cosine | Remote Sensing

Hyperspectral, Thermal Sensing and Artificial Intelligence for Breakthrough In-Space Applications

Small Sat Symposium 2020

EARTH OBSERVATION – CLOUD SERVICES, DATA PROCESSING AND ANALYSIS WORKSHOP

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Unit Manager Remote Sensing
Silicon Valley
February 2020

two decades of heritage
from the largest ESA missions to fast-track new space

Earth observation | space science | manned space flight | planetary science | navigation missions

credits ESA, NASA

HERITAGE | HAYABUSA2

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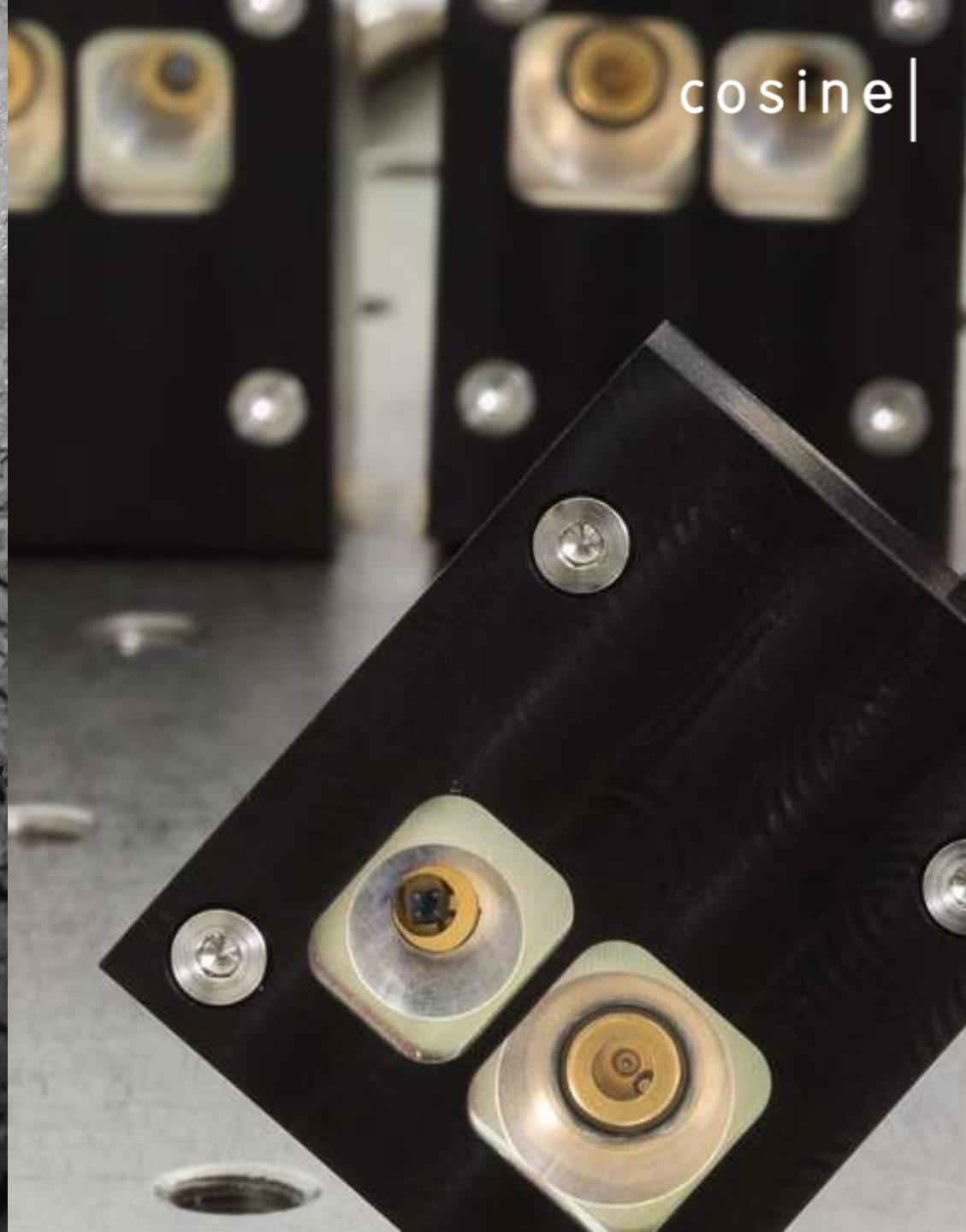

