

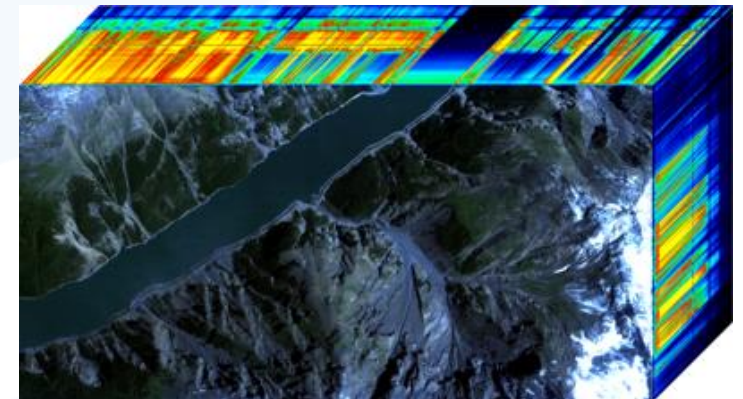
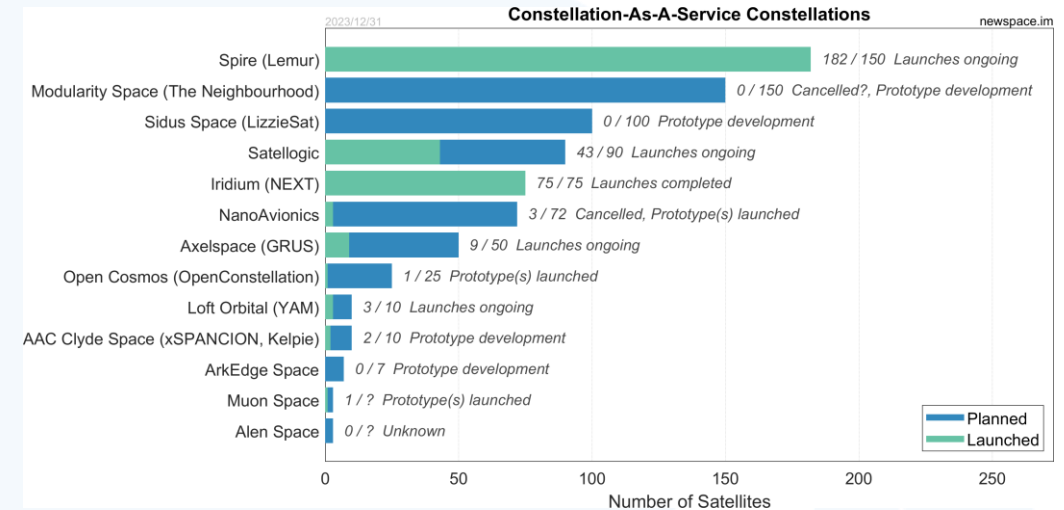
MOVIQ: an end-to-end approach to enable high-resolution hyperspectral vision intelligence on board satellites

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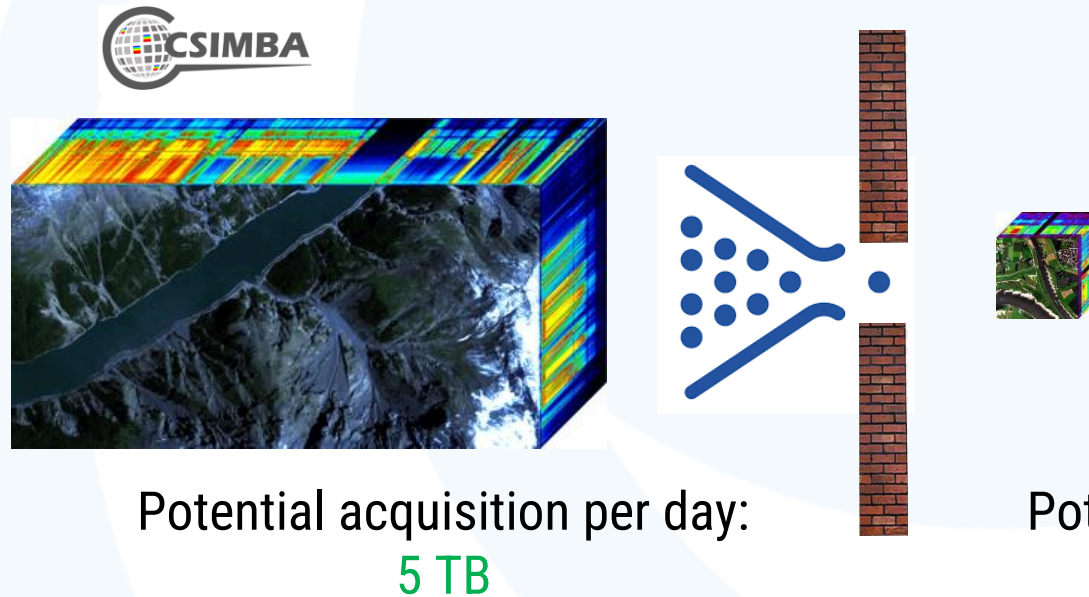
Hyperspectral EO: opportunities

