KP LABS
Mission Complete

A NEW CHAPTER IN ON-BOARD DATA PROCESSING

End-to-End Hardware, Software, and Algorithm Solutions for Nano & Small Satellites

What's inside

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Who we are

Introduction

KP Labs is a New Space company, founded in 2016 in Poland, operating as a comprehensive provider, offering an integrated package of hardware, software, and algorithms developed inhouse for on-board data processing.

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 such as Earth Observation, Inorbit Operations 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.

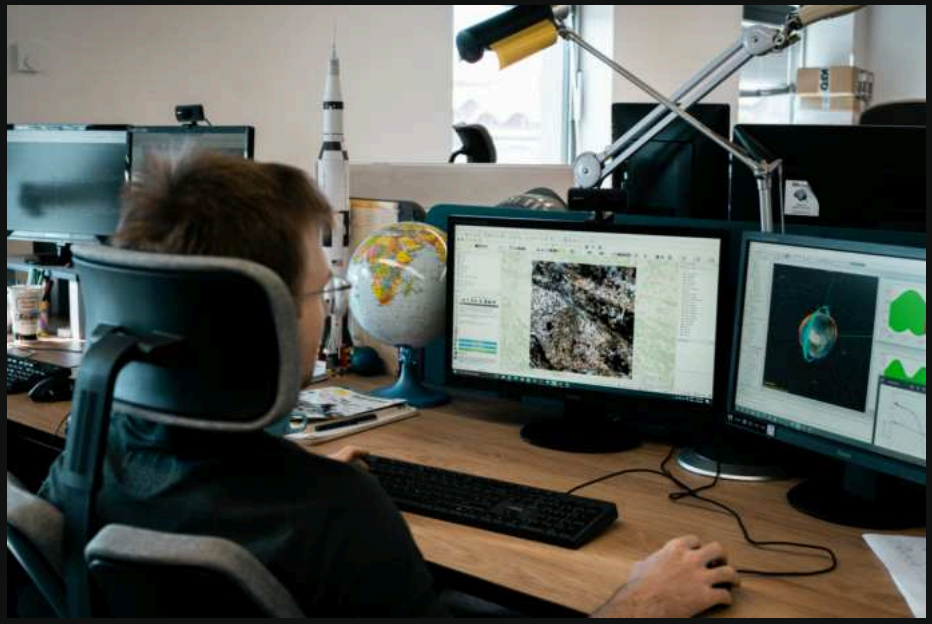
9+
missions

80+
team members

35+
projects


LEOPARD


LEOPARD
ANTELOPE



Competences

Multi-domain project expertise

On-Board Data Processing

- Designing pipelines for real-time, mission-critical data processing.
- Ensuring precision through in-orbit calibration of data systems.
- Leveraging hardware-accelerated algorithms for speed and accuracy.

Software Development

- Developing robust software for bare-metal, RTOS, and Linux systems.
- Focusing on reliable communication protocols and payload management.
- Writing software in C, C++, and Python, tailored to mission requirements.

AI and Data Analysis

- Developing AI-driven systems for satellite telemetry and Earth observation.
- Focusing on explainable AI to enhance transparency and reliability.
- Optimizing AI models for edge computing with tooling for pre-, post-, and in-orbit data processing.

FPGA Engineering

- Designing high-performance FPGA cores with integrated AI capabilities.
- Implementing advanced RTL coding using VHDL, Verilog, and SystemVerilog.
- Utilizing industry-standard tools like Xilinx Vivado for FPGA design.

Electronics Design

- Designing high-density PCBs and custom DPUs for space missions.
- Conducting component testing and thermal simulations to ensure reliability.
- Meeting space mission requirements with compliant and durable electronics.

Thermal and Mechanical Engineering

- Conducting thermal simulations using FloEFD and ESATAN-TMS to ensure system performance.
- Designing thermal solutions, including conduction cooling and heat pipes, for space electronics.
- Testing electronics for durability under thermal and mechanical stress.

System Engineering & Payload Analysis

- Managing mission architecture and ensuring technical objectives are met.
- Performing radiation analysis and optimizing mission performance.
- Adapting industry standards to ensure mission success and efficiency.

What we do

Technology Pillars

Data Processing Payload

Software, hardware and algorithms to perform operations on-board of the spacecraft.

Flight Software

Payload and mission specific software for data handling, processing, management and control.

Edge Computing

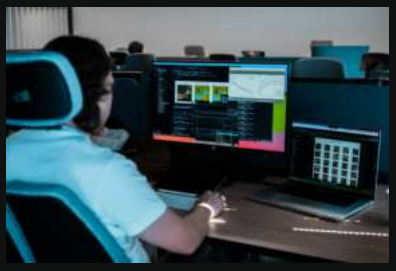
Full data handling pipeline for vision and signal data, for critical and non-critical applications.

Solutions

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 a 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.



To lower operations costs

Important for large number of small spacecraft, where operations costs become a bigger percentage of the overall costs.

To make spacecraft more autonomous

Important for spacecraft management, proximity maneuvering, planetary rover operations and deep space missions.

