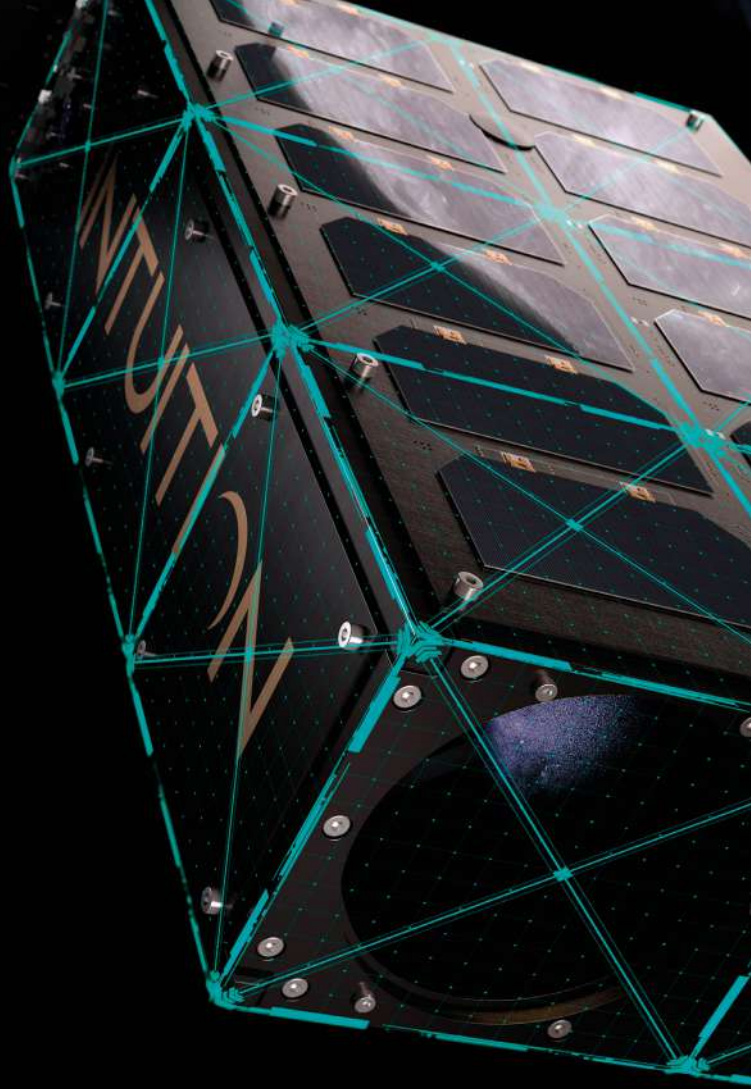
KP LABS
Mission Complete

WE DELIVER AI COMPUTERS AND SOFTWARE

To bring autonomy into demanding space missions

www.kplabs.pl



2022

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INTRODUCTION

KP Labs is an innovative New Space company based in Poland.

Our mission is to accelerate space exploration by advancing autonomous spacecraft operation and robotic technology.

Our vision is to become a European Leader in delivering Autonomous Systems for space applications. We believe that space missions can be simple and self-managed. Applying Autonomy in space domains like Earth Observation or Space Robotics is an inevitable step towards reducing the cost of operations and risk of mission failure. Our goal is to make this step possible.

COMPETENCES

Imagery

- Image processing.
- Advanced vision-based systems.

Software

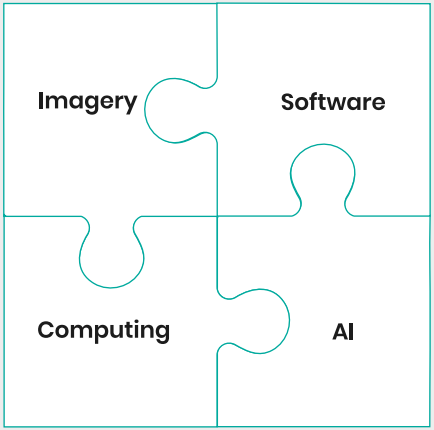
- Flight software & mission automation.
- Testing and simulation.

Computing

- High-performance computing.
- Flight computers.

AI

- Computer vision.
- Machine learning.



Through implementing a wide range of different projects, we have gained valuable experience as a leader, partner or sub-contractor. We support project implementation with our knowledge of software, hardware, artificial intelligence and hyperspectral imaging, in the following areas:

Electronic design:

- Schematics and PCB design (high-speed circuits with FPGA, SoCs, DDR4, etc),
- Preparation of platforms for Xilinx SoCs (bitstreams+embedded linux, including Vitis AI for ML acceleration),
- FPGA IP Cores development (Xilinx, Microchip).

Software development:

- Extensive experience in software development (C, C++ 17, Python3, Lua, .NET, JavaScript, TypeScript),
- Experience in developing and operating flight software (PW-Sat2, KRAKsat).

Artificial Intelligence (ML&DL) and data analysis:

- Image pre-processing, super-resolution reconstruction, image analysis (focus on MSI/HSI),
- Anomaly detection in telemetry data (signal processing),
- Verification and validation.

Mechanics, thermal and optics design:

- Opto-Mechanics and optics design for catadioptric optical tracks,
- Design, testing and production of thermal systems for space electronics.

Mission analysis and system engineering:

- Mission definition, ConOps and feasibility study,
- Space segment & ground segment architecture planning,
- System engineering.

TECHNOLOGY PILLARS:

In-orbit data processing

On-board extraction of high-level information (hardware and software).

Spacecraft management

On-board computer software, predictive maintenance and fully automated spacecraft operations.

Navigation and spatial orientation

From simple manoeuvres to more advanced scenarios.

INTUITION-1

PROCESSING OF HYPERSPECTRAL IMAGES IN-ORBIT

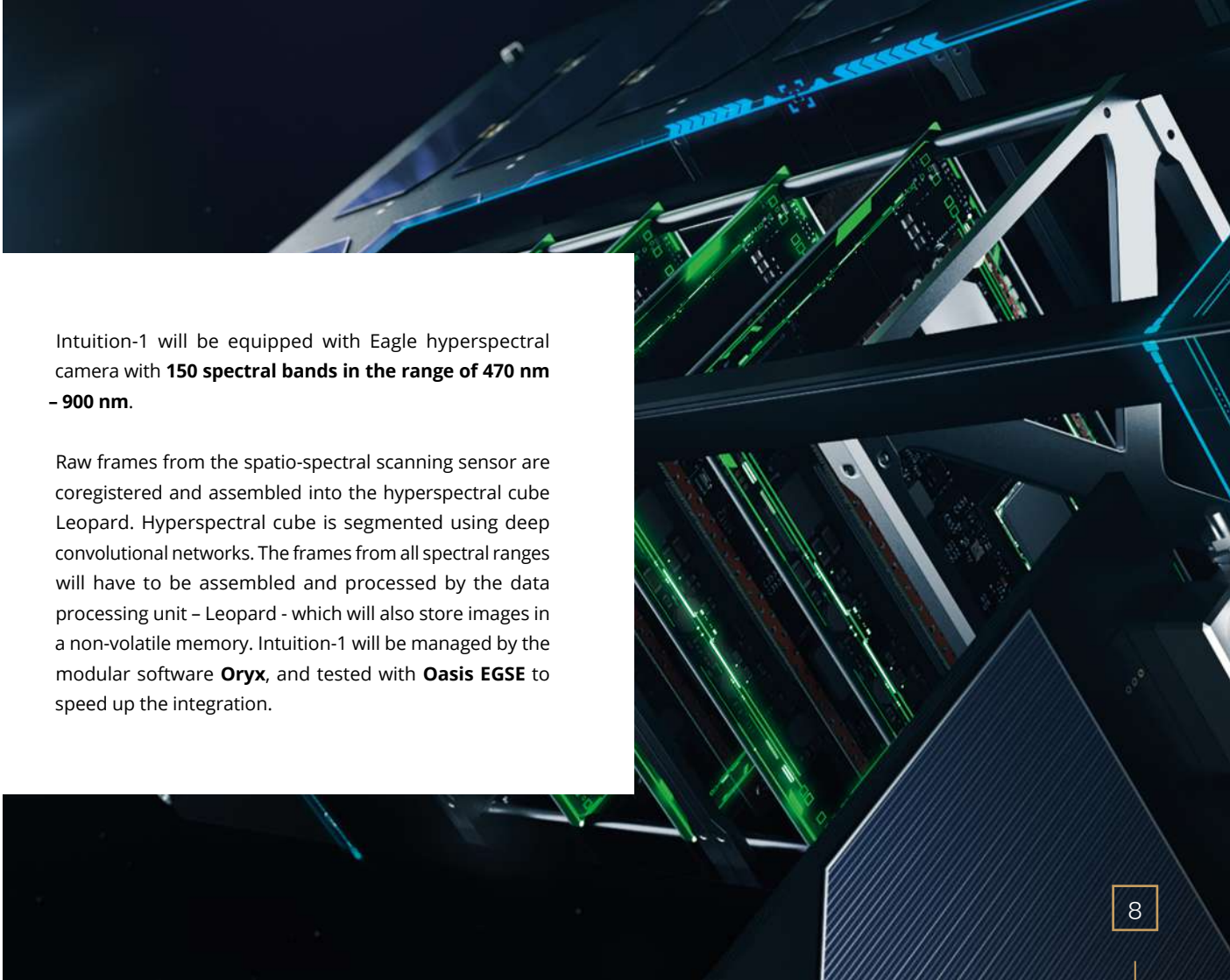
Intuition-1 is the flagship project of KP Labs. The mission aims to bring a satellite for Earth observation into low orbit, which, thanks to innovative solutions in the field of **artificial intelligence and a specially prepared on-board computer,** will automate the process of obtaining images in orbit.

