Sentinel-5 Precursor: Preparing the first Copernicus Atmospheric Mission

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Courtesy KSAT

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Sentinel-5 Precursor

First spacecraft in series of atmospheric observing systems within the Copernicus (former GMES) initiative

*Preparatory mission for the next generation, EUMETSAT operated atmospheric missions*

Sentinel-4   *geo-stationary component (part of MTG-S payload)*

Sentinel-5   *polar orbiting component (part of MetOp Second Generation)*

Launch window Sentinel 5P   -> April – July 2016

S-5P Mission Objectives

➢ *Focus on chemical composition of the Troposphere and lower Stratosphere; global monitoring capabilities for air quality and climate*

➢ *Pre-operational mission, to ensure continuation of predecessor missions SCIAMACHY/ENVISAT and OMI/AURA beyond 2012 … 2015*

➢ *Enhanced radiometric sensitivity & spatial resolution (typ. 7x7 km^2) enabling sampling of small-scale variabilities specifically in the lower troposphere*

➢ *Archiving & dissemination of global L1B & 2 data products over a design lifetime of 7 years*

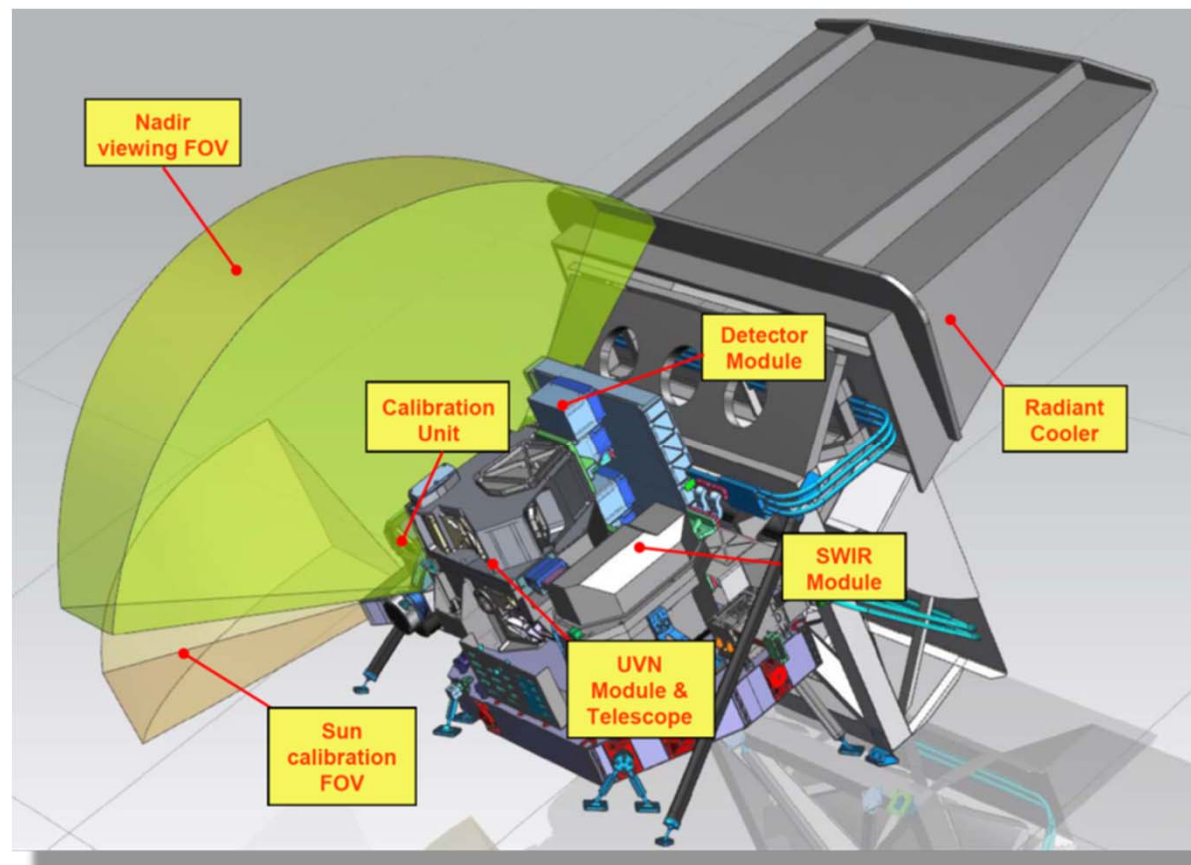➢ *Near real time service for a subset of Level 2 products*
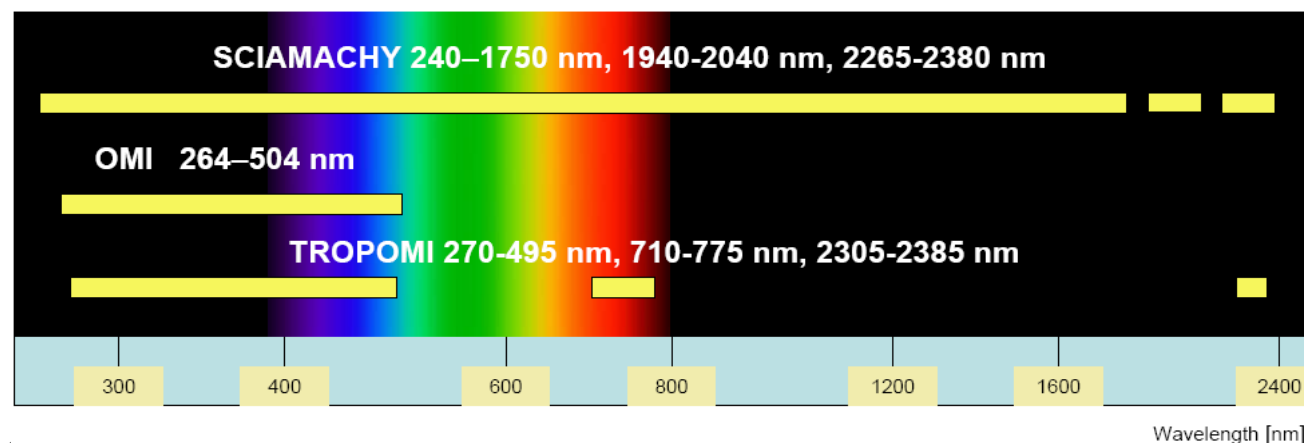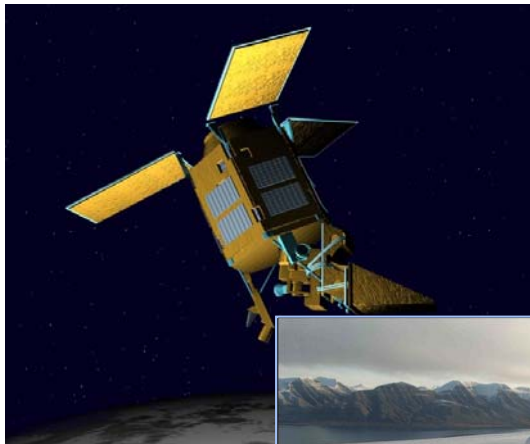
TROPOspheric Monitoring Instrument

TROPOMI/UV-VIS-NIR spectrometers developed as national contribution by The Netherlands Space Office (NSO)

Contractor: Airbus D & S NL (former Dutch Space)

