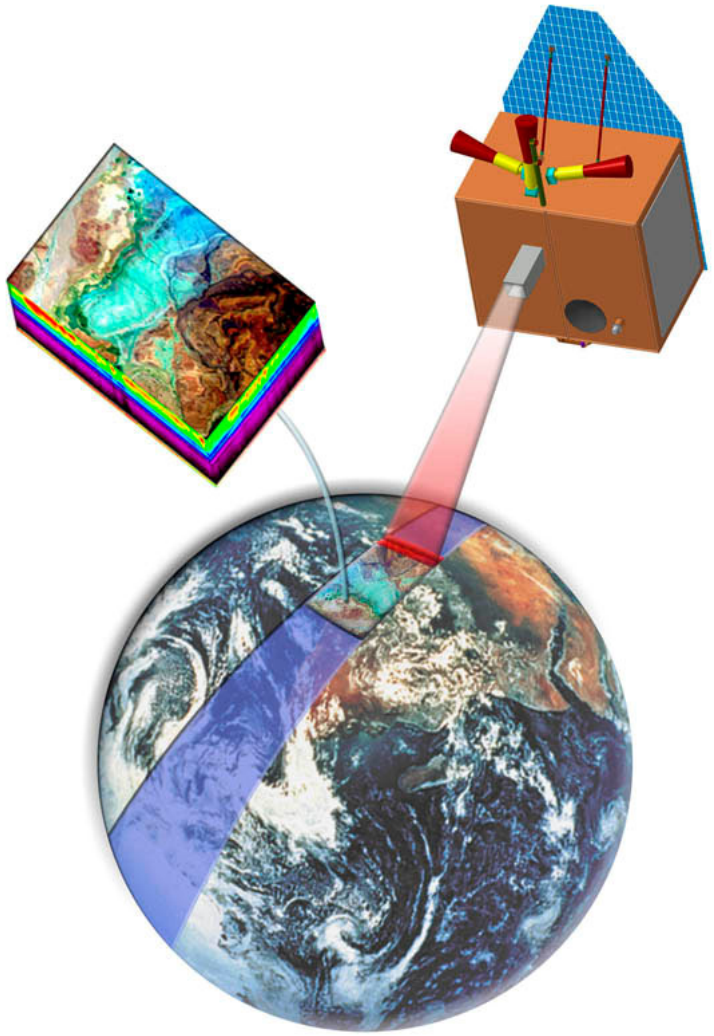
EnMAP
Hyperspectral Imager

Environmental Mapping and Analysis Program

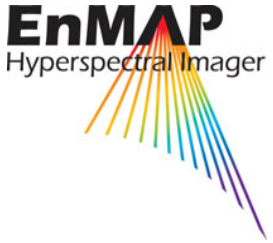


The EnMAP Mission

Timo Stuffler

CEOS WGISS-24, 17.10.07, DLR Oberpfaffenhofen

Overview



Programmatic of the EnMAP mission

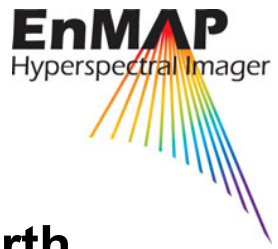
Background hyperspectral measurements

EnMAP HIS & mission

Internationalisation of EnMAP

Summary & Outlook

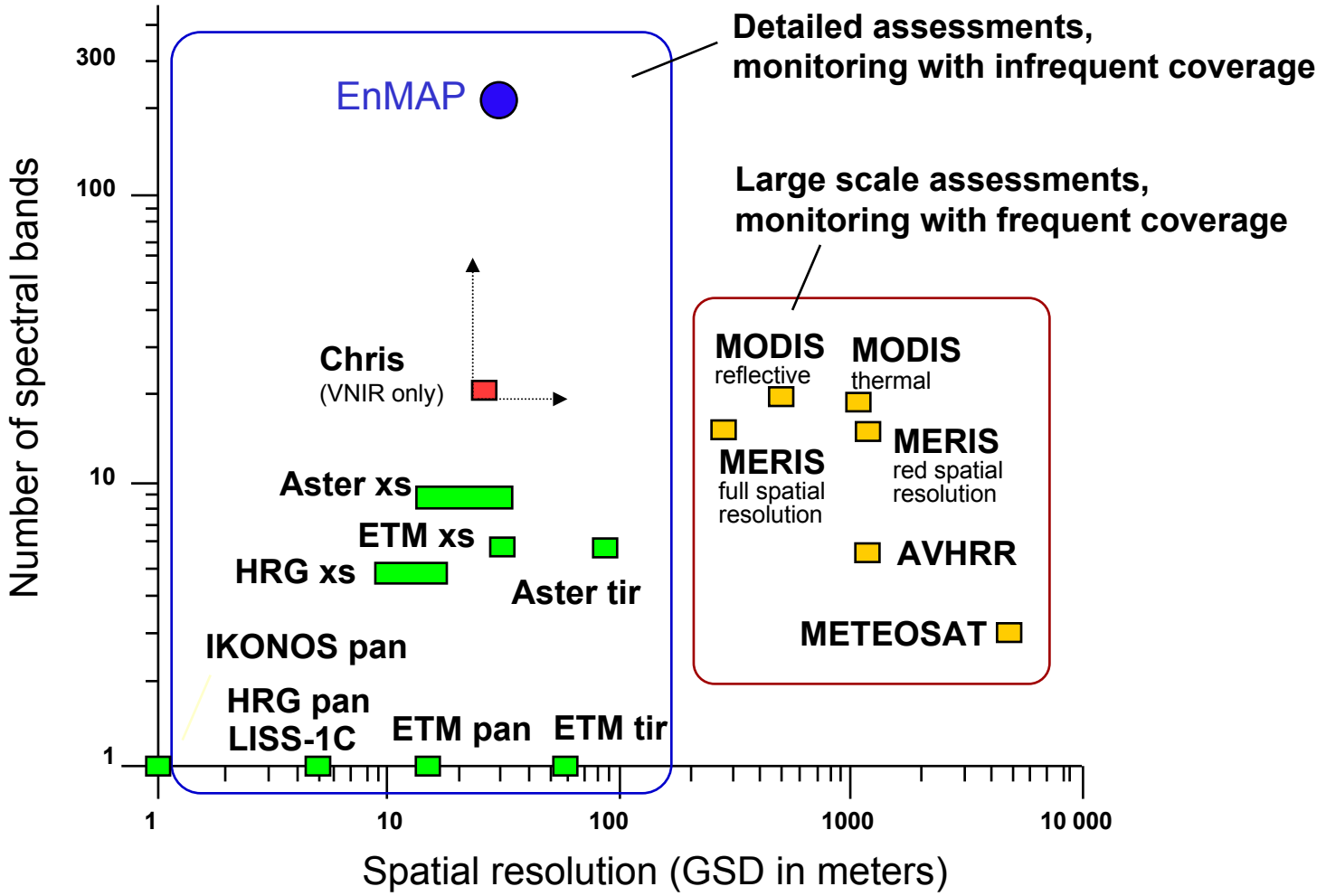
Background for the EnMAP Mission



- In 2003 DLR-Agency started a selection process for a future Earth observation missions
- 9 different missions have been proposed
- 2 out of 9 have been selected for phase A studies in 2004, one of them: EnMAP
- Phase A study for EnMAP accomplished successfully end of 2005

  => selection for implementation
- EnMAP boundary conditions:
  - financial budget € 60 Mio
  - Running phase B finished by the end of 2007
  - envisaged launch date 2011

