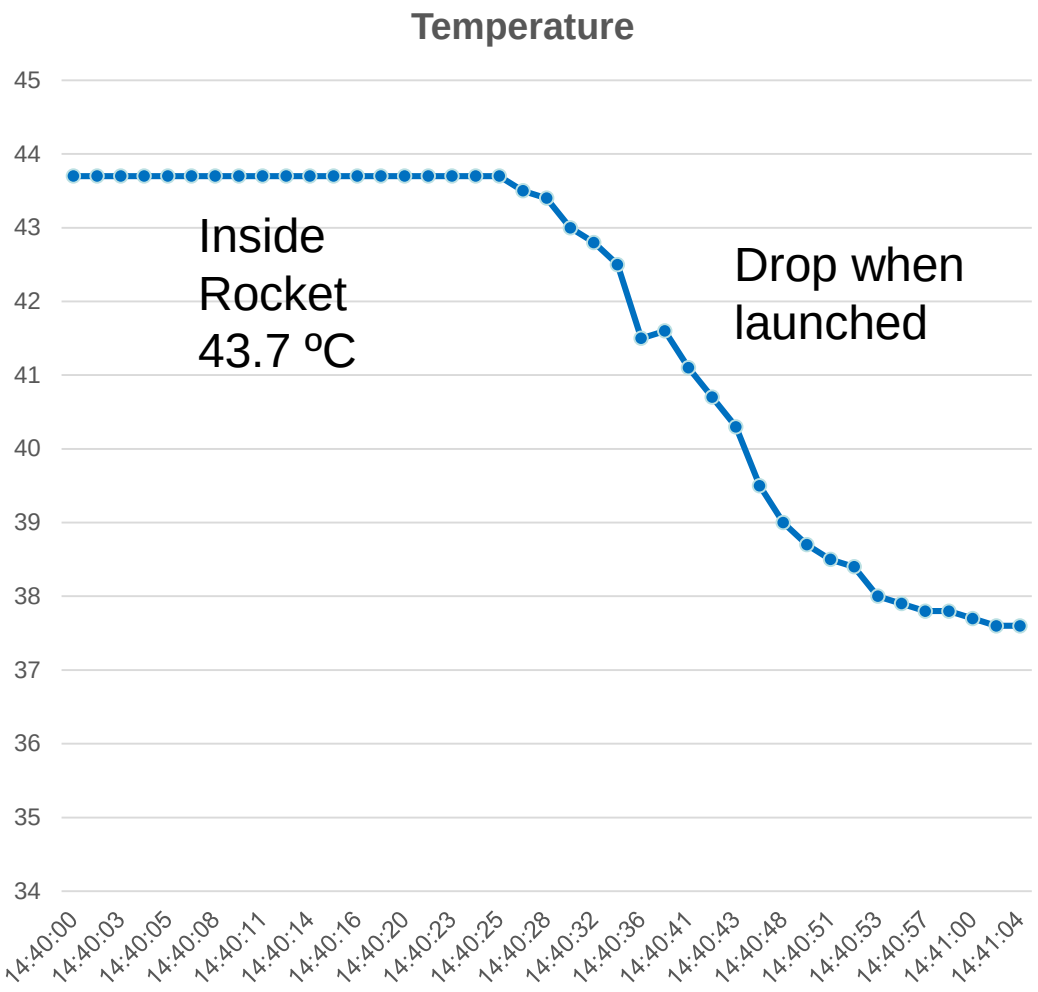
- **Pressure correlated with altitude as expected**
- **Ground pressure is 97.7kPa**
- **Pressure at 688m is 90kPa**

Altitude Plot



- **Max Altitude Recorded: 688m**
- **Heatshield deployment stage fell at ~17m/s**
- **Estimated 18m/s in CDR**
- **Parachute failed to open**

Temperature Plot



- **Temperature inside the rocket is 43.7 ºC**
- **Drops when launched. Sensor temperature cools to ~37.5 ºC**
- **Range: 37-44 ºC**

