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

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and the EnMAP & TES-GAP Teams

EnMAP
Hyperspectral Imager

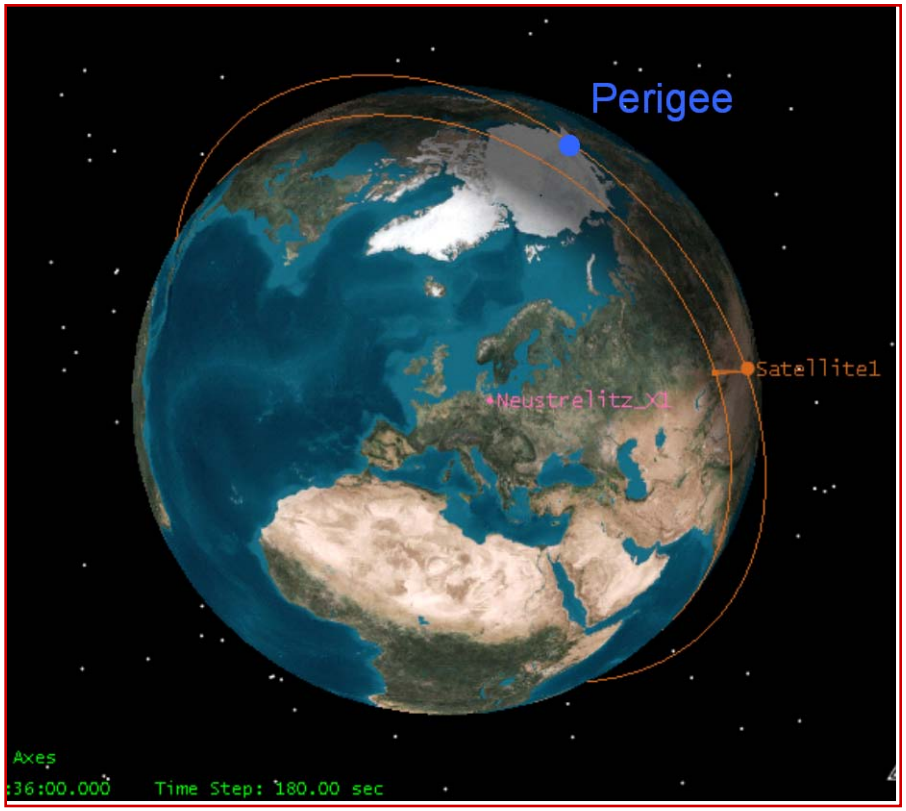
TES GAP

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

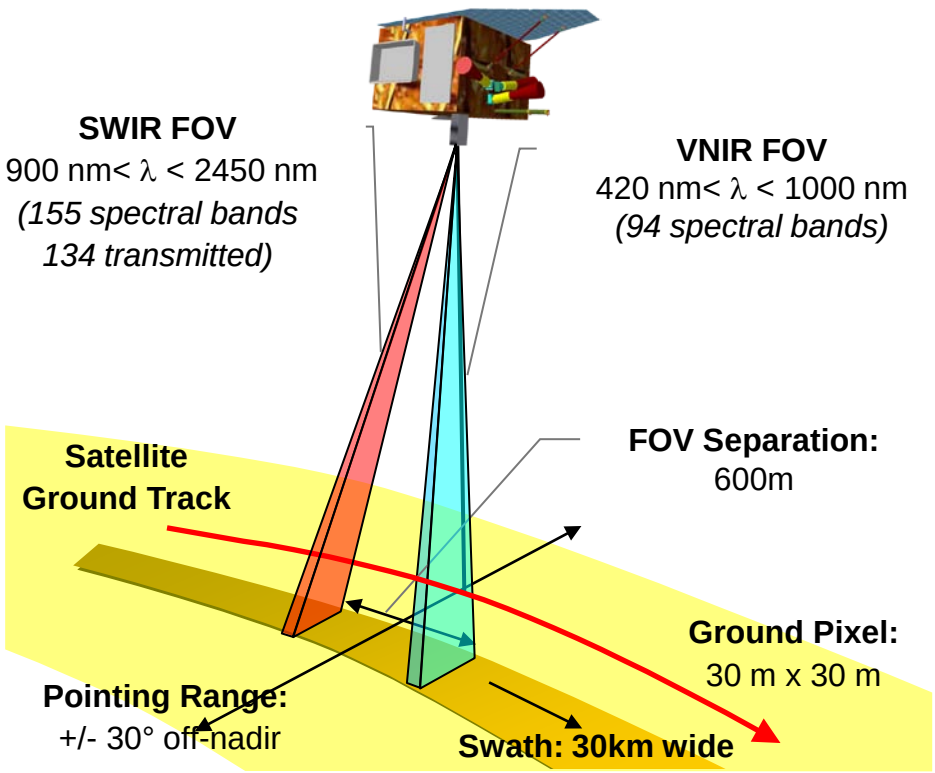
- To Provide Imaging Spectrometer
- To Precisely Measure Ecosystem Parameters
- To Improve the Understanding of Land Surface Processes

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

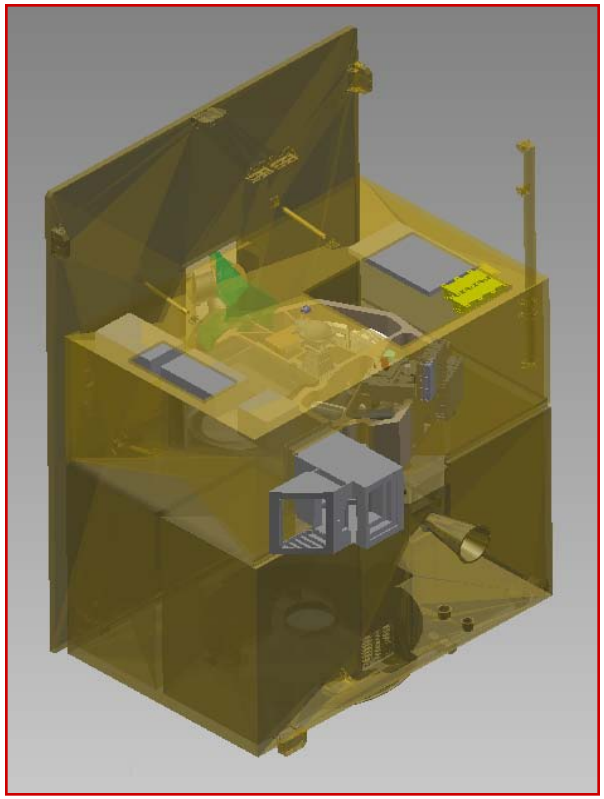
Sensor Parameter



schlanke Kontur - Leitfarbe

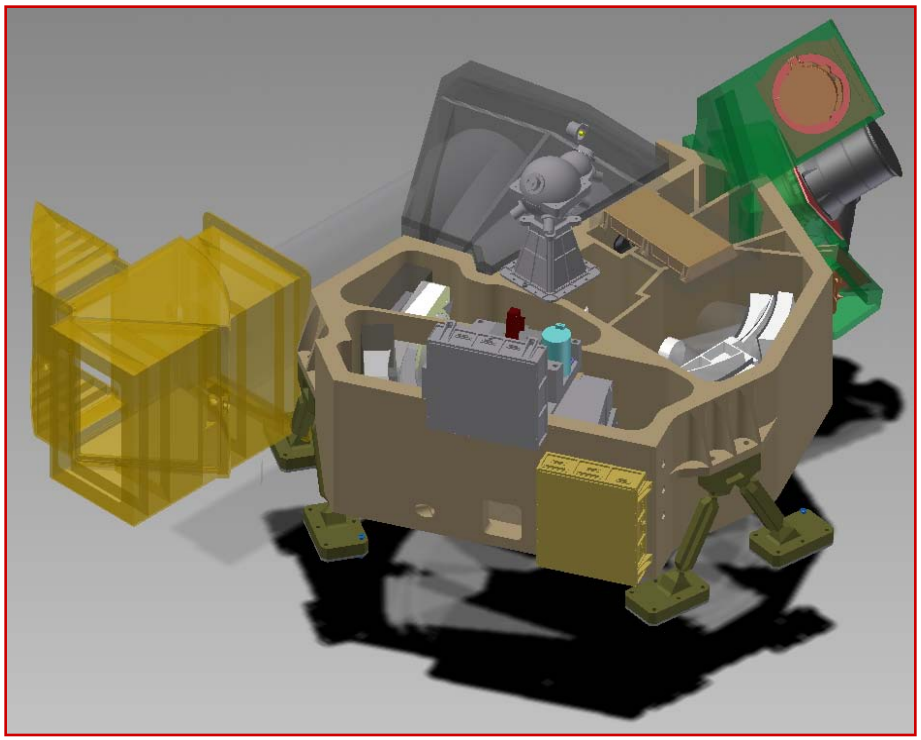
- Pushbroom type hyper spectral imager
- Wavelength 420 - 2450 nm
- 30m GSD, 30 km swath (nadir)
- 228 spectral bands
- VNIR 6.5 nm sampling
- SWIR 10 nm sampling
- SNR > 150 @ 2200nm (ref. radiance)
- Polarization sensitivity < 5%
- Smile and Keystone < 0.2 pix
- Pointing knowledge 100m
- Radiometric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