- Provide application flexibility post launch
 - Adapt to changing mission requirements
 - Software-defined satellites
 - Satellite-as-a-Service
- Enable new applications → much richer feature set
 - Geology and mineral exploration
 - Monitoring ecosystems
 - Growing interest for defence and security applications



Hyperspectral EO: challenges

- Large data cube sizes present downlink challenges



Full benefits of high spatial/spectral resolution advancements remains **untapped** due to **downlink constraints** and **long latencies** for processing and analytics

- Timely information extraction hampered with downstream processing

Hyperspectral EO: the price of latency

- Flooding is most frequent type of disaster affecting over 2 billion people worldwide between 1998 and 2017.
- Over the past 3 years, forest fires have caused over \$63.5 Billion in losses in the U.S. alone (excl. 2022)
- A total of \$110 Billion in total damage and economic loss due to the fires which took place in Australia between 2019 and 2020.

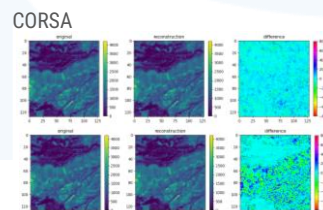
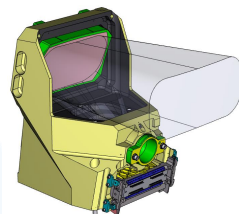
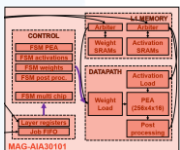
State-of-the-art satellites today allow for a **minimum latency between 4 and 6 hours** between the time an image is acquired and when this is delivered to the end-user.

This is the **same amount of time that takes for a forest fire to consume over 40 thousand acres of forest.**

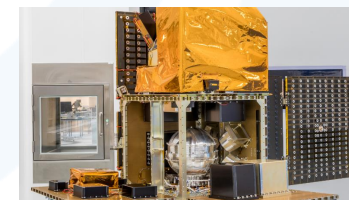
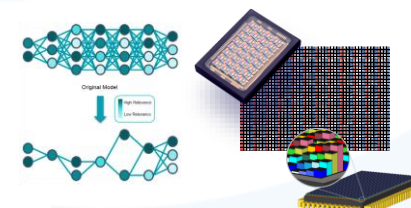
MOVIQ mission and consortium

Develop key technologies to enable large-scale hyperspectral imaging with high spatial and spectral resolution

- HS challenges tackled by a Flemish vertical collaborative R&D initiative
 - Focus on on-board processing and intelligence
 - Flexible next-generation HS optical instrument
 - Resource-optimized AI workloads
 - Software-defined satellite platform