The images do not need to be sent to Earth for processing, but **will be analysed on-board the satellite**, which will speed up the whole process of acquiring information from the data.

Intuition-1 will be **a 6U-class satellite with a data processing unit** enabling on-board data processing acquired via a hyperspectral instrument with spectral resolution in the range of visible and near infrared light. The applied neural networks can be reconfigured during the mission to ensure adjustment to current needs. Thanks to the **neural network-based analysis** and processing of images in orbit, the amount of data sent to the ground station will be reduced by up to 100 times.

Intuition-1 = **Leopard DPU*** enabling on-board data processing + **The Herd** AI-powered algorithms + **Eagle hyperspectral camera** with 150 bands

* Data Processing Unit



Intuition-1 will be equipped with Eagle hyperspectral camera with **150 spectral bands in the range of 470 nm – 900 nm**.

Raw frames from the spatio-spectral scanning sensor are coregistered and assembled into the hyperspectral cube Leopard. Hyperspectral cube is segmented using deep convolutional networks. The frames from all spectral ranges will have to be assembled and processed by the data processing unit – Leopard - which will also store images in a non-volatile memory. Intuition-1 will be managed by the modular software **Oryx**, and tested with **Oasis EGSE** to speed up the integration.

DATA PROCESSED THIS WAY CAN BE USED IN NUMEROUS SECTORS, SUCH AS:

Agriculture

Land coverage classification, crop forecasting, crop maps, soil maps, plant disease detection, biomass monitoring, weed mapping.

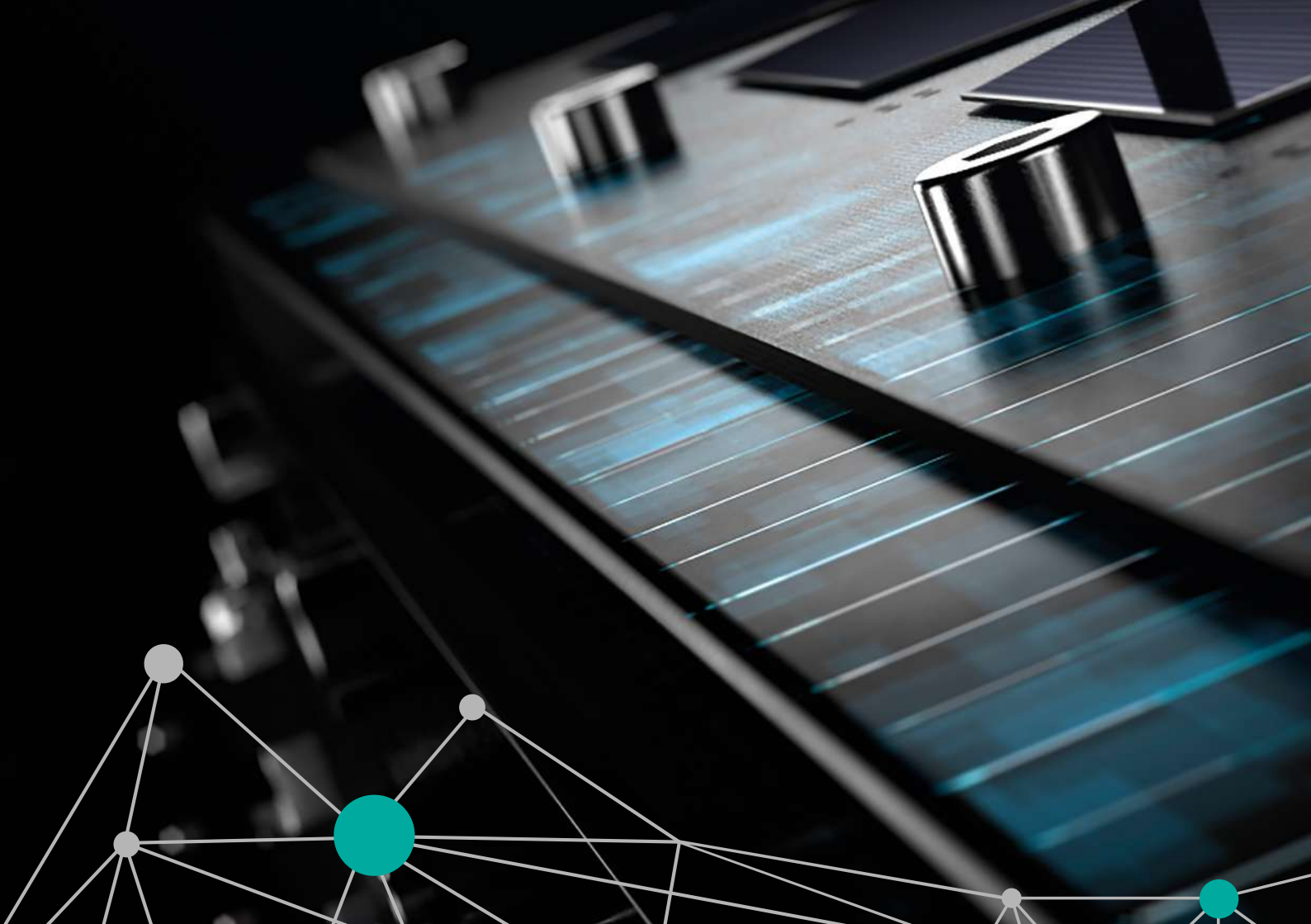
Forestry

Forest classification, identifying species and the condition of forests, forestation planning.

Environmental protection

Water and soil pollution maps, land development management and analysis.

Intuition-1 project has been commissioned by The National Centre for Research and Development and is executed together with our partners: Future Processing and FP Instruments.



PRODUCTS

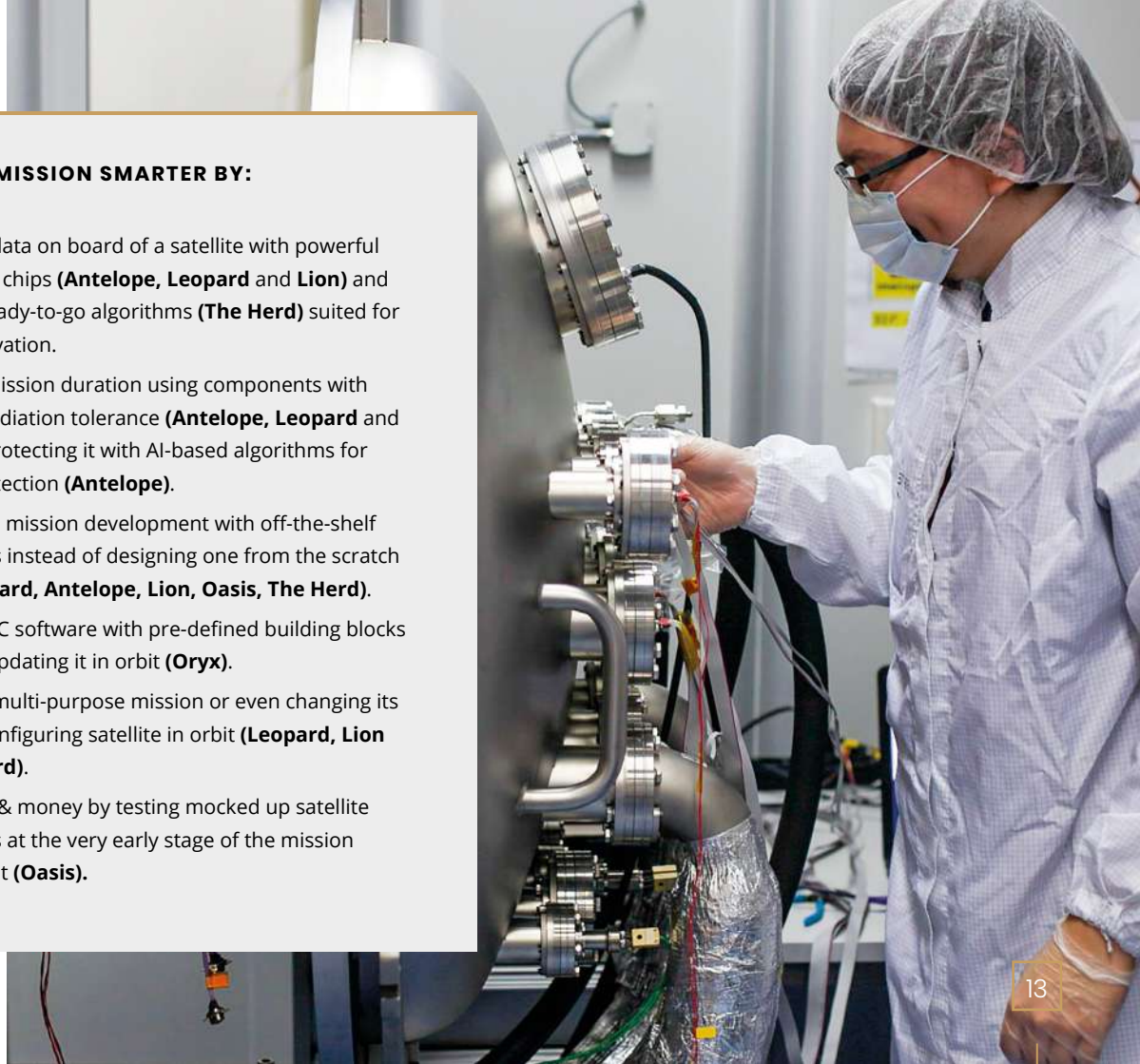
SMART MISSION ECOSYSTEM

For the mission integrators and operators who need to build advanced spacecrafts, **Smart Mission Ecosystem (SME)** brings together hardware, software and AI-powered algorithms. Unlike fragmented and unintegratable solutions, the SME was designed with the holistic approach to enable on-board data processing on the payload and satellite level, as well as to make the mission more fault-tolerant and safer.

