DOMINO-E

Workshop on EU-funded R&I for Earth Observation Technologies
21st February 2025

DOMINO

www.domino-e.eu
DOMI-PS-ADST-1002060222

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101082230.

Agenda

- Project summary and objectives
- Key Exploitable Results
- Use cases and exploitation
- Collaboration with other funded projects
- Use of European technologies and building blocks at component level
- Technological challenges, gap and needs

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Project summary and objectives

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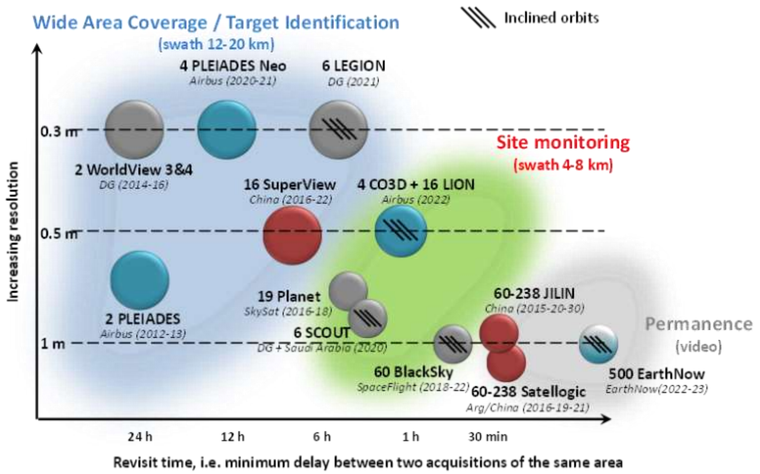
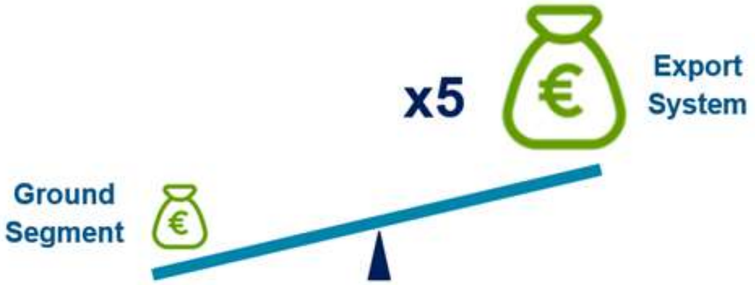
Strategic Importance of the Ground Segment

Technological aspects

- Multiplicity, customization and complementarity of EO systems
- Race for higher reactivity, revisit and throughput through constellations of Earth Observation satellites
- From image and missions to information
- From raw image data products to high-level data-driven services





Business aspect

- Addressable civil market for EO systems for the next 10 years is estimated at 24 Billion USD (captive market excluded) while it was at 18 Billion USD for the last decade (Euroconsult 2021)
- Earth Observation systems represents 200 000 to 500 000 hours of activity for the space industry per export program.
- **While solely representing 20 to 25% of the price of an EO system, GS ensures the end-to-end performance of the system and is the front store for the user.**