Satellite Design



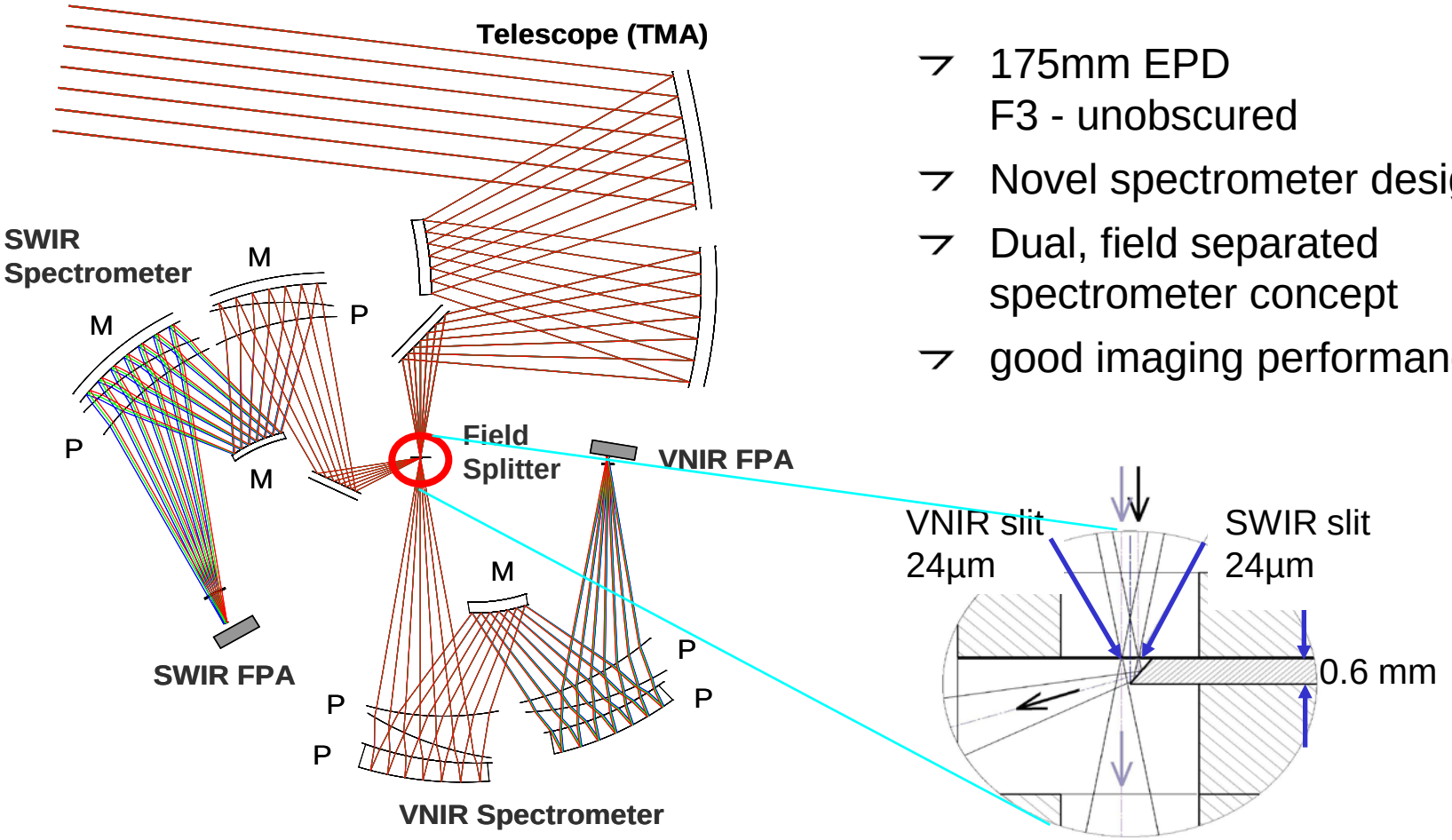
- Total Weight: ca. 850 kg
- Aver. Power: 450 W
- 512 Gbit mass memory
- 3 axis stabilized platform
- Pointing Stability: 1,5 m / 4 ms
- Pointing Knowledge: 100 m
- ± 30° off nadir pointing for observation
- Hydrazine propulsion system for orbit maintenance & disposal
- 320 Mbit/s X-Band science data 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

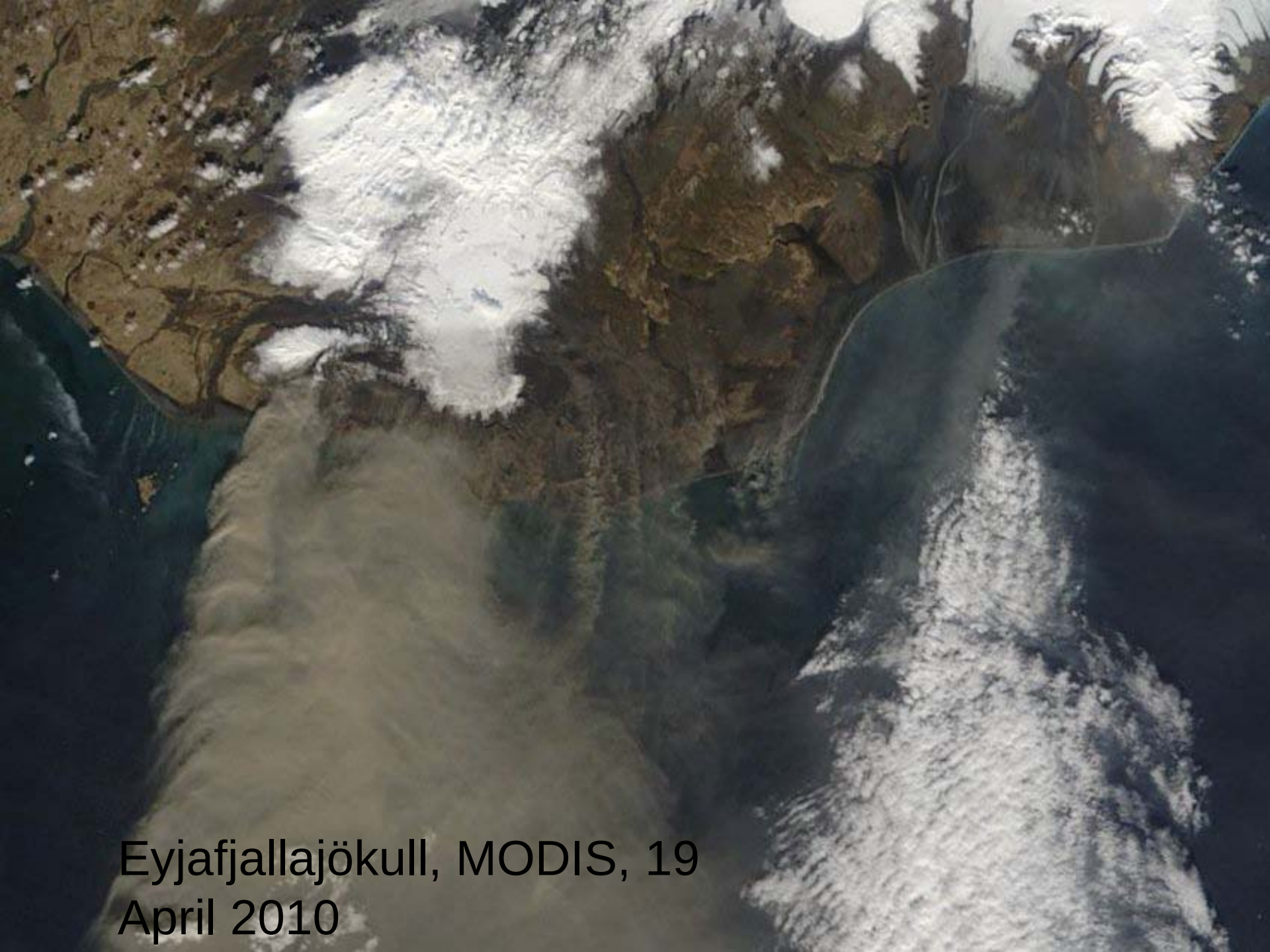


- 175mm EPD
  F3 - unobscured
- Novel spectrometer design
- Dual, field separated spectrometer concept
- good imaging performance

