00:25

ITION

CanSat 2018
Critical Design Review (CDR)

1138

Robotics for Space Exploration

Presentation Outline

00:25

1. Team Organization: Johnny
2. Systems Overview: Ryan
3. Sensor Subsystem Design: Shahin
4. Descent Control Design: Ryan
5. Mechanical Subsystem Design: MC
6. Communication and Data Handling Subsystem Design: Eric
7. Electrical Power Subsystem Design: Shahin
8. Flight Software Design: Eric
9. Ground Control System Design: Johnny
10. CanSat Integration and Test: Johnny
11. Mission Operations & Analysis: Johnny
12. Requirements Compliance: Johnny
13. Management: Johnny
14. Conclusion: Johnny

00:25

Team Organization

Team Leads
Johnny Wang (M.A.Sc.)

Faculty Advisor
Prof. Jonathan Kelly, PhD

Mechanical Lead
MC De Beer (M.A.Sc AERO)

- Ali Mahdavifar (3rd year AERO)

Aerodynamics Lead
Ryan Taylor (M.A.Sc AERO)

- Ali Mahdavifar (3rd year AERO)

Electronics & Software Lead
Johnny Wang (M.A.Sc. ECE)

- Shahin Jafari (3rd year ROBO)
- Eric Boszin (3rd year ECE)

AERO = Aerospace
ECE = Electrical and Computers
ROBO = Robotics and Mechatronics

Acronyms

00:25

Acronym	Meaning
AC	Alternating Current
C_D	Coefficient of Drag
CDH	Communication and Data Handling
CoG	Center of Gravity
COTS	Commercial Off-the-Shelf
DC	Direct Current
EPS	Electrical Power System
FSW	Flight Software
GCS	Ground Control System
GPS	Global Position System
HS	Heat Shield

Acronym	Meaning
IDE	Integrated Development Environment
LED	Light Emitting Diode
LOS	Line of SIght
Ni-Cad	Nickel-Cadmium Battery
Ni-MH	Nickel-Metal Hydride
PB	Probe
UART	Universal Asynchronous Receiver Transmitter

03:20

System Overview

Ryan Taylor

Mission Summary

03:20

- As per the mission requirements, the CanSat shall:
  - Upon release, 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 atmospheric data throughout the flight and protect one egg from damage during descent.
- In order to pursue simplicity, the bonus objective is not to be attempted.
- No external objectives are required/attempted.

Summary of Changes Since PDR

03:20

- **Pre-launch responsibilities**
  - To reflect team member who are able to come to Texas
- **Descent Control Changes**
  - Angle of heat shield deployment changed from 40º to 30º
  - Prototyping completed on first heat shield attempt and proof-of-concept of heat shield latch
- **Mechanical**
  - Updated mass budget
  - Lowered the center of mass
- **Flight Software**
  - Added the use of accelerometer data to predict ejection from rocket
- **Ground Control antenna**
  - Changed from grid antenna to Yagi antenna

System Requirement Summary

03:20

No.	Requirement
1	Total mass of the CanSat (probe) shall be 500 grams +/- 10 grams.
2	The aero-braking heat shield shall be used to protect the probe while in the rocket only and when deployed from the rocket. It shall envelope/shield the whole sides of the probe when in the stowed configuration in the rocket. The rear end of the probe can be open.
6	The probe with the aero-braking heat shield shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.
7	The probe shall hold a large hen's egg and protect it from damage from launch until landing.
11	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.
12	The rocket airframe shall not be used as part of the CanSat operations.
13	The CanSat, probe with heat shield attached shall deploy from the rocket payload section.
14	The aero-braking heat shield shall be released from the probe at 300 meters.
15	The probe shall deploy a parachute at 300 meters.
22	All mechanisms shall be capable of maintaining their configuration or states under all forces.

System Requirement Summary

03:20

No.	Requirement
23	Mechanisms shall not use pyrotechnics or chemicals.
24	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.
25	During descent, the probe shall collect air pressure, outside air temperature, GPS position and battery voltage once per second and time tag the data with mission time.
26	During descent, the probe shall transmit all telemetry. Telemetry can be transmitted continuously or in bursts.
31	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.
32	Each team shall develop their own ground station.
37	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.
38	Both the heat shield and probe shall be labeled with team contact information including email address.
40	No lasers allowed.
41	The probe must include an easily accessible power switch.

System Requirement Summary

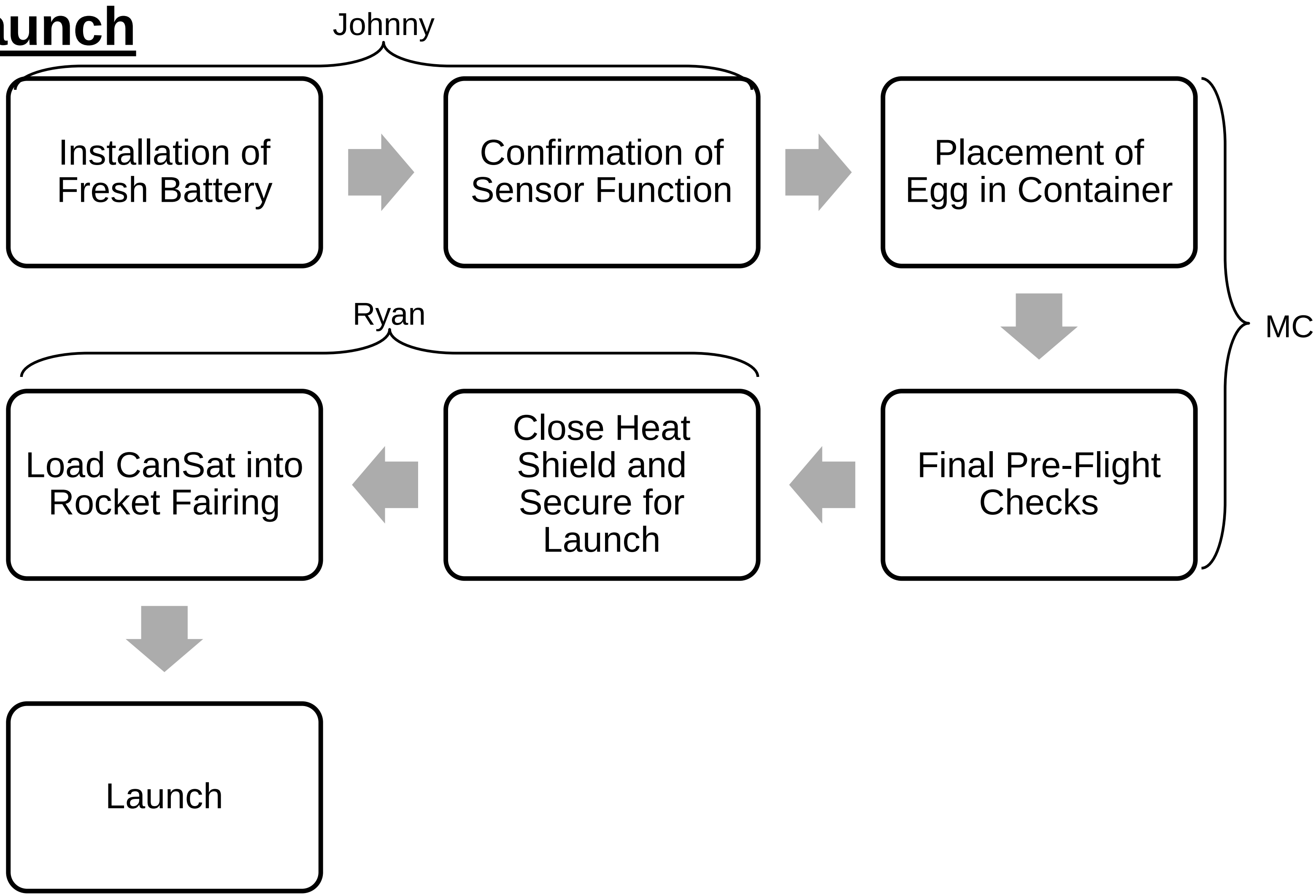
03:20

No.	Requirement
45	An audio beacon is required for the probe. It may be powered after landing or operate continuously.
47	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.

System Concept of Operations

03:20

Pre-Launch



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System Concept of Operations

Post-Launch

1. Detection of Launch
2. Detection of Release from Fairing
3. Deploy Heat Shield
4. At 300 m Altitude: Drop Heat Shield and Deploy Parachute
5. Detection of Landing
6. Recover CanSat and Heat Shield
7. Assess Egg for Damage

Ryan and MC

03:20

Ground Station

Johnny

Confirm Telemetry from Pre-Launch Checks

Monitor Launch and Descent of CanSat

Johnny

Post-Process Collected Data for PFR

All

Compile PFR Document Based on Flight

Payload Physical Layout

03:20

Parachute Release Mechanism:
Servo latch

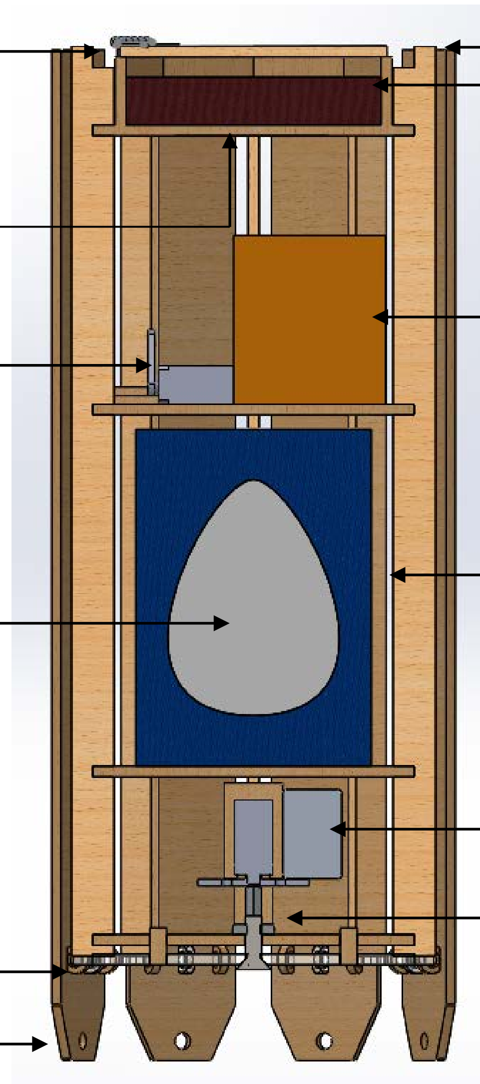
Patch Antenna

Heatshield Deployment Mechanism:
Servo latch and string

Egg

Heat Shield Hinges

Heat Shield Slats



On/Off Switch

Parachute Container:
Spring loaded

Electronics Hub

Egg Container

Battery

Heat Shield Ejection Mechanism:
Servo and screw

Launch Vehicle Compatibility

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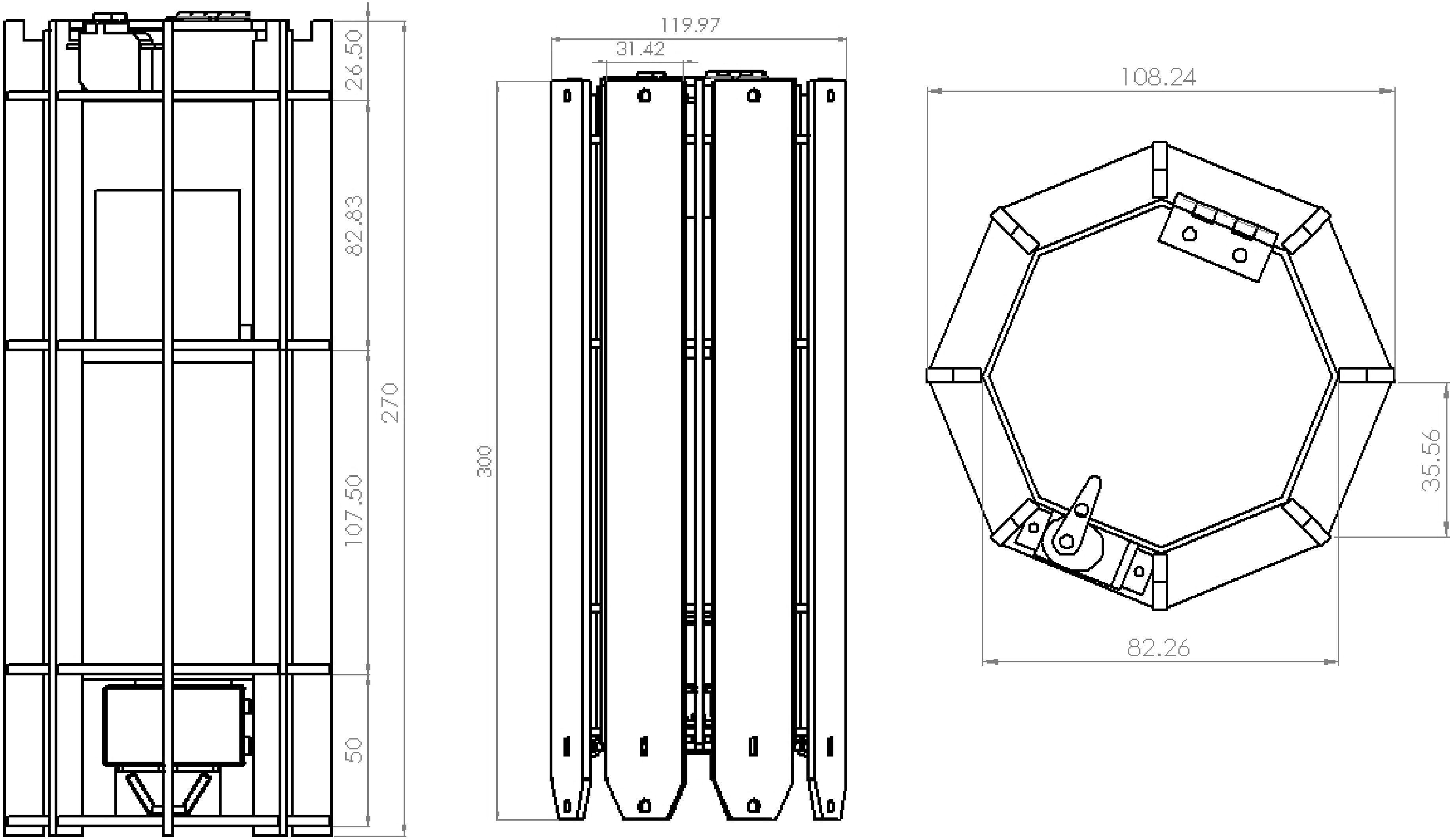


05:00

ITION

Sensor Subsystem Design

Shahin Jafari

Sensor Subsystem Overview

05:00

Sensor Type	Sensor Model	Description
Magnetometer	MPU-9250	Used to obtain direction measurements, as well as the tilt.
Air Pressure	BMP180	Used to obtain atmospheric pressure, temperature and altitude.
GPS	NEO-7M-C	Used to calculate the location of the probe.
Air Temperature	BMP180	Used to obtain atmospheric pressure, temperature and altitude.
Power Voltage Sensor	Voltage Divider Circuit, two 10KΩ resistors	Used to measure voltage of power source.