SWIR module provided by ESA

Nadir viewing FOV

Detector Module

Calibration Unit

Radiant Cooler

SWIR Module

UVN Module & Telescope

Sun calibration FOV

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S-5P Satellite

Spacecraft

➢ *Mass: ~ 980 kg (TROPOMI ~220 kg)*

➢ *SA peak power 1,500 W*

➢ *Mass Memory: 480 Gbit*

Launch & Orbit

➢ *launcher: Rockot (Plesetsk)*

➢ *Near polar, sun-synchronous*

➢ *LTAN: 13:30 h*
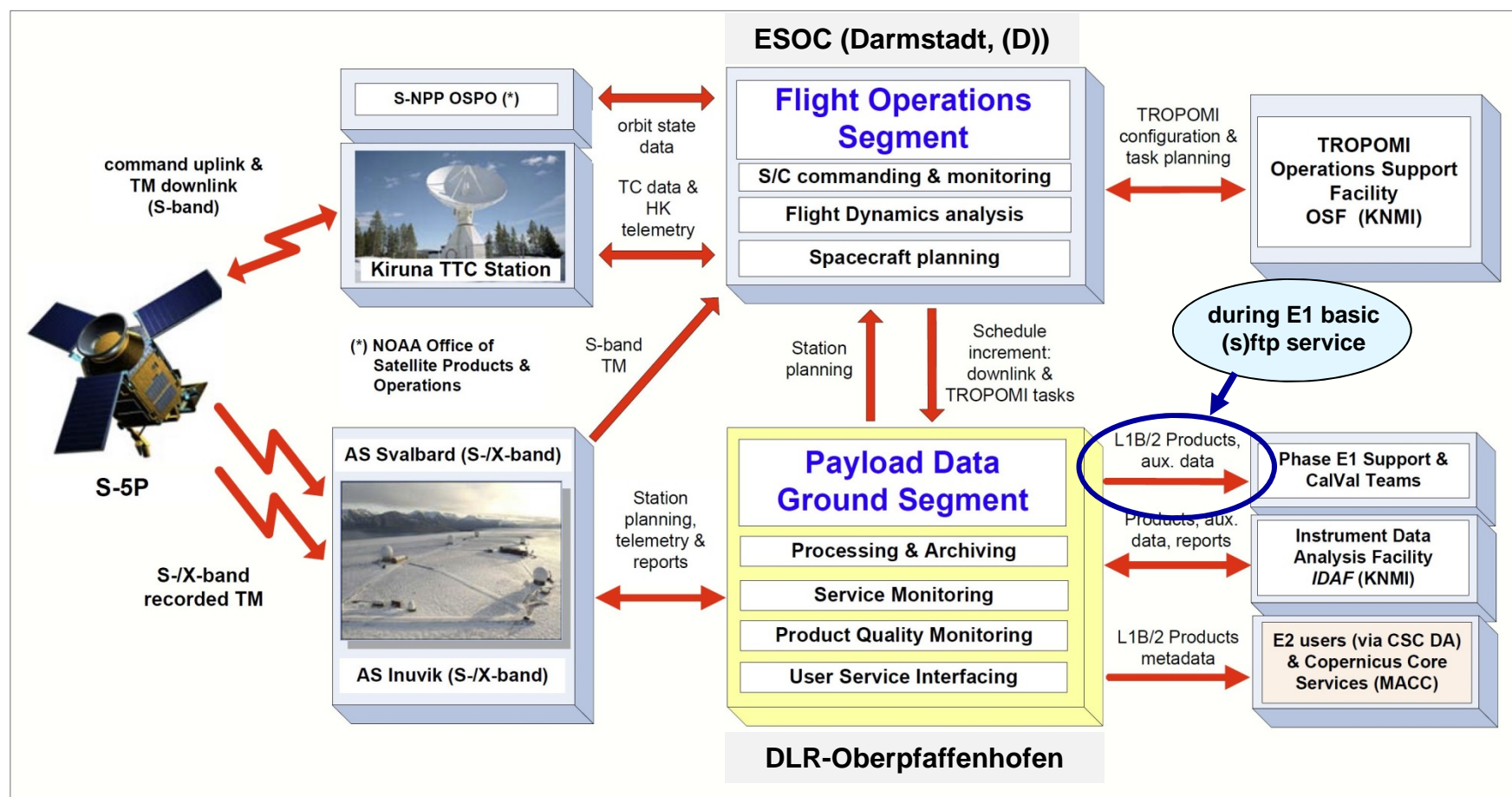
➢ *Repeat cycle: 227 orbits / 16 days*

