

Artificial Intelligence for mission operations automation roadmap

Gabriele De Canio, Federico Antonello, Evridiki Ntagiou, James Eggleston

European Space Operations Centre

European Space Agency

ESA UNCLASSIFIED – Releasable to the Public

© 2025 by European Space Agency. Published by The Aerospace Corporation with permission.

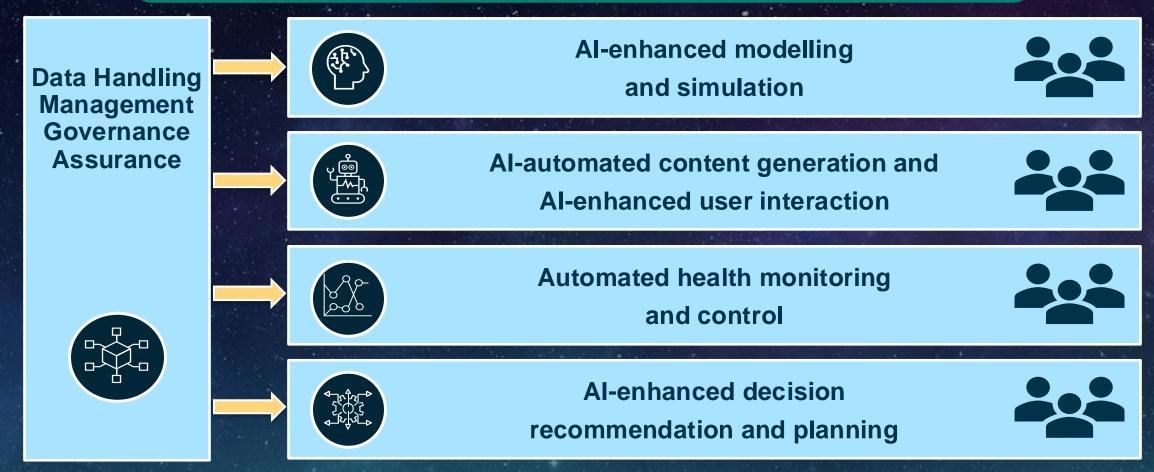




Al and Data Foundation Roadmap

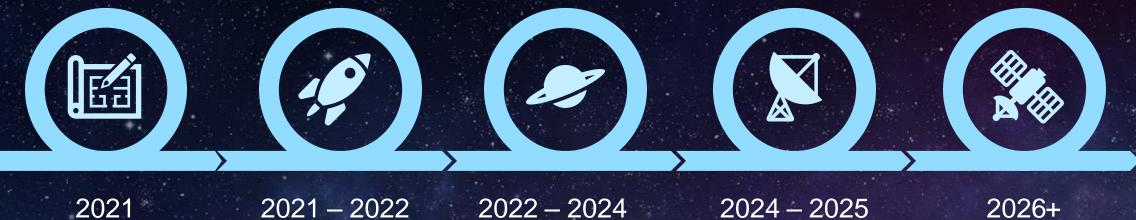


We are developing 5 AI and Data capabilities for ground segment engineering and operations to support the vision of operating twice as many missions by 2030



Our journey so far





- 2021
- Created Al Roadmap to support ground segment automation
- 2021 2022
- Proved business case and feasibility
- Started implementation

- Delivered first operational
 - products
- Validation beyond ESOC

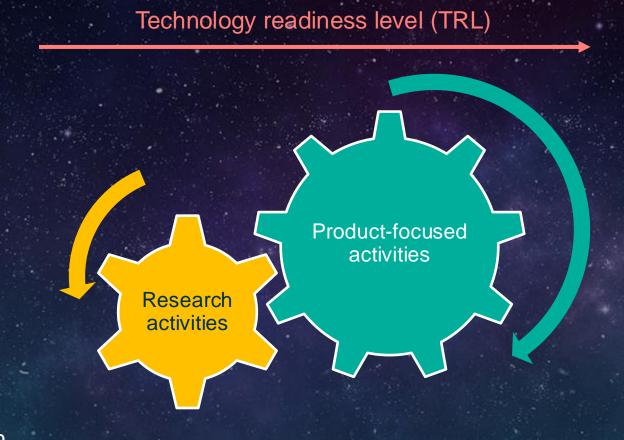
- 2024 2025
- Continue delivery of operational products