The ground segment has become decisive for the sale of new systems

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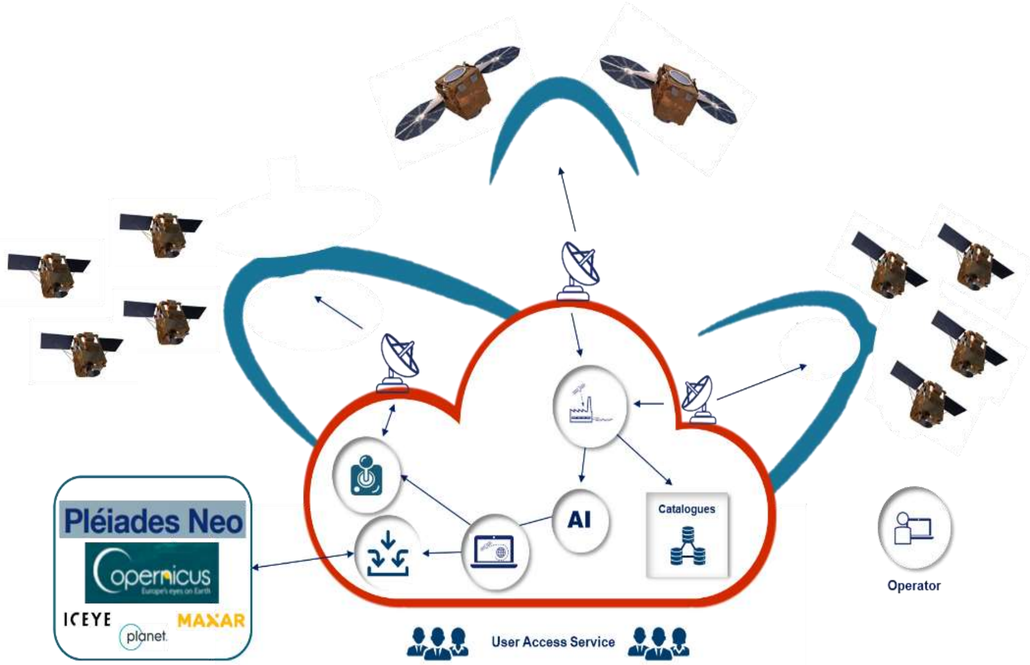
Why a Domino approach for Ground Segment?

Challenges to address:

- Space market is evolving fast with new comers
- Customer needs are evolving
- Future systems will be more complex and multi-missions
- Sovereignty and Trustability on the system and the data
- Hybrid and public Cloud costs and deployments
- Maximization of component reuse reducing costs, risks and schedules
- Low coupling between components to provide modularity and localize impacts, constraints and evolutions



Better solutions for customers and better profitability for industries through a standardization

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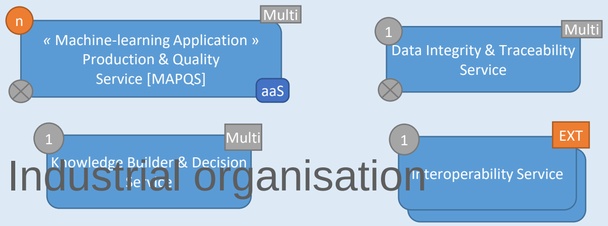
Domino: the next Ground Segment – A ready to start architecture

