


Technology trends and capabilities for maximizing useful throughput per downlinked data unit by enabling onboard image processing

Andreas Thorvaldsen*, Jānis Gailis, Michael Soukup,
Arnoud Jochemsen, Christina Aas, S[&]T Norway
OBDP2019, ESTEC, February 26th, 2019

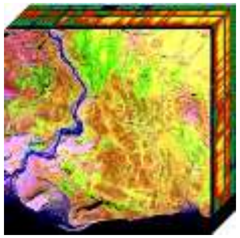
s[&]t

Outline

- Why process onboard?
- HyperScout experience
- The FONDA project
- Training/test data generation

The main reason

- Image sensors == big data.



(NASA)

- Image sensor data rates >> cubesat downlink data rates.

Limit the number of acquisitions

Timeliness of the data is poor

The HyperScout mission

"Miniaturized hyperspectral imager with its own brain"

European Space Agency (ESA) GSTP project.

- 2014: Development started
- 2016: Engineering model ready
- 2017: Flight model ready
- 2018: Launch onboard GOMX-4B

esa

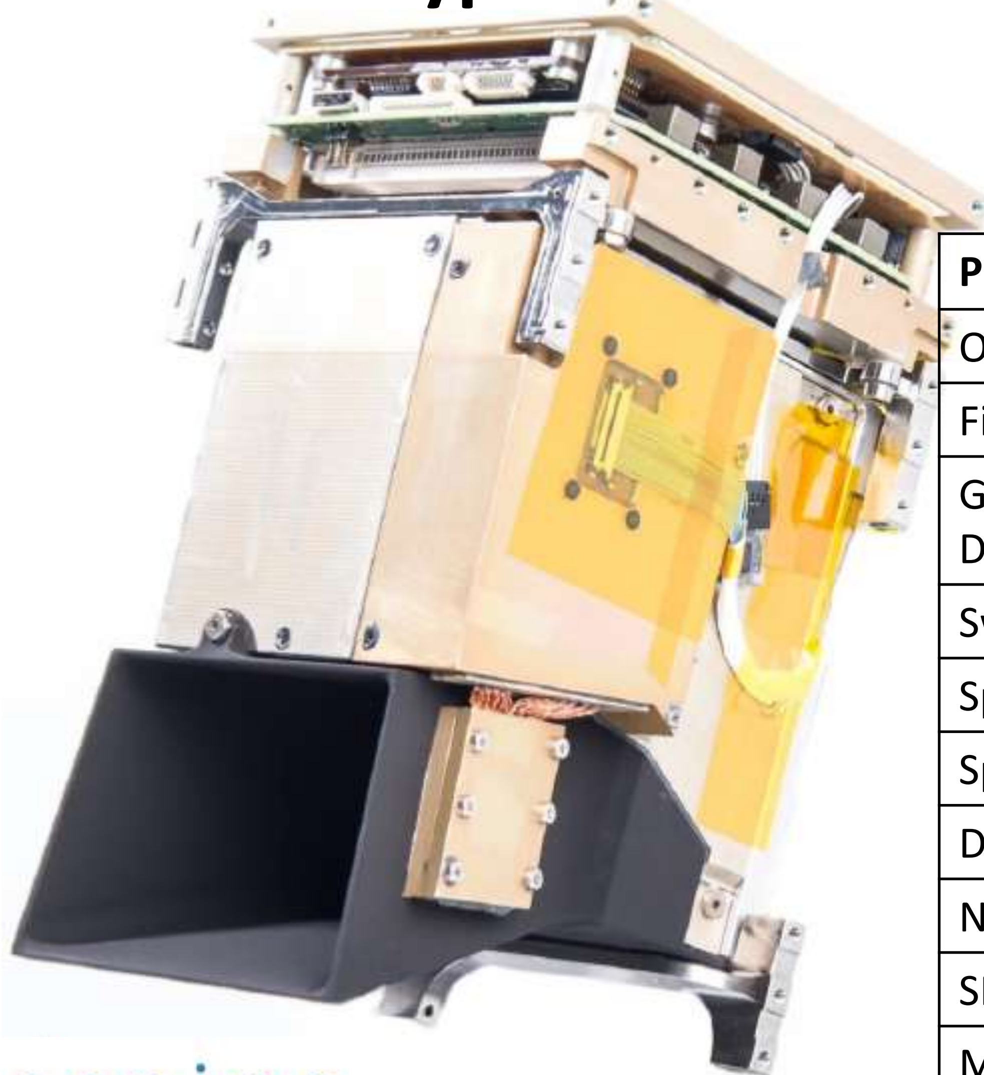
cosine measurement systems

s[&]t

vito

TU Delft

The HyperScout instrument on GOMX-4B



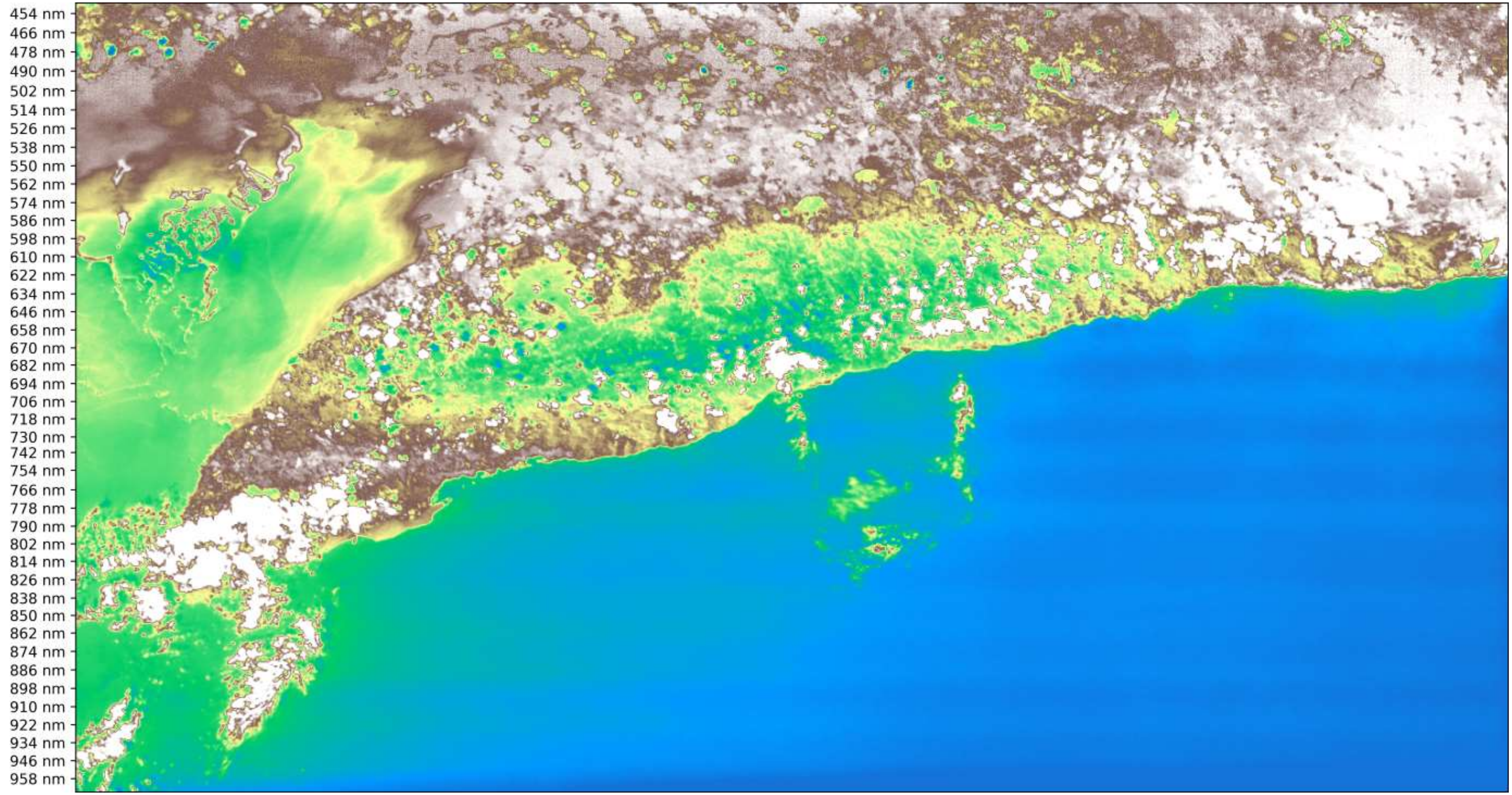
cosine

Parameter	Value
Orbit	Sun synchronous, 500 km
Field of View	23º (ACT) x 16º (ALT)
Ground Sampling Distance	70m
Swath	200 x 150 km (ACT x ALT)
Spectral range	400 – 1000 nm
Spectral res.	15 nm
Dynamic range	12 bit
Number of bands	~45
SNR	50-100
Mass	1.3 kg
Power	9 W (peak)