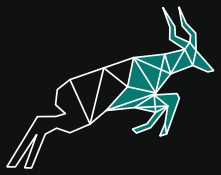
To incrase reaction speed to events

Important for missions where communication barrier becomes an issue or operator becomes a bottleneck.

Smart Mission Ecosystem

ORYX

Payload and Mission-Specific Flight Software

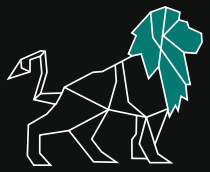


ANTELOPE

Enabling Edge Processing for CubeSats

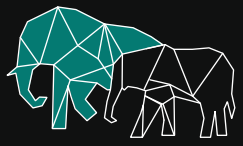
LEOPARD

Egde Processing for Micro and Mini Satellites



LION

Edge Capabilities for Satellites Utilizing ADHA



THE HERD

Earth Observation and Signal Processing Algorithms

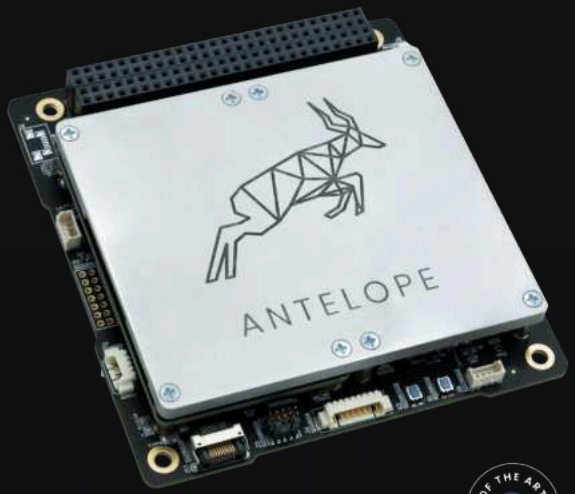
✓ - Flight Heritage

Hardware

Antelope DPU

Enabling Edge Processing for CubeSats.

Antelope is a Data Processing Unit (DPU) designed for CubeSats to run algorithms and perform data or signal processing on board. This DPU offers flexible capabilities for on-board processing when it comes to processing in space – real-time analysis of Earth Observation payloads or telemetry from other satellites' subsystems has never been so easy.



Processing Speed

Powered by Zynq UltraScale+ MPSoC, providing 160 GOPS, Antelope efficiently handles processing tasks directly on board.

Data-Intensive Applications

Built for managing substantial datasets, it allow satellites to operate with minimal ground dependency.

Reliable Operation

With advanced fault tolerance and radiation shielding, Antelope ensures consistent performance in harsh space environments.

Suitable for Lunar Missions

Lightweight and versatile, Antelope is suitable for various missions, including lunar rover applications.

Technical Sheet

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
Memory	•8 GB DDR4 with ECC •4 GB SLC NAND Flash •Optional SATA SSD
Interfaces	•CAN, I2C, GPIO, SPI, RS422/485, UART, GPS PPS, LVDS or GTH transceivers, USB 3.0, USB 2.0, Ethernet 1Gb, SATA
Specifications	•Supply Voltage: 6 to 14 V (VBAT) or 5V regulated •Operating Temperature: -40 to 85°C •FPGA bitstream (reconfigurable in orbit)
Software ecosystem	•64-bit Linux or bare-metal applications
Form-factor	•PC-104

Flight Heritage

- Demonstrates continuous operation of the Antelope system in Low Earth Orbit (LEO) for 8 weeks without failures or errors, showcasing its reliability and resilience.
- Focuses on validating the long-term performance of on-board machine learning algorithms for telemetry and anomaly detection, highlighting the robustness of the system during extended operations.
- Utilizes advanced machine learning techniques, including RandomForest and Telemanom, to refine satellite strategies based on telemetry and thermal data, ensuring optimal satellite management throughout the mission.

NCBiR

D-Orbit

Hardware

Leopard DPU

Egde Processing for Micro and Mini Satellites

Leopard is a cutting-edge Data Processing Unit (DPU) designed for Micro and Mini Satellites in a compact PC-104 form factor, offering powerful on-board data analysis using Artificial Intelligence.

Now, instead of sending huge, unprocessed sets of data to ground stations, focus on the most important and valuable insights.

High-Performance Processing

Up to 3 Tera Operations Per Second (TOPS) for fast and efficient data processing.

AI-Driven

Utilizes deep learning algorithms directly in space, reducing the need and costs of data transfers to Earth.

Compact Design

CubeSat-compatible (<1U) with the ability to integrate seamlessly with various Micro and Mini satellite platforms.