Sensor Changes Since PDR

05:00

- **No sensor changes were made since the PDR**

Sensor Subsystem Requirements

05:00

No.	Requirement
18	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.
21	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.
25	During descent, the probe shall collect air pressure, outside air temperature, GPS position and battery voltage once per second and time tag the data with mission time.
41	The probe must include an easily accessible power switch.
42	The probe must include a power indicator such as an LED or sound generating device.
45	An audio beacon is required for the probe. It may be powered after landing or operate continuously.
46	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.
47	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.
49	A tilt sensor shall be used to verify the stability of the probe during descent with the heat shield deployed and be part of the telemetry.

Probe Air Pressure Sensor Summary

Sensor Chosen - BMP180

- Good accuracy (Highest Resolution 0.25m)
  - Actual noise ~0.7m (empirical data)
- Low Current Draw (5µA @ 1Hz)
- Communicate over I2C: Open source library provides simple usage
- Data format:
  - Altitude: ####.# (m)
  - Pressure (abs.): ###.## (kPa)
- Altitude calculated using measured pressure:

$$altitude = 44330 * \left(1 - \left(\frac{p}{p_0}\right)^{\frac{1}{5.2}}\right)$$

Probe Air Temperature Sensor Summary

05:00

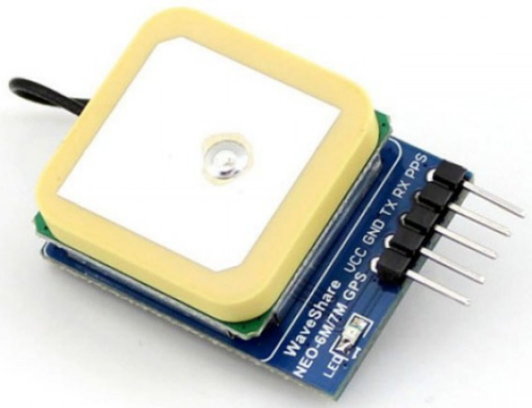
Sensor Chosen - BMP180

- Good accuracy (Highest Resolution 0.25m)
  - Actual noise ~0.7m (empirical data)
- Low Current Draw (5µA @ 1Hz)
- Communicate over I2C: Open source library provides simple usage
- Data format:
  - Altitude: ####.# (m)
  - Pressure (abs.): ###.## (kPa)
  - Temperature: ##.# (Deg C)
- Temperature calculated using measured pressure

GPS Sensor Summary

05:00

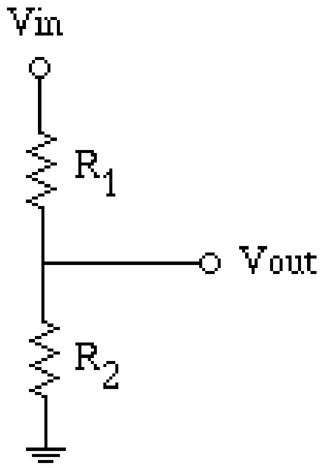
- **The NEO-7M-C**
  - Serial communication
    - Software serial ports available
  - Good accuracy
    - 2.5m accuracy
  - Includes antenna
  - Small size



05:00

10K + 10K Voltage Divider

- **Good accuracy**
  - ± 10 mV Max
- **Low Current Draw (0.4mA Max)**
- **Use analog pin**
- **Data format:**
  - Voltage: #.# (V)



$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$$

05:00

- **The MPU-9250**
  - Small size
  - Magnetometer and Gyro
    - Gyro allows for fast dynamic updates
    - Magnetometer allows for error correction
  - Both sensor types allows for accurate attitude tracking

Bonus Objective Camera Summary

05:00

- **This bonus will not be pursued due to results of score function analysis**
  - To achieve camera bonus, all primary objectives need to achieved
  - Choose to focus on all primary objectives
  - If we are confident all primary objectives will be achieved, we will pursue the bonus given the resources and time.

Bonus Objective Wind Sensor

05:00

- **The wind sensor bonus will be pursued if time permits**
  - This will be an add-on to the ground station
  - No significant changes needs to be made to the core design if we decide to use the remaining time to pursue this bonus

Descent Control Design

Ryan Taylor

Descent Control Overview

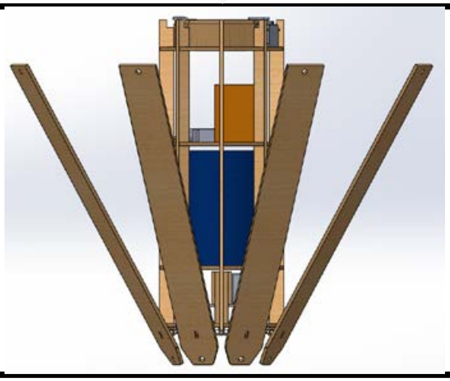
08:20

Launch Configuration

- From launch to immediately after deployment
- Heat shield in stowed configuration, no active or passive descent control

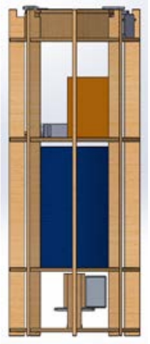
Deployed Configuration

- From deployment to 300 m altitude
- Heat shield deployed to fullest extent
- Increased surface area reduces speed to ~18 m/s while shape stabilizes to prevent tumbling



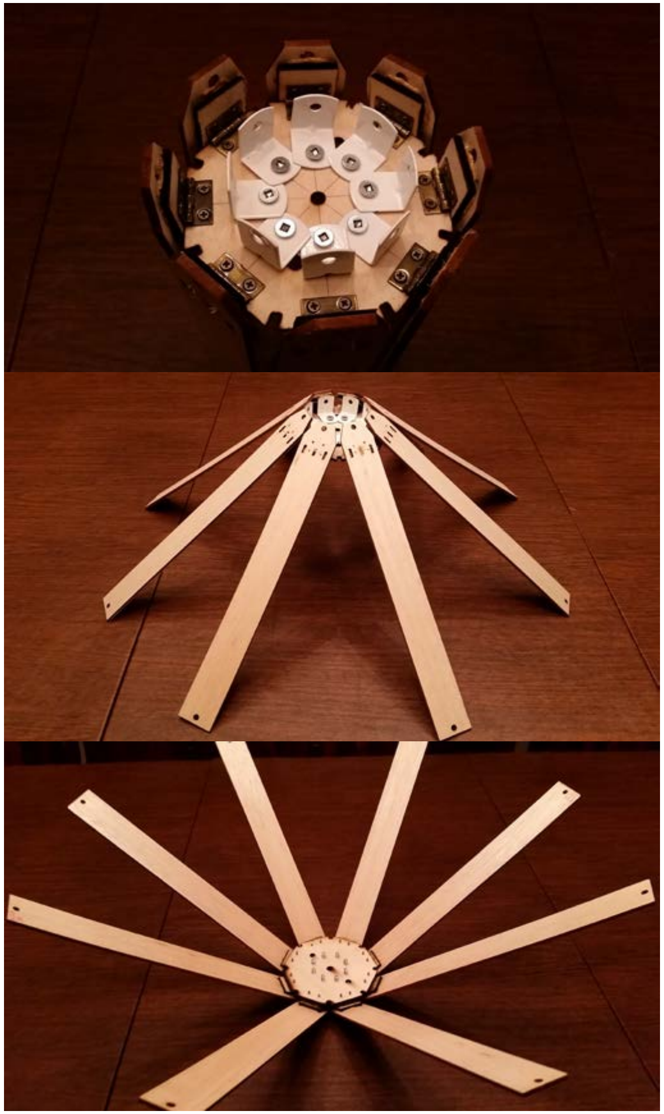
Landing Configuration

- From 300 m altitude to landing
- Heat shield separated from probe
- Probe descends at 5 m/s via parachute
- Heat shield descends at ~8 m/s



Descent Control Changes Since PDR

- Angle of heat shield deployment changed from 40º to 30º due to stability concerns
- Prototyping completed on first heat shield attempt and proof-of-concept of heat shield latch



Descent Control Requirements

No.	Requirement
2	The aero-braking heat shield shall be used to protect the probe while in the rocket only and when deployed from the rocket. It shall envelope/shield the whole sides of the probe when in the stowed configuration in the rocket. The rear end of the probe can be open.
3	The heat shield must not have any openings.
4	The probe must maintain its heat shield orientation in the direction of descent.
5	The probe shall not tumble during any portion of descent. Tumbling is rotating end-over-end.
6	The probe with the aero-braking heat shield shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.
9	The aero-braking heat shield shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.
10	The aero-braking heat shield shall be a florescent color; pink or orange.
11	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.
14	The aero-braking heat shield shall be released from the probe at 300 meters.

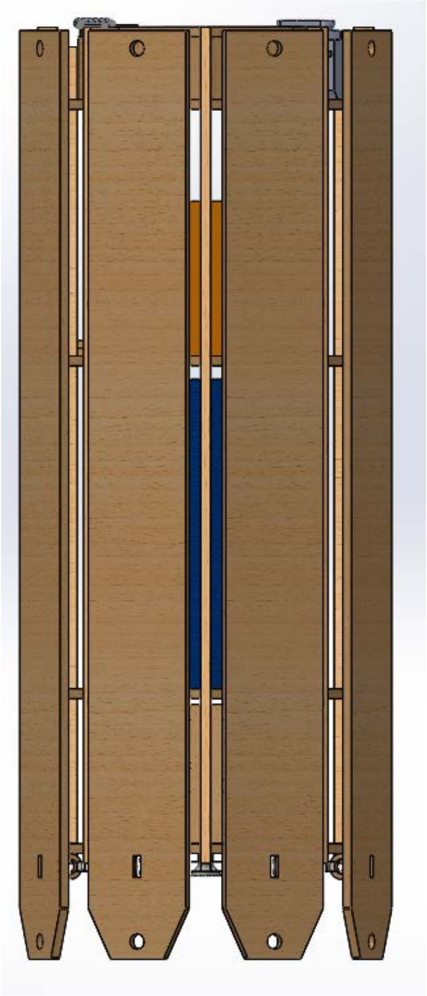
Descent Control Requirements

08:20

No.	Requirement
15	The probe shall deploy a parachute at 300 meters.
16	All descent control device attachment components (aero-braking heat shield and parachute) shall survive 30 Gs of shock.
17	All descent control devices (aero-braking heat shield and parachute) shall survive 30 Gs of shock.
22	All mechanisms shall be capable of maintaining their configuration or states under all forces.
24	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.
38	Both the heat shield and probe shall be labeled with team contact information including email address.
43	The descent rate of the probe with the heat shield deployed shall be between 10 and 30 meters/second.
44	The descent rate of the probe with the heat shield released and parachute deployed shall be 5 meters/second.

