



On-Board Data Processing Workshop

ESA ESTEC

25-27 February, Noordwijk, The Netherlands

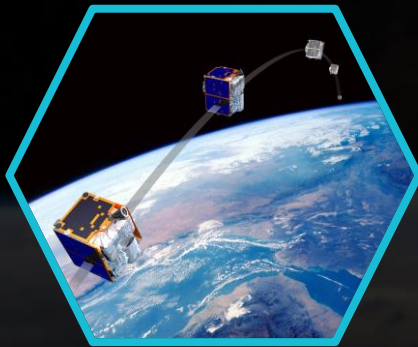
DEEP LEARNING FOR ENHANCED ON-BOARD AUTONOMY

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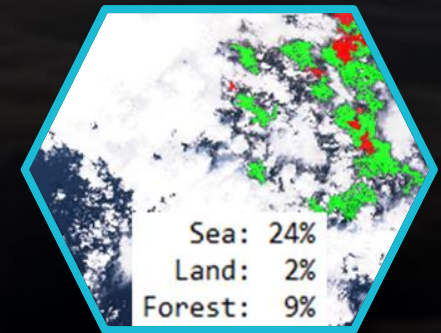
AUTONOMY

spacecraft do not **take decisions** in real time
hours to days of delays on the ground



mega-constellations will be **difficult to manage**
current infrastructure is not ready for these missions

downlinked data is **not always relevant**
data processing is done on the ground, creating bottlenecks



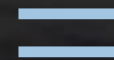


Telemetry &
Payload data



MiRAGE AI
Library

www.aikospace.com/#mirage



Autonomous
Operations

- ◇ Software library for autonomous operations
 - State of art autonomy: detection, planning, predictive maintenance
 - TRL 6

- ◇ Infused with Artificial Intelligence
 - Deep Learning, Knowledge-based Systems
 - In-house developed

- ◇ Compatible with ground and space segments
 - Enhances Earth Observation, Telecommunication and Scientific missions
 - Automates space missions and supports operators

- ◇ Funded by H2020 program



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Co-funded by the Horizon 2020 programme
of the European Union



Detection

Reasoning

Planning

Payload:

- Feature detection
- Segmentation
- Classification

Platform:

- Failure detection
- Anomaly detection
- Behaviour correlation

AI-based

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Reasoning

Goal Generation:

- Relevance of the detected feature
- Characteristics of the event
- System health

AI-based

Planning

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AI-based

Planning

Scheduling:

- Timing constraints
- Availability of resources

Traditional algorithms



Autonomous

Enabling *reaction to events* during the missions

Effective

Identifying features, objects and targets in satellite payload data



Mission cost reduction

Operations costs reduction thanks to enhanced autonomy

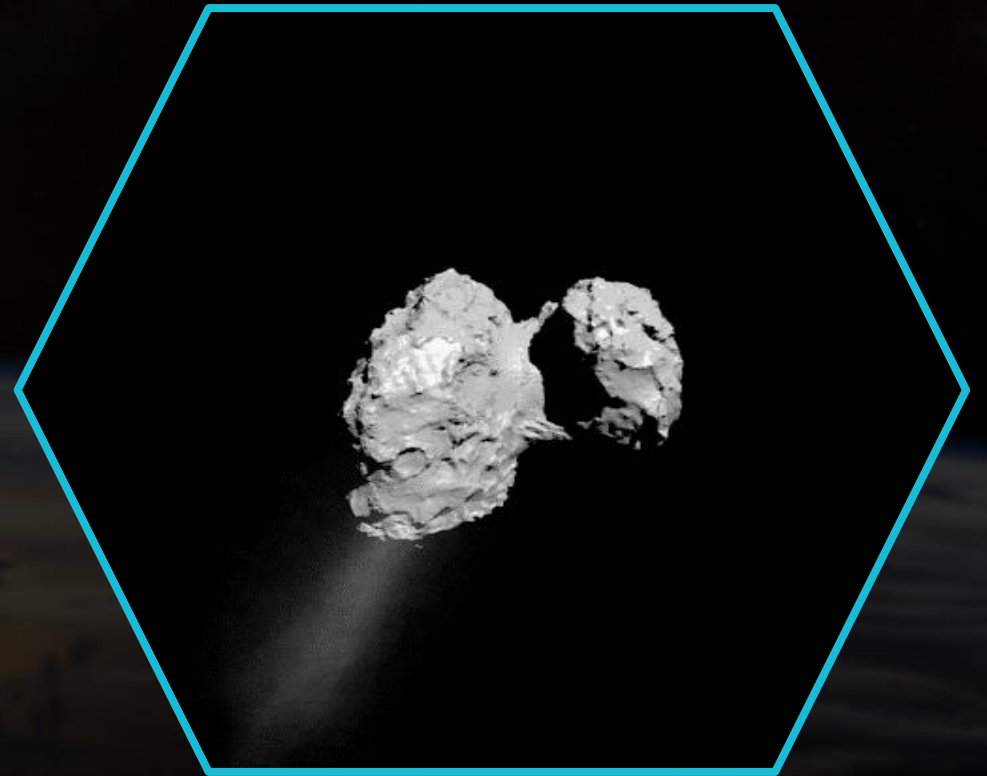
DETECTION

- ◇ Is the data being aquired useful for the mission?
 - Basic understanding of the data acquired during the mission
 - Various types of architectures can be used

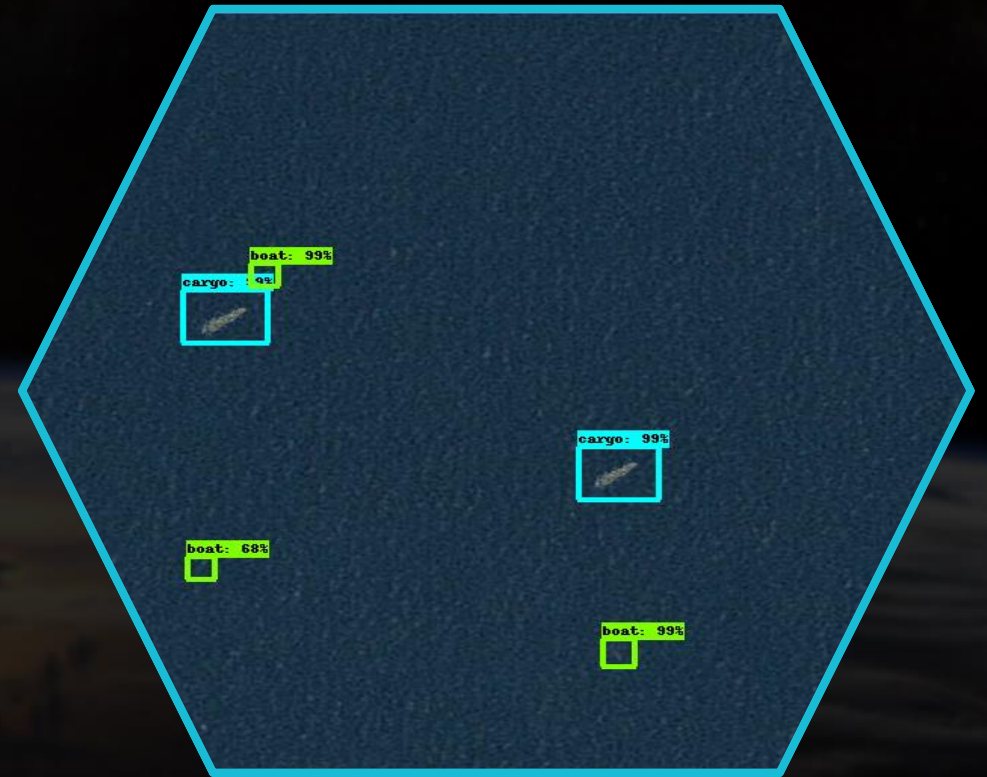
- ◇ Classification is enough to increase autonomy
 - Perform data selection / prioritization before downlink
 - Trigger enhanced acquisition modes



