

EnMAP mission overview: status, calibration and quality control

EnMAP Ground Segment
Processor and Calibration Segment
German Aerospace Center (DLR), Earth Observation Center, Oberpfaffenhofen

Infrared and Visible Optical Sensors (IVOS) 35
CEOS, Working Group on Calibration and Validation (WGCV)
Oberpfaffenhofen, 27.09.2023



Outline



EnMAP mission overview:

- Mission status
- In-orbit calibration
- Data quality control

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EnMAP GS manager:

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EnMAP PCV team:

- Processors
- Calibration
- Quality control
- Instrument monitoring

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Raquel de los Reyes (L2A), Maximilian Langheinrich (L2A)

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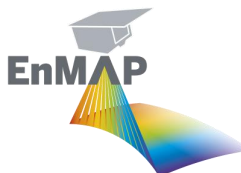
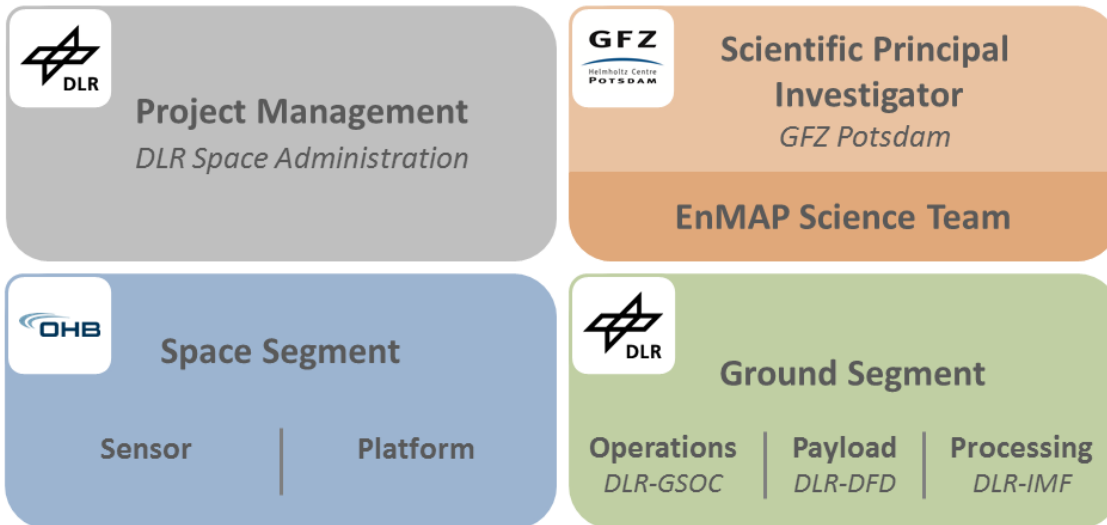
Birgit Gerasch

EnMAP (Environmental Mapping and Analysis Program)

<https://www.enmap.org/>



- EnMAP is a German hyperspectral satellite mission that monitors and characterizes Earth's environment on a global scale.
- EnMAP measures geochemical, biochemical and biophysical variables providing information on the status and evolution of terrestrial and aquatic ecosystems.
- The mission's main objective is to provide high-quality, regional scale hyperspectral data to improve our understanding of coupled environmental processes and to assist in the sustainable management of Earth's resources.



EnMAP (Environmental Mapping and Analysis Program)