Payload Descent Control Hardware Summary – Stowed Configuration

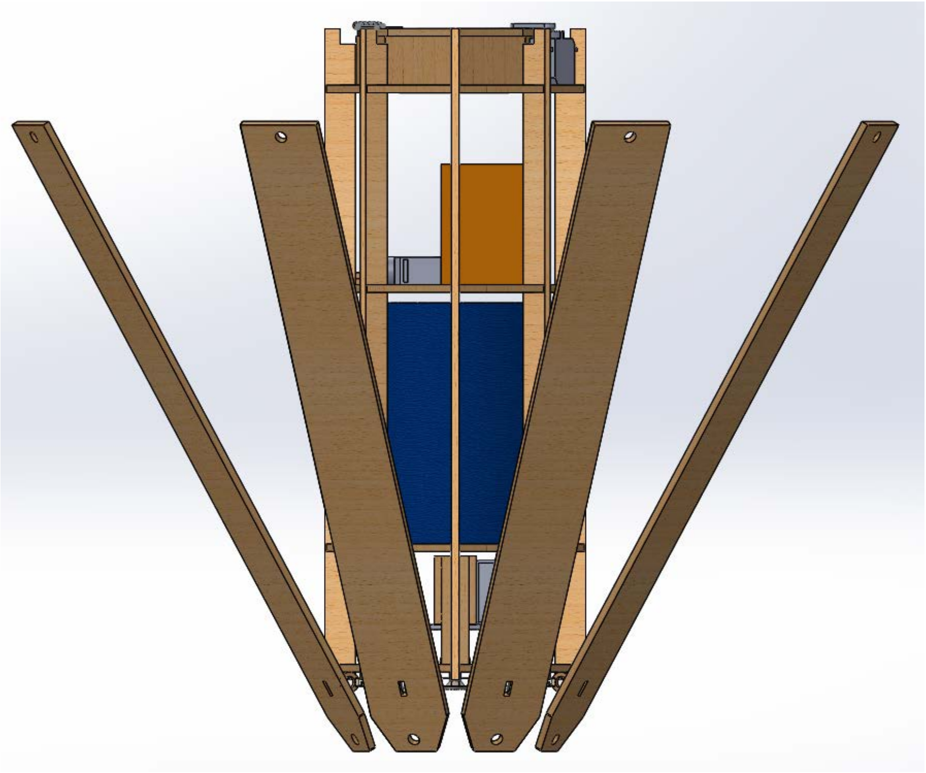
- In stowed/launch configuration, the slats of the heat shield are tensioned to spring outwards by elastics at the base
- Slats are restrained from opening by a single line threaded through loops at top of slats
- Line is restrained by a servo-driven latching mechanism near parachute compartment
- Upon detection of release from rocket, the latching mechanism is released and the heat shield deploys under its own power



Payload Descent Control Hardware Summary – Deployed Configuration

08:20

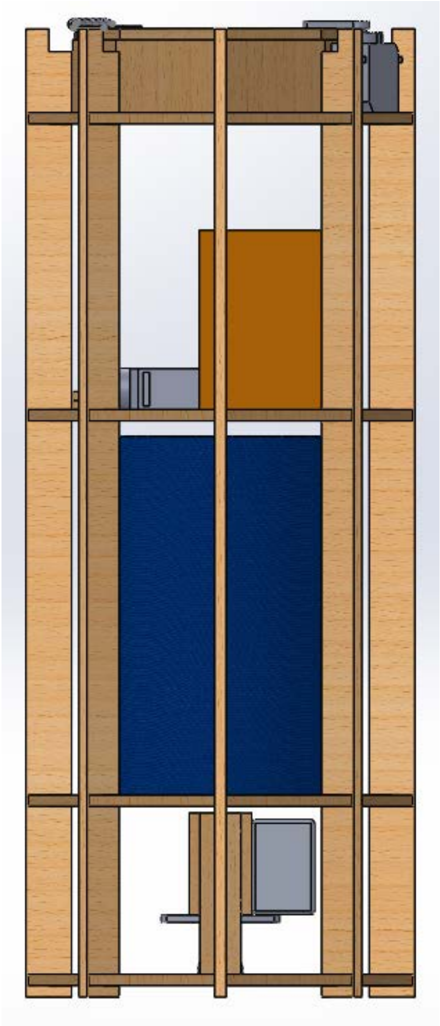
- The heat shield slats are held at the appropriate angle (30º, see following slides) by physical stops beneath the baseplate
- Elastics provide tension to maintain this angle and combat aerodynamic forces acting on slats, keeping the shape of the heat shield constant



Payload Descent Control Hardware Summary – Parachute Configuratio

08:20

- Throughout flight, parachute compartment is restrained by a servo latching mechanism
- Similarly, the heat shield is held to the probe via a nut and bolt connecting the probe to the baseplate
- Upon reaching 300 m altitude, the parachute released by the latching mechanism and the baseplate is detached immediately afterwards by a continuous servo unscrewing the bolt



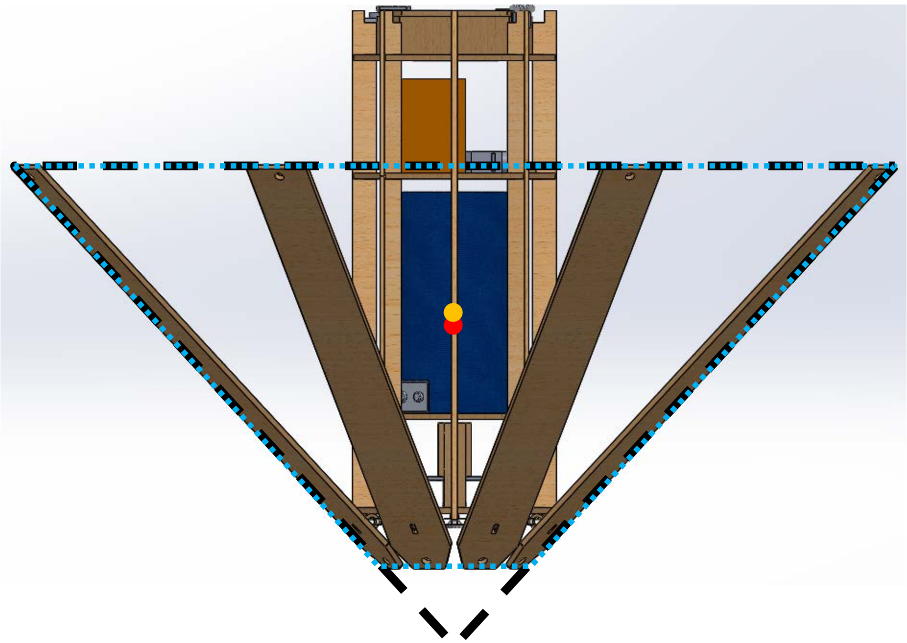
Payload Descent Control Hardware Summary – Sensors

- Two sensors used for descent control: the accelerometer and pressure sensor (acting as an altimeter)
- Upon estimation of release from rocket by accelerometer and rapid descent rate by the altimeter, the heat shield will be triggered
- Upon reaching 300 m altitude (determined by pressure sensor) the heat shield is released and parachute deployed.

Descent Stability Control Design

08:20

- Stability is ensured by conical shape of heat shield; no active components are included/necessary to provide stability
- A full cone has its neutral point at one-third of its height from the base; stability is assured if the CoM of the CanSat is below this point
- Truncating the cone such that the tip is missing will move the neutral point further back
- The neutral point of the CanSat (ignoring the effects of the probe) is estimated to be 13.2 cm above the baseplate of the heat shield
- The current estimate of the CoM places it at 11.8 cm above the base plate.



● Neutral point of full cone
● Neutral point of truncated cone

Descent Rate Estimates

- Estimates and calculations unchanged since PDR.
- The table below shows the estimates of descent rate with varying drag coefficients at a heat shield angle of 40º.
- Parachute was sized to produce a descent rate of 5 m/s, currently estimated at 60 cm diameter.

Stage	Pre-Deployment	Deployed Heat Shield	Detached Heat Shield
Best Case (C_D = 1.1)	29 m/s	13 m/s	6 m/s
Best Estimate (C_D = 0.5)	43 m/s	18 m/s	8 m/s
Worst Case (C_D = 0.295)	54 m/s	24 m/s	12 m/s

Mechanical Subsystem Design

MC de Beer

Mechanical Subsystem Overview

11:15

Device	Material	Description	Interface
Heat Shield	Balsa wood with ply wood mounting plates.	Induces drag, slows down and stabilizes the payload to allow for parachute deployment. Attached to the probe and released via a motorized screw.	A central screw attached to a motor connects the heatshield to the probe. Additional passive pins prevent rotation.
Parachute	Ripstop Nylon 1.7 oz. fabric	Induces drag, slows down the payload to allow for landing. Attached to the probe and released via spring-and-cap mechanism.	Parachute will be threaded through holes at the top of the probe. Will also be hooked up with a rubber band to absorb some shock at deployment.
Egg Containment	Insulating foam core	Foam core helps to absorb shock and dampen forces on the egg during launch and upon impact of probe with ground.	Light adhesive (two part epoxy) to stick to probe frame.
Circuit Board Platforms	Perforated board and acrylic sheet base (5 mm)	Perforated boards containing circuits mounted on to octagonal acrylic disks (10 cm diameter, 5 mm thick).	Circuit boards attached to frame via light adhesive and screws.
Probe Shell and Frame	Plywood and balsa wood	Houses all of the components inside the probe.	Attached to Heat Shield by a motor screw mechanism. Internal components attached with adhesive and screws.

Mechanical Subsystem Changes Since PDR

11:15

- Updated mass budget with more accurate estimates
- In order to lower the center of mass:
  - The battery was moved into the lower most compartment and will be secured to the heat shield release mechanism.
  - Lowered the egg and electronics compartments in the probe frame

Mechanical Sub-System Requirements

11:15

No.	Requirement
1	Total mass of the CanSat (probe) shall be 500 grams +/- grams.
2	The aero-braking heat shield shall be used to protect the probe while in the rocket only and when deployed from the rocket. It shall envelope/shield the whole sides of the probe when in the stowed configuration in the rocket. The rear end of the probe can be open.
6	The probe with the aero-braking heat shield shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket.
7	The probe shall hold a large hen's egg and protect it from damage until landing.
8	The probe shall accommodate a large hen's egg with a mass ranging from 54 grams to 68 grams and a diameter of up to 50 mm and length up to 70 mm.
10	The aero-braking heat shield shall be a florescent colour; pink or orange.
11	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.
12	The rocket airframe shall not be used as a part of the CanSat operations.
16	All descent control device attachment components (aero-braking heat shield and parachute) shall survive 30 Gs of shock.
17	All descent control devices (aero-braking heat shield and parachute) shall survive 30 Gs of shock.
19	All structures shall be built to survive 15 Gs of launch acceleration.
20	All structures shall be build to survive 30 Gs of shock.
22	All mechanisms shall be capable of maintaining their configuration or states under all forces.
23	Mechanisms shall not use pyrotechnics or chemicals.

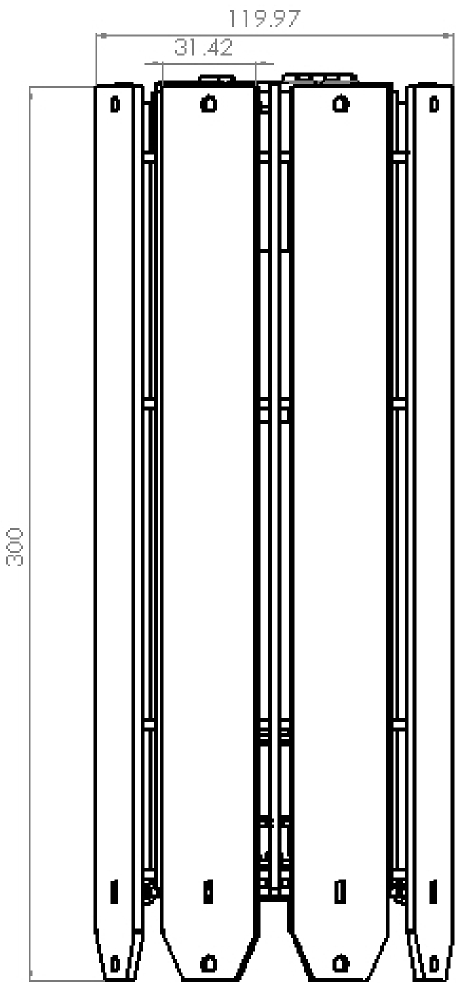
Mechanical Sub-System Requirements

11:15

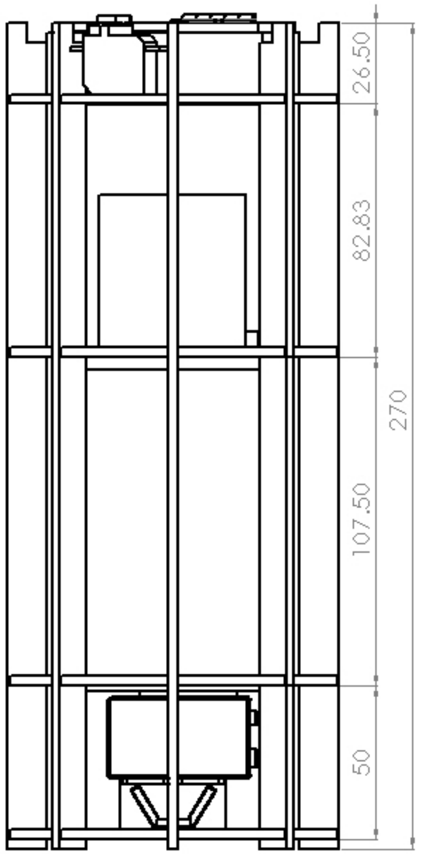
No.	Requirement
24	Mechanisms that use heat (eg. Nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.
38	Both the heat shield and probe shall be labelled with team contact information including email address.

