OPS-SAT Space Lab and the Thales Cyber Security Demo

David Evans

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Overview

- What is OPS-SAT Space Lab?
- OPS-SAT-1 Space/Ground Segment
- Mission Results so far
- Thales Cyber Security Demo Context

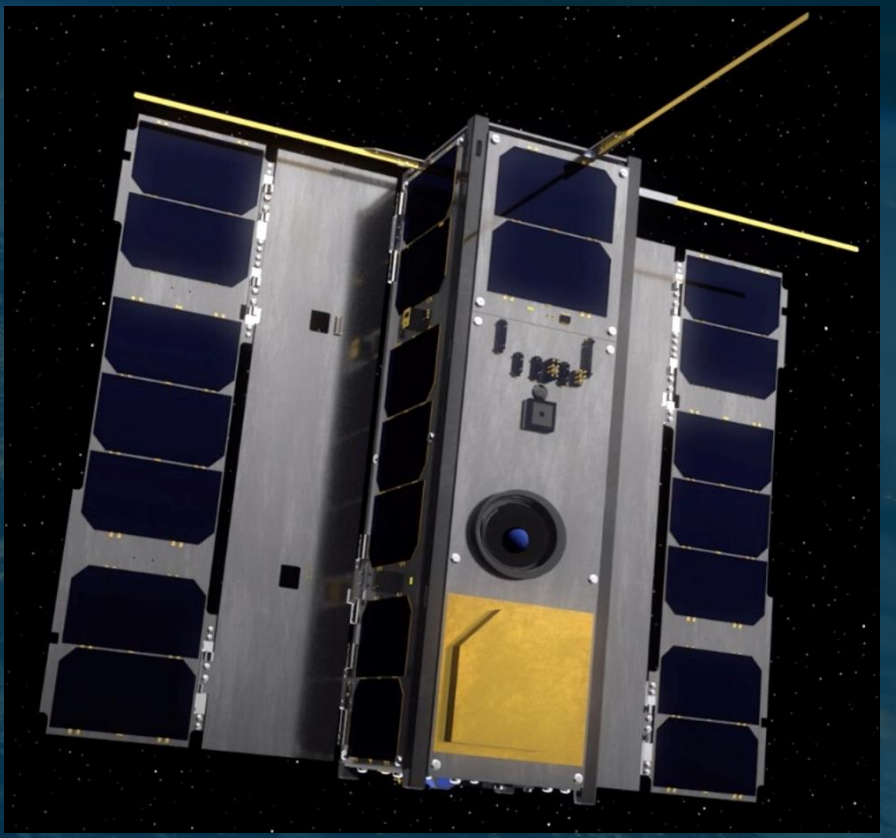


Image: ESA

What is the OPS-SAT Space Lab?

OPS-SAT-1 theme: Communication Protocols

OPS-SAT-2 theme: Optical and Quantum Communication

Images: ESA

OPS-SAT Space Lab is an **ESA service** to help accelerate innovation in ops related areas.

- It uses **powerful, reconfigurable** space elements that can be used for in-flight experimentation **not possible or desirable** on other missions
- The service provides access to these labs for **all** European industry and institutions, using a **fast, cost free, non bureaucratic process**
- ESA assumes the **risk and cost** of executing these in-flight experiments

OPS-SAT-1 Intro

- 1st nanosatellite (3U CubeSat) to be owned and operated by ESA
- Development funded by GTSP and ESOC innovation funding
- Launched 18th Dec 2019 from Kourou (VS23)
- 236 registered experiments from 26 countries
- Academia, start-ups, large corporations and other space agencies (CNES, DLR, JPL, JAXA, EU commission) are all innovating using OPS-SAT
- OPS-SAT-1 is 1st ESA led mission to receive the International SpaceOps Award for outstanding achievement (Dubai, March)