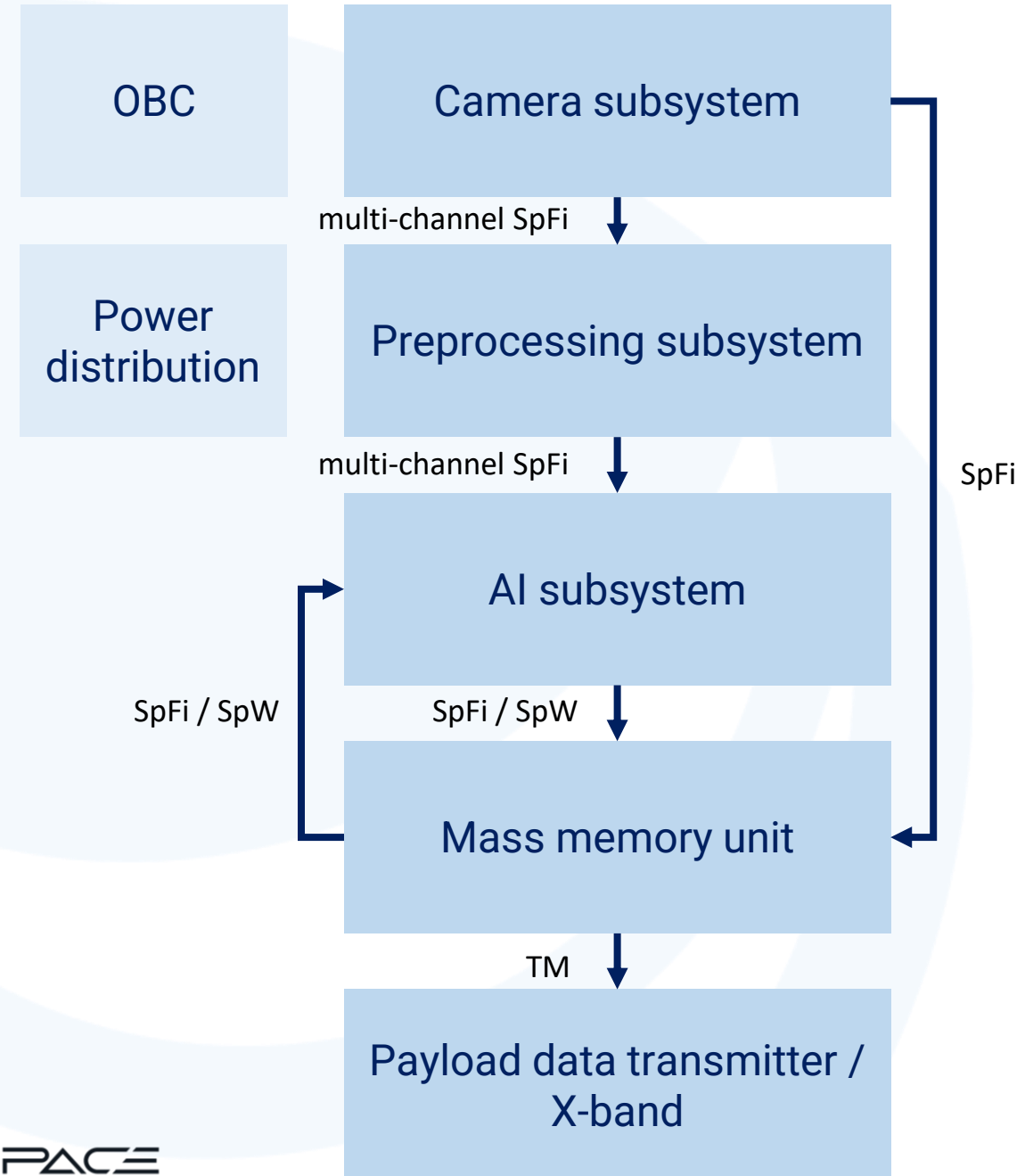


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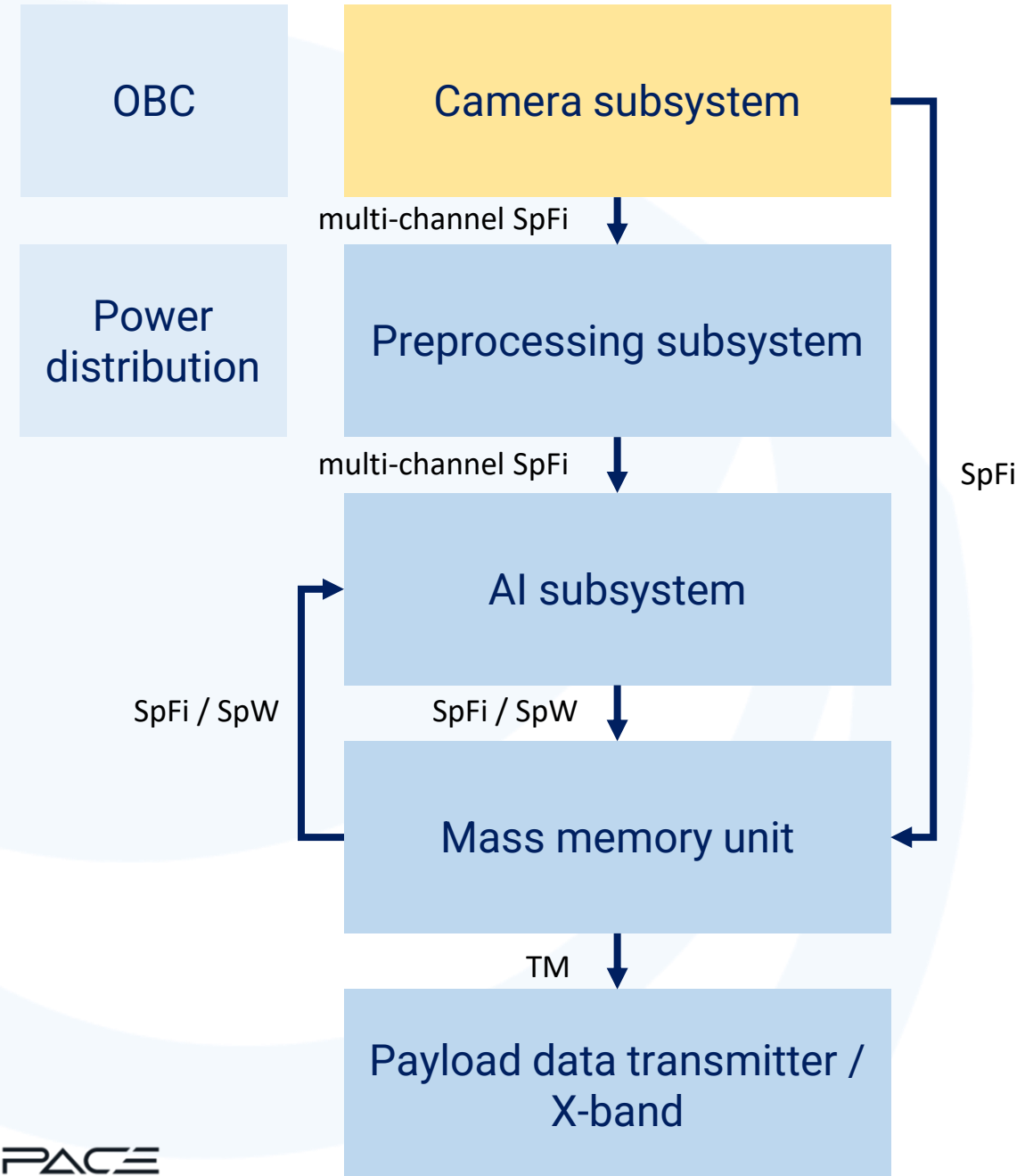
Project solution architecture