EnMAP Summary

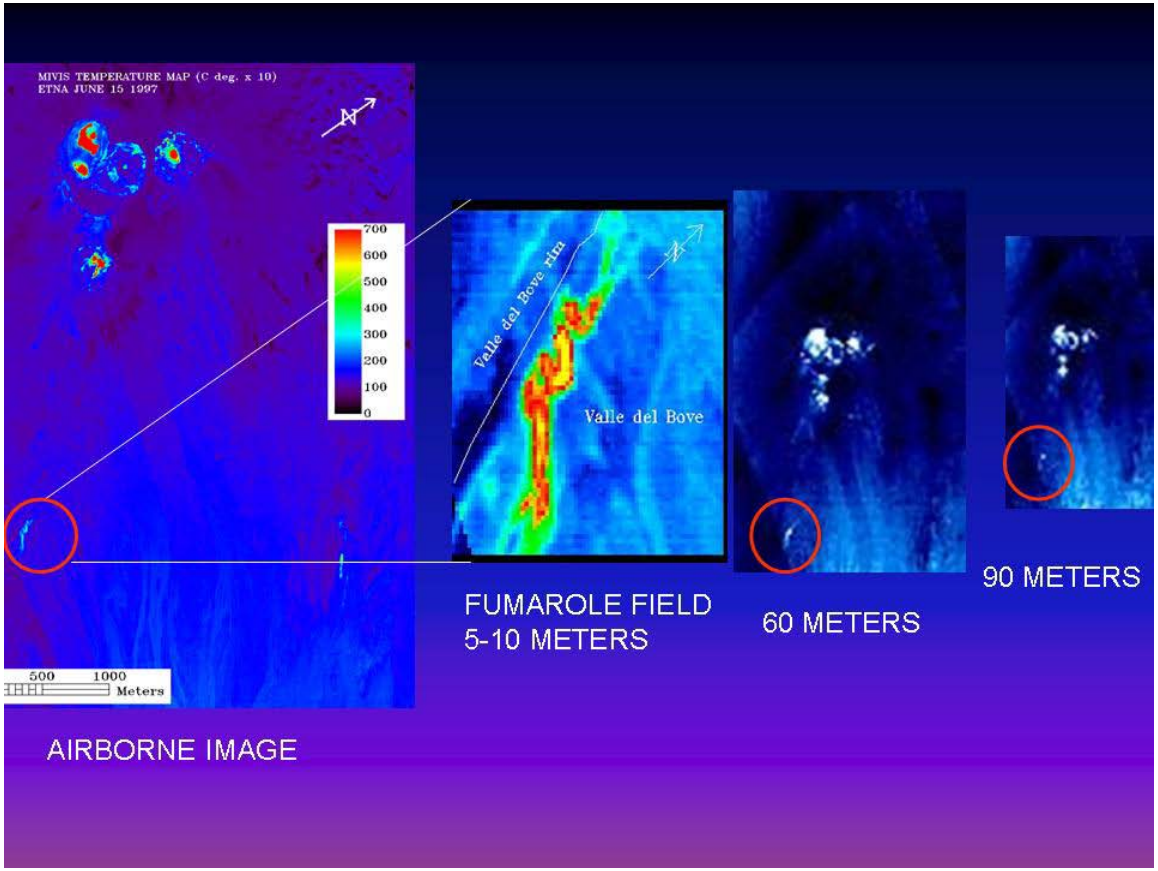
- EnMAP primarily is considered as an environmental research satellite focusing on process oriented land surface dynamics
- PI: Charly Kaufmann, GFZ Potsdam
- Phase C/D in work, CDR of GS completed
- Launch scheduled for mid 2014
- 30 km Swath, 30m spatial resolution, 5-10 nm spectral bandwidth
- Level 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

