OPS-SAT-2: An ESA in-orbit laboratory for optical and quantum Ground-Space experimentation

David Evans, Vladimir Zelenevskiy. Dominik Marszk. Sam Bammens, Vasundhara Shiradhonkar

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What is a OPS-SAT Space Lab?

An OPS-SAT Space Lab is a collection of ESA ground and space assets that:

- Includes **powerful, reconfigurable, open labs** in space that can be used for in-flight experimentation **not possible or desirable** on other missions

- ESA provides access to this lab 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

It is not flight proven… We wont fly it…

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OPS-SAT-1 Space Lab

- 3U CubeSat, first nanosatellite to be owned and operated by ESA

- Funded by GTSP and ESOC innovation funding

- Launched 18th Dec 2019 from Kourou (VS23) in a 515km SSO

- 100+ European companies from 17 countries have now registered 216 experiments

- 55 additional experiments applied via the recent OSIP campaign (12 best have received ESA discovery funding)

- Academia, start-ups, large corporations and other space agencies (CNES, DLR, JPL, JAXA) are all innovating using OPS-SAT
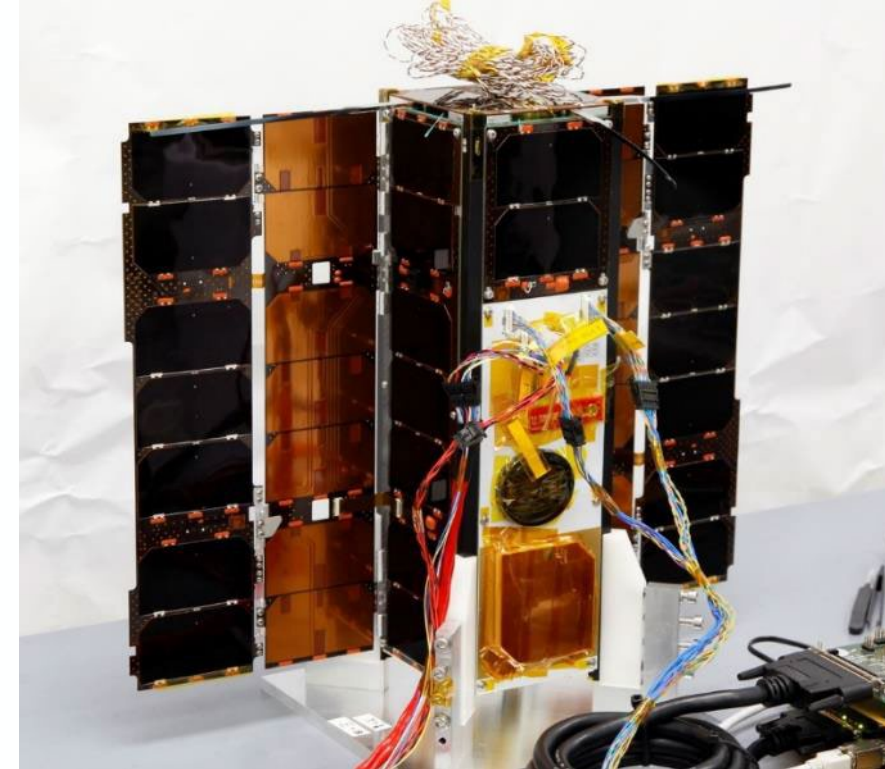
Experiment idea to IOD test in 72 hours

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Some OPS-SAT-1 success stories….

- First worldwide reprogramming of Neural Network on a FPGA **in space**

- **On-board AI** used on a daily basis to classify camera pictures

- Spacewire implemented **in orbit** by reconfiguring FPGAs attached to a raw LVDS line (increased download capacity by ten)

- TCP/IP direct connectivity implemented **in orbit** from internet to spacecraft processor

- Spectrum recording of GNSS frequencies to monitor and test jamming techniques

- First ever live cyber security experiments on a flying spacecraft (on hold due to present security situation)

- Interplanetary internet successfully tested

- First ever **in orbit** decoding of international search and rescue messages

- Robust delay tolerant networks **in space** demonstrated for the first time

- AI assisted ADCS algorithms (Solar Orbiter), file based protocols (Euclid), compression techniques (new generation Sentinels)…..