SME supports the complete lifecycle of advanced missions from the analysis and design, through faster satellite integration thanks to the built-in algorithms, software and hardware-in-the-loop tests to the increased reliability of operations in space and the on-board data processing supported by the artificial intelligence.

MAKE YOUR MISSION SMARTER BY:

- Processing data on board of a satellite with powerful FPGA-based chips **(Antelope, Leopard** and **Lion)** and on-board ready-to-go algorithms **(The Herd)** suited for Earth observation.
- Extending mission duration using components with increased radiation tolerance **(Antelope, Leopard** and **Lion)** and protecting it with AI-based algorithms for anomaly detection **(Antelope)**.
- Speeding up mission development with off-the-shelf components instead of designing one from the scratch **(Oryx, Leopard, Antelope, Lion, Oasis, The Herd)**.
- Creating OBC software with pre-defined building blocks and safely updating it in orbit **(Oryx)**.
- Making it a multi-purpose mission or even changing its goal by reconfiguring satellite in orbit **(Leopard, Lion** and **The Herd)**.
- Saving time & money by testing mocked up satellite components at the very early stage of the mission development **(Oasis).**



Smart Mission **Ecosystem** by KP LABS

ORYX

Modular on-board software

ANTELOPE

On-board computer with predictive maintenance

LEOPARD

High-performance data processing unit for AI applications

LION

High-performance DPU for more advanced missions

THE HERD

AI-powered algorithms for Earth Observation

OASIS

Electrical Ground Support Equipment created to test satellite on the Earth

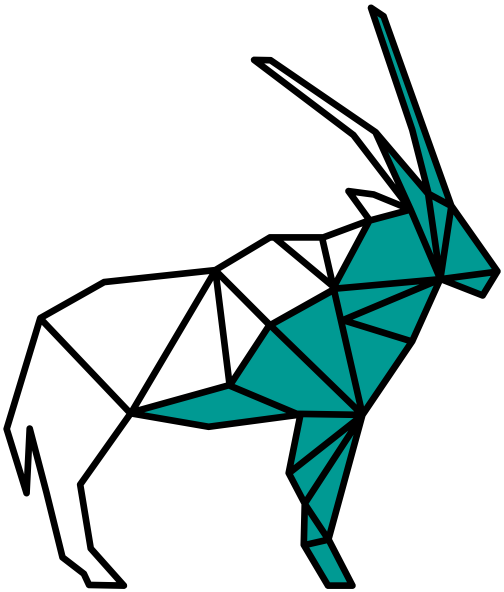
ORYX OBCS

MODULAR FLIGHT SOFTWARE TAILORED FOR YOUR MISSION

Oryx is **a modular flight software** tool developed for the mission control of small satellites. This on-board computer software manages all satellite tasks – namely, **processing telecommands sent by the operators, monitoring the power budget, executing pre-defined schedules, managing emergencies and handling data from all the sensors on board.**

Oryx utilises an innovative framework that facilitates the customised development of your own mission. Thanks to its **modular architecture,** it supports the rapid development of the mission's software by using a vast **library of components – logging, scheduling, testing and communication.**

The ease at which a testing environment and software simulator can be set up ensures in-depth evaluation of your applied solutions from the onset of the project. Should your component not be supported by Oryx, you can simply **extend your simulation by creating customised drivers.** Knowing how crucial your mission and its safety are, Oryx not only provides the possibility of updating the software in orbit but also the application of a critical hotfix.



ORYX

SOFTWARE DEVELOPMENT KIT

A set of libraries written in C++ containing crucial onboard services for telemetry and telecommands, hardware abstraction layer and a library of drivers for popular systems.

DEVELOPMENT TOOLS

A framework for satellite systems simulators and automated tests suite allowing testing the flight software either running locally on PC (using QEMU) or by connecting to hardware engineering model (using Oasis EGSE board).

OASIS EGSE

A single-board, CubeSat PC-104 compatible EGSE that serves as an interface between PC-running simulators and hardware engineering model.

ORYX CAPABILITIES:

Satellite management
Telemetry, tracking and command handling.

Fault detection
Isolation and recovery support.

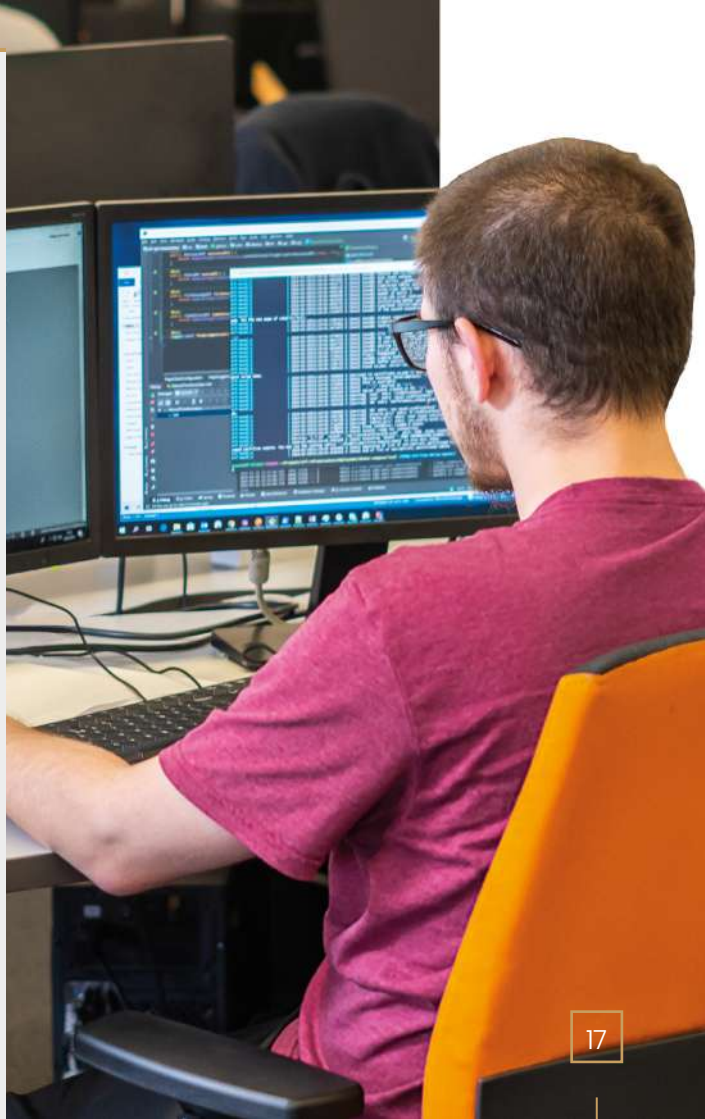
Task scheduling
Flexible task management based on the time, position and platform status.

Data storage
Managing up to 4 GB file-based storage with a short boot time.

Communication
Access to the satellite through secure data links.

Extensibility
Using scripting language to manage in-flight issues and extend the OBC features after the launch.

Testability
Faster satellite integration thanks to the built-in algorithm, software and hardware-in-the-loop tests.



CASE STUDIES:

Oryx will be the heart of the **Intuition-1** mission, which is planned for launch in 2022/2023. Intuition-1 is a 6U-class satellite with a data processing unit that enables on-board data processing acquired via a hyperspectral optical instrument. The spacecraft is based on AAC Clyde Space 6U bus with Kryten M3 on-board computer based on SmartFusion 2 SoC with ARM Cortex-M3 processor @50 MHz with KP Labs flight software for OBC and in-house designed payload. Oryx OBCS libraries and tools provided with it (including simulators engine and hardware-in-the-loop tests) are utilized to build complete flight software for satellite mission, used in every phase of the mission, including ground AIVT, LEOP, bus and payload commissioning, routine operations, as well as end-of-life/disposal.

Oryx will be also utilized by the **PW-Sat3** satellite, coupled with KP Labs's on-board computer Antelope. PW-Sat3 is an in-orbit demonstrator of a new cold gas propulsion and is planned to be launched at the beginning of 2023. Antelope will be responsible for satellite management and mission safety.

TECHNICAL SPECIFICATION	
Memory	▪ Min. 1 MB (code) (depending on the selected features) ▪ Min. 1 MB (data) (depending on the selected features)
Supported MCUs	ARM Cortex-M, ARM Cortex-R
Recommended minimum clock	50 MHz
Storage	▪ Data storage: NAND flash memory up to 4 GB ▪ High reliability FRAM-based storage
Development tools	▪ Open-source, cross-platform tools: CMake, GCC, Python ▪ Modern technologies: C++17
Supported on-board computers	▪ Kryten M3 by AAC Clyde Space ▪ Antelope OBC by KP Labs ▪ Others with ARM Cortex-M or Cortex-R
Ground segment communication	▪ AX.25 based modules ▪ S/X stream-based modules (CCSDS compliant) ▪ Flexible communication stack ▪ Optional: encryption, authentication

TECHNICAL SPECIFICATION cont.	
Ground software support	▪ XTCE and SEDS-compliant spacecraft database ▪ YAMCS integration ▪ Easy integration with any MCS during the whole process (from mission development to in-orbit operations)
Compatible off-the-shelf subsystems	▪ EPS (STARBUCK) + Batteries by AAC Clyde Space ▪ ADCS by AAC Clyde Space ▪ UHF Transceiver by CPUT ▪ Leopard DPU by KP Labs ▪ UVTRX by ISIS ▪ IMTQ by ISIS ▪ ANT module by ISIS ▪ uCam III camera module by 4D Systems ▪ Q20 HD GPS (and all NMEA based) by QinetiQ ▪ EWC27-SRX X/S Transceiver by Syrlinks ▪ Easy to add support for any subsystem using I2C, UART, CAN, SPI