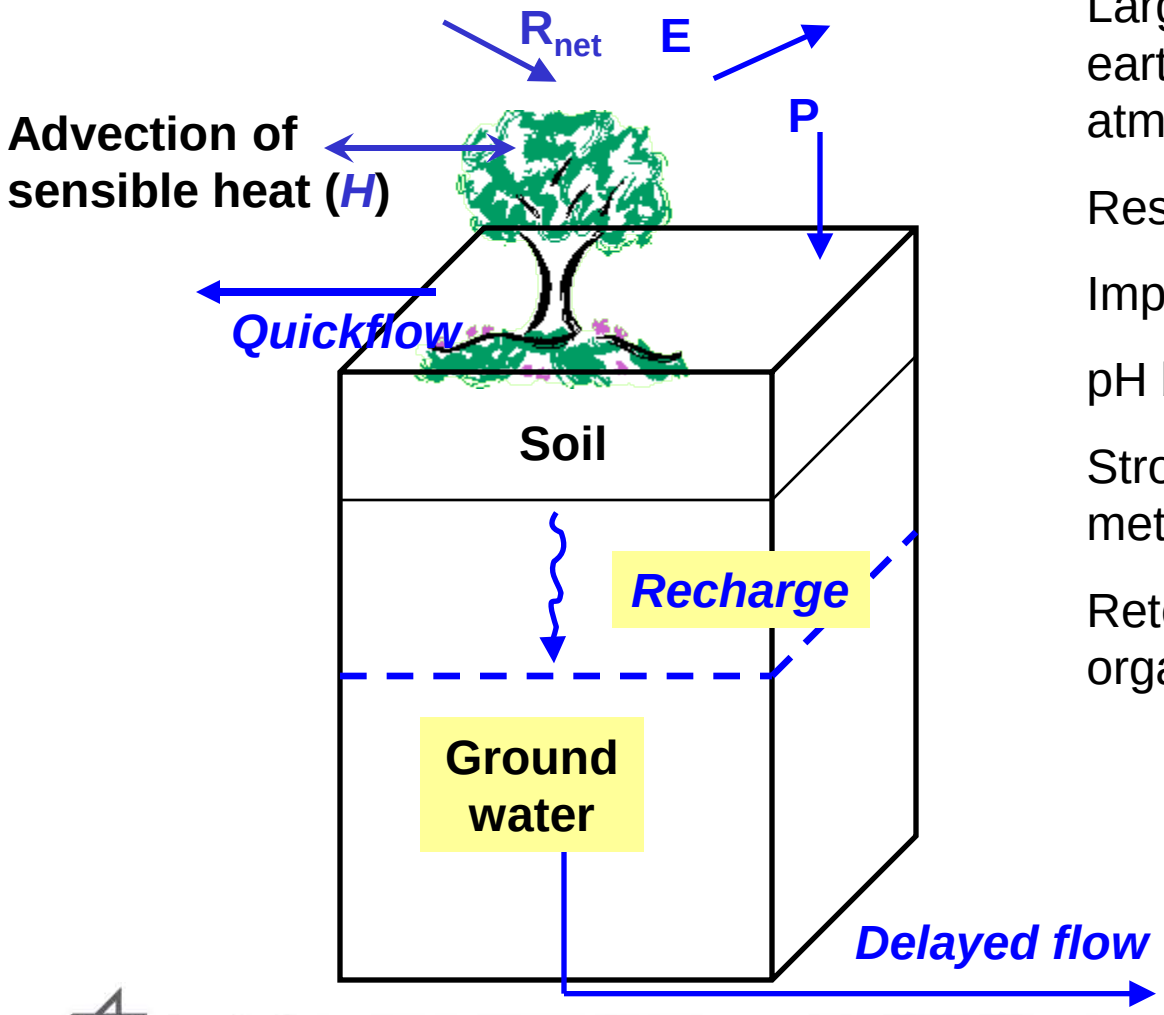


Eyjafjallajökull, MODIS, 19 April 2010

Monitoring of Precursor Indicators



Characterisation of Soils



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

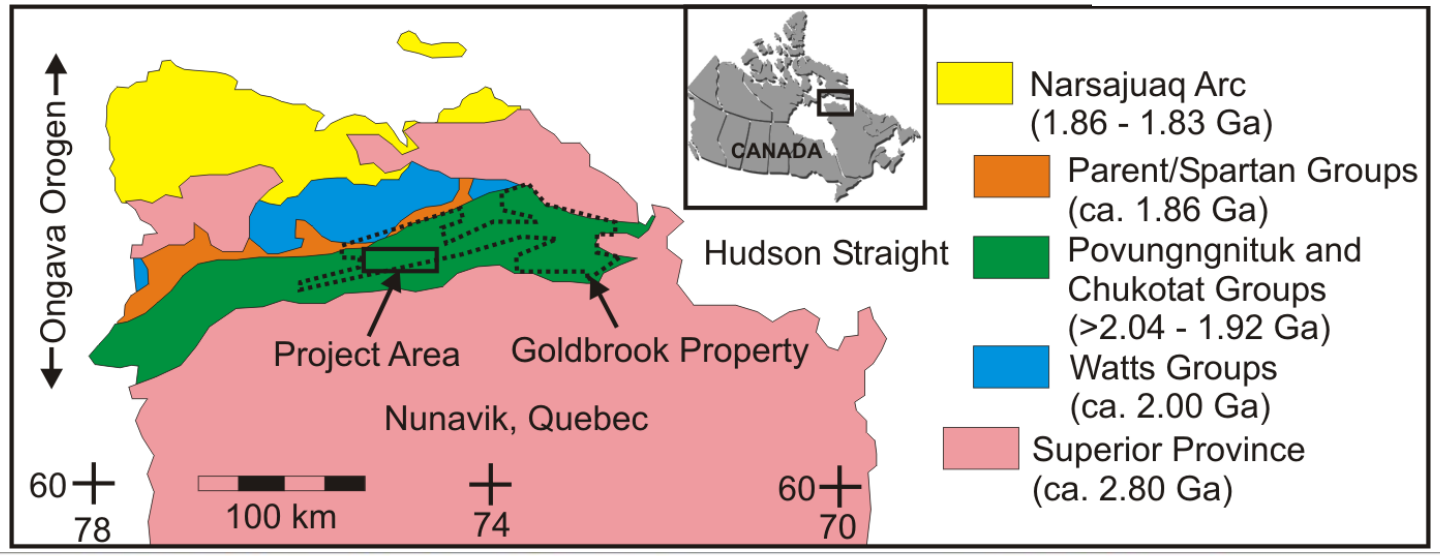
Reservoir of C, N, P, and S

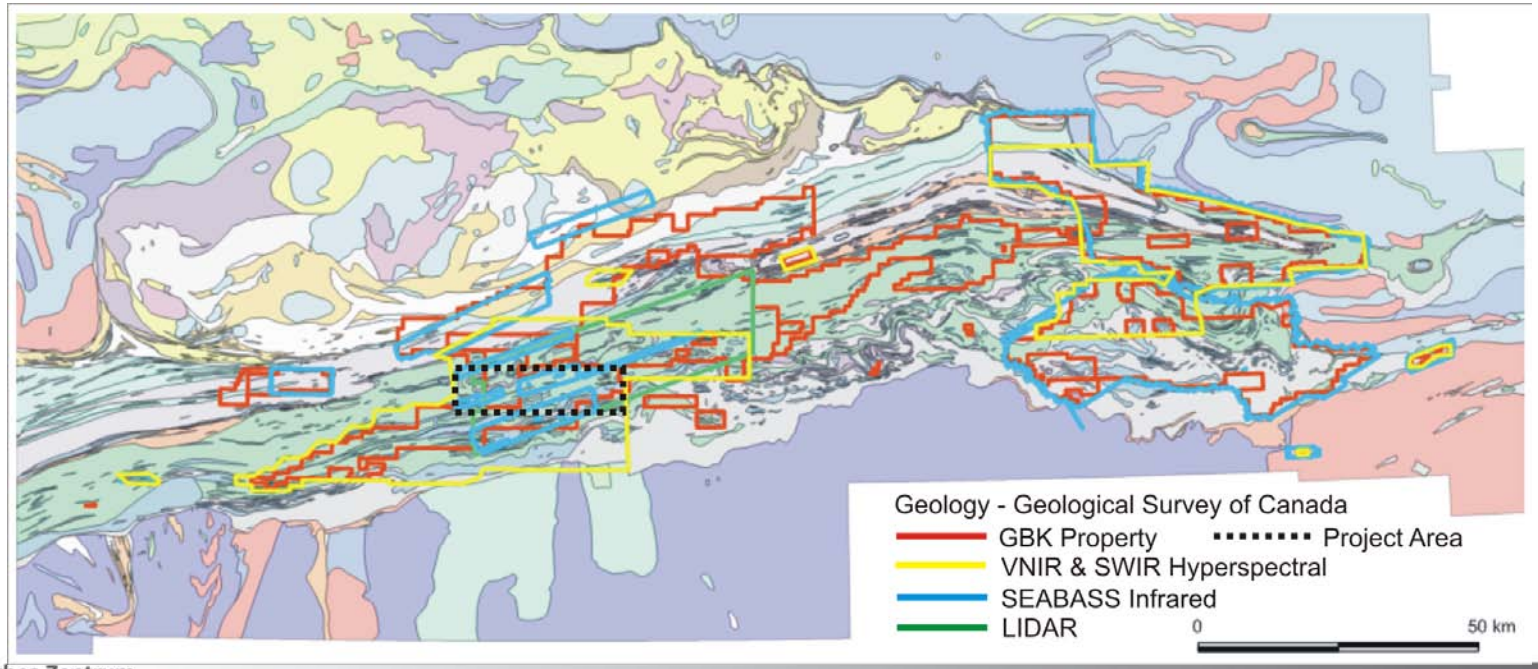
Important role in C sequestration

pH buffering

Strong retention of Al and heavy metals

Retention of pesticides and other organic chemicals

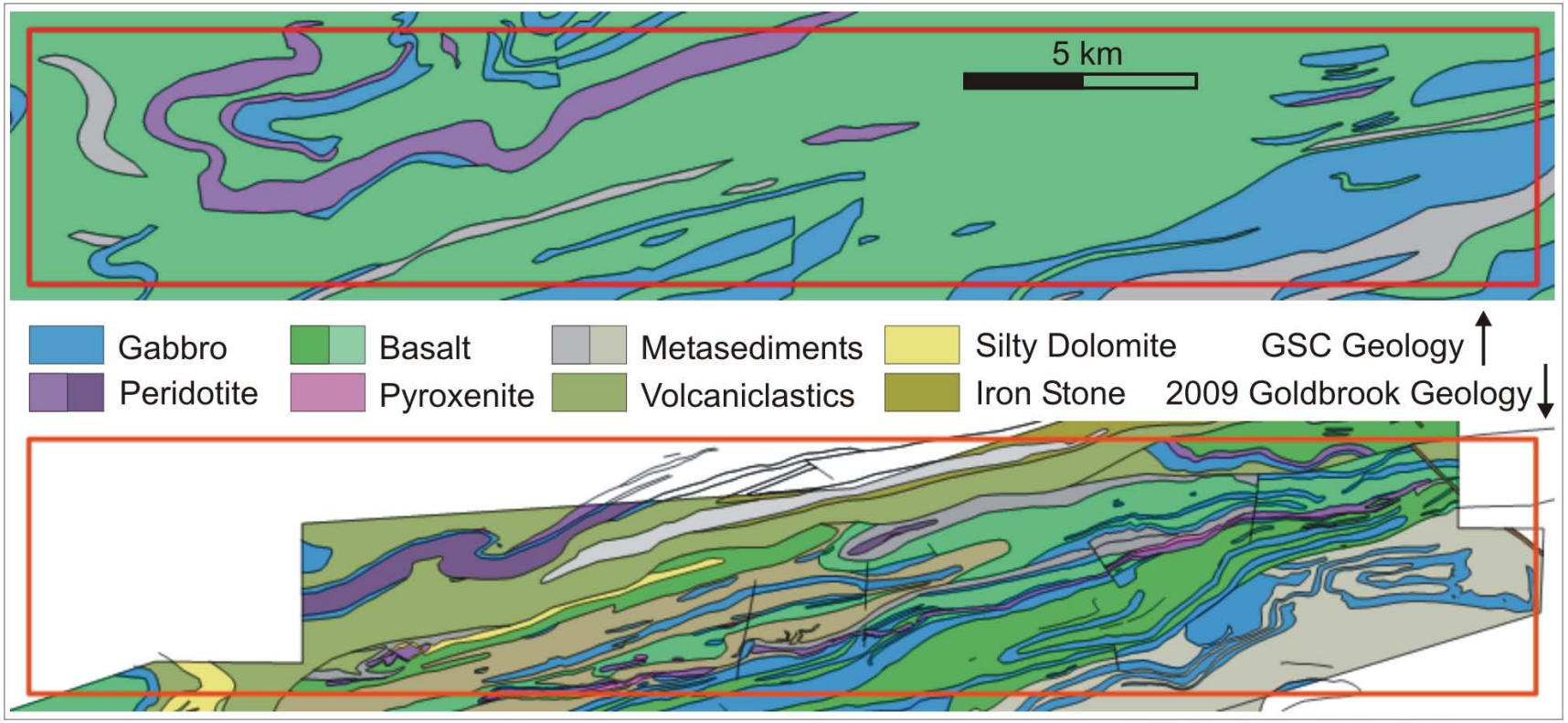

Ongava Orogen
CANADA
Hudson Straight
Project Area
Goldbrook Property
Nunavik, Quebec
60
78
100 km
74
60
70
Narsajuaq Arc
(1.86 - 1.83 Ga)
Parent/Spartan Groups
(ca. 1.86 Ga)
Povungngnituk and
Chukotat Groups
(>2.04 - 1.92 Ga)
Watts Groups
(ca. 2.00 Ga)
Superior Province
(ca. 2.80 Ga)