Courtesy Khrunichev

Courtesy KSAT

X-band downlink ('science TM' only)

➢ *downlink rate: 310 Mbps*

➢ *data volume (X-band):   164 Gbits/orbit*

➢ *Ground stations: Svalbard (N) / Inuvik (Ca)*

S-5P Ground Segment (schematic)

Sentinel 5P data products

Product	Description	Remarks
Level 0	Unprocessed instrument measurement & housekeeping data	internal use only
Level 1B	Calibrated, geo-located Earth radiance and solar irradiance spectra in all spectral bands	Systematic processing
Level 2	Column densities / profile data for S5P primary species: ***UVN channel products*** O_3 — total column & tropospheric column, profiles NO_2 — total & tropospheric column SO_2, HCHO — total column aerosols — aerosol index and aerosol layer height clouds — cloud fraction, top height, optical thickness ***SWIR channel products*** CO, CH4 — total column	OFL all products. NRT: for all species except methane

Algorithm Development [1 / 2]

Contract with KNMI & SRON by NSO on L1B & L2 development &

TROPOMI support activities (covered by Dutch national funding)

Algorithms   *- L1B / L2 development & verification*

                       - calibration processors

                       - operational processors L1B & L2 components

TROPOMI support   *- on ground calibration & data analysis*

                       - TROPOMI operations concept

                       - in-orbit commissioning tasks

Algorithm Development [2 / 2]

Separate contracts for L2 work in Germany, Belgium and UK

Germany **DLR-Oberpfaffenhofen, IUP Bremen, MPI Mainz**

  tasks **L2 development, verification, operational processors**

Belgium **Belgian Institute for Space Aeronomy (BIRA)**

  tasks **L2 prototyping, verification**

United Kingdom **Rutherford Appleton Laboratory (RAL)**

  tasks **L2 verification, S-NPP cloud processing**

➢ *IUP, MPIC tasks fully funded by German national resources*

➢ *complementary funding for DLR, BIRA and RAL tasks by Germany, Belgium and UK, respectively*