Domino architecture agreed baseline T0

Instantiate Domino architecture for the project

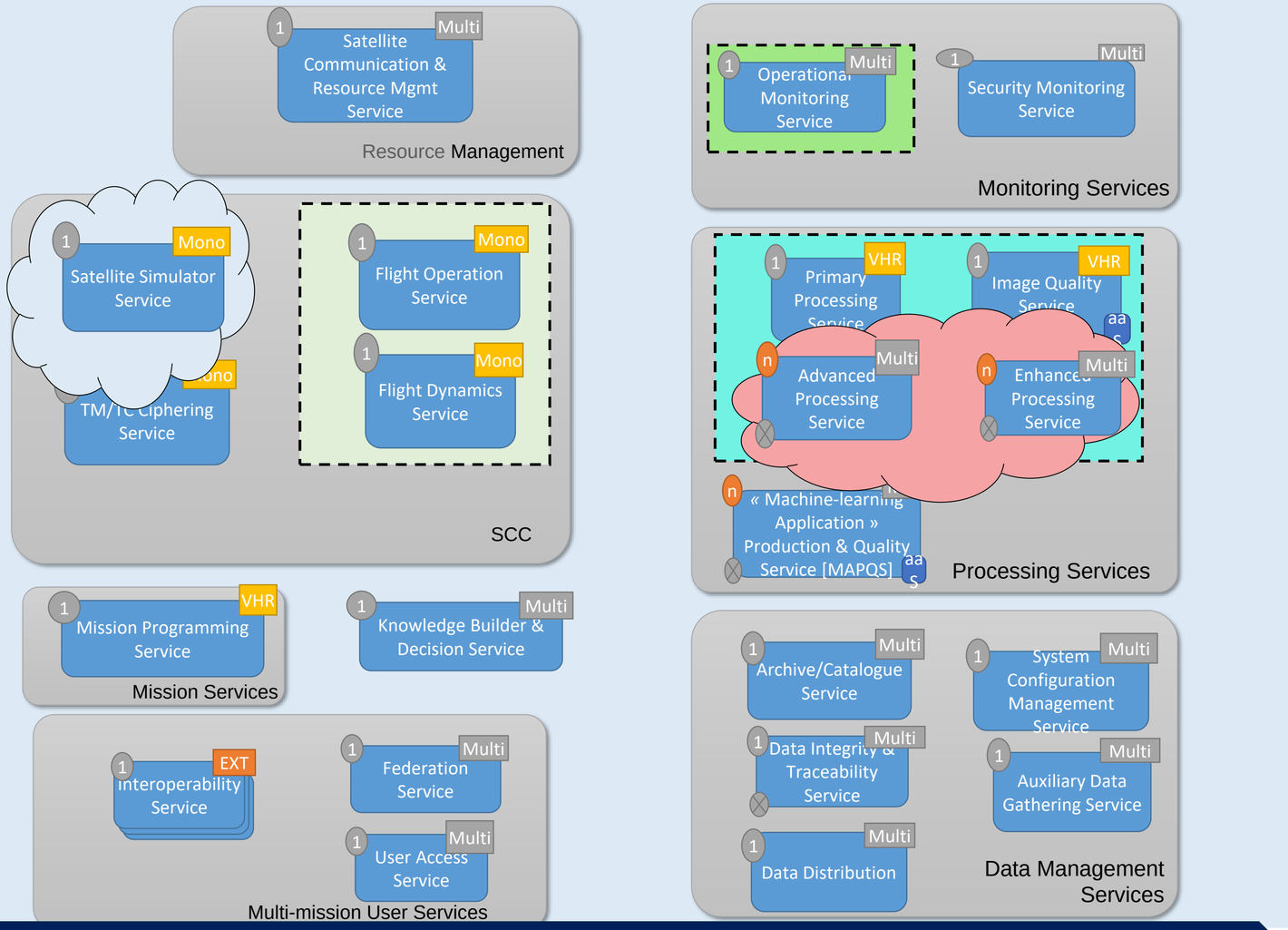
Dominos not relevant for the project



Industrial organisation

Ground Segment Deployment

Ground Segment architecture



Decrease time to market thanks to mature architecture and relying on existing Dominos

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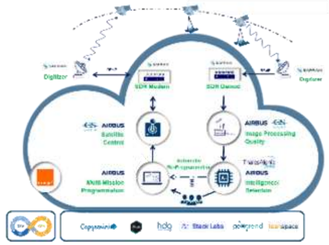
DOMINO Saga

DOMINO-A (GSTP ESA)
02/2024-02/2026

Radar Ground Segment (SAR Dominoes)
API Governance (Domino Interfaces)
Immersive environment (OMS Domino)
PaaS for space operation (FOS Domino)

DOMINO-X (CNES/DGE)
11/2021-11/2023



Reference System Service (ESA)
2021-2025

Adaptative PDGS
Evolving Technology

MESEO (HE EC)
12/2023-12/2026

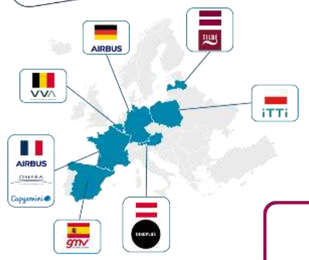
Data Management and System Security

AIRBUS
SPIDER (EC EDF)
2024-2026
+30 EU partners

Interconnect multiple Domino-based systems

Coverage service (Federation Domino)
Communication booking service (Sat Comm & Res Man Domino)
Virtual Assistant Service (User Access Domino)