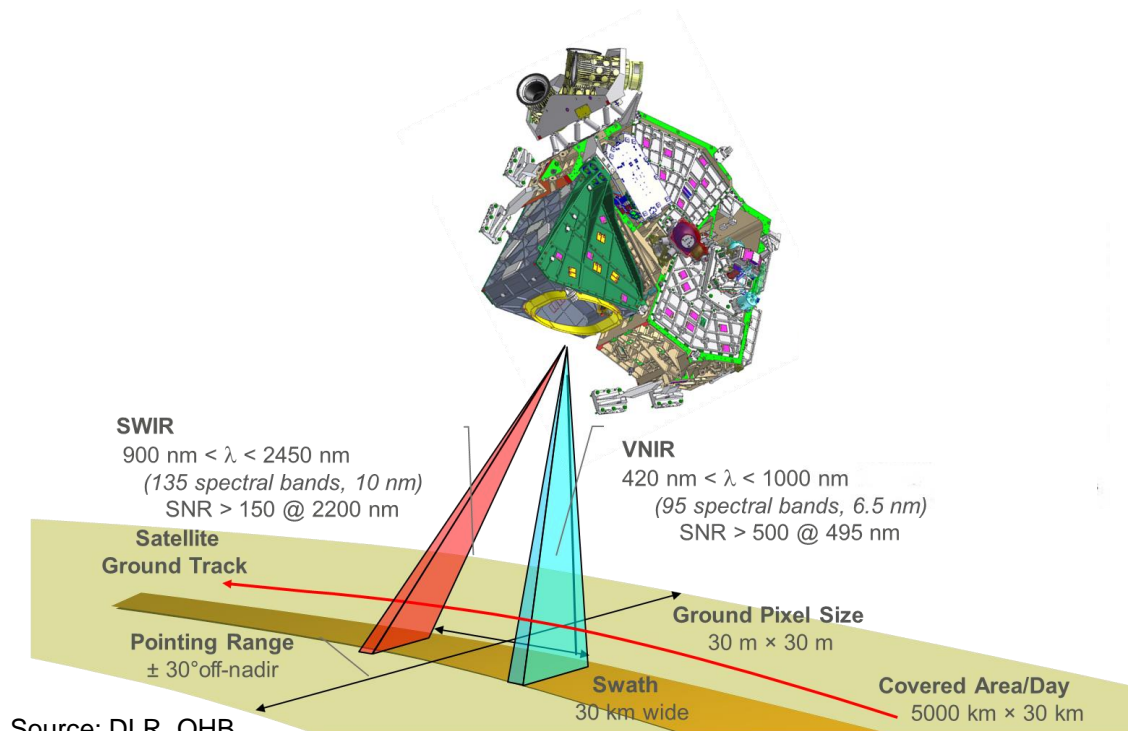
<https://www.enmap.org/>



EnMAP specification	VNIR	SWIR
Spectral range	420 – 1000 nm	900 – 2445 nm
Number of spectral bands	91	133
Spectral sampling distance	6.5 nm	10 nm
Spectral full width at half maximum	6 – 11 nm	7 – 11 nm
Spectral accuracy	0.5 nm	1 nm
Radiometric accuracy	<5%	
Radiometric stability	<2.5%	
Orbit type, altitude and inclination	Sun-synchronous, 653 km, 97.96°	
Orbit period and repeat cycle	1.6 h, 398 revolutions in 27 days	
Local time descending node	11:00 h ± 18 min	
Revisit time	4 days (±30° off-nadir tilt) 21 days (±5° off-nadir tilt)	
Ground sampling distance	30 m (at nadir; sea level)	
Swath width	30 km (2.63° across track)	
Swath length	1000 km / orbit; 5000 km / day	
Product size	30 km x 30 km	

Mission fact sheet (abbreviated)

In-orbit calibration type	Mechanism	Frequency
Relative radiometric (lamp)	white spectralon	4x / month
Absolute radiometric (Sun)	Sun diffuser	1x / month
Spectral	doped spectralon	2x / month
Linearity	focal plane LEDs	1x / month
Deep space	dark sky	1x / month
Dark frames	closed shutter	before/after imaging



Source: DLR, OHB

EnMAP mission status



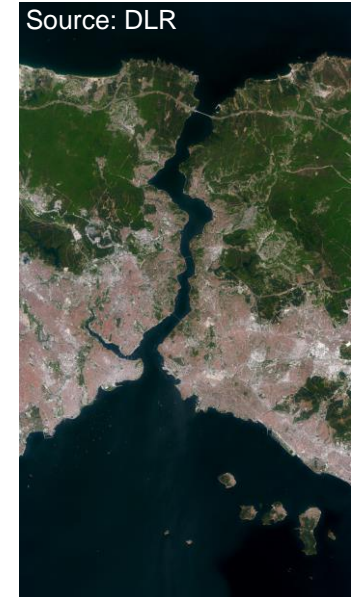
Mission timeline:

- Launch: Apr 1, 2022
- Commissioning: Apr – Oct 2022
- Flight Qualification Review (FQR): Oct 2022
- Operations started in Nov 2022
- Mission open to global users

Source: SpaceX

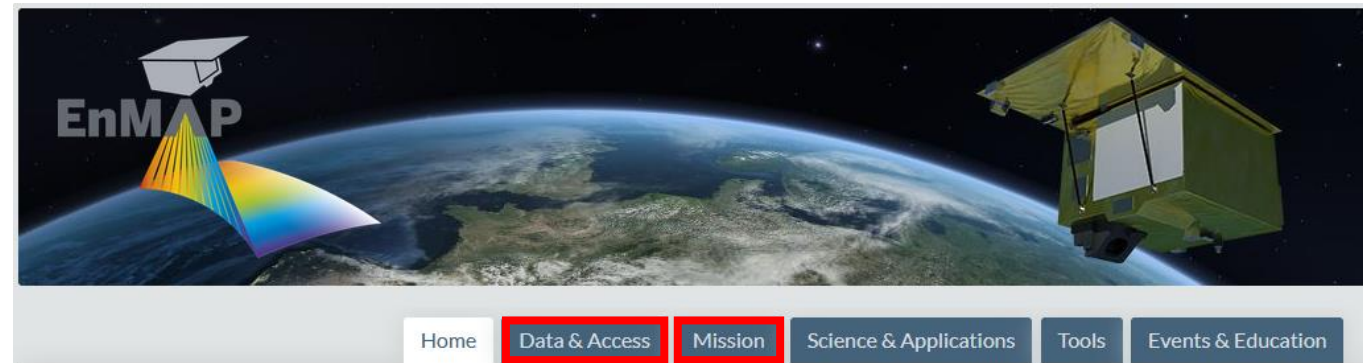


Source: DLR



Useful links:

- Tasking orders and catalog browsing:
<https://planning.enmap.org/>
- Mission quarterly reports:
<https://www.enmap.org/mission/>
- Product specification and ATBDs:
https://www.enmap.org/data_access/



<https://www.enmap.org/>

EnMAP mission status



Challenges:

- | | | |
|---------------------------------------|----------------------------|-------------------------|
| ▪ SWIR loop heat pipe (1 of 3) failed | → delay of commissioning | use as-is |
| ▪ Turn-off due to diffuser switch | → outage Dec 22 – Feb 23 | solved |
| ▪ Acquisition conflicts over Europe | → not all orders fulfilled | under discussion |
| ▪ VNIR degradation | → dynamic coefficients | solved |
| ▪ Across-track striping | → destriping algorithm | solved |
| ▪ Geometric performance | → reprocessing of old data | solved |