Geology - Geological Survey of Canada
GBK Property
Project Area
VNIR & SWIR Hyperspectral
SEABASS Infrared
LIDAR
0
50 km

Map Information Needs

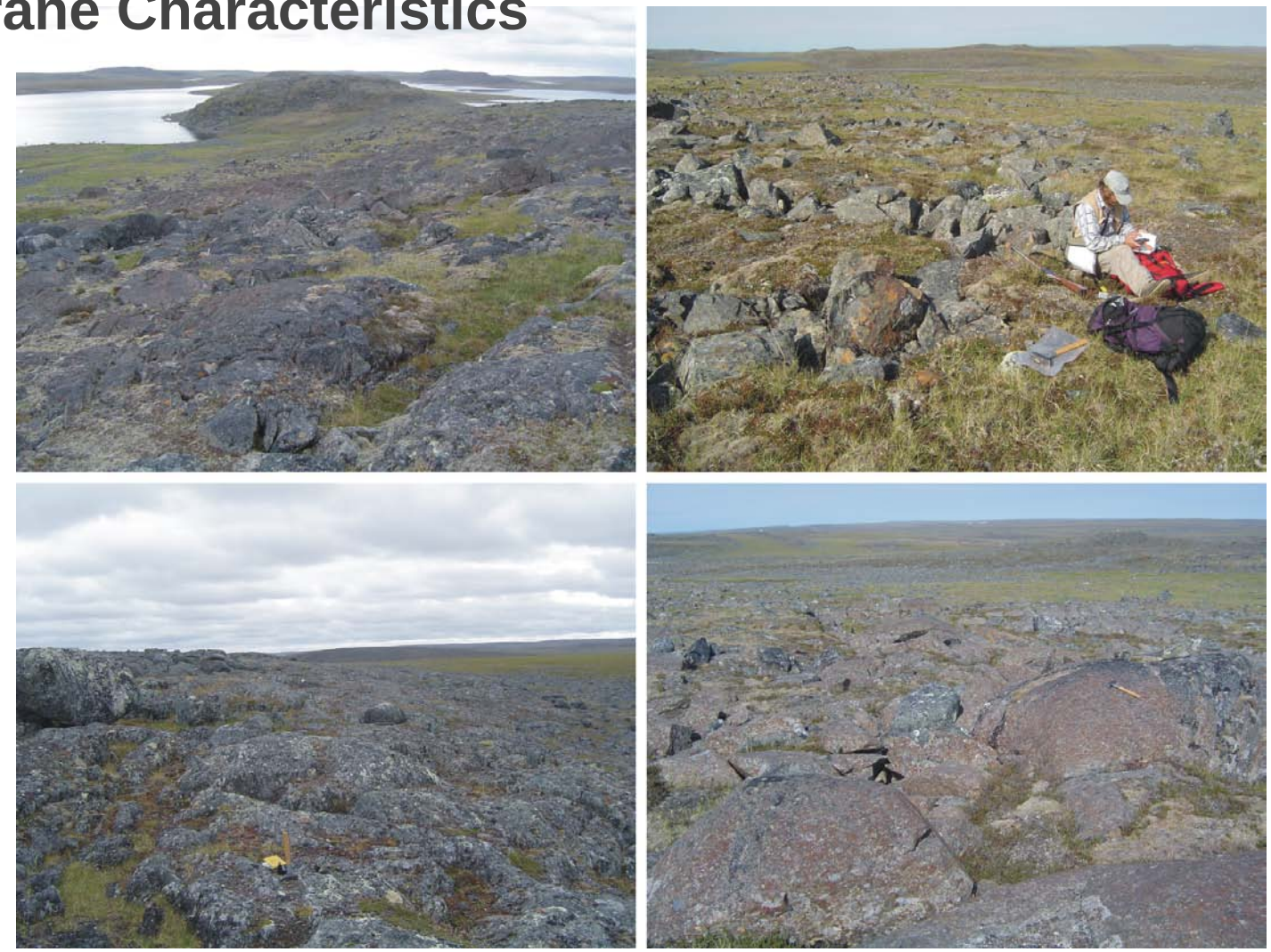
- Mineral exploration requires detailed maps
- Ore bearing horizon is peridotite
- All rocks visibly dark but differing in mineralogical detail (type and abundance)

Regional map (1980's)



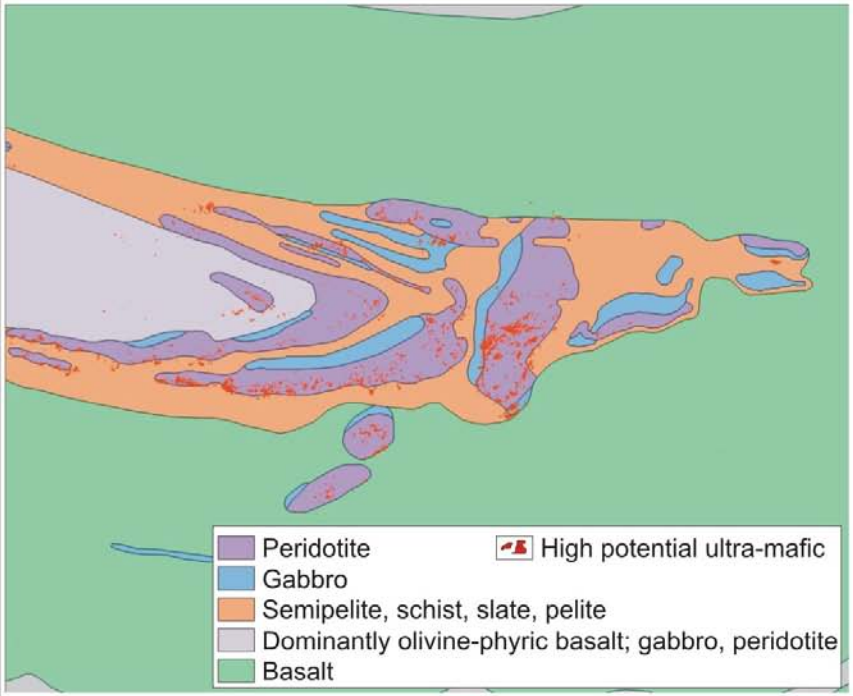
Detailed map (2009)

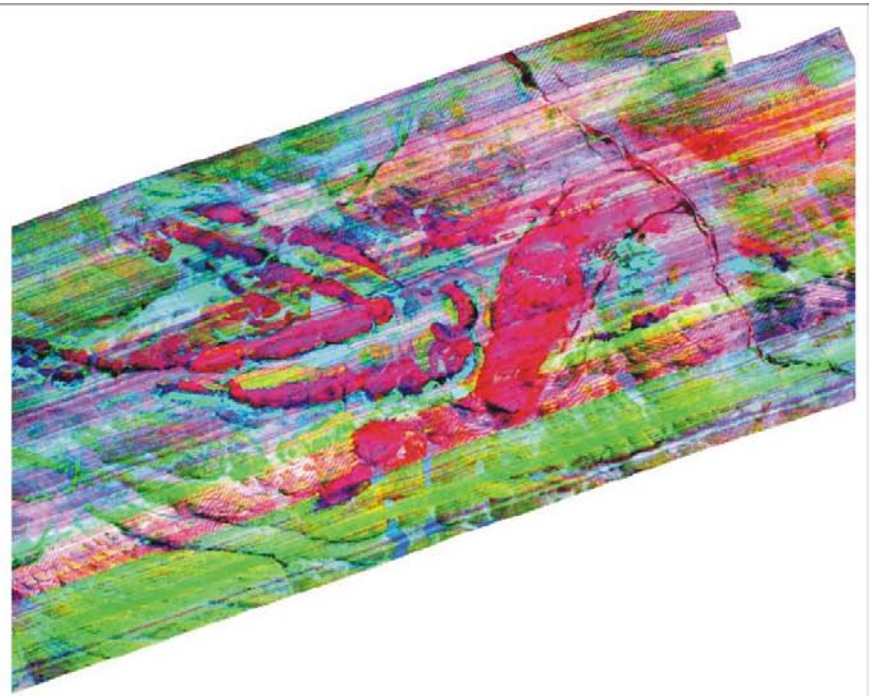
Terrane Characteristics



Frost heave, spatial continuity, lichen imparting color to bedrock

Mapping with SEBASS (4 meter data)





TES-GAP Science Objectives

- **Provide high precission 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 precurser 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