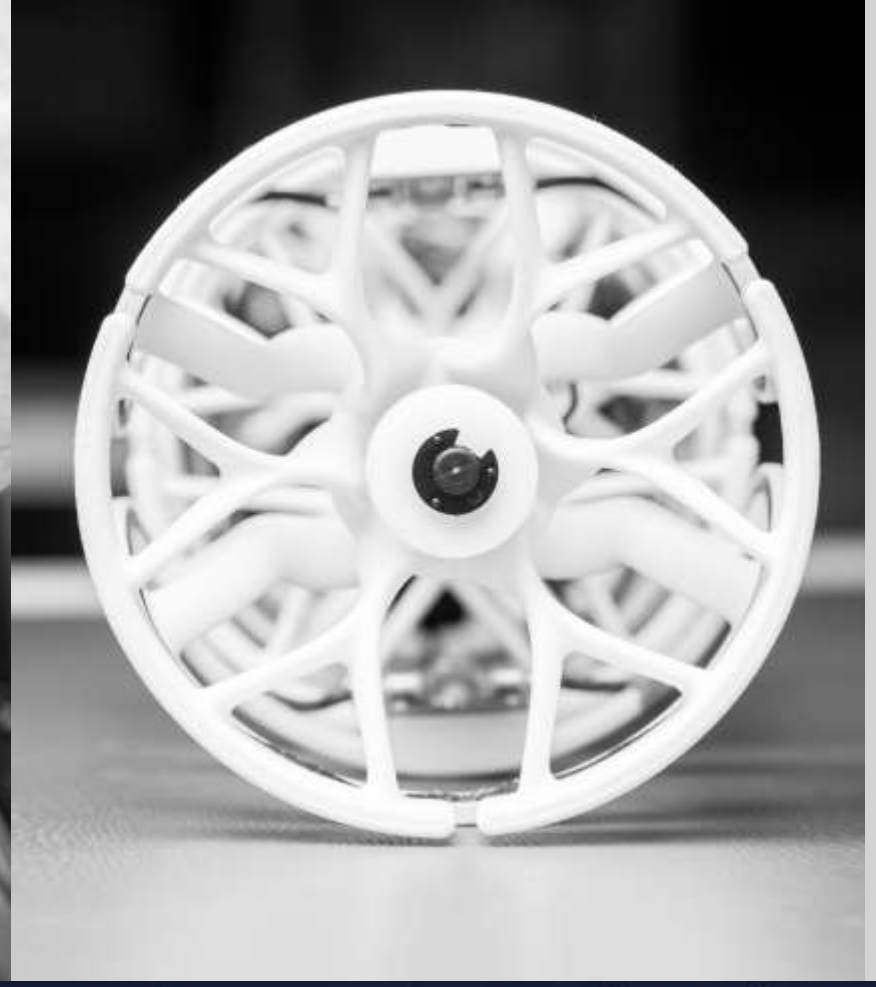

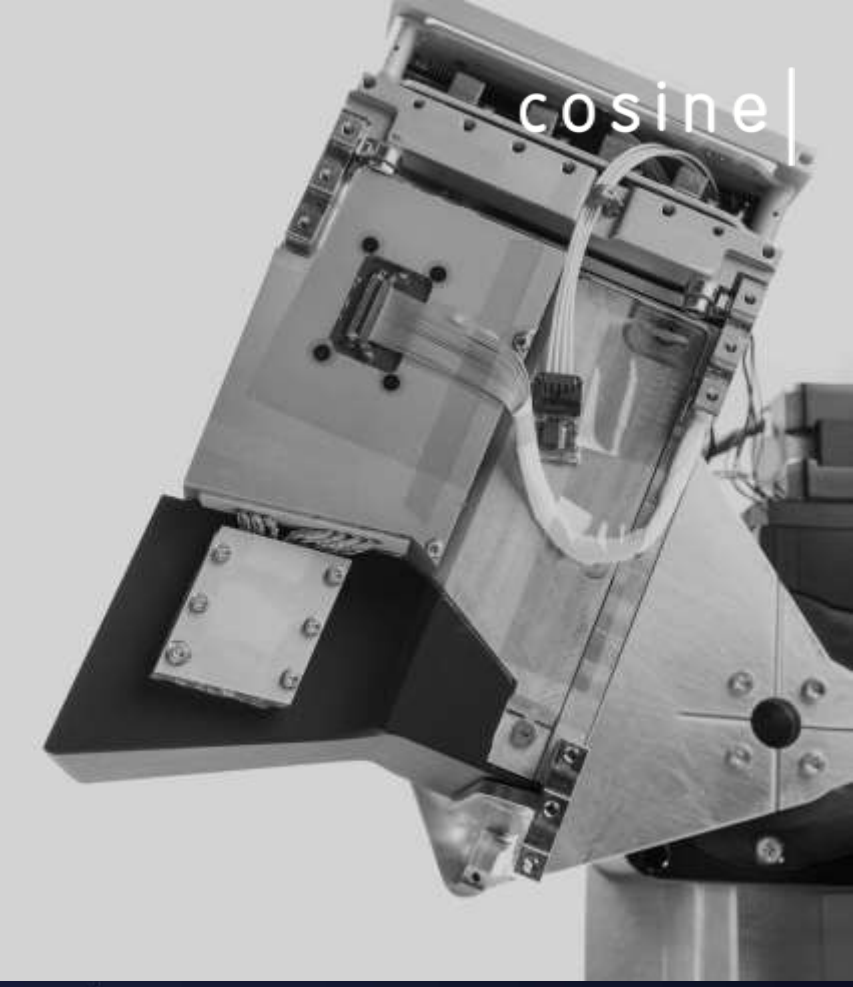

high energy optics

astronomy | material analysis | health

inspection systems

medical | oil/gas | food/pharma

remote sensing systems

agriculture | disasters | environment

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high energy optics

X/γ-RAY & PARTICLE OPTICS

astronomy | material analysis | health

REMOTE SENSING | TECHNOLOGY LINES

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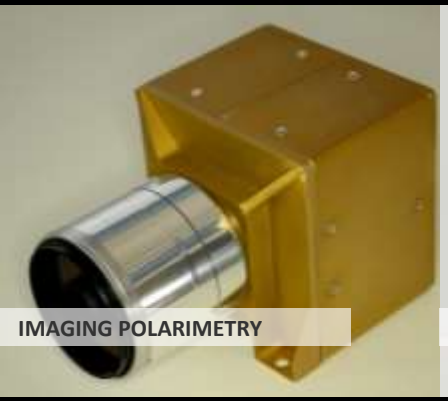
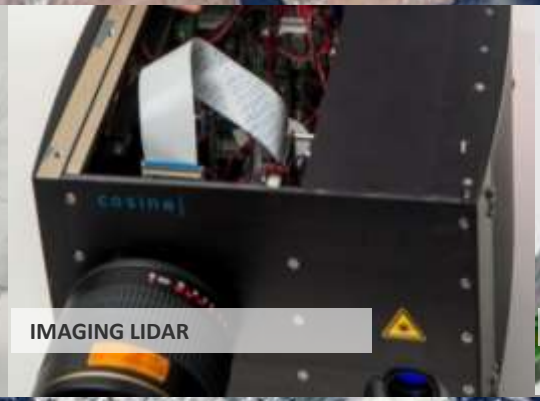
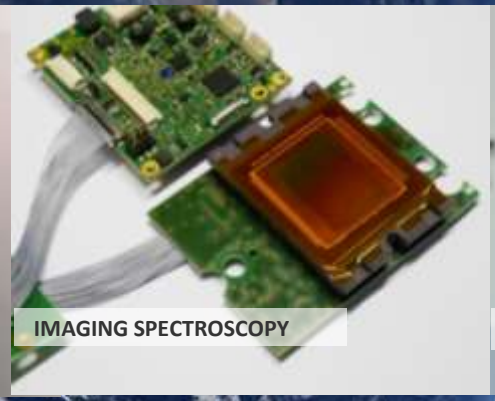
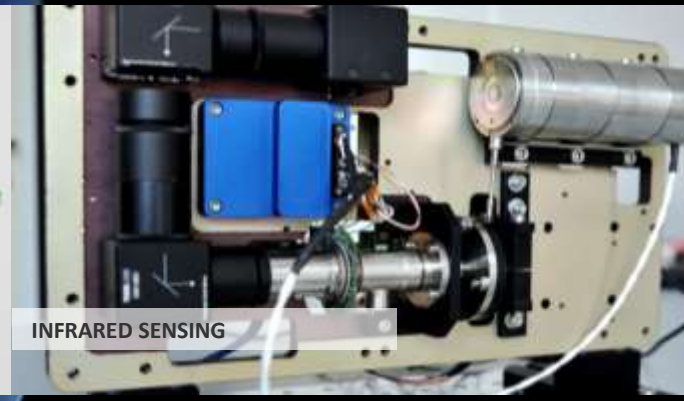

IMAGING POLARIMETRY


HYPERSPECTRAL IMAGING


IMAGING LIDAR


IMAGING SPECTROSCOPY


INFRARED SENSING

sats | smallsats | aircraft | uav | drones | field | towers | vehicles

REMOTE SENSING | TO MEASURE WHAT

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ATMOSPHERE

HYDROSPHERE

GEOSPHERE

BIOSPHERE

REMOTE SENSING | FROM WHERE

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REMOTE SENSING | FURTHER FAR …