DOMINO-E (HE EC)
11/2022-11/2025



Our next project together

Deploy ground segment following (at least partially) Domino architecture

AIRBUS **ThalesAlenia Space**
Export customers

The Domino saga is to be continued

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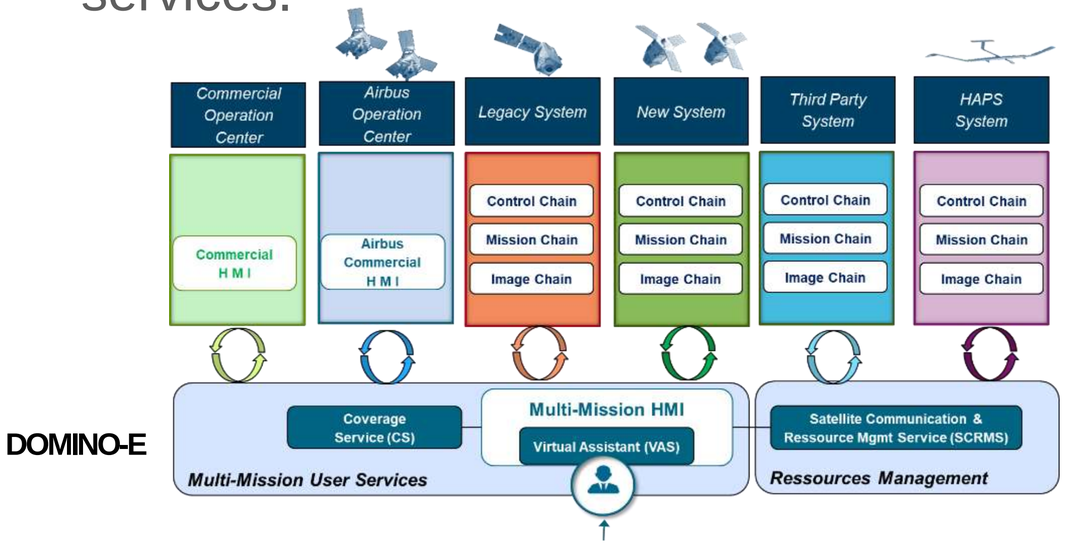
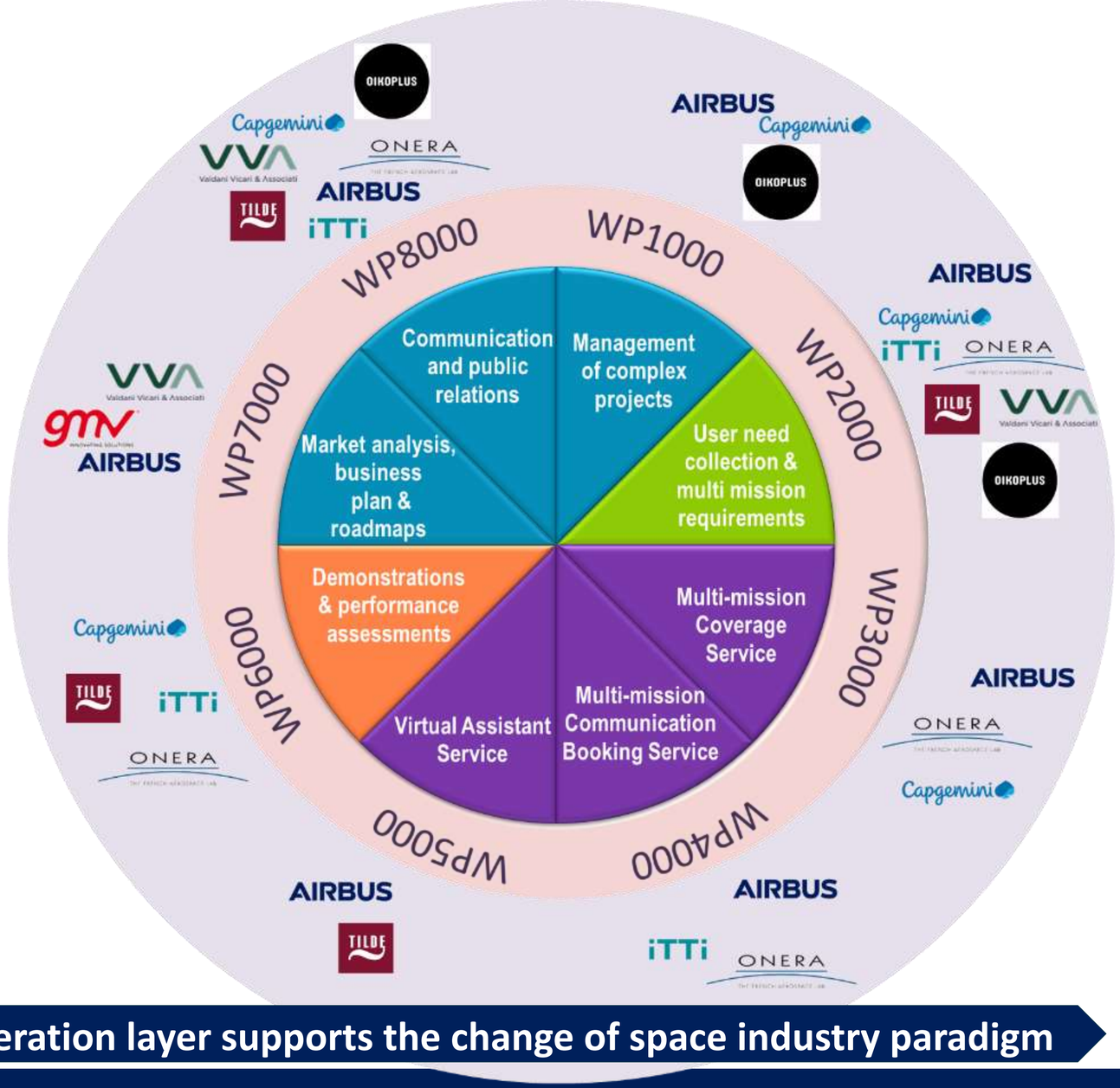
Why DOMINO-E?

