Sentinel-4 Mission Overview

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ESA/ESTEC

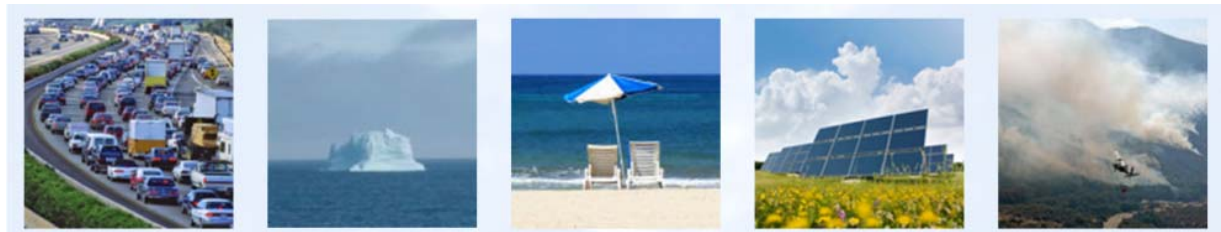CEOS ACC Meeting 11, April 2015
ESRIN, Frascati, Italy

Overview

- Sentinel-4 mission objective
- Sentinel-4 mission overview
- Sentinel-4 mission implementation status

European Space Agency

Sentinel-4 Mission Objective

Sentinel-4 is designed to provide

- Tropospheric composition measurements
- With fast revisit time
- At high spatial resolution over Europe
- Operationally over 15 years
- For the Copernicus Atmosphere Monitoring Services

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Copernicus Atmosphere Monitoring Service

- Operational information services for policy makers, …, citizens

- Protocol compliance monitoring: ozone layer (Montreal, …), air quality (Göteborg, …), climate (Kyoto, …), emission verification

- Near-real-time services: Local air quality, health warning, aviation routing

- Assessments: Improve understanding of processes, validate chemical transport models, ground measurement networks

- Pre-operational: MACC, http://atmosphere.copernicus.eu

- Uses observations from current satellites,
  in the future also from Sentinel-4, -5, -5P, …

