Payload components of the Copernicus CO2M mission

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Overview

- This poster presents the preliminary design and key components of the Copernicus CO2M mission (see Y. Meijer's talk for mission context)
- OHB System and Thales Alenia Space in France were selected for system and payload prime, respectively
- CO2M will be a constellation of satellites, (currently 2 planned, option for additional units)
- Low Earth Orbit, sun-synchronous, 11:30 LTDN, swath width >250 km, global coverage in 4 days
- 4 instruments on each satellite
 - CO2 Imager (CO2I): 3 band (1 NIR, 2 SWIR) co-located push-broom imaging spectrometer
 - NO2 Imager (NO2I): VIS imaging spectrometer, co-located with the CO2I bands in the same instrument
 - Multi-Angle Polarimeter (MAP) for aerosol measurements
 - Cloud imager (CLIM): 3 band (VIS, NIR, SWIR)







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CO2M: Concept and design of CO2I/NO2I



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Spectral Band ID	Spectral Range (nm)	Spectral Resolution Δλ (nm)	Spectral Sampling Ratio (*)
VIS	405-490	0.6	2.8 (worst case) 3.0 (average)
NIR	747-773	0.12	2.8 (worst case) 3.0 (average
SWIR-1	1590-1675	0.30	2.8 (worst case) 3.0 (average
SWIR-2	1990-2095	0.35	2.8 (worst case) 3.0 (average

Combined CO₂ and NO₂ spectrometer



Three sub-benches for collimator, VIS&NIR, and SWIR assembles, bound together by triangular Si3N4 ceramic bench

Courtesy of Thales Alenia Space in France

Telescope	Three-Mirror-Anastigmat with folding mirror, polarisation scrambler and fiber-based entrance slit (homogeniser)	
Collimator	One reflective collimator (TMA), common for all bands	
Band separation	Dichroic split in collimated beam: 1.) VIS-NIR / SWIR; 2.) VIS / NIR, and 3.) SWIR-1 / SWIR-2	
Dispersers	Prism-Grating-Prism assemblies with bonded binary structure transmission grating	
Imagers	Two aspherical lenses, glass (VIS/NIR) and silicon (SWIR- 1/SWIR-2) equipped with band-pass filters	
Detectors	Mercury-Cadmium-Telluride CMOS detectors in SWIR, Si CMOS in Vis/NIR	

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Copernicus CO2M: Slit homogeniser

Fiber-based entrance slit (TASiCH):

- made of stacked rectangular multi-mode fibers
- Fiber cores define instantaneous FOV and slit width (core dimensions: 319μm x 121 μm)
- Excellent homogenization performance in both ALT and ACT directions (2D slit homogenizer)
- Stable ISRF (slit function) independent of ground scene contrast
- Quasi-perfect spatial co-registration (between spectral channels): Cladding "stripes" allow for distinction of ACT spatial samples, independent of keystone and smile distortion
- Manufacture and environmental test campaign successfully completed
- Alignment parameters, Focal Ratio Degradation (FRD) and transmission measurements performed
- Straylight and homogenization (near- and farfield) measurements in progress
- End-to-end performance testing with "Elegant Breadboard" (EBB)





Figures courtesy of Thales Alenia Space, Switzerland







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CO2M Pre-Developments: Diffraction gratings / Detectors



Diffraction gratings (Fraunhofer IOF)

- Grism + Prism assemblies, transmission 1st order operated in Littrow configuration
- Photonic sub-wavelength structures
- Manufacture: e-beam lithography and reactive ion-etching •
- NIR: TiO₂ over-coating by applied by ALD •
- SWIR: Nano-laminate multi-layer coating (alternating stack of $Al_2O_3 + TiO_2$) ٠
- Grooves completely filled by multi-layer coating, enclosed in SiO₂
- Measured performance
 - Diffraction efficiency > 90%
 - Polarisation Sensitivity < 10%
 - Low wavefront error and straylight







VIS-NIR detector: Teledyne CIS 120

Teledyne e2v	CIS120	
Sensor Format	5.05 mm	
	2048 x 2048, global shutter, 10 μ m pitch	
Technologies	BSI, no microlenses	
FWC	Standard 45 ke-, Variant for CO2M 80 ke-	
QE x Fill Factor	Customized ARC based on multi 2 coating	
λ = [405-490nm]	87%	
λ = [747-773nm]	70%	

SV

I vnred NGP	Sofradir NGP Characteristics	
Lymed Nor	QE	>0.8 over 0.35 μm - 2.5 μm
	Format	1024x1024
	Pixel pitch	15 μm x 15 μm
	СНС	680 ke-
	ROIC noise	< 170 e- (mean 138 e-)
I I I I I I I I I I I I I I I I I I I	Cut-Off	2.5 μm
	Input stage	СТІА
	Video Out	4 outputs up to 8 MHz $\left(\begin{array}{c} \Im \end{array} \right) \right)_{4}$

CO2M: Multi-Angle Polarimeter and Cloud Imager

Multi-Angle Polarimeter



Light path correction by measuring effective aerosol parameters

- Heritage missions without MAP require bias correction and filtering for AOD<0.3
- Anthropogenic areas in India and China on average AOD>0.3
- \rightarrow Higher accuracy CO₂ data (less dependence on bias correction)
- \rightarrow More data and also at higher aerosol loading; up to 0.5 AOD

Multi-angle polarimeter (MAP): Pushbroom spectral band imager with

- Continuous along track coverage, 47 viewing angles (+/- 60°)
- 6 spectral bands in VIS and NIR (see table below)
- 3 polarisation directions (0°, 60°, 120°) sampled by micropolarizers at detector pixel-level
- Spatial resolution: 4x4 km² and sampling <2x2 km²

CLIM instrument (OIP)

- Proba-V heritage
- Three mirror telescope
- F= 110, f/6
- Folding mirror for SWIR channel
- Spectral filters in front of detectors
- 2 focal planes: VNIR and SWIR with linear array detectors
- Lunar and vicarious calibration
- All native samples sent to ground Courtesy of OIP







Payload design

- 1) Si3N4 ceramic structure
- 2) Thermal guard
- 3) Telescope
- 4) Flight Calibration Unit
- 5) Instrument Support Panel
- 6) Dissipative electronics
- 7) Ultra Stable Interface Bench
- 8) MAP
- 9) CLIM
- 10) Star trackers
- 11) Cryogenic passive radiator
- 12) External housing panels overlayed with MLI





- > Triple bench concept
- Thermally stabilised CO2I & MAP instruments & USIB
- CO2I SWIR FPA passively cooled
- > Detectors:
 - CO2I VIS & NIR: 2x CIS120 (Te2v)
 - CO2I SWIR: 2x NGP (Lynred)
 - MAP: 4x CIS120 (Te2v)
 - CLIM VNIR: AT71547 (Te2v)
 - CLIM SWIR: Xlin-1.7-3000 (Xenics)

Courtesy of Thales Alenia Space in France



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