

# Galassia System and Mission

**National University of Singapore**

**Department of Electrical & Computer Engineering**

Authors:

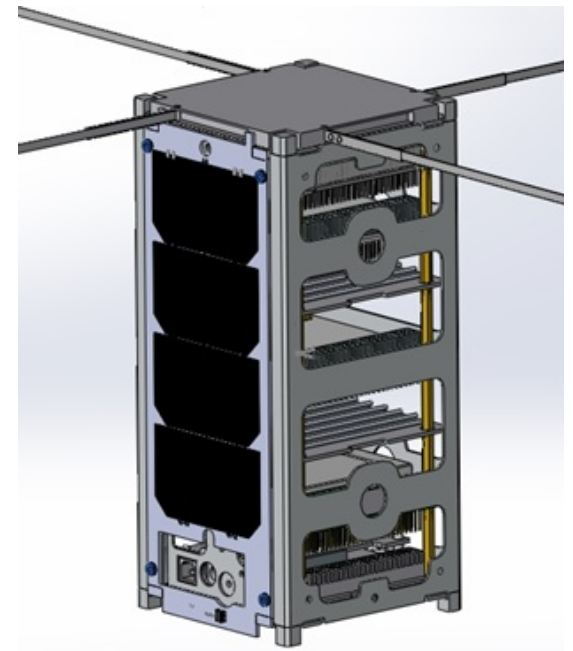
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# Outline

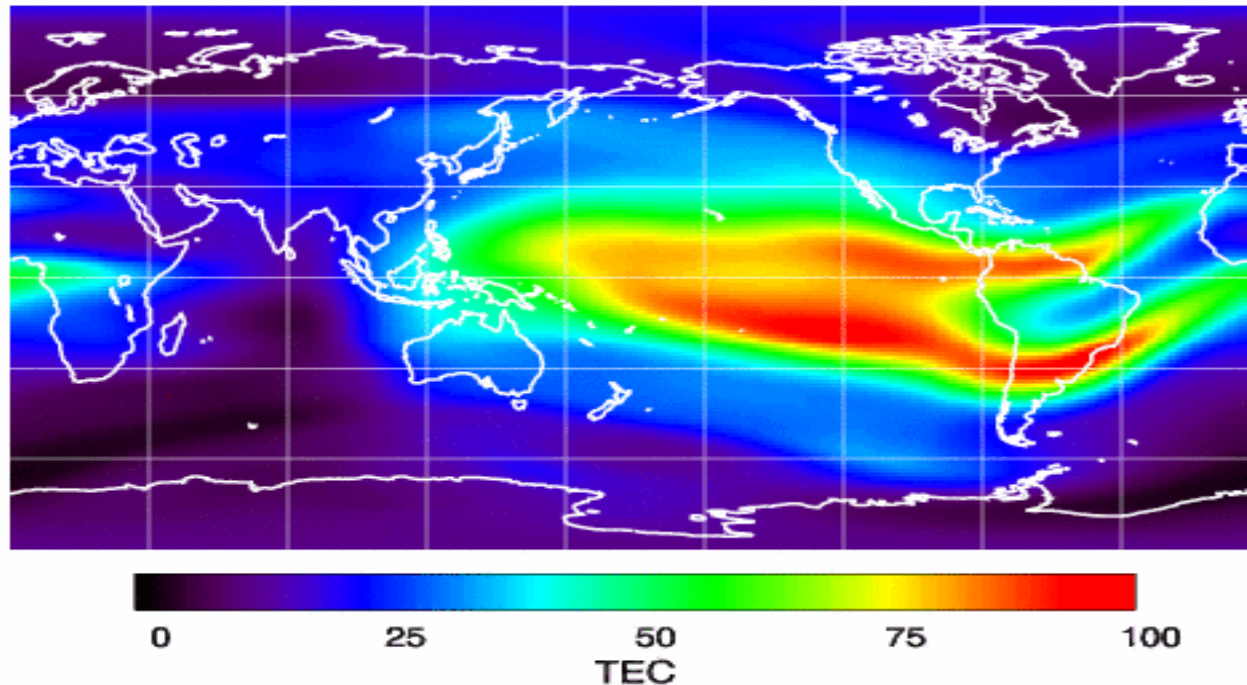
- Missions & Objectives
- Selected Orbit
- System Design Overview
- Operation Modes
- Schedule