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Some examples of EO relevant experiments

- Deep Learning Model Implementations to Support a Satellite-based Coastline Anomaly Monitoring System

- Versatile data compression software for sustained high-throughput in-orbit data acquisition

- Tracking deforestation – based on segmentation DNNs

- Onboard Multi-Frame Super Resolution Image

- Onboard Machine Learning Software as a Service
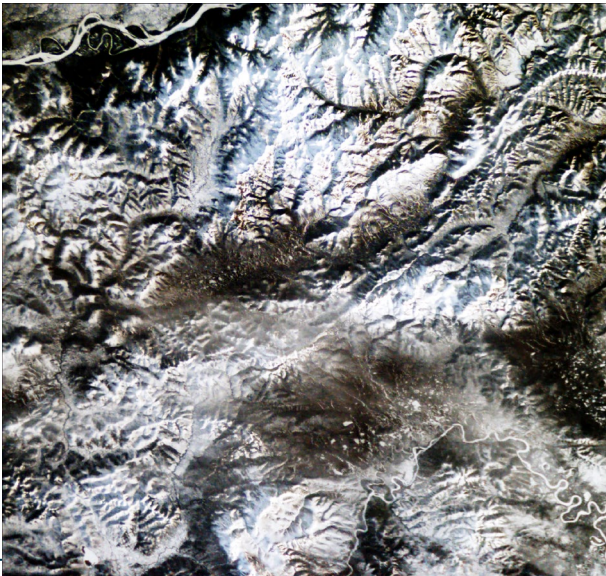
KELVINS competition

https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Teach_an_Earth-observing_satellite_to_know_what_it_sees

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OPS-SAT-2: Why Optical Communications?

We are at the start of a crisis in space-ground communications

- RF spectrum traditionally allocated is constantly under attack from very well resourced terrestrial applications
- The regulation of the remaining spectrum is becoming tighter
- The number of space actors wanting access to that spectrum is dramatically increasing
- The amount of communications bandwidth needed by space-ground applications is constantly increasing
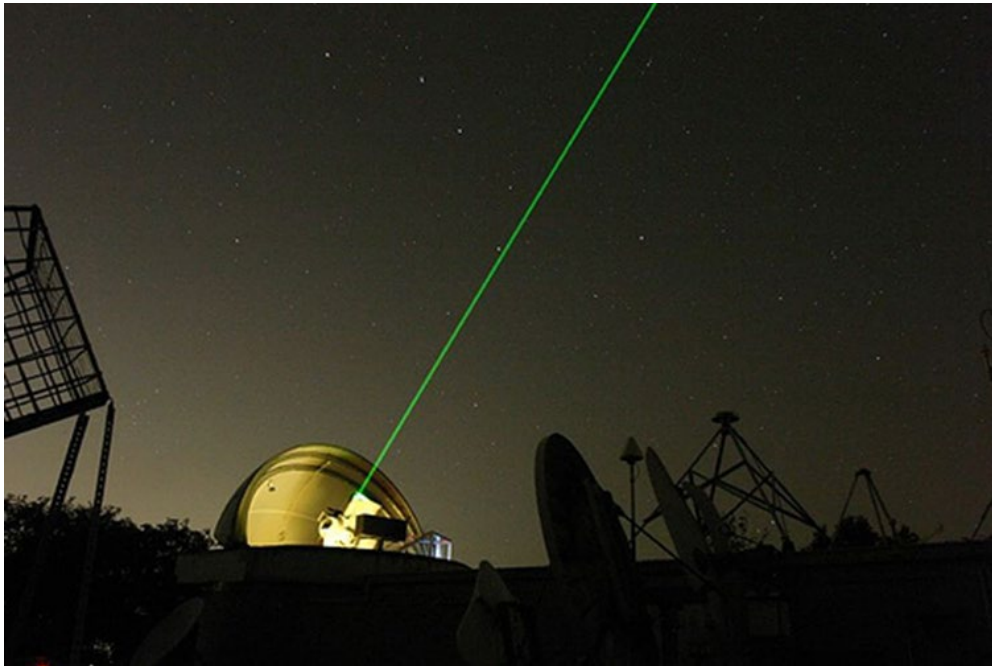
Source: IWF/OEAW