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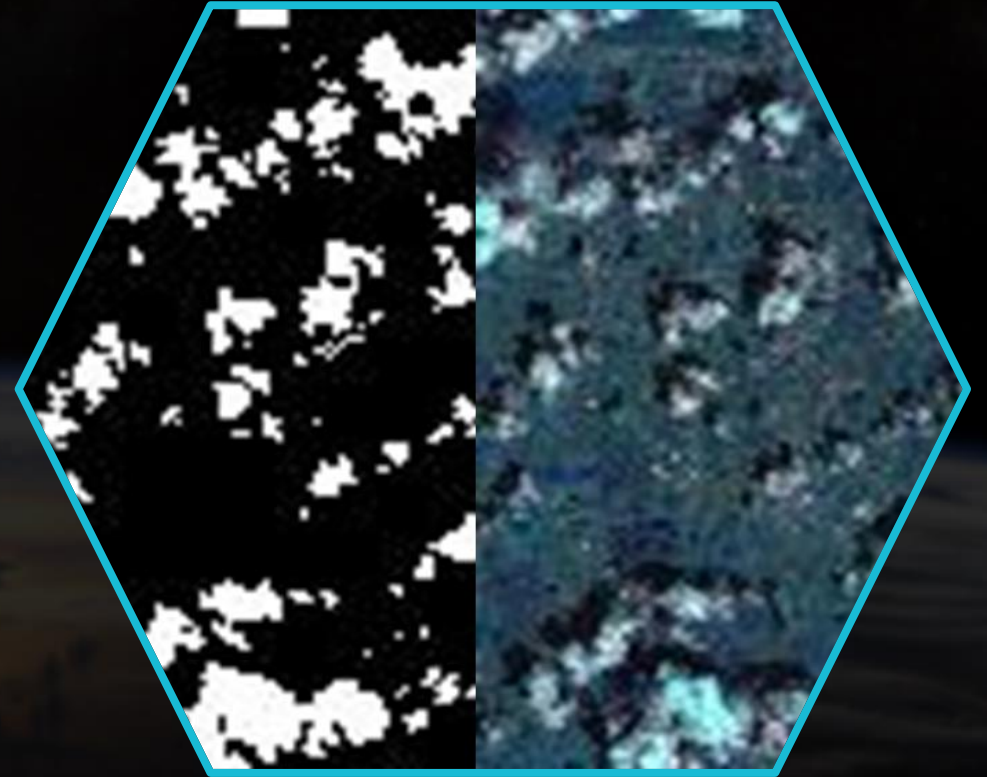
- ◇ Why is the data useful? What is inside it?
 - Deeper understanding of the data acquired
 - CNN networks are predominant here
- ◇ Object Detection enables advanced autonomy features
 - Image crop only to relevant portions before downlink
 - Tracking of ground features
 - Generation of higher-level information



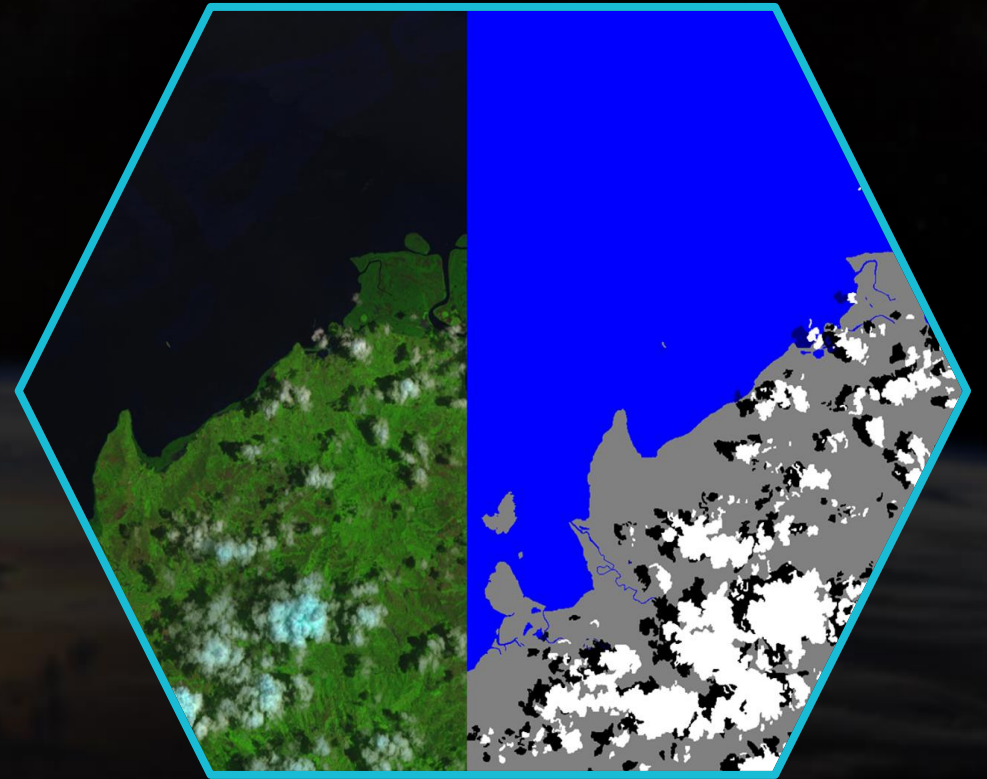
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- ◇ Can we provide insights on the acquired data?
 - Extracting high level information from an image
 - Customization of the architecture increases in importance