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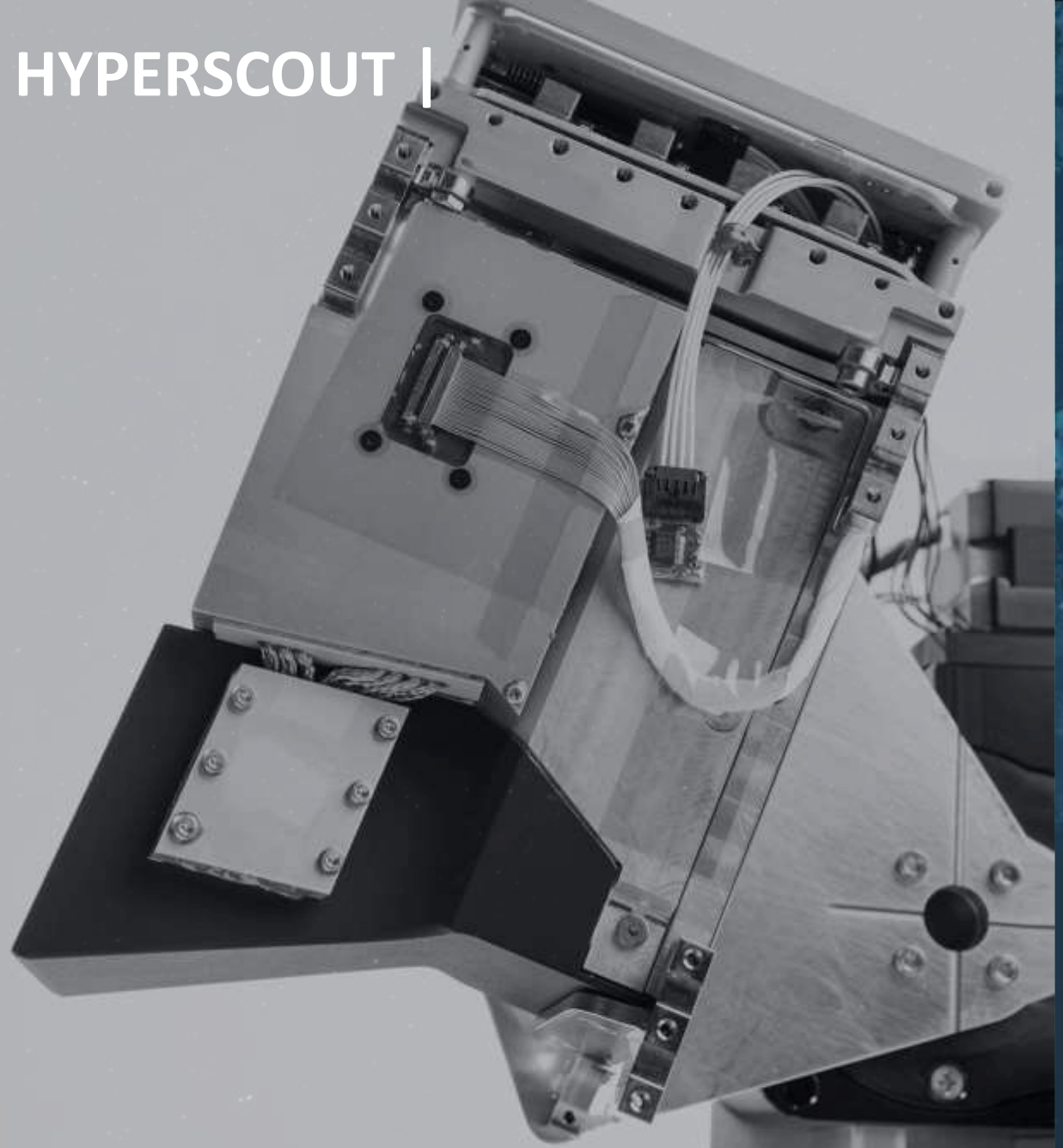
PLANETARY SCIENCE AND NAVIGATION

HYPERSCOUT |



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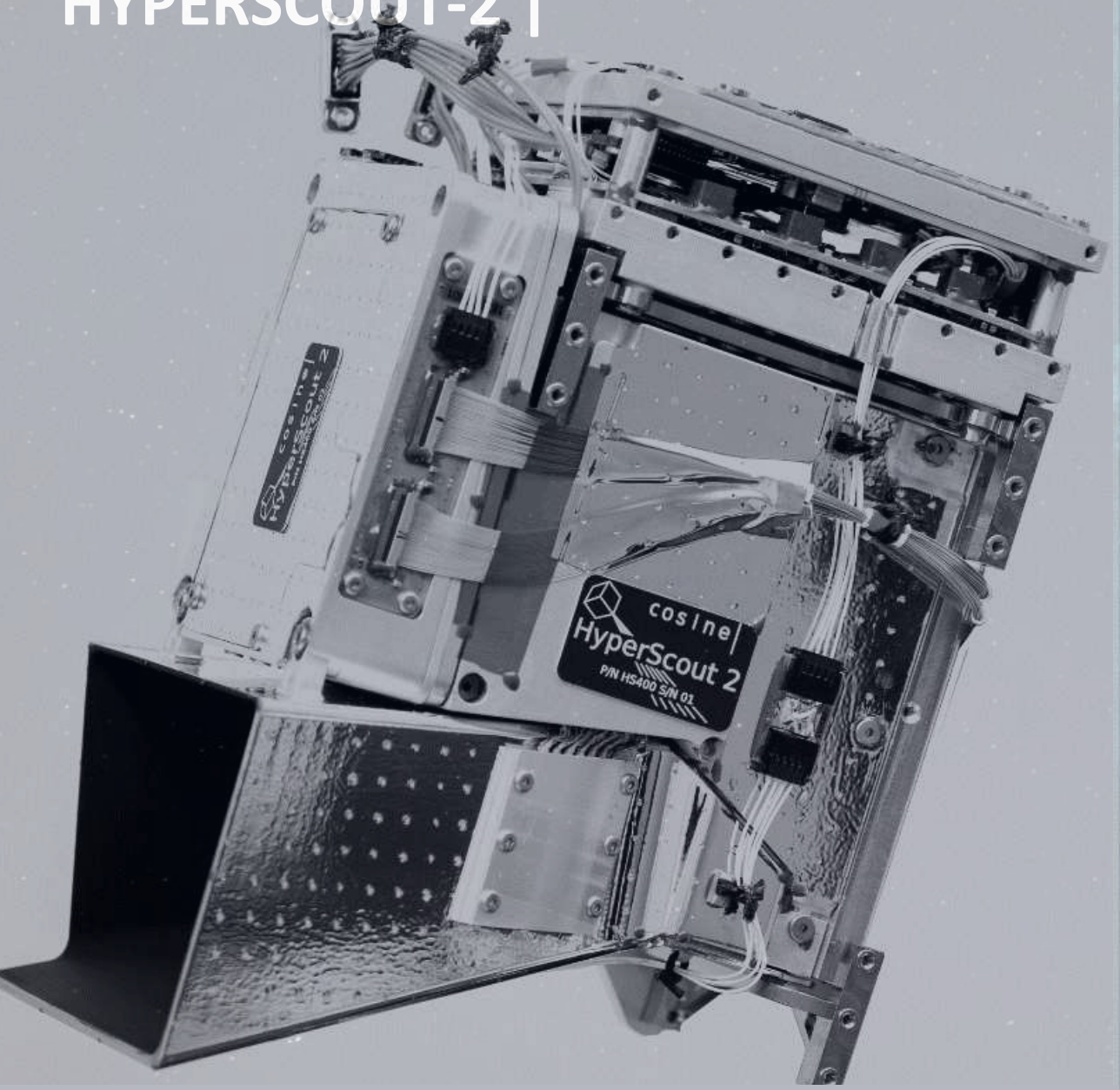
- HyperScout is the first ever 1.3 kg full-fledged hyperspectral camera in orbit since February 2018
  - Full performance at a fraction of weight
- large field of view
  - high revisits with a few units deployed
- full processing chain
  - application parameter retrieved in orbit
  - Analysis Ready Data (ARD) processed onboard were calculated for the first time ever in Nov 2018
- commercially available
  - business based on operational hyperspectral remote sensing from nanosatellites now possible