Sentinel-4/UVN Instrument

Satellite:
Meteosat Third Generation Sounder

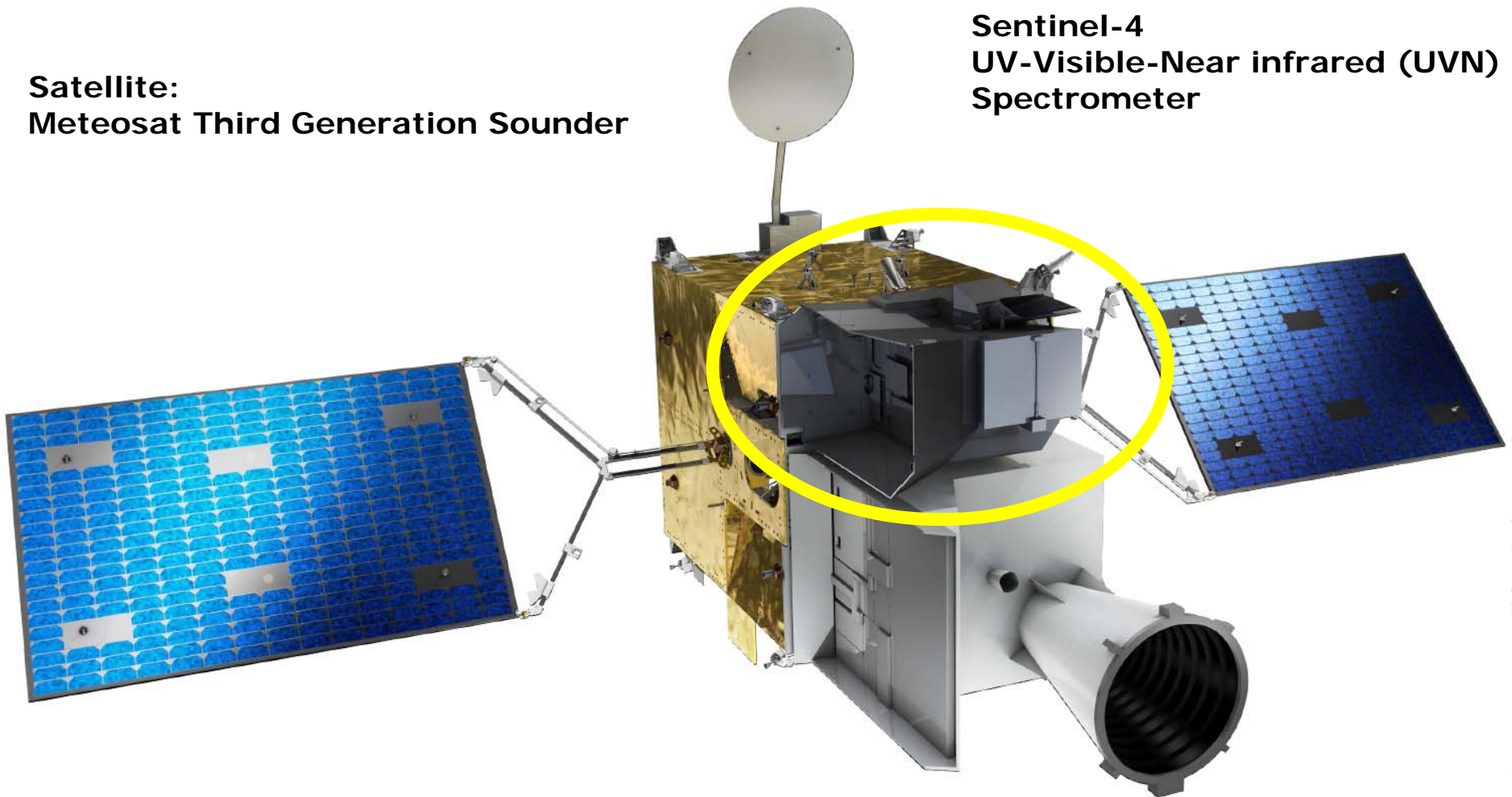**Sentinel-4**
UV-Visible-Near infrared (UVN)
Spectrometer