EnMAP mission status

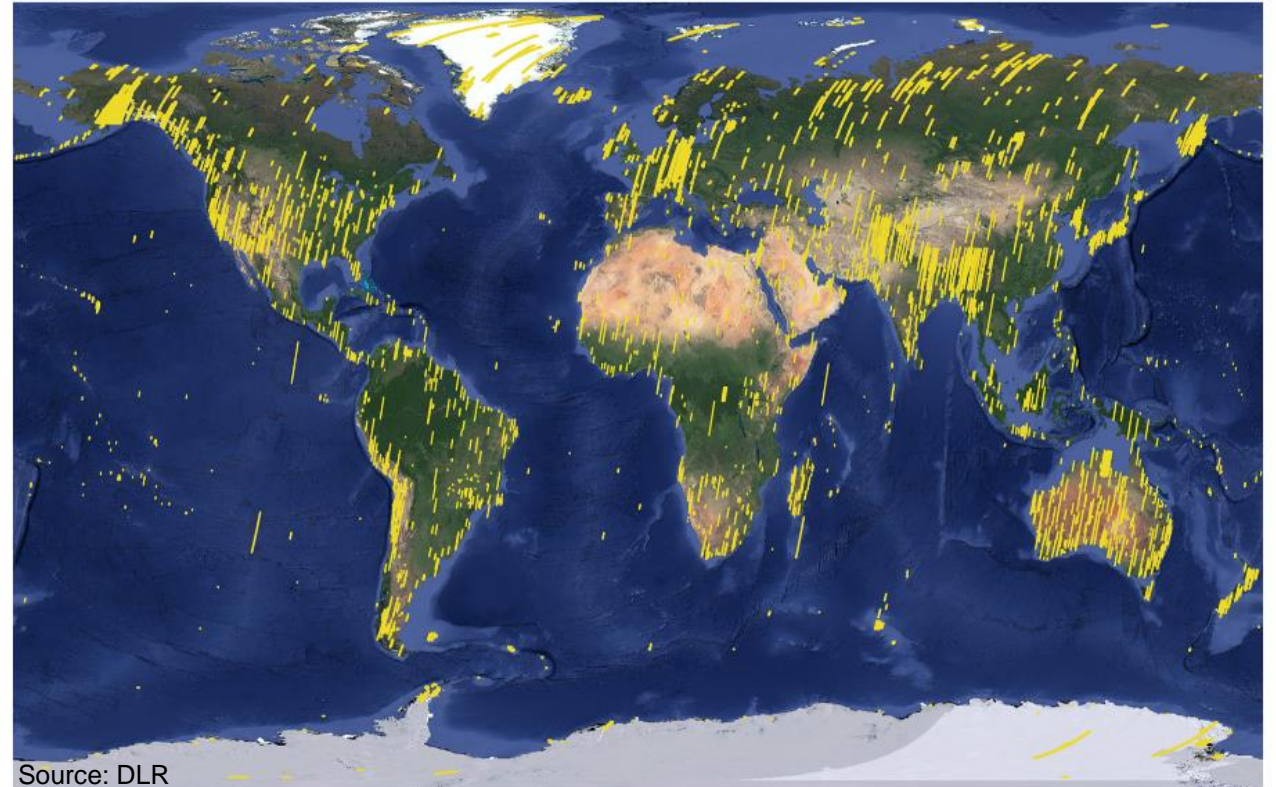
Registered users (as of 30.06.2023):

- Total: 1584
- Europe: 910 (Germany: 429)
- Asia: 228
- N America: 198

Archived data (as of 25.09.2023):