- 2026+
- Adoption at scale
- Products evolution

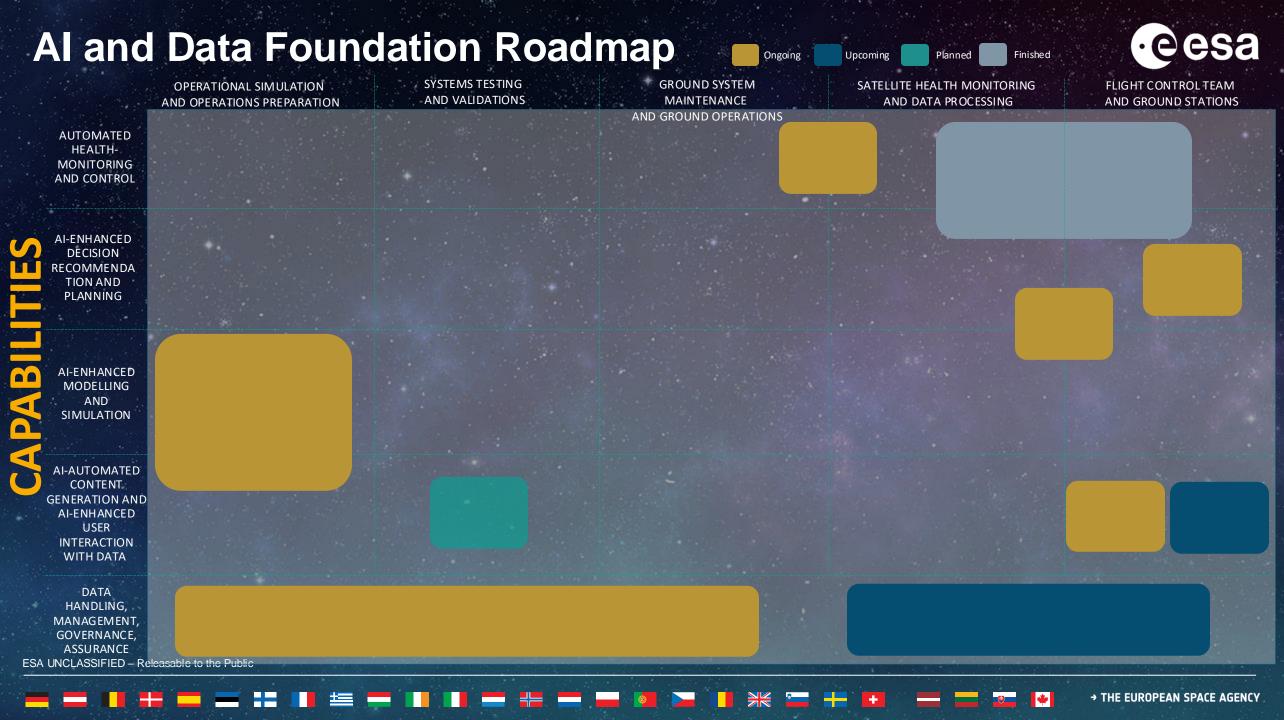
Spinning in innovation in technology and execution



- ☐ We solve real pain points in current processes
- We develop user-centric solutions for both ESOC and non-ESOC environments under ESA Community License
- ☐ We use modular architectures to easily upgrade to the latest Al paradigms and models
- We integrate our solutions into existing tools to ease adoption
- We develop and deploy with our users to demystify the use of AI
- ☐ We develop solutions covering the whole TRL spectrum



We generate tangible benefits



Prototypical implementation



Two phases



Proof-of-Concept (PoC) Ideation and Inception



Al-Based Application Continuous Testing and Validation while Operationalization

Principles



Impact assessment and Scalability



Agile Management Approach



CI/CD/CT and Code Management



ESA Community License



User-centric, Cross-functional Teams

ESA UNCLASSIFIED - Releasable to the Public

Data & Al Transformation in Ground Segment



Data & Al is supporting ground segment engineering and operations automation for ESA and the European ecosystem

Path to success

Benefits

Results



Technology transfer



ESA absorbs the risks



Developed and deployed products in record time



Continuous "small wins"



Enhance industry competitiveness



Improved work quality, reduced mundane tasks

We are delivering on time and on budget with outstanding results and impact on daily business

Deep dive into key achievements



Application

Al assistant (OCAI) for automated correlation & retrieval of information

OPERATIONAL

> 50%

adoption by ESOC

missions



MLOps platform (Alnabler) for all

Al applications at **ESOC**

OPERATIONAL



Al-optimised mission planning

system for 1 **ESOC** mission

OPERATIONAL



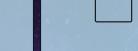
Ground operations support tooling

(AIIA) incident classification & maser maintenance assistance



Spacecraft Health Assistance

(SMAI) for anomaly detection, short and long-term trend analysis



Data Foundation Layer

Qualification. validation, assurance, security, catalogues... **Anonymous Data** Release

