SENTINEL-5 PRECURSOR SYSTEM

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ABSTRACT

Global Monitoring for Environment and Security (GMES) is a joint initiative of the European Community and of the European Space Agency. The Declaration on the GMES Space Component Programme provides that the Sentinel-5 Precursor mission is planned to be implemented in co-operation with the Kingdom of the Netherlands, which in the frame of the development of the TROPOMI Instrument, will provide the Ultraviolet-Visible-Near-Infrared instrument as a national contribution. The Sentinel-5 Precursor is a UV-VIS-NIR-SWIR spectrometer atmospheric chemistry mission derived through tailoring of Sentinel-5 specifications with priority on spectral resolution, coverage, spatial sampling distance, signal-to-noise ratio and only high priority bands.

1. INTRODUCTION

In line with the relevant provisions of the Declaration on the GMES Space Component Programme, ESA's undertaking for the Sentinel-5 Precursor mission consists of the development of a satellite system encompassing the spacecraft, accommodation of the TROPOMI payload (jointly funded by ESA and the Netherlands), a basic ground segment and the launch and in-orbit commissioning.

Sentinel-5 Precursor is a polar orbiting satellite with the objective to provide information and services on air quality, climate and the ozone layer after launch. Following TROPOMI payload delivery, the satellite will be integrated and environmentally tested at the satellite prime contractor's ASTRIUM Ltd. facility. Before delivery, TROPOMI will have been fully tested, calibrated and environmentally qualified for launch.

The spacecraft will be launched into a near-polar, sun-synchronous orbit, with an orbit height of approx. 820 km. The orbit repeat cycle (17 days /227 orbits) and the local time of ascending node crossing (13.30 h) have been chosen to allow co-located measurements with the NOAA/NASA NPP/JPSS spacecraft.

A dedicated launcher will be used to inject the Sentinel-5 Precursor spacecraft directly into its final orbit. The nominal launcher is of the VEGA/ROCKOT category. The nominal launch date is within 2015 and the in-orbit lifetime of the spacecraft is seven years.

2. THE TROPOMI PAYLOAD

The TROPOspheric Monitoring Instrument (TROPOMI) payload consists of an UV-VIS-NIR-SWIR imaging spectrometer of the push broom type, featuring a wide swath of 2600 km, facilitating a daily revisit of the atmosphere above any point on the Earth. The spatial resolution will be <10x10 km^2 enabling fine resolution of trace gases in the troposphere. The spectral band definition and spectral properties are summarized as:

Detector	Band ID	Spectral properties [nm]			Spatial sampling [km^2]
		Range	Resolution	Sampling	
UV	1	270-300	1.0	0.065	21 x 28
	2	300-320	0.5	0.065	7 x 7
UVIS	3	310-405	0.55	0.2	7 x 7
	4	405-500	0.55	0.2	7 x 7
NIR	5	675-725	0.5	0.1	7 x 7
	6	725-775	0.5	0.1	7 x 1.8
SWIR	7	2305-2385	0.25	<0.1	7 x 7

A functional block diagram of TROPOMI is provided in Figure 1 with a CAD model of its main constituent elements in Figure 2. The main characteristics of TROPOMI are:

- Mass: 200 kg
- Overall dimensions: 1.4 x 0.65 x 0.75 m
- Average Power: 170 W
- Data Volume: 140 Gbit/orbit.

3. THE SPACECRAFT

The spacecraft uses the ASTRIUM Astrobus-L platform which draws on the heritage from the SEOSAT/Ingenio and SPOT 6&7 programmes. The structure is of an aluminium hexagonal construction with honeycomb panels. The dimensions stowed are 2.2 m diameter by 2.9 m high. The on-board computer is a LEON 3 with standard Remote