Image courtesy Airbus Defence & Space

Infrared Sounder
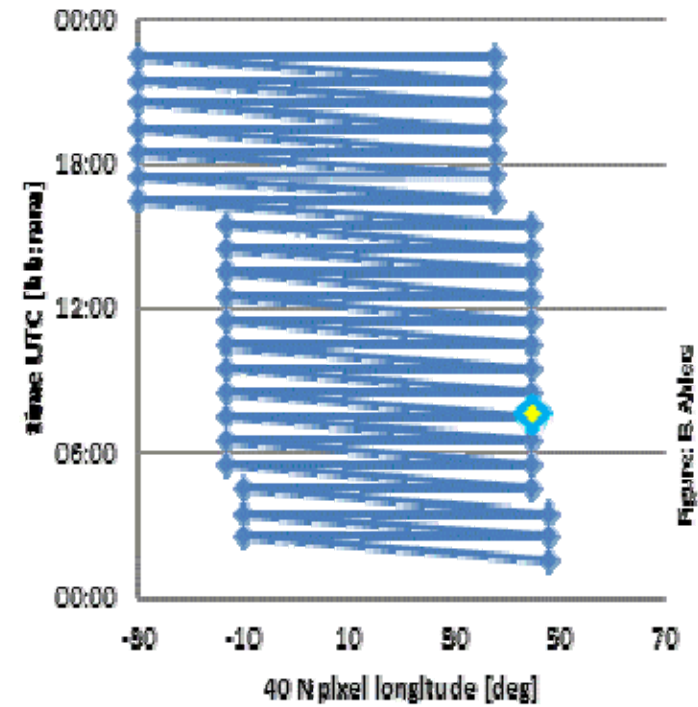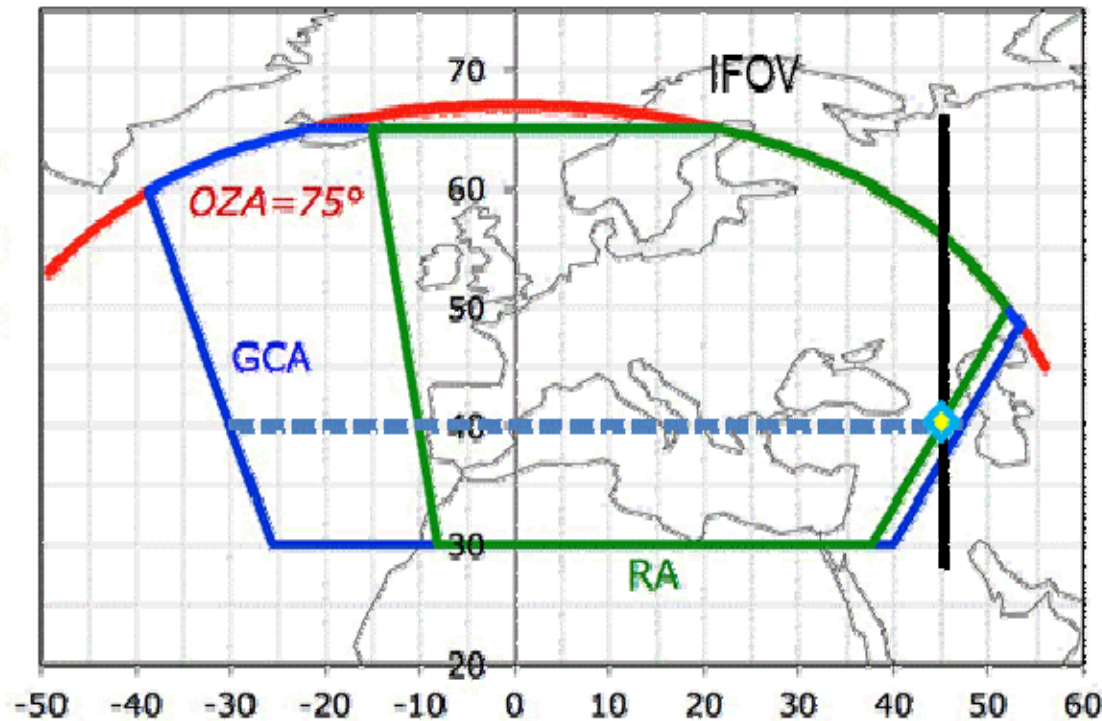
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Sentinel-4/UVN Instrument

Spectral range	UV-VIS: 305-500 nm NIR: 750-775 nm
Spectral resolution Spectral oversampling	UV-VIS ≤ 0.5 nm NIR ≤ 0.12 nm UV-VIS & NIR ≥ 3.0 pixels
Spatial sampling at 45° North latitude, sub-satellite longitude	≤ 8 x 8 km^2
Number of spatial samples (approx.): 　　N/S (detector pixel) 　　E/W (meas. samples)	 530 570
Operational field of view (approx.): 　　N/S 　　E/W	 4° 11° (possible scan range is larger: 14°)
Temporal resolution (reference area)	60 min
Envelope	1000 x 1000 x 1500 mm^3
Mass	200 kg
Power	180 W
Data rate (nominal operation)	30 Mbps

Sentinel-4/UVN Instrument

GCA = Geographic Coverage Area
RA = Reference Area covered in 1h
IFOV = Instantaneous Field of View

East-West Scan Pattern

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Sentinel-4 Level-2 Products

Product	Application			Comment
	Air Quality	Climate	Surface UV	
O_3 total & tropospheric column	X		X	
O_3 enhanced sensitivity to lower troposphere	X		X	**Synergy with infrared data from IRS**
NO_2 total & trop. column	X			
SO_2 total column	X			Also for volcanic eruption monitoring
CHOCHO total column	X			By-product
CH_2O total column	X			
Aerosol extinction coeff. profile, column optical depth / type / index	X	X		Also for volcanic eruption monitoring Also auxiliary for other S4 products **Synergy with imager data from FCI**
Cloud optical thickness, fraction, altitude			X	Mainly auxiliary for other S4 products **Synergy with imager data from FCI**
Surface reflectance daily map			X	Mainly auxiliary for other S4 products

IRS alone products such as CO, HNO_3 by EUMETSAT (TBC)

The Atmospheric Sentinel Missions

GEOstationary (GEO)