- ◇ The satellites provide improved services
 - From wake features to speed information
 - Estimation of ship speed for security applications



HARDWARE REQUIREMENTS

◇ What is the best architecture?

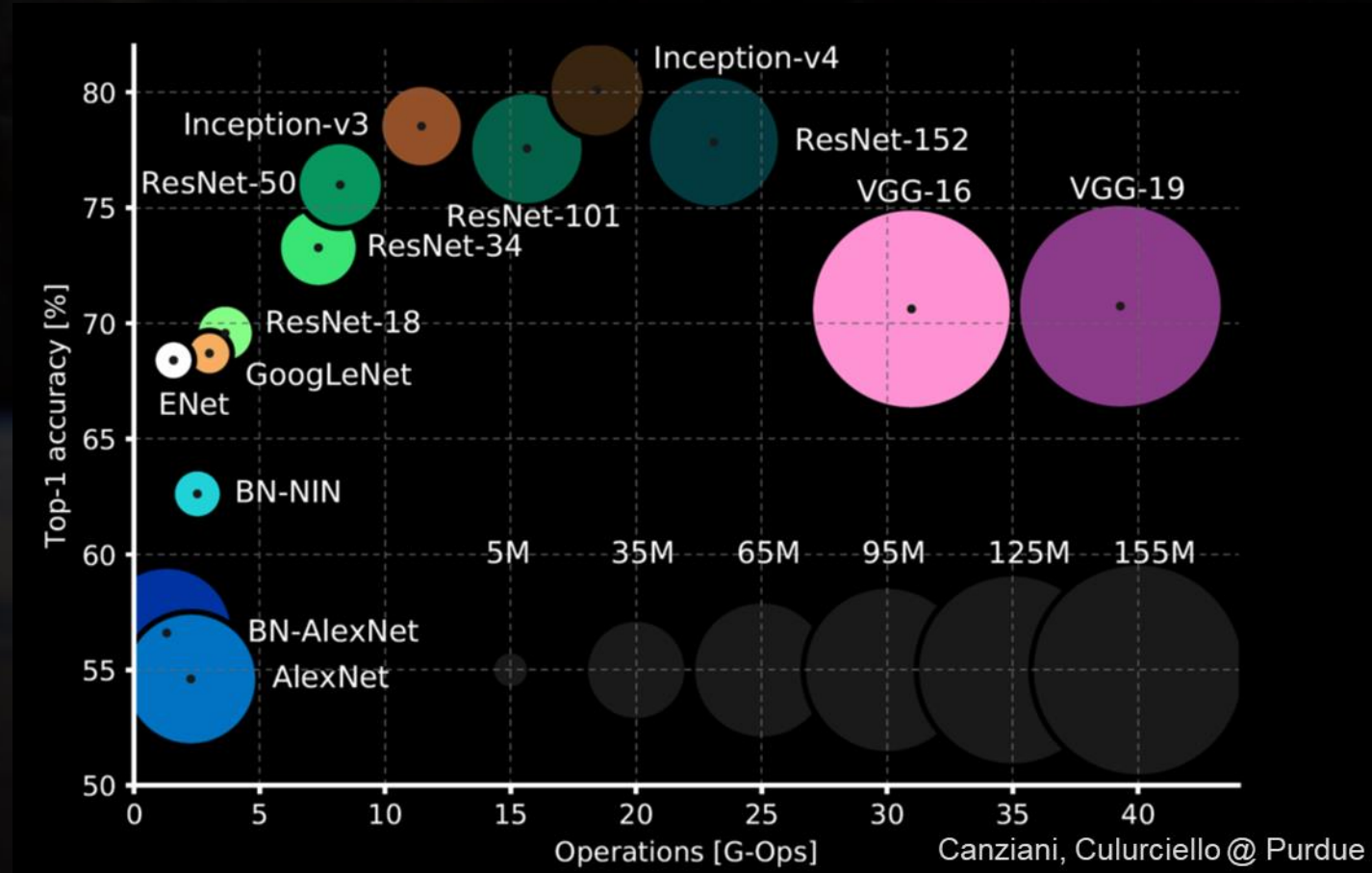
- Problem-specific
- Platform-specific

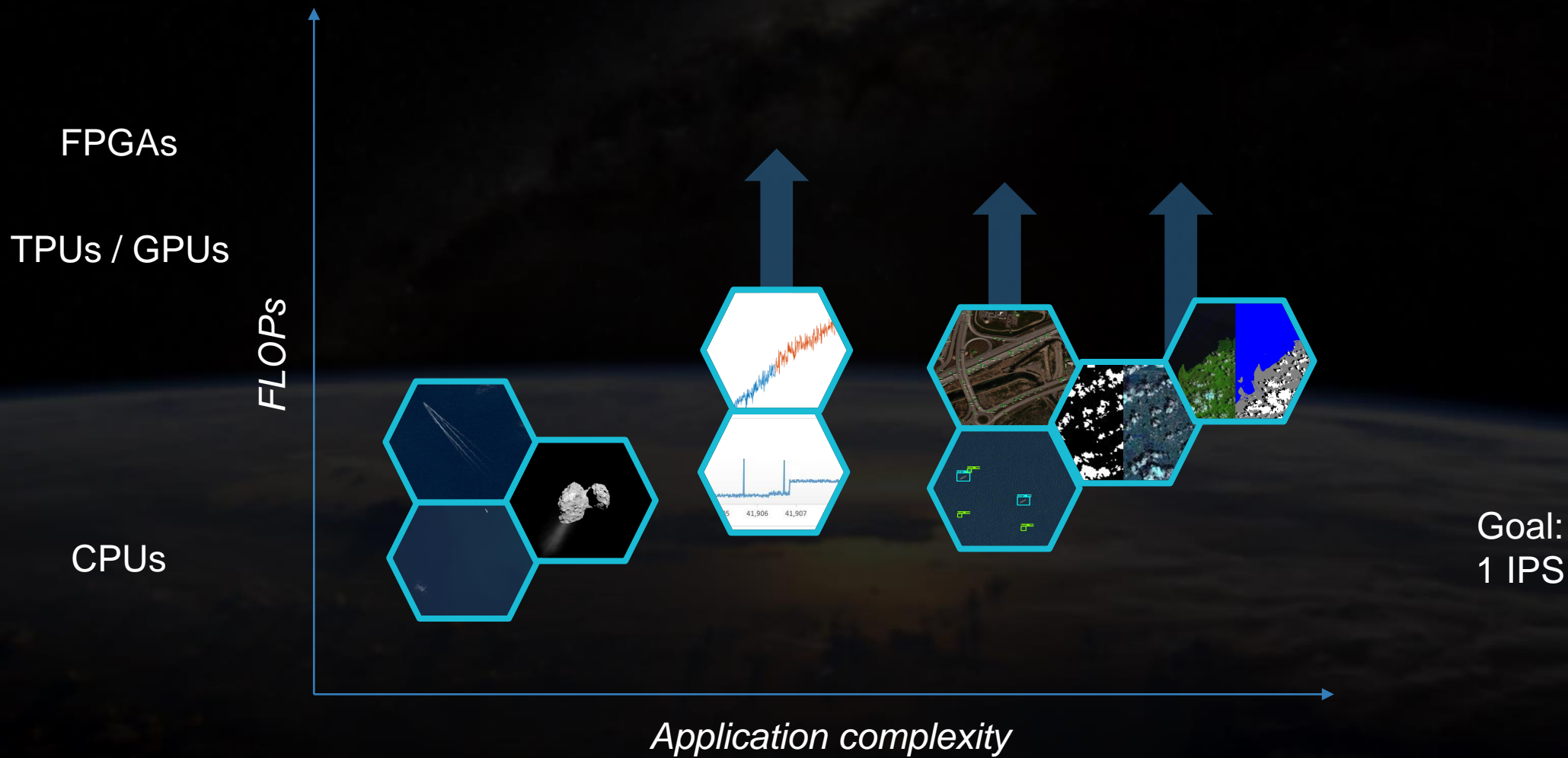
◇ What performances requirements?