Payload Mechanical Layout of Components

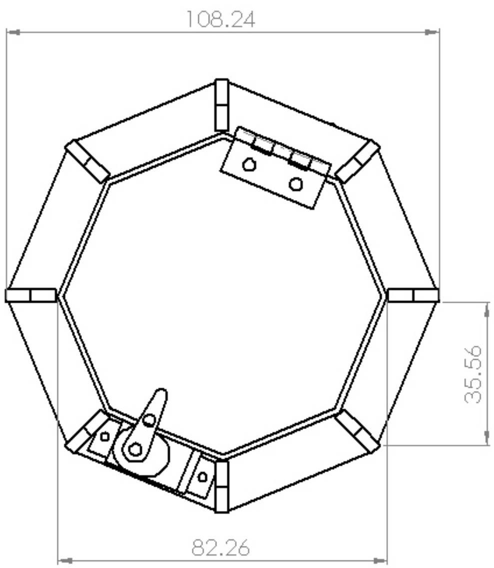
11:15



With Heat Shield Slats

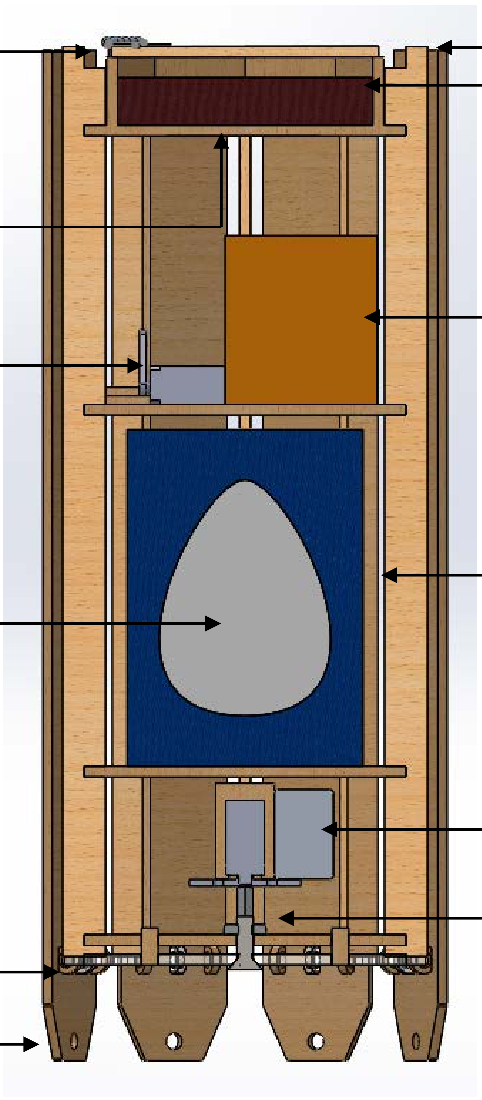


Without Heat Shield Slats



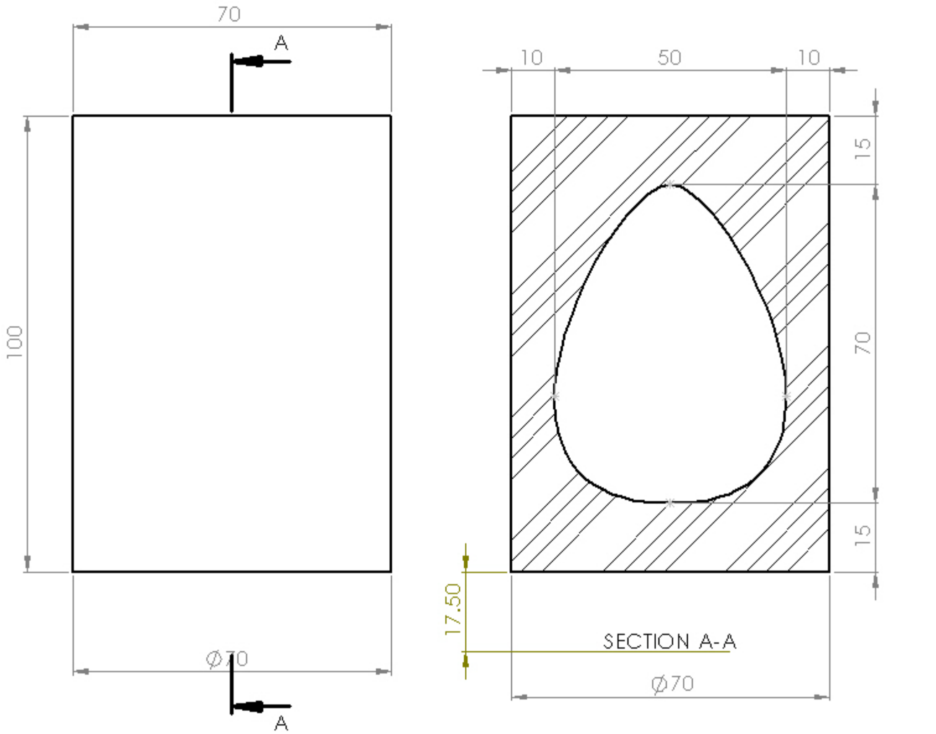
Without Heat Shield Slats:
Top view

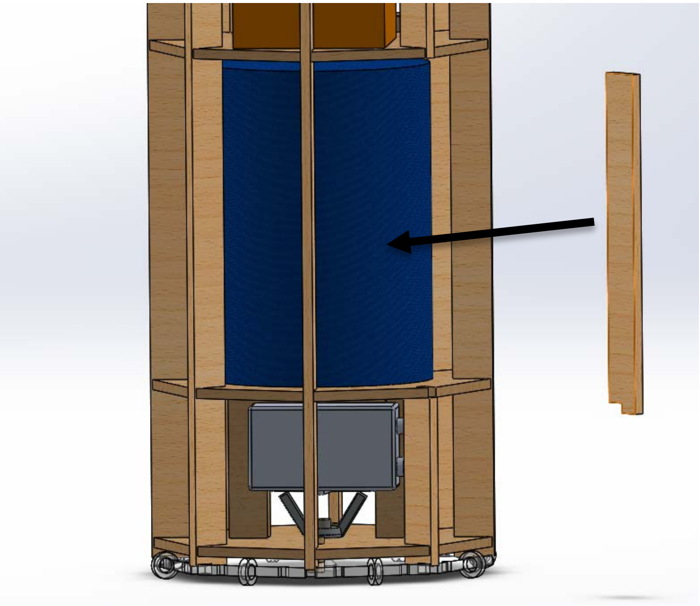
Payload Mechanical Layout of Components



Egg Protection Mechanical Layout of Components

11:15





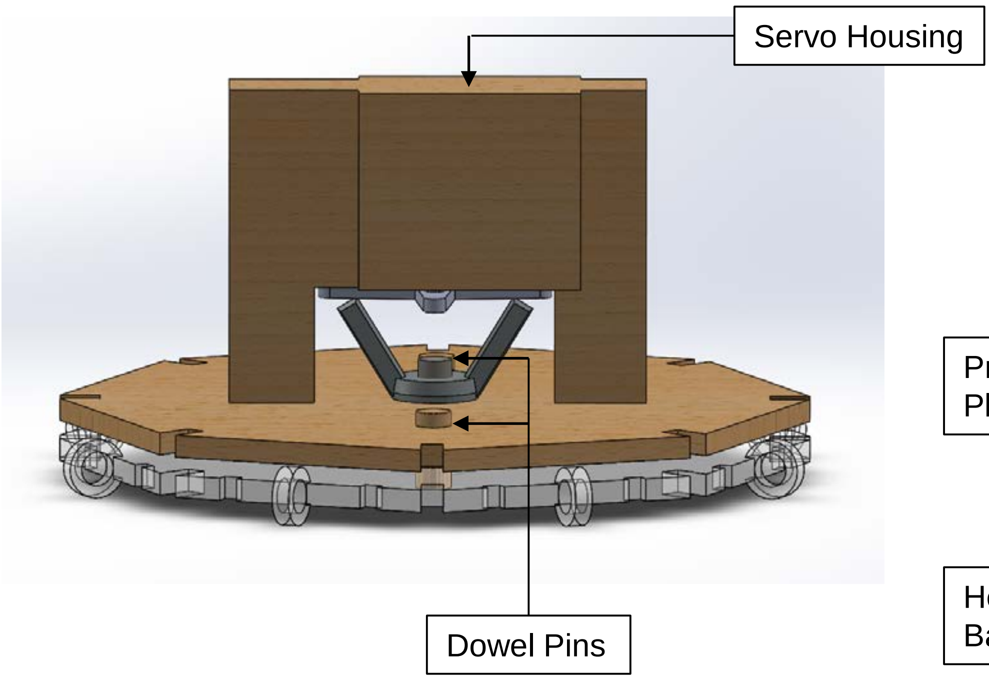
- Egg will be stored in a soft foam core.
- The foam padding will be:
  - Approximately 15 mm at the top and bottom of the egg
  - Approximately 10 mm on each side

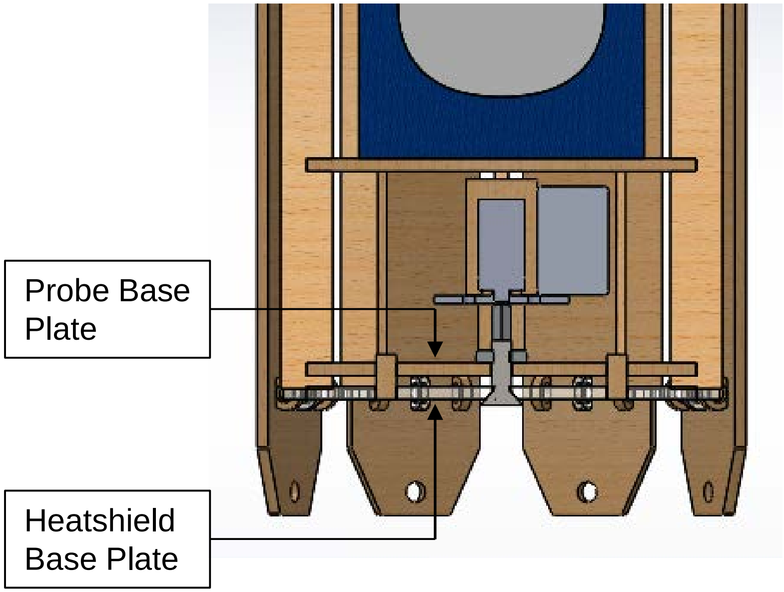
- The egg will accessible through a removable section of the beam.
- There will be a horizontal slice in the foam through which to move the egg.
- That slice will be covered with duct tape during flight.

Heat shield Release Mechanism

11:15

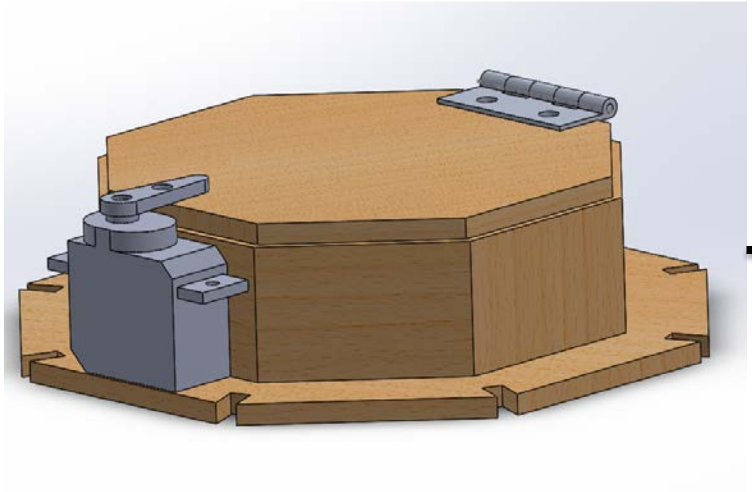
- A servo turns a wing nut which allows the heatshield base plate (attached to the heatshield slats) to separate from the probe base plate.
- To prevent the heatshield from twisting two dowels are used as pins.

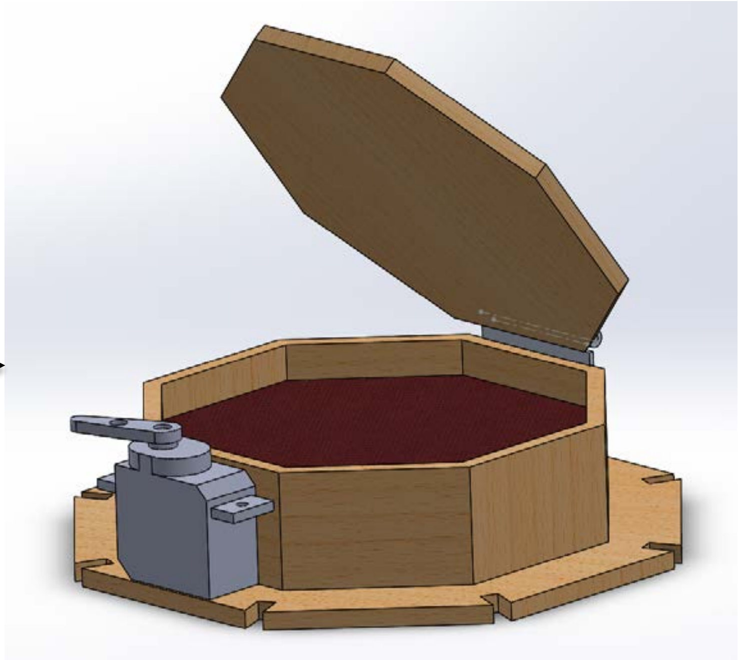




Probe Parachute Release Mechanism

- The parachute employs a spring and cap mechanism.
- When the servo is actuated it frees the lid which is opened by a spring loaded system.
- The parachute is then ejected out of the container by a spring allowing it to deploy.





Structure Survivability

- Electronic component mounting methods
  - All components will be mounted via stand offs
    - Based on previous experience this is able to withstand forces
  - Memory card and batteries will be secured with duck tape to minimize risk of ejection

- Electronic component enclosures
  - Probe frame shall act as the enclosure for the electronics
  - Reduces weight relative to individual enclosures

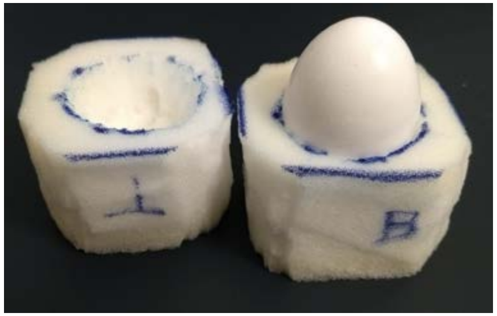
- Acceleration and shock force requirements and testing
  - Descent control device attachment components to survive 30 Gs of shock
    - To be tested with a drop test, 80 cm drop of payload while being held by parachute
  - All structures 15 Gs of acceleration and 30 Gs of shock
    - To be tested with vibration test, mount payload on an orbital sander and allow it to reach full speed and then turn it off.
  - Egg must survive the landing at around 5 ms
    - Tested with a prototype egg container and a drop test from around 1.3 m to simulate a 5 m/s landing

Structure Survivability

11:15

- Securing electrical connections
  - Hot glue will be used to ensure electrical connections do not separate.