GOMX-4A and GOMX-4B

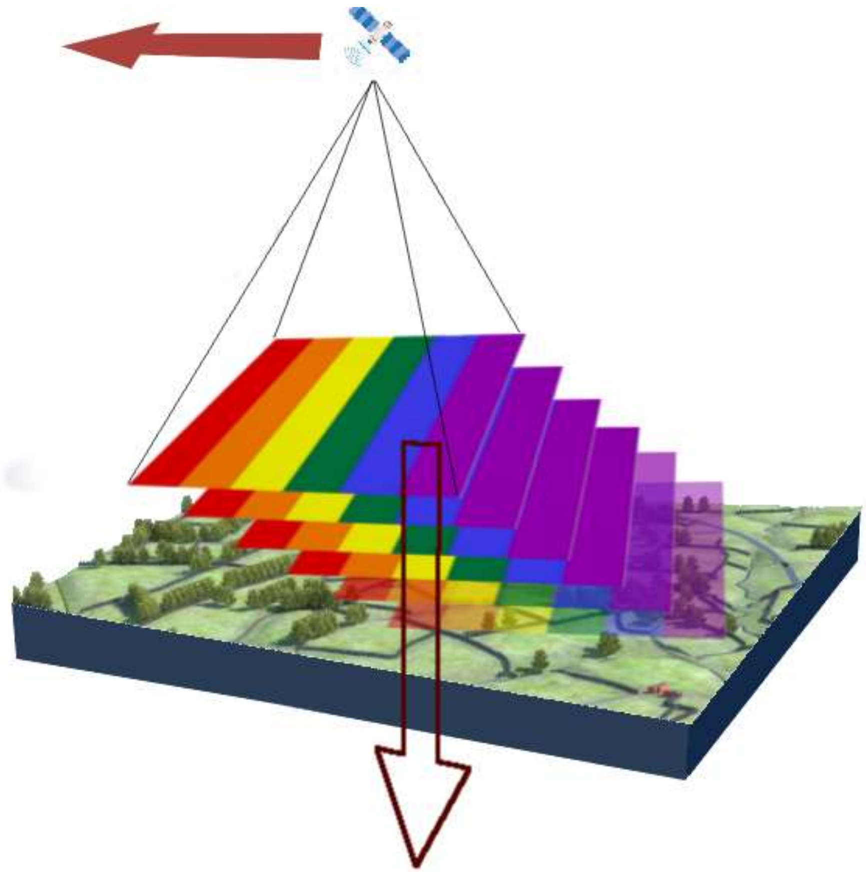
(Photo by ESA)

First light



Commissioning image of HyperScout®. Flase colour single image of the southern Cuban costline. Image acquired on the 20th March 2018 (cosine)

HyperScout on-board data processing



For any area, the full spectrum is present. Different spectral data are provided by subsequent images.