EnMAP in Comparison with other Optical Sensors



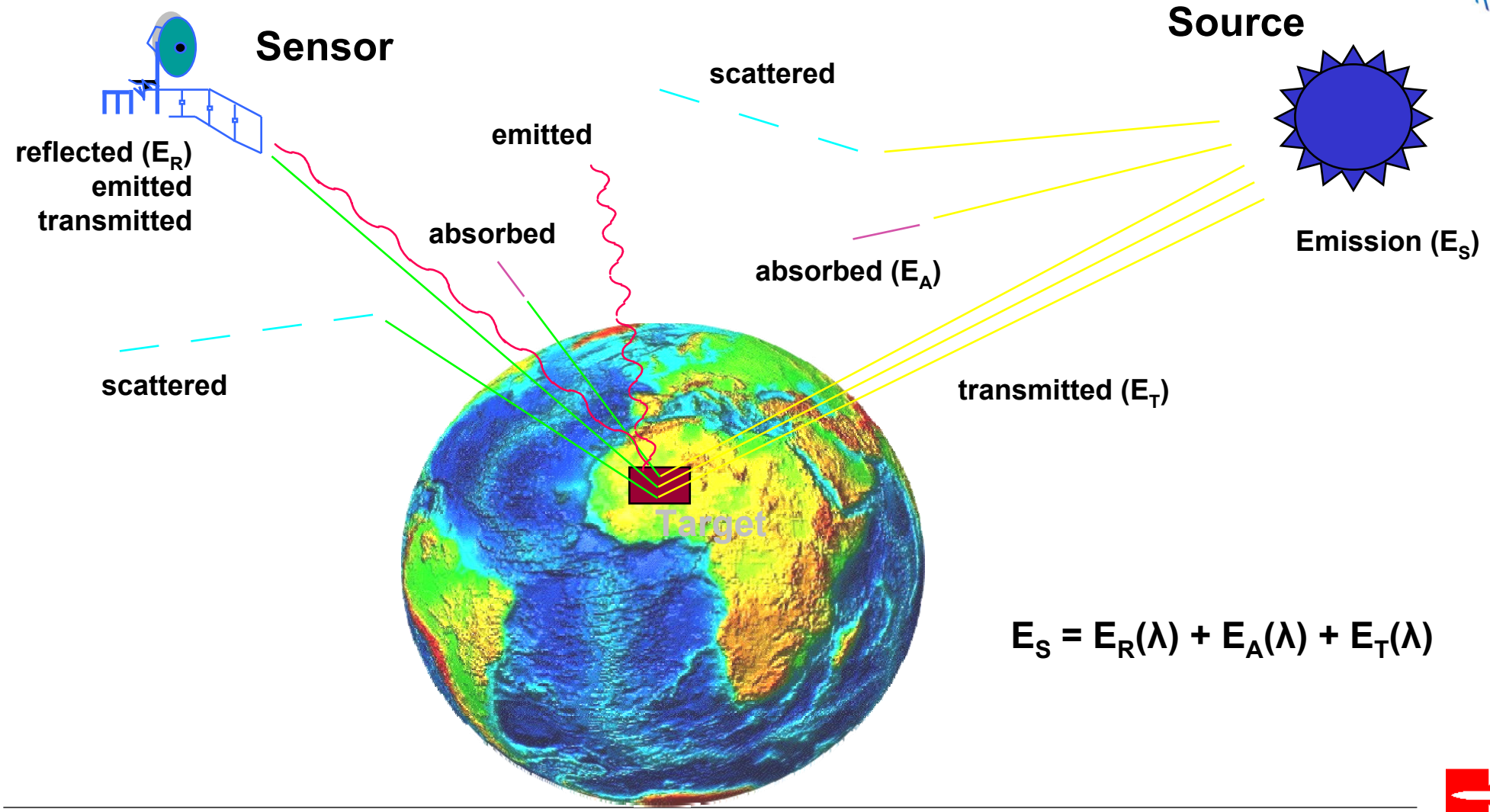
Overall Mission Goals

EnMAP Hyperspectral Imager

- To provide high-spectral resolution observations of bio-geochemical and geophysical variables
- To observe and develop a wide range of ecosystem parameters encompassing agriculture, forestry, soil/geological environments and coastal zones/inland waters
- 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