HYPERSCOUT-2 |



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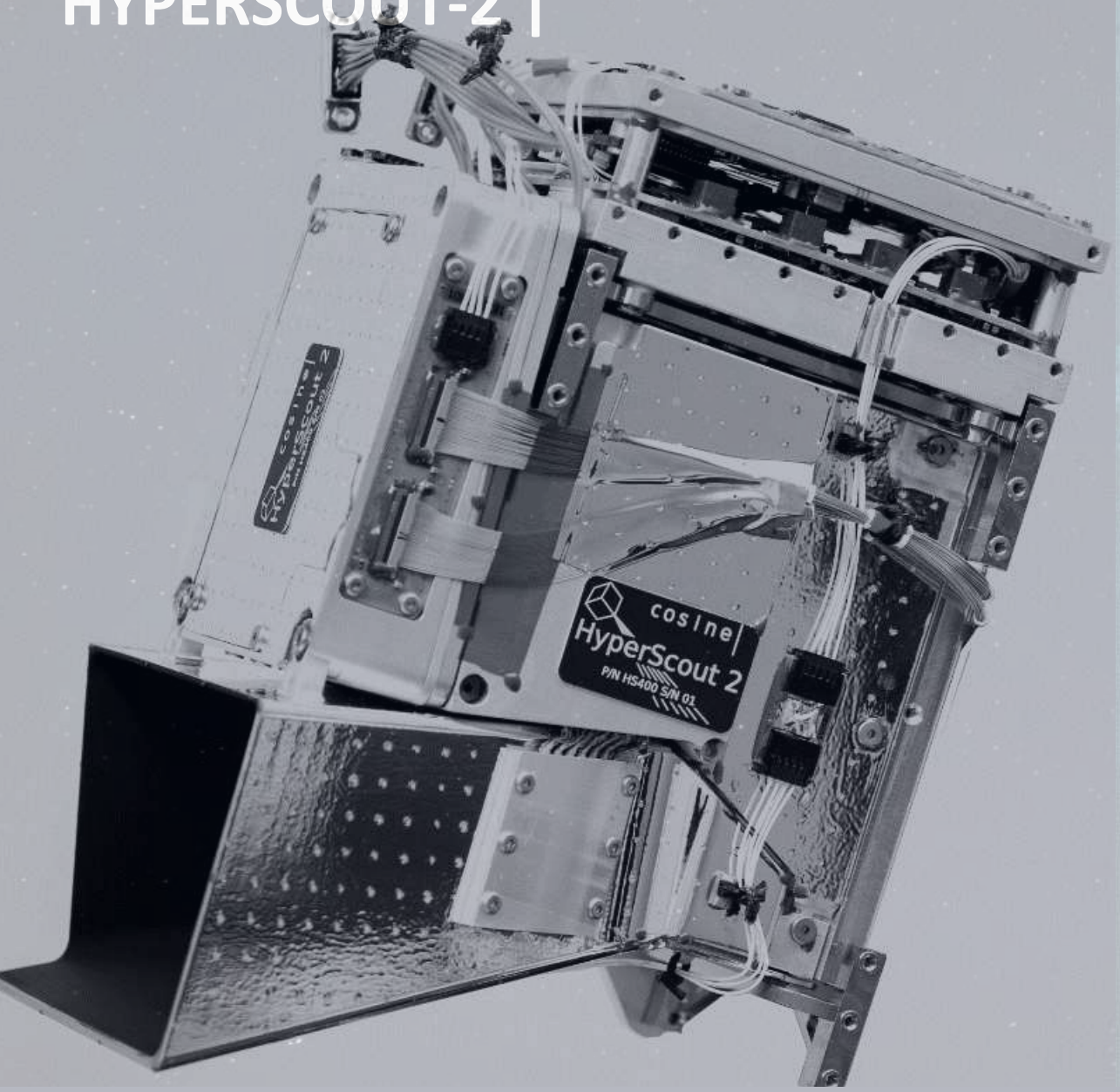
- HyperScout-2 is the first ever 1.7 kg full-fledged hyperspectral + TIR multispectral imager. To be launched in March 2020
- larger field of view
  - Up to 310 km
- increasing platform compatibility
- bringing hardware Artificial Intelligence Accelerator in flight
  - new applications on AI chip

HYPERSCOUT-2 |



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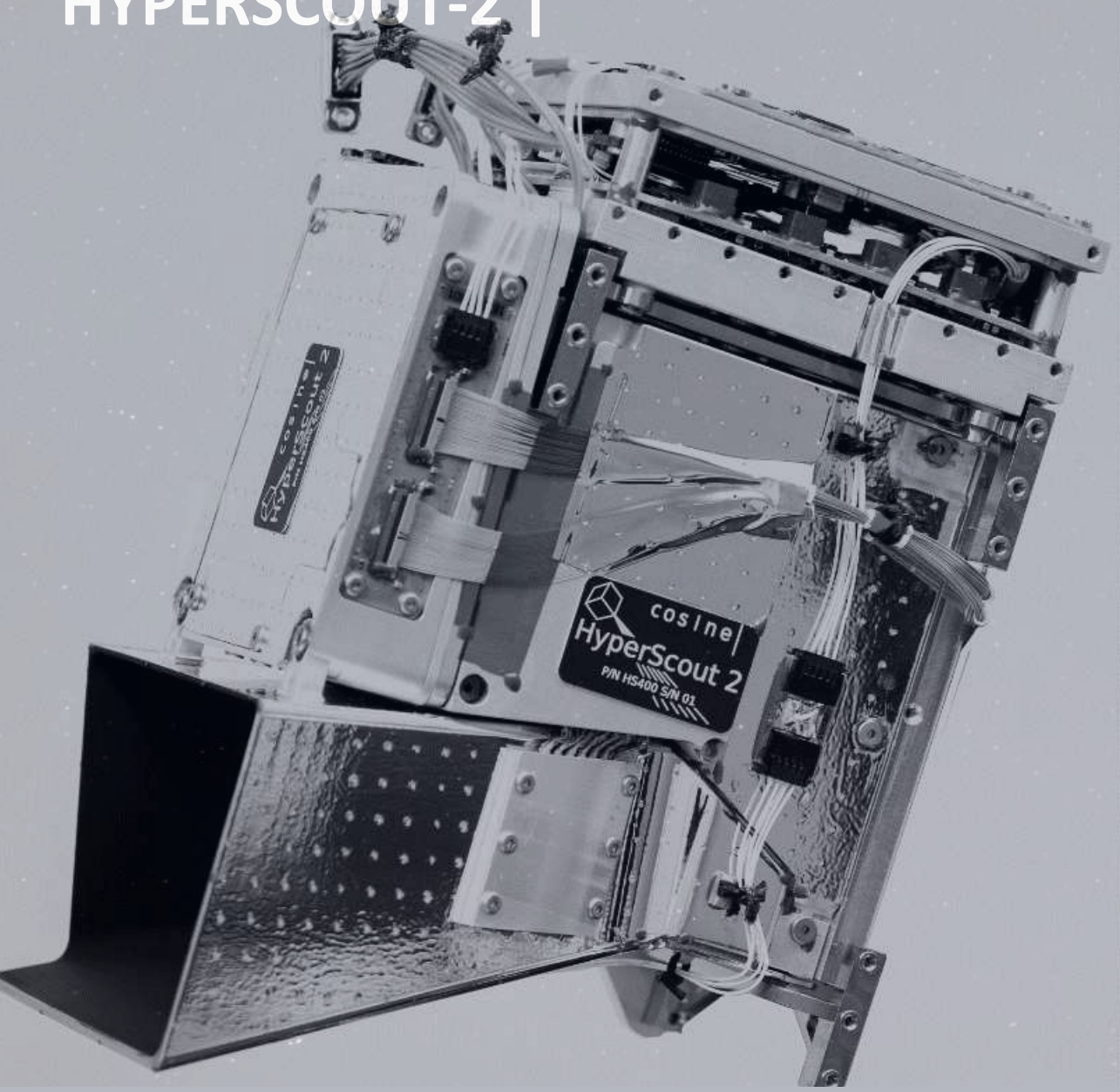
- Enhanced imaging/vision accelerators
- group of 12 specialized vector VLIW processors called SHAVEs and 2 CPUs connected by intelligent memory fabric
- Ultra low power
- Integrated on top of HS2 electronics stack inclusive of protection board
- **Ready to be launched!**

HYPERSCOUT-2 |



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	HyperScout-1	HyperScout-2
Orbit	500 km	540 km (3 km)
FoV (ACT c ALT)	23° x 16°	CH1: 31° x 16° CH2: 31° x 16°
GSD	~70 m	CH1: 75 m (0.5 m) CH2: 390 m (9.6 m)
Swath	~ 200 km x 140	CH1: ~ 310 km x 150 km (12.4 x 5.6) CH2: ~ 310 km x 150 km (12.4 x 5.6)
Active pixels	3000 x 1850 px	CH1: 4000 x 1850 px CH2: 1024 x 768 px
Spectral range and bands	400 nm – 1000 nm 45 bands	CH1: 400 nm – 1000 nm, hyperspectral CH2: 8 μm – 14 μm, multispectral
Spectral resolution	16 nm	CH1: 16 nm CH2: 1 μm to 6 μm
SNR (NeDT@300 K)	50 – 100	CH1: 50 – 100 CH2: (0.5 – 3 K) * NeDT improvement with temporal and spatial averaging will be experimented
Mass, volume, power	1.3 kg, 1.5 L, 10 W	1.7 kg, 1.8 L, 12 W

