Overview of the Hyperion Imaging Spectrometer for the NASA EO-1 Mission

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Hyperion Imaging Spectrometer

Hyperion is a push-broom imager

- 220 10nm bands covering 400nm - 2500nm
- 6% absolute rad. accuracy
- Swath width of 7.5 km
- IFOV of 42.4 μradian
- GSD of 30 m
- 12-bit image data
- Orbit is 705km alt (16 day repeat)
EO-1 Sensor Swaths

Landsat 7 ETM+
EO-1 Atmospheric Corrector
EO-1 ALI
EO-1 Hyperion
Swaths LS7
Hyperion ALI
NADIR Pointing
Scene-based Pointing
PERFORMANCE CHARACTERIZATION

A broad range of traditional and non-traditional techniques were used to characterize Hyperion
Desert Sites used for Vicarious Calibration

Lake Frome

RR Valley

Arizaro/Barreal Blanco
Out of this World Calibration

Hyperion image of the moon

Lunar image provides direct-viewing radiometric measurements for calibration without atmospheric effects.

Issues of the lunar model and analysis techniques are being addressed

courtesy of P. Barry & H. Kieffer
Special targets for characterization

Searchlights
- California

Planets
- Venus

Gas Flares
- Moomba

90 deg Yaw
Hyperion SNR

Radiometric performance model based on 60° Solar zenith angle, 30% albedo, standard scene

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Hyperion Measured SNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>550 nm</td>
<td>161</td>
</tr>
<tr>
<td>650 nm</td>
<td>144</td>
</tr>
<tr>
<td>700 nm</td>
<td>147</td>
</tr>
<tr>
<td>1025 nm</td>
<td>90</td>
</tr>
<tr>
<td>1225 nm</td>
<td>110</td>
</tr>
<tr>
<td>1575 nm</td>
<td>89</td>
</tr>
<tr>
<td>2125 nm</td>
<td>40</td>
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</table>
# Hyperion Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pre-launch Cal</th>
<th>On-orbit Cal</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSD (m)</td>
<td>29.88</td>
<td>30.38</td>
</tr>
<tr>
<td>Swath (km)</td>
<td>7.5</td>
<td>7.75</td>
</tr>
<tr>
<td>No. of Spectral Channels</td>
<td>220</td>
<td>200 (L1 data)</td>
</tr>
<tr>
<td>VNIR SNR (~550-700nm)</td>
<td>144-161</td>
<td>140-190</td>
</tr>
<tr>
<td>SWIR SNR (~1225nm)</td>
<td>110</td>
<td>96</td>
</tr>
<tr>
<td>SWIR SNR (~2125nm)</td>
<td>40</td>
<td>38</td>
</tr>
<tr>
<td>VNIR X-trk Spec. Error</td>
<td>2.8nm@655nm</td>
<td>2.2nm</td>
</tr>
<tr>
<td>SWIR X-trk Spec. Error</td>
<td>0.6nm@1700nm</td>
<td>0.58</td>
</tr>
<tr>
<td>Spatial Co-Reg: VNIR</td>
<td>18% @ Pix #126</td>
<td>*</td>
</tr>
<tr>
<td>Spatial Co-Reg: SWIR</td>
<td>21% @ Pix #131</td>
<td>*</td>
</tr>
<tr>
<td>Abs. Radiometry (1Sigma)</td>
<td>&lt;6%</td>
<td>3.40%</td>
</tr>
<tr>
<td>VNIR MTF @ 630nm</td>
<td>0.22-0.28</td>
<td>0.23-0.27</td>
</tr>
<tr>
<td>SWIR MTF @ 1650nm</td>
<td>0.25-0.27</td>
<td>0.28</td>
</tr>
<tr>
<td>VNIR Bandwidth (nm)</td>
<td>10.19-10.21</td>
<td>*</td>
</tr>
<tr>
<td>SWIR Bandwidth (nm)</td>
<td>10.08-10.09</td>
<td>*</td>
</tr>
</tbody>
</table>

* Consistent with Pre-Launch Calibration or not measured
APPLICATIONS

Evaluating space-based hyperspectral imaging
Hyperion addresses a broad range of issues and world-wide sites.
Hyperion Maps Mt. Fitton Geology

Automatic mineral mapping algorithm creates, in 30 seconds, a quick-look mineral map (left & centre). More precise detail is on right. (Courtesy of CSIRO Australia)

Mineral Spectra

Colours of spectra match the thematic image to left.