DOMINO-E consists of designing, analysing and modelling the multi-mission federation layer based on users' requirements and is supported by demonstrations of added value services.





This innovative federation layer supports the change of space industry paradigm

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Key Exploitable Results

Services	Related DOMINO	Operational Challenges	Enabling Technologies	TRL at start of project	TRL at end of the project	Validation
Coverage Services SCRMS	Federation Service SCRMS	**Predict multi mission or station load and other uncertain parameters**	Deep Learning	TRL 3/4	TRL 6	Demonstration and Airbus internal TRL review
Coverage Services SCRMS	Federation Service SCRMS	**Check feasibility with respect to hard constraints concerning schedules and mission or station load**	Constraint Programming	TRL 4	TRL 6	Demonstration and Airbus internal TRL review
Coverage Services	Federation Service	**Search for optimal allocation/cost with respect to users' preferences**	Mixed Integer Linear Programming	TRL 3/4	TRL 6	Demonstration and Airbus internal TRL review
Coverage Services	Federation Service	**Adapt system parameters at runtime**	Reinforcement Learning	TRL 4	TRL 6	Demonstration and Airbus internal TRL review
Virtual Assistant Services	User Access Service	**Describe the wide variety of different and changing Earth systems**	Ontology	TRL 5	TRL 6	Demonstration
Virtual Assistant Services	User Access Service	**Allow the transformation of natural language utterances into requests to external information sources and to translate output into natural language**	Natural language	TRL 4	TRL 6	Demonstration