Optical Earth Observations

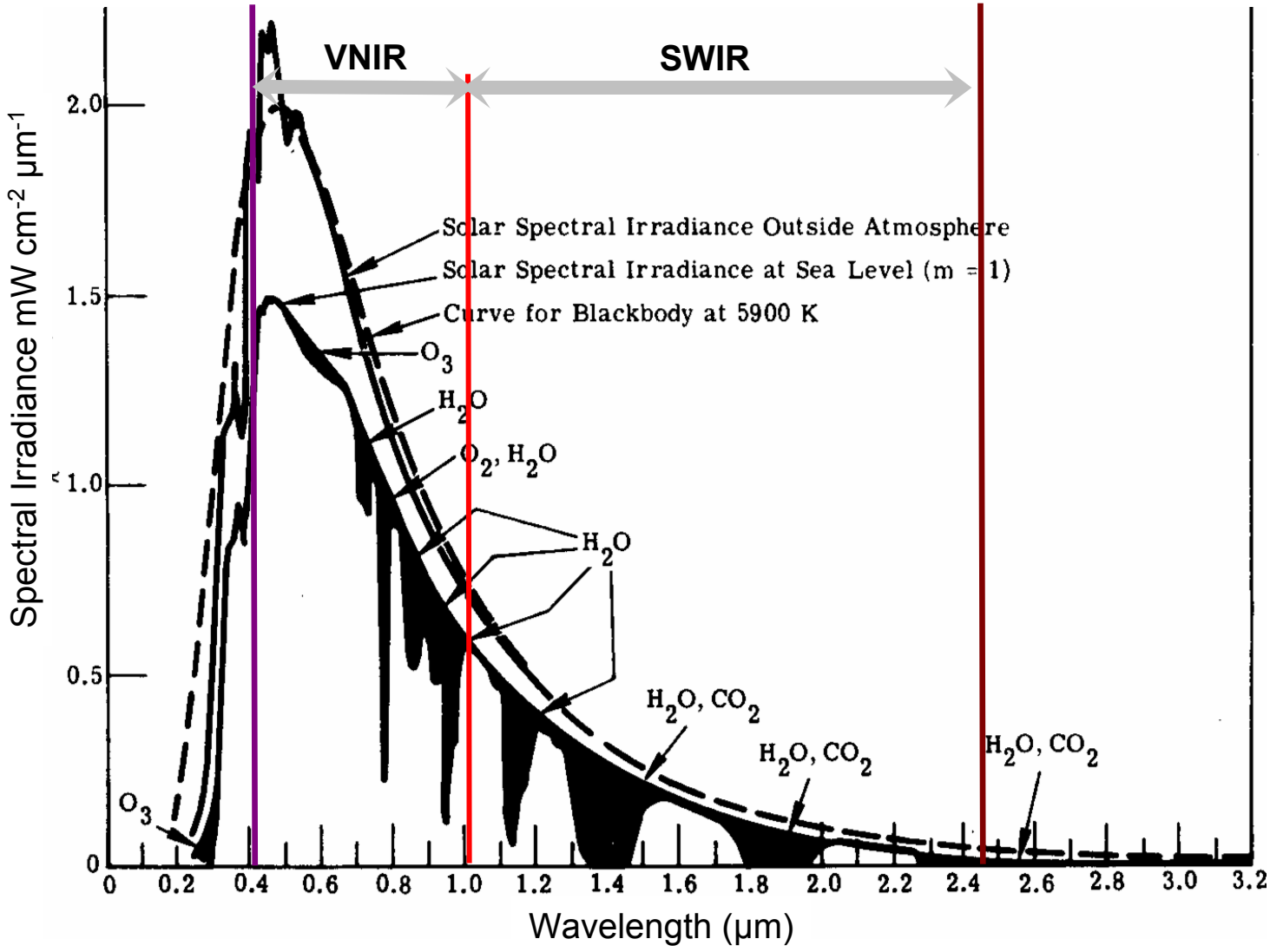
EnMAP Hyperspectral Imager



$$E_S = E_R(\lambda) + E_A(\lambda) + E_T(\lambda)$$

Irradiation from the sun

EnMAP Hyperspectral Imager



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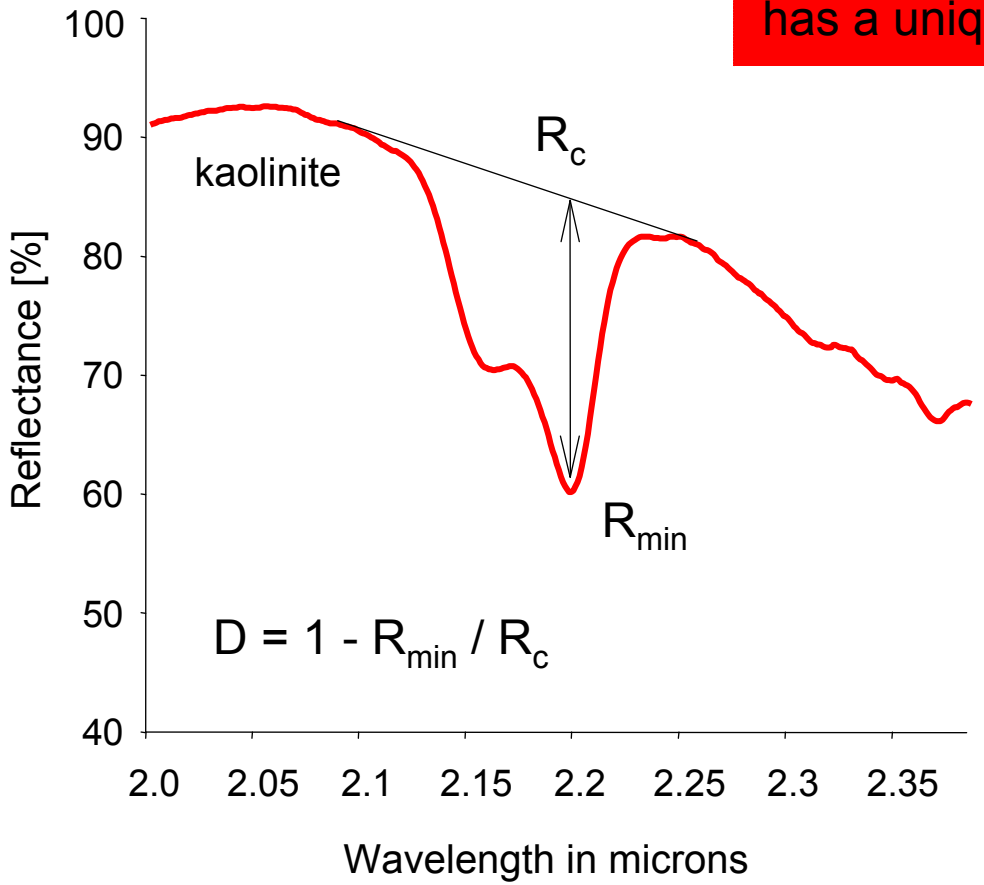
Identification/Quantification => Diagnosis

EnMAP Hyperspectral Imager

Each material on the Earth´s surface has a unique spectral characteristic



Individual Absorptions

of pigments, minerals, man made objects

Shape
Position
→ Identification

Depth → Quantification

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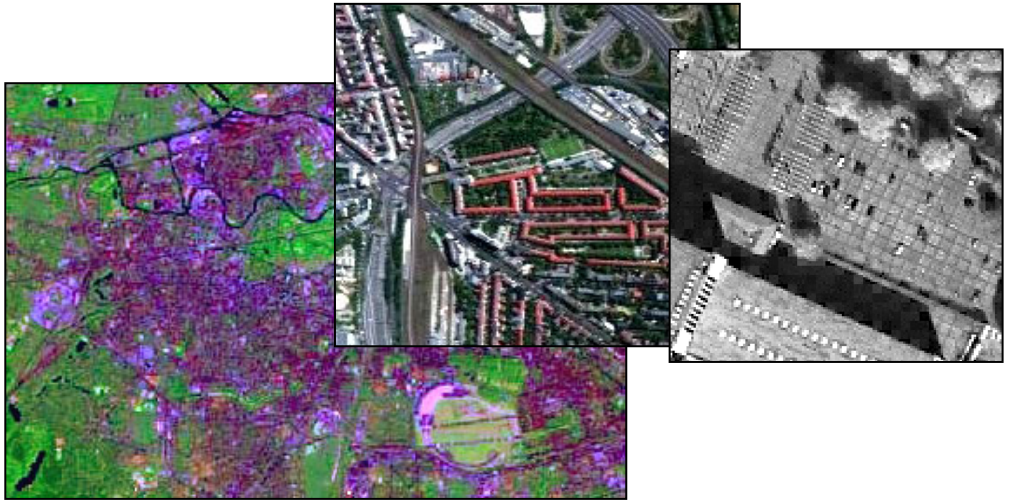
EO Scenario – 30 years of tech. Development

EnMAP Hyperspectral Imager

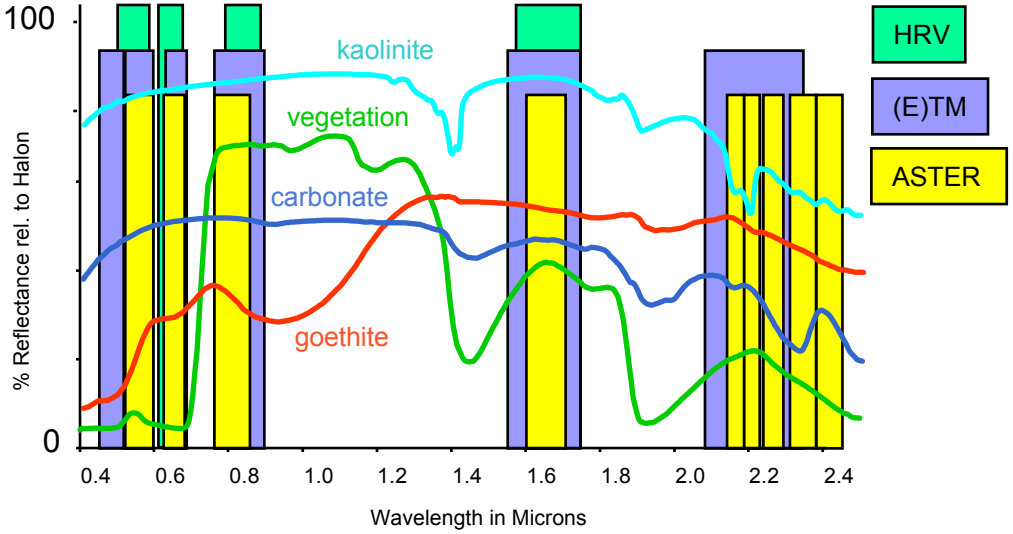


Spatial Resolution

MSS (80m) -> Ikonos (1m)

More details discernable

Benefits: pattern recognition/DTMs



Spectral Resolution

SPOT/HRV (3/5 opt. bands)

-> Landsat/TM (6 opt. bands)