Tremolite + mica
Dolomite
Unknown
Mica + chlorite
Mica 2
Chlorite/mica
Mica 1
Talc/Tremolite

Colours to the right indicate the relative abundance of talc/tremolite.

Red shows areas of greatest abundance and blue shows the least.
Landsat and EO-1 Images

Landsat 7

Landsat 7 Subset

Hyperion

Study Area

P92/R84

CIA
Temporal Sequence of Hyperion Images
Coleambally Irrigation Area

Day 001
Day 033
Day 065
Day 072

Julian calendar days of 2001
Time Sequence of Corn
(Paddock 33B)
Work in Process

• Recent data release

• Atmospheric Correction

• Space-ground data comparisons

• Inter-instrument comparisons

• Science Validation
Ground Data Teams
Long Term Directions

![Image of hats]

![Graph showing reflectivity vs. wavelength for kangaroo, rabbit, and cowhide materials]
Backup
Hyperion Subassemblies

Hyperion Electronics Assembly (HEA)

Cryocooler Electronics Assembly (CEA)

Hyperion Sensor Assembly (HSA)
EO-1 Orbit

- EO-1 Spacecraft launched November 21, 2000 from Vandenberg Air Force Base
- EO-1 orbit is one minute behind Landsat-7
Extensive Pre-flight Calibration
Lake Frome Calibration Site
Hyperion Spectral Calibration –

atmospheric absorption lines

Hyperion Spectra – red

Atmospheric Reference – black

Diffuse Reflectance of cover – blue

Identification of Spectral Features

![Graph showing spectral features and absorption lines]
Spectral Calibration – SWIR

Identification of Spectral Features

Hyperion Spectra – red
Atmospheric Reference – black
Diffuse Reflectance of cover – blue

Process:
1.) Create Pseudo-Hyperion Spectra from reference: Modtran-3 for atmosphere, and Cary 5 & FTS measurements for diffuse reflectance of the cover
2.) Correlate Spectral Features: band number units of Hyperion max/min correlated with reference wavelength of max/min
3.) Calculate Band to Wavelength map: apply low order polynomial to fit the data over the entire SWIR regime
MTF Approach

- Calculate cross-track and in-track MTF using a step response and impulse response example

- Results of on-orbit analysis give good agreement with the pre-launch laboratory measurements
Example: Cross-track MTF

- Scene is Port Eglin from Dec 24, 2000. Bridge is the Mid-bay bridge. Bridge width is 13.02 meters.
- Bridge angle to the S/C direction is small so every 5th line is used to develop the high resolution bridge image.
- MTF result at Nyquist is between 0.39 to 0.42 while the pre-flight measurement was 0.42.
Hyperion Maps Mt. Fitton Geology

Hyperion-based apparent reflectance compares with library reference spectra

(1) Published Geologic Survey Map
(2) Hyperion three color image (visible) showing regions of interest
(3) Hyperion surface composition map using SWIR spectra above

Hyperion surface composition map agrees with known geology of Mt. Fitton in South Australia

(a) Hyperion Spectra
(b) Reference Spectra

Courtesy of CSIRO, Australia
VNIR/SWIR Repeatability

- Solar Calibration demonstrates good pixel-to-pixel repeatability
  - VNIR is highly repeatable - <0.05% variation
  - SWIR is repeatable - <0.75% variation

- Spectral Calibration indicates stability based on comparisons of Pre-launch and On-Orbit measurements
DATA CHARACTERISTICS
Hyperion Data Flow

**Science Data:** Level 0 or Level 1 (radiometrically corrected) data products with VNIR and SWIR data frames combined. Includes solar, lunar calibrations, earth images, dark and light calibrations.

**Metadata:** Data about the science data. Information to support higher level processing, e.g., pre-flight characterization data.

**Ancillary Data:** Supporting data derived from spacecraft telemetry during image collection.
Hyperion Data - Comments

Level 1 data: 438-926nm and 892-2406nm
Bands 9-57 and 75 - 225;
SWIR is West of VNIR and rotated CCW by one pixel

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<th>Band</th>
<th>Center(nm)</th>
<th>FWHM(nm)</th>
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<tr>
<td>50</td>
<td>854.66</td>
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