Applications

Ideal for Earth Observation tasks such as image segmentation and object detection, as well as Space Situation Awareness (SSA) missions

Processing cores	Zynq UltraScale+ ZU6EG | ZU9EG | ZU15EG • 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 with ECC • 4-16 GiB SLC flash-based file system storage (EDAC) • Up to 2x256 GiB SLC flash-based data storage
Interfaces	• CAN, LVDS, SPI, RS422/485, UART, GTY and GTH transceivers • Additional customisable interfaces upon request: SpaceWire, Ethernet
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
Redundancy	• Possibility to introduce additional redundancy to each version
Form factor	• PC-104
Software ecosystem	• 64-bit Linux • Deep Learning Accelerator fed with Caffe or TensorFlow models

LeopardISS

- Part of the Polish Mission to the International Space Station (ISS) in 2025.
- Allow to test and refine algorithms in actual space conditions resulting in flight heritage
- At the first phase, the Poznan University of Technology, a project partner, will focus on 3D image mapping to be applied to planetary rovers in the future.

European Space Agency

Poznan University of Technology

Intuition-1

- A 6U hyperspectral mission equipped with an optical payload and the Leopard Data Processing Unit (DPU) for onboard data processing, provided by KP Labs.
- Demonstrates AI-driven hyperspectral image processing directly in orbit, reducing data transmission requirements through algorithms like cloud detection and data reduction.
- Focuses on real-time analysis of environmental conditions such as vegetation health and soil composition.

The National Centre for Research and Development

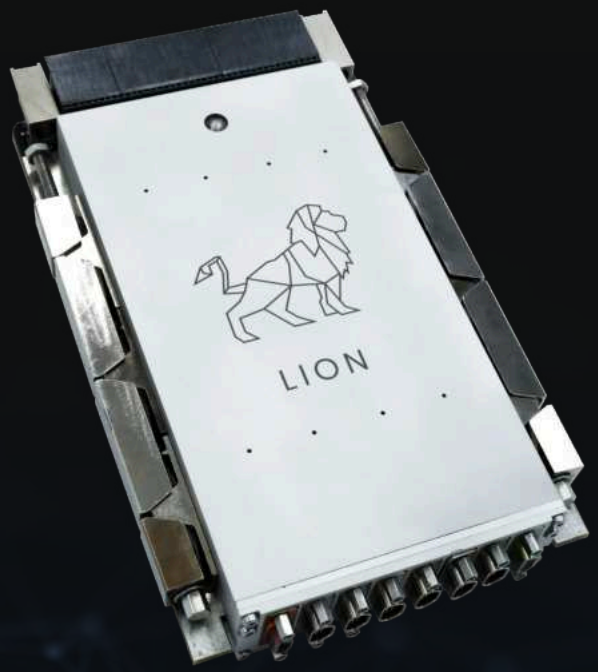
AAC Clyde Space

Hardware

Lion DPU

Edge Processing for Satellites Utilizing ADHA

Lion is a backplane-based DPU in 3U ADHA designated to satellites up to 600 kg. Designed for the ESA Mission Class III and IV, it utilizes Kintex Ultrascale FPGA to deliver enhanced resilience and processing power for critical applications. The standardized design enables faster, cost-effective mission development and adaptability across diverse satellite programs. Available in 2027.



*Advanced Data Handling Architecture (ADHA) is a pioneering ESA initiative that simplifies satellite data handling with standardized, interoperable modules. By enabling seamless integration across suppliers and reusability across missions, ADHA reduces development time and costs while enhancing flexibility and scalability. ADHA is poised to drive a new era of high-performance, adaptable satellite systems for EO missions.

Recurrence

Core modules can be reused in various missions, with different performance/ interface requirements

Improved quality

By reusing the same modules, quality of the end-to-end solution can be increased over time due to growing heritage

Scalability

Increased performance can be supported by the data handling system, simply by adding additional modules

Flexibility

New functions and interfaces can be integrated without requiring the redesign of core modules

Processing Cores	Kintex Ultrascale KU060
Supervising Circuit	Gaisler GR716B
Memory	•16 GiB DDR4 with ECC •1Gb bitstream storage
Backplane Interfaces	•Can work as ADHA Extended Peripheral module or as ADHA Peripheral Module •4x SpaceWire + 4x SpaceFiber on ADHA P4 connector •12x SpaceFiber on ADHA P6 connector •2x CAN on ADHA P1 connector
Backplane Interfaces	Mission specific. Baseline configuration: 4x SpaceWire + 8x SpaceFiber
Specifications	•Supply voltage 12V •Power Consumption up to 30W - depending on workload and specified processing speed
Form-factor	ADHA 3U module


LEOPARD
Hogetex

Compare products

	Antelope	Leopard	Lion
Size	13.24 x 95.9 x 90.1 mm	Non-redundant: 90.17 x 95.86 x 50.00 mm Redundant: 90.17 x 95.86 x 78.00 mm	-
Form factor	PC-104	PC-104	ADHA 3U module
Mass	Around 130-150 g	Non-redundant: <900 g Redundant: <1200 g	-
Processing cores	Zynq UltraScale+ MPSoC ZU3/4/5EG: • Dual ARM Cortex-A53 CPU up to 1.5 GHz • Dual ARM Cortex-R5 in lock-step	Zynq UltraScale+ ZU9/15EG: • Quad ARM Cortex-A53 CPU up to 1.5 GHz • Dual ARM Cortex-R5 in lock-step	Kintex Ultrascale KU060
Interfaces	CAN, I2C, GPIO, SPI, RS422/485, UART, LVDS, GTY and GTH transceivers	CAN, LVDS, SPI, RS422/485, UART, GTY and GTH transceivers	• Mission specific. Baseline configuration: 4x SpaceWire +8x SpaceFiber
Memory	8-32 GiB DDR4 with ECC	• 4-16 GiB DDR4 with ECC • 4-16 GiB SLC flash-based file system storage (EDAC) • Up to 2x256 GiB SLC flash-based data storage	• 16GiB DDR4 with ECC • 1Gb bitstream storage