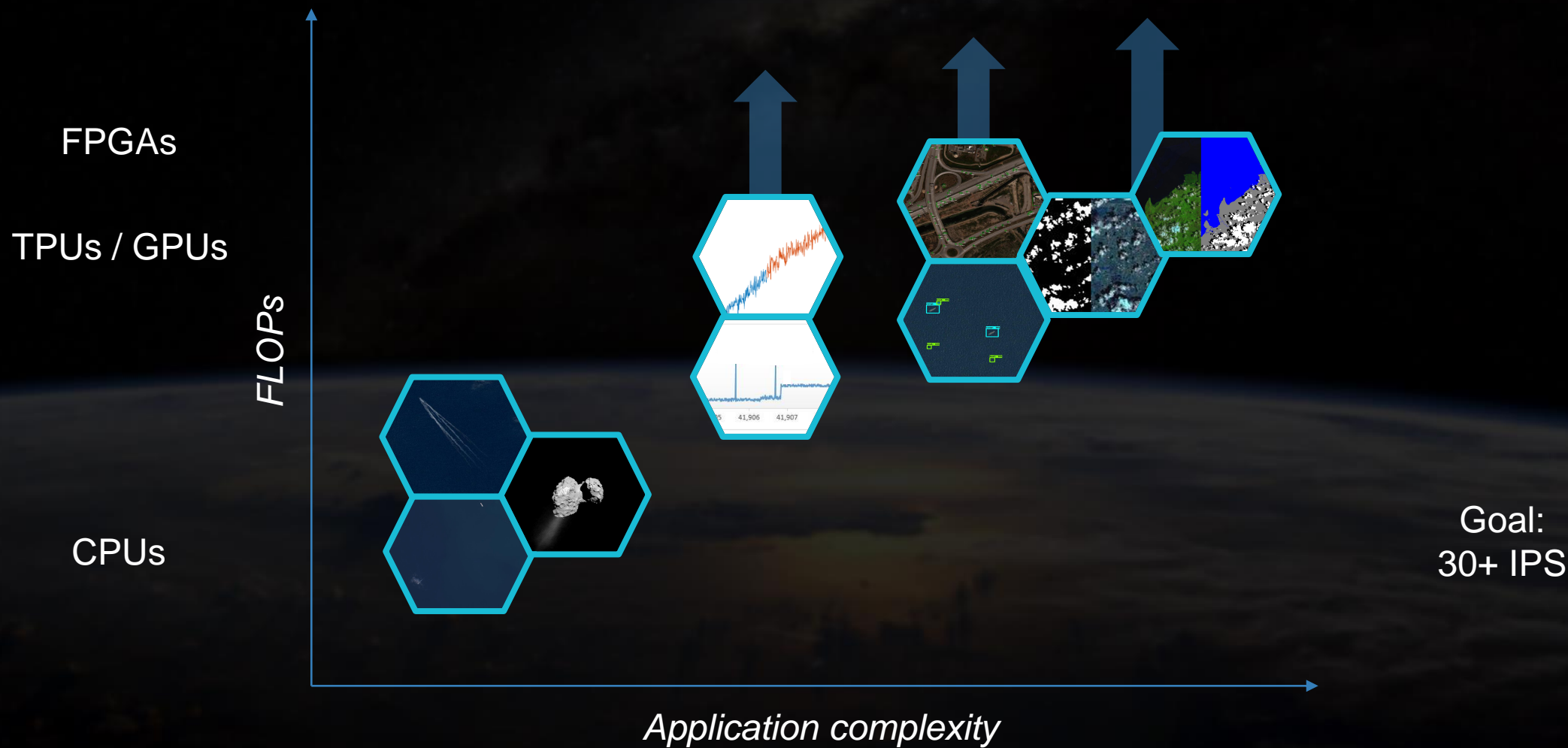
- State of the art networks that traditionally win image competitions are not compatible with on-board processors
- Mandatory to move towards smaller architectures