-> ASTER (9 opt. bands

Not sufficient for identification of most surface materials

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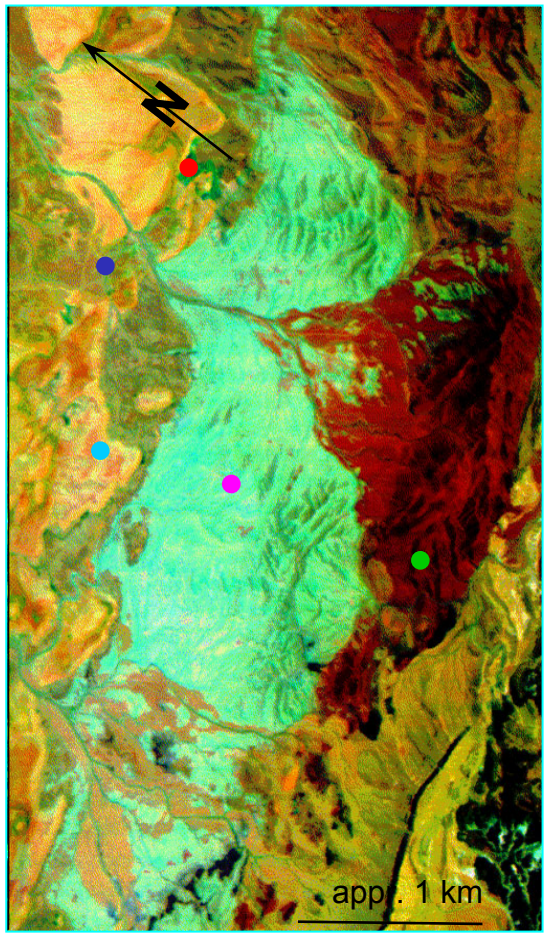
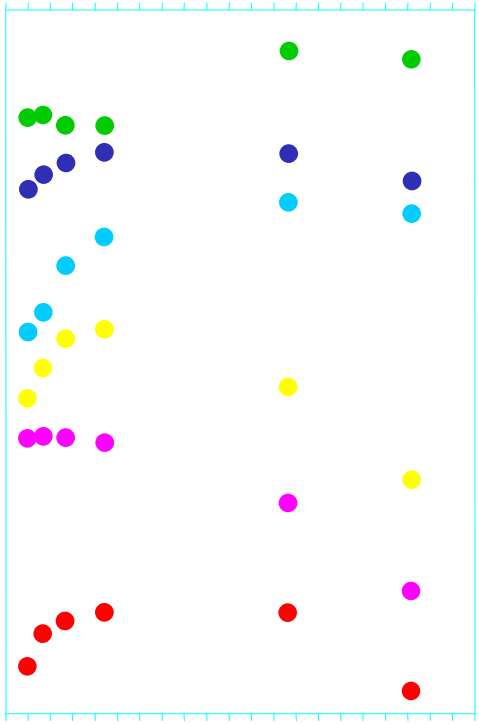
Multi- versus Hyper-spectral / Potentials

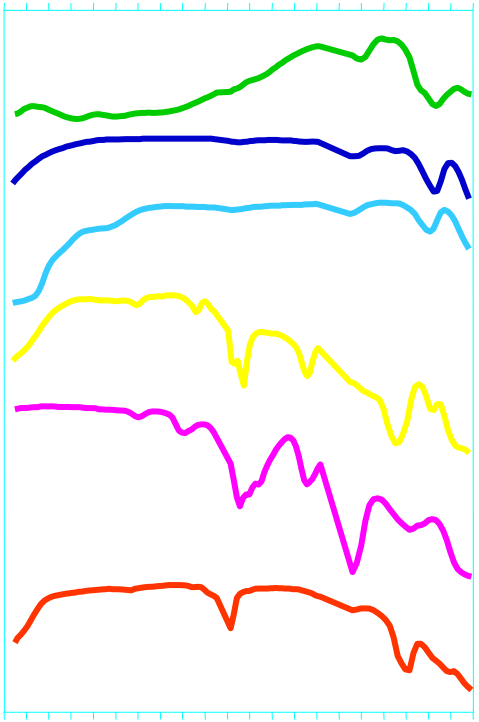


Makhtesh Ramon
color composite of bands 1, 20, 48

Multi-spectral



Hyper-spectral



Few fixed bands

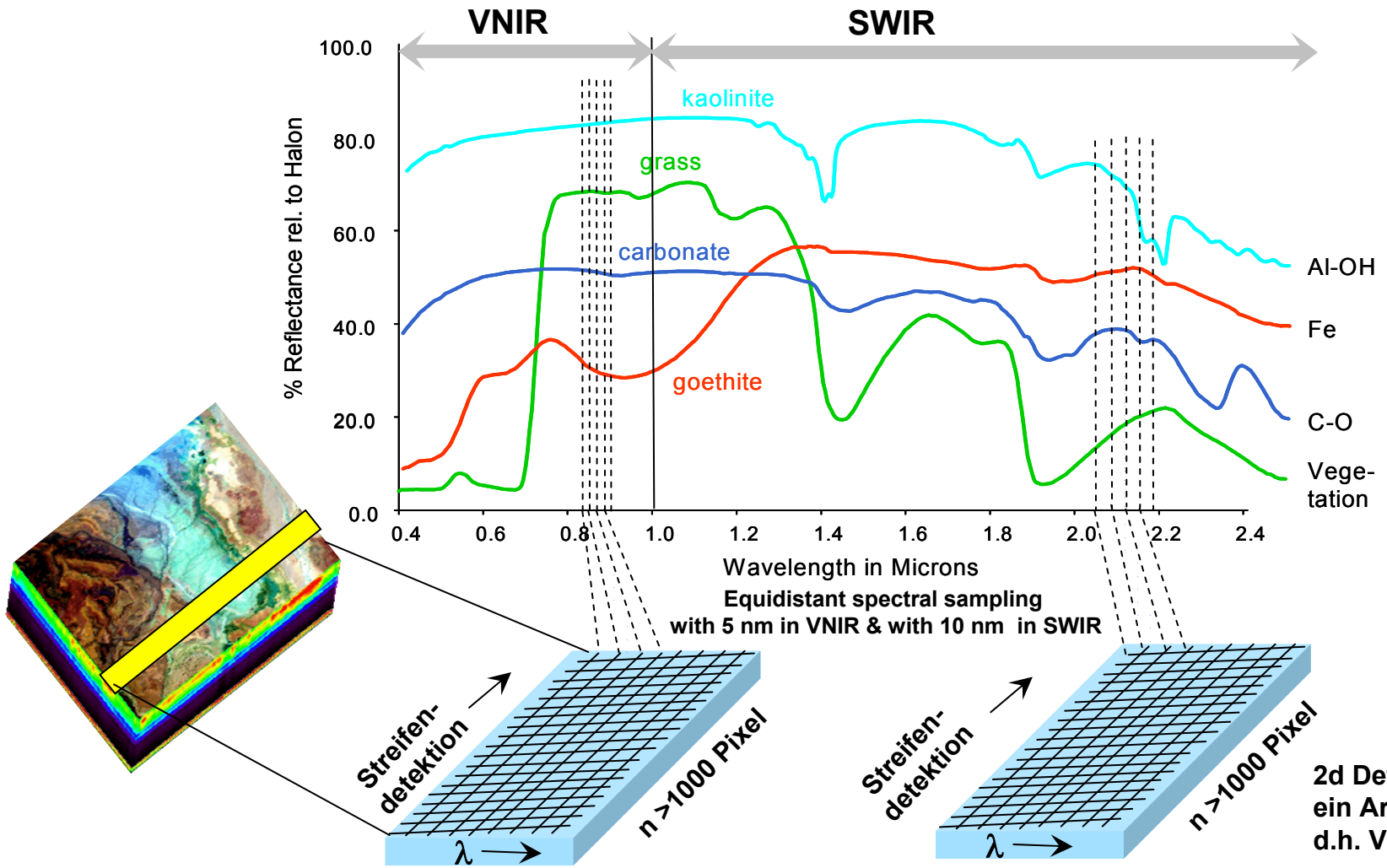
- minimum identification
- field knowledge and lab analysis required
- low confidence