- Hourly revisit time over Europe
- Mainly air quality
- Diurnal cycle of tropospheric composition

→ **Sentinel-4**

Low Earth Orbit (LEO)

- Daily revisit time global coverage
- Climate, air quality, ozone & UV
- Tropospheric & stratospheric composition

→ **Sentinel-5**

→ **Sentinel-5 Precursor**

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Sentinel-5p																
Sentinel-4 - 1																
Sentinel-5 - 1																
Sentinel-4 - 2																
Sentinel-5 - 2																
Sentinel-5 - 3																

The Atmospheric Sentinel Missions

Mission	Instrument	Utilization of data from		
		Imager	Infrared sounder	Other
Sentinel-4	UVN spectrometer [1]	FCI [2]	IRS [1]	LI [2,*]
Sentinel-5	UVNS spectrometer [3]	VII [3]	IAS [3]	3MI [3]
Sentinel-5 Precursor	UVNS spectrometer TROPOMI [4]	VIIRS [5]	CRIS [5,*]	OMPS [5,*]

[1] on MTG sounder (GEO)
[2] on MTG imager (GEO)
[3] on MetOp-SG (LEO)
[4] on dedicated platform (LEO)
[5] on SNPP/JPSS (LEO)
[*] synergy on higher data level

MTG = Meteosat Third Generation
MetOp-SG = MetOp-Second Generation
SNPP = Suomi National Polar-orbiting Partnership
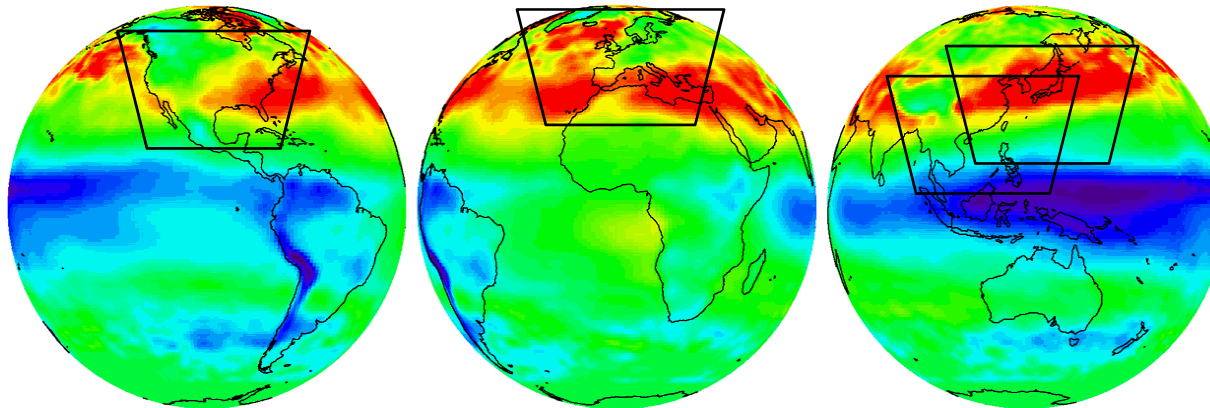JPSS = Joint Polar Satellite System

UVN = Ultraviolet + Visible + Near infrared
FCI = Flexible Combined Imager
IRS = InfraRed Sounder
LI = Lightning Imager

UVNS = UVN + Short wave infrared
VII = Visible/Infrared Imager (MetImage)
IAS = Infrared Atmospheric Sounder (IASI-NG)
3MI = Multi-viewing, -channel, -polarisation Imager

TROPOMI = TROPOspheric Monitoring Instrument
VIIRS = Visible Infrared Imaging Radiometer Suite
CrIS = Cross-track Infrared Sounder
OMPS = Ozone Mapping Profiler Suite

Sentinel-4 Mission Implementation Status

- S4/UVN instrument & Level-1b Prototype Processor developed by ESA with Airbus Defence & Space as prime
  - Preliminary Design Review completed
  - Intermediate Instrument Performance Review end 2015
  - Critical Design Review mid 2016
  - Flight Acceptance Review early 2021

- Level-2 Operational Processor developed by ESA (activity not yet kicked off)
  - Kick-off expected June 2016
  - Prototype and Operational Processor
  - System Integration & Verification, support to Commissioning

- EUMETSAT will operate the instrument and process the mission data up to Level-2

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How to make these GEO + LEO missions an Air Quality Constellation?