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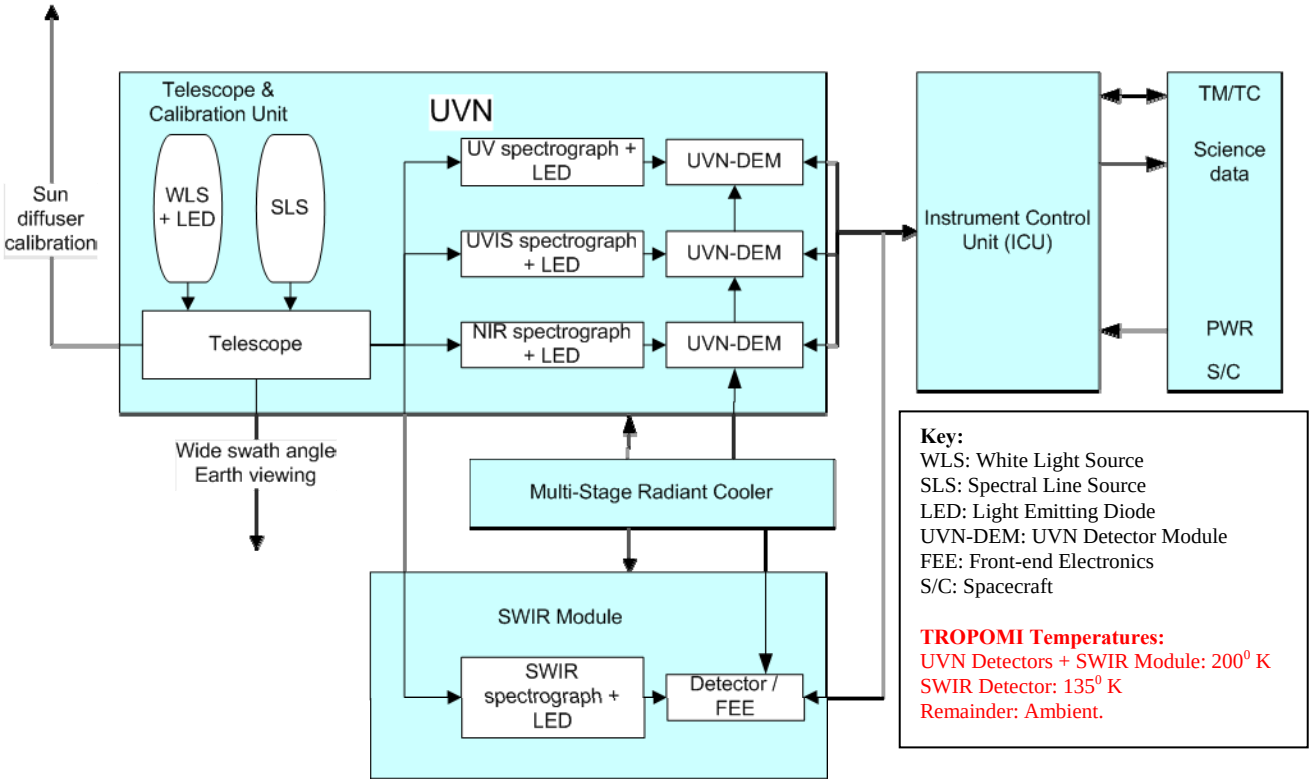

Figure 1: TROPOMI Functional Block Diagram.

Interface Unit (RIU) for serial, analogue and digital acquisitions. The data handling sub-system consists of a Mass Memory unit with 480 Gbit capacity using flash memory technology with 310 Mbps downlink rate. Three deployable solar arrays (5.4 m^2) using GaAs triple-junction solar cells supplying 1500W and two Li-ion batteries with a capacity of 156 A.h. make up the power sub-system. The spacecraft will be equipped with S-Band and X-Band communication channels for uplink commanding and housekeeping telemetry downlink and for the downlink of instrument data, respectively. The propulsion sub-system is a mono-propellant hydrazine design operating in blow-down mode with 4 x 1 N thrusters configured in two redundant pairs. The platform is a 3-axis stabilized design with yaw steering. An artist impression of the satellite is presented in Figure 3.

4. GROUND SEGMENT

The Ground Segment main elements are the Flight Operations Segment (FOS) located at ESOC in Darmstadt and the Payload Data Ground Segment (PDGS) located at DLR in Oberpfaffenhofen, both in Germany. Their tasks are the commanding, tracking and monitoring of the spacecraft as well as the acquisition, processing, archiving and dissemination of science data, respectively. The PDGS will, in particular, host the Level 0-1b & Level 2 Processing Facility which will generate routine Level 0 / 1b and Level 2 data products.

The envisaged near-real-time dissemination scheme for Level 1b and 2 data products implies that the recorded science telemetry is downlinked at least once per orbit. This will be accomplished by use of high latitude X-Band stations in the Svalbard region of Spitzbergen, Norway and Inuvik in Canada. A schematic view of the primary elements of the Ground Segment is given in Figure 4.

5. DATA PRODUCTS

The primary goal of the Sentinel-5 Precursor mission is the systematic delivery of global measurements of a set of atmospheric species in the Troposphere and lower Stratosphere. The mission will further support applications in air quality monitoring and forecasting to enhance the understanding of interactions between trace gas abundances, aerosols and climate.