DEVELOPMENT

Centralised coordination

and enablement at scale

 \sim 3-7x time reduction in repetitive tasks

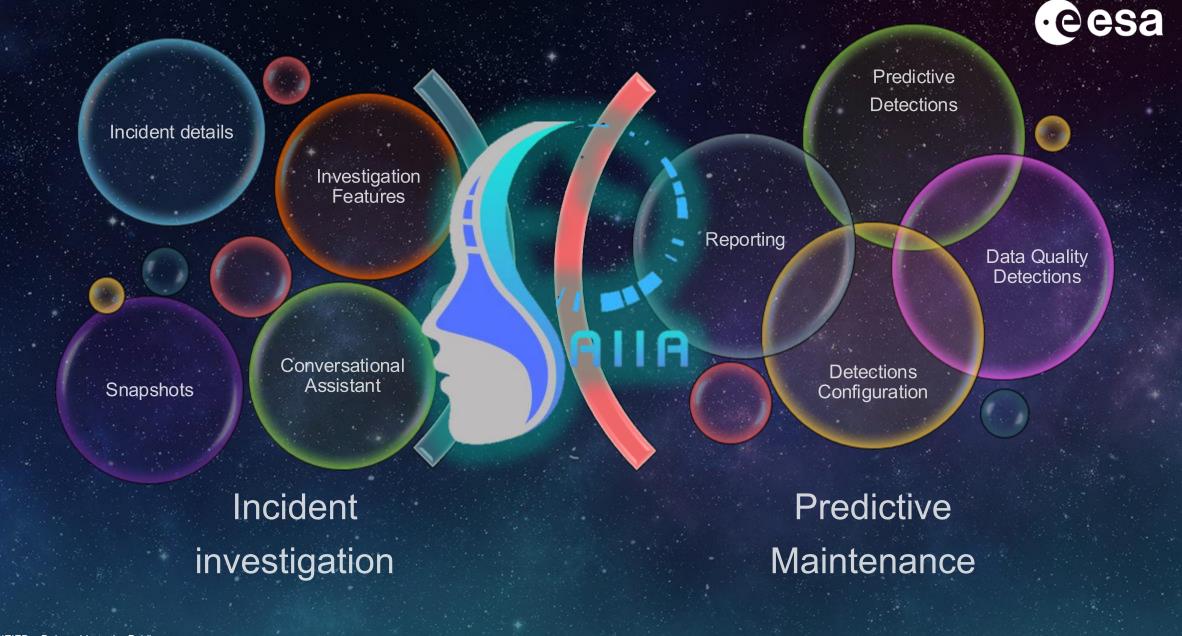
MVPs have Product Owners convinced by impact and usefulness

BETA PRODUCTS IN OPERATIONS

Definition and Features for Data Layers completed

ESA UNCLASSIFIED - Releasable to the Public

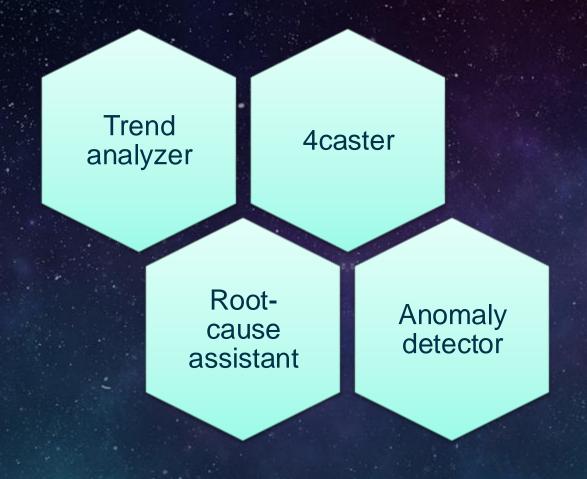








Spacecraft Monitoring Al-powered suite



ESA UNCLASSIFIED - Releasable to the Public

Lessons learned



Technical

- Data Availability and Preparation
- Best Practices in SW Development
- Infrastructure
- > Modular architecture
- UX expertise in dev team



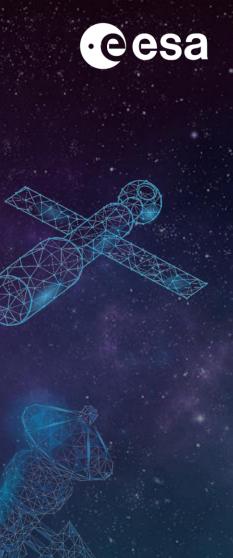
- Identify pain points
- Flexibility in execution
- Product-driven agile execution
- User-centric
- Fully-allocated teams
- Identify and monitor KPIs
- > Translator in dev team





Conclusions

- ☐ Our Al applications are supporting users at ESA's ESOC and beyond
 - Deployment also at EUMETSAT, DLR, ...
- ☐ Al aids automation of mundane and repetitive tasks
- ☐ Adoption achieved by having users involved from the beginning
- □ From MVP to operational application is hard!
- ☐ Achieved already significant quantitative and qualitative benefits
- ☐ We are derisking AI for ground segment engineering and operations
- ☐ Clear implementation roadmap for future functionalities and integration
 - Multiple research activities to support development and spin in innovation









New Anomaly Detection
Challenge on Kaggle using
ESA-ADB. Launch event at
ESOC on 13 March

Thank you!

Talks at GSAW 2025

- Artificial Intelligence for mission operations automation roadmap
- Continual Learning for on-ground satellite health monitoring
- Enhancing Spacecraft Operations with Digital Twins Solutions
- Data-X: Pioneering the Future of Data in Mission Operations