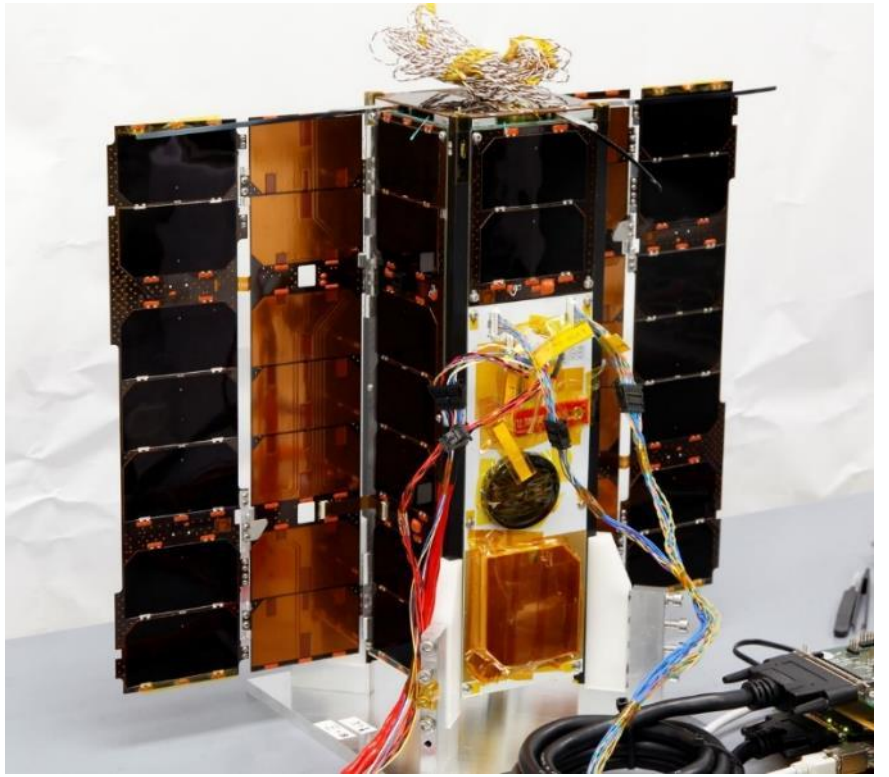


Image: TU Graz

OPS-SAT-1 Orbit

Launched 2019-12-18 (VS23)

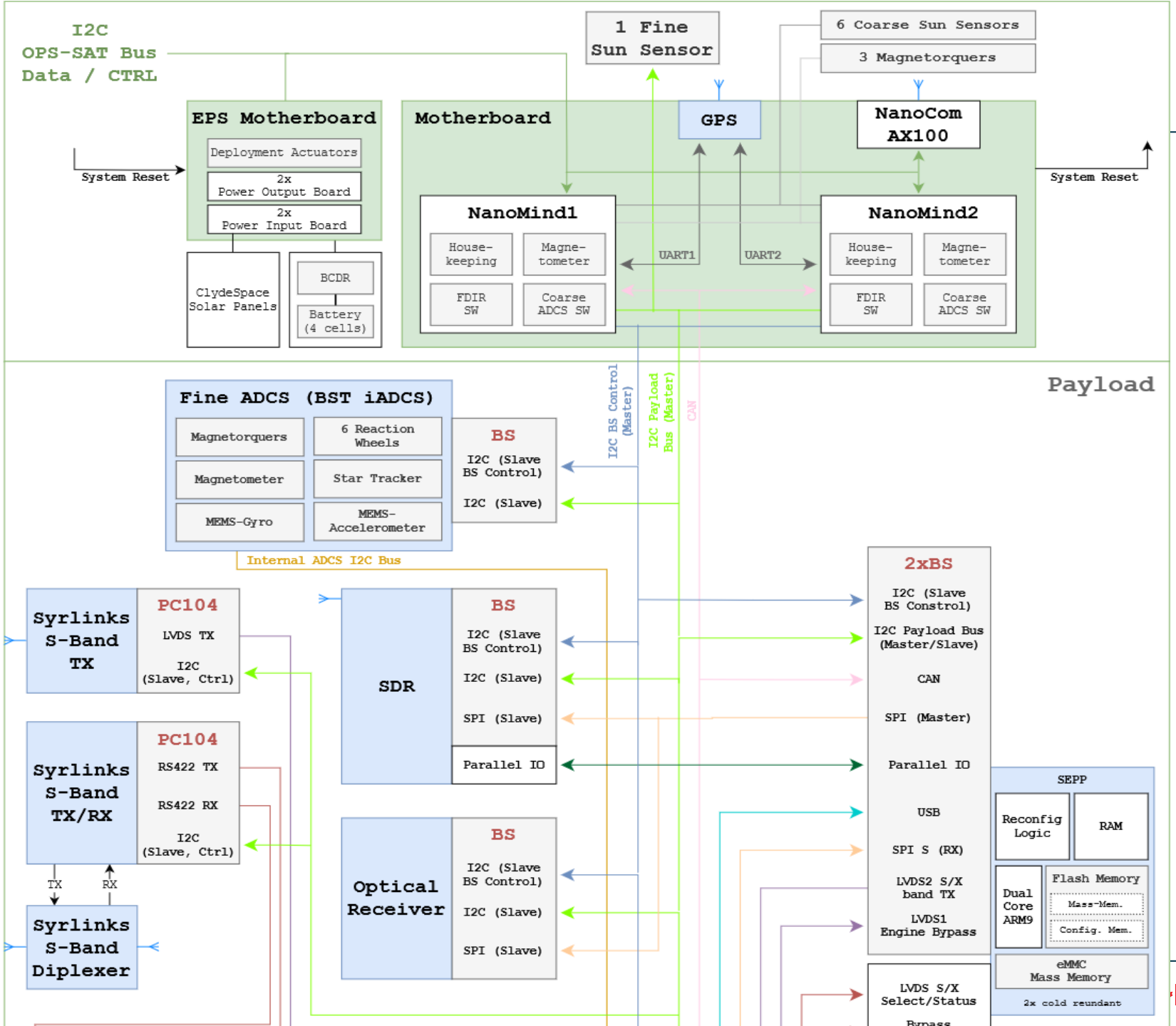
from Kourou with CHEOPS and COSMO-SkyMed SG