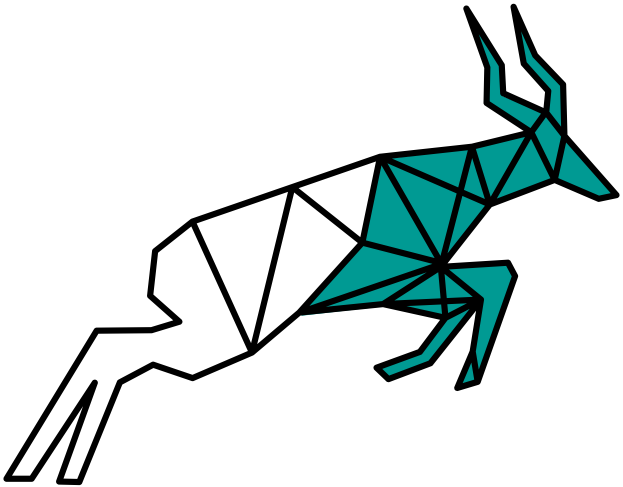
ANTELOPE OBC

ON-BOARD COMPUTER DESIGNED TO KEEP YOUR MISSION SAFE

Antelope on-board computer (OBC) is the combination of **a Telemetry, Tracking & Command (TT&C)** module and a **Data Processing Unit (DPU)**. It is the powerful heart of the satellite, responsible for satellite control and basic task performance such as communication handling, monitoring the satellite's subsystems, handling the classic **Fault Detection, Isolation and Recovery (FDIR)** mechanism and performing planned tasks.

Thanks to the powerful **(160 GOPS) FPGA system** it can also handle advanced on-board data processing tasks enabling Earth Observation, telecommunication and other demanding data processing applications.

Antelope was designed to **maximize spacecraft safety**. Thanks to customised mechanisms which protect against effects related to space radiation it can be applicable in more demanding missions. An optional layer of security is provided by the **machine learning algorithms** which, on the basis of telemetric data, **detect events which may be considered as threatening to the security of the mission**. If such an event is detected, the computer will notify the operator in order to take corrective actions.



KEY ADVANTAGES:

1 Mission Safety

- 20 kRad tolerance and SEE protections.
- Classic FDIR mechanisms.
- Optional Artificial Intelligence for preventive failure detection of all types of anomalies: point, contextual, collective.

2 Mission Power

- 160 GOPS of computing power enables exciting possibilities in Earth observation, telecommunication and AI-based applications.

3 Mission Extensibility

- Compatibility with Leopard Data Processing Unit. By pairing Antelope and Leopard you can extend the on-board processing power by 3000 GOPS to enable the processing of more demanding calculations.

CASE STUDY

Antelope will be utilized by the PW-Sat3 satellite, coupled with KP Labs's on-board computer software - Oryx. **PW-Sat3** is an in-orbit demonstrator of a new cold gas propulsion and is planned to be launched at the beginning of 2023. Antelope will be responsible for satellite management and mission safety.

	TECHNICAL SPECIFICATION	
TT&C	**Processing Cores**	RM57 Hercules microcontroller: ▪ Dual 300 MHz ARM Cortex-R5F with FPU in lock-step
	Memory	▪ 12 MiB of MRAM ▪ ECC protected Program Flash ▪ 1-4 GiB SLC flash-based filesystem storage with ECC ▪ 256 kiB of FRAM
	Interfaces	▪ Interfaces: CAN, I2C, GPIO, LVDS, SPI, RS422/485, UART ▪ Additional custom interfaces upon request: SpaceWire, Ethernet ▪ LVDS/RS422 interfaces compatible with X/S-Band radios and CCSDS-compatible communication channel upon request.
	Specifications	▪ Supply Voltage: 5.5 to 14 V (VBAT) or 5V regulated ▪ Operating Temperature: -40 to 85 °C ▪ Supercap-powered RTC ▪ Flash FPGA for custom function implementation
	Software Ecosystem	KP Labs's On-board Computer Software - Oryx
	Form-Factor	PC-104 board

TECHNICAL SPECIFICATION

DPU	**Processing Cores**	Equipped with Zynq UltraScale+ MPSoC ZU2EG | ZU3EG | ZU4EG | ZU5EG: ▪ Quad ARM Cortex-A53 CPU up to 1.5 GHz ▪ Dual ARM Cortex-R5 in lock-step ▪ FPGA for custom function implementation DPU with Kintex Ultrascale is also possible on request.
	Memory	▪ 1-2 GiB DDR4 with ECC
	Interfaces	▪ Interfaces: LVDS, SPI, RS422/485, GTY and GTH transceivers ▪ Additional custom interfaces upon request: SpaceWire
	Specifications	▪ Supply Voltage: 5.5 to 14 V (VBAT) or 5V regulated ▪ Operating Temperature: -20 °C to 100 °C ▪ FPGA bitstream loaded by TT&C (reconfigurable in orbit)
	Software Ecosystem	64-bit Linux or bare-metal applications
	Form-Factor	70x45mm daughterboard compatible with TT&C

LEOPARD DPU

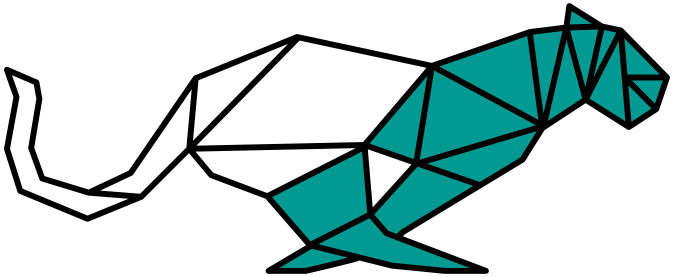
A NEW CHAPTER IN ON-BOARD DATA PROCESSING

Leopard is a CubeSat standard compliant **Data Processing Unit** which enables mission designers to apply artificial intelligence solutions in space. It was designed **to support capturing, managing and processing of data in orbit.** Leopard redefines the current approach to remote sensing. Now, instead of sending huge, unprocessed sets of data to ground stations, Leopard **uses deep neural networks to process data on-board and therefore only sends the most important and valuable insights to the ground**.

By reducing the time and cost of data transfer and processing, it enables you to focus on a rapid response to any detected phenomena.

Leopard is integrated with a powerful FPGA to accelerate execution of deep learning algorithms and has a throughput of up to **3 tera operations per second.** A number of hardware and software measures protect the computer against the influence of radiation.

With its extraordinary capabilities-to-size ratio (**less than 1U)**, wide supply voltage range and universal interfaces, it is compatible with most CubeSats platforms. Its scalable and customisable architecture makes it possible to create larger and more powerful versions dedicated to bigger platforms as well.

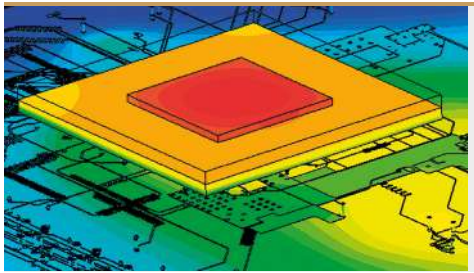


TECHNICAL SPECIFICATION

	Zynq UltraScale+ MPSoC		
	ZU6EG	ZU9EG	ZU15EG
Processing cores	▪ Quad ARM Cortex-A53 CPU up to 1.5 GHz ▪ Dual ARM Cortex-R5 in lock-step ▪ FPGA for custom function implementation		
Memory	▪ 4-16 GiB DDR4 providing with ECC ▪ 4-16 GiB SLC flash-based file system storage (EDAC) ▪ Up to 2x256 GiB SLC flash-based data storage		
Interfaces	▪ Interfaces: CAN, LVDS, SPI, RS422/485, UART, GTY and GTH transceivers ▪ Additional customisable interfaces upon request: SpaceWire, Ethernet ▪ LVDS/RS422 interfaces compatible with X/S-Band radios and CCSDS-compatible ▪ Communication channel upon request		
Specifications	▪ A radiation hardened Payload Controller ▪ Supply Voltage: 6.5 to 14 V (VBAT) ▪ Power Consumption: 7.5 W to 40 W – depending on workload and specified processing speed ▪ Computational Throughput for Neural Networks: up to 3 TOPS ▪ Thermal interface customisable for satellite architecture		
Software ecosystem	▪ 64-bit Linux ▪ Deep Learning Accelerator fed with Caffe or TensorFlow models ▪ Fully reconfigurable in orbit		
Redundancy	▪ Possibility to introduce additional redundancy to each version		
Form-Factor	▪ CubeSat standard-compatible, < 1U		

CASE STUDY

Leopard will be utilized by the **Intuition-1 satellite**, coupled with a **150-band hyperspectral** sensor to perform image segmentation and object detection thanks to The Herd – algorithms dedicated to Earth Observation. For the purpose of on-board data processing during the mission, it will use two high performance nodes for redundancy and parallel operation.

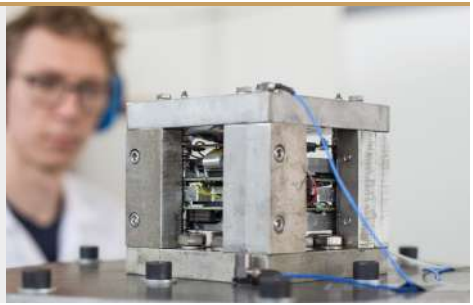


THERMAL MANAGEMENT OF ELECTRONICS

Our Engineers and Scientists pay special attention to all the demanding requirements which stem from the application environment. We ensure maximum care of the proper thermal management of IC components and system-level behaviour to safeguard reliability in terms of the space mission lifetime.