GPS Plots

- **Starting coordinates:**

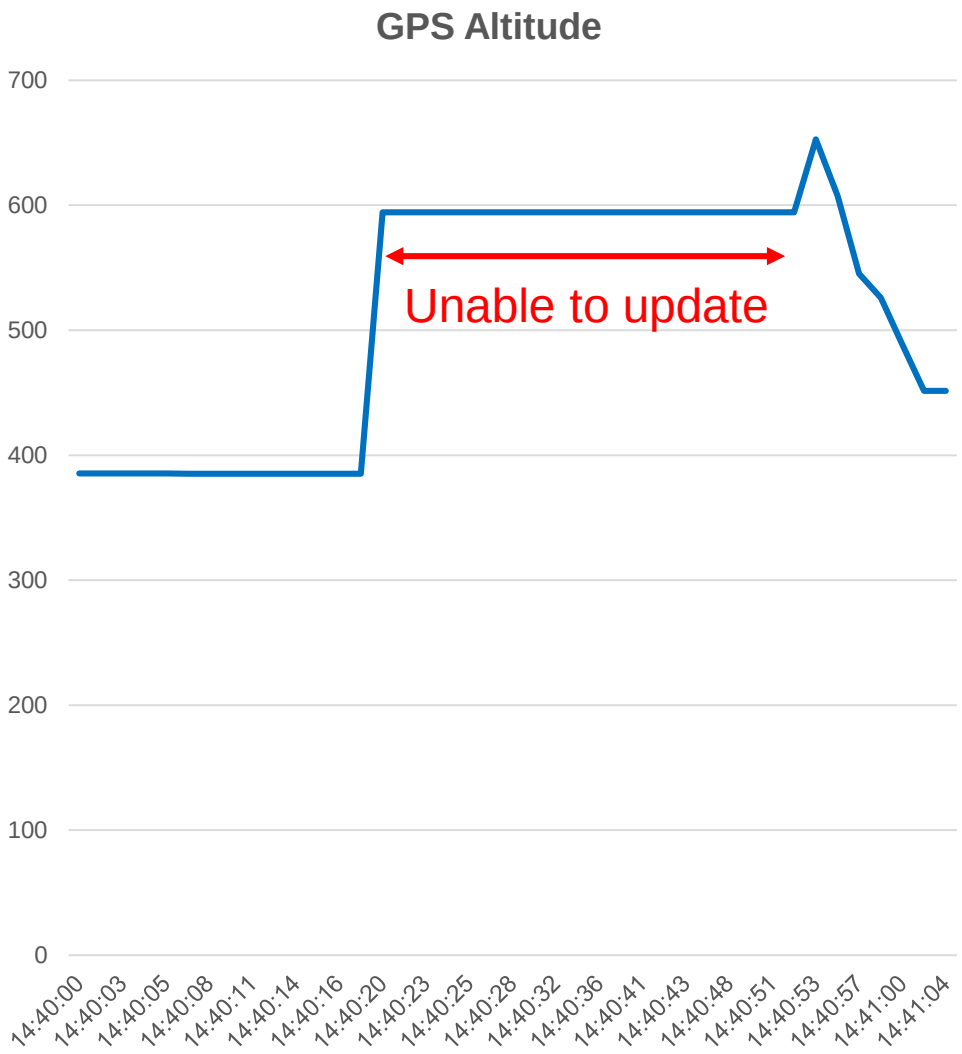
32.240798, -98.199958

- **Landing coordinates:**

32.241786, -98.199958

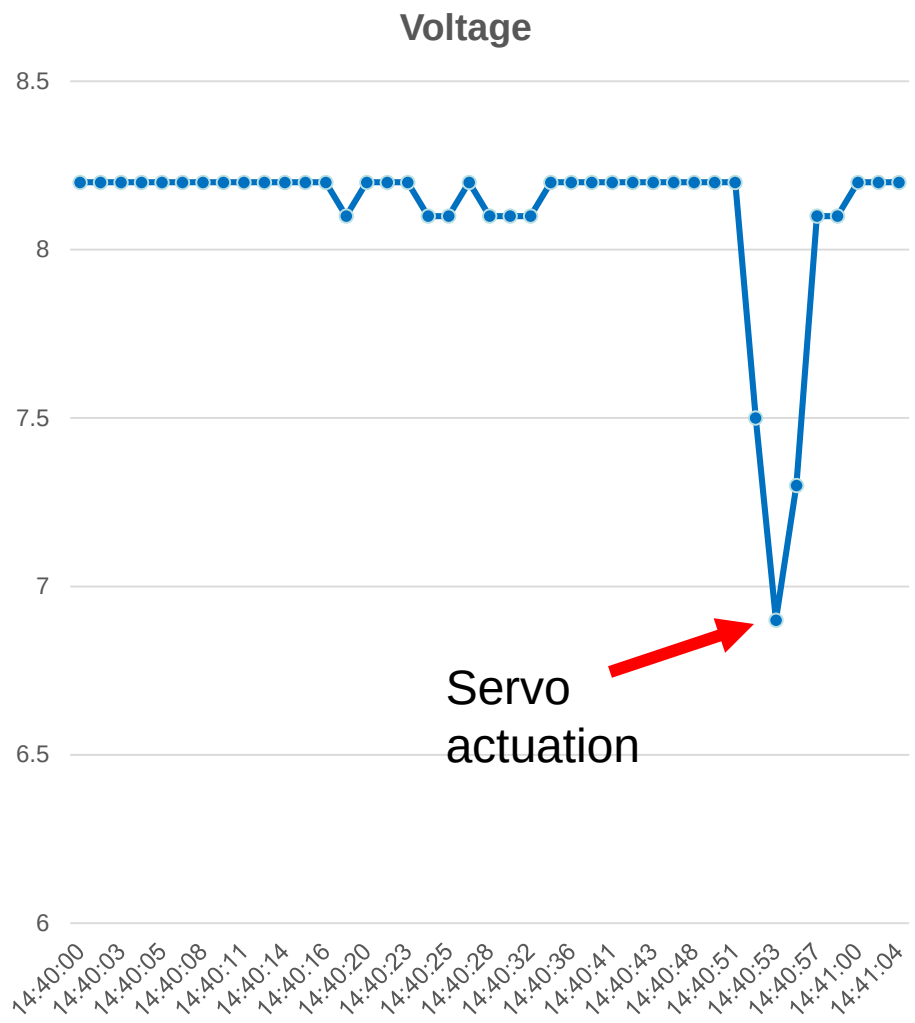