Orbit: LEO 515km, Dusk-Dawn Sun-Synchronous Orbit

Image: ESA - AOES Medialab

Image: ESA

Image: Arianespace



BUS

PAYLOAD

SEPP

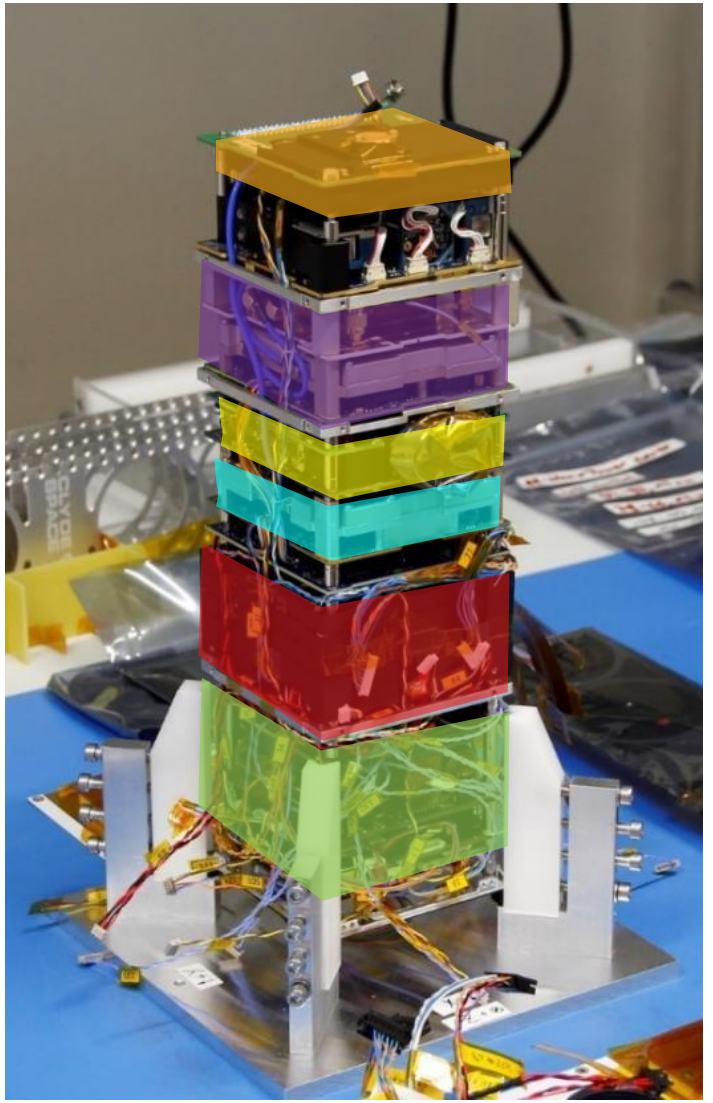
OPS-SAT-1 Space Segment

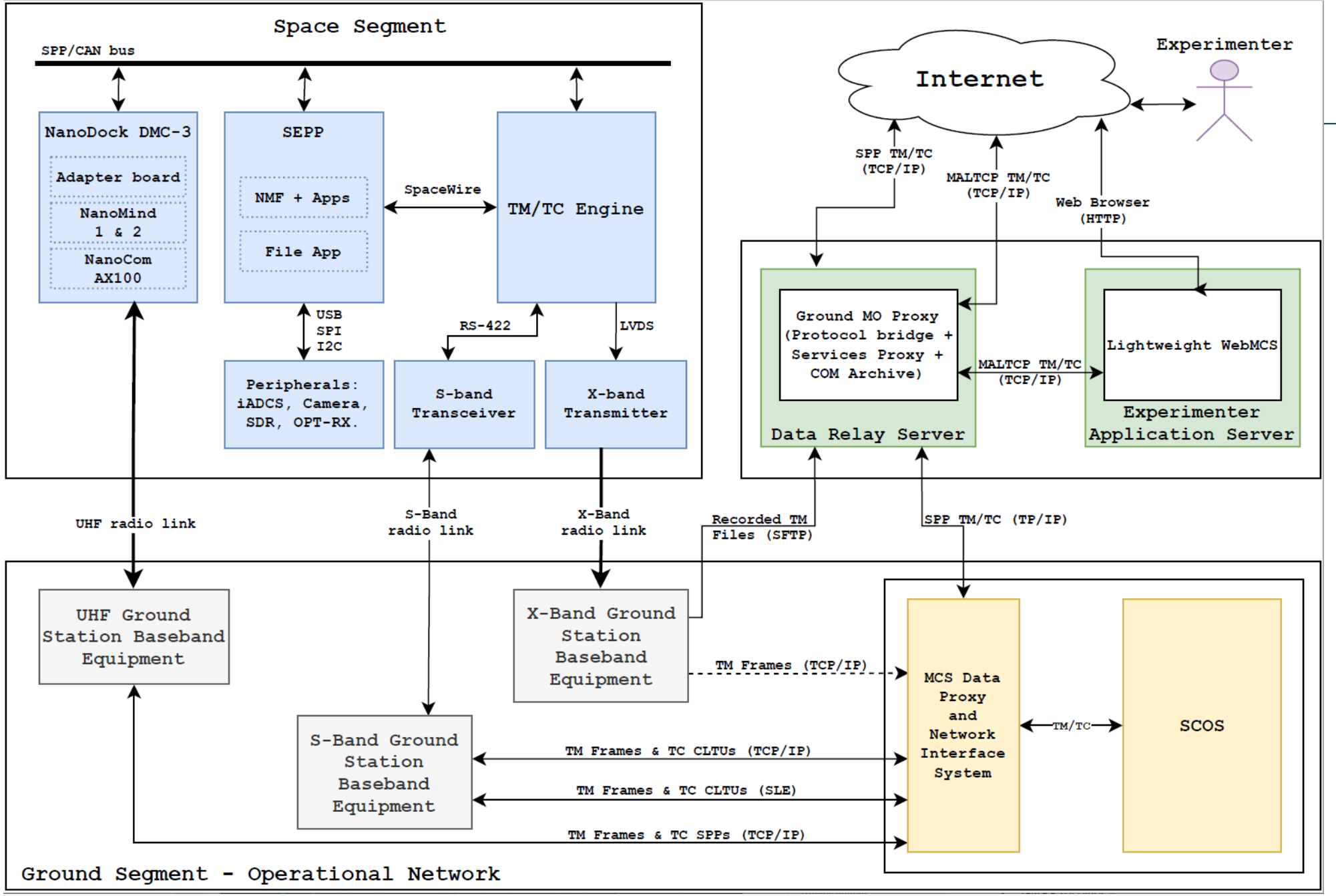
Satellite bus:

- Gomspace UHF AX100 radio + EPS/ACU
- Nanomind A3200 OBC (On-board computer, AVR32)
- S-band (2.2 GHz) TRX TMTC encoder/decoder (256kbps↑ 1Mbps↓)