MECHANICAL ENCLOSURES FOR ELECTRONIC SYSTEMS

Our electronic products are supported by exclusively designed housings that take into account: required mechanical vibration resistance, form factor and coatings. We perform a wide spectrum of environmental tests which can satisfy the challenging expectations of our customers.



LION DPU

MORE AI POWER LOCKED IN THE HARDWARE

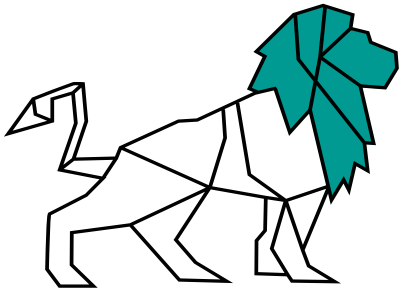
Lion is a **data processing unit for advanced operations** with the use of artificial intelligence and on-board data processing. The Lion DPU is dedicated to micro and small satellites weighing **between 50 and 500kg.**

Lion is developed to process multi-dimensional and multi-sensor data in orbit and is composed of high-performance COTS components that satisfy the processing power, high reliability and memory bandwidth demands for a wide range of missions. Combined with **The Herd** (our library of AI-powered on-board data processing algorithms), this technology will connect the eyes (sensors) with the brain (DPU), thus enabling artificial intelligence to ensure **autonomous decision making in situ**.

It supports challenging activities allowing, for example, close-proximity operations through vision-based relative navigation between two spacecrafts for active debris removal or in-orbit servicing.

The Lion DPU hardware platform is composed of the Kintex Ultrascale FPGA with an accompanying external supervisor which provides **single-event effects (SEE) and single-event functional interrupt (SEFI) protections,** including configuration memory scrubbing and specialized watchdogs.

Thanks to the built-in bootloader, the external supervisor can update itself and reprogram the Kintex Ultrascale FPGA in-flight. Lion is also equipped with up to 8 GiB of DDR4, up to 16 SLC NAND Flash and up to 1 TiB of SSD storage. The developed thermal storage system can extend the on-orbit operation of the DPU to **at least five years.**



LION IS BUILT OUT OF 3 KEY ELEMENTS:

Data Processing Unit

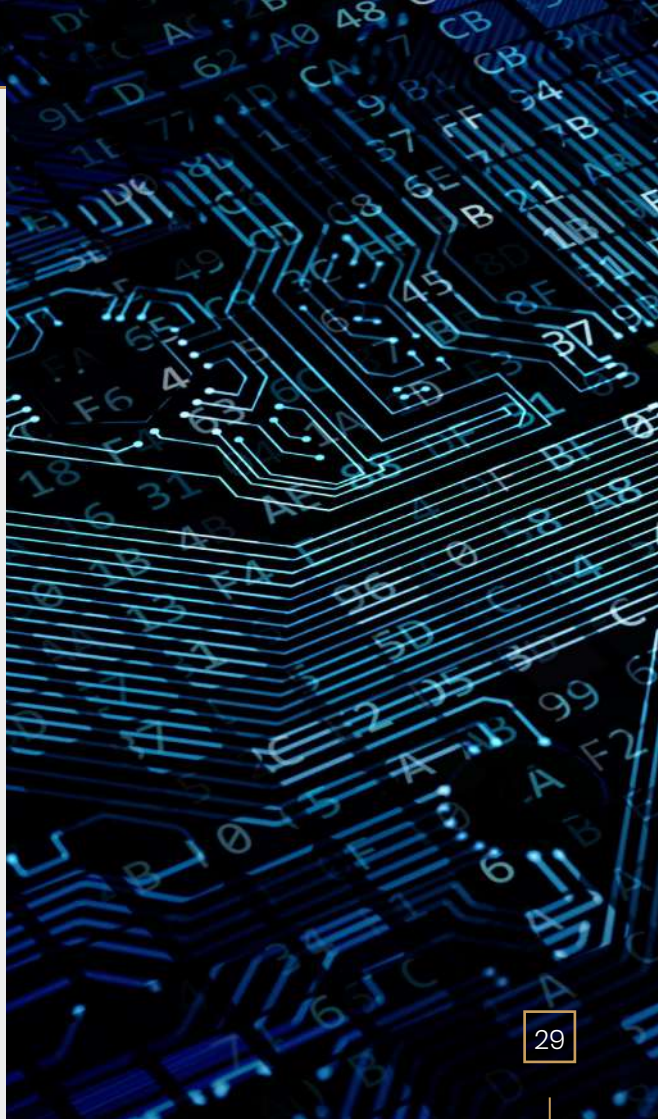
The DPU allows uninterrupted operation in orbit. Thanks to being equipped with specialised components it is **able to perform continuous and dynamic correction of errors** which may occur in space.

Thermal Accumulation System

The system **reduces the adverse effects of temperature cycling** on the risk of failure. The optional Phase Change Material-based TCS **enables the averaging of temperatures and thus prolongs lifetime.**

Customised DPU management software

The customised software delivers the following: smooth communication with other satellite subsystems; **telemetry data collection, monitoring and provision; the management and running of data processing algorithms** provided by the customers.



TECHNICAL SPECIFICATION

	Xilinx Kintex Ultrascale FPGA		
	KU035	KU060	KU095
Processing cores	▪ Kintex Ultrascale FPGA for custom function implementation ▪ Optional Microblaze soft-core running on Kintex equipped with an external 4 MiB of MRAM in which the application software may be loaded by an external supervisor ▪ 3x64 MiB of NOR Flash to store FPGA bitstreams ▪ Multiple FPGA bitstreams can be stored and selected for in-flight loading		
Memory	▪ 2-8 GiB DDR4 providing with ECC ▪ 4-16 GiB SLC flash-based file system storage (EDAC) ▪ Up to 2x256 GiB SLC flash-based data storage (possible redudancy)		
Interfaces	▪ Exposed interfaces: CAN, LVDS, SPI, RS422/485, UART and GTH transceivers ▪ Additional customisable interfaces upon request: SpaceWire Lite, SpaceWire RMAP, Gigabit Ethernet ▪ LVDS/RS422 interfaces compatible with X/S-Band radios ▪ CCSDS-compatible IP-cores for X/S/Ku-Band radios upon request		
Specifications	▪ Up to 15W at the KU035 version with the option of scaling up for a more powerful FPGA ▪ TID resistance - minimum 20kRad ▪ Embedded SEU and SEFI mitigation techniques – MRAM-equipped supervisor, Kintex's CRAM scrubbing by external supervisor, SEFI detection, RAM scrubbing, etc. ▪ Thermal control system for SpaceVPX version heatsink with wedge locks that provide a thermal interface to a carrier box ▪ Client-driven customisation available upon request ▪ A PCM-based thermal control system available upon request		

TECHNICAL SPECIFICATION cont.	
Software ecosystem	▪ Both Supervisor and Microblaze can run FreeRTOS (default) or RTEMS ▪ Linux support on Microblaze available upon request ▪ AI-based neural network engine running on Microblaze, accelerated by FPGA upon request ▪ OpenCV support available upon request ▪ Fully reconfigurable in orbit (Supervisor software and Kintex's bitstreams can be uploaded from the ground station)
Redundancy	▪ Possibility to introduce additional redundancy to each version
Form-Factor	▪ SpaceVPX 3U (mass up to 2.5 kg) or a custom form factor

THE HERD

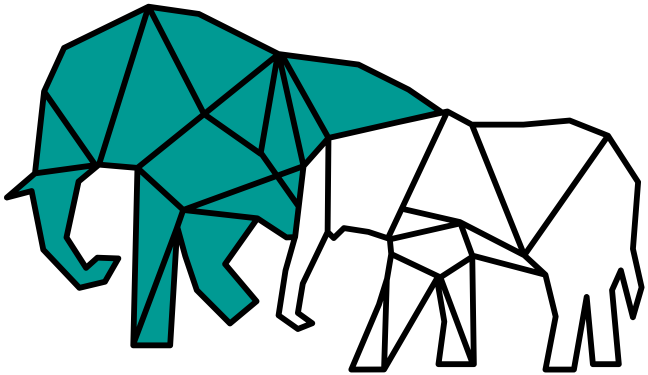
AI-POWERED ALGORITHMS TO PREPARE AND ANALYSE EARTH OBSERVATION DATA

The Herd is a set of AI-powered algorithms designed to facilitate Earth Observation data analysis. It comprises three elements – data pre-processing techniques, approaches to spatial resolution enhancement of image data, and data analysis algorithms. The Herd fully supports the Earth Observation processing chain – from optical data acquisition, through data preparation and manipulation, up to data classification, segmentation, unmixing, compression, and much more.