Continuous bands

- maximum identification
- increased classification accuracy
- high confidence

Hyperspektrale Messungen

EnMAP Hyperspectral Imager



VNIR Detektor, CCD

SWIR Detektor, MCT

2d Detektor Arrays,
ein Array für jeden Bereich,
d.h. VNIR & SWIR

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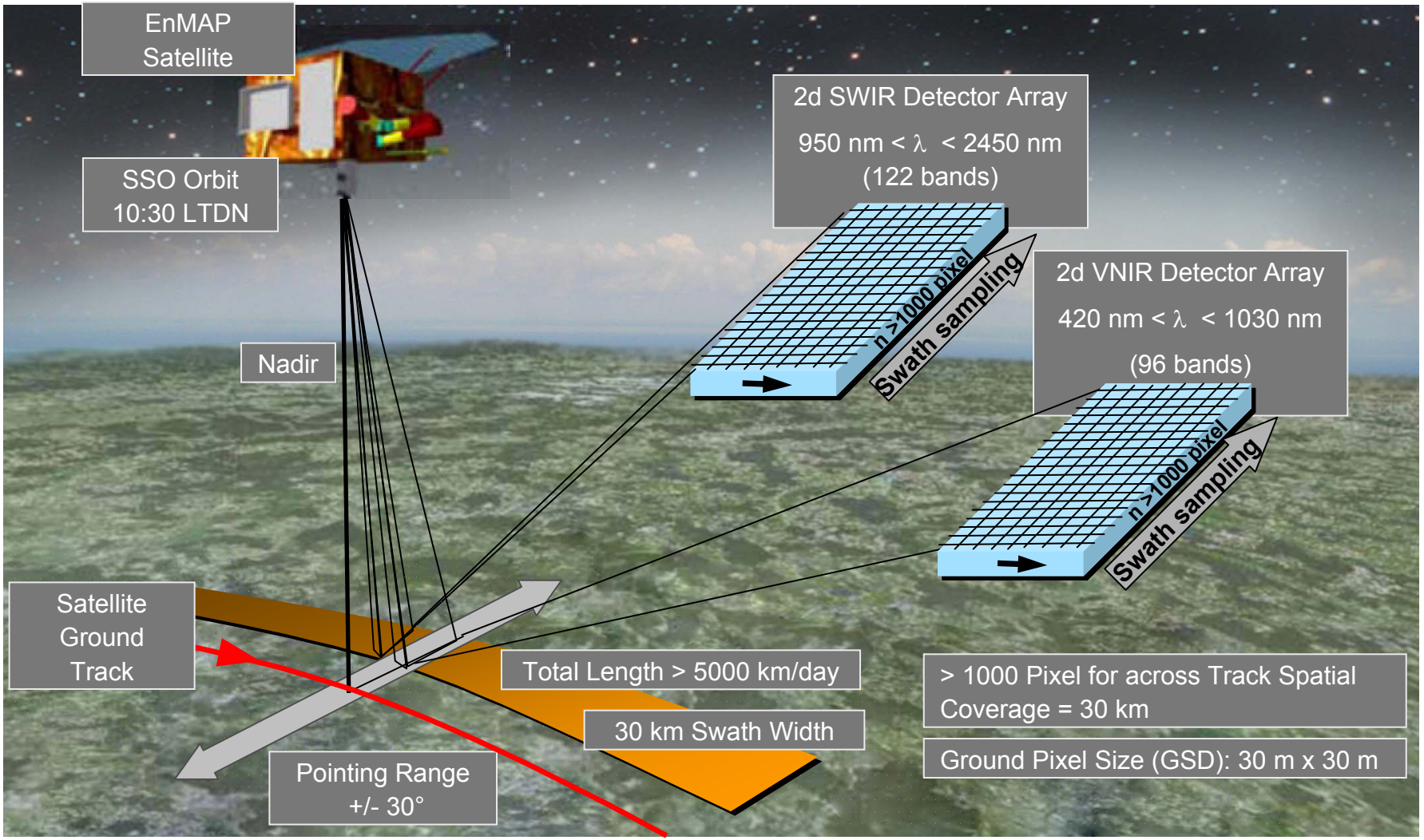
Spectral Imaging from a Satellite

EnMAP Hyperspectral Imager



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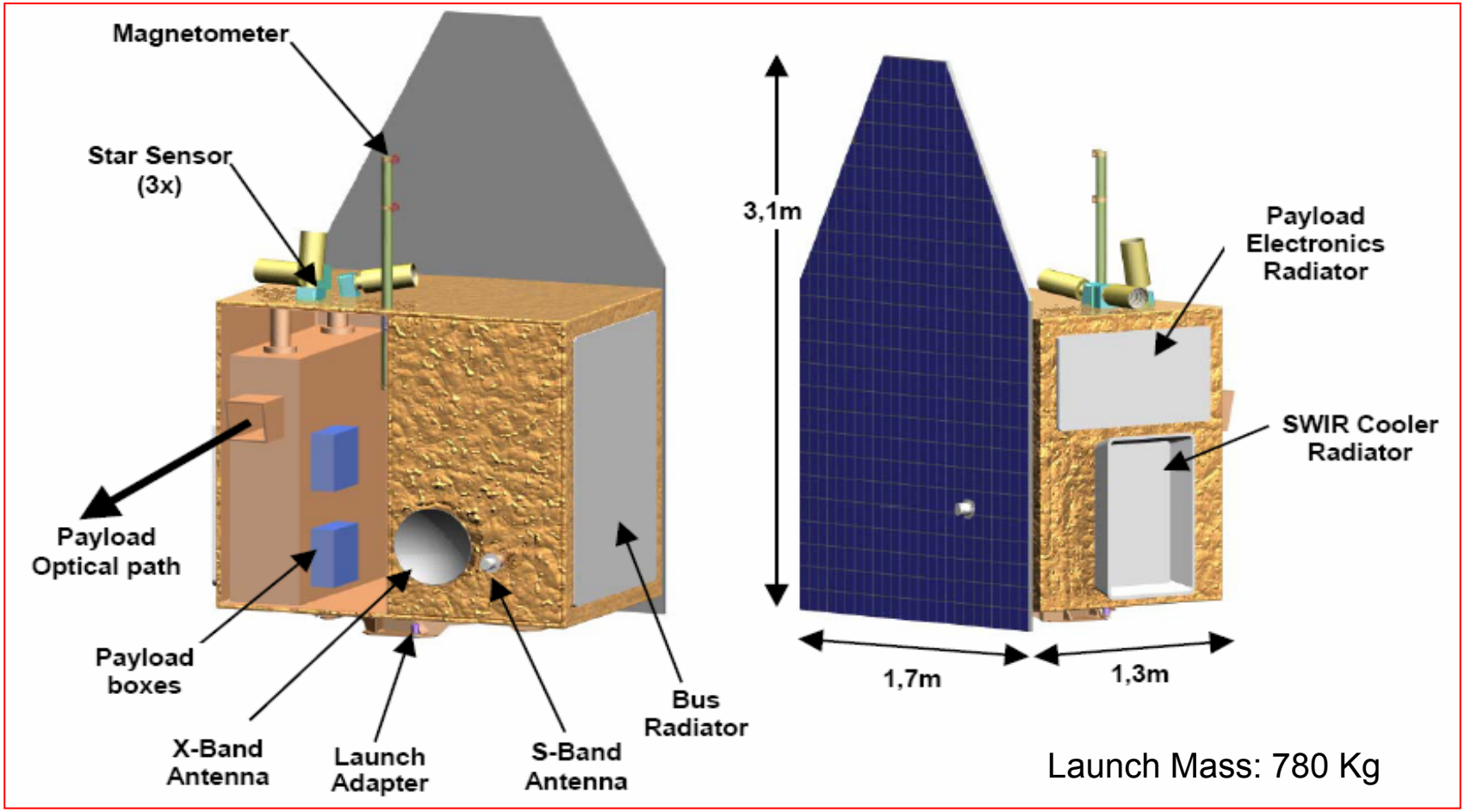
Space Segment Outline