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European Space Agency

TROPOMI FM

**Radiant cooler
prior to integration**

Airbus D&S Stevenage

June '15

courtesy: Airbus D&S UK

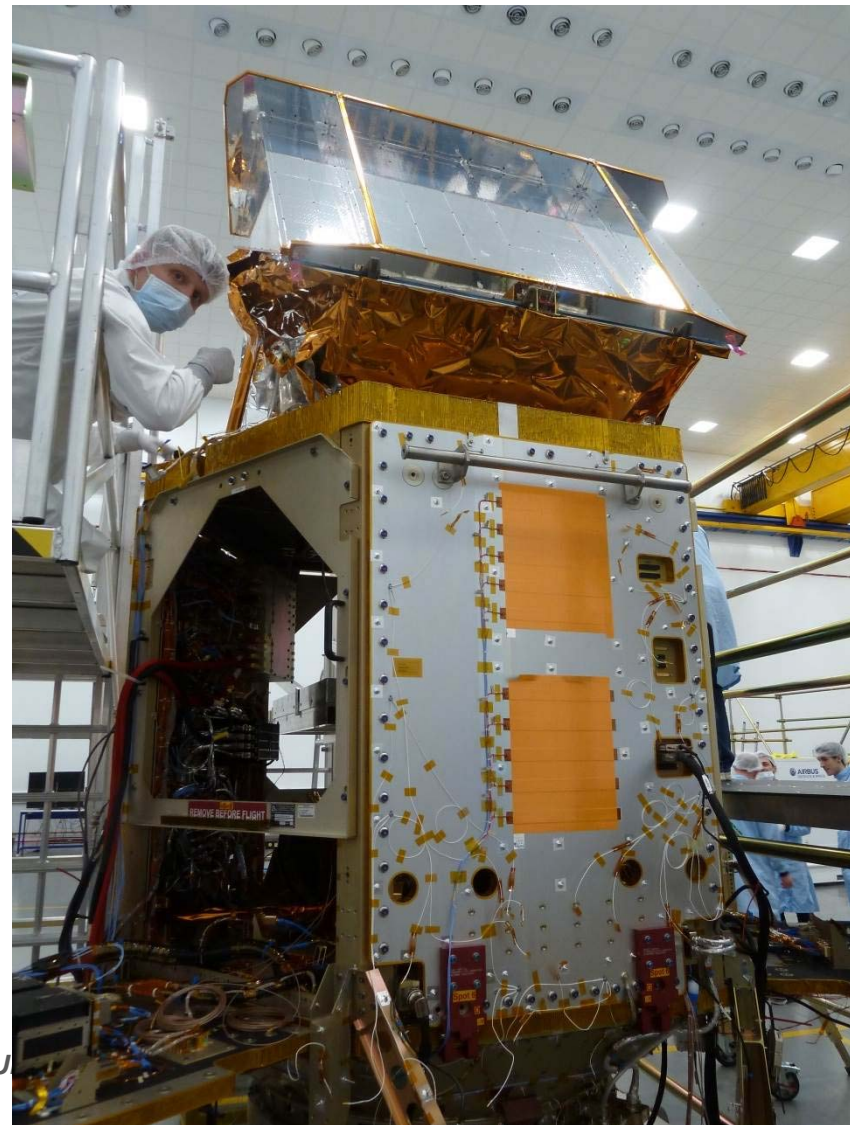*Sentinel-5 Precursor | ATMOS 2015 | Univ. of Crete | Heraklion, GREECE*

TROPOMI FM

**after mechanical integration
on platform**

Airbus D&S Stevenage, June '15

courtesy: Airbus D&S UK

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European Space Agency

Joint Operation S-NPP + Sentinel 5P

➢ *Level 2 processing of CH_4 challenging due to high accuracy requirement (< 2 % total column) -> retrievals performed only for cloud-free pixels*

➢ *Use of Suomi-NPP / VIIRS cloud mask data at high resolution (< 1 km^2), covering TROPOMI SWIR & NIR pixels*

➢ *'Loose' formation with S-NPP -> along track separation 5 min +/- 5 min & common ground track for both spacecraft*

➢ *Cross-track separation less critical due to larger swath of VIIRS (~ 3,000 km) compared to TROPOMI (~ 2,600 km)*