- Calibration: 147 datatakes
- Earth: 42677 tiles / 7062 datatakes
- Moon: 2

EnMAP acquisitions June 2023

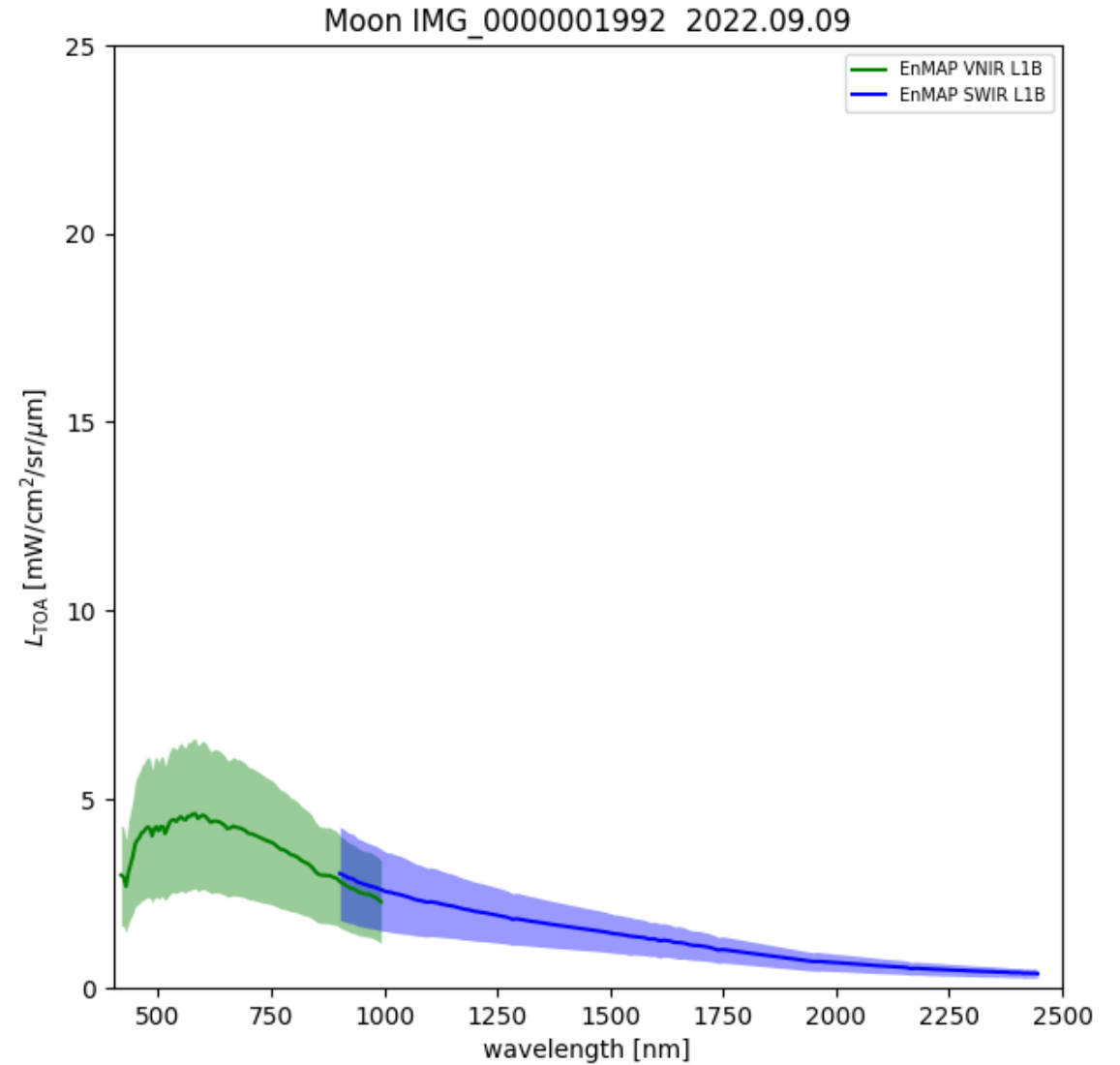
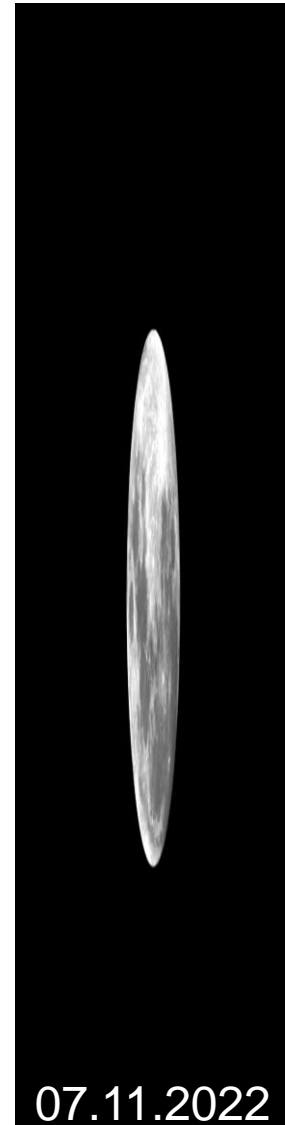