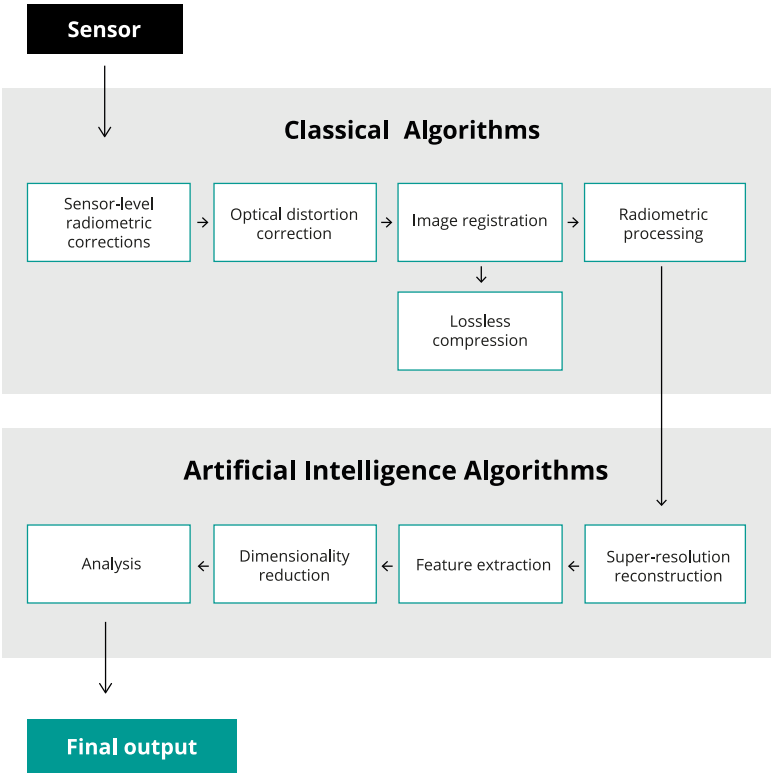
All key elements of The Herd were designed to be used both on Earth and on-board the satellite – they fit FPGA processors and are compatible with the Xilinx-based Data Processing Units.

WHAT OUR ALGORITHMS CAN DO?

- Image pre-processing.
- Super-resolution reconstruction.
- Image analysis.
- Thorough quantitative, qualitative & statistical validation.



THE HERD FULLY AUTOMATES THE FOLLOWING STEPS OF THE PROCESSING CHAIN:



CASE STUDY

The Herd will be used in the Intuition-1 mission, which **is planned for launch in 2022/2023**. Intuition-1 is a 6U-class satellite with a data processing unit Leopard – enabling on-board data processing using deep learning in a variety of applications and use cases, including smart image compression, segmentation, object detection, classification, and many more.

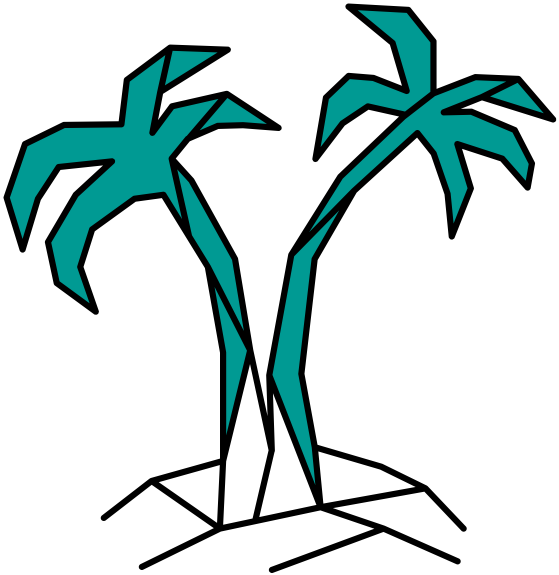
OASIS EGSE

TEST MOCKED-UP SATELLITE COMPONENTS FROM THE INITIAL STAGE OF THE MISSION DEVELOPMENT

Oasis is a single-board, CubeSat PC-104 compatible electrical ground support equipment that serves as an interface between the PC-running satellite systems simulators and the hardware engineering model.

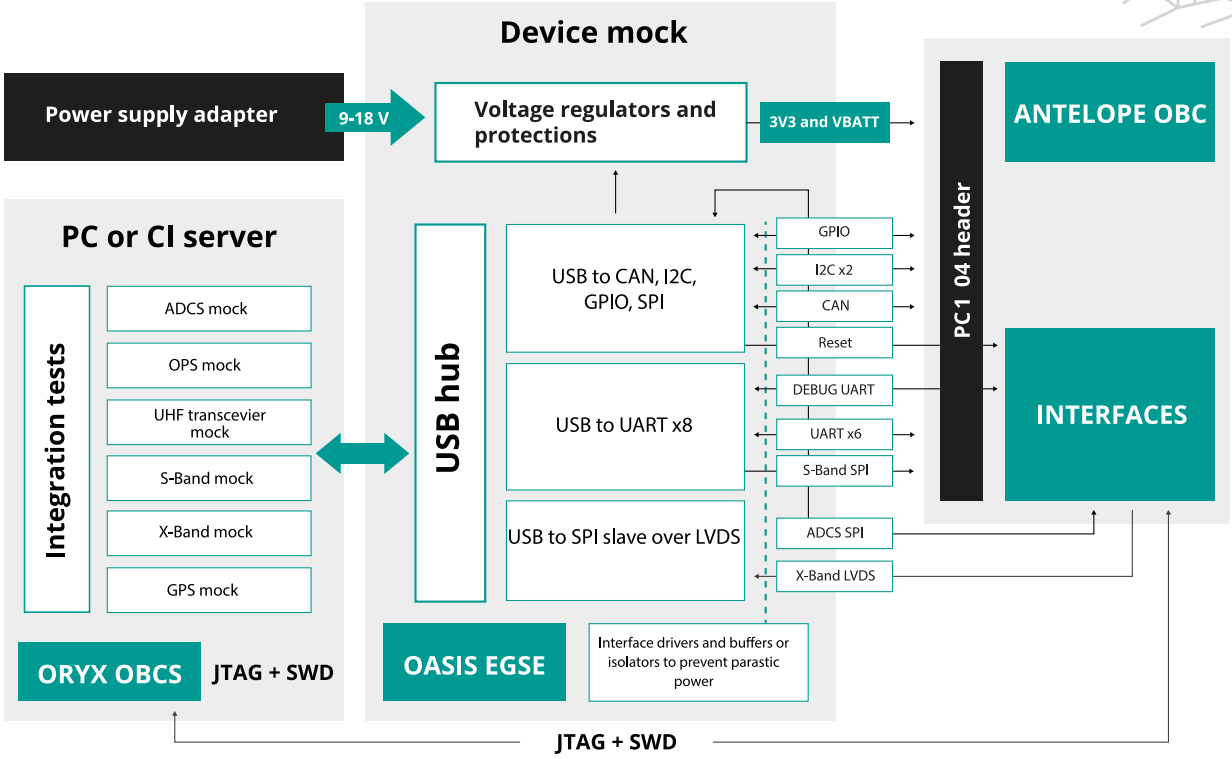
It enables the running of a complete flight version of on-board computer software on actual hardware before the subsystems are physically present.

Safety is crucial while developing space missions. Thanks to Oasis, it is possible to integrate and validate the work of satellite subsystems before launch and guarantee their smooth operation in orbit. Testing a mocked-up satellite and continuous integration at the initial stage of the mission development is crucial to ensure faster spacecraft integration – saving time and money.



OASIS SETUP:

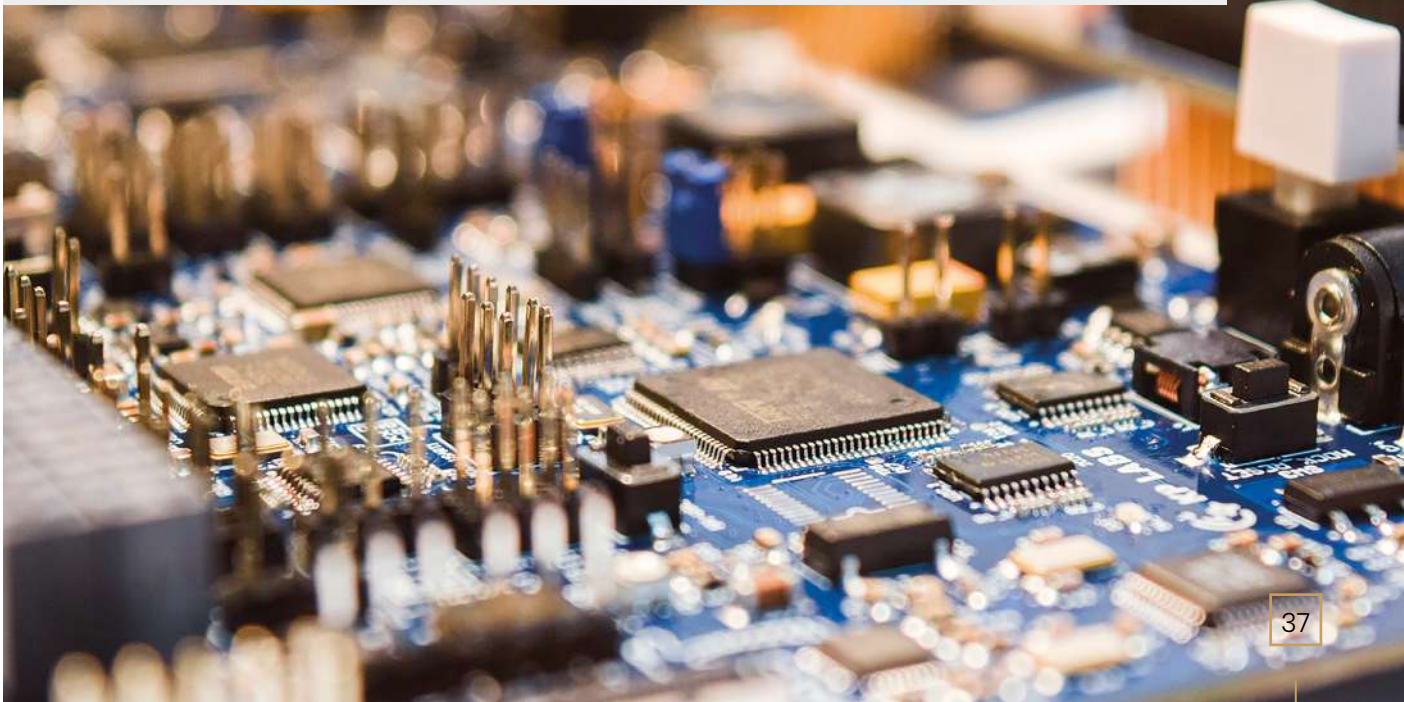
Oasis can be setup with other KP Labs' subsystems – Antelope OBC and Oryx OBCS.