# Missions & Objectives

## Missions (1)

1. To acquire Total Electron Count (TEC) data in the ionosphere for future use.



## Missions (2)

1. Total Electron Count (TEC) data acquired by the 3 frequency method.

$$I = \int_0^R N ds$$

Where,

$$N = 5.97 \times 10^5 \times \frac{f_o^3}{f_m^2} \Delta\Phi \quad (\text{Electron Density})$$

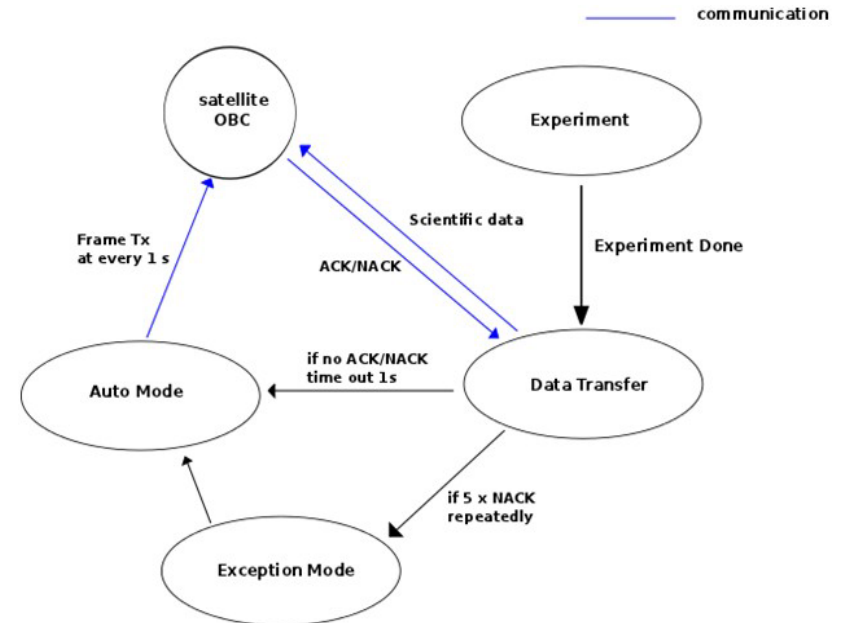
R is the vertical path between cubesat and ground station

$f_o$  and  $f_m$  are the carrier and modulation frequencies

$\Delta\Phi$  is the phase difference between of signals at ground station after mixing

## Missions (3)

- To acquire quantum correlation data in space for the concept verification of **quantum-based communication** scheme, using Small Photon-Entangling Systems (SPES) developed by NUS Centre for Quantum Technologies (CQT).



*Mission life: approximately 0.5-1 year upon the date of launch.*

# Objectives

## 1. Primary objectives:

- ✓ Test and verification of the scientific methodology to obtain TEC in the ionosphere using a cubesat.
- ✓ Test and demonstration of SPES scientific experiment in space.

## 2. Secondary objective:

- ✓ Test and demonstration of new small/nano satellite technologies.