Try our products remotely

SMART MISSION LAB

by KP Labs

Smart Mission Lab (SML) is a platform providing remote access to KP Labs' high-performance Data Processing Units. It allows engineers to develop and validate AI models, onboard software, and data processing algorithms without purchasing unknown hardware. Thanks to the platform, users can make informed decisions before purchase while reducing development time, costs, and risks.

Remote Access to DPUs

Develop and validate FPGA-based solutions, Linux applications, and machine learning algorithms

Cost-Effective Development

Experiment with different hardware configurations to find the right one for your mission

Fast and Efficient

Reduce testing time from months to minutes, speeding up mission development.

The power of SML lies in its ability to transform the mission development process. By enabling on-demand testing through secure VPN connections, customers can instantly configure and optimize hardware setups, significantly reducing time to market and costs. This streamlined approach enhances mission readiness and offers unparalleled flexibility, making it an indispensable tool for any space mission.

Choose

Run your experiment on a real DPU located in our server room

Book

Reserve a DPU via our secure online platform

Test

Deploy, monitor, and optimize your model on real hardware

Software

Oryx

Payload and Mission-Specific Flight Software.

Oryx is a software tool to develop payload and mission-specific flight software. Its modular architecture, built from flexible building blocks, supports rapid software development. With a vast library of components – such as logging, scheduling, testing, and communication – Oryx simplifies the development process, ensuring smooth and efficient operations.

Custom Payload Management

Specializes in real-time satellite communication and data handling, ensuring seamless operation between space systems and ground stations.

Fault Detection and Recovery

Incorporates robust systems for monitoring, detecting anomalies, and initiating automatic recovery to maintain mission continuity.

Use Cases

GLOWS-IMAP

- Developed by CBK PAN, GLOWS is one of ten instruments on NASA's IMAP mission, studying the heliosphere and solar wind interactions with interstellar hydrogen.
- KP Labs developed onboard software for GLOWS to operate the Lyman-alpha photometer, a sensor designed to measure interactions between solar wind and interstellar hydrogen.
- Implementation includes data collection, archiving, preliminary processing algorithms, and histogram generation to ensure efficient transmission back to Earth.

Governmental funds

Space Research Centre of the Polish Academy of Sciences (CBK PAN)

PW-Sat2

- PW-Sat2, developed by students from Warsaw University of Technology, aims to test a de-orbit sail to reduce space debris, ensuring quicker disposal of non-operational satellites.
- Onboard computer software built thanks to Oryx helped to stabilize PW-Sat2's power consumption after sail deployment and monitor its telemetry and telecommand.
- The updated Oryx software was successfully uploaded to PW-Sat2, enabling efficient "Deep Sleep" operation and extending the satellite's functionality until its planned de-orbit.

Ministry of Science and Higher Education

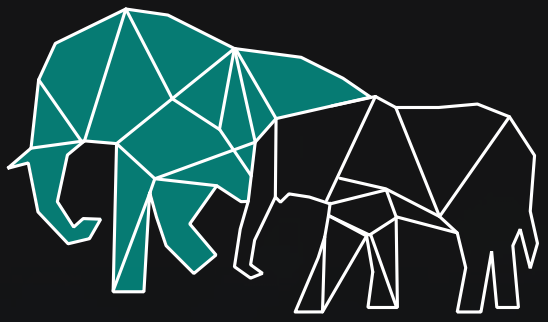
Warsaw University of Technology

Algorithms

The Herd

Earth Observation and Signal Processing Algorithms

The Herd is a set of AI-powered algorithms designed to facilitate various data analyses. It comprises three elements – data pre-processing, data analysis algorithms and post-processing techniques.



Earth Observation and Remote Sensing

Provides efficient processing for multi- and hyperspectral data, improving satellite imagery with tasks like semantic segmentation, object detection, classification, and super-resolution reconstruction.

Satellite Telemetry Analysis

Enables real-time monitoring and analysis of satellite telemetry data, ensuring more efficient signal processing and anomaly detection.

Onboarding AI Models

Facilitates the deployment of AI models directly on satellite hardware, with robust verification processes ensuring reliability in performing tasks like image analysis and object detection during the mission.

Step 1:
Design and implementation of AI models

Each space mission is unique. AI models are designed using cutting-edge techniques to push the limits of current capabilities in satellite data processing. Solutions are crafted specifically to meet the needs of individual missions, ensuring optimal performance.

