Small-sat Ionosphere Exploration at Several Times and Altitudes (SIESTA)

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## Satellite Overview

<table>
<thead>
<tr>
<th></th>
<th>FORMOSAT-5</th>
<th>INSPIRESat (6U)</th>
<th>IDEASat (3U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass (kg)</td>
<td>475</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Orbit Altitude (km)</td>
<td>720</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Orbit Inclination (deg)</td>
<td>98</td>
<td>45</td>
<td>97</td>
</tr>
<tr>
<td>Launch Date</td>
<td>August 24, 2017</td>
<td>November, 2019</td>
<td>2020</td>
</tr>
</tbody>
</table>
AIP/CIP Overview

• Advanced/Compact Ionosphere Probe
• Four measurement modes
  • Planar Langmuir Probe (PLP)
  • Retarding Potential Analyzer (RPA)
  • Ion Trap (IT)
  • Ion Drift Meter (IDM)
• With the following measurements
  • Ion density
  • Ion drift velocity
  • Ion and Electron Temperature
  • Ion Composition
• Duty Cycles
  • FORMOSAT-5 – Always On
  • IDEASat/INSPIRESat – Eclipse Only

AIP : Photo courtesy of Ya-Chih Mao
FORMOSAT-5 AIP First Data

- First measurements from the AIP instrument
- Courtesy Dr. Chi-Kuang from NCU
- Vertical axis can be converted to ion density
FORMOSat, INSPIRESat, IDEASat Mission Design
FORMOSat, INSPIRESat, IDEASat Mission Design
SIESTA Science Objectives

1. What are the occurrence rates and characteristics of plasma irregularities at low and mid latitudes?
2. What are the spatial and temporal variations of the midnight temperature maximum (MTM)?
3. How do the ionospheric density and electric field respond to the MTM thermospheric dynamics?

GIF courtesy of Chi-Ting Liao
Plasma Bubbles

- Plasma bubbles form around the magnetic equator in the early evening where there is a density gradient and magnetic field lines don’t extend to upper parts of the ionosphere (Kil, 2015).

- Bubbles propagate along magnetic field lines allowing the bubble to expand to latitudes far from their initiation site (Sultan, 1996).

- Bubbles can be hundreds of kilometers across (in longitude) and extend hundreds of kilometers up in altitude above the F-layer (>150 km)(Kil, 2015).

- Bubbles can cause communications disruptions via scintillation (large drops in signal intensity and a shift in phase).
Smith and Heelis (2017) used C/NOFS data to plot plasma density through local time to try and identify plasma bubbles in the data.

Smith and Heelis (2017) found that bubbles were present in all longitude sectors both post midnight and post sunset with post midnight preferred in low solar activity conditions.
The Midnight Temperature Maximum (MTM)

• The MTM is a neutral temperature peak and characteristic wind pattern around midnight local time.

• Individual black lines are single days in a month of the Whole Atmosphere Model with clear $\Delta T$ peaks in both summer (bottom) and winter (top) with stronger peaks in the former.

• The MTM is a feature likely driven by migrating tides whose contribution by zonal wave number can be seen by the green and blue lines.

Akmaev, 2009

Figure 1. Temperature deviation from the zonal mean near 285 km in (top) March at 20°N and (bottom) December at 30°S at (left) UT = 6:00 and (right) UT = 6:00. See text for details.
The INSPIRESat-1 at PDR
## Components of the INSPIRESat-1

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Components used</th>
</tr>
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<tbody>
<tr>
<td>C&amp;DH</td>
<td>Custom design</td>
</tr>
<tr>
<td>EPS</td>
<td>Custom design</td>
</tr>
<tr>
<td>ADCS</td>
<td>Blue Canyon Technology XACT</td>
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<tr>
<td>CIP-Payload</td>
<td>Custom design</td>
</tr>
<tr>
<td>UHF Rx</td>
<td>SpaceQuest TRXU</td>
</tr>
<tr>
<td>UHF Tx</td>
<td>SpaceQuest TRXU</td>
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<tr>
<td>S-Band Tx</td>
<td>SpaceQuest TX2400</td>
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</table>
INSPIRESat-1 Functional Block Diagram

C&DH (IIST)

- UART
- I²C
- SPI
- CIP_PPS
- SD Card
- UHF_Data
- S-Band_Data

Compact Ionosphere Probe

- Power
- Ground
- I²C (3.3V)
- UART
- RS422

HK = Housekeeping

Processor

Power Supply

ADCS Computer

- Star camera
- Torque Rods
- Magneto meter
- GPS
- Reaction Wheels

Battery

12/10/2017
## INSPIRESat-1 Margins

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Mass 3U (kg)</th>
<th>Nominal Power (W)</th>
<th>Volume 3U (mm³)</th>
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<tr>
<td>CIP</td>
<td>0.61</td>
<td>2.13</td>
<td>600</td>
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<td>1000</td>
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<td>COMM</td>
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<td>C&amp;DH</td>
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<td>Battery</td>
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<td>Solar Arrays</td>
<td>0.51</td>
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<td>54.43</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>3.60</strong></td>
<td><strong>8.86</strong></td>
<td><strong>2696.58</strong></td>
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<td><strong>Allocated</strong></td>
<td><strong>10</strong></td>
<td><strong>12.38</strong></td>
<td><strong>3000</strong></td>
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<td><strong>Margin (%)</strong></td>
<td><strong>153</strong></td>
<td><strong>40</strong></td>
<td><strong>10</strong></td>
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</table>
Sequence of Operations

Enter Orbit:
Phoenix Mode → Sun pointing to gain battery charge.
Safe mode

SUNLIT period
Charge mode, Payload off

Send data down to ground during access

ECLIPSE period
Science Mode Payload on
Mode Flow Diagram

- **PHOENIX MODE**
  - <55%
  - >65%

- **SAFE MODE**
  - >75%
  - <70%

- **CHARGING MODE**
  - >75%
  - <70%

- **SCIENCE MODE**
  - >80%
  - <70%
<table>
<thead>
<tr>
<th>Subsystem</th>
<th>EMERGENCY MODES</th>
<th>NOMINAL MODES</th>
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<tbody>
<tr>
<td></td>
<td>Phoenix</td>
<td>Safe</td>
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<tr>
<td>C&amp;DH</td>
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<td>ON</td>
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<tr>
<td>EPS</td>
<td>ON</td>
<td>ON</td>
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<td>ADCS</td>
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<td>CIP-Payload</td>
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<td>UHF Tx</td>
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<td>S-Band Tx</td>
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<td>Beacon</td>
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<tr>
<td>Battery Heater</td>
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<td>As required</td>
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Summary

• Three platforms flying the same instrument provides a depth of data not normally seen in space science

• The goal of the SIESTA concept is to characterize small-scale plasma irregularities and the MTM

• The INSPIRESat-1 is heading for CDR and the IDEASat is using lessons learned to improve upon the INSPIRE programs first satellite
References


Questions?