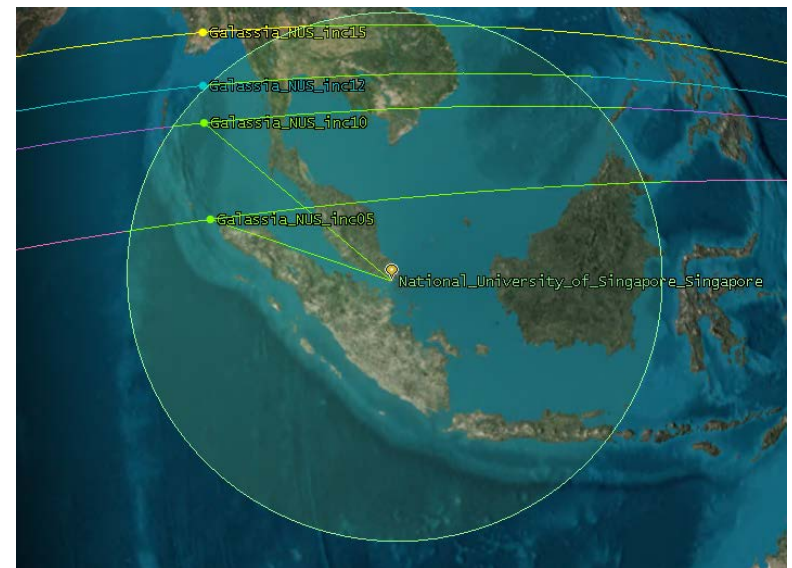
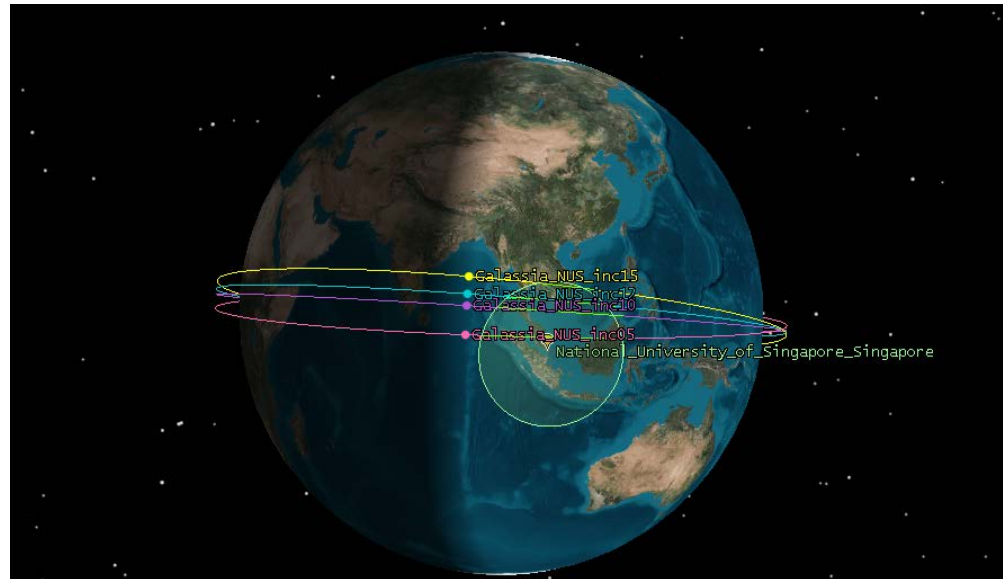


# Selected Orbit



## Selected Orbit

- Altitude: 550km (near equatorial orbit)
- Inclination: 15 degrees
- Eccentricity:  $<0.0003$
- RAAN: 0 degrees
- Simulation Period: 00:00:00:000 on 1<sup>st</sup> Oct 2015  
to 23:59:59:999 on 30<sup>th</sup> Apr 2016
- Ground Station Antenna Half Angle: 75 degrees



## Results

Inclination Angle	Total Number of Accesses	Average Number of Access per Day	Longest Access Time (sec)
5	3002	12.996	416.128
10	3002	12.996	415.809
12	2598	11.247	415.623
15	1867	8.082	415.281