HYPERSCOUT-1 | SPECTRAL DATA

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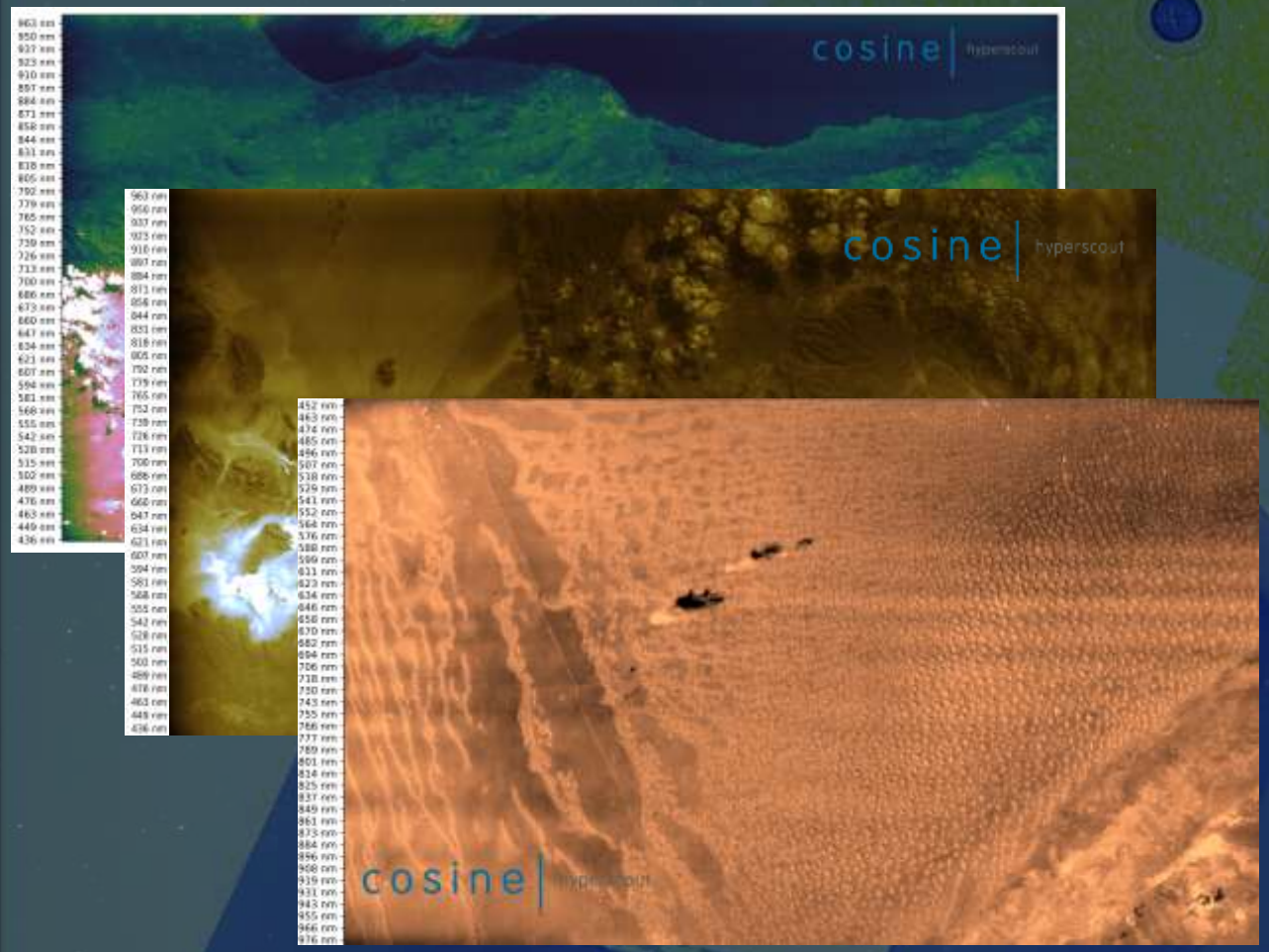

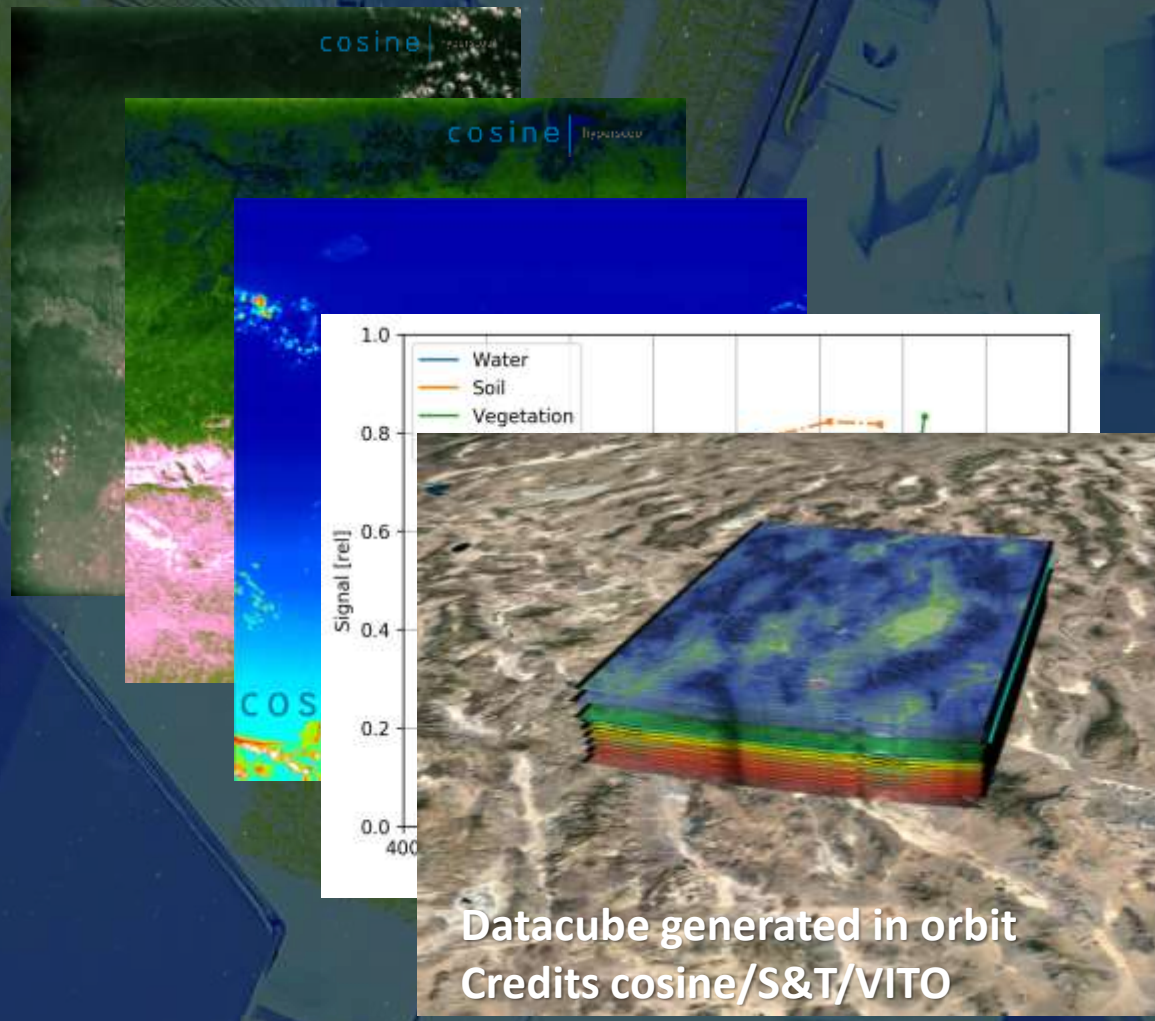

Datacube generated in orbit
Credits cosine/S&T/VITO

HYPERSCOUT 2 | APPLICATIONS

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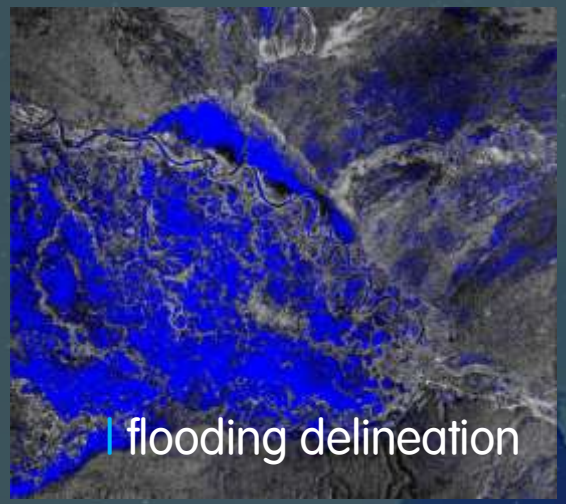

