EnMAP and TES-GAP
Status of the Missions and Relevance to HyspIRI

A. Müller, H. Kaufmann T. Stuffler, S. Hofer, F. Buongiorno
and the EnMAP & TES-GAP Teams
EnMAP Overall Mission Goals

- To provide high-spectral resolution observations of bio-geochemical and geophysical variables
- For Multipurpose Applications
- To observe and develop a wide range of ecosystem parameters encompassing agriculture, forestry, soil/geological environments and coastal zones/inland waters
- As Input to Ecosystem Models
- To enable the retrieval of presently undetectable, quantitative diagnostic parameters needed by the user community
- To provide high-quality calibrated data and data products to be used as inputs for improved modelling and understanding of biospheric/geospheric processes
Missionsparameter

- Sun-synchronous, 11:00
- LTDN LEO – reference altitude 653km
- 3 axis stabilized platform with OCS
- mass 850 kg / power 550 W avg.
- 512 Gbit mass memory / 320 Mbit/s X-band science data downlink
- 4 day global accessibility (±30° off-nadir)
- 4 day target revisit capability
- up to 50 data takes per day / total length 5000km
Sensor Parameter

- Pushbroom type hyper spectral imager
- Wavelength 420 - 2450 nm
- 30m GSD, 30 km swath (nadir)
- 228 spectral bands
- VNIR 6.5 nm sampling
- SWIR 10 nm sampling
- SNR > 150 @ 2200nm (ref. radiance)
- Polarization sensitivity < 5%
- Smile and Keystone < 0.2 pix
- Pointing knowledge 100m
- Radiometric accuracy 5%
- Radiometric stability 2.5%
- Response Linearity 0.5%
- Spectral accuracy 0.5nm / 1nm
Satellite Design

- Total Weight: ca. 850 kg
- Aver. Power: 450 W
- 512 Gbit mass memory
- 3 axis stabilized platform
- Pointing Stability: 1.5 m / 4 ms
- Pointing Knowledge: 100 m
- ± 30° off nadir pointing for observation
- Hydrazine propulsion system for orbit maintenance & disposal
- 320 Mbit/s X-Band science data downlink
- Lifetime in Orbit: > 5 years
Instrument Optik Unit Design

- Polished NiP coated Aluminum mirrors
- Monolithic Aluminum structure
- Quasi-isostatic mounting to platform
- Starcameras attached to IOU for pointing knowledge
- Redundant SWIR FPA due to cryocooler without flight heritage
- Gravity release < 5µm – opt. elements
- Eigenfreq. > 100 Hz
- Active thermal stabilization to 21°C ± 1K
Instrument Optik Design

- 175mm EPD
  F3 - unobscured
- Novel spectrometer design
- Dual, field separated spectrometer concept
- Good imaging performance

Telescope (TMA)

SWIR Spectrometer

Field Splitter

VNIR FPA

VNIR slit 24µm

SWIR slit 24µm

0.6 mm
EnMAP Summary

- EnMAP primarily is considered as an environmental research satellite focusing on process oriented land surface dynamics
- PI: Charly Kaufmann, GFZ Potsdam
- Phase C/D in work, CDR of GS completed
- Launch scheduled for mid 2014
- 30 km Swath, 30m spatial resolution, 5-10 nm spectral bandwidth
- Level 2 Product: Ortho-rectified and atmospherically corrected data
- Strong scientific user support planned: Toolbox, Spectral Archive
- Open for international partnerships with respect to data utilization
- Information: http://www.enmap.org
Temperature Emissivity Signatures for Geosphere and Pedosphere
Eyjafjallajökull, MODIS, 19 April 2010
Monitoring of Precursor Indicators
Characterisation of Soils

Largest pool of organic C on the earth's surface. 3x larger than atmospheric C

Reservoir of C, N, P, and S

Important role in C sequestration

pH buffering

Strong retention of Al and heavy metals

Retention of pesticides and other organic chemicals
Map Information Needs

- Mineral exploration requires detailed maps
- Ore bearing horizon is peridotite
- All rocks visibly dark but differing in mineralogical detail (type and abundance)

Regional map (1980’s)

Detailed map (2009)
Terrane Characteristics

Frost heave, spatial continuity, lichen imparting color to bedrock
Mapping with SEBASS (4 meter data)
TES-GAP Science Objectives