- **GPS failed to update during a portion of flight**

GPS Plots - Altitude



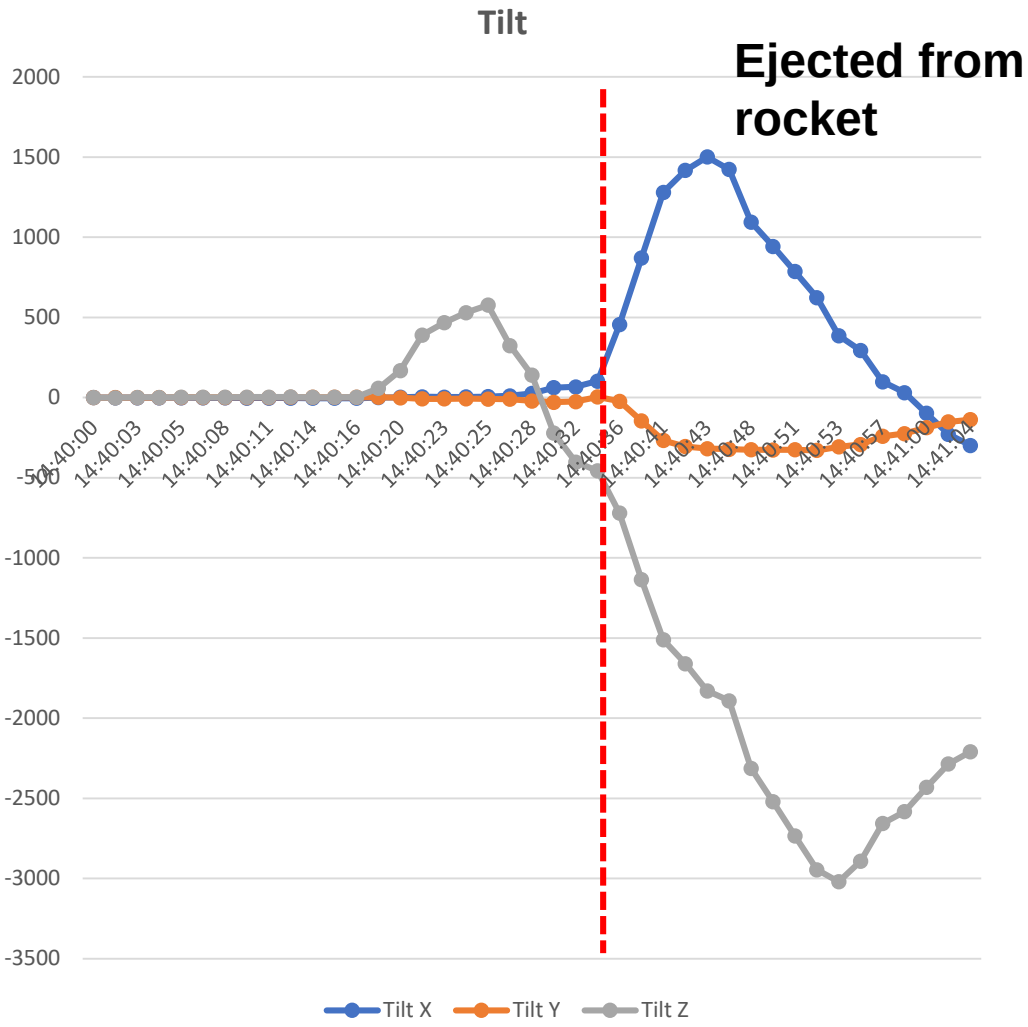
- **GPS failed to update during a portion of flight**
- **Started at ~400m above sea level**