- Architecture build on standardized IFs
- Camera subsystem
 - Optics, hyperspectral filters, sensor
 - TDI, radiometric corrections, data reduction
- Preprocessing subsystem
 - Streaming buffer
 - Geometric and atmospheric corrections
 - Hypercube assembly
- AI subsystem
 - Radiation-hard AI accelerator
 - Data compression foundation model
 - End-user applications
- Satellite platform and additional payloads



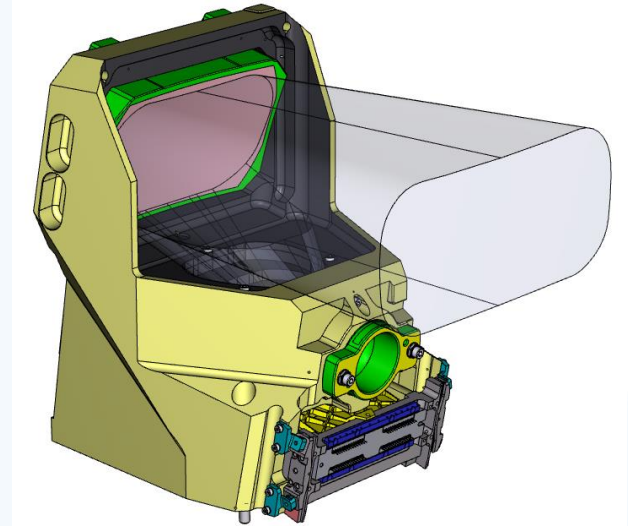
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Camera subsystem: optics

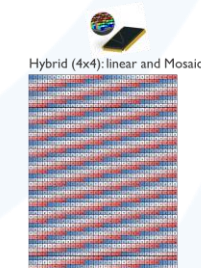
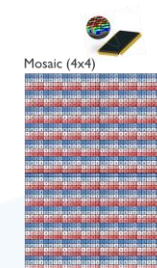
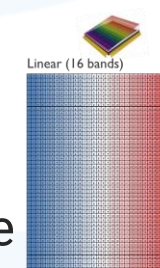
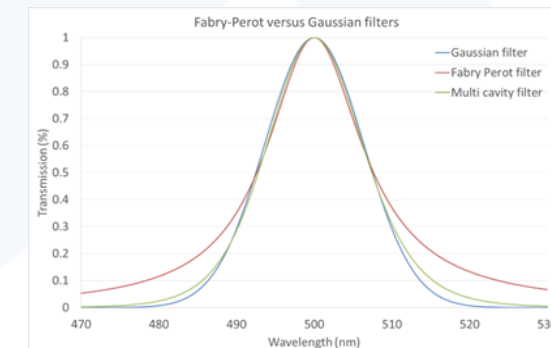
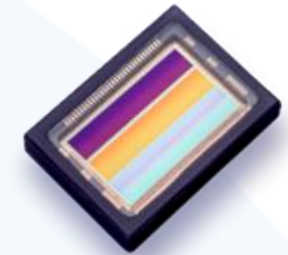
- Compact instrument for small-sat constellations
- Optimized for wide range applications
- Design is based on TMA with aspherical optics
- No chromatic aberration and broad temperature range



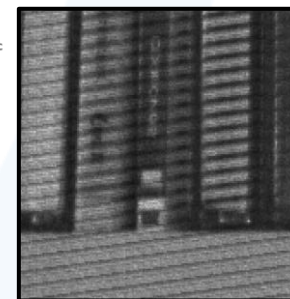
		SWIR extension
Ground sampling distance [m]	10	
FOV	9,5° x 3,6	
Swath [km]	80	
Spectral range hyperspectral filters [nm]	400 - 900	Up to 2300
FWHM [nm]	10	
SNR @reference radiance	100	

Camera subsystem: on-chip spectral filters

- On-chip filter technology
 - Spectral filters are monolithically deposited on top of CMOS image sensor with pixel level accuracy
 - Characterisation of latest Fabry-Pérot filter technology
- **Design study**
 - Line-based filter layout for push-frame operation
 - Multiple detector lines per band along flight direction to enable TDI
 - Double-cavity Fabry-Pérot for improved out-of-band blocking and SNR
- **Proof of concept** of a hybrid filter layout
 - Demonstrator chip integrated in the camera
 - Can be operated in both line and mosaic acquisition mode