- Descent control attachments
  - Parachute
    - Attached to plywood base container with nylon rope and elastics to help dampen shock of parachute deployment
  - Head shield
    - Attached to probe with a central screw connection with dowel pins to prevent rotation



$$v_f^2 = v_i^2 + 2ad$$

$$v_i = 0\ m/s\ , v_f = 5\ m/s\, , a = 9.81\ m/a^2$$

$$d\ \approx 1.3\,m$$

Mass Budget

Component/Structural Element	Quantity	Mass/Unit (g)	Margin (g)	Total Mass (g)	Source
Probe - Total Mass 385.57g					
Frame Beams	8	7	0.35	56.35	Measured
Frame Plates	4	17	0.85	68.85	Measured
Parachute	1	45	2.25	47.25	Data Sheet
Parachute Release Mech	1	15	2.25	17.25	Estimate
Patch Antenna	1	1.5	0.075	1.575	Data Sheet
Electrical Hub and Wires	N/A	25	3.75	28.75	Estimate
Fasteners	N/A	15	2.25	17.25	Estimate
Battery	1	33.9	1.695	35.595	Data Sheet
Heatshield Release Mech	1	15	2.25	17.25	Estimate
Egg	1	68	10.2	78.2	Estimate
Egg Foam Container	1	15	2.25	17.25	Estimate
Heat Shield – Total Mass 114.55g					
Slats	8	5	0.75	40.75	Measured
Mounting Squares	8	2	0.3	16.3	Measured
Fabric	1	10	1.5	11.5	Estimate
Fasteners	N/A	20	3	23	Estimate
Base Plate	1	20	3	23	Estimate
Total Mass				**500.12**	

- Total estimated mass is 500.12 g
- Probe mass: 385.57 g
- Heatshield mass: 114.55 g
- 15% error margin is applied to estimated values
- 5% error applied to measured values or values from data sheets

Communication and Data Handling (CDH) Subsystem Design

Eric Boszin

CDH Overview

Communications

- XBee Pro 900HP (x2): wireless transmission/reception of telemetry data to and from GCS and CANSAT
- Arduino Nano : Establishes a serial (UART) communication between XBee and sensors for the probe
- Taoglas FXP290: patch antenna used for communication between GCS and probe

Data Handling

- Arduino Nano: Parses data from GPS, sensors, and XBee and initiates storage
- DS3231 Chip (x2): real-time clock with battery backup capabilities

CDH Changes Since PDR

14:35

- **No major CDH system changes since PDR**

CDH Requirements

14:35

No.	Requirement
6	The probe with the aero-braking heat shield shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.
18	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.
21	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.
25	During descent, the probe shall collect air pressure, outside air temperature, GPS position and battery voltage once per second and time tag the data with mission time.
26	During descent, the probe shall transmit all telemetry. Telemetry can be transmitted continuously or in bursts.
27	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.
28	XBEE radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900 MHz XBEE Pro radios are also allowed.
29	XBEE radios shall have their NETID/PANID set to their team number.
30	XBEE radios shall not use broadcast mode.

Probe Processor & Memory Selection

14:35

- **Board:** Arduino Nano
- **Pin Count:** 14 Digital (6 PWM), 6 Analog
- **Communication:** UART, SPI, I2C
- **Processor:** ATmega328 (16MHz**)**
- **Memory Storage Requirements**:
  - 32 KB Flash (2 KB used for bootloader), 2KB SRAM, 1KB EEPROM
  - Sufficient memory for mission

Probe Real-Time Clock

- **Hardware:** DS3231
- **Interface**: I2C
- **Output**: Active-low RST Output
- **Reset Tolerance:**
  - V_{PF} is power failure voltage
  - Min: 2.45 Typ: 2.575 Max: 2.70

SUPPLY CONDITION	ACTIVE SUPPLY
$V_{CC} < V_{PF}$, $V_{CC} < V_{BAT}$	V_{BAT}
$V_{CC} < V_{PF}$, $V_{CC} > V_{BAT}$	V_{CC}
$V_{CC} > V_{PF}$, $V_{CC} < V_{BAT}$	V_{CC}
$V_{CC} > V_{PF}$, $V_{CC} > V_{BAT}$	V_{CC}

$V_{BAT,typ}$ = 3.0 and $V_{PF,typ}$ = 2.575.

If $V_{CC} < V_{BAT}$ ***and*** *$V_{CC} < V_{PF}$: RTC switches to low current battery backup mode*

Thus reset tolerance is set to max($V_{BAT,typ}$,$V_{PF,typ}$) = 3.0 V.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}		2.3	3.3	5.5	V
	V_{BAT}		2.3	3.0	5.5	V
Logic 1 Input SDA, SCL	V_{IH}		0.7 x V_{CC}		V_{CC} + 0.3	V
Logic 0 Input SDA, SCL	V_{IL}		-0.3		0.3 x V_{CC}	V

Probe Antenna Selection

14:35

- **Selected Antenna:** Taoglas FXP920
- **Description:** Linearly polarized patch antenna with MHFII (U.FL Compatible) connector, easily mountable and extremely lightweight. Operating temperature from -40°C to +85°C.
- **Return Loss:** -20 dB
- **Gain:** 1.5 dBi
- **Efficiency:** 40%
- **VSWR:** <2:1
- **Size:** 75mm x 45mm x 0.1 mm
- **Mass:** 1.5 g

Probe Radio Configuration

14:35

Protocol

- XBee Pro 900HP operates on the IEEE 802.15.4 wireless network communication protocol
- For serial interface it operates on the Application Transparent (AT) – UART serial protocol

Configuration

- **Wireless network feature – Unicast**

  Unicast mode is used to transmit to a specific radio and does not transmit to all radios in its vicinity.

  - Constraints: Broadcast and multicast modes are not chosen as the intent is to communicate to only the radio on our team's CANSAT.
  - Specifications:
    - Radios are identified and linked on the network by setting NETID as 1138
    - When using transparent mode set DH:DL to the SH:SL of the destination radio.

Probe Radio Configuration

Configuration

- **Serial interface feature - AT *Command* and AT *Operating* Mode**:

  Command mode is used to send configuration commands while operating mode allows execution of the commands.
  - Constraint: A structured communication interface requiring API frames is not desired and hence API mode is not chosen
  - Specifications:
    - Delivery method: Point to Point/Multipoint (P2MP) delivery method for the network must be used as unicast mode is chosen and to ensure that data is transmitted and received solely by the CANSAT radio.

Probe Telemetry Format

14:35

- **Format of packets:**

  <TEAM_ID>, <MISSION_TIME>, <PACKECT_CNT>, <ALTITUDE>, <PRESSURE>, <TEMP>, <VOLTAGE>, <GPS TIME>, <GPS LATITUDE>, <GPS LONGITUDE>, <GPS ALTITUDE>, <GPS SATS>, <TILT X>, <TILT Y>, <TILT Z>, <SOFTWARE STATE>

In terms of ASCII characters (each character is a placeholder):

tmID,hh.mm.ss,pac#,altd.#,Psi.xx,To,Vi,GPSTIME###,-##.latitu,-##.longitu,-alt.##,S#,Tlx,Tly,Tlz,#\n

  – 100 ASCII characters (8 bits each) = 800 bits per packet excluding overhead

- **With overhead and repeat requests, data transmission rate should still only be in the range of 1-10 kbps assuming 1 Hz sample rate**
- **Burst transmission**
- **Testing will yield an appropriate data rate and hence sample rate**

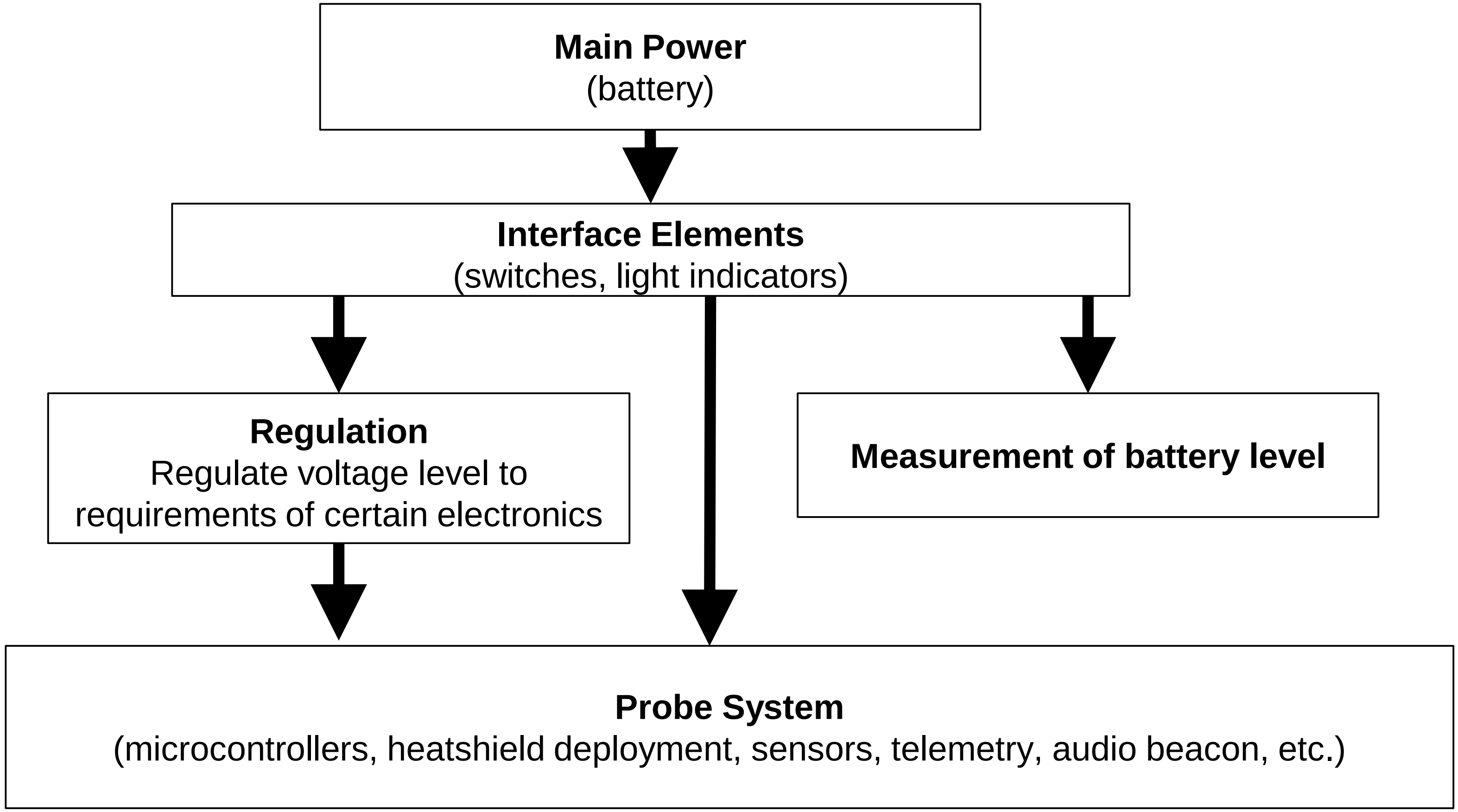
17:50

Electrical Power Subsystem Design

Shahin Jafari

EPS Overview

17:50



EPS Changes Since PDR

17:50

- **No major changes since the PDR**

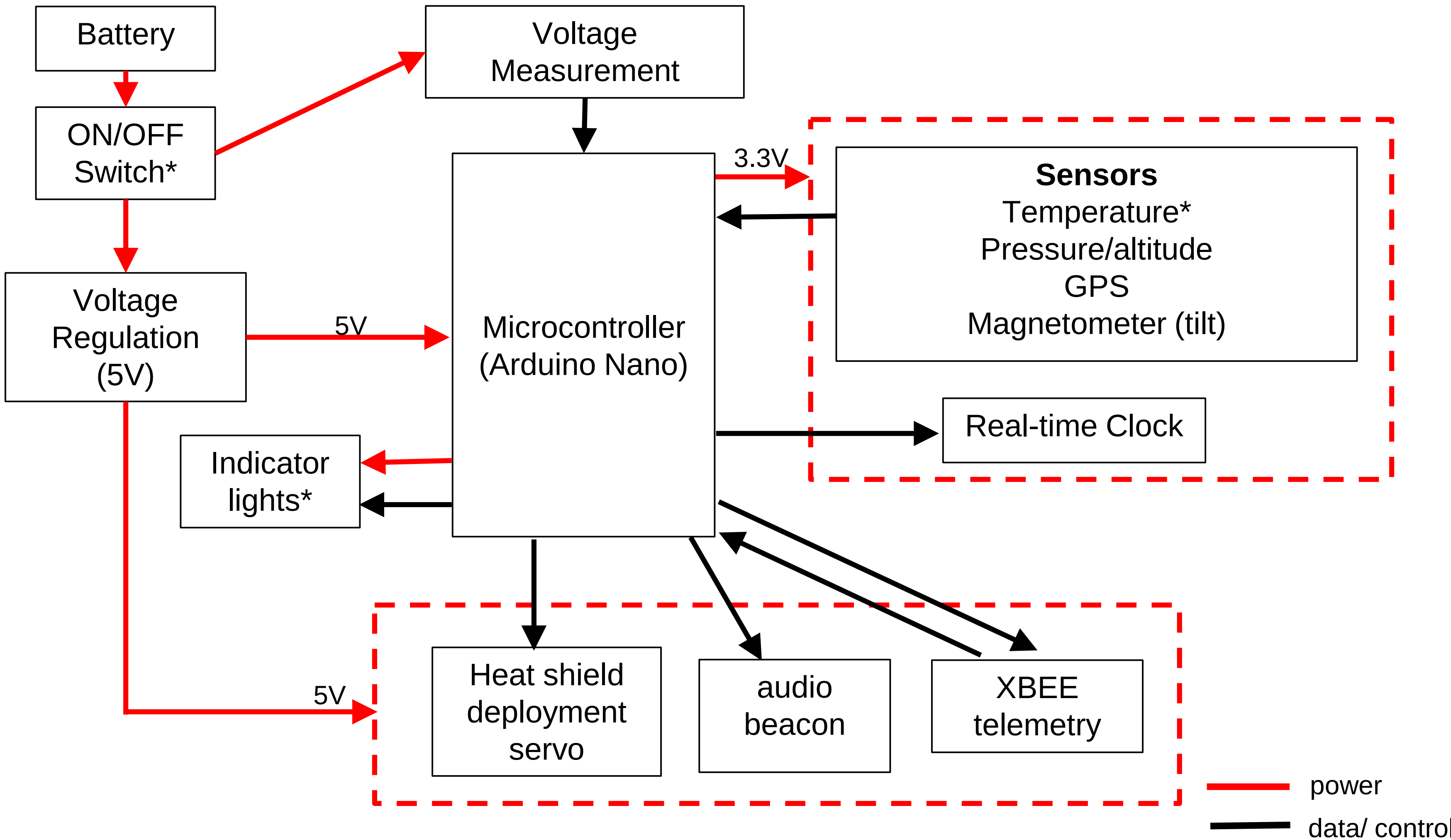
EPS Requirements

17:50

No.	Requirement
6	The probe with the aero-braking heat shield shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.
18	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.
21	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.
40	No lasers allowed.
41	The probe must include an easily accessible power switch.
42	The probe must include a power indicator such as an LED or sound generating device.
45	An audio beacon is required for the probe. It may be powered after landing or operate continuously.
46	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.
47	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.
48	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.