TRL reviews to reach Ready to Bid features

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Use Cases and Exploitation

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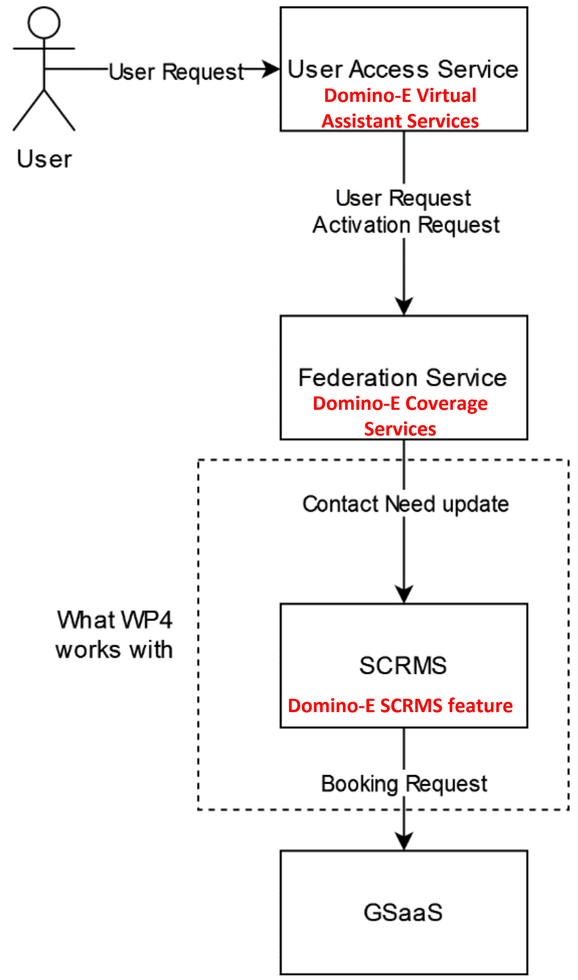
Demonstrations

- Each Service **validates its use cases on a representative test beds**. This step dives into the specificities and limits of the developed algorithms
- The **Dominos outside of DOMINO-E scope are simulated** with their Domino-X interface.
- An **End-to-end scenario connects all 3 Services in a common use case**. This scenario demonstrates that they can interact and communicate through the Domino-X interfaces, and improve the overall service.



An End-to-end scenario to connect all features developed by Domino-E project

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Primary planned exploitation routes and lead partners

- Answering to Governmental agencies' RFPs on End to End systems with a solution that includes DOMINO-E Services (Airbus as integrator)
- Selling DOMINO-E Services to Ground Segment and/or End to End systems integrators:
  - Coverage Service (Capgemini)
  - Satellite Communication & Ressource Mgmt Service (ITTI)
  - Virtual Assistant Service (Tilde)

Each DOMINO provider is in charge of providing a compliant implementation and architecture

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Path towards increasing the TRL after the end of EU-funding

Continued Validation & Demonstration (TRL 7-8)

- Conduct real-world pilot deployments with national and European space agencies;
- Strengthen partnerships with B2B and institutional customers for real-world trials.

Commercialization and Industrialization (TRL 8-9): Include Services in answers to RFPs

Proposing Ready to Bid Services for Commercialization

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Challenges for commercial use/exploitation

Technical Challenges: Complexity of Data Handling - integrate multiple EO missions from different sources, which increases data volume and interoperability issues.

Market and Business Model Challenges:

- Competition with Established Players: price and schedule are crucial.
- Business Model Complexity: balance the needs of integrators and end-users.

Regulatory Constraints: Export-Control and national security/policies may restrict access to high-resolution EO data in certain regions.

Clear roadmap to commercial exploitation

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(Planned) use of EU support mechanisms

- **Horizon Booster and Other EU Support Programs:** DOMINO-E’s partners will seek additional business acceleration support, networking opportunities, and access to investors through this program (SME).
- **Follow-up Funding through Horizon Europe Calls**

Adequate support programs for effective industrial phasing

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Other EU / ESA / national funded projects

Main established collaborations / synergies

DOMINO-X

Domino-X was a common project with 11 partners trying to build the best system architecture for future Earth Observation Ground Segments. The project worked on system architectures with stable and public breakdowns and interfaces, at the right level of granularity, with low coupling between building blocks, enabling the development of an ecosystem of component providers. Our team will also be able to propose offers with Public Cloud and Ground Station as a Service.