Voltage Plot



- **9V battery was used**
- **Voltage mostly steady at around 8.2V**
- **Surged to 7V when parachute and heat shield servos actuate**
- **Recovered from surge when actuation stopped**

Tilt Plots



- **X-axis and Z-axis shows that the probe was rotating during flight**
- **Actual flight looked like a steady descent**
- **Error may be due to piecewise integration of gyroscope readings**

Wind Sensor and Video Bonus

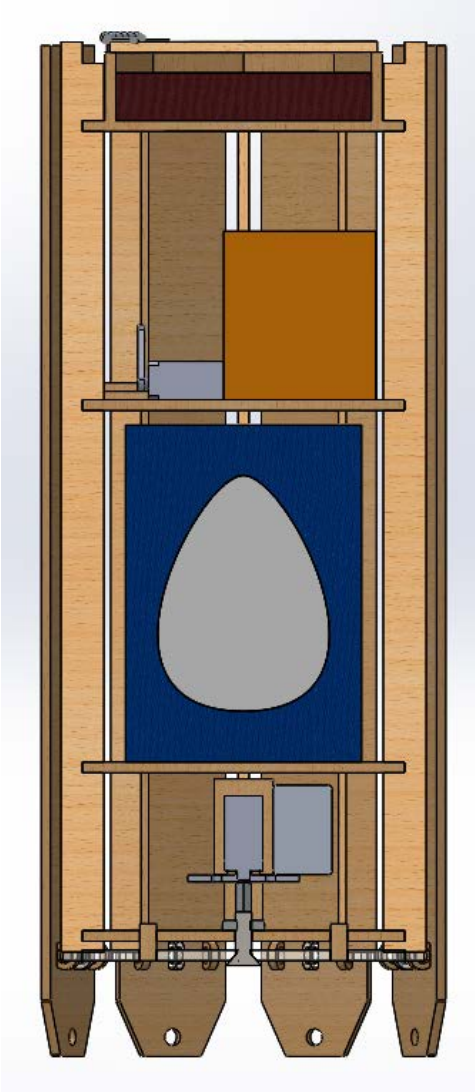
- **Wind sensor and video bonus were not pursued**

Failure Analysis

Ryan Taylor

Identifications of Major Failures and Root Causes

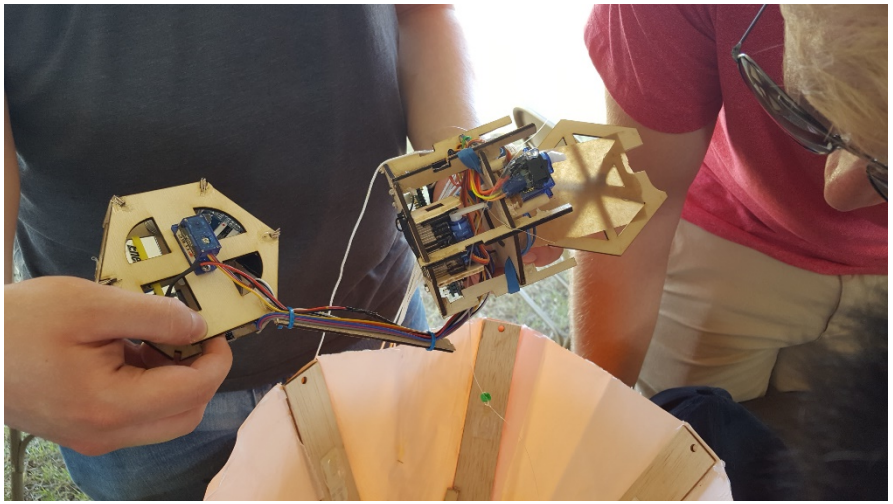
- The probe failed to separate from the heat shield at 300 m, causing the whole CanSat to impact the ground at 17 m/s.
- The failure to separate can be traced to a single failure: that of the parachute to deploy properly.
- The probe successfully detached itself from the heat shield and unlatched the parachute compartment.