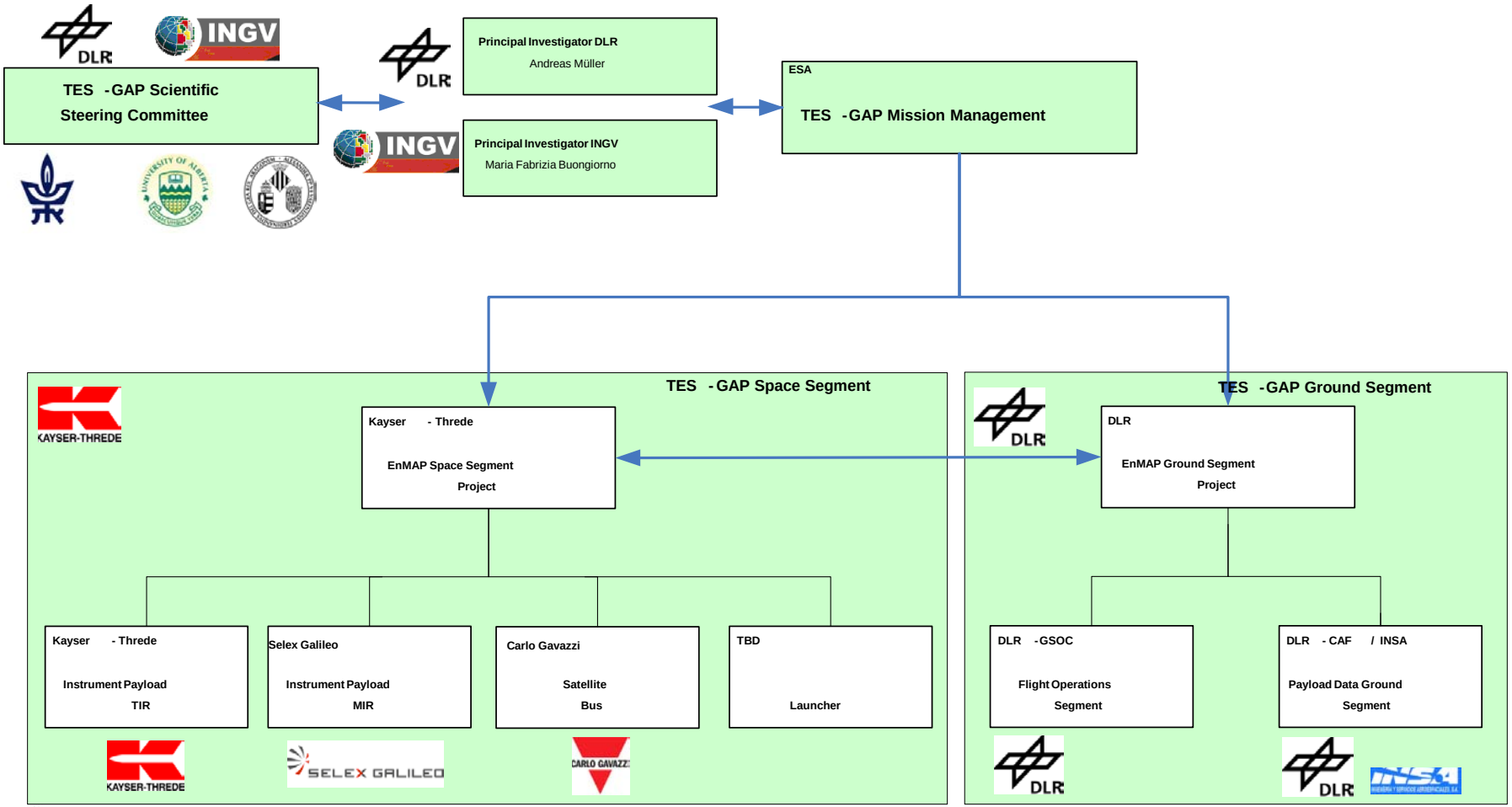
TES-GAP History & way forward

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

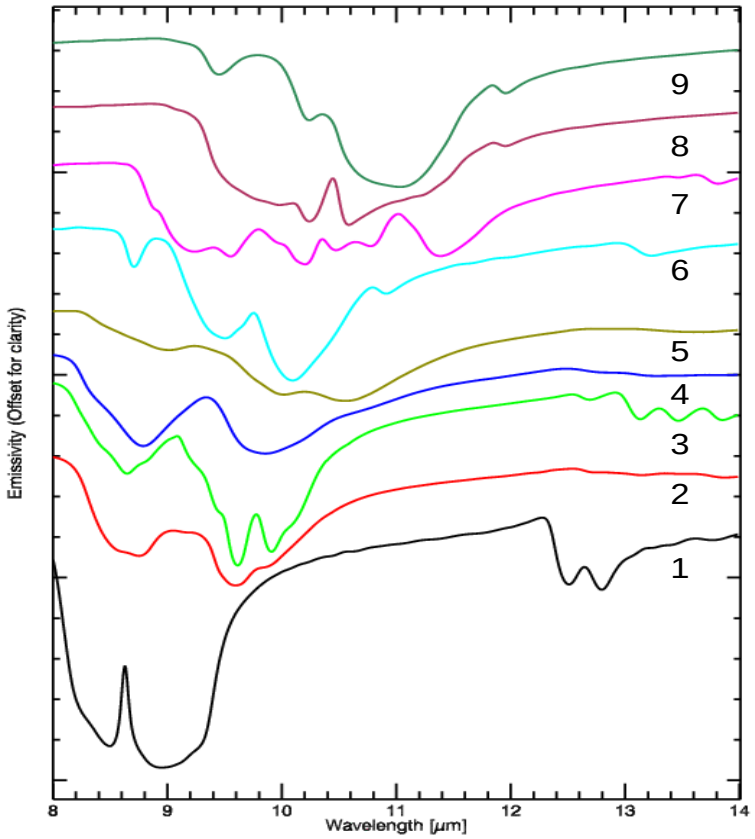
TES-GAP - Proposal Team

- Andreas Müller, Dr. Tobias Storch, German Aerospace Center (DLR)
- Dr. Maria Fabrizia Buongiorno, Istituto Nazionale di Geofisica e Vulcanologia (INGV)
- Dr. Timo Stuffler, 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

