# Enabling AI applications for Space Operations through a multi-missions DevOps Platform


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| *Pablo Beltrami* | RHEA Group |
| *Nieves Salor Moral* | RHEA Group |
| *Mads Hedegaard* | Airbus Defence and Space |
| *Jonas Hansen* | Airbus Defence and Space |
| *Nicola Policella* | Solenix |
| *Rui Santos* | ESA/ESOC |
| *Evridiki Ntagiou* | ESA/ESOC |
| *Francois Trifin* | ESA/ESOC |



Artificial Intelligence/Machine Learning (AI/ML) technologies have reached a state of maturity where they can help to substantially increase the level of automation in ground segment operations. ESA/ESOC has established a multi-projects roadmap for the adoption of AI by mission operations teams, which includes establishing and making available the required infrastructure, including processes and reference information.

In this context, the AI4OPS project aims at the definition and implementation of a platform for developing and supporting AI-based applications targeting the automation of space operations and demonstrating it with a set of novel proof of Concept AI Applications.

The developed platform enables its users to build, train, and deploy ML models of AI applications, supporting mission operations. Additionally, the platform can also be used for general data engineering and software development purposes, allowing easy interface to data from ongoing or past space missions. The goal is the provision of a "platform as a service" (PaaS) available to internal ESOC projects and to data and software developments driven by ESA affiliates, contractors or other 3rd party collaborators.

Companies, institutions and researchers may be hindered in the use of AI methods and applications due to the data access and lacking infrastructure, which typically cannot be met due to budget and knowledge limits. The common platform aims to reduce this gap with the mentioned PaaS approach, so users can focus on the logic of the AI models and not on setup, deployment and infrastructure topics, in addition to ease the process of accessing data.

However, to increase the use and adoption of AI in operations, having a platform is not enough. Hence, the AI4OPS activity also defined guidelines focused on the practical use of AI for ESA missions by:

- Defining an AI strategy for deploying Artificial Intelligence applications for space operations (at ESOC and elsewhere) and to get an overview of the challenges and solutions, when utilizing AI and ML.
- Defining an AI Information architecture for a multi-user platform, which allows for the development and deployment of applications to support space operations.
- Establishing Operational data acquisition guidelines addressing the best way to collect any required information and defining what information needs to be collect, why it needs to be collected, where the information is and how it must be provided.

- Establishing an Operational Data Access Governance including initial processes and security aspects, analysis of data types, actors, and types of access in the context of AI/ML projects.

For Mission Operations personnel to adopt, trust and start using the developed AI platform, proofs of concepts and demonstrators were required. So, three AI Applications were implemented after the development of the core platform, guidelines and strategies to be followed by projects. The Applications, covering use cases identified in mission operations at ESOC, allowed the demonstration and validation of the platform capabilities, using real mission data available at ESOC.

**Platform design**

The platform design uses a specific DevOps chain, known as MLOps, which focuses on automating much of the lifecycle of AI applications and ML models, allowing the deployment of the applications, the continuous integration (CI), continuous delivery (CD), and continuous training (CT). ESAs AI roadmap[1] foresees a level 2 MLOps[2] for the platform at ESOC which represents near full automation of the CI/CD/CT, including gathering of model metadata and tracking models/pipelines based on versioning. Although the initial AI4OPS implementation targeted Level 1 (as it focused on the initially automated CI/CD system), the architecture is designed to be open and cloud ready to support Level 2 in the next stage of the platform evolution, to cover a wide range of missions and users (both internal and external). The platform is also intended to be compatible with other ESA AI initiatives.

The platform is designed to be deployed in a Kubernetes cluster based on microservices to leverage the scalability of the system as the number of users and/or resources may vary, however an increase of demand is expected due to the still early stage of adoption of AI within ESA. The structure of loosely coupled services reduce all types of dependencies and complexities around it. Services can be developed independently of each other, interact via well-defined APIs and be organized into groups each with a distinctive role and purpose within the platform. It is likewise easy to scale up applications by simply running duplications, and by distributing applications on multiple nodes, making the whole solution more robust to downtime.

The initial design of the architecture is based on the lambda architecture [3]framework, which defines three layers with the following service groups:

- The Batch layer is mainly used for batch processing of large amounts of operational data including the Model Training services.
- The Serving layer stores and serves the output of the batch and speed layer and includes the Storage, Model Inference, Monitoring and OPS Interface service components.
- The Speed layer is used for real-time processing of streaming data including the Data Stream Service and the individual Application components developed using the platform.

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[1] *https://esoc.esa.int/a2i-roadmap*

[2] *https://cloud.google.com/architecture/mlops-continuous-delivery-and-automation-pipelines-in-machine-learning*

[3] *https://en.wikipedia.org/wiki/Lambda_architecture*

## Data Access

In AI and ML related projects, data is key.  Data and AI are merging into a synergistic relationship, where AI is useless without data, and mastering data is insurmountable without AI.

With this idea in mind, we may think AI only needs vast amount of data, but the key is really quality data. However, ensuring data is of good quality, e.g. that it is labelled and is sufficient for the training/validation, can be a difficult task.

The increasing use of ESA systems (i.e., MUST and ARES) and MBSE across ESA missions helps provide access to operational data in a form that is more accessible to be used for AI methods. However, further work is still required to discover and prepare the data.

In the frame of AI platform development, initial steps are being taken into developing catalogues and ontologies through the definition of metadata (data that describes or summarizes data) for operational mission datasets. It will help application developers and users find the most appropriate data for their purposes creating an informative and searchable inventory of all data assets in and out of an organization in connection with the AI platform.

Security is vital putting these pieces together.  ESA operational environment enforces it explicitly by a separation between the operations LAN (OPSLAN) and the pre-operations LAN (PREOPS LAN) with strict controls on the data that can be exchanged between them and with external entities. This division is also being considered in the platform DevSecOps, in addition to the data accessibility and cataloguing.

## Summary

This paper will present the AI4OPS activity including the platform design, initial use cases, applications and achieved results. Being just a piece of a bigger picture, the paper will also show how users interact with the platform, their impressions to be considered for the ongoing ESOC AI Roadmap implementation in operations and plans for future improvements and extensions.