Technical Baseline for Domino Architecture

MESEO

MESEO aims to design, prototype and demonstrate an open, flexible and scalable multi-mission End-to-End Earth Observation (EO) system for massive data processing. MESEO puts into place an approach designed to improve quality of service and timeline reactivity by improving the End-to-End EO chain at different levels and processing edges. At the same time, it seeks to reduce communication bandwidth and incorporate new technology with optimised power consumption and processing capabilities.

Architecture
Security analysis
Shared Communication

EO4EU
Earth Observation Data & Service Accessibility

The project "AI-augmented ecosystem for Earth Observation data accessibility with Extended reality User Interfaces for Service and data exploitation" or EO4EU is a European Commission funded innovation project bringing forward the EO4EU Platform which will make access and use of EO data easier for environmental, government, and even business forecasts and operations. The project will promote pre-operational European services like DestinE and will utilise existing platforms and services through the extensive use of disruptive technologies. EO4EU is made up of 16 consortium partners from 11 countries.

Knowledge Exchange

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Use of European technologies and building blocks at component level

Use of existing European technologies and/or building blocks at component level, contributing to European non-dependence:

- Orekit Library (https://www.orekit.org/)
- Domino architecture implemented in each Service (https://domino-x.space/)

Main challenges for use of European-sourced components/building blocks in the supply chain: setting up an integration platform, that respects export control, licences and sensitivity of each part, which is different for each company and part of the system.

DOMINO open-source architecture as starting point

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Technological challenges, gap and needs

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Key technology enablers

- **DOMINO Architecture:** Modular architecture and standardised interfaces
- **Key Innovations of the Testbed**
  - **Accessibility:** The testbed is available across Europe to all consortium members.
  - **Security:** Enhanced protection for external access, as well as secure internal traffic management through resource isolation by project.
  - **Tested Applications:** A variety of applications, differing in functionality and scope, are tested on the same testbed.

Architectural design and Demonstration testbeds as key success factors

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Technological challenges

- **Complexity of Data Handling** - integrate multiple EO missions from different sources
- **Algorithms** of each Services: e.g.,
  - how to dispatch a load efficiently between multiple heterogeneous constellations
  - How to update that dispatch to answer unforeseen events such as updates in workloads or changes in weather
  - how to build a contact schedule for multiple constellations, with multiple ground station providers including GSaaS providers
- **Transnational/Company** technical communication (disparate network of tools and platforms)

Known and evaluated technological challenges

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Main R&I gaps and future needs

- **Multi-mission federation:** Optimality of dispatch, extend the scope of the dispatch method to new client’s needs. Dispatch managing site-monitoring & coverage, **SAR & SIGINT & Optical**

- **Communication ressource management:** still are remaining areas to research, such as jammings mitigation, slot cancellation, booking prediction, workload detailed definition and upload optimality

Complementary use cases to increase market penetration

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Specific needs for standardisation

Domino architecture is currently at most partially applied: It is still difficult to apply Domino architecture as this proposed architecture needs

- to become a standard and
- to be adopted by all the whole Earth Observation eco-system
- support from all the stakeholders (industry and agencies)

.

DOMINO Architecture standardization at EU level contributes to reusability and profitability for all European stakeholders.

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Domino-E Webinar Series

To share our findings and engage with future developers, innovators, and stakeholders, we are launching an exclusive three-part webinar series designed to disseminate our insights and connect with potential contributors to the Domino ecosystem.

Webinar #1 – The Domino Architecture: A New Era of Earth Observation
Date & Time: 19.03.2025; 10:30 – 12:00 CET

Webinar #2 – Developing within Domino: Examples from Domino-E
Date & Time: 25.03.2025; 10:30 – 12:00 CET

Webinar #3 – The Domino Ecosystem: Opportunities for SMEs
Date & Time: 31.03.2025; 10:30 – 12:00 CET

Join us to unlock the future of EO

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Thank you for your attention!

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