Design, AIT, Launch & Early Operations of Galassia Nano-Satellite

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Outline

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- Mission Objectives
- System Overview
- Assembly, Integration and Testing
- Launch & Early Operations
- Preliminary Results
Executive Summary

- 1st NUS Nano-Satellite
- Student-Centric Nano-satellite Project (35 FYP Students, 2012-2015)
- 2U CubeSat Bus Design with Passive Magnetic Attitude Control
- 3 Mission Payloads
  - Primary 1: A Total Electron Content payload (TEC)
  - Primary 2: A Quantum Science payload from Centre For Quantum Technologies (CQT)
  - Secondary: Experimental Active Attitude Determination & Control Subsystem (ADCS)

- Successfully Launched on 16 Dec 2015 (NEqO, 15° inclination, 550km altitude)
- Status: All systems functional and Payload Exp in progress
Mission Objectives (1)

- Student built payload to acquire **Total Electron Content (TEC)** in the ionosphere above Singapore.

- Novel approach using **3 equally spaced tones** is used to acquire TEC.

  \[ TEC = 5.97 \times 10^5 \times \frac{f_0^3}{f_m^2} \Delta \Phi \]

  Where, TEC is in the units of TECU = $10^{16}$ electrons/m², $f_0$ and $f_m$ are the carrier and modulation frequencies, and \( \Delta \Phi \) is the phase difference between the signals on ground after mixing.

- Knowledge of TEC can be used to improve **GPS navigation** and **radio communication**.
Mission Objectives (2)

- The **Small Photon Entangling Quantum Systems** (SPEQS) developed by NUS Centre for Quantum Technologies (CQT) will be used to verify if quantum based communication is possible in space.

- Qualification of a quantum light source for use in space.
ADCS-EP is a student built secondary payload.

To conduct experiments on various attitude control which are useful for future missions.
# System Overview

## System Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bus</strong></td>
<td>2U Cubesat</td>
</tr>
<tr>
<td><strong>Dimension (mm)</strong></td>
<td>$100 \times 100 \times 227$</td>
</tr>
<tr>
<td><strong>Mass (kg)</strong></td>
<td>1.64 (Measured)</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>UHF (436.4 MHz)</td>
</tr>
<tr>
<td><strong>Power (W)</strong></td>
<td>Max Consumption: 2</td>
</tr>
<tr>
<td><strong>Battery</strong></td>
<td>20 Whr (Li-Ion)</td>
</tr>
<tr>
<td><strong>Solar Panels</strong></td>
<td>GaAs Cells</td>
</tr>
<tr>
<td><strong>Flight Computer</strong></td>
<td>ARM 7</td>
</tr>
<tr>
<td><strong>Attitude Control</strong></td>
<td>Passive: Permanent Magnet &amp; Hysteresis Rods</td>
</tr>
<tr>
<td><strong>Orbit Altitude</strong></td>
<td>550 km, 15 deg Inc Near Equatorial Orbit</td>
</tr>
</tbody>
</table>
Assembly, Integration and Testing (1)

- A customized **2-Model Philosophy** is used to Assemble, Integrate and Test Galassia.
  - Engineering Model ("FlatSat")
  - Flight Model
Assembly, Integration and Testing (2)
Assembly, Integration and Testing (3)

- **Flight Model Testing**
  - Done at ST Electronics (Satellite Systems)
  - Shaker & Thermal Vacuum Chamber in **Class 100K cleanroom**

- **Tests Conducted**
  - **Vibration Test**
    - Sinusoidal Vibration
    - Random Vibration
  - **Thermal Vacuum Test**
Assembly, Integration and Testing (4)

- **Test Levels**
  - *Tests on Flight Model done at Protoflight Model Levels (i.e. Qualification Level at Acceptance Duration).*

- **Test Campaign (29th July – 09th Sept 2015)**
Assembly, Integration and Testing (5)

- Test Campaign (29th July – 09th Sept 2015)

Galassia Vibrational Tests

Galassia Thermal Bake
Thermal Vacuum Test

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Cycle</td>
<td>Hot</td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>25°C</td>
</tr>
<tr>
<td>Vacuum Pressure</td>
<td>$10^{-5}$ Torr</td>
</tr>
<tr>
<td>No. of Cycles</td>
<td>2</td>
</tr>
<tr>
<td>Dwell Time</td>
<td>1 hour cold soak</td>
</tr>
<tr>
<td></td>
<td>1 hour hot soak</td>
</tr>
<tr>
<td>Temperature Ramp</td>
<td>1°C/min</td>
</tr>
<tr>
<td>Range</td>
<td>-15°C to +35°C</td>
</tr>
</tbody>
</table>

Galassia During Thermal Vacuum Test
Assembly, Integration and Testing (7)

- Thermal Vacuum Test Profile
Launch & Early Operations (1)

- Launch Site Integration at Sriharikota, India
Launch & Early Operations (2)

- PSLV-C29 Launch on 16\textsuperscript{th} Dec 2015, 2030 Hrs SGT
- First signal received on 16\textsuperscript{th} Dec 2015, 2218 Hrs SGT
Preliminary Results (1)

- **Temperature Data from In Orbit Test**

  ![Graph showing temperature data](image)

  **1 Feb 2016**
  **20:34hrs — 22:09 SGT**

  **Internal Temperature**
  Min: **2.5 °C**
  Max: **25 °C**

  **Solar Panel Temperatures**
  Min: **-21.5 °C**
  Max: **34.5 °C**
Preliminary Results (2)

- TEC Preliminary Test Data

Max. Elevation 82 deg

Peaked at -85 dBm with 15 dB SNR
Thank You

Questions?

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