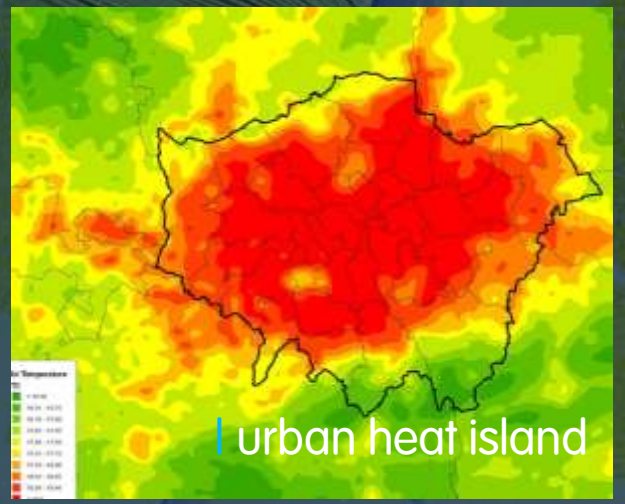

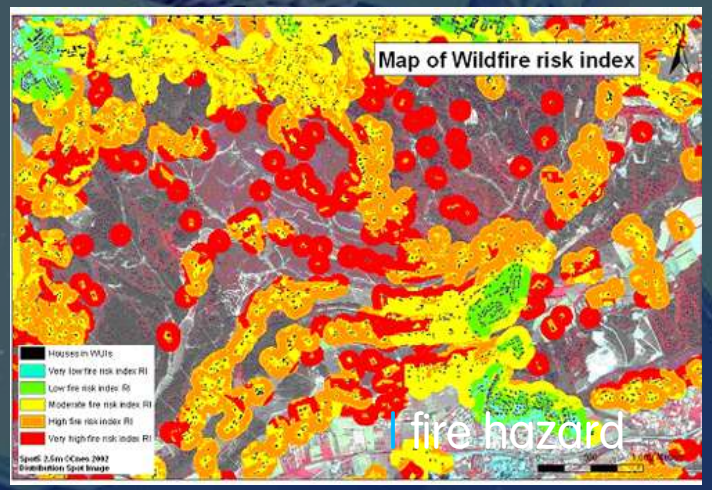

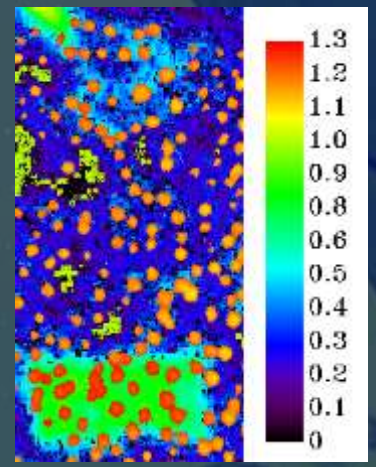

evapotraspiration

Lampin-Maillet (2009)

HYPERSCOUT | MULTIPLE APPLICATIONS WITH AI IN REAL TIME

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- Multiple applications
  - Mozambique (fire hazard, floods)
  - Tanzania (fire hazard, floods)
  - Uganda, Kenya (fire hazard, change detection)
  - Sudan (droughts)
  - Egypt (floods, droughts, crops, change detection)
  - Greece (fire hazard, change detection)
  - Balkan regions (floods, crops)

HYPERSCOUT | CHANGE DETECTION ONBOARD

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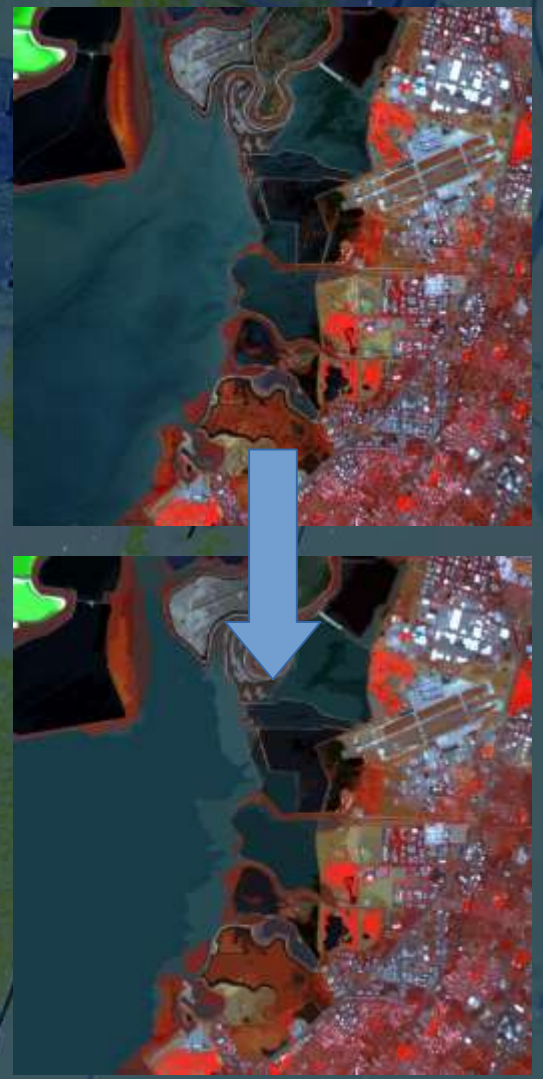
- Hyperspectral Image Segmentation:
  - In both spectral and spatial domain.
  - From 1.21 GB to 2.9 MB (~ 0.25%)
- Land cover classification
  - From 2.9 MB to 1.9 MB
- Change detection
  - From 1.9 MB to 0.2 MB (depending on actual detected changes)