Probe Electrical Block Diagram

17:50



*These components are externally accessible and/or visible

Probe Power Source

- **Energizer Advanced Lithium 9V Battery (LA522)**
  – Voltage: 9V
  – Max Discharge: 1000mA continuous
  – Capacity: 750 mAh @ 100 mA discharge rate

  – Able to last >1.5 hr to on-board electrics

Probe Power Budget

17:50

Component	Duty Cycle	Power (mW)	Time (min)	Uncertainty (%)	Total (mWh)	Source
Microcontroller	>100	250	60	20	300	testing
Pressure/Altitide	>300	0.7	60	15	0.805	data sheet
Temperature	>300	1.25	60	20	1.5	data sheet
GPS	>300	66	60	10	73	data sheet
Magnetometer	>300	0.36	60	20	0.432	data sheet
Audio	>300	40	60	20	48	data sheet
Indicator Lights	>300	50	60	10	55	data sheet
Voltage Regulation	>300	10	60	30	13	data sheet
XBEE	>300	7.7	60	20	9.24	data sheet
Deployment Servos (x3)	>100	3750	0.08	30	390	Data sheet
				Total	**891**	**mWh**

Probe Power Budget

Choose the Energizer L522:

- **750mAh of power @ 200mA discharge rate**
- **750mAh ~= 5400mWh (@ ~7V average)**
- **9V Lithium Ion with metal casing**

Available Power	Power Required
5400mWh	891mWh

- **Source for specifications: http://data.energizer.com/pdfs/l522.pdf**

Flight Software (FSW) Design

Eric Boszin

FSW Overview

- **Basic FSW architecture**
  - Initialize daemons and backend scripts
  - Initialize sensors, report/log status
  - Perform system checks (CPU, memory, signal, battery)
  - Create new directories and logging files for new mission profile
- **Development language(s):**
  - C/C++
- **Development environment(s):**
  - Sublime, Eclipse, Arduino IDE

FSW Overview

20:25

- **Major tasks to perform:**
  - Configure and poll sensors
  - Collect and transmit data
  - Monitor system status and log errors
  - Determine different fight stages and actions
  - Command actuators for deployment
  - Count data packets
  - (optional bonus; not pursued) Command color video camera to capture image data for the final 300m of descent
  - (optional bonus; pursued if time permits) Custom radio transmitter to indicate wind speeds during mission

FSW Changes Since PDR

20:25

- Added the use of accelerometer data to predict ejection from rocket to more accurately estimate the proper heatshield deployment time

FSW Requirements

20:25

No.	Requirement
14	The aero-braking heat shield shall be released from the probe at 300 meters.
15	The probe shall deploy a parachute at 300m.
25	During descent, the probe shall collect air pressure, outside air temperature, GPS position and battery voltage once per second and time tag the data with mission time.
26	During descent, the probe shall transmit all telemetry. Telemetry can be transmitted continuously or in bursts
27	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.
29	XBEE radios shall have their NETID/PANID set to their team number.
30	XBEE radios shall not use broadcast mode.
32	Each team shall develop their own ground station.
33	All telemetry shall be displayed in real time during descent.
34	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)
35	Teams shall plot each telemetry data field in real time during flight.
39	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.

FSW Requirements

20:25

No.	Requirement
45	An audio beacon is required for the probe. It may be powered after landing or operate continuously.
49	A tilt sensor shall be used to verify the stability of the probe during descent with the heat shield deployed and be part of the telemetry.

Probe CanSat FSW State Diagram

20:25

Stabilization State
- Wait 3 sec to release HS
- Listen for release command
- Monitor altitude @ 5Hz

Proceed if: Ground prompt / altitude < 300m

Release State
- Command servo and release heat shield
- Deploy parachute
- Report to ground station

Proceed if: Descent rate > 0 & Rocket Eject = True

Proceed if: 2 s delay from release

Ascent State
- Stream telemetry data
- Monitor altitude @ 5Hz

Descent State
- Probe FSW running
- Stream telemetry data
- Time keeping

Proceed if: Command from GCS

Proceed if: Zero descent rate > 5s

Pre-launch State
- Probe FSW running
- Check processor status and telemetry link
- Test battery and sensors

Landed State
- Check for zero descent rate
- Power off the probe
- Activate audio buzzer

Probe CanSat FSW State Diagram

RESET LOGIC

FSW recovery to correct state after processor reset during flight:

State = Ascent state

If (Descent rate > 0 & altitude > 300 & RocketEject = True)
  State = Stabilization State
Elseif (Descent rate > 0 & altitude <= 300)
 State = Release State
Elseif (Zero descent rate > 5s)
  State = Landed State
end

% descent state is entered from release state only (not directly on reset) to ensure the probe is released regardless of a processor reset

Software Development Plan

20:25

- **Subsystem development (21 Feb. – 28 Mar.)**
  - Modularity: divide system codes into different modules to enable parallel development
  - Encapsulation: define module interfaces, black box module implementation to reduce mutual dependencies

- **Testing methodologies (30 Mar. – 6 May)**
  - Unit tests: used to debug and refine sub-modules
  - Simulated environment: used to examine codes in the absence of actual input
  - Benchmarks: used to evaluate software performances
  - Quick and dirty implementations, frequent and early testing

Software Development Plan

20:25

- **Development team**
  - Flight Software: Eric, Philip, Shahin
  - Communication (Taoglas, XBEE): Johnny, Shahin
  - Ground Station: Johnny

- **Prototyping environment**
  - Software simulation in Eclipse & Arduino IDEs
  - Module prototyping on individual peripherals
  - Operation simulation on the Cansat with integrated code
  - Parameter tuning and optimization on separate modules or with the Cansat as a whole

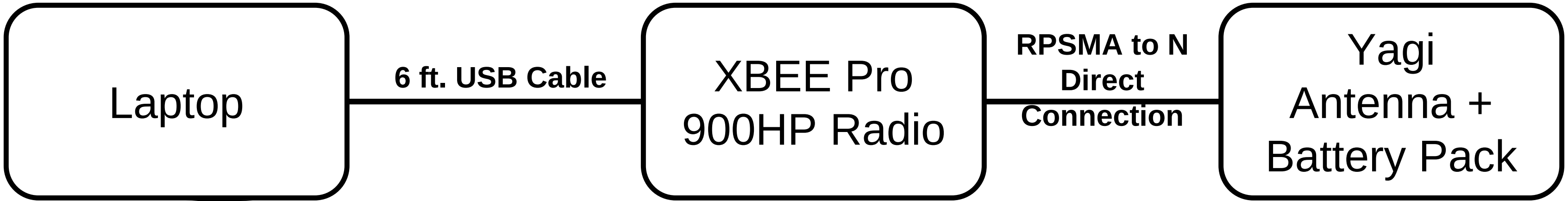
Software Development Plan

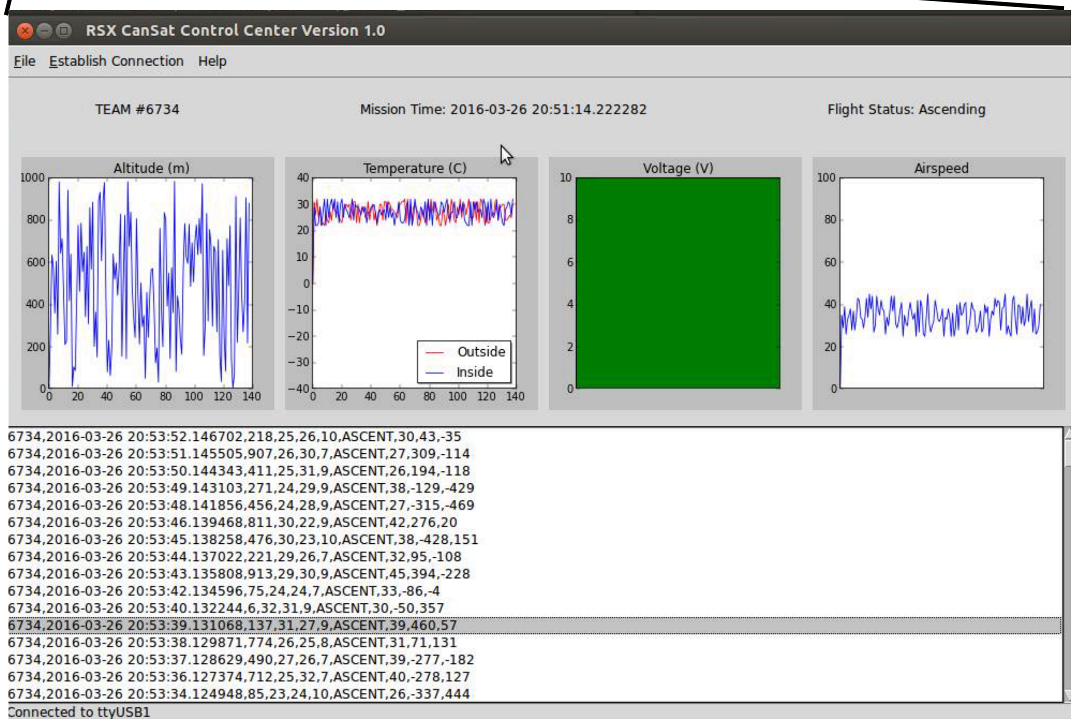
- **Progress since PDR**
  - Defined various modules pertaining to FSW
  - Performed basic testing of modules

Ground Control System (GCS) Design

Johnny Wang

GCS Overview





Screenshot of GUI using dummy data

GCS Changes Since PDR

24:10

- **Antenna Type Changed from a grid antenna to a Yagi antenna**
  - It was readily available to us
  - 900 MHz antenna
  - Tested for connectivity and range
  - Performs well

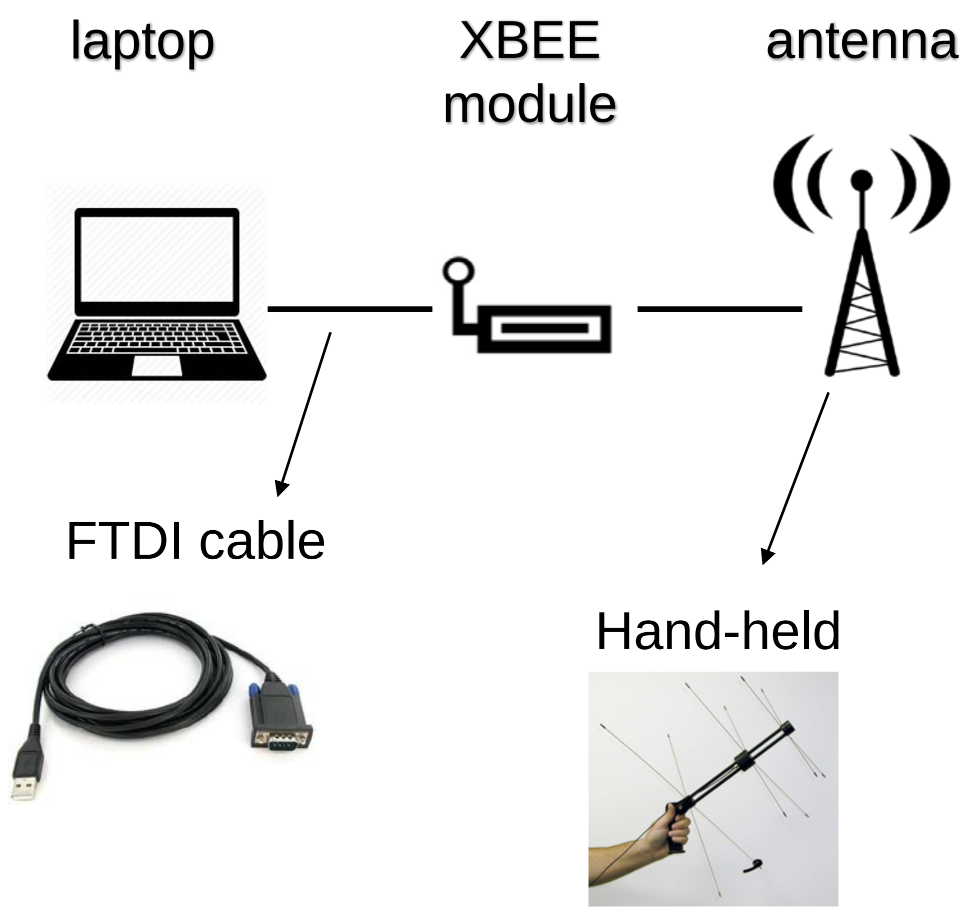
GCS Requirements

24:10

No.	Requirement
28	XBEE radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900 MHz XBEE Pro radios are also allowed.
29	XBEE radios shall have their NETID/PANID set to their team number.
30	XBEE radios shall not use broadcast mode.
32	Each team shall develop their own ground station.
33	All telemetry shall be displayed in real time during descent.
34	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)
35	Teams shall plot each telemetry data field in real time during flight.
36	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand held antenna.
37	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.