TECHNICAL SPECIFICATION	
Supported Physical Interfaces	I2C, CAN, UART, RS422, SPI, GPIO, LVDS, SpaceWire
Available controlled supply lines for a tested board	CubeSat PC-104 compatible: 3.3V, 5V, VBAT
Development Platform	▪ Open-source, cross-platform tools: CMake, GCC, Python ▪ Modern technologies: C++17
Supported off-the-shelf subsystems	▪ Leopard DPU by KP Labs ▪ Antelope OBC by KP Labs ▪ Kryten M3 by AAC Clyde Space ▪ EPS (STARBUCK) + Batteries by AAC Clyde Space ▪ ADCS by AAC Clyde Space ▪ UHF Transceiver by CPUT ▪ UVTRX by ISIS ▪ IMTQ by ISIS ▪ ANT module by ISIS ▪ uCam III camera module by 4D Systems ▪ Q20 HD GPS by QinetiQ and all NMEA-based receivers ▪ EWC27-SRX X/S Transceiver by Syrlinks ▪ Easy to add support for any subsystem using supported physical interfaces ▪ Additional mock-ups might be delivered upon request or written by a final user

CASE STUDY

Coupled with the Antelope on-board computer, Oasis will be utilized to develop the PW-Sat3 mission. Oasis will support testing mocked-up satellite components from the very early stages of the mission development and Antelope will be responsible for satellite management and the mission safety. PW-Sat3 is an in-orbit demonstrator of a new cold gas propulsion and is planned to be launched at the beginning of 2023.



PROJECTS

HYPERSPECTRAL IMAGE SEGMENTATION USING DEEP NEURAL NETWORKS (HYPERNET)

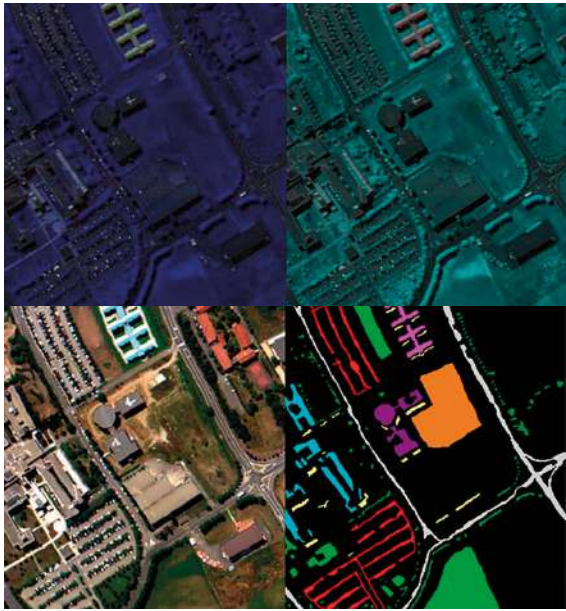
Project purpose: The objective of this project was to develop techniques to effectively analyse hyperspectral satellite imaging with the use of deep learning technology. The project involved introducing the approaches to pre-process, augment, visualize, and precisely segment hyperspectral imagery, with the ultimate objective of helping practitioners better utilize such data.

Project output: KP Labs developed a ready-to-use library of deep learning algorithms for hyperspectral band selection, feature extraction, multi- and hyperspectral image classification and segmentation, and much more. We introduced an end-to-end validation pipeline that allows us to thoroughly assess the existent and emerging image analysis algorithms in a quantitative, qualitative, and statistical manner.

Project implementation: KP Labs.

Project duration: 04.2018 - 04.2019.

Project commissioner: The European Space Agency.



ROBUST AND RESOURCE-FRUGAL DEEP NEURAL NETWORKS FOR HYPERSPECTRAL IMAGE SEGMENTATION (BEETLES)

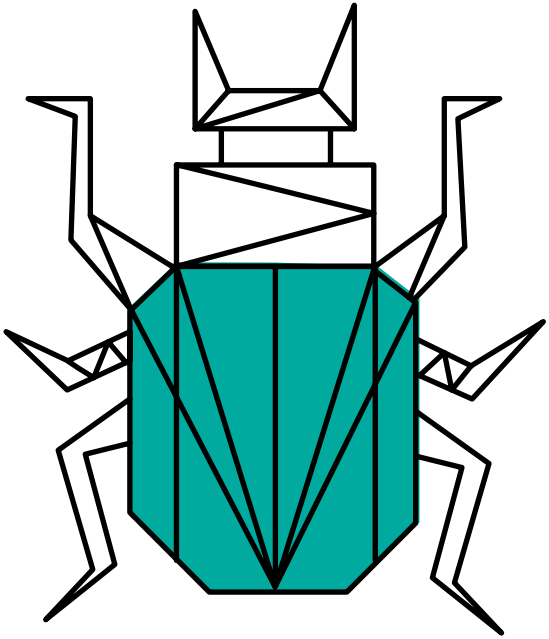
Project purpose: The objective of this project is to design, implement, and evaluate deep learning algorithms for effective hyperspectral image analysis that are ready to be deployed in target hardware environments, and are robust against noise, low-quality image data and other real-life acquisition settings.

Project output: KP Labs developed a battery of deep learning-powered algorithms that allow us to build robust and hardware-efficient hyperspectral image analysis pipelines (especially hyperspectral image segmentation and unmixing) that generalize well over unseen data. The algorithms are use case agnostic and may be easily exploited in emerging applications, hence significantly accelerating the adoption of on-board deep learning for Earth observation.

Project implementation: KP Labs.

Project duration: 04.2020 - 06.2021.

Project commissioner: The European Space Agency.



SUPER-RESOLUTION RECONSTRUCTION OF SATELLITE IMAGES USING DEEP CONVOLUTIONAL NEURAL NETWORKS (SUPERDEEP)

Project purpose: The objective of ishe project was to explore the capabilities of deep neural networks for super-resolution reconstruction of satellite images.

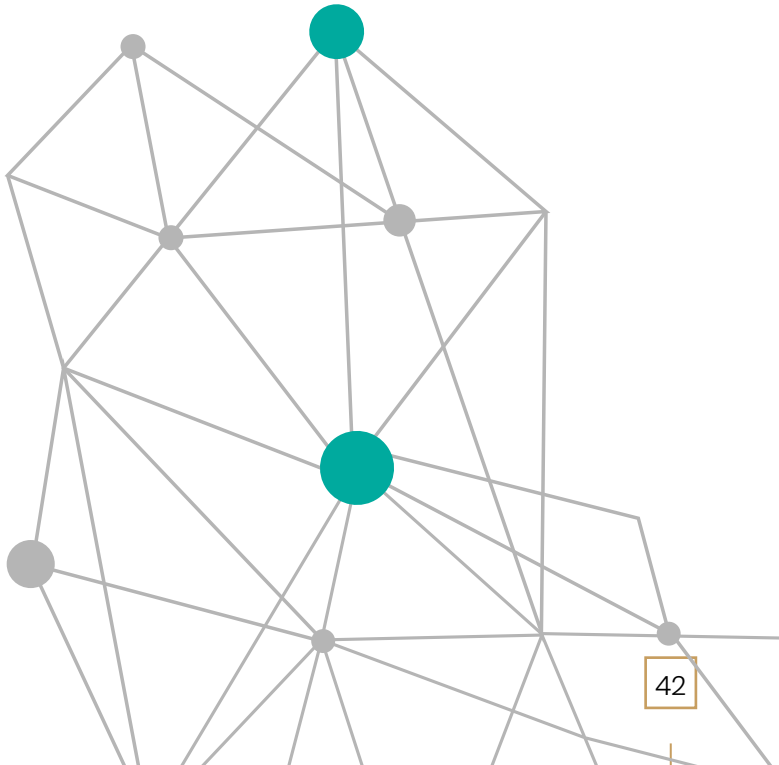
Project output: KP Labs developed a set of tools and algorithms underpinned with deep learning to enhance the spatial resolution of satellite images.

At first, the existing convolutional neural networks for single-image super-resolution were applied to enhance satellite images, and subsequently they were exploited for the reconstruction of a high-resolution image from multiple images showing the same area of Earth.

Project implementation: KP Labs.

Project duration: 12.2018 - 02.2020.

Project commissioner: The European Space Agency.



DEEP LEARNING-BASED MULTIPLE-IMAGE SUPER-RESOLUTION FOR SENTINEL-2 DATA (DEEPSENT)

Project purpose: The objective of this project was to enhance the capacities of super-resolution reconstruction applied to multispectral Sentinel-2 images, especially if multiple images of the same region, captured at a different time, are available. This is achieved by adapting existing deep neural networks, which were very recently proposed for multiple-image super-resolution, to process the data acquired within the Sentinel-2 mission.

Project output: KP Labs has developed a set of algorithms and tools for super-resolution reconstruction from multiple images presenting the same area. They are expected to enable the selection of the most valuable data from a group of input images, so that the spatial resolution can be improved at least by a factor of 3. Although the developed solution will be primarily aimed at enhancing the multispectral Sentinel-2 data, it will be adaptable to enable the processing of images acquired by different sensors as well.

Project implementation: KP Labs.

Project duration: 09.2020 - 08.2021.

Project commissioner: The European Space Agency.