◇ Execution times are promising

- < 1s inference time for OD on a ARM9 processor for cloud detection

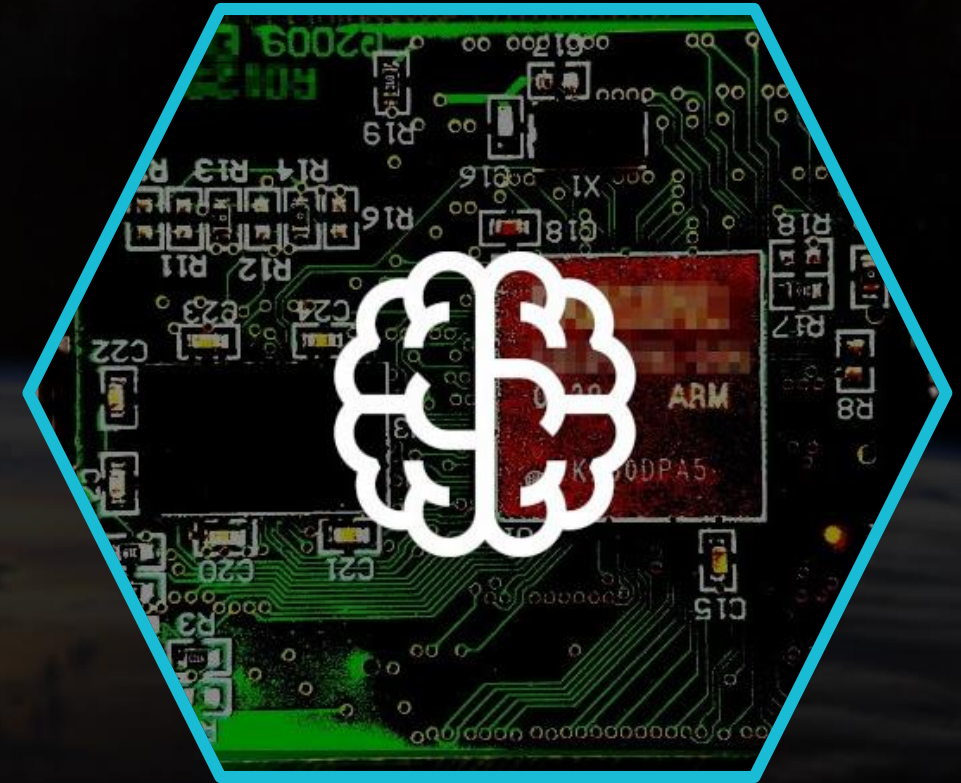






Goal:
30+ IPS

- ◇ Today technology is ready for enhanced autonomy
 - COTS processors are already meeting requirements for some Deep Learning algorithms to be run on-board
 - Complete E4 autonomy is at reach with COTS CPUs
- ◇ Evolution of the computing capabilities is required:
 - For complex AI applications
 - For high FPS
- ◇ Enhanced autonomy will be a key driver in:
 - Reducing operations costs
 - Achieving more complex missions



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