Loose formation
S-NPP + Sentinel 5P

5 min separation

Sentinel-5P

S-NPP

LTAN 13.25 h

LTAN 13.30 h
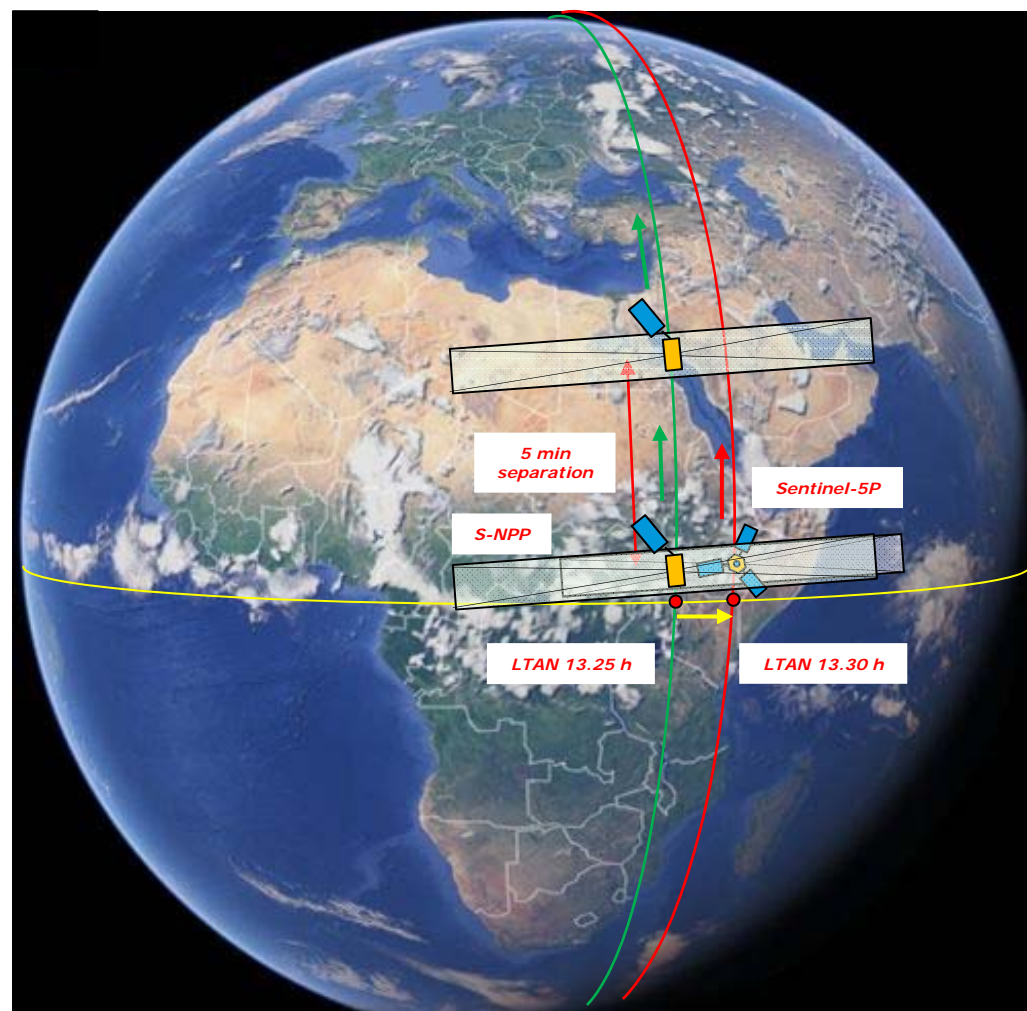
map: Google Earth

sentinel-5p

esa

S-5P: Phase E1 planning

Launch & Early In Orbit Operation [LEOP]

L + 24 h

equipment switch-on (TROPOMI at L + 4 weeks), verification & S/C commissioning

initial X-band data for PDGS validation tasks

L + 6 weeks

initial TROPOMI calibration; L1B check-out

algorithm checks & verification of PDGS processing chains (L1B & calibration)

L + 12 weeks

Systematic L1B processing; error budget compilation; L2 functional checks

algorithm checks & verification of processing chains (L2 included)

L + 16 weeks

stable TROPOMI operations & processing

L + 4 … 6 months: Products for specific applications; contents non-validated

L + 6 months

E2: routine operations & long-term validation

from L + 6 months: Products for CalVal projects; contents non-validated, long-term validation projects

Summary & Conclusions

➢ **Sentinel-5P to ensure availability of atmospheric products between predecessor missions SCIAMACHY & OMI and S-4 / -5**

➢ **Joint development of TROPOMI payload by NSO (Netherlands) and ESA**

➢ **TROPOMI FM integration on platform started in May '15**

➢ **L2 algorithms developed under parallel contracts (NL, D, B, UK); co-funding by national agencies**

➢ **validation of Ground Segment (FOS, PDGS, KNMI IDAF/OSF) in progress**

➢ **consolidation of CalVal projects and Phase E1 planning in progress**

➢ **Launch: April - July '16, with 6 months commissioning (E1) phase**