AERO & VISTA
Demonstrating HF Radio Interferometry with Vector Sensors

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Target: The Radio Aurora

High-latitude aurora viewed from the ISS (~350 km altitude)  
September, 2011 (NASA ISS Crew Earth Observations experiment)
AERO and VISTA are twin 3U CubeSats that will launch & deploy together into a polar orbit, using drag to control separation.

Individually, they will answer key scientific questions about the nature and sources of auroral radio emissions.

Together, they will demonstrate interferometric imaging, beamforming, and nulling using electromagnetic vector sensors at low frequencies (50 kHz – 5 MHz).

A key goal is to demonstrate that interferometric arrays of VS’s will maintain sensitivity in the presence of terrestrial interference.

- This would allow low frequency interferometers be placed in LEO, reducing cost and increasing data volume.
Electromagnetic Vector Sensing

- 3 dipoles + 3 loops (electrically small)
- Measures full E and B field vectors
  - \( \mathbf{E} \times \mathbf{B} = \mathbf{S} \) (Poynting vector)
- Determines source intensity, polarization, and direction (to a few degrees)
- Some imaging capability

Spatially resolved detection with a single electrically small sensor!
Vector antenna deployment

Single Node Thermal Model

Monopole Burn-Wire

Central Telescoping Deployment

Loop Tip Deployment

Deployable Tapes
Central Telescoping Deployment
Deployable Vector Antenna Prototype
Mission Objectives

Table 1: Top level objectives for AERO and VISTA missions.

<table>
<thead>
<tr>
<th>AERO</th>
<th>VISTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO1: Characterize auroral radio emissions in the ionosphere</td>
<td>VO1: Demonstrate vector sensor interferometry (VSI) in space</td>
</tr>
<tr>
<td>AO2: Connect radio emissions to overall auroral geospace system</td>
<td>VO2: Apply VSI to auroral radio emissions</td>
</tr>
<tr>
<td>AO3: Demonstrate polarimetric HF radio signal detection [Tech validation]</td>
<td>VO3: Characterize low Earth orbit (LEO) radio frequency interference (RFI) environment [at HF frequencies]</td>
</tr>
</tbody>
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Nominal launch date in 1st Quarter of 2022
Backup
Twin 3U CubeSats will be placed in polar orbit for a nominal 90-day mission to:

• Qualify and validate a novel electromagnetic Vector Sensor (VS)
• Answer key scientific questions about the nature and sources of auroral radio emissions.
• **Demonstrate low frequency interferometry**

• Orbiting at >400 km, above the ionospheric peak, allows sensing of radiation not visible from Earth
• Each deployable *vector sensor* (50 kHz – 5 MHz) can determine direction of arrival of auroral radio emission
• Together, they demonstrate how interferometry enables high resolution imaging
• An Auxiliary Sensor Package includes magnetometers and optical aurora sensors
## Developments in auroral radio emissions

<table>
<thead>
<tr>
<th>Type</th>
<th>frequency</th>
<th>polariz’n</th>
<th>outstanding problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auroral Hiss</td>
<td>&lt;1 MHz (below $f_{ce}$)</td>
<td>Right (W-mode)</td>
<td>Structure: hissers, LF cutoff etc. Dayside/nightside Source altitudes</td>
</tr>
<tr>
<td>AKR</td>
<td>50-750 kHz (below $f_{ce}$)</td>
<td>Right</td>
<td>Confirm connection How W-mode generated? Ducted? Area illuminated? Remote sensing application?</td>
</tr>
<tr>
<td>Auroral Roar</td>
<td>$2f_{ce}$, $3f_{ce}$, $4f_{ce}$, $5f_{ce}$</td>
<td>Left (sometimes Right?)</td>
<td>Nonlinear mode conversion?</td>
</tr>
<tr>
<td>Medium Freq Burst</td>
<td>1.5-4.5 MHz (above $f_{ce}$)</td>
<td>Left (L-mode)</td>
<td>Generation mechanism? Use for substorm onset timing? Connected to Langmuir cavitation?</td>
</tr>
</tbody>
</table>
CubeSat Deployable Vector Sensor

- Deployed
  - Upper Tape Hub
  - Lower Tape Hub
- Telescoped
- Stowed
  - Diagonal Tape
  - Corner Tape
  - Perimeter Loops
- Corner Fittings
- (4 m tip-to-tip)