ESAW 2017: Current OPS-SAT mission status and opportunities for experimenters

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“OPS-SAT is a safe, hard/software laboratory

• flying in a LEO orbit,
• reconfigurable at every layer from channel coding upwards
• available for authorised experimenters
• to demonstrate innovative new mission operation concepts.”

Mission Statement
Why do we need OPS-SAT?

Operators

Ground Segment Developers

ESA Project

Industrial Primes
Mission Summary

Platform: 3U CubeSat (5.9 kg)
Space Segment Funding: GSTP
Ground Segment/Operations Funding: ESOC
Status: Phase D
Expected Launch: Q1 2019
Orbit: circular SSO

First Nanosatellite to:
- be registered by ESA
- be controlled from ESOC (fully compliant with ESTRACK)
- uplink at 256 kbps (4 x faster than any other ESA satellite)
- downlink at 50 Mbps (1.5 x times faster than PROBA-V)
- implement an optical uplink
- carry a 800 MHz processor and a powerful fully reconfigurable FPGA
- implement new CCSDS space-ground application interfaces: CCSDS MO Services and CCSDS File Delivery Protocol (CFDP)
Space Segment

Triple CubeSat (10 x 10 x 30 cm) with deployable solar arrays
System Overview

- GPS
- OBC & Coarse ADCS
- FDIR Computer
- Attitude Sensors/Magnetorquer
- Solar Cells
- EPS
- Satellite Bus
- UHF Transceiver
- Data and power buses
- S-Band Transceiver
- X-Band Transmitter
- CCSDS Engine
- Fine ADCS
- HD Camera
- 2 x SEPP
- SDR Front-end
- Optical Receiver
- Payload
- UHF SDR antenna
- Antennas
- Payload Bus
- Data and power buses
- UPS Band Transceiver
- UHF antenna
Bus

Flight-proven subsystems
GOMSPACE OBC, EPS, UHF transceiver

Clydespace structure, deployable solar arrays
S-Band Transceiver – CCSDS Engine

Operating in telemetry S-band
Fully compatible with CCSDS standard
Uplink data rate: 256 kbit/s
Downlink data rate: 1 Mbit/s

SYRLINKS, France
Space Research Institute & CREOTECH, Poland
X-Band Transmitter Payload

EWCS 27 by SYRLINKS
CCSDS-compatible
Data rate up to 50 Mbit/s
Antennas

2 S-band patch antennas on opposite faces of spacecraft
X-band patch antenna on Nadir panel
The heart of OPS-SAT

- **2 x System on Modules in cold redundancy**
- **Processor**
  - Dual-core 800 MHz ARM Cortex-A9 processor
  - Altera Cyclone V FPGA, reconfigurable in flight, directly connected to S-band transponder
- **Memory**
  - 1 GB DDR3 RAM (ECC)
- **Mass Memory**
  - external 8 GB Industrial SD-Cards (SLC)
- **Software**
  - Linux, Java, NMF (see later)

Radiation-tested at ESTEC up to 20 krad
Software-defined Radio Receiver

RF front-end based on LTE chip
Interfacing with processing platform
Frequency range: 300 MHz – 3.8 GHz
„Spectrum analyser in Space“
UHF signal monitoring
Optical Uplink Experiment

16 kbit/s data rate, but...
Uplink of cryptographic key for RF downlink
Hardly interceptable
One-time pad method (not breakable)
Never done before in satellite communications
Payloads

Fine attitude control system with star sensor and 6 reaction wheels (iADCS)
HD Camera with 50 – 60 m ground resolution

Berlin Space Technology BST
NanoSat MO Framework (NMF)

A software framework for nanosatellites based on CCSDS Mission Operations services.

Collaboration between ESOC and TU Graz (César Coelho)

Characteristics and new concepts:

- Brings “Apps” into space
- Simple Software Management: install/start/stop
- Monitoring and control capabilities for NMF Apps
- Open-source
Software Validation Tests
Experimentation

119 OPS-SAT Experiments submitted from big primes to one man shows

Covering every aspect of end to end operations
Experimentation

ESA’s aim to remove as many barriers to experimentation as possible:

Technical: Use of SEPP allows „normal“ software as OBSW e.g. Java rather than embedded

Technical: Lots of on-board resources e.g. processing power, memory, downlink capacity

Technical: Synergy between experiments. Building on each other, offering data or services to each other..

No paper work! Reduce the overheads to close to zero

Automated testing infrastructure at ESOC. Submit an experiment remotely and have it tested automatically with a test report
Experimentation

Ease of Access. Mission allows experimenters to communicate directly with on-board experiment i.e. remote operations of payloads

Use of NanoSat MO Framework
  Monitor and control of experiment

EUD4MO provides a web-based solution for the M&C of NMF Apps

Direct forwarding of space packets to spacecraft by OPS-SAT ground segment

Exchange of files via SFTP with data relay server at ESOC on the ground and to the spacecraft using new CCSDS file transfer standard CFDP
Operational facilities

Special Mission Infrastructure Lab Environment

- Hosts multiple projects and services simultaneously
- Agile prototyping
- Easy to maintain
- Highly customizable and extendable
  - Network setup
  - Processing power
  - Data storage
- Software Defined Radio access to OPS-SAT antennas
Operational Ground Station

**SMILE Ground Terminal**

- Available in 3Q 2017 at ESOC
- 3.7 meter dish covered by a radome
- S-Band up/down link
- X-Band down link (up to 15Mbit/s)
- Velocity up to 10deg/s

![Diagram of SMILE Ground Station](image-url)
Teams

Space Segment:

TU Graz (A) (Technical Lead)
UniTel IT-Innovationen (A), Prime Contractor

Subcontractors:
Berlin Space Technologies (D)
GMV (PL)
GOMSPACE (DK)
MAGNA STEYR Aerospace (A)
MEW Aerospace (D)
Space Research Centre, Warsaw (PL)

Ground Segment Team:

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Moritiz Woitelle
José Luís Feiteirinha
César Coelho
Dominik Marszk
Thorsten Graber
Conclusion

OPS-SAT is a unique flexible platform for on-board software and hardware experimentation

Demonstration and validation of new operational concepts (MO Services, File-based ops, remote payload ops..)

ESA offers open policy for experimenters
Encouraging novel experiments
Registration is very easy and has advantages for execution order

GSTP funding for experimenters (limited to 20K per experimenter) request process in progress

OPS-SAT Launch is expected in early 2019 but the innovation is already happening
Don’t just say we can do it better..

Fly it!

Prove it!