Step 2:
Onboarding AI models to edge devices

Enables real-time monitoring and analysis of satellite telemetry data, ensuring more efficient signal processing and anomaly detection. Algorithms are hardware-optimized and can be remotely updated during the satellite's mission.

Step 3:
Verification and validation of AI models

Reliability is essential. Quantitative, qualitative, and statistical verification and validation processes are used to ensure models perform effectively in harsh space environments, such as sensor noise and corruption, providing robust, reliable performance throughout the mission.

Genesis

- Aims to estimate soil parameters from hyperspectral imagery onboard the Intuition-1 satellite
- Utilizes machine learning for real-time analysis of soil health, including cloud segmentation and soil detection
- Developed using a data-level digital twin and explainable AI techniques for validation.

European Space Agency

QZ Solutions

Φsat-2

- A CubeSat mission by ESA showcasing onboard AI data processing for Earth observation.
- Focuses on filtering out cloud-covered images to optimize data transmission and storage.
- Reduces bandwidth usage by ensuring only cloud-free images are sent to Earth.

European Space Agency

Open Cosmos

Missions

Hardware

Intuition-1

Purpose:

Intuition-1 is a 6U KP Labs' hyperspectral satellite launched in November 2023, aiming to demonstrate onboard processing of hyperspectral data to minimize data transmission needs. KP Labs developed key payloads, including the 192-band hyperspectral sensor (HSI) and the Leopard Data Processing Unit (DPU). The satellite processes complex image data in orbit, enabling near-instant analysis of environmental conditions like vegetation health and soil composition. The mission is ongoing, continuing to validate advanced onboard AI capabilities.

Mission Results to Date:

- Successfully implemented AI-driven hyperspectral image processing directly on the satellite, drastically reducing the volume of data transmitted back to Earth.
- Demonstrated stable real-time image segmentation and object detection, operating at a processing speed of 3 Tera Operations Per Second (TOPS) on the Leopard DPU.
- Achieved effective cloud detection, filtering cloud-covered images with high accuracy, thereby optimizing bandwidth by sending only cloud-free, relevant data.
- Validated the reliability of on-board AI technologies, with X days of uninterrupted performance, proving the robustness of the system under real space conditions.

2023 – 2027

NCBR

Uatumã Biological Reserve, Brazil

CAPTURED AND PROCESSED IN ORBIT BY INTUITION-1

Hardware

LeopardISS

Purpose:

LeopardISS is an experiment featuring KP Labs' Leopard Data Processing Unit (DPU), set to launch to the International Space Station (ISS) in early 2025 as part of the Polish Mission, in collaboration with the Poznan University of Technology (PUT). This project provides a unique platform for testing AI algorithms directly in space, allowing researchers and companies to gain valuable flight heritage for their technologies.

It aims to advance Edge Computing technology and Space-Based Data Centers, promoting autonomous data processing in orbit.

Mission Phases:

- Phase 1: PUT will utilize the Leopard DPU to perform complex data processing tasks, focusing on 3D image mapping. These tools will have potential applications for future planetary exploration, including use on lunar rovers.
- Phase 2: Scientists, institutions, and companies worldwide will have the opportunity to run their AI algorithms on the Leopard DPU, gaining critical flight heritage by validating their technologies' effectiveness in real space conditions.