EnMAP Hyperspectral Imager



EnMAP Satellite Model & Sticker

EnMAP Hyperspectral Imager

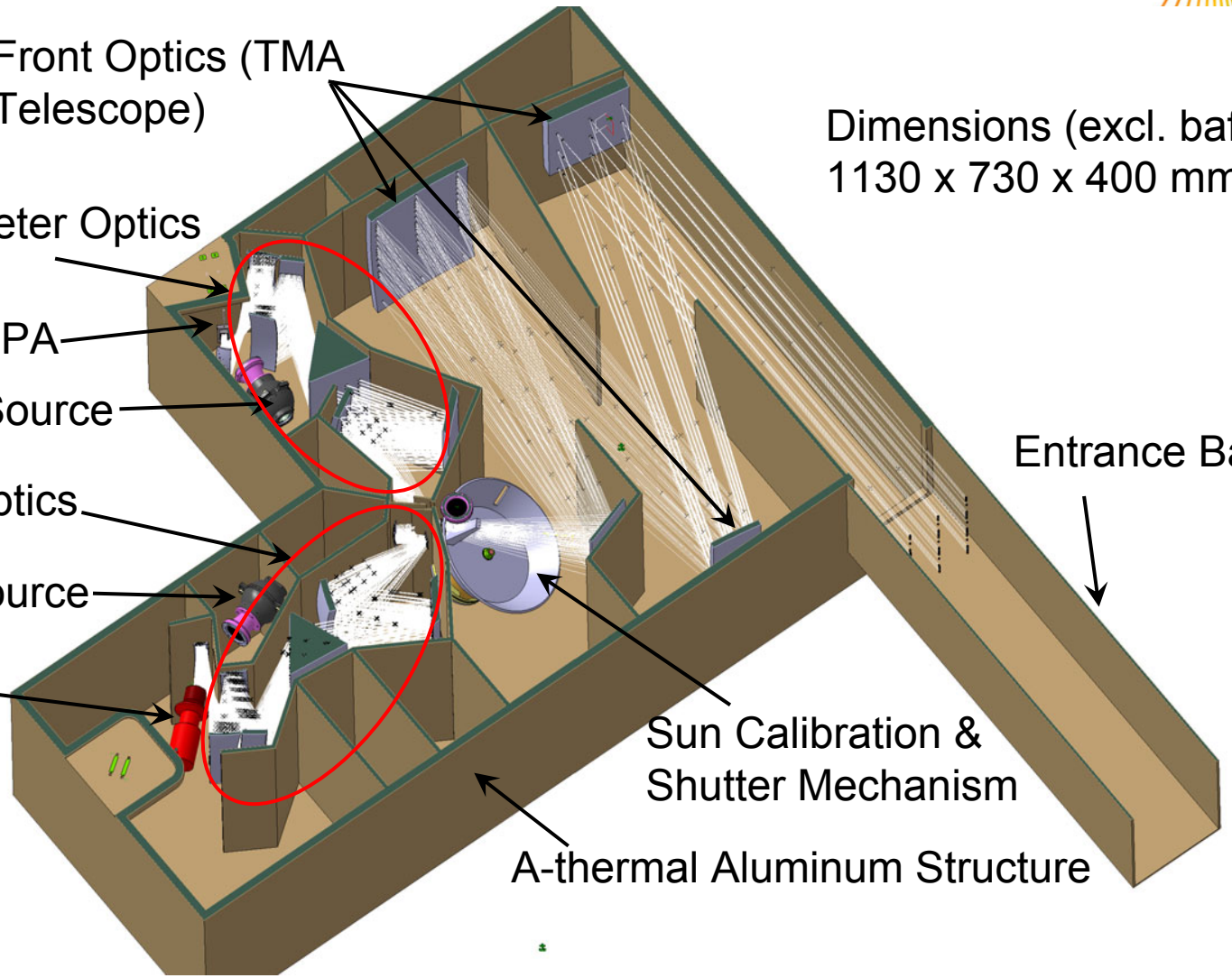
Mission Parameters

EnMAP Hyperspectral Imager

	Requirements
Coverage	Global coverage in near nadir mode (≤ 5°); Polar caps may be excluded
Target revisit time	4 days with pointing capability
Pointing capability	± 30° cross-track pointing
Local crossing time	10.30 hrs ± 15 min
Pointing knowledge	100 m at sea level
Orbit altitude	643 km
Orbital period	ca. 98 minutes
Orbit inclination	97.96°
Repeat cycle	23 days
Mission lifetime	5 years

Outline Instrument Opto-Mechanics

EnMAP Hyperspectral Imager



Instrument Calibration

EnMAP Hyperspectral Imager

- On-ground calibration

- On-board calibration:
  - Radiometric calibration
  - Spectral calibration
  - Detectors parameters: Dark Signal & Photo Response Non-Uniformities; memory effects

- On-board calibration sources:
  - External calibration sources (e.g. Sun, Moon, dark sky) introduced via integrating sphere or sun diffuser (the latter is a fallback)
  - Internal calibration sources; foreseen are incandescent lamps & laser diodes

- Vicarious calibration campaigns with ARES underflights during the mission

Sensor Parameters

EnMAP Hyperspectral Imager

	Requirements
Signal-to-noise ratio (SNR) at 30% reflectance; 30° sun zenith angle; visibility 21 km; target 500 m a.s.l.	VNIR: > 500:1 (at 495 nm) SWIR: > 150:1 (at 2200 nm)
Spectral calibration accuracy	0.5 nm
Spectral stability	0.5 nm
Radiometric calibration accuracy	5 %
Quantification / Radiometric stability	14 bit / < 2.5 %
Spectral smile/keystone effect	< 20 % of detector element
Ground sampling distance (GSD)	30 m x 30 m (at nadir; sea l.)
Swath width	30 km
Geometric co-registration	≤ 0.2 x GSD
Swath length (at least)	1000 km /orbit; 5000 km /day
Data Rate / Mass Memory	860 Mbit/s / 512 Gbit
Weight	170 kg (780 kg incl. bus)