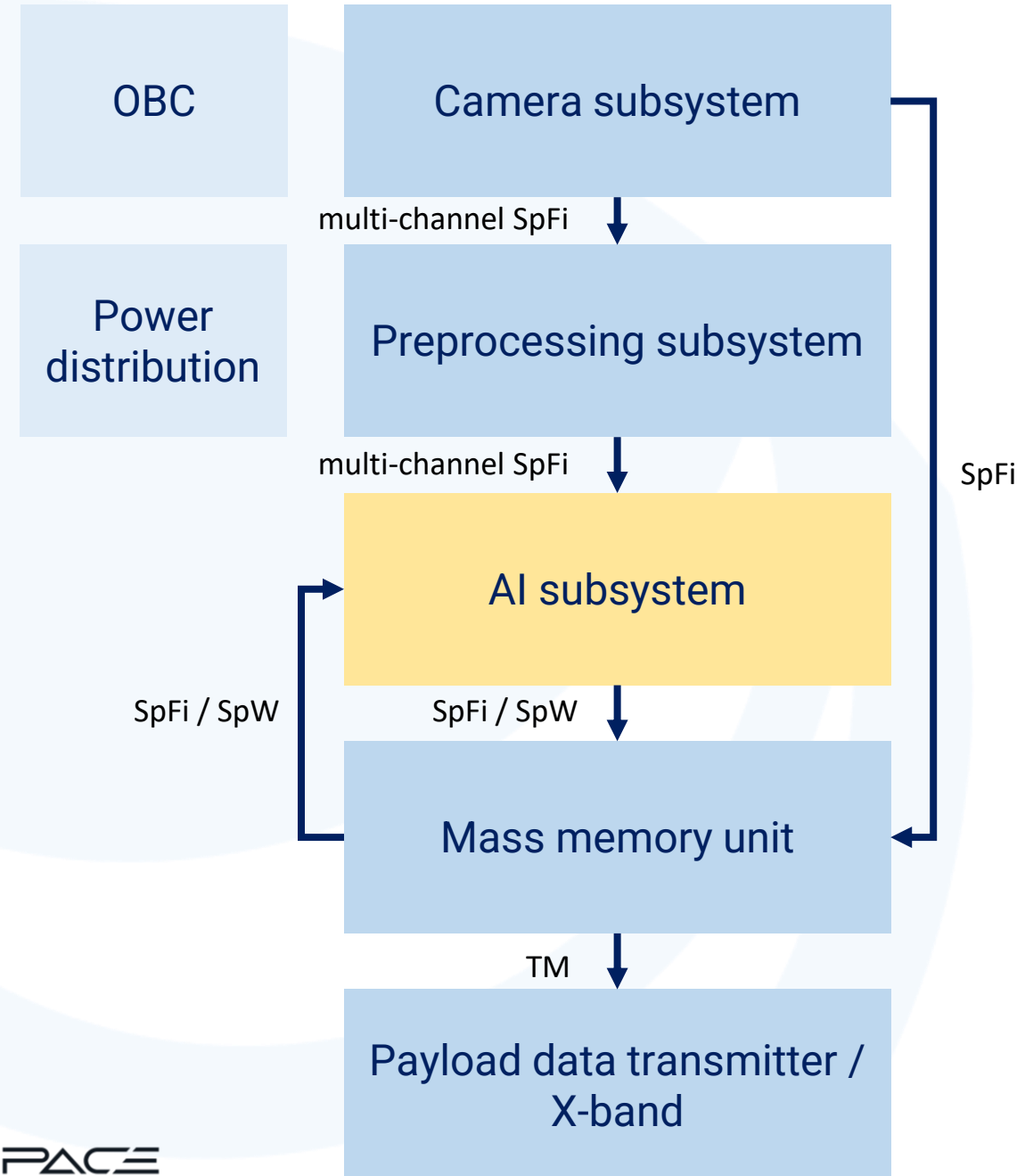
Multi mode operation



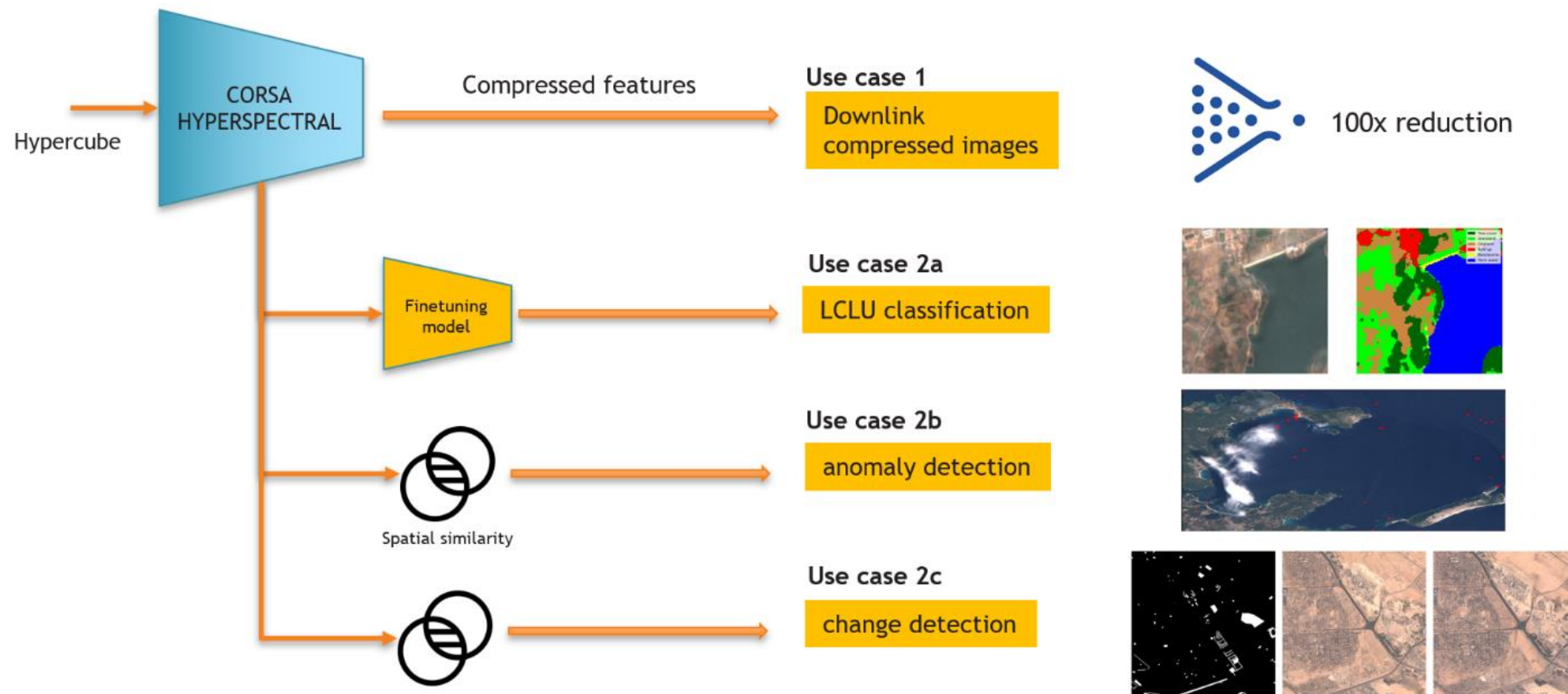
Real image