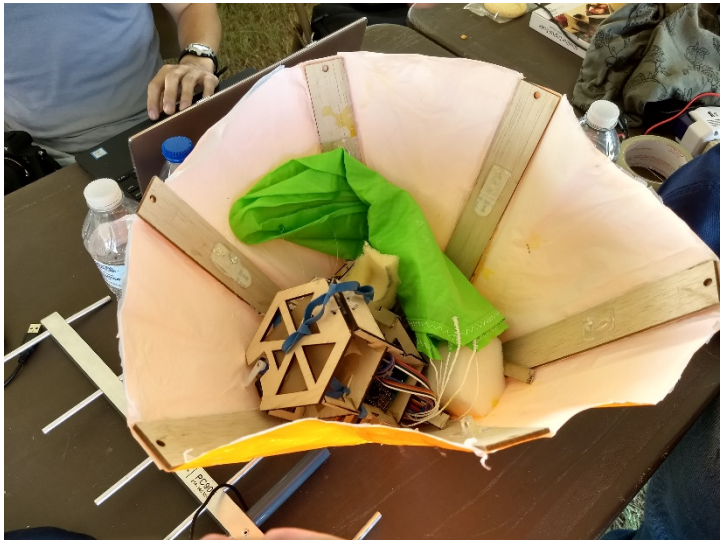


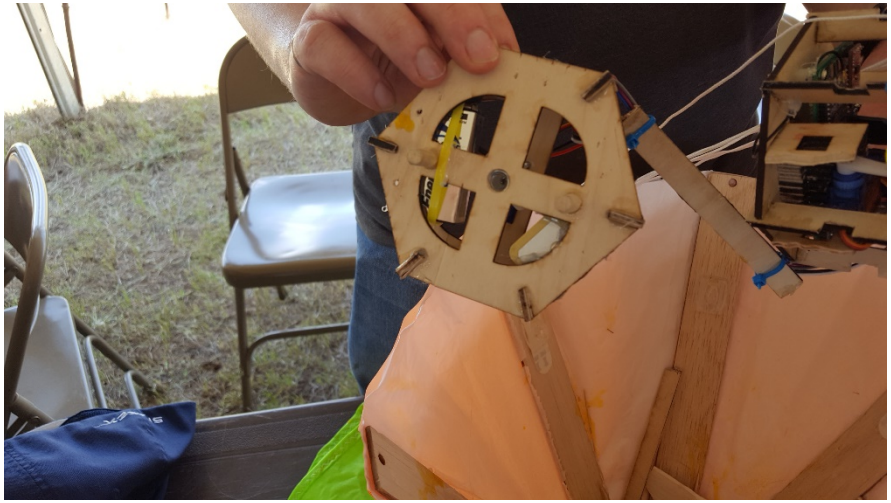
Identifications of Major Failures and Root Causes

- Either the parachute lid failed to open, or the parachute fell between the probe and the heat shield and did not open.
- A fix for either problem would have been to increase the force acting on the parachute compartment lid, helping it open and/or launching the parachute farther to clear the heat shield and unfurl properly.

Identifications of Major Failures and Root Causes







Identifications of Minor Failures and Root Causes

Failure	Root Cause	Corrective Action
Tilt sensor indicates tumbling, despite visual and logical evidence of steady flight.	Poor mounting of tilt sensor and/or erroneous interpretation of data.	Account for impact of poor mounting and/or use more sophisticated integration techniques.
GPS failed to update for a short time.	Probably poor connections between GPS and rest of electronics.	Mount GPS more securely and make connections more secure.

Lessons Learned

Ryan Taylor

Discussion of what worked and what didn't

Worked

- CanSat met all pre-flight testing requirements.
- RSX met CanSat launch submission deadline.
- Telemetry successfully received throughout the entire flight.
- All subsystems worked as intended, with the exception of parachute deployment.
- The heat shield descent appeared to be stable, and the descent rate was within 4% of the predicted velocity.

Did not work

- Parachute did not deploy properly.
- Tilt sensor was improperly mounted and/or interpreted erroneously
- GPS failed to update during portion of the flight

Conclusions

CanSat Accomplishments:

- Our CanSat was a mostly-successful failure; all subsystems (with one notable exception) appear to have worked exactly as designed.

Team Comments:

- Had a lot of fun designing, building, testing, and flying the Cansat
- Thank you to our CanSat hosts and organizers!