NASA TEMPO   **ESA Sentinel-4**   **KARI GEMS** **JAXA GMAP-ASIA**

	USA TEMPO	Europe Sentinel-4	Korea GEMS
Orbit	Geostationary	Geostationary	Geostationary
Domain	North America	Europe and surrounding	Asia-Pacific
Revisit [h]	1 hour	1 hour	1 hour
Spectral ranges	UV-Vis	UV-Vis-NIR	UV-Vis
Key products	O_3, NO_2, SO_2, HCHO, CHOCHO, aerosol	O_3, NO_2, SO_2, HCHO, CHOCHO, aerosol	O_3, NO_2, SO_2, HCHO, aerosol
Spatial resolution [km^2]	9 x 5 at 35°N	8 x 8 at 40°N	8 x 7 (gas), 8 x 3.5 (aerosol) at 38°N

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Sentinel-4 Level-2 Processor Development Challenges

Tropospheric NO_2 diurnal variation

- good precision and accuracy
- avoid diurnal biases!
- $\rightarrow$ need to account for
  - surface anisotropy
  - tropospheric profile
  - stratospheric sub-column
  - aerosol vertical distribution
  - aerosol phase function

Aerosol layer height

- from O_2A band
- little heritage
- spectroscopy
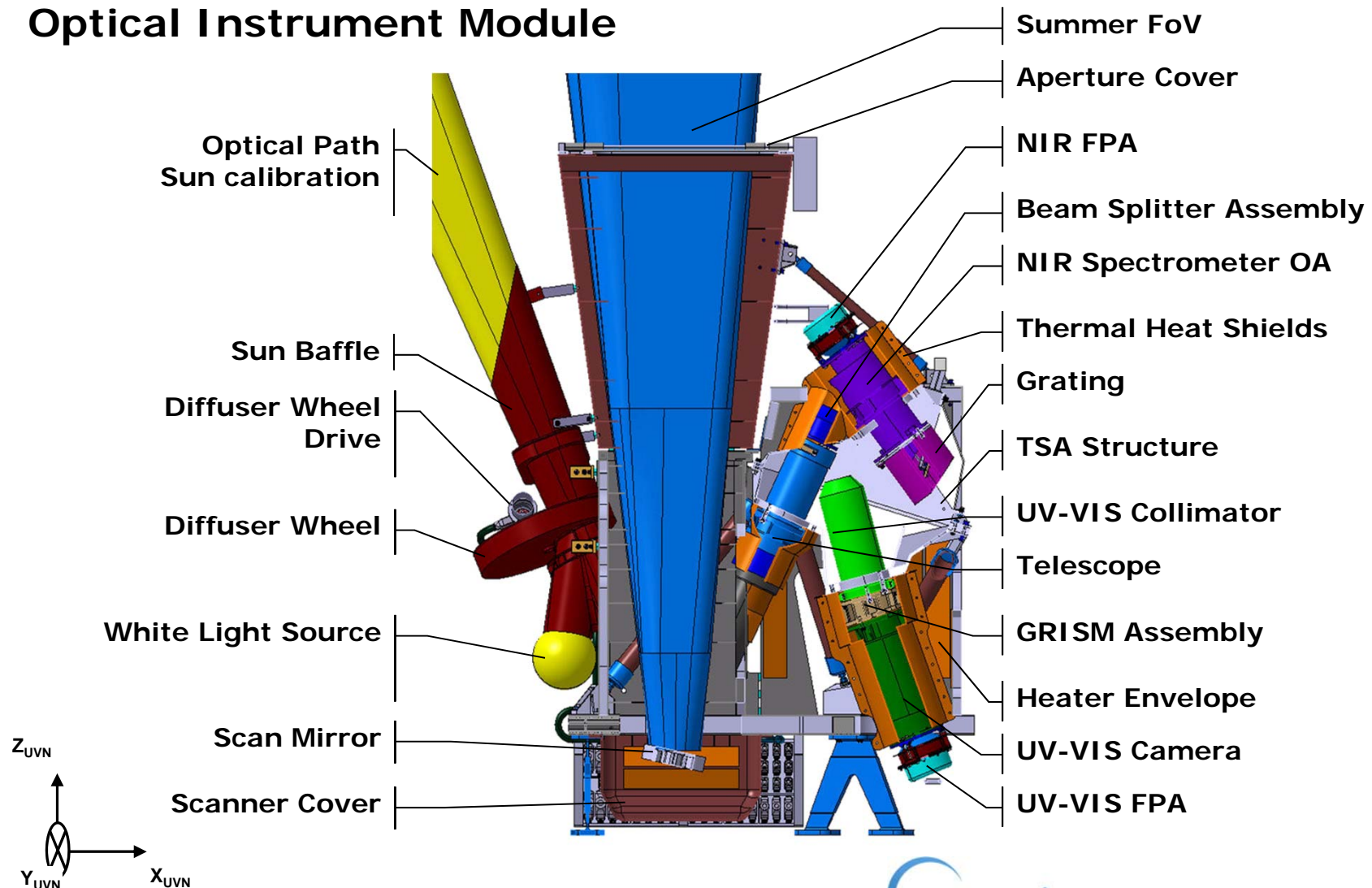- pseudo-noise mitigation
- spectral calibration
- computational speed

Aerosol & surface characteristics

- joint retrieval from aggregated data
- little heritage
- processor architecture
- computational speed

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Sentinel-4 UVN Instrument

Optical Instrument Module

Labels: Summer FoV, Aperture Cover, NIR FPA, Beam Splitter Assembly, NIR Spectrometer OA, Thermal Heat Shields, Grating, TSA Structure, UV-VIS Collimator, Telescope, GRISM Assembly, Heater Envelope, UV-VIS Camera, UV-VIS FPA

Optical Path Sun calibration, Sun Baffle, Diffuser Wheel Drive, Diffuser Wheel, White Light Source, Scan Mirror, Scanner Cover

Z_{UVN}, Y_{UVN}, X_{UVN}
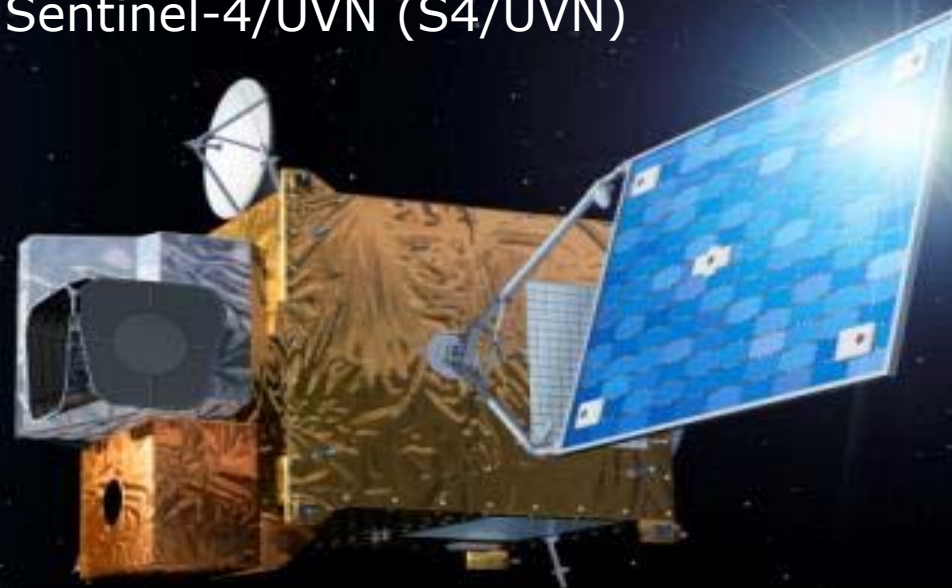
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**Sentinel-4 Instrument
on Meteosat Third Generation (MTG)**

MTG-Sounder
InfraRed Sounder (IRS)
Sentinel-4/UVN (S4/UVN)

MTG-Imager
Flexible Combined Imager (FCI)
Lighting Imager (LI)

UVN = UV + Visible + Near infrared