PHISAT-1 | PROCESSING PIPELINE FOR AI ACCELERATOR

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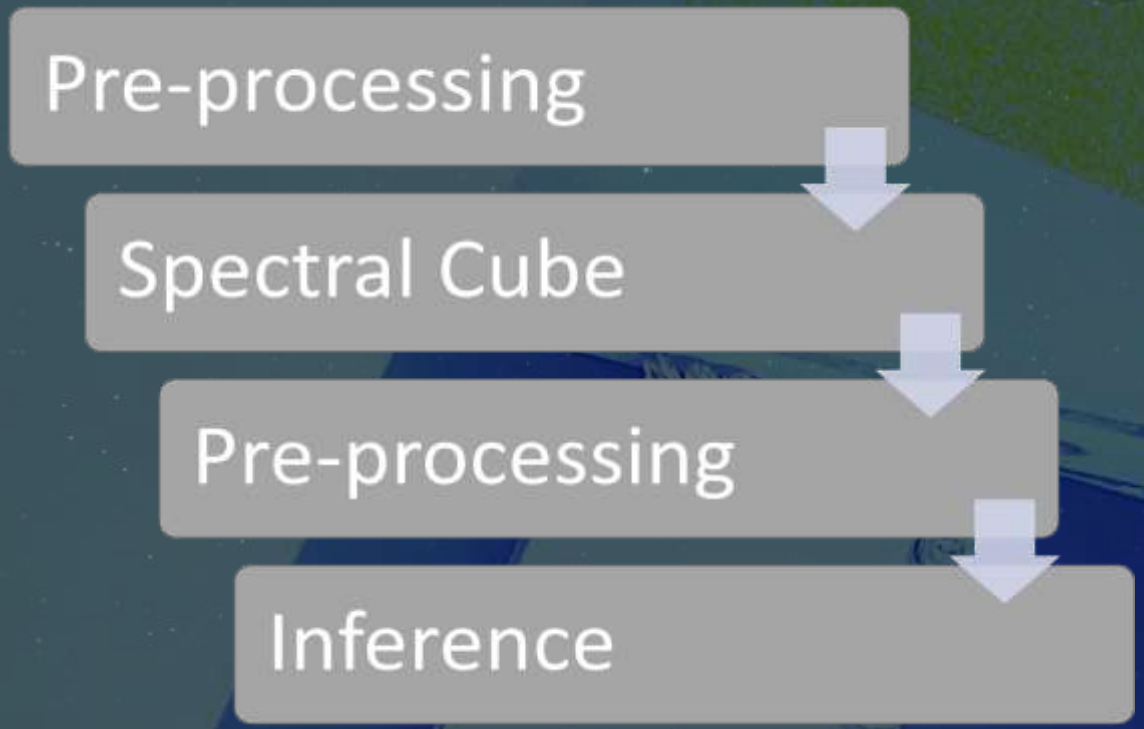

- "Pre-processing 1" corrects for known, telescope induced, aberrations
- "Spectral Cube" constructs a datacube, eirther relative or absolute
- "Pre-processing 2" alters the datacube so that it can be loaded into the VPU.
- The "inference" step is based on application

HYPERSCOUT | THE POWER OF HYPERSPECTRAL

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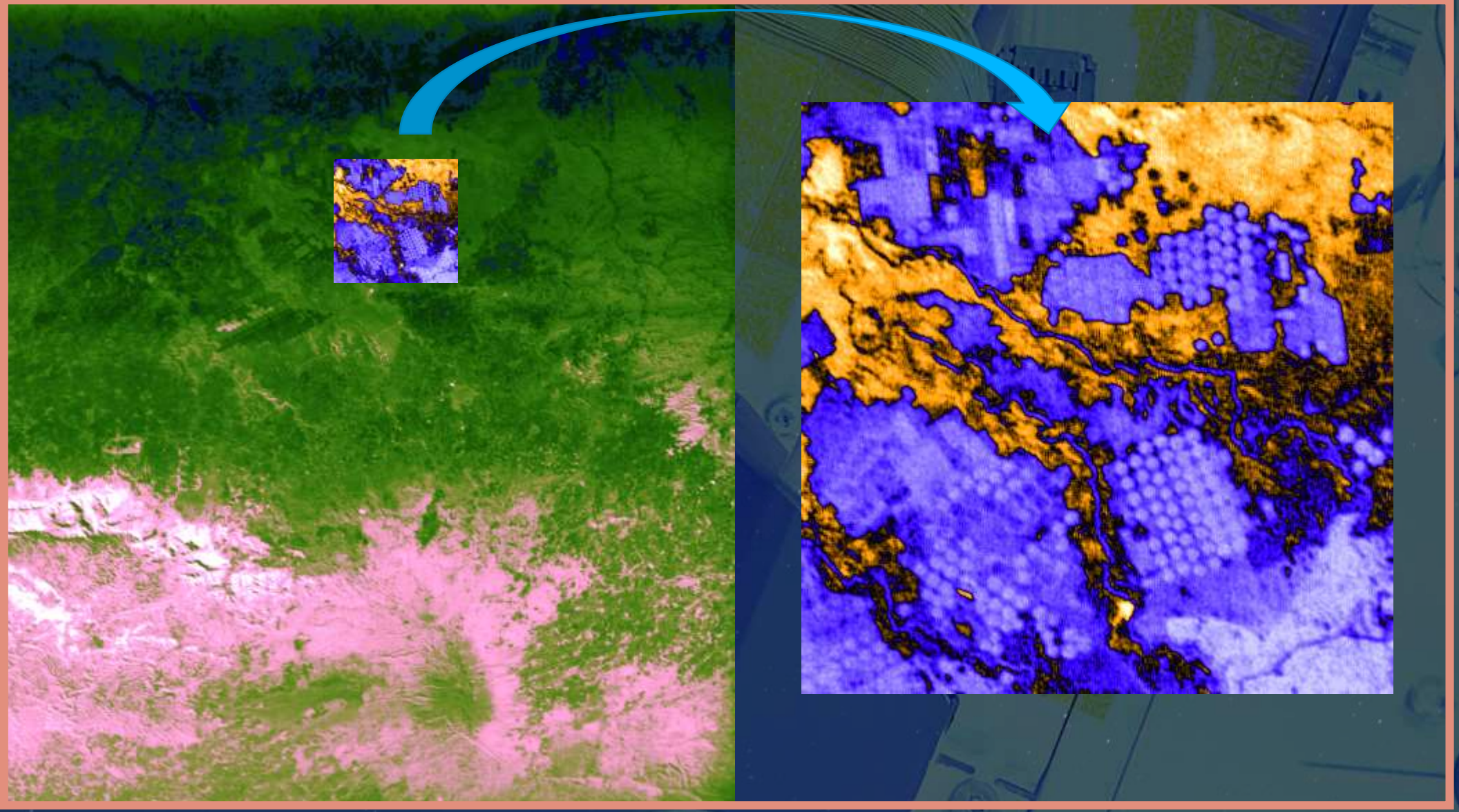

>300 km swath

HYPERSCOUT | MATCH

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- HyperScout - Sentinel 2A/B cross calibration with machine learning
  - activity under ESA contract
- A framework to cross-calibrate small satellite constellations against the data institutional reference satellites
- HyperScout - Sentinel 2A/B data product fusion
  - Best from Sentinel 2 calibration and spatial resolution
  - Best from HyperScout spectral resolution and revisit time