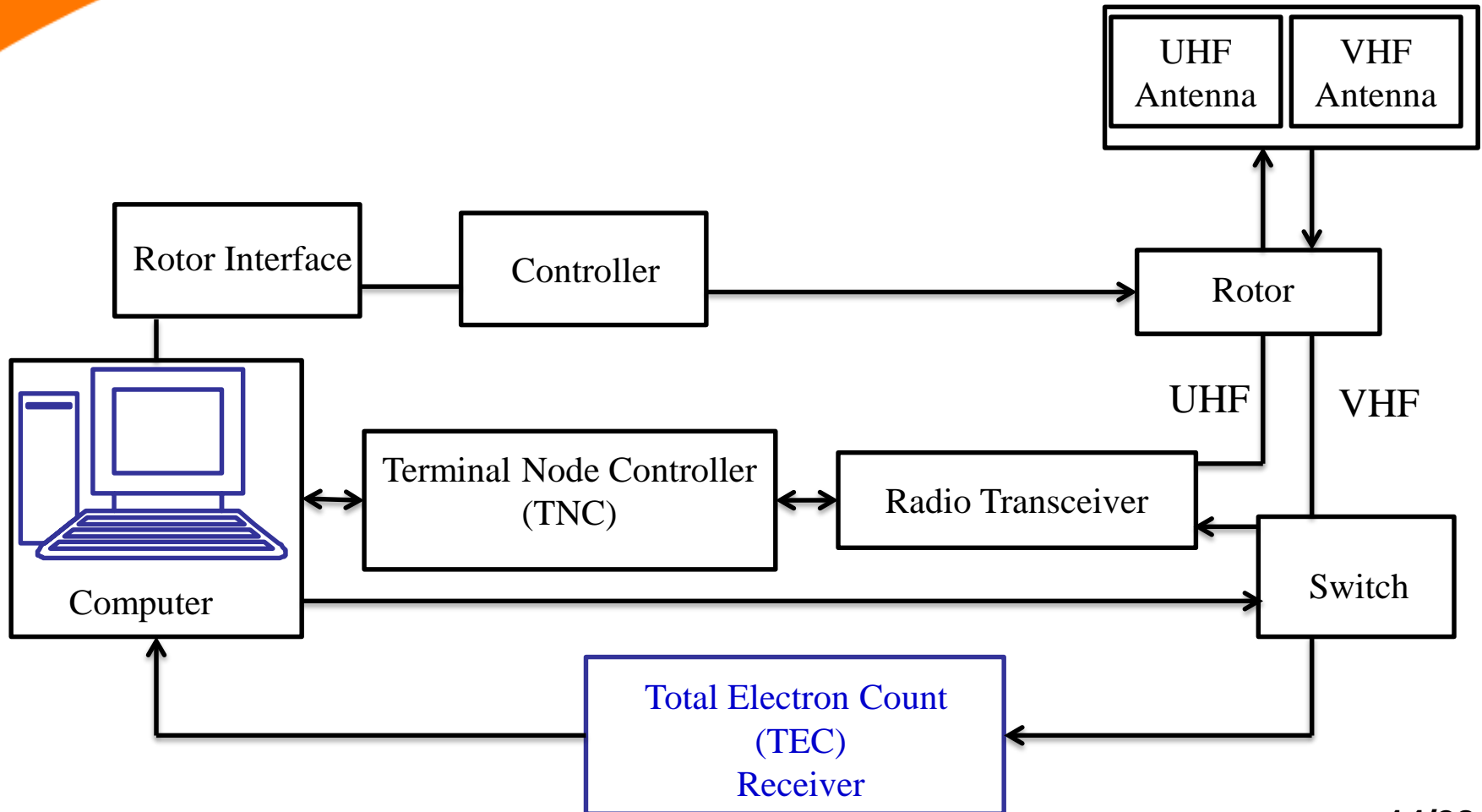


# System Design Overview

## Ground Segment

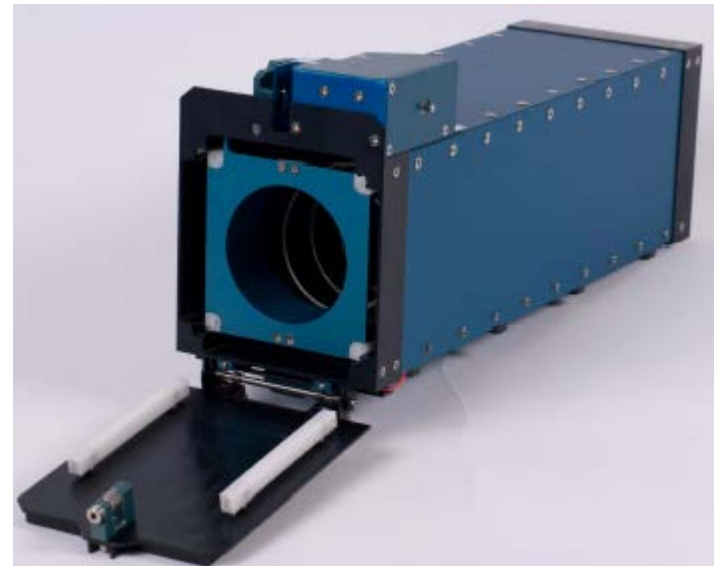
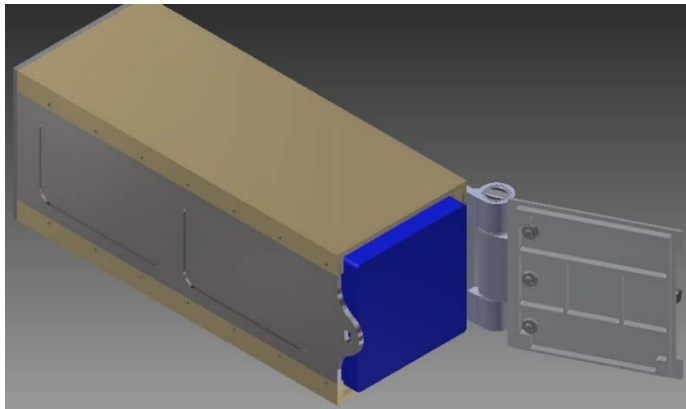
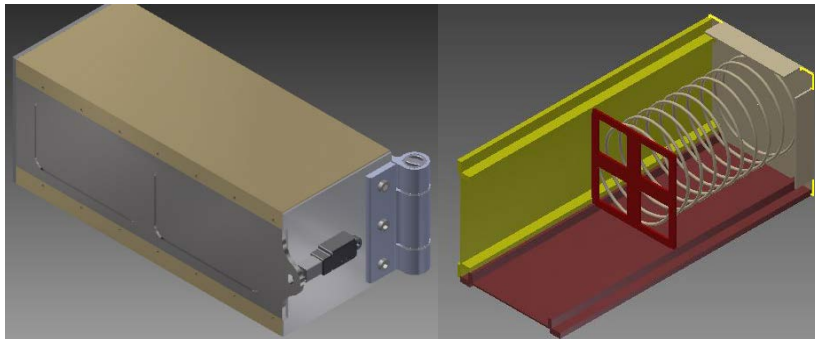
- NUS Faculty of Engineering
  - ✓ Mission planning & operation (VHF & UHF)
  - ✓ Receiving and analyzing TEC payload data (VHF transmitters)
  - ✓ Receiving the SPES experiment data (VHF downlink)