TROPOMI will measure key atmospheric constituents including ozone, NO_2, SO_2, CO, CH_4, CH_2O and aerosol properties. It will extend the data records of missions such as SCIAMACHY on ENVISAT and OMI on AURA as well as be a preparatory mission for the Sentinel-5 future mission. Table 1 shows the selected Level 2 main Products and corresponding Development Tasks.

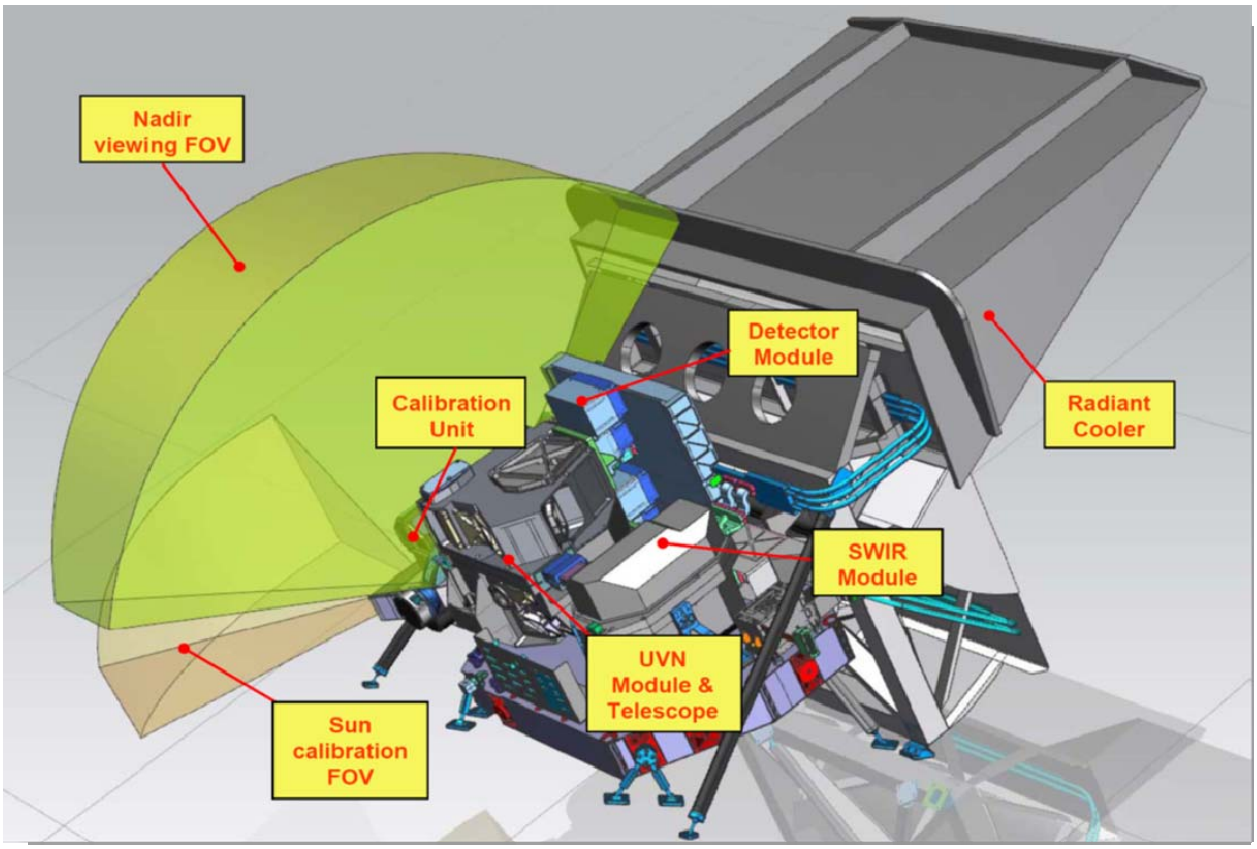

Figure 2: TROPOMI Main Constituent Elements.

The corresponding ground processors will be developed in the frame of a coordinated activity involving institutes located in The Netherlands, Germany and Belgium. The development work comprises both scientific prototyping and validation activities as well as the generation of operational processor components to be integrated into the PDGS. Moreover, the in-flight functional verification of algorithms (part of commissioning, Phase E1) will be included, in preparation of the geophysical validation tasks and the routine processing and data dissemination during the operational Phase E2.