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Spectral Requirements

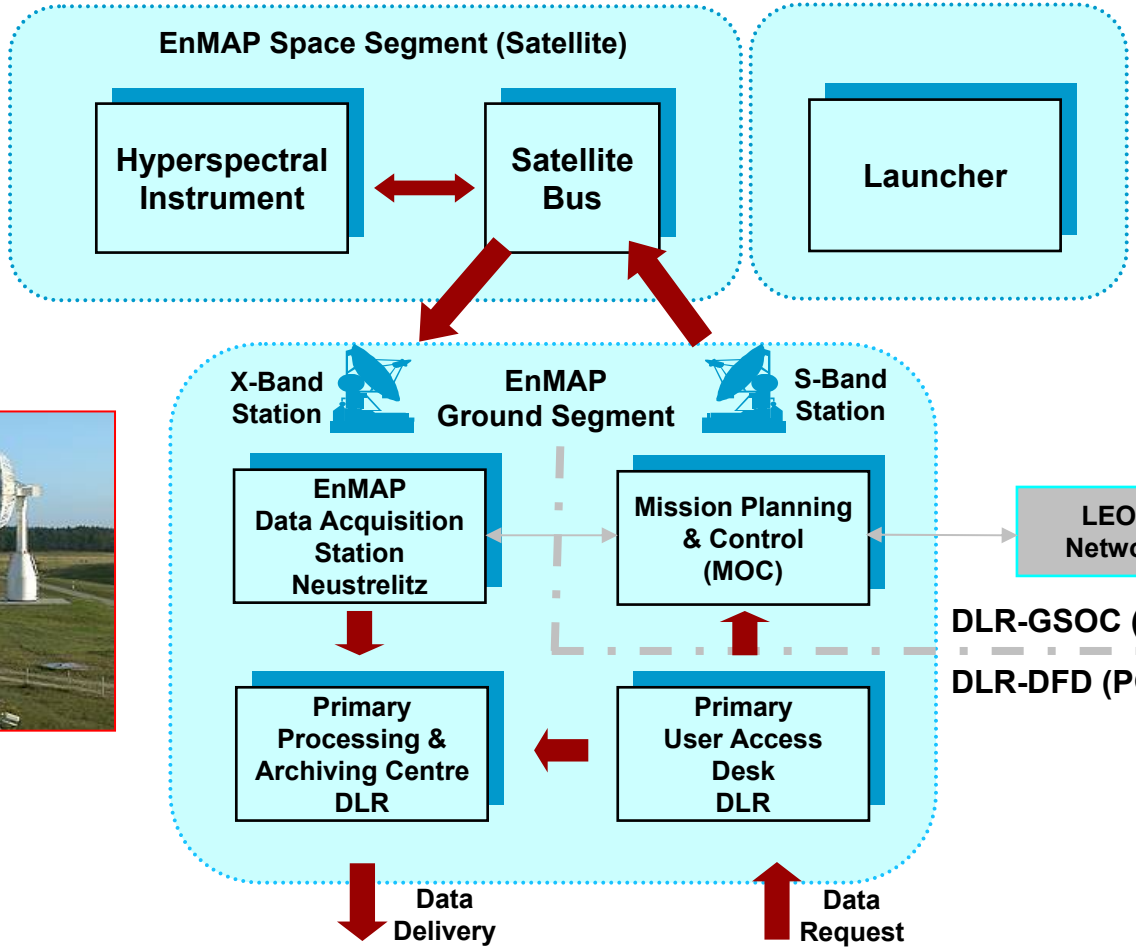
EnMAP Hyperspectral Imager

		Spectral Sampling interval	Spectral Bandwidth (FWHM)	Number of Bands (total of 218)
VNIR-range				
I	420 nm - 500 nm	10 nm	10 ± 1 nm	8
II	500 nm - 850 nm	5/10 nm	5/10 ± 1 nm	* 70/35
III	850 nm - 1030 nm	10 nm	10 ± 1 nm	18
SWIR-range				
Ia	950 nm - 1390 nm	10 nm	10 ± 1 nm	44
Ib	1480 nm - 1760 nm	10 nm	10 ± 1 nm	28
II	1950 nm - 2450 nm	10 nm	10 ± 1 nm	50

* Water/Land Mode

EnMAP Mission Elements

EnMAP Hyperspectral Imager



International EnMAP User Community

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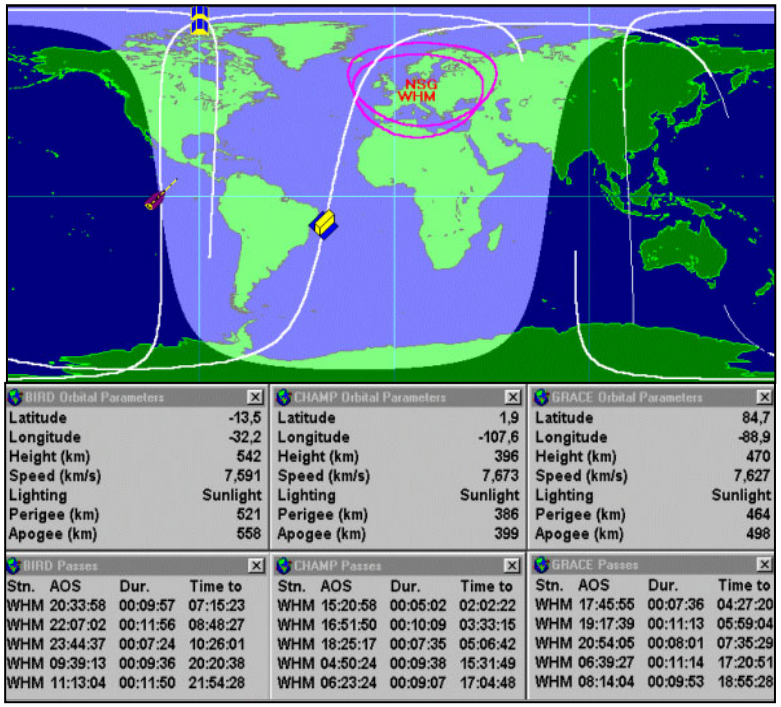
EnMAP and the Multi Mission Environment

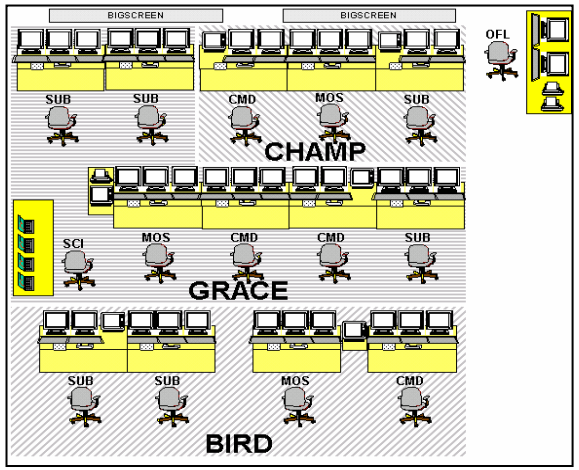
EnMAP Hyperspectral Imager

- Multi-Mission-Team
- 7d/24h Operations
- Polar Orbits (LEO)
- 6-8 contacts/day



Multi-Mission Operations with :

- Assignment of a multi-mission team
- Multiple use of operations systems (Data processing, mission planning etc.)



Leads to:

- Reduction of operation costs
- Increased efficiency and reliability
- Facilitated integration of new missions

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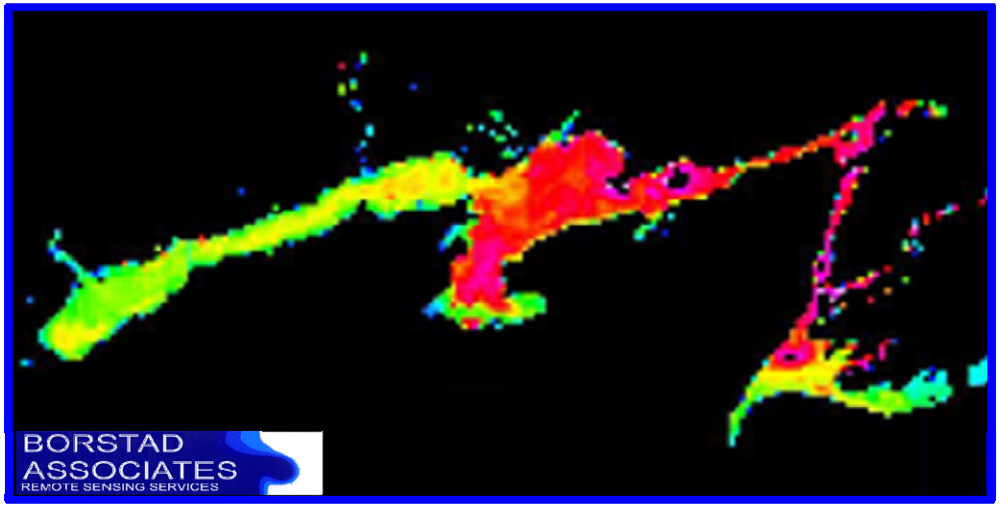
Hyperspectral Measurement on Inland Water

EnMAP Hyperspectral Imager

Chlorophyll Concentration



mg Chlorophyll / m^3

<5 <15 <25

Datei Bearbeiten Ansicht Gehe Lesezeichen Extras Hilfe

Go

Welcome to ENMAP Online

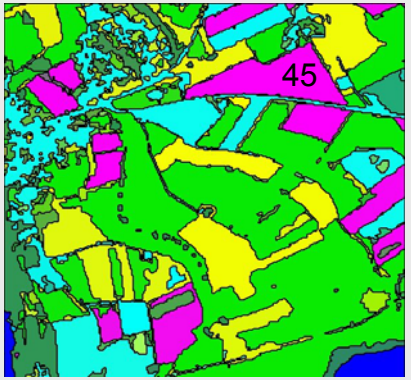
User Profile: 92

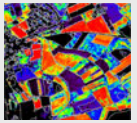
EnMAP Hyperspectral Imager

EnMAP Harvest Prediction

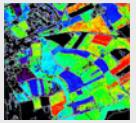
Input:
GIS + EnMAP level 2 products

Download Polygon for GIS:
Field based crop type and biochemical parameters

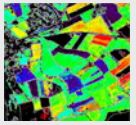




☐ Chlorophyl in [microgr / $cm^{2]}$



☐ Leaf Water Content (LH_2O) in [g / cm^2]