EnMAP: Moon observations



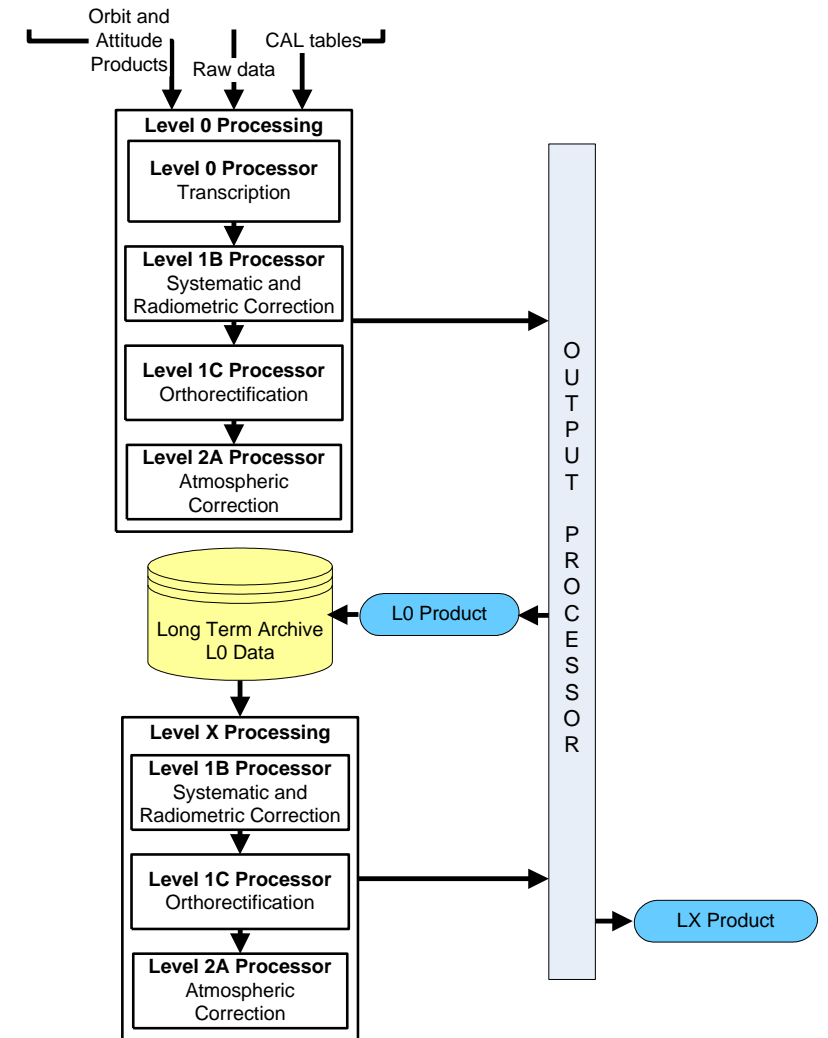
- Moon calibrations not part of EnMAP calibration procedures, but commitment to acquire two Moon observations during commissioning.
- We are considering acquiring more Moon acquisitions in the future.
- EnMAP Moon observations so far:
 - Strategy: along-track scan of the Moon with 10x oversampling in ascending orbit.
 - Dates: 09.09.2022, 07.11.2022 (both $\sim 7^\circ$ phase).
 - Pointing problem on first observation, fixed for second observation.
 - Internal products only, not distributed to users.
- Applications:
 - Straylight studies (during commissioning).
 - Check of VNIR/SWIR mismatch (during commissioning and operations).
 - On-going discussion with USGS and GFZ for comparison to lunar models.

EnMAP: Moon observations



EnMAP: Processors

- A complex processing chain has been developed by the PCV team to calibrate the raw EnMAP data.
- The chain and processing algorithms are under continuous improvement.
- The following higher level EnMAP products are generated and archived:
 - L0 raw data (internal only)
 - L1B top-of-atmosphere radiances
 - L1C orthorectified top-of-atmosphere radiances
 - L2A orthorectified bottom-of-atmosphere reflectances



Processor improvements since FQR (Oct 2022):

- Implemented across-track destriping algorithm at L1B level for both VNIR and SWIR.
- Implemented dynamic radiometric coefficients to deal with VNIR degradation.
- Improved geolocation and VNIR/SWIR co-registration of L1C/L2A products.
- Fixed and improved L2A processing in specific cases (e.g., snow, water).
- Supported new SWIR band configuration uplinked in July 2023.

Ongoing work:

- SWIR along-track striping in bands with strong spectral slope.
- Mismatch between VNIR and SWIR in overlapping spectral range.
- Investigation of L2A scenes based on user feedback.