GCS Design

24:10



- **Base laptop and the XBEE radio module are connected by a FTDI cable.**
- **To allow a dynamic and accurate detection, the antenna will be hand-held instead of being fixed to the ground**

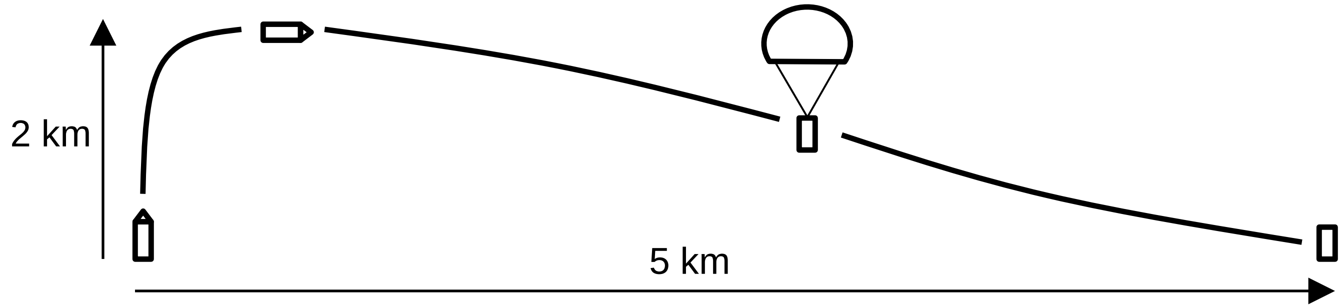
GCS Design

- **Laptop has a minimum of 2 hours battery and an average of 4 hours battery when fully functioning.**
- **Covers will be used to prevent laptop from exposing in the open sun. Laptop cooling pad can help mitigate heating effect.**
- **Ubuntu Linux will be used to run the GCS to avoid auto-updates.**

GCS Antenna

24:10

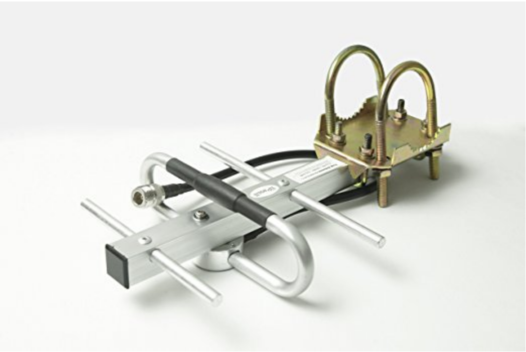
- Maximum expected distance from GCS to Cansat is ~ 5km with Line of Sight (LOS):



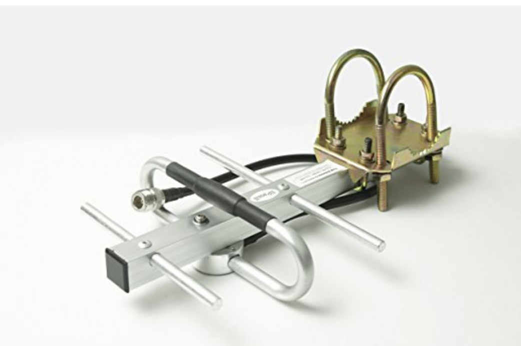
- Link budget:

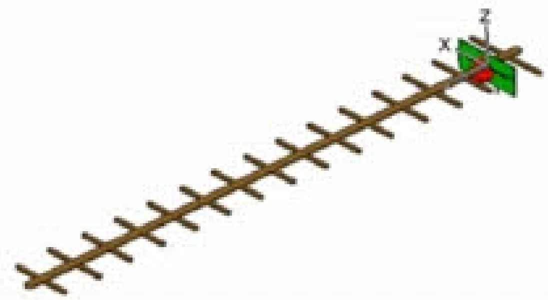
Term	P_t	G_t	FSPL	G_r	Wire Loss	P_r	RX Sensitivity	Margin
Value [dBm]	24	2	105.5	2	1	-78.5	-101	22.5

- To avoid Cansat tracking issues, a directional antenna will be used for higher gain
- Changed to a Yagi Uda antenna:
  - Provides sufficient directional beam propagation
  - Does not require highly accurate hand tracking
  - Available sizes to be hand-held
  - Tested and functional

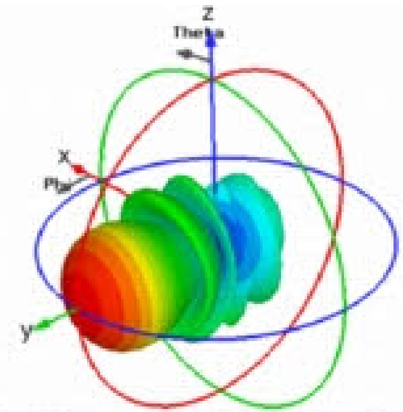


GCS Antenna

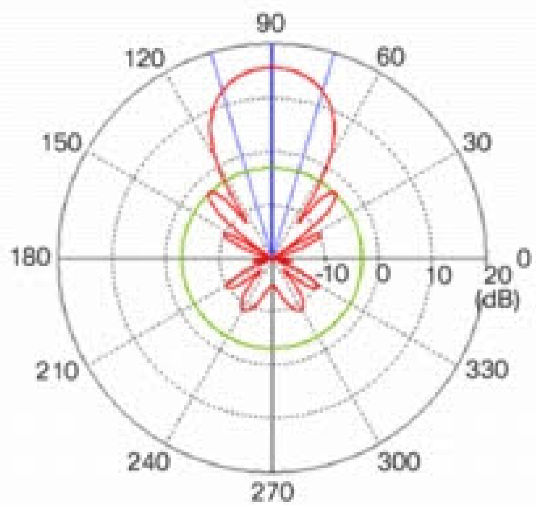




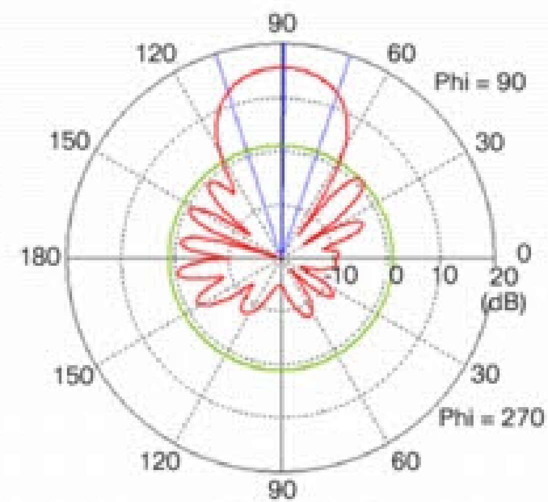
(a) Yagi Antenna Model



(b) Yagi Antenna 3D Radiation Pattern



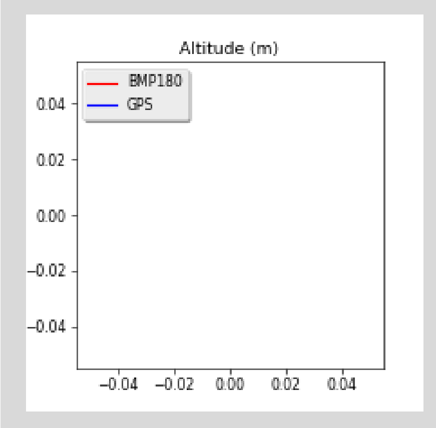
(c) Yagi Antenna Azimuth Plane Pattern

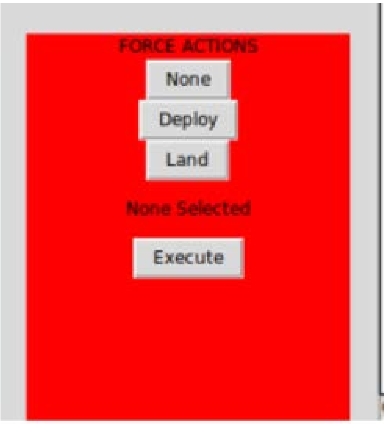


(d) Yagi Antenna Elevation Plane Pattern

- Development language(s): Python
- Tkinter library: design the user interface
- Matplotlib: render 2D real time data plotting

- GUI includes control commands, settings and data display
- The display support auto-scaling for dimension changes
- No COTS software packages are used

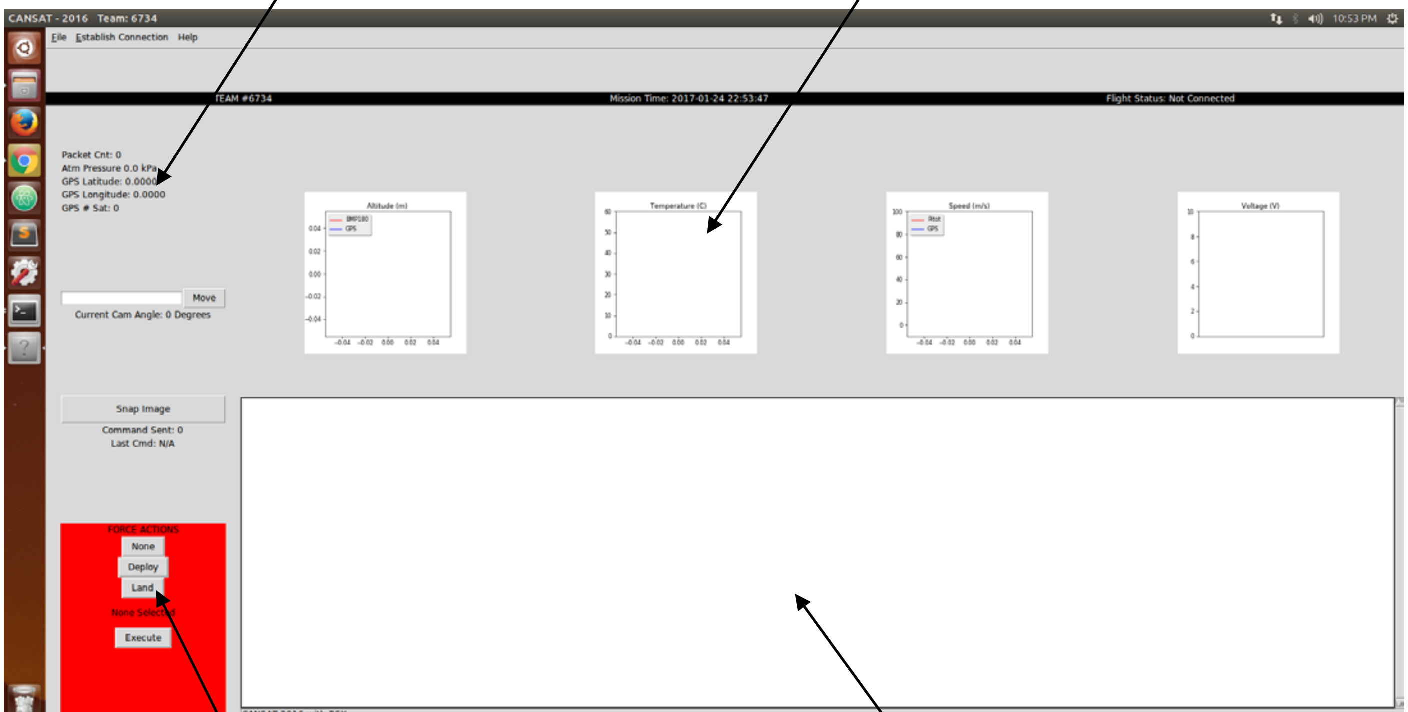




GCS Telemetry Display

Probe configuration

Telemetry plots



Control commands

Telemetry data stream

GCS Bonus Wind Sensor

24:10

- **This topic will be pursued if all core requirements are tested to be achieved**

CanSat Integration and Test

Johnny Wang

CanSat Integration and Test Overview

24:35

- **CDH, Sensors:** breadboard and PCB testing
- **EPS:** power supply and stress testing
- **Radio communications:** radio range tests
- **FSW:** GUI test
- **Mechanical:** payload drop test
- **Descent Control:** heatshield and parachute tests

Integrated-system tests:

- **Drop test**
- **Thermal test**
- **Vibration test**

Test Procedures Descriptions

24:35

Test Proc	Test Description	Rqmts	Pass Fail Criteria
1	Breadboard testing: use breadboard to test sensors' accuracy and CDH system data processing and logic	21, 39, 48	
2	Power generation testing: place probe battery under simulated load to assess power supply duration	18	
3	Radio range test: test range of radio and antenna on the ground to validate if required performance is met	25-30	
4	GUI test: feed simulated sensor data to FSW to ensure GUI works as planned	32-37	
5	Payload drop test: probe will be dropped 80cm when suspended by the parachute line as per the Environmental Testing Requirements document	Environmental Testing Requirements document	
6	heatshield and parachute tests: drop the descent control mechanisms from a high balcony to test effectiveness in reducing rate of descent	16-20	
7	Thermal test: thermal chamber fabricated for 2016 competition will be used to test the CanSat at high temperatures (55-60°C) as per the Environmental Testing Requirements document	Environmental Testing Requirements document	
8	Vibration test: orbit sander will be used as a "shake table" for the CanSat system as per the Environmental Testing Requirements document	Environmental Testing Requirements document	

Mission Operations & Analysis

Johnny Wang

Overview of Mission Sequence of Events

25:25

1. Arrival at launch site (All members)
2. Construction and mounting of antenna (Johnny & Shahin)
3. Set up and test ground station (Johnny & Eric)
4. Set up and assemble CanSat (MC, Ryan, Ali)
5. Power on CanSat and conduct subsystem tests (MC, Ryan, Johnny)
6. Walk through CanSat preflight checklist (All members)
7. Load CanSat in container, ensure CanSat is securely latched (MC, Ryan)
8. Final telemetry tests (Johnny, Eric)
9. Load container into rocket (MC)
10. CanSat is launched and continues autonomously through flight states
11. Tracking and retrieval of CanSat upon touchdown (Johnny, Ali, Shahin)
12. Retrieval of data stored onboard for further analysis (Johnny, Eric)

Field Safety Rules Compliance

25:25

- **Primary components of Mission Operations Manual**
  - Testing of subsystem functionalities and nominal operations
  - Pre-flight checklist
- **Development**
  - Each subteam is creating their own documents summarizing key checkpoints and important details of components
    - Allows for isolated testing and debugging
  - Members involved in subsystem integration summarizing key aspects of integration and updating documents accordingly
- **2 Copies will be made**

CanSat Location and Recovery

25:25

- CanSat will be visually tracked from launch until touchdown by all members
  - Some members will be equipped with binoculars
- CanSat can be audibly tracked using piezo beacon signal after landing
- CanSat heatshield will be fluorescent pink in order to have a colour contrast with the field
- In the event that the CanSat drifts too far and is lost or unreachable, our return address, phone number and email will be written on the heatshield and the probe to ensure its return

Mission Rehearsal Activities

- **Mission operations rehearsal activities to date:**
  - Heatshield stowage and probe setup
  - Sensors data collection
  - Telemetry processing and analysis

25:50

Requirements Compliance

Johnny Wang

Requirements Compliance Overview

25:50

Current design complies with most stated requirements.