AUTOMATIC OPTIMIZATION OF SENSORY CONFIGURATIONS THROUGH ASSESSING THEIR ROBUSTNESS AND FUSING MULTI-MODAL SENSORY DATA USING MACHINE LEARNING (CHAMELEON)

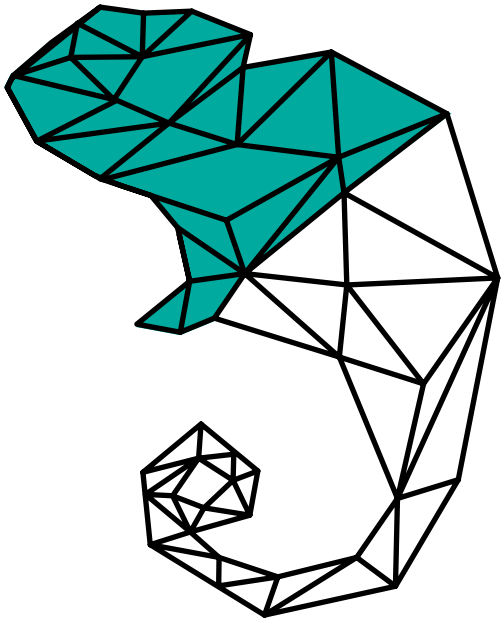
Project purpose: The objective of this project is to develop a system that will allow us to not only automate the process of selecting sensors for a vehicle in the context of detecting objects in its close vicinity, but also to understand the robustness of such sensory configurations and effectively fuse multi-modal sensory data. Chameleon is our step towards the autonomy of vehicles – ranging from cars straight through to satellites.

Project output: A system for automatic optimization and assessment of multi-modal sensory configurations.

Project implementation: KP Labs.

Project duration: 09.2020 - 10.2022.

Project commissioner: The European Regional Development Fund.



AUTOMATED METHOD FOR MEASURING EUTROPHICATION OF INLAND WATER USING REMOTE SENSING (AMMER)

Project purpose: The objective of this project was to develop an approach for non-invasive monitoring of inland reservoir water quality through estimating phytoplankton concentration from satellite image data.

Project output: KP Labs developed a hands-free system that automatically processes the available satellite image data and extracts quantifiable information concerning phytoplankton concentrations in inland water reservoirs. The estimations are visualized as concentration maps to ensure straight forward data anaylsis.

Project implementation: KP Labs.

Project duration: 01.2018-03.2019.

Project commissioner: The European Space Agency.

ESTIMATING MACROELEMENTS AND PH IN SOIL WITH THE USE OF ON-BOARD DEEP LEARNING AND HYPERSPECTRAL IMAGES (GENESIS)

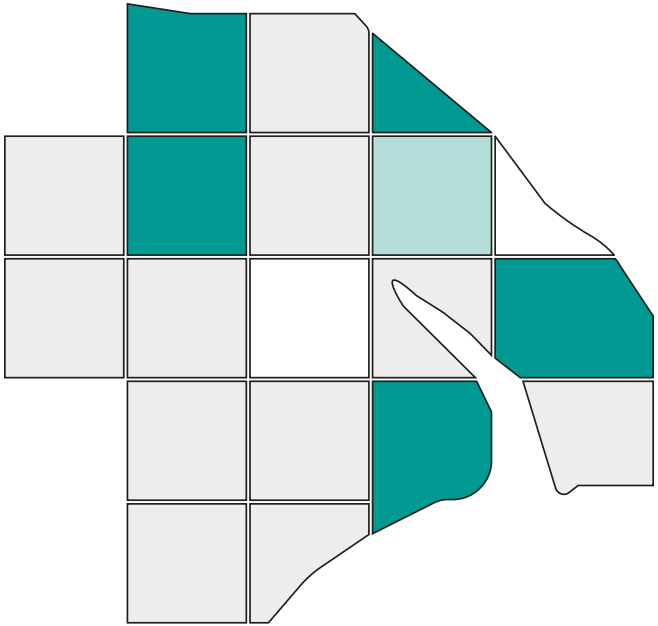
Project purpose: Farmers and field owners need information about the soil parameters to optimize the fertilization process. This may ultimately lead to selecting a better mix of fertilizers, and to reducing the overall amount of them. The current approach toward quantifying the soil parameters (e.g., macro-elements) is very user-dependent, laborious, time-consuming, vastly manual – we have to gather and mix soil samples in the field and pass them to the lab for further chemical analysis. Also, this process does not allow us to accurately capture the information concerning the macroelements, and the number of sampling points in the field is commonly limited.

Project output: KP Labs and QZ Solutions intend to use the hyperspectral data to remotely detect soil parameters (specifically: potassium – K2O, phosphate – P2O5, magnesium – Mg and pH) using machine learning techniques.

Project implementation: KP Labs + QZ Solutions.

Project duration: 06.2021 - 06.2022.

Project commissioner: The European Space Agency.



ON-BOARD AI COMPUTER VISION SOLUTION ARCHITECTURE FOR SPACE APPLICATIONS (RED KYTE)

Project purpose: The objective of this project was to develop a set of artificial intelligence-powered algorithms for a range of space applications and fine-tune them to exploit the target execution hardware as optimally as possible.

Project output: KP Lab's role is to support GSTS in the task of assessing the performance of Leopard, the on-board AI for Deep Learning inferencing for a range of space mission applications.

Project implementation: KP Labs + Global Spatial Technology Solutions.

Project duration: 07.2020 –12.2021.

Project commissioner: The Canadian Space Agency.

QUANTUM - SAFE REPROGRAMMABILITY OF CRITICAL AVIONICS FUNCTIONS (QUASAR)

Project purpose: The objective of this project is to implement a prototype of the long-term secure digital signature standard XMSS, currently securing in-flight FPGA updates, in a design that can meet the safety criteria posed by critical avionics functions. We will design a set of in-flight updatable critical avionics functions and implement them at the breadboard level using FPGA technology. Finally, we will demonstrate the update of the critical avionics functions using a different cryptographic or coding algorithm to ensure cryptographic agility.

Project implementation: KP Labs + Eidel.

Project duration: 09.2020 – 03.2022.

Project commissioner: The European Space Agency.

Project output: KP Labs is developing a set of in-flight updatable critical avionics functions and the implementation of the design at breadboard level using FPGA technology. Finally, the Project Team will test and demonstrate the critical avionics functions with a different cryptographic or coding algorithm to ensure cryptographic agility. The ESA plan to use this solution in future satellite communications to update data as soon as possible. KP Labs is the prime contractor and is responsible for all hardware. EIDEL is the sub-contractor and will develop cryptographic primitives and a long-term secure digital signature scheme.

Φ-SAT-2 – ESA CUBESAT MISSION

Project purpose: The objective of this project is to develop a new generation Artificial Intelligence (AI) satellite mission for the European Space Agency - ESA. The Φ-sat-2 mission will be used to demonstrate the AI enabling capability for new useful innovative EO techniques of relevance to EO user communities. The overall objective is to address innovative mission concepts, foster novel architectures or sensors that enable the realisation of user-driven science and/or applications by means of onboard processing. The latter will be based on state-of-the-art AI techniques and onboard AI-accelerator processors.

Project output: During its phase of the Project, KP Labs will develop and implement Cloud Detection app based on the Convolutional Neural Networks.

Project implementation: KP Labs.

Project duration: 06.2021–06.2023.

Project commissioner: The European Space Agency.

SATELLITE IMAGE SPATIAL RESOLUTION ENHANCEMENT (SISPARE)

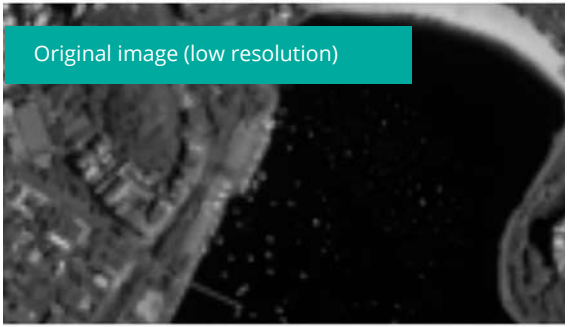
Project purpose: The objective of the SISPARE project was to implement the algorithms for super-resolution reconstruction and to validate them for satellite images.

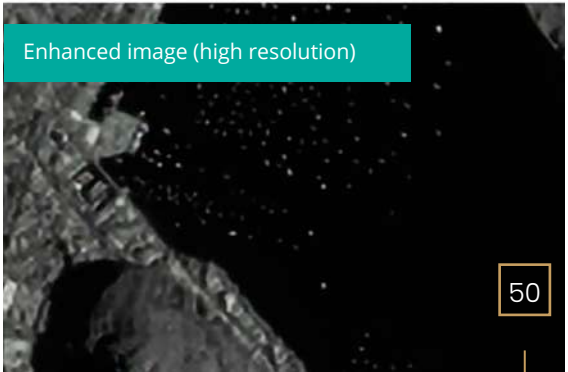
Project output: KP Labs developed a software suite with implemented algorithms for super-resolution reconstruction. This embraced both the techniques that operate from a single low-resolution image as well as those that rely on information fusion from multiple images presenting the same scene.

Project implementation: KP Labs.

Project duration: 01.2017 - 06.2018.

Project commissioner: The European Space Agency.





PUBLICATIONS

Several papers, in which we describe our approaches, have been published and presented in distinguished journals and conferences, including, among others - **IEEE Geoscience and Remote Sensing Letters**, **Neurocomputing, Soft Computing, Artificial Intelligence Review, IEEE International Geoscience** and **the Remote Sensing Symposium** as well as **the IEEE International Conference on Image Processing.**

For more details check out our website: ***www.kplabs.space/space-ai-publications***

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CONTACT US FOR MORE INFORMATION

Please get in touch to discuss the needs of your business and find out how we can facilitate your future.

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