## VHF and UHF Ground Station

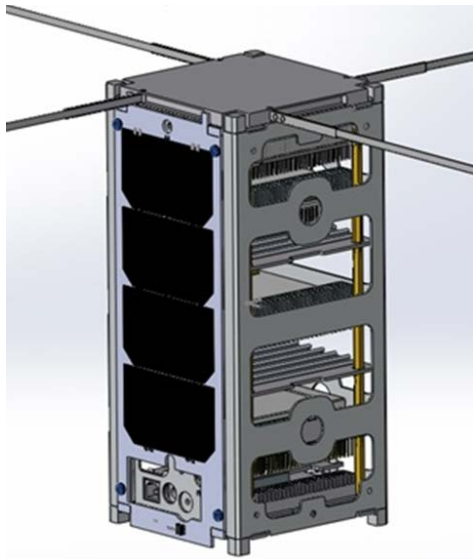


# Launch Segment

- PSLV
- 2 PPOD Options



## Space Segment Specs



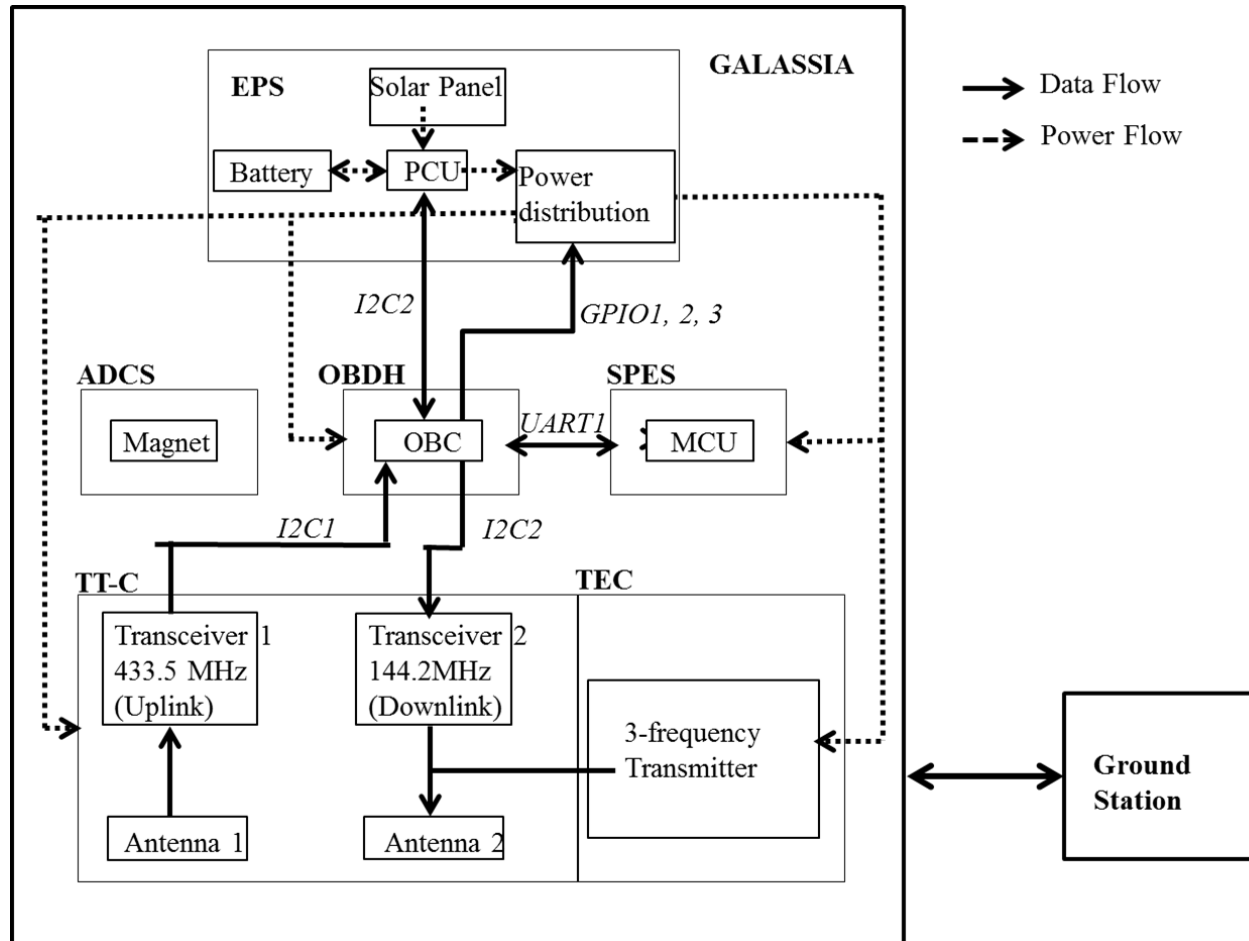
<b>Bus</b>	<b>2U Cubesat</b>
<b>Dimension</b>	<b>100mm x 100mm x 200mm (to comply with PSLV cubesat deployer)</b>
<b>Mass</b>	<b>Maximum 2kg</b>
<b>Communication</b>	<b>VHF (Downlink) UHF (Uplink)</b>
<b>Power</b>	<b>Max Consumption: 2W</b>
<b>Battery</b>	<b>20 Whr (Lithium-ion)</b>
<b>Solar Array</b>	<b>GaAs Cells</b>
<b>Flight Computer</b>	<b>16bit dsPIC33 Microcontroller</b>
<b>Attitude Control</b>	<b>Slew Rate 10deg/sec</b>
<b>Orbit Altitude</b>	<b>550+/-20km, 15°+/-0.2° inclined, Circular</b>



## Mass Budget

Subsystem	No.	Part Name	Quantity	Mass of unit (g)	Total mass (g)
Payloads	1	SPES	1	300	300
	2	TEC	1	150	150
Structure	3	Chassis	1	210	210
	4	Others (wires, connectors etc)	1	100	100
Power system	5	EPS (Battery and PCU)	1	203	203
	6	Solar Panels	4	80	320
Communication	7	Antenna system	1	84	84
	8	TT&C	1	86	86
ACDS	9	Magnets	4	3.39	13.56
		rods	4	5.09	20.36
OBDH	10	OBC	1	150	150
			<b>Grand total:</b>		<b>1636.92</b>
			<b>10% Safety Factor:</b>		<b>1800.612</b>