6. ACKNOWLEDGEMENTS

The contributions of the ESA/NSO Project Team, ASTRIUM Ltd, the Satellite Prime Contractor and Dutch Space, TROPOMI Prime Contractor, are gratefully acknowledged.

Figure 3: Sentinel-5 Precursor Satellite.

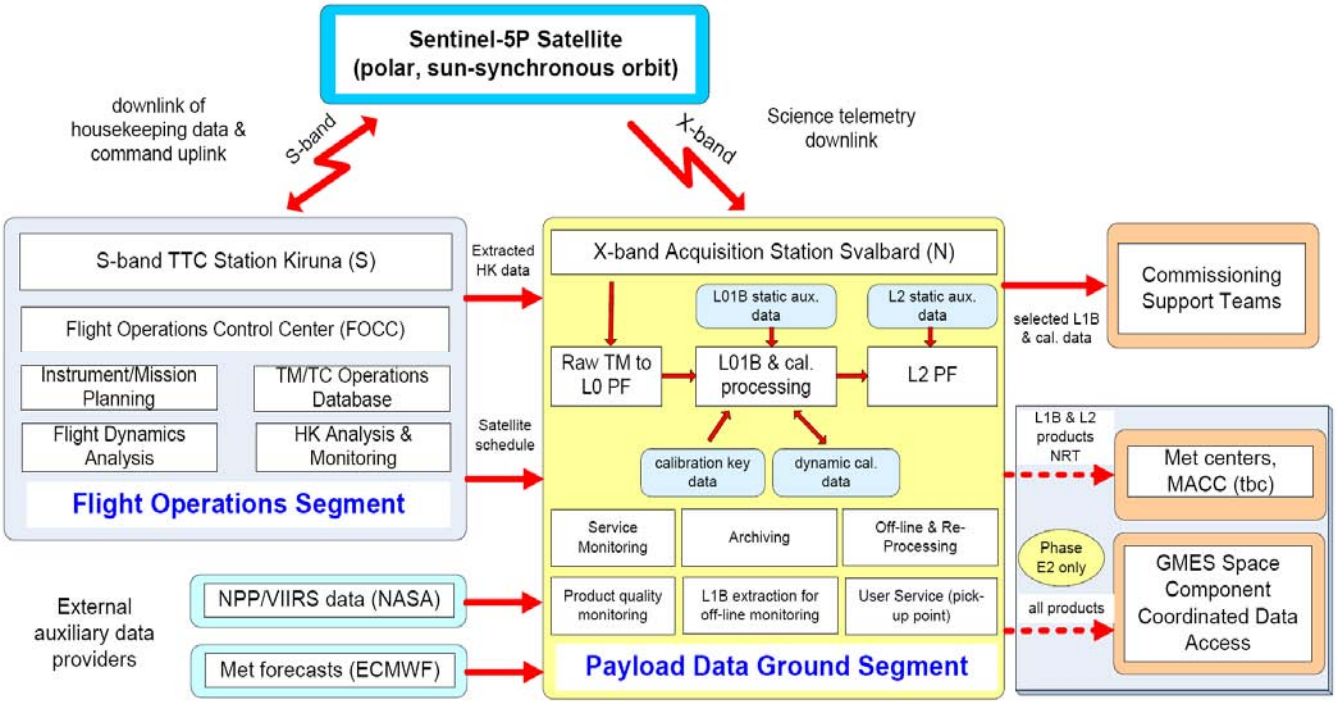

Figure 4: Ground Segment Schematic and Data Flows.

Product / processor component	Development		Operational Processor
	Algorithm prototyping	Independent verification	
mandatory products			
O_3 total column	D / BIRA (B)	KNMI (NL)	DLR-OP (D)
O_3 profile (incl. troposphere)	KNMI	RAL (UK)	KNMI
O_3 tropospheric column, clouds	D	KNMI / D	DLR-OP
NO_2 total & tropospheric column, aerosols	KNMI	D	KNMI
SO_2, HCHO	BIRA	D	DLR-OP
CO, CH_4	SRON	D	KNMI
CHOCHO	D	BIRA / D	DLR-OP
H_2O	D	SRON / D	DLR-OP
External aux. data			
Cloud data from NPP	RAL		

Table 1: Level 2 Products and Development Tasks.

DLR: German Aerospace Centre
SRON: Netherlands Institute for Space Research
KNMI: Royal Netherlands Meteorological Institute
BIRA: Belgian Institute for Space Aeronomy
RAL: Rutherford Appleton Laboratory
“D” denotes IUP/Universitst Bremen, Max-Planck-Institut Mainz