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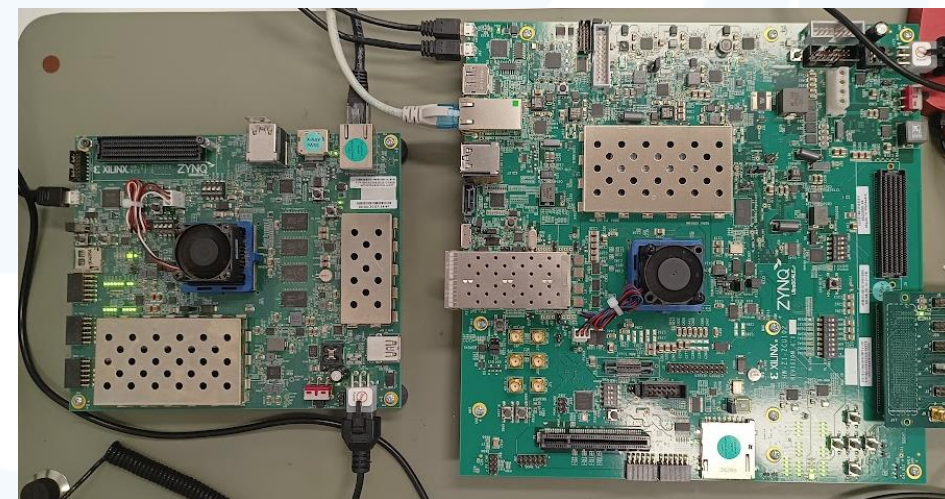
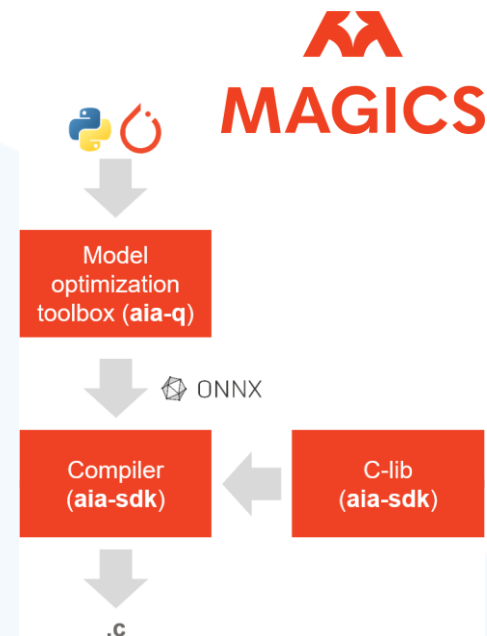