Proposed Mission Organisation



Thermal Signatures of Minerals



9) Forsterit
8) Olivin
7) Pyroxen
6) Hornblende
5) Labradorit
4) Oligoklas

Basalt

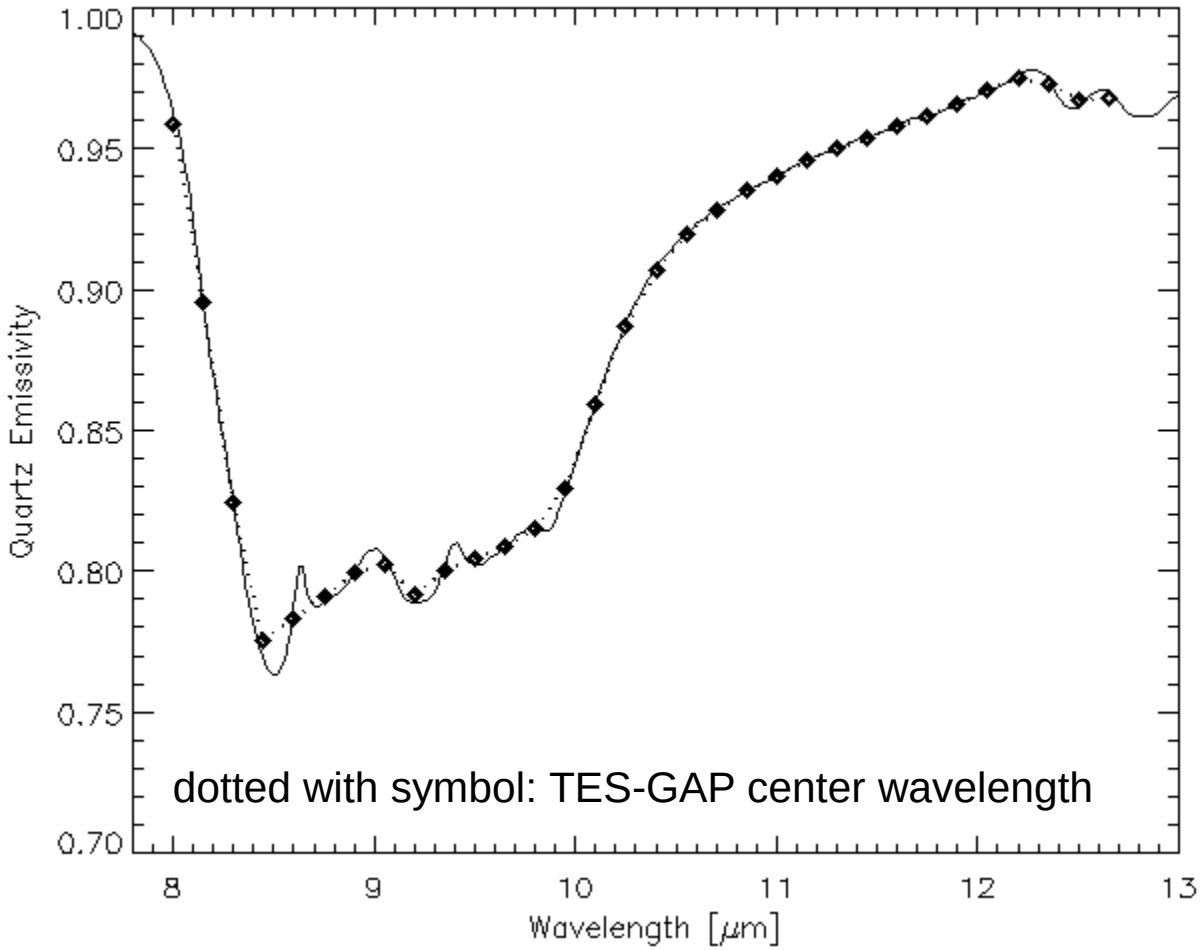
3) Albit
2) Orthoklas
1) Quarz

Granites

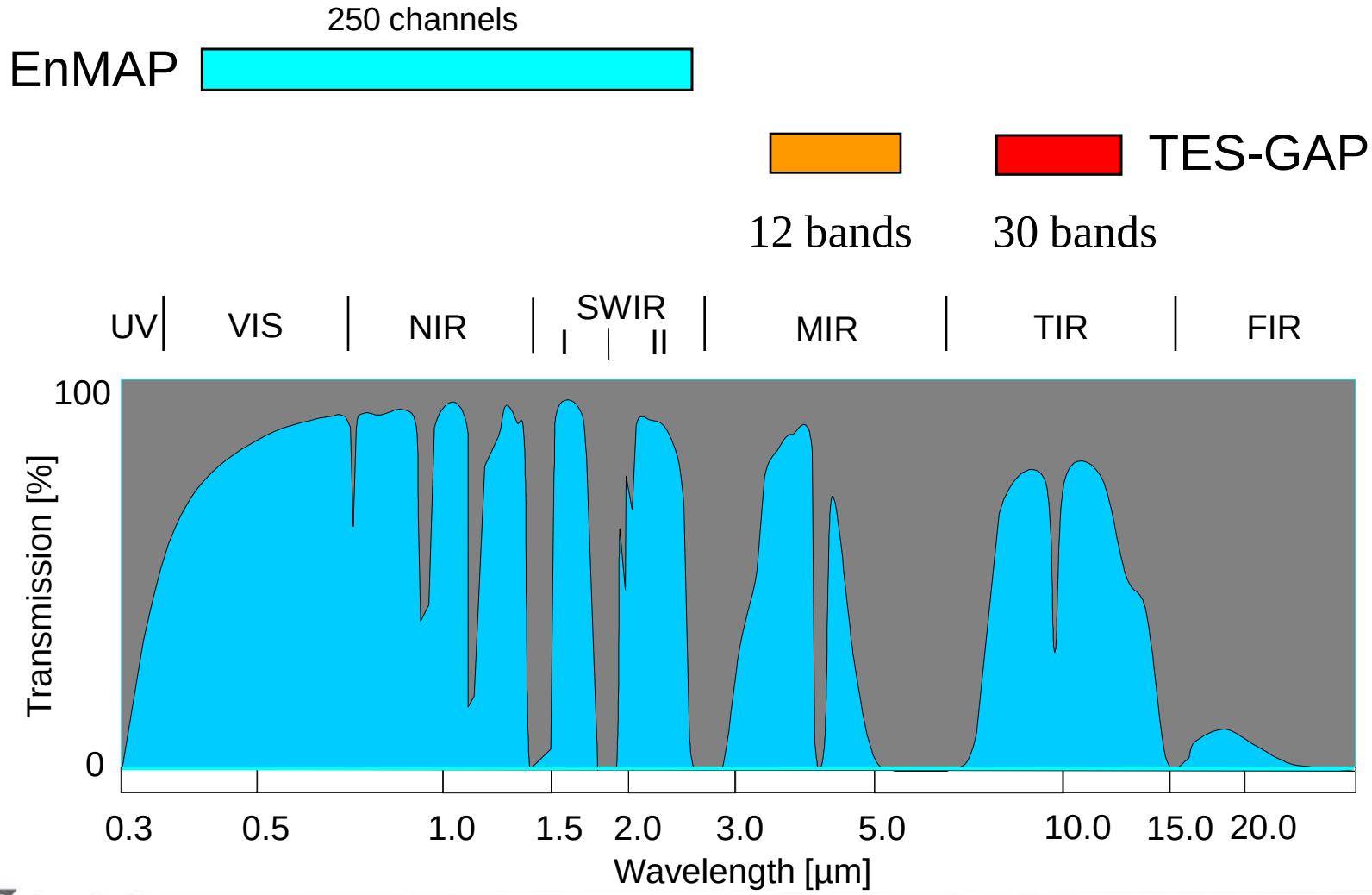
Rock forming Minerals

H. Kaufmann, GFZ

Instrument Requirements Simulations

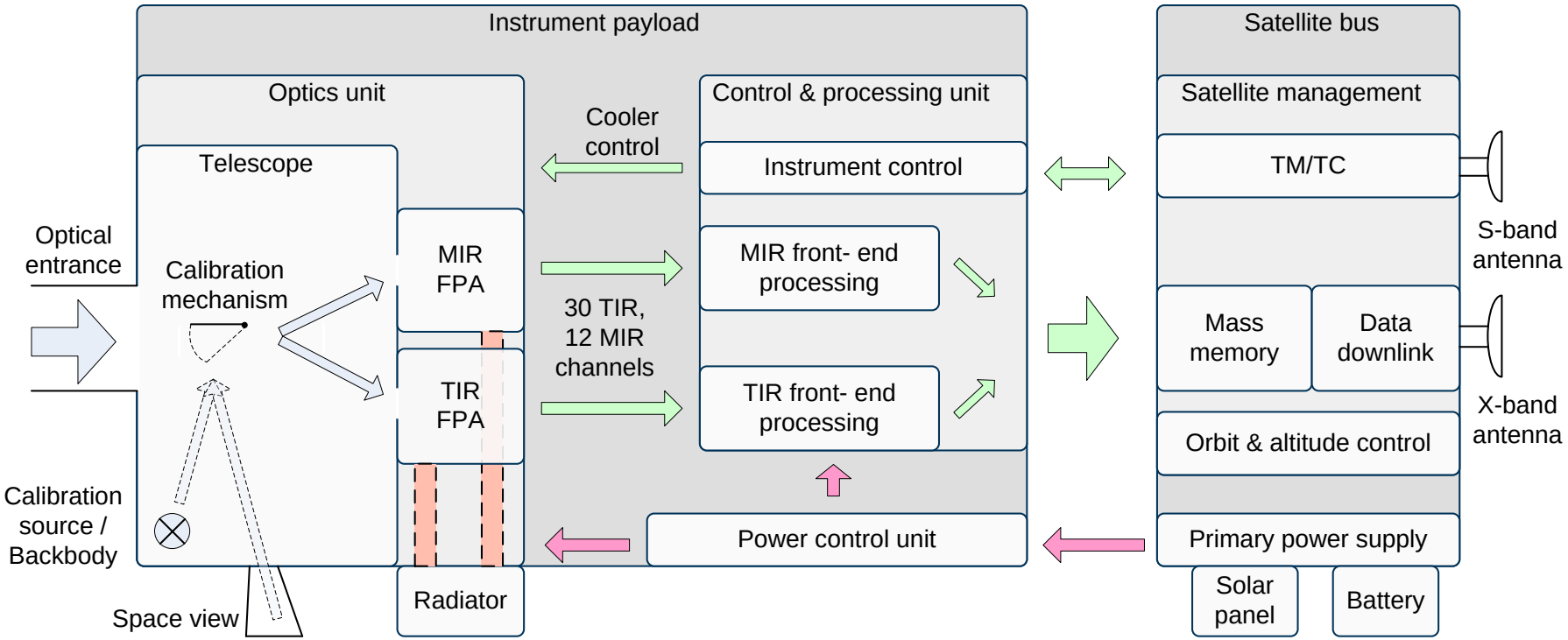


Spectral Coverage

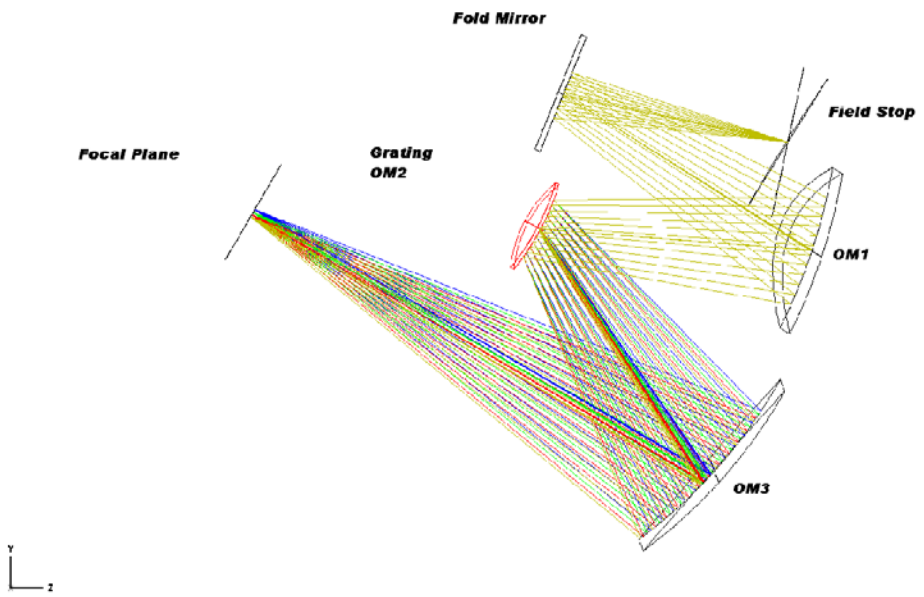


Preliminary TES-GAP Instrumentation / Mission Requirements

- MIR Radiometer Spectral and Radiometric Requirements
  - Coverage: 3-5 µm
  - No. of bands: ~12 , bandwith: ~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, bandwith: ~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