- GNSS receiver

Satellite payloads available to experimenters:

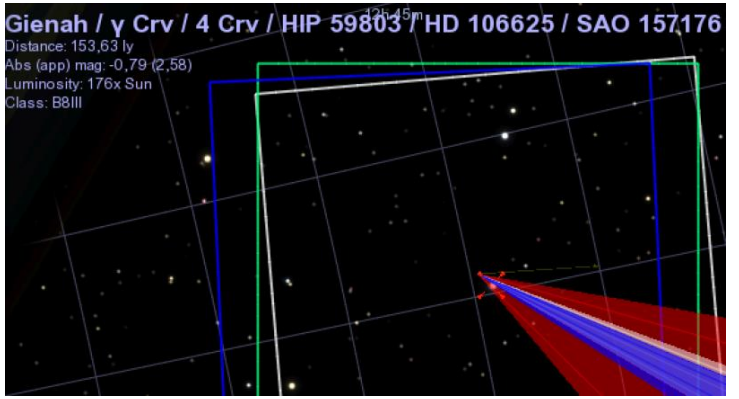
- Software Defined Radio (LMS6002D)
- HD-camera (Nadir-facing)
- Optical receiver (data uplink via laser)
- Advanced iADCS (Attitude Determination & Control Sys.)
- X-band transmitter (3-50MBit/s)
- 2x Cyclone V SoC (800MHz Dual Core ARM Cortex-A9 + FPGA fabric)