The solution is optical communications

- High data rates
- No regulation
- New applications e.g. Quantum based encryption

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OPS-SAT-2 Optical Space Lab

Thanks to projects such as AlphaSat and EDRS, Europe now has lots of hard won operational experience in optical inter-satellite links. However there is very little for Ground to Space optical links

The experience that exists, mainly involves expensive, professional ground terminals with large apertures (usually sitting on top of volcanoes in stable weather conditions)

This is a long way from the concept of operations proposed for commercial constellations in which significant investments are now being made i.e. ground terminals in city centres, near airports etc.

It is therefore essential to deploy a mission as soon as possible to de-risk these operational concepts so that the experience can feed back into the design of the respective space and the ground segments

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OPS-SAT-1 optical comms lessons learnt
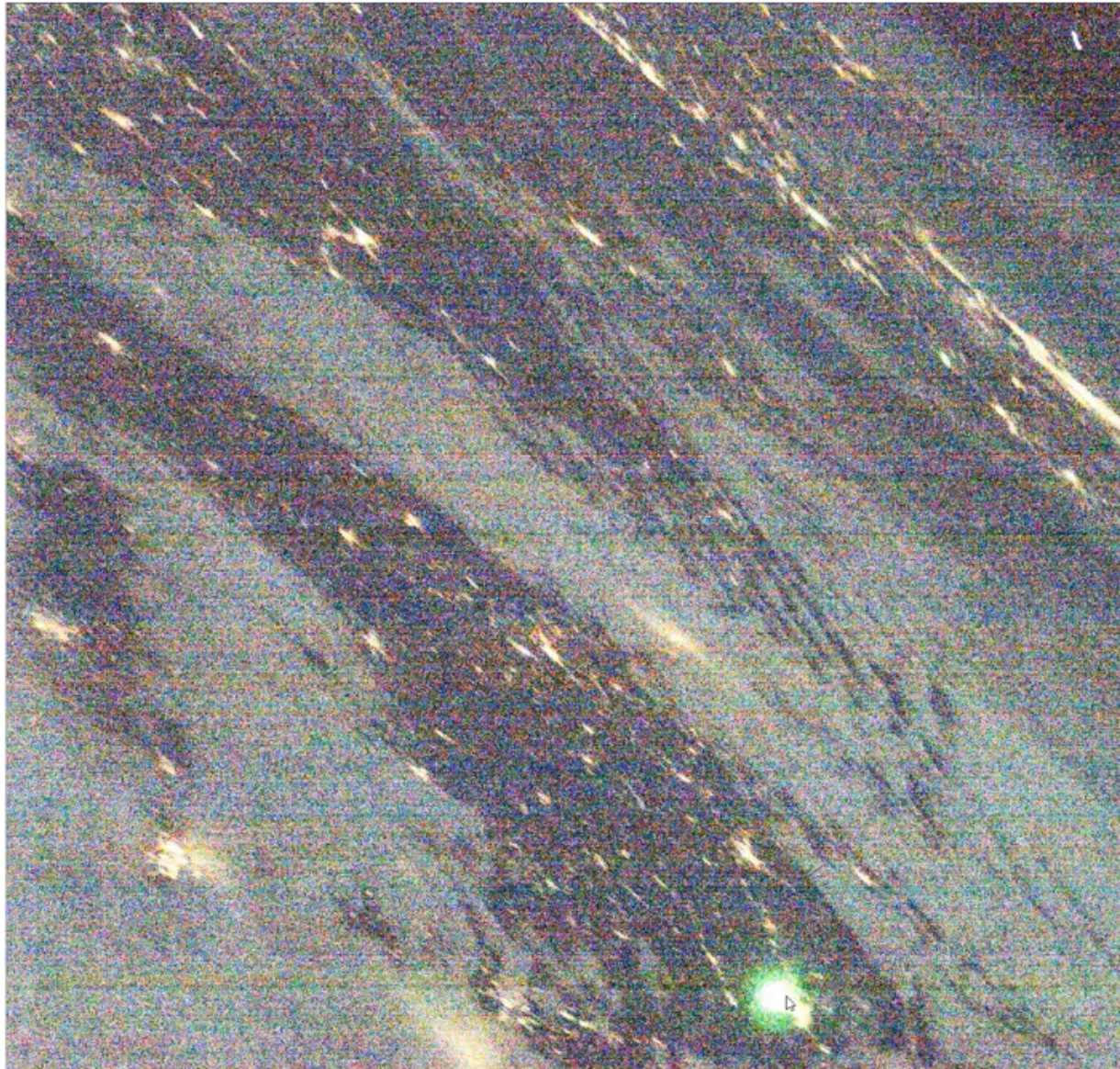
- ADCS
- GNSS
- Clouds
- Testing
- Diagnostics
- Ground truth