No serious issues due to non-compliance.

Requirements which require further testing to confirm compliance (testing to be completed in May):

- 12: All descent control device attachment components shall survive 30 Gs of shock.
- 13: All descent control devices shall survive 30 Gs of shock.
- 15: All structures shall be built to survive 15 Gs acceleration.
- 16: All structures shall be built to survive 30 Gs of shock.

Requirements Compliance

25:50

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	Total mass of the CanSat (probe) shall be 500 grams +/- 10 grams.	Comply	61	
2	The aero-braking heat shield shall be used to protect the probe while in the rocket only and when deployed from the rocket. It shall envelope/shield the whole sides of the probe when in the stowed configuration in the rocket. The rear end of the probe can be open.	Comply	10, 51	
3	The heat shield must not have any openings	Comply	51	
4	The probe must maintain its heat shield orientation in the direction of descent.	Comply	10	
5	The probe shall not tumble during any portion of descent. Tumbling is rotating end-over-end.	Comply	10	
6	The probe with the aero-braking heat shield shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Comply	12	
7	The probe shall hold a large hen's egg and protect it from damage from launch until landing.	Comply	59	
8	The probe shall accommodate a large hen’s egg with a mass ranging from 54 grams to 68 grams and a diameter of up to 50mm and length up to 70mm.	Comply	59	
9	The aero-braking heat shield shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	Comply	12, 45, 51	

RSX Robotics for Space Xploration

Requirements Compliance

25:50

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
10	The aero-braking heat shield shall be a florescent color; pink or orange.	Comply	110	
11	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	16	
12	The rocket airframe shall not be used as part of the CanSat operations.	Comply	16	
13	The CanSat, probe with heat shield attached shall deploy from the rocket payload section.	Comply	16	
14	The aero-braking heat shield shall be released from the probe at 300 meters.	Comply	85	
15	The probe shall deploy a parachute at 300 meters.	Comply	85	
16	All descent control device attachment components (aero-braking heat shield and parachute) shall survive 30 Gs of shock.	Partial	47,55	Requires testing
17	All descent control devices (aero-braking heat shield and parachute) shall survive 30 Gs of shock.	Partial	47,55	Requires testing
18	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	60	
19	All structures shall be built to survive 15 Gs of launch acceleration.	Partial	47,55	Requires testing
20	All structures shall be built to survive 30 Gs of shock	Partial	47,55	Requires testing
21	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	60	
22	All mechanisms shall be capable of maintaining their configuration or states under all forces	Comply	47,55,59	

Requirements Compliance

25:50

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
23	Mechanisms shall not use pyrotechnics or chemicals.	Comply	N/A	
24	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Comply	N/A	
25	During descent, the probe shall collect air pressure, outside air temperature, GPS position and battery voltage once per second and time tag the data with mission time.	Comply	17-23	
26	During descent, the probe shall transmit all telemetry. Telemetry can be transmitted continuously or in bursts.	Comply	71	
27	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Comply	71	
28	XBEE radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Comply	68	
29	XBEE radios shall have their NETID/PANID set to their team number.	Comply	70	
30	XBEE radios shall not use broadcast mode.	Comply	70	
31	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Comply	119-120	
32	Each team shall develop their own ground station.	Comply	89-101	
33	All telemetry shall be displayed in real time during descent	Comply	98-100	
34	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	98,100	

Requirements Compliance

25:50

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
35	Teams shall plot each telemetry data field in real time during flight.	Comply	98	
36	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand held antenna.	Comply	93	
37	The ground station must be portable so the team can be positioned at the 9 ground station operation site along the flight line. AC power will not be available at the ground station operation site.	Comply	93	
38	Both the heat shield and probe shall be labeled with team contact information including email address.	Comply	110	
39	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	Comply	82	
40	No lasers allowed.	Comply	N/A	
41	The probe must include an easily accessible power switch.	Comply	45	
42	The probe must include a power indicator such as an LED or sound generating device.	Comply	75	
43	The descent rate of the probe with the heat shield deployed shall be between 10 and 30 meters/second.	Comply	39	
44	The descent rate of the probe with the heat shield released and parachute deployed shall be 5 meters/second.	Comply	39	
45	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Comply	110	

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
46	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells	Comply	79	
47	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Comply	45	
48	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	79	
49	A tilt sensor shall be used to verify the stability of the probe during descent with the heat shield deployed and be part of the telemetry	Comply	18, 24	

Management

Johnny Wang

RSX Robotics for Space Xploration

Status of Procurements

26:40

Component	Ordered	Arrived	Estimated Arrival
Arduino Nano	Yes	No	2 Apr 2018
DS3231 RTC Module	Yes	Yes	-
Taoglas FXP290 Antenna	Yes	Yes	-
RTC coin battery	Yes	Yes	-
XBEE Pro 900HP	Yes	Yes	-
MPU-9250 Magnemometer	Yes	Yes	-
Bosch BMP180	Yes	Yes	-
NEO-7M-C	Yes	Yes	-
10kΩ resistor	Yes	Yes	-
Buzzer	Yes	No	13 Apr 2018
9V Battery	Yes	Yes	-

Status of Procurements

26:40

Component	Ordered	Arrived	Estimated Arrival
PAR-24 24” Parachute	Yes	No	5 Apr 2018
Plywood 12” x 12”	Yes	Yes	-
Balsa Wood 9” x 36”	Yes	Yes	-
Insulation Foam	Yes	Yes	-
Feetech FS90R Servo	Yes	No	1 Apr 2018
Yagi Antenna	Yes	Yes	
Antenna Cord	Yes	No	13 Apr 2018

CanSat Budget – Hardware

26:40

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

CanSat Budget – Hardware

26:40

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”	3	18.07	54.21	A&J Hobby
Mech	Balsa Wood 9” x 36”	1	6.77	6.77	A&J Hobby
Mech	Insulation Foam	1	20.00	20.00	Hobby shop
Mech	Feetech FS90R Servo	1	7.22	7.22	Canada Robotix
	Subtotal			**258.08**	

Ground Station Costs

Subsystem	Component	Quantity	Unit Price (USD)	Total Price (USD)	Source
CDH	XBEE Pro 900HP	1	55.00	55.00	Sparkfun
CDH/GCS	Yagi Antenna	1	44.00	44.00	Amazon
GCS	Mast Hardware	1	30.00	30.00	Equipment from past year
Mech	Mechanical Attachments	1	50.00	50.00	Equipment from last year
GCS	Laptop	1	1500.00	1500.00	Equipment from last year

CanSat Budget – Other Costs

26:40

Travel Costs

Item	Description	Cost (USD)
Hotel	Super 8 Stephenville: USD 60/night x 4 nights x 1 rooms	240.00
Car Rental	Fullsize SUV: USD 72.50 x 4 days	290.00
Gas	~600 miles @ 15mpg x $2.25/gal	90.00
Flights	YYZ-DFW USD450 x 4 pax + 2 x Check-in luggage (USD25)	1850.00
Food	USD40/day x 4 days x 4 members	640.00
Subtotal		**3110.00**

Income

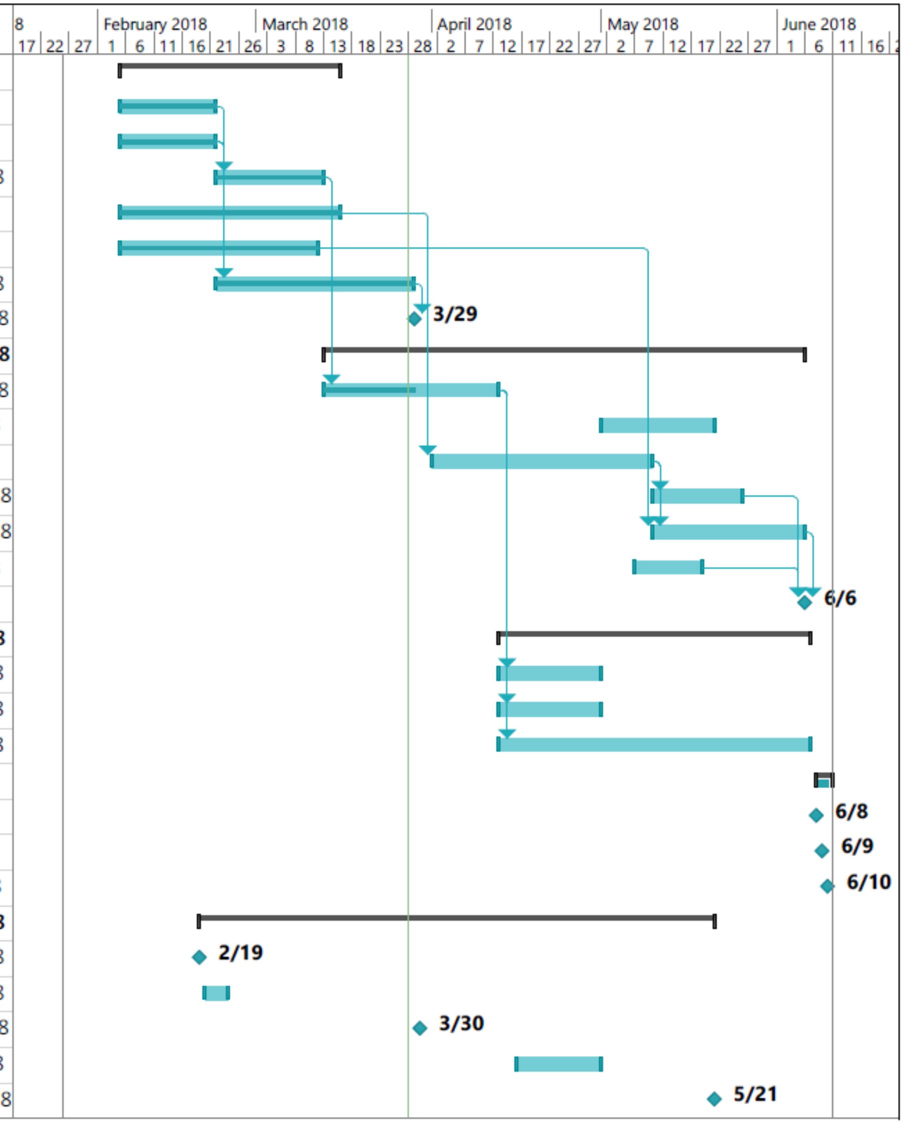
-$5500 is supplied by the RSX club to the CanSat division

-This fund comes from various sources such as university endowments, basic club funding, sponsorships, etc.

Program Schedule

26:40

ID	Task Name	Start
1	**Detailed Design**	**Feb 5 '18**
2	Aerodynamic Optimization	Feb 5 '18
3	Structural Detailed Design	Feb 5 '18
4	Internal Detailed Layout Design	Feb 22 '18
5	PCB Design	Feb 5 '18
6	Software Module Development	Feb 5 '18
7	Create Critical Design Review slide package	Feb 22 '18
8	Submit Critical Design Review slide package	Mar 29 '18
9	**Fabrication**	**Mar 13 '18**
10	Airframe Fabrication Protyping	Mar 13 '18
11	Airframe Fabrication	May 1 '18
12	PCB Fabrication	Apr 1 '18
13	Integration of airframe and circuits	May 10 '18
14	Software Integration	May 10 '18
15	Simulated Data Testing	May 7 '18
16	Fabrication Completion Deadline	Jun 6 '18
17	**Testing**	**Apr 13 '18**
18	Descent Control Flight Testing	Apr 13 '18
19	Mission Simulation Drop Tests	Apr 13 '18
20	Environmental Testing Requirements	Apr 13 '18
21	**2018 CanSat Competition**	**Jun 8 '18**
22	Competition Inspection	Jun 8 '18
23	Competition Launch	Jun 9 '18
24	Post Flight Review	Jun 10 '18
25	**Important Dates and Holidays**	**Feb 19 '18**
26	Family day (Statutory Holiday)	Feb 19 '18
27	University of Toronto Reading Week	Feb 20 '18
28	Good Friday (Statutory Holiday)	Mar 30 '18
29	University of Toronto Examinations	Apr 16 '18
30	Victoria Day (Statutory Holiday)	May 21 '18



Shipping and Transportation

- **Assembled CanSat will be transported to Dallas-Fort Worth International Airport in check-in luggage, and transported to Stephenville, as well as to and from competition sites by car.**
- **Backup structural pieces will be laser-cut, and backup PCBs will be constructed**
  - In the unfortunate event that CanSat is damaged or lost by airline, we will have enough parts to rebuild CanSat in the day before competition
- **Tools will be transported in check-in luggage due to regulations against liquids (adhesives) and sharp objects (scissors and exacto knives)**
  - In worst case scenario, most tools can be acquired from local craft and hardware shops at low cost

Conclusions

27:50

- Major accomplishments
  - Detailed design completed
  - Materials, avionics and actuators have been acquired and/or ordered
  - Prototyping of CanSat has commenced
  - GCS GUI completed
- Major unfinished work
  - Subsystem construction, testing and integration
  - System testing
- Proceeding to next stage of development
  - Testing of prototypes for descent control and drop tests
  - Improving design for better manufacturability based on test results from prototypes