# EO Virtual Constellation

Toward a new generation of Earth Observation

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# 1. INTRODUCTION

Earth Observation is increasingly confronted with the need for faster, more targeted, and information-driven responses to dynamic environmental and societal events. Traditional mission-centric acquisition schemes, while powerful, are often limited in their ability to react in real time to rapidly evolving situations such as floods, disasters, or emerging hazards. In this context, the EO Virtual Constellation concept introduces a new paradigm: a federated, software-defined approach in which heterogeneous EO space assets and ground-based data sources are dynamically orchestrated to operate as a unified system.

By abstracting individual platforms and enabling intelligent, event-driven tasking and processing, the EO Virtual Constellation aims to shift the focus from sensor availability to information needs. Leveraging interoperable interfaces, cloud-native infrastructures, and emerging AI- and agent-based orchestration mechanisms, this approach enables low-latency acquisition, adaptive processing, and closed-loop observation workflows. The objective is to maximise the collective value of existing and future assets while enabling more responsive, scalable, and anticipatory Earth Observation capabilities.

This document introduces an opportunity for collaboration with space asset operators and providers of ground-based data who are willing to contribute capabilities, ideas, and technologies to the development and demonstration of the EO Virtual Constellation.

# 2. OVERALL CONCEPT

## 2.1. From Mission-Centric EO to a Federated, Intelligent Virtual Constellation

The concept of an EO Virtual Constellation represents a fundamental shift from mission-centric Earth observation toward a federated, software-defined sensing ecosystem in which heterogeneous assets are orchestrated dynamically to behave as a single, coherent system. Rather than relying on fixed acquisition plans from individual missions, the virtual constellation abstracts away platform boundaries and treats all available sensing resources (public satellites, commercial constellations and even ground-based IoT networks) as components of a unified observational fabric. This abstraction layer is enabled by interoperable interfaces (e.g. STAC, STAPI) and cloud-native infrastructures that allow data and tasking requests to flow seamlessly across organizational and technological boundaries. In this paradigm, the emphasis shifts from “which satellite acquires the data” to “what information is needed and how the system can best obtain it,” effectively decoupling user intent from sensor-specific constraints and enabling a more flexible and scalable approach to Earth observation.

At the core of the EO Virtual Constellation lies an intelligent orchestration layer that leverages artificial intelligence, optimization algorithms, and increasingly agent-based architectures to dynamically request sensing, downlink, and processing resources in response to evolving conditions. The system operates in an event-driven manner, where triggers derived from ground-based measurements, predictive models, or real-time analytics request targeted acquisitions and prioritized processing workflows. This orchestration extends beyond acquisition to include adaptive data routing, edge processing, and cloud-based analytics, forming a closed-loop pipeline in which detection, sensing, and insight generation continuously inform one another. The result is a system that is not only reactive but anticipatory, capable of forecasting events and proactively mobilizing observational resources.

## 2.2. An Extensible System-of-Systems and Innovation Ecosystem

The architecture is inherently extensible, allowing new data sources, algorithms, and service providers to be incorporated with minimal friction, fostering an ecosystem of innovation around shared standards and interoperable services. In this sense, the EO Virtual Constellation is not merely a technical construct but a system-of-systems paradigm, redefining how Earth observation capabilities are composed, accessed, and exploited in an increasingly interconnected and data-driven world.