2024 – 2025 | European Space Agency | Poznan University of Technology

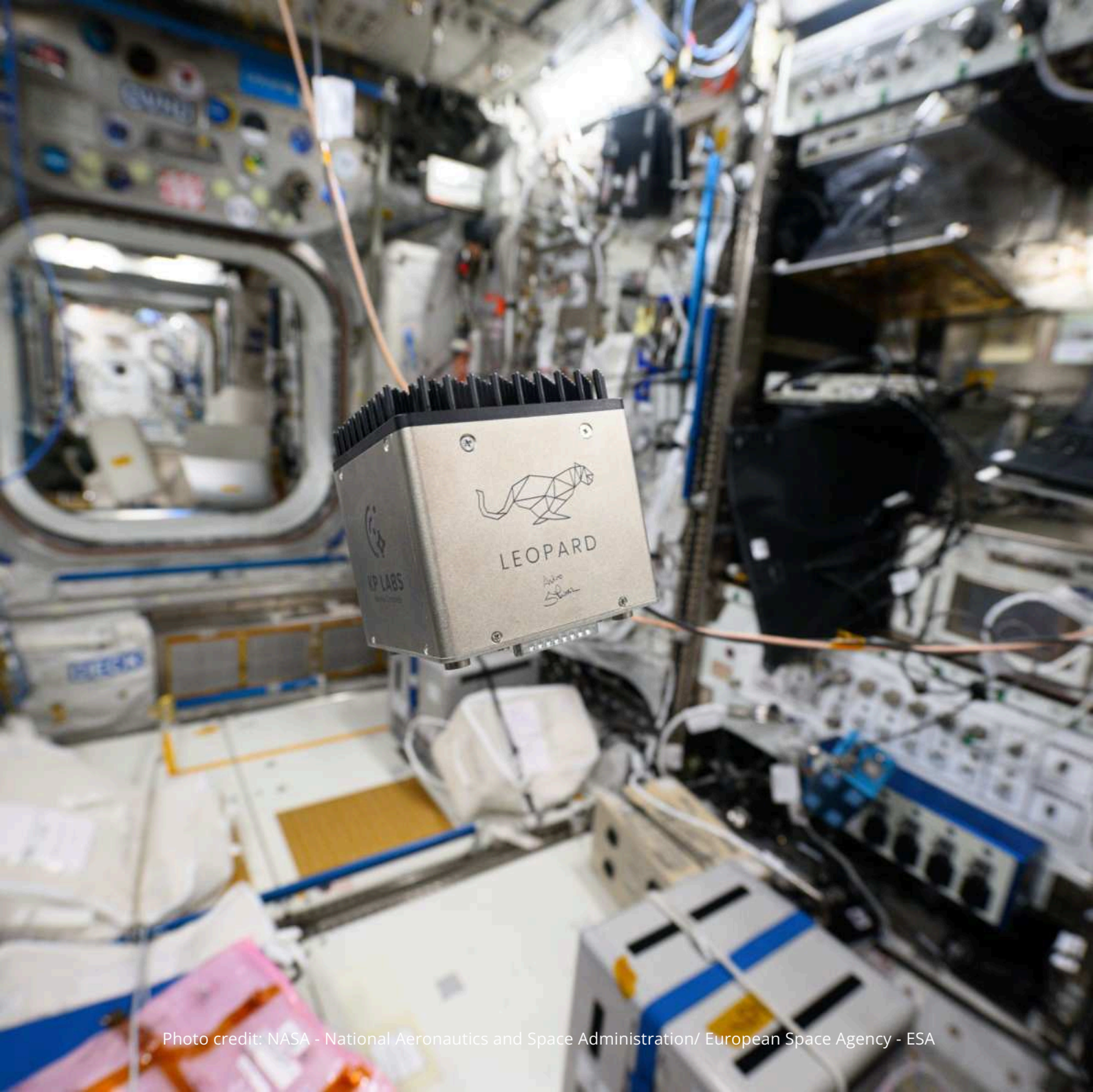


Photo credit: NASA - National Aeronautics and Space Administration/ European Space Agency - ESA

Hardware

OPS-SAT VOLT (Versatile Optical Laboratory for Telecommunications)

Purpose:

OPS-SAT VOLT is a mission led by Craft Prospect Limited (CPL) in partnership with ESA, focused on demonstrating advanced optical and quantum communication technologies in space. The mission, as part of ESA's ScyLight programme, tests Quantum Key Distribution and AI-driven software for autonomous satellite operations in a Low Earth Orbit environment, supporting ESA's Telecom Directorate in evaluating novel techniques for secure and resilient space communications. The planned launch year for the mission is 2026.

KP Labs' Contribution:

- KP Labs delivers the Leopard Data Processing Unit (DPU) into OPS-SAT, offering a high-performance onboard computing solution.
- Leopard DPU is a platform for real-time validation of AI algorithms, allowing researchers to test performance in the unique conditions of space.
- It enables external users to conduct in-orbit testing without deploying dedicated satellite hardware.

2023 – 2025 | European Space Agency | Craft Prospect

Hardware

Φsat-2

Purpose:

Φsat-2 is a 6U satellite developed by ESA with Open Cosmos as the prime contractor and launched in August 2024. The mission demonstrates the benefits of using AI paired with a multispectral instrument that captures images across seven bands, from visible to near-infrared, for Earth observation. These AI capabilities enable real-time data processing, optimizing both the quality and quantity of data sent back to Earth.

KP Labs' Role:

- Developed a CNN-based algorithm to automatically detect and discard cloud-covered images, ensuring only clear, usable images are downlinked to Earth.
- Reduced data transmission requirements by filtering out irrelevant, cloud-obscured data, enhancing data efficiency.
- Applied 8-bit quantization to decrease model size and inference time, making the algorithm compatible with CubeSat hardware constraints.

2021 – 2024 | European Space Agency | Open Cosmos

Software

IMAP-GLOWS

Purpose:

GLOWS (GLObal Solar Wind Structure) is one of 10 instruments on board the NASA IMAP (The Interstellar Mapping and Acceleration Probe) mission to be launched in 2025. The satellite will be positioned at the first Lagrange Point (L1), approximately 1.5 million kilometres from Earth. IMAP aims to investigate the structure of the solar wind and its interactions with interstellar hydrogen, contributing to improved space weather prediction models and a better understanding of heliospheric dynamics.

KP Labs' Role:

- Developed onboard software for GLOWS to operate the Lyman-alpha photometer, a sensor designed to measure interactions between solar wind and interstellar hydrogen.
- Implemented algorithms for pulse shaping, histogram generation, and data preparation to ensure efficient transmission back to Earth.
- Ensured software resilience in challenging space conditions using RTEMS, meeting high reliability standards for deep-space operations.
- Leveraged open-source tools, including YAFFS and RTEMS, with plans to open-source parts of the software for the scientific community.