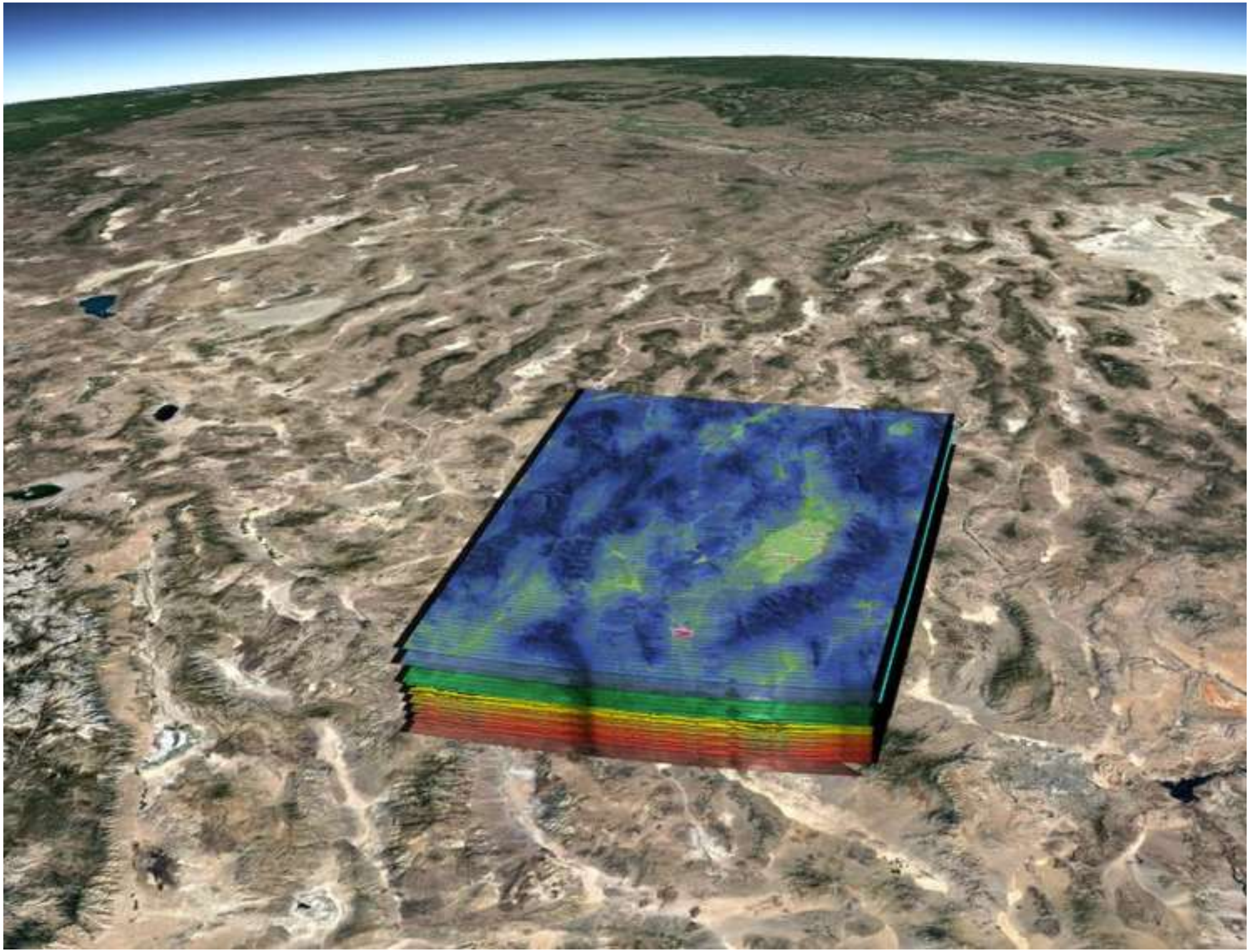
Data level	Processing step
L1a	Geometric calculations
L1b	Radiometric corrections
L1c	Data reshaping
L2a	Projection and resampling
>=L2b	Cloud masking, atmospheric correction, segmentation, classification, change detection

s[&]t

Image courtesy VITO

(slide with confidential content removed)

10-band-image L2a at 150m



(slide with confidential content removed)

FONDA project

Flexible ONboard Data Analysis:

CPU

↓ / Watt
↓ / time
↑↑↑ / manhour (Python, C++)

- orchestration
- landmark/object recognition
- change detection
- identify CNN training holes
- prioritize downlink

FPGA

↑↑ / Watt
↑ / time
↓↓↓ / manhour (VHDL)

- radiometric processing
- cloud masking (CNN)
- ship detection (CNN)
- iceberg detection (CNN)

GPU

↑ / Watt
↑↑ / time
↑ / manhour (C)

- spectral calibration
- atmospheric correction
- haze cloud detection (CNN)
- cloud shadow detection (CNN)
- projection
- land cover classification (CNN)

s[&]t

Test/training data generation

Spectrally and spatially downsample data from existing satellite instrument into data for a future satellite instrument:

- To make good training data, existing data should have at least the same
  - Spatial resolution
  - Spectral resolution
  - Spectral range
- Sentinel-2 possible alternative for RGB
- General purpose hyperspectral sources preferable:
  - Hyperion
  - HICO
  - CHRIS
  - DESIS
  - PRISMA
- HyperScout processor used PROBA-V, Balloon and AVIRIS for test data

s[&]t