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# OPS-SAT-2 Mission Statement

OPS-SAT-2 Optical Space Lab Mission will enable European industry, to gain the necessary operational experience, to take optical ground-space communications from the domain of specialists with ground terminals on volcanos, to companies deploying thousands of ground terminals in world city centres
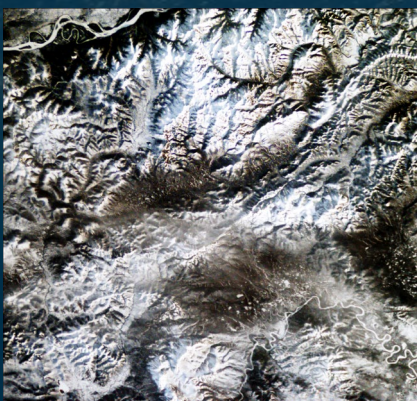
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OPS-SAT-2 CDF configuration
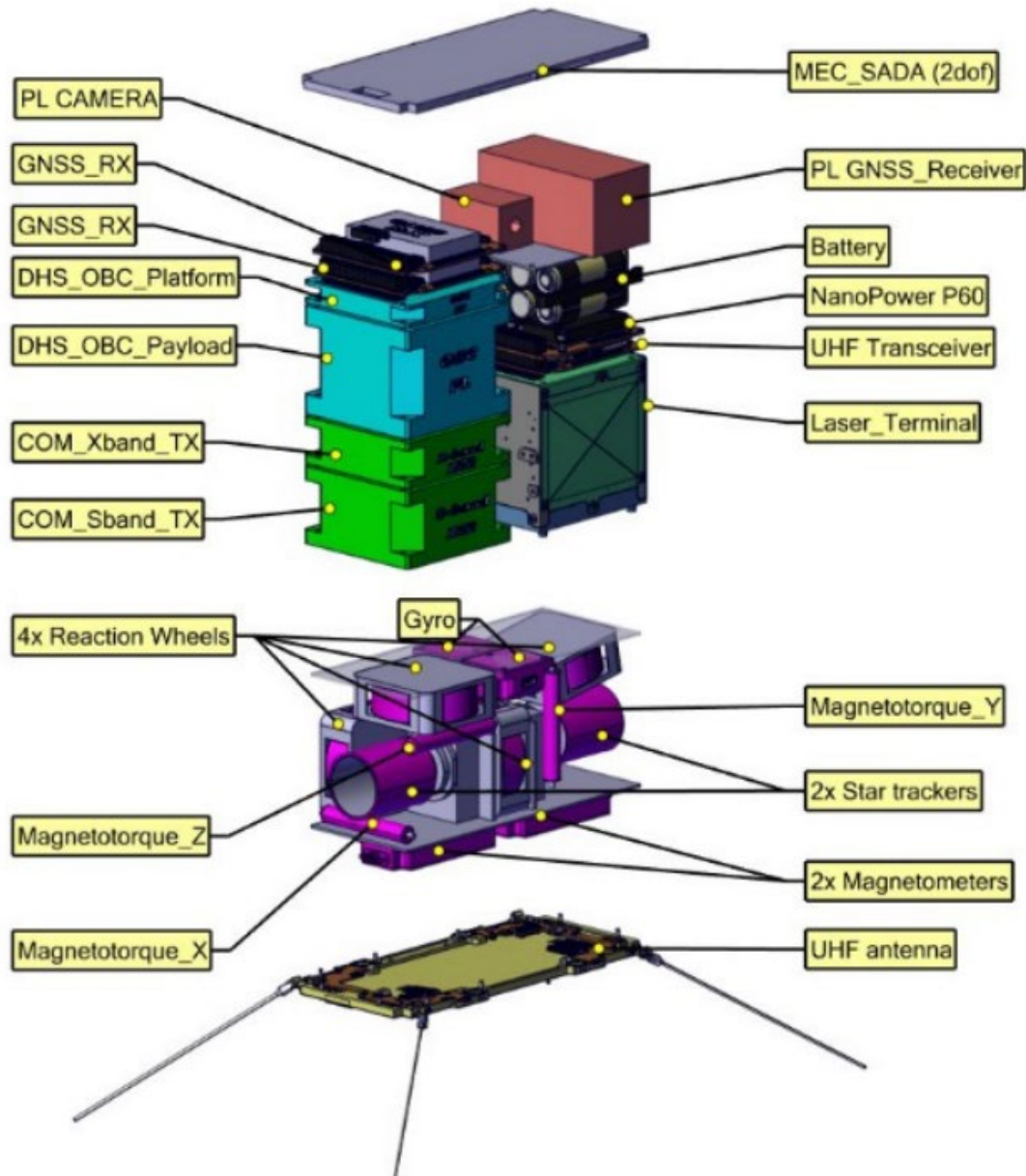
- Payload computer a thousand times more powerful than on OPS-SAT-1
- 1 Mbps optical duplex communications
- ADCS capable of meeting the challenge scenario
- cm level GNSS measurements