AI subsystem: CORSA and applications



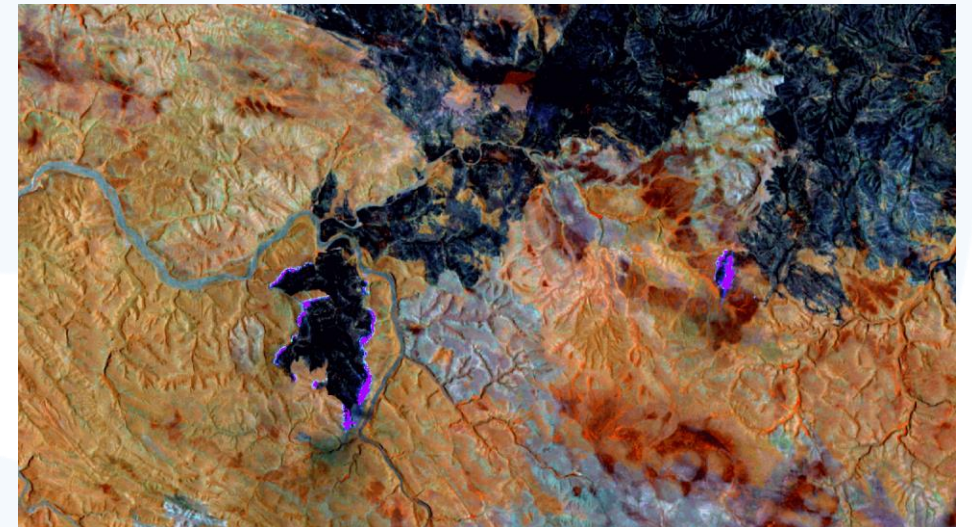
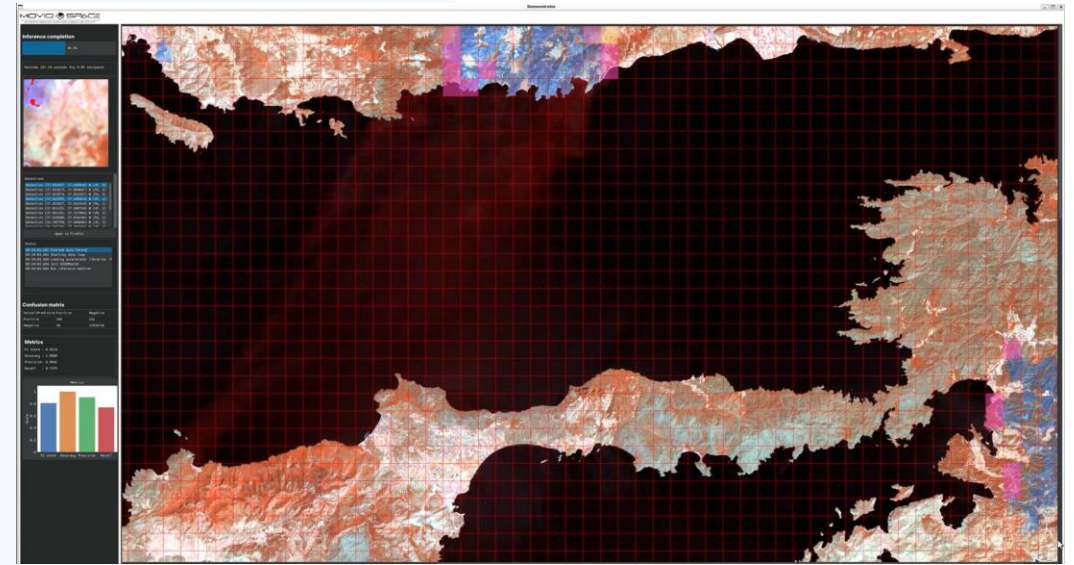
AI subsystem: space-grade AI processor

- Enable on-board AI processing for high-criticality applications
- Power-efficiency optimized to meet both computational demands and power constraints
- SDK and compiler based on Apache TVM
- Remote access to processor prototype for consortium partners
- Key specifications
 - Up to 10 TMACs/s (int8)
 - 1 W typical active power consumption
 - 4 MB local scratch pad
 - Optimized for CNN workloads
 - SEU-immune control and data path
 - Available as a soft IP
 - Targeting heterogeneous RISC-V SoC integration



