EnMAP – Technical Update and future Science Issues

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HyspIRI Science Workshop 2011, Washington DC
Outline

• Mission introduction and current status
• Updates on instrument
• Calibration and validation activities
• Recent Advances
• Scientific program activities
• Synergies to HyspIRI (Hisui)
Co-operative international Networks

- methodological development
- synergies to xs and radar (InSAR)

management of agricultural and forest ecosystems

hazard assessment

urban development

inland & coastal waters

dry-land degradation

mineral exploration

Retrieval of bio-geochemical and geophysical variables

Science Program / Fields of Applications
Introduction - History and Current Status

- 2005 Phase A study accomplished
- 2006 Start of phase B
- 2007 End of phase B
- 2008 Start of phase C/D
- 2010 CDR Ground Segment
- 2011 CDR Space Segment
- 2015 Launch date

Present Instrument Status

- Mission Preparation Phase
  - Phase A
  - Phase B
- Commissioning Phase
- Operational Phase 5 years
- Decommissioning Phase
- Launch 2015
## Instrument - Main Sensor/Orbit Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal-to-noise ratio (SNR) at 30% reflectance; 30° sun zenith angle; visibility 21 km; target 500 m a.s.l.</td>
<td>VNIR: &gt; 500:1 (at 495 nm) SWIR: &gt; 150:1 (at 2200 nm)</td>
</tr>
<tr>
<td>Quantification / Radiometric stability</td>
<td>14 bit / &lt; 2.5 %</td>
</tr>
<tr>
<td>Spectral Sampling</td>
<td>6.5 nm VNIR; 10 nm SWIR</td>
</tr>
<tr>
<td>Ground sampling distance (GSD)</td>
<td>30 m x 30 m (at nadir; s. l.)</td>
</tr>
<tr>
<td>Swath width</td>
<td>30 km</td>
</tr>
<tr>
<td>Swath length</td>
<td>1000 km /orbit; 5000 km /day</td>
</tr>
<tr>
<td>Geometric co-registration</td>
<td>$\leq 0.2 \times$ GSD</td>
</tr>
<tr>
<td>Data Rate / Compression method</td>
<td>860 Mbit/s / loss less</td>
</tr>
<tr>
<td>Downlink rate (X-band) / Daily downlink</td>
<td>300 Mbit/s / 389 Gbit</td>
</tr>
<tr>
<td>Inclination</td>
<td>97.96°</td>
</tr>
<tr>
<td>Repeat cycle</td>
<td>23 days</td>
</tr>
<tr>
<td>Repeat rate</td>
<td>4 days (± 30° tilt)</td>
</tr>
<tr>
<td>LTDN</td>
<td>11:00 ± 15 min</td>
</tr>
</tbody>
</table>
Instrument Optics Unit (IOU) - Main Elements

- Star trackers
- Telescope optics
- VNIR detector
- VNIR optics
- Telescope entrance baffle
- Calibration unit
- SWIR detector
- SWIR optics
- Field splitter slit assembly
- Diffuser/solar cal. entrance baffle
- Nominal SWIR-FPA
- Redundant SWIR-FPA
Instrument - CADs and STDM of Current Instrument Design Status

Problem: Thermoelastic deformation
Calibration and Validation

Objectives

- Data quality check and incidence reporting
- Assurance of L1 & L2 products traceability to international standards

Onboard calibration and long term monitoring

Validation

- Image-based analysis: image processing techniques to assess EnMAP instrument performance and data quality (e.g. SRFs, PSF, MTF assessment)
- Field-based validation using in-situ measurements of atmospheric and surface parameters for the validation of L1 and L2 products.
- Validation plan being framed in the internat. Cal/Val scenario (CEOS/WGCV)

Establishment of international partnerships in progress:

USA/JPL: White Sands; Australia/CSIRO: Lancelin & LJCO; Israel/Tel Aviv Uni.: Negev

Ground Segment

EnMAP Space Segment (Satellite)
- Hyperspectral Instrument
- Satellite Bus
- Launcher PSLV, India

EnMAP Ground Segment
- X-Band Station
- S-Band Station
- Mission Planning & Control (MOC)
- Primary User Access Desk DLR
- Primary Processing & Archiving Centre DLR

Data Delivery
Data Request

LEOP Network

International EnMAP User Community

Remote Sensing Section
EeteS: an End-to-End Image Simulation Tool for the EnMAP Mission

- Onboard Calibration
  - Non-linearity
  - Dark Current
  - Absolute Calibration
- L1 Processor
  - L2 Processors
    - Co-registration
    - Atmospheric Correction
    - Orthorectification
- EnMAP Scene Simulator
  - Radiometric Module
  - Spectral Module
  - Spatial Module
  - Atmospheric Module
- Sensor Data (DN)
- Input Data (Reflectance)
- Output Data (Reflectance)

Forward Simulation

Backward Simulation
Simulated EnMAP Data – M. Ramon, Israel

BRDF Issues

- Simulation of any canopy structure (e.g. row distance, plant density)
- Simulation of each growth stage
- Simulation of plant stress and disease

**MATERIAL ASSIGNMENT**

- Leaf spectra
- Stem spectra
- Soil spectra

**RAY TRACING**

- Illumination position (azimuth, altitude)
- Viewing position (azimuth, altitude)

**3D GEOMETRY**

- 4D plant model
- Plant positions within the canopy
- 3D soil surface model

**RESULTING CANOPY SPECTRUM**
## Science activities - Core Science Team (ECST)

### TASKS

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<td>Science Plan &amp; AO</td>
<td>M1</td>
<td>SP1</td>
<td>M2</td>
</tr>
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</table>

### Geology and Soil Science
Prof. Dr. Hermann Kaufmann (Principle Investigator and Chair) GFZ German Research Centre for Geosciences

### Coastal and Inland Waters
Dr. Roland Doerffer
HCG Research Centre

### Forest and Vegetation
Prof. Dr. Joachim Hill
University of Trier

### Ecosystems and Gradual Transitions
Prof. Dr. Patrick Hostert
Humboldt-University Berlin

### Agriculture
Prof. Dr. Wolfram Mauser
Ludwig-Maximilian-University München

### Urban Areas
Andreas Mueller
DLR German Aerospace Establishment
Themes within the young EnMAP Program

Hdhhd
kskks
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<td>SP</td>
<td>1</td>
</tr>
<tr>
<td>Summer Schools</td>
<td>S1</td>
<td>S2</td>
<td>S3</td>
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### 2010: 1st Summer School, Trier: Introduction to hyperspectral image analysis

### 2011: 2nd Summer School, Munich: Hyperspectral field campaigns: Methods, Instruments, Planning Strategies

### 2012: 3rd Summer School, Berlin
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<td>SP3</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>W5</td>
</tr>
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**W1** Int. Hyperspectral Workshop 2010 (Frascati, Italy)  
**W2** Soil Workshop (GFZ)  
**W3** National Workshop 2010 (GFZ Potsdam)  
**W4** National Workshop 2011 (GFZ Potsdam)

shifted to Feb. 2012
EnMAP Toolbox

- License free and platform independent processing environment
- Optimized for EnMAP/hyperspectral processing
- Shortly (autumn) available via [www.enmap.org](http://www.enmap.org)
- Developed by Humboldt-Universität zu Berlin, Geomatic Section
User Portal

EnMAP - German Hyperspectral Satellite Mission

EnMAP (Environmental Mapping and Analysis Program) is a German hyperspectral satellite mission providing high-quality hyperspectral image data on a timely and frequent basis. Main objective is to investigate a wide range of ecosystem parameters encompassing agriculture, forestry, soil, and geological environments, coastal zones, and inland waters. This will significantly increase our understanding of coupled biogeochemical and geospatial processes and thus enable the management and ensure the sustainability of our vital resources. The envisaged launch of the EnMAP satellite is 2012.

Mission Outline:
- Dedicated imaging pushbroom hyperspectral sensor mainly based on modified existing or pre-developed technology
- Broad spectral range from 420 nm to 1000 nm (VISIR) and from 900 nm to 2450 nm (SWIR) with high radiometric resolution and stability in both spectral ranges
- Swath width 50 km at high spatial resolution of 30 m x 30 m and off-nadir (10°) pointing feature for fast target revisit (4 days)
- Sufficient on-board memory to acquire 1,000 km swath length per orbit and a total of 5,000 km per day

http://www.enmap.org/
Cooperation with HyspIRI (and Hisui)

- Common identification of environmental relevant core themes and resp. sites for long term observation and analyses
- Common aircraft campaigns (esp. TIR capability)
- Exchange program for seniors and young academics

- Technical issues
  - Sensitivity studies to different GDS's (30m<->60m) for various applications compatibility for long term observations extended end to end simulation for TIR range
  - Cross calibration of systems
Thank you for listening

Contact:
Hermann Kaufmann
charly@gfz-potsdam.de
www.gfz-potsdam.de
Calibration and Validation

Objectives

• Data quality check and incidence reporting
• Assurance of L1 & L2 products traceability to international standards

Onboard calibration and long term monitoring

Radiometric and spectral calibration

• Dark value
• Relative radiometric calibration
• Sun calibration
• Spectral calibration
• Linearity measurements
• House keeping data analysis