Space Segment
SPP/CAN bus
NanoDock DMC-3
Adapter board
NanoMind 1 & 2
NanoCom AX100
SEPP
NMF + Apps
File App
SpaceWire
TM/TC Engine
USB SPI I2C
RS-422
LVDS
Peripherals: iADCS, Camera, SDR, OPT-RX.
S-band Transceiver
X-band Transmitter
Internet
Experimenter
SPP TM/TC (TCP/IP)
MALTCP TM/TC (TCP/IP)
Web Browser (HTTP)
Ground MO Proxy (Protocol bridge + Services Proxy + COM Archive)
MALTCP TM/TC (TCP/IP)
Lightweight WebMCS
Data Relay Server
Experimenter Application Server
UHF radio link
S-Band radio link
X-Band radio link
Recorded TM Files (SFTP)
SPP TM/TC (TP/IP)
UHF Ground Station Baseband Equipment
X-Band Ground Station Baseband Equipment
TM Frames (TCP/IP)
MCS Data Proxy and Network Interface System
TM/TC
SCOS
S-Band Ground Station Baseband Equipment
TM Frames & TC CLTUs (TCP/IP)
TM Frames & TC CLTUs (SLE)
TM Frames & TC SPPs (TCP/IP)
Ground Segment - Operational Network

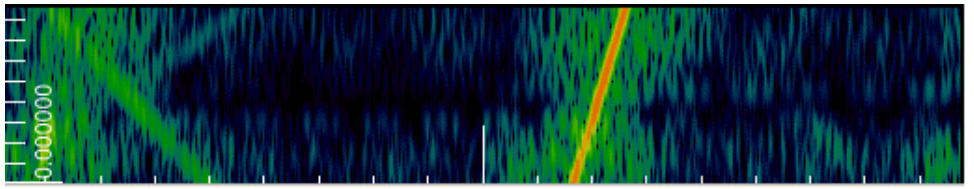
Experiment Highlights

- AI assisted attitude control loop, picture classification, FDIR
- Reprogramming of the Field Programmable Gate Array on a daily basis
- Software Defined Radio: experiments acquiring and processing on-board
- Direct command and control by experimenters over the internet
- Different experiments building on top of each other, e.g. AI, compression



Firsts by OPS-SAT

- First in-orbit use of CCSDS File Delivery Protocol (CDFP) by ESA
- First machine learning model training done on-board an ESA mission
- First stock market transaction in space
- First spacecraft controlled via EGS-CC (new ESA mission control software)
- First mission directly controllable by public over internet



More information on OPS-SAT

Thales Cyber Security Experiment Context

The OPS-SAT mission is a specially created environment that lends itself to performing in flight demonstrations of cyber security

- The ground infrastructure used for these exercises is completely isolated from that used by operational missions
- The satellite has been designed with the idea of an evil experimenter in mind. Therefore the bus is constantly monitoring the behaviour of the system and can shut it down if necessary. The emphasis is not on prevention but on recovery
- On-board operations are conducted in RAM only. Hence the system can be recovered by a power cycle of the experimental processor (SEPP)
- ESA was in control of system at all times, actively assisting the Thales team to perform the cyber security experiment.

Thales Cyber Security Experiment Context

This was a very informative educational demonstration. However the specific conclusions are not directly applicable to the security of operational ESA missions:

- OPS-SAT flies very unique hardware and software
- OPS-SAT is designed to, and therefore permits, third parties to load experimental software and firmware
- OPS-SAT is utilizing a fully separated ground segment and hence gives the possibility to third parties to interact directly with their on-board experiment in real-time
- To allow for meaningful testing, ESA provides a system image of OPS-SAT processor to experimenters..

Having said that, the OPS-SAT Team learnt a lot by assisting with these exercise and ESOC is becoming even stronger in the area of applied cyber security thanks to this experiment

We want to thank Thales and CYSEC for coming up with the idea and the opportunity to learn fast in a controlled manner

Thank you from the OPS-SAT Space Lab Team Members