A Flight and Ground Operations Concept for the Intelligent Payload Module for the Proposed HyspIRI Mission

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Intelligent Payload Module Summary

• The Intelligent Payload Module will enable near real-time downlink of selected subset (spatial, spectral, product) of VSWIR/TIR data using heritage Direct Broadcast/Direct Readout technology

• Direct Broadcast enables effective
  ~10 \times 10^6 \text{ bits/sec} \text{ out of VSWIR + TIR} = \sim 800 \times 10^6 \text{ bits/sec data stream}
## High Interest Heritage Products

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Products</th>
<th>Heritage (not exhaustive)</th>
<th>Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryosphere</td>
<td>Snow, Water, Ice Land</td>
<td>Hyperion/EO-1 (onboard), MODIS, ASTER, AVHRR, Landsat (Ground)</td>
<td>High</td>
</tr>
<tr>
<td>Volcanology</td>
<td>Thermal emission</td>
<td>AVHRR, ASTER, MODIS (ground), Hyperion (onboard)</td>
<td>High</td>
</tr>
<tr>
<td>Hydrology</td>
<td>Surface Water Extent</td>
<td>MODIS, Landsat, WV2, Geo-Eye, Ikonos, ASTER (ground), Hyperion (onboard)</td>
<td>High</td>
</tr>
<tr>
<td>Wildfire</td>
<td>Thermal Mapping</td>
<td>MODIS, (Ground), Hyperion (onboard)</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Burn Scar</td>
<td>Landsat, AVHRR, Aviris, ALI, Hyperion, ASTER (ground)</td>
<td>High</td>
</tr>
</tbody>
</table>
EO-1/ASE Onboard:
At left hot and extreme pixel classification maps developed onboard from Hyperion Data.
At right Level One full data downlinked and processed on ground. Both acquired of the Mount Erebus volcano 7th May 2004 on two overflights. Courtesy NASA/GSFC/EO-1, A. Davies.
For further information: [Davies et al. 2006, RSE]

For further information: [Ip et al. 2006, RSE]

Courtesy NASA/GSFC/EO-1/U. AZ/JPL
EO-1 Onboard: Cryosphere Classifier

Deadhorse (Prudhoe Bay), Alaska
For further information: [Doggett et al. 2006 RSE]

 Courtesy NASA/EO-1/GSFC/ASU
More Advanced Products
Flood Tracking

• Integrated WV-2 data (2m spatial resolution)
• Developed algorithms and workflows for water depth and volume estimation (incorporating DEM) – potential HyspIRI IPM algorithms

Reflectance of WV2 scene of Bangkok w/ flooded Don Muang Airport, acquired 11.3.2011

Surface water extent (blue) from SVM classifier using 5th degree polynomial kernel on 8 WV2 bands

Resulting water depth map calculated using SVM-classified surface water extent map and DEM. Total water volume calculated: ~27,872,000 m³; average flooded pixel depth: 0.64 m.

For further details see [Mclaren et al. 2012a, SPIE]
Plume & Shadow Classification using TextureCam Decision Forest Machine Learning [Thompson et al., LPSC, 2012]

Plume height calculation using classification, viewing and solar geometry, DEM.

Reasonable correlation with visual, radar based measurement from [Arason et al. 2011]

For further details see [Mclaren et al. 2012b, SPIE]
Onboard Hyperspectral Analysis

Superpixel segmentation + SMACC endmember extraction = onboard spectral search

Results from onboard EO-1 (9/2011)

For further details see [Thompson et al 2009, TGARS] [Thompson et al. 2012, i-SAIRAS]
Intelligent Payload Module Operations

- How will Ground/Science/Applications team designate which data/products to downlink?
HyspIRI IPM Operations Concept

Users input product requests in Google Earth

Planning system determines products based on overflights and resources (CPU, RAM downlink) CLASP+ ASPEN (ground), CASPER (onboard)

Spacecraft acquires imagery, generates product onboard (including onboard event detection), downlinks product

“lights out” payload operations

Electronic automatic tasking requests via Sensorwebs
Input via Google Earth KML

User region of Interest (ROI), specifies products, latency, priority

Upcoming instrument swaths highlighted: TIR and VSWIR
Users can view upcoming acquisition and processing plans.
Operations Concept Maturity

- The software for this automated operations concept is *already implemented*.
- Software was first demonstrated in 2010, and has undergone minor enhancements since.
  - **Enhancement**: specification of latency so that products can be designated for later downlink over desired target ground stations.
  - **Enhancement**: enables dynamic across track swaths based on overlap with regions of interest
Intelligent Payload Experiment (IPEX)

- IPEX Cubesat will validate elements of HyspIRI IPM concept (launch scheduled 10/13)
  - IPEX will generate products onboard
    - Some based on onboard image analysis
  - IPEX will use proposed HyspIRI IPM web-based, automated operations concept
IPEX Acquisition Plan
Conclusions

• HyspIRI Intelligent Payload Module will enable delivery of low-latency products and data subsets (spectral, spatial)
  – Mature, heritage (minimal onboard computing required) and
  – More advanced products (enhanced onboard computing needed)
• Operations concept uses a simple, web-based interface to specify products, regions, priorities
• Operations concept is fully automated and does not require dedicated operations staff