☐ Leaf Area Index (LAI)

☐ Crop Type

ID	Crop Type	Chlophyl	LH_2O	LAI	owner	last year [ton/ha]	prediction: [tons/ha]
23	meadow-cut	38	0.007	1.2-1.9	101	no access	no access
45	maize	60	0.012	5.3-5.8	92	**8.5**	**9**
34	meadow-long	49	0.010	2.0-5.7	101	no access	no access

Fertig

EnMAP Hyperspectral Imager

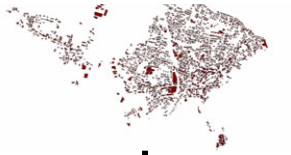
Hyperspektral Satellite Data in the European Context

EnMAP Hyperspectral Imager

Ground Movement from InSAR (NPA)

Gaz leakage

Collateral GIS information



Information rather than data

Spaceborne hyperspectral data

Airborne data

Pipeline Information Management System

Message Oriented Middleware

Database Server

RDBMS And File System

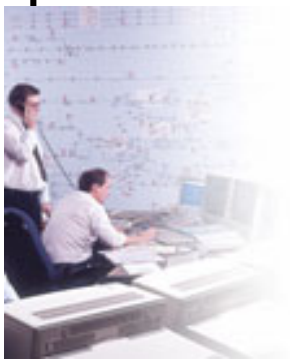
Cluster of Servers

eCognition Server

eCognition Server

eCognition Server

Possible hazard



Rule base for feature extraction and information fusion

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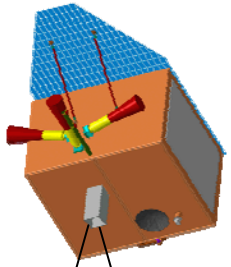
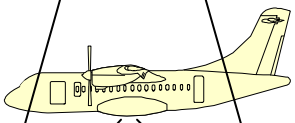
Science Program / Fields of Applications

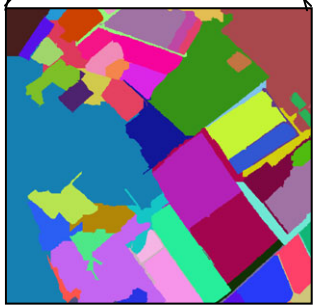
EnMAP Hyperspectral Imager



EnMAP



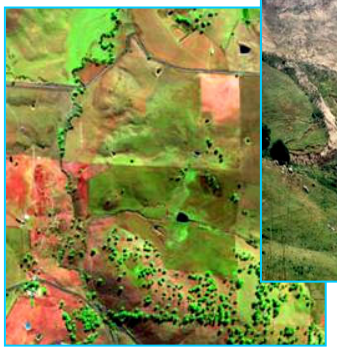
ARES

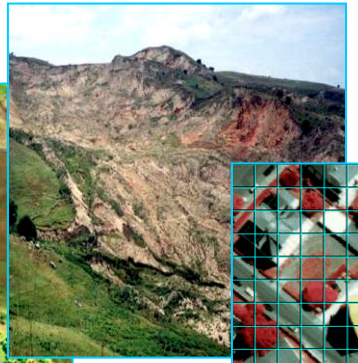


parameter extraction and modeling

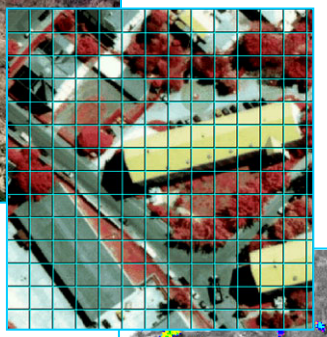
Co-operative Network GFZ – DLR

management of agricultural and forest ecosystems



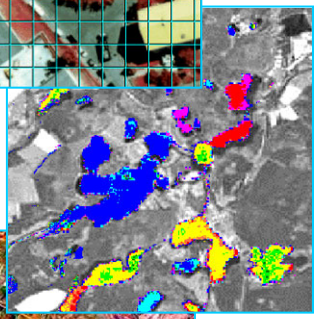


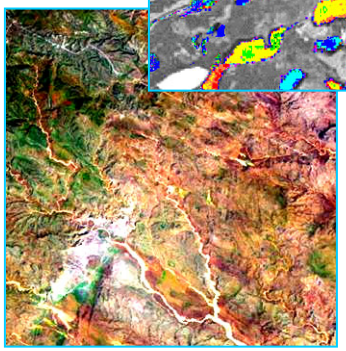
hazard assessment



urban develop-ment

inland water





dry-land degradation

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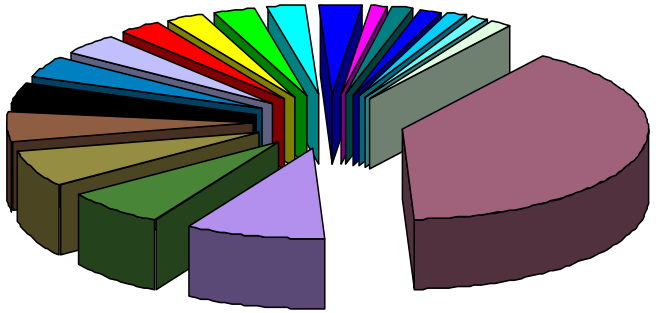
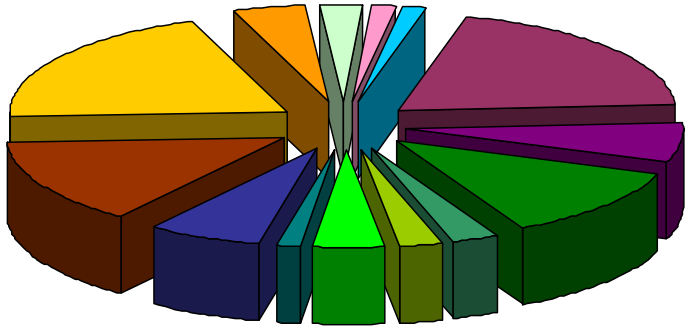
Interested Parties



Participating Countries

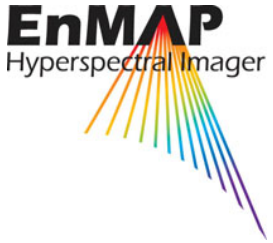
- Germany
- India
- France
- USA
- Israel
- South Africa
- Italia
- Sweden
- Hungary
- Denmark
- Canada
- Spain
- Australia
- Netherlands
- China
- Poland
- New Zealand
- Switzerland
- Finland



Represented Disciplines

- Agriculture/Forestry
- Biodiversity
- Ecology
- Wetlands
- Climate Change
- Water
- Soils/Landdegradation
- Geology/Mineralogy
- Arid Zones
- Cartography
- Urban
- Fisheries
- Meth. Development
- Cal./Val.

Summary & Outlook



The EnMAP mission with its hyperspectral instrument as presented is

- a purely national financed project scheduled for a launch in 2011
- fully compliant with the requirements according to the EnMAP User Requirements Document (URD) elaborated in phase A and detailed in phase B
- operated by DLR-GSOC (German Space Operations Center) and DLR-DFD (Deutsches Fernerkundungs-Datenzentrum)
- open for international partnerships with respect to data utilization and data downlink and may include the operation of additional international ground stations
- a scientific ‘pathfinder’ for commercial and dual use applications on hyperspectral satllite data
- Future applications of EnMAP data, within the GMES program & follow on hyperspectral instruments for e.g. military applications, planetary satellites & ..