2021 – 2024

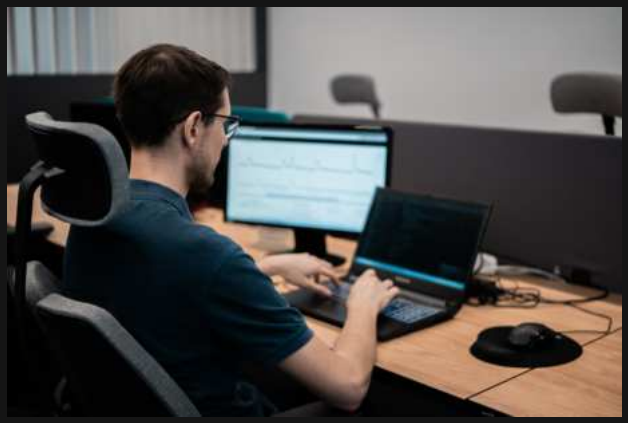
Governmental funds

Space Research Centre of the Polish Academy of Sciences (CBK PAN)

Projects

Software

ORCHIDE (Orchestration of Reliable Computing on Heterogeneous Infrastructures at the Edge)



Problem:

Satellites rely on communication with Earth, which limits flexibility, introduces delays, and consumes bandwidth. In the face of current conditions, the satellites require real-time data processing and autonomous decision-making. Integrating AI across diverse onboard systems also presents challenges for reliable computing in space.

Solutions:

This project creates an edge computing ecosystem for autonomous data processing with AI and machine learning across satellite systems.

KP Labs' objectives:

- A software framework for in-orbit reprogramming, ensuring adaptability.
- Deployment of machine learning models directly on satellites for autonomous data handling.
- Real-time decision-making for anomaly detection, monitoring, and resource optimization.
- Decentralized computing to support long missions and enhance autonomy.
- Enhanced resilience and autonomy through reliable computing across diverse onboard systems.

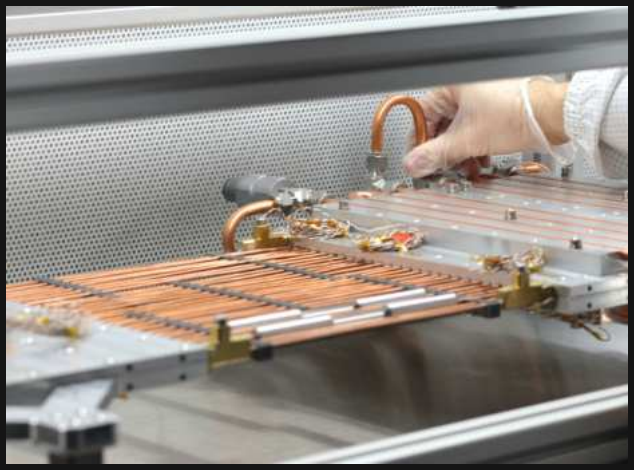
2023 – 2026

Horizon Europe

Thales Alenia Space

Hardware

MITIGATE (Micro-G Disturbance Characterization)



Problem:

Micro-vibrations from Pulsating Heat Pipes (PHPs) in microgravity environments can disrupt the performance of sensitive spacecraft instruments, while effective thermal management is essential for maintaining stable satellite operation, especially for high-power electronics like Data Processing Units (DPUs).

KP Labs' objectives:

- Manufacturing and refining PHP prototypes at KP Labs to deliver superior thermal performance.
- Reducing micro-vibrations affecting sensitive instruments through optimized PHP design.
- Progressing PHP miniaturization for integration into high-power components like DPUs, aiming to set a new standard in thermal management.

Solutions:

The MITIGATE project is advancing PHP technology to address these issues. PHPs are passive devices that transfer heat from hot components to colder areas, such as external radiators, using a fluid-driven evaporation and condensation process.

2023 – 2025 | European Space Agency | Wroclaw University of Technology

Software

QUASAR (1&2) -Safe Reprogrammability of Critical Avionics Functions

Problem:

Satellites operating in space are increasingly vulnerable to cybersecurity threats and the damaging effects of high radiation. Traditional FPGA systems lack the capability to adapt in real-time, exposing satellites to potential security risks and functional degradation over time.

Solutions:

QUASAR project addresses these challenges by enabling secure in-flight reprogramming of FPGA functions, reinforced with post-quantum secure signatures for cybersecurity resilience.

KP Labs' objectives:

- Allows flexible, in-flight updates to FPGA functions, adapting to new threats and mission needs.
- Utilizes Triple Modular Redundancy (TMR) and EDAC for reliable performance and data integrity.
- Ensures robustness in high-radiation conditions, supporting long-term missions.
- Validated through extensive breadboard testing, establishing a new standard for secure, adaptable satellite systems.

2020 – 2024/2025

European Space Agency

EIDEL

Space-Based Data Centers

Problem:

As satellite data volumes grow, transferring all information back to Earth for processing is increasingly inefficient, leading to delays and high bandwidth costs.