opernicus MATCH

HYPERSCOUT | AIRBORNE AS SUPPORT TO CALIBRATIONS AND DEV

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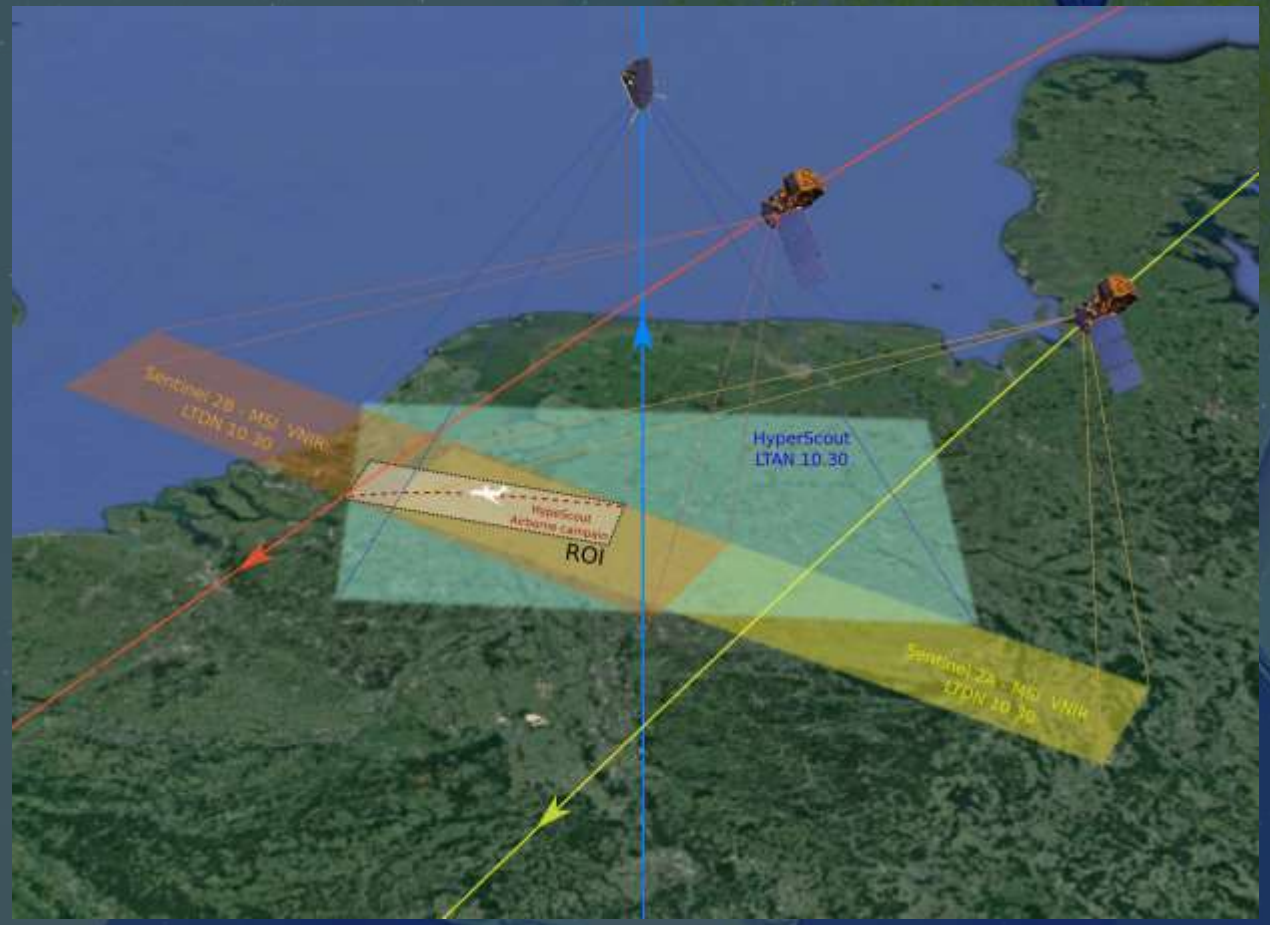

- training sets for machine learning
- airborne flights over different land covers and instrumented towers


Map layer
Crops
Filter
All fields
Year
2018
Random beautiful fields
Overijssel
Fields size, ha
221.7K
Top 3 crops
Grass
Maize
Potatoes
Ground truth
Flight path
Lelystad
Zwolle
Deventer
Apeldoorn
Amersfoort
Emmen
Harderwijk
Nunspeet
Elburg
Kampen
Dronten
Meppel
Hoogeveen
Coevorden
Dedemsvaart
Hardenberg
Ommen
Vroomshoop
Nordhorn
Denekamp
Oldenzaal
Bad Bentheim
Nijverdal
Rijssen
Vaassen
Epe
Ermelo
Zeewolde
Putten
Nijkerk
Barneveld
Lochem
Zutphen
Borculo
Goor
Gronau
Ochtrup
Losser
Hengelo
Oostvaardersplassen
Powered by OneSoil
mapbox

HYPERSCOUT | AIRBORNE CUBES

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466nm

HYPERSCOUT-1 AND -2| AVAILABLE INFLIGHT LABS

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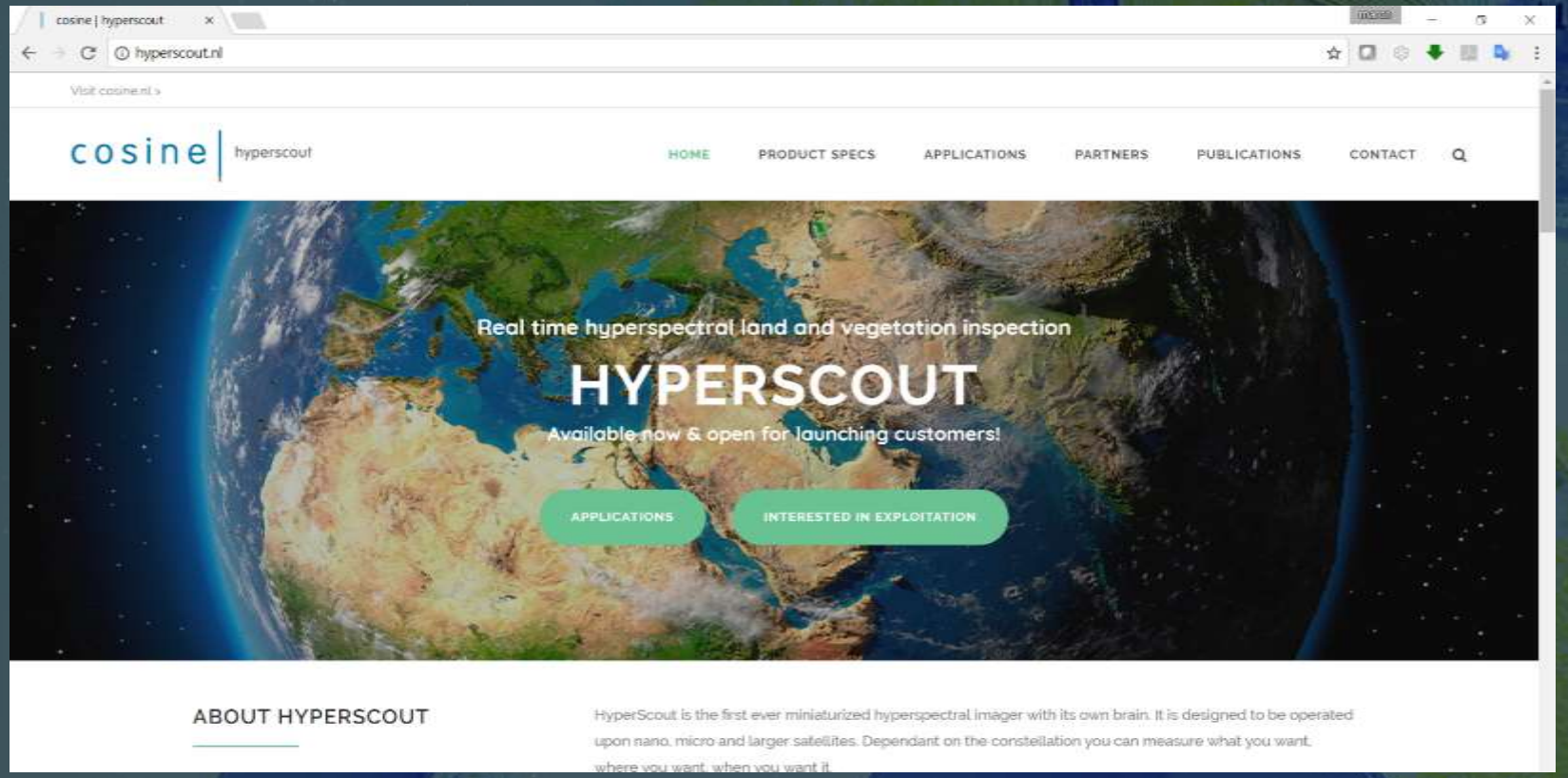

- Contact us to start a collaboration on your in-orbit experiment
- hyperscout.nl
- Test your novel onboard software
- Verify new hyperspectral applications
- Choose which implementation to like
  - FPGA, GPU, CPU, VPU
  - SDK coming soon

HYPERSCOUT| ACKNOWLEDGMENTS

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- HyperScout 1: ESA TEC/MMO GSTP program. Netherlands, Belgium and Norwegian Space Offices.

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- CloudScout: ESA philab.

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