- **The CDF report is available on request**
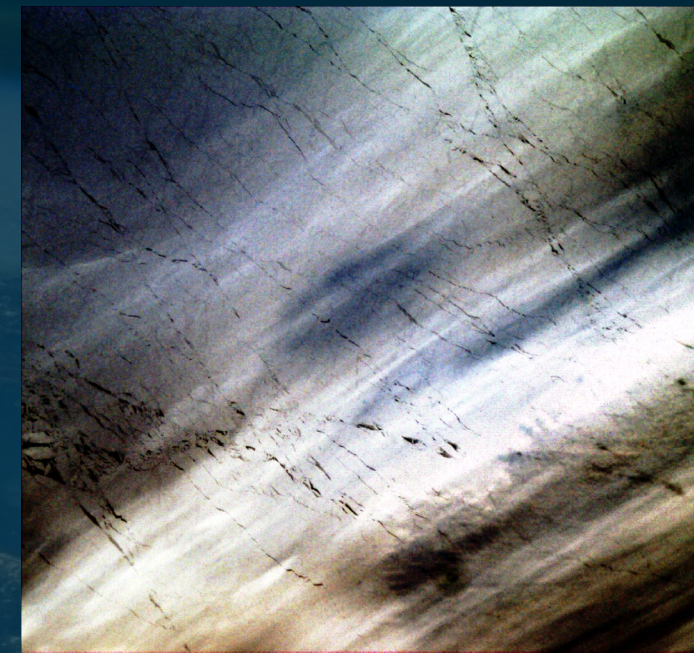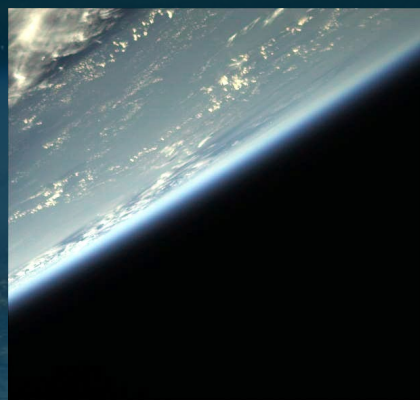
Thank you!

More OPS-SAT-1 pictures (and now videos) below
https://www.flickr.com/photos/esa_events/albums/72157716491073681

David.Evans@esa.int

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