Solutions:

The Space-Based Data Centers project developed autonomous, in-orbit data processing systems to streamline data handling.

2022 – 2023

European Space Agency

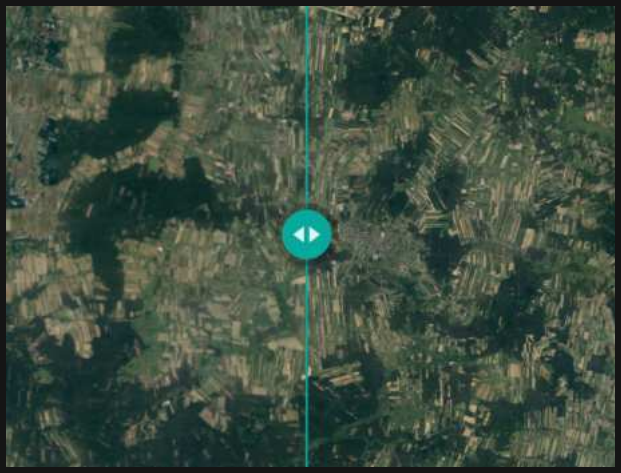
IBM Research Europe – Zurich

KP Labs' objectives:

- Designed distributed architectures for large-scale data storage and processing directly in space.
- Validated machine learning models for space-based systems.
- Explored innovative uses in space exploration, such as scout-mothership and lander-rover configurations.
- Proposed expanding data centers by shifting computation closer to data sources.
- Enabled real-time processing of Earth observation and research data, reducing latency and bandwidth needs.

Software

PIGEON (HyPerspectral ImaGE super-resolutiON)



Problem:

Hyperspectral satellite imagery often lacks the spatial resolution needed for detailed environmental assessments, precision agriculture, and air quality monitoring. The challenge was to improve image clarity without losing essential spectral information.

Solutions:

The PIGEON project developed advanced super-resolution algorithms to enhance hyperspectral imagery.

Key features includes:

- Deep learning-based algorithms that boost spatial resolution while preserving spectral integrity.
- Improved visualization of fine details in hyperspectral images, allowing for clearer interpretation.
- Enhanced monitoring capabilities for air pollution, crop health, and natural resource management.
- Real-world validation through case studies in precision farming and environmental protection.
- Strengthened global monitoring by providing sharper insights from satellite data.

2022-2023 | European Space Agency | GEO-K

Software

GENESIS (1&2)

Problem:

Traditional soil monitoring is labor and cost-intensive, slow, and limited in scope, preventing farmers from accessing large-scale, real-time soil health data for effective crop management.

Solutions:

The GENESIS project uses machine learning and hyperspectral imaging on the Intuition-1 satellite to transform soil monitoring.

Key features includes:

- Created algorithms for real-time soil composition analysis from space, tracking elements like pH and nutrients
- Enabled large-scale, continuous monitoring, eliminating the need for ground sampling.
- Provided farmers with accurate, timely data for informed decisions on fertilizer and crop management.
- Streamlined precision farming by reducing manual interventions.
- Supported sustainable practices, enhancing yields and reducing environmental impact. has context menu.

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ESA Anomaly Detection Benchmark

Problem:

Inconsistent methods across the space industry for detecting and classifying satellite telemetry anomalies create challenges in developing and evaluating anomaly detection algorithms.

Solutions:

The ESA Anomaly Detection Benchmark provides a standardized dataset and unified framework to streamline anomaly detection. ESA released the first large-scale satellite telemetry anomaly dataset, with anomalies curated and annotated, featuring 31 GB of data from 3 missions.

2022-2023

European Space Agency

Airbus Defence and Space Germany

Key aspects includes:

- Created the first comprehensive dataset of real and synthetic telemetry anomalies.
- Built a reproducible evaluation pipeline, offering tailored metrics for operational needs.
- Introduced specialized algorithms and metrics for satellite telemetry anomaly detection.
- Enabled effective comparison and assessment of detection algorithms for engineers and researchers.
- Fostered industry collaboration by making the dataset publicly accessible.

OPS-SAT - Anomaly Detection

Problem:

In satellite operations, detecting anomalies in telemetry data in real-time is essential to ensure optimal performance and reduce dependency on ground-based interventions. Traditional systems are limited by latency and may not catch irregularities promptly.

Solutions:

Leveraging OPS-SAT—a flying laboratory by ESA designed to test and validate advanced satellite control techniques—the project implemented an onboard anomaly detection system with machine learning capabilities.

Key features includes:

- Developed an anomaly detection model using a machine learning pipeline that integrates handcrafted features with a RandomForest classifier, achieving 95.7% accuracy.
- Enabled autonomous satellite monitoring for deviations in telemetry, reducing the need for ground control interventions.
- Introduced fast inference capabilities, allowing real-time anomaly detection and immediate response.
- Demonstrated the feasibility and efficiency of onboard anomaly detection for enhanced mission autonomy.

2022 – 2022

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Scientific Research

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