- Provide high precision emissivity and temperature measurements of land surfaces
- Measure soils surface composition and monitor soil dynamics
  - determine SOM, soil mineralogy, moisture, roughness
  - monitor soil degradation and pedogenic processes
  - improve understanding of soil-atmosphere interaction
- Measure volcanic thermal behaviour and gas emissions as precursor indicators to predict eruptions
  - determine temperature of lava flows, craters and fumarol fields
  - quantitatively measure volcanic emission gases
- Foster applications of thermal spectroscopy in other science areas
  - Urban heat island
  - Biomass burning
  - Heat stress in inland and coastal waters
TES-GAP History & way forward

- ESA EEOM Call EE8 in 2009, Deadline for Lol: Dec 2009
- Lol from DLR & KT (TERM) and INGV & SelexGalileo (MARTHA)
- Decision on merge of both proposals in April 2010
- Submission of TES-GAP in June 2010
- ESA decision on Phase A studies (up to three) in Nov 2010
- ESA decision on implementation of one mission end of 2011
- Launch in 2018
TES-GAP - Proposal Team

- Andreas Müller, Dr. Tobias Storch, German Aerospace Center (DLR)
- Dr. Maria Fabrizia Buongiorno, Istituto Nazionale di Geofisica e Vulcanologia (INGV)
- Dr. Timo Stoffler, Markus Plattner, Kayser-Threde GmbH (KT)
- Tiziano Mazzoni, SelexGalileo
- Prof. Eyal Ben Dor, Tel Aviv University (TAU)
- Prof. Benoit Rivard, University of Alberta (UA)
- Prof. Jose Sobrino, University of Valencia (UV)
- Ivan Pippi, Istituto di Fisica “Nello Carrara” (IFAC)
- Dr. Martin Wooster, King’s College London (KCL)
- Prof. Sergio Teggi, Prof. Sergio Pugnaghi, University of Modena (UM)
- Dr. Stefania Amici, Dr. Stefano Corradini, Dr. Valerio Lombardo, Dr. C. Spinetti, INGV
- Dr. Simon Hook, Dr. Michael Abrams, Dr. Dave Pieri, NASA JPL
Thermal Signatures of Minerals

Rock forming Minerals

1) Quarz
2) Orthoklas
3) Albit
4) Oligoklas
5) Labradorit
6) Hornblende
7) Pyroxen
8) Olivin
9) Forsterit

Basalt

Granites

1) Quarz
2) Orthoklas
3) Albit
4) Oligoklas
5) Labradorit
6) Hornblende
7) Pyroxen
8) Olivin
9) Forsterit

H. Kaufmann, GFZ
Instrument Requirements Simulations

![Graph showing quartz emissivity vs. wavelength with a dotted line representing TES-GAP center wavelength.]

**dotted with symbol: TES-GAP center wavelength**
Spectral Coverage

EnMAP 250 channels

TES-GAP
12 bands 30 bands

Transmission [%]

Wavelength [µm]
Preliminary TES-GAP Instrumentation / Mission Requirements

- **MIR Radiometer Spectral and Radiometric Requirements**
  - Coverage: 3-5 µm
  - No. of bands: ~12, bandwidth: ~150 nm
  - NEΔT: 0.05 K @ 300K & 0.1 K @ 1000K

- **TIR Spectrometer Spectral and Radiometric Requirements**
  - Coverage: 8-12.5 µm
  - No of bands: 30, bandwidth: ~150 nm
  - NEΔT: 0.05 to 0.1 K @ 300K

- **Geometric Requirements**
  - Ground Sampling Distance: 60x60 m2
  - Swath width: 60-100 km
  - Repeat Cycle: tbd
  - Target Revisit: tbd (i.e. pointing)
  - Coverage: global access, regional coverage, focus on core test areas
TIR Instrument Design
MIR Instrument design
TES-GAP Bus & Orbit

- MITA (Carlo Cavazzi)
- 500 kg total mass
- lifetime of 3 to 5 years
- communication downlink in S- and X-band
- data rate 320 Mbit/s, X-Band
- 400 W electrical power (EOL)
- mass memory 512 Gbit

Orbit (identical to EnMAP)
- sunsynchronous
- altitude of 640 km
- inclination angle 98°
- Equator crossing at 10:30 LTDN
# Mission Schedule

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<th>TES-GAP</th>
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<td>Sa 01.01.11</td>
<td>Mo 30.01.12</td>
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<td>Phase B</td>
<td>Mi 01.02.12</td>
<td>Mo 30.09.13</td>
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<td>Phase C</td>
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<td>Phase D</td>
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<td>Phase F</td>
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Launch 2018
## Summary and Comparison to HyspIRI

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<th>TES-GAP</th>
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<td>Probability</td>
<td>-&gt; HyspIRI Team</td>
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thank you for your attention!
## Cost Estimate

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