Instrument payload
Optics unit
Telescope
Optical entrance
Calibration mechanism
MIR FPA
TIR FPA
Calibration source / Backbody
Space view
Radiator
Cooler control
30 TIR, 12 MIR channels
Control & processing unit
Instrument control
MIR front- end processing
TIR front- end processing
Power control unit
Satellite bus
Satellite management
TM/TC
S-band antenna
Mass memory
Data downlink
X-band antenna
Orbit & altitude control
Primary power supply
Solar panel
Battery

TIR Instrument Design



3D LAYCUT

ILRM
MON MAY 3: 2010

KAYSER-THREDE
MUNICH

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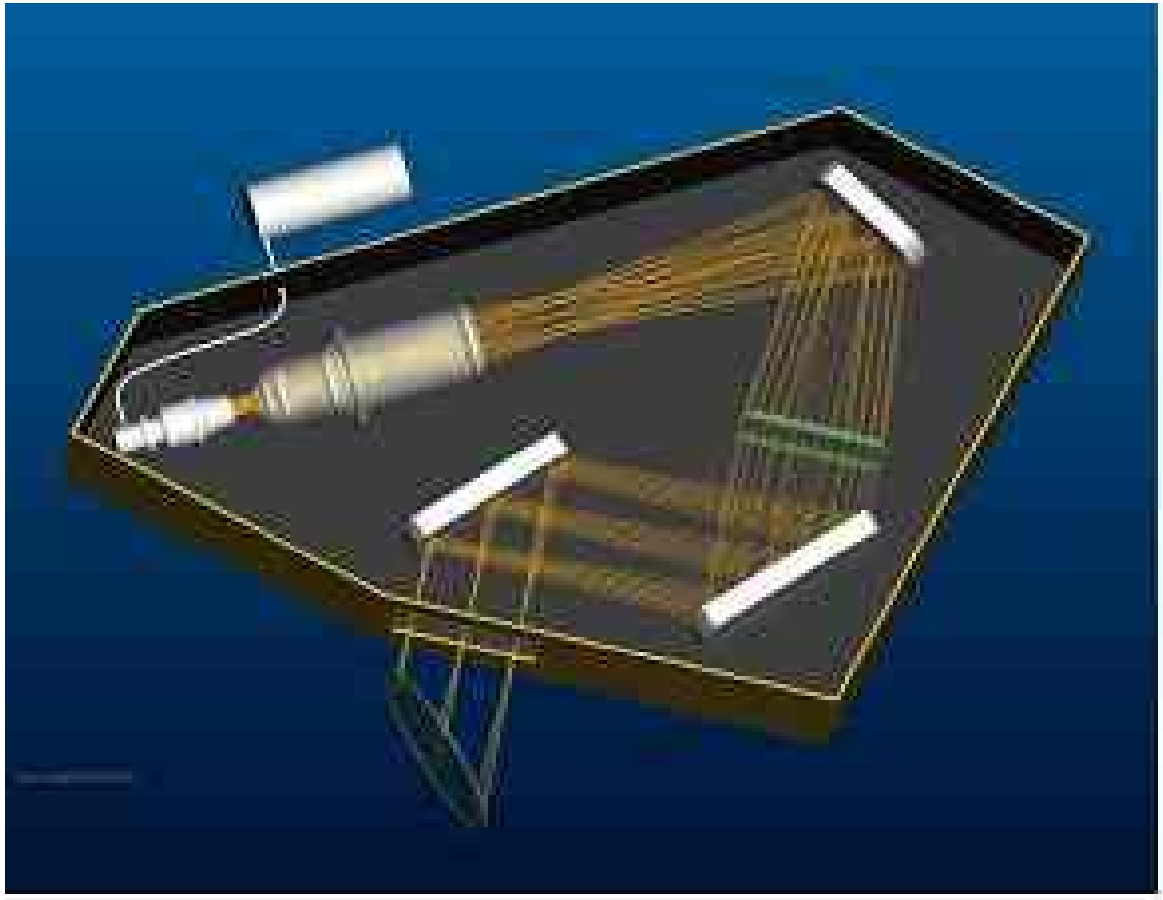
CONFIGURATION 1

MIR Instrument design



TES-GAP Bus & Orbit

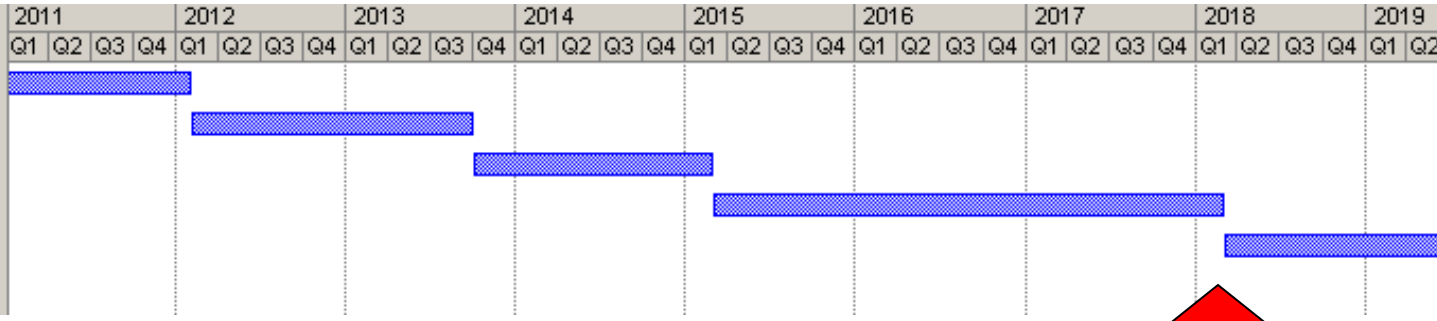
- MITA (Carlo Cavazzi)
- 500 kg total mass
- lifetime of 3 to 5 years
- communication downlink in S- and X-band
- data rate 320 Mbit/s, X-Band
- 400 W electrical power (EOL)
- mass memory 512 Gbit

Orbit (identical to EnMAP)

- sunsynchroneous
- altitude of 640 km
- inclination angle 98°
- Equator crossing at 10:30 LTDN

Mission Schedule

TES-GAP	Start	End
Phase A	Sa 01.01.11	Mo 30.01.12
Phase B	Mi 01.02.12	Mo 30.09.13
Phase C	Di 01.10.13	Sa 28.02.15
Phase D	So 01.03.15	Mi 28.02.18
Phase E	Do 01.03.18	Di 28.02.23
Phase F	Mi 01.03.23	Fr 28.04.23



Launch 2018

Summary and Comparison to HyspIRI

	HyspIRI	EnMAP	TES-GAP
Specral Coverage	VSWIR/MIR/TIR	VSWIR	MIR/TIR
Spectral Bands	200+/1/7	200+	~12/30
Spatial Resolution	60 m2	30m2	60-90m2
Swath Width	150km/500km	30km	50-60km
Revisit Time	19 d	24d	~ 20 d
Coverage	Global	Regional	Regional
Purpose	Global Monitoring	Process Understanding	PU + Reginal Monitoring
Lifetime	3 years	5 years	5 years
Est. Launch Date	2021	2014	2018
Propability	-> HyspIRI Team	high	1:30

EnMAP
Hyperspectral Imager

TES GAP

thank you for your attention!

Cost Estimate

ID	Mission Element	Costs [MEUR]	Comments
01	Satellite Bus	28	
02	Instrument Payload MIR/TIR	55	
03	Launcher	tbd	excluded
04	Ground Segment	12	operations and generic elements excluded
05	Margins	5	
Sum		100	