# System Block Diagram

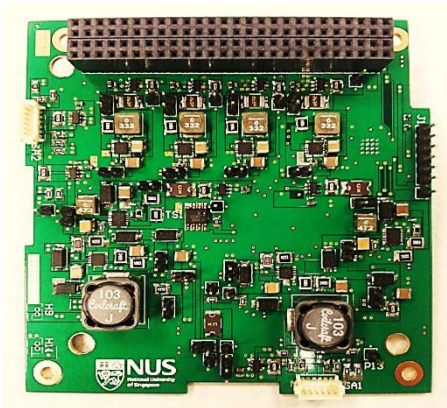


## Engineering Models (1)

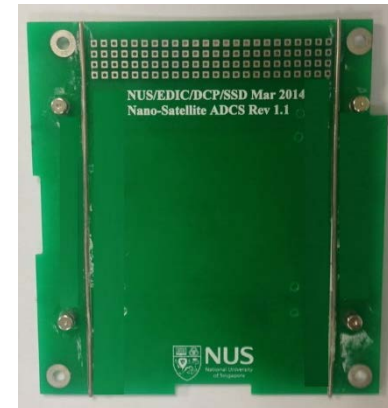


*NUS 2U Cubesat Structure and Solar Panels*

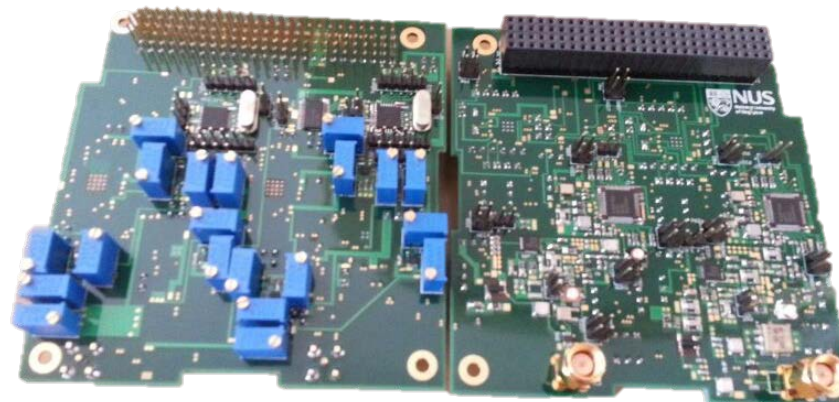
## Engineering Models (2)



*Experimental EPS*



*Experimental Passive ADCS*



*Experimental TT&C*



# Operation Modes

## Pre-Launch Mode

- Time period: from Galassia sitting in the launch vehicle till it being released from the launch vehicle
  - All electrical sub-systems are off

## Deployment Mode

- Time period: from Galassia being released from the launch vehicle till antennas being deployed
  - OBDH/OBC, EPS and TT&C receivers are on
  - TT&C transmitter, SPES board and TEC board are off

## Normal Operation Mode

- Enters this mode once antennas are deployed
- Re-enters this mode when the system exits from Power Saving Mode
- Exits this mode when battery level drops below a threshold
  - OBDH/OBC, EPS and TT&C receiver are always on
  - TT&C transmitter, SPES board and TEC board can be turned on/off



## Power Saving Mode

- Enters this mode once battery level drops below a threshold
- Exits when battery is fully charged
  - OBDH/OBC, EPS and TT&C receiver are always on
  - TT&C transmitter can be turned on for handshaking and beaconing purpose, but the transmission of previously-stored SPES data is prohibited
  - SPES board and TEC board are off

# Schedule

## Schedule

Important Milestones	Planned Date	Status
Project Kickoff	16 Aug 2013	Completed
Preliminary Design Review (PDR)	20 Sep 2013	Completed
Critical Design Review (CDR)	8 May 2014	Completed
Flight Readiness Review (FRR)	23 Mar 2015	
Launch Window	Sep to Dec 2015	
Scientific Experiments	Dec 2015 to Sep 2016	

# Thank you

Comments & Questions

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# Spacecraft Configuration