AI subsystem: resource-constrained ML techniques

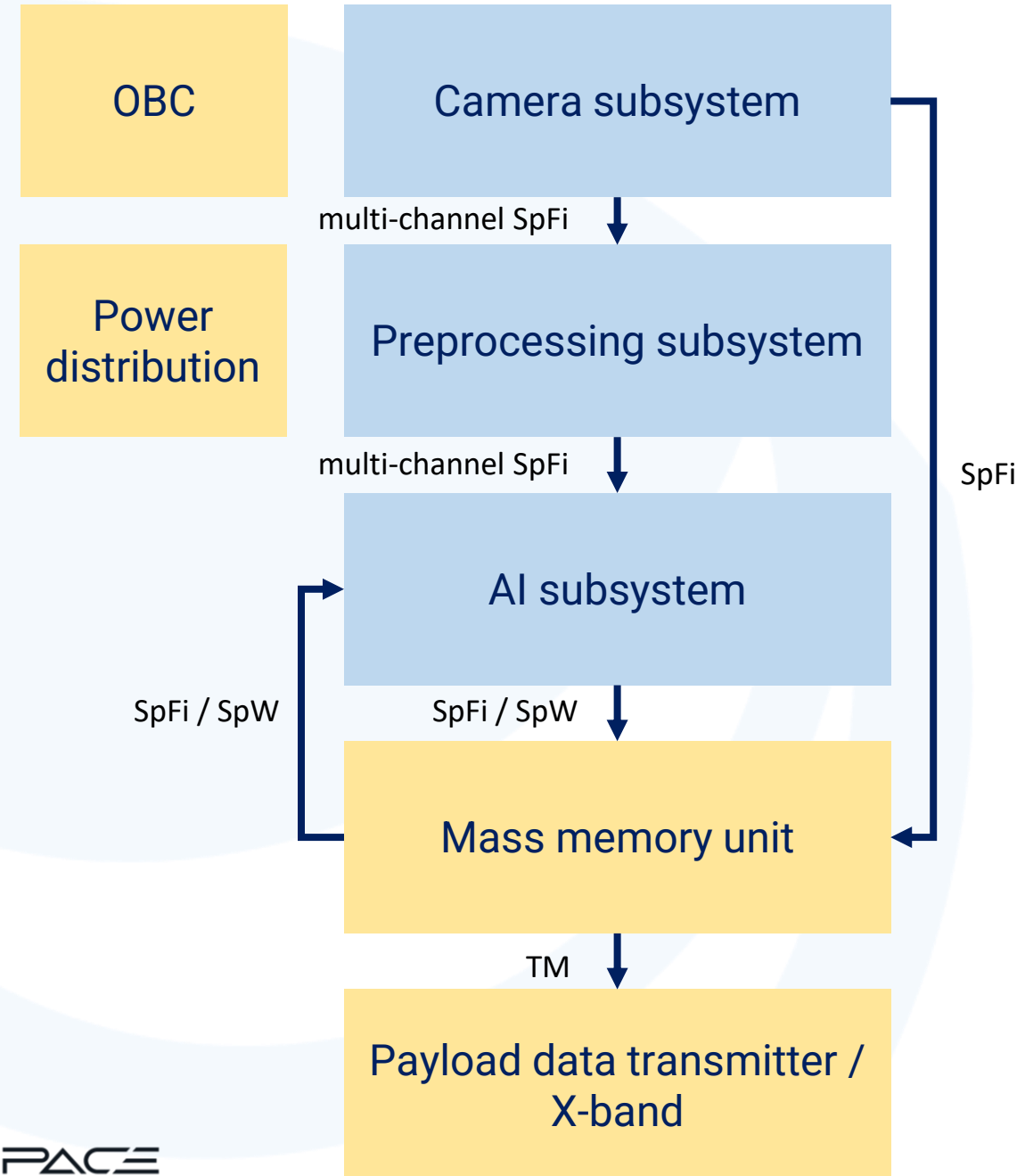
- Optimal neural network generation for hyperspectral imaging
- High model compression through relevancy
- Adaptable models post-deployment
- Reliable execution through software-based fault tolerance
- Target use-case: wildfire detection



Example wildfire detection on Australia data from Sentinel-2 imagery.

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Next-generation autonomous platform

- P200 small satellite platform
 - State-of-the-art autonomous platform
 - Space-qualified avionics suite
 - Powerful AI and ML integration
 - Continuous “evolution” in reach and efficiency
 - Software-defined on-board processing
- Next-generation ADPMS
 - 3rd generation Advanced Data and Power Management System
 - OBC – On-Board Computer (TRL9, flying on HERA)
 - PCDU – Power, Conditioning & Distribution Unit
 - RTU – Remote Terminal Unit



Conclusions and way forward

- MOVIQ consortium is a multi-disciplinary EO initiative
- Modular building blocks to enable large-scale hyperspectral imaging (among others)
- TRL 6 partner timelines for 2026-2027
- Evolutions towards multi-modal/sensor fusion envisioned
- Open to new collaborations involving complementary sensor modalities
- *Acknowledge importance of pre-processing subsystem in follow-up activities*
- Separate TBBs are application agnostic

Thank you for your attention!

MOVIQ is supported by VLAIO and Flanders Space and has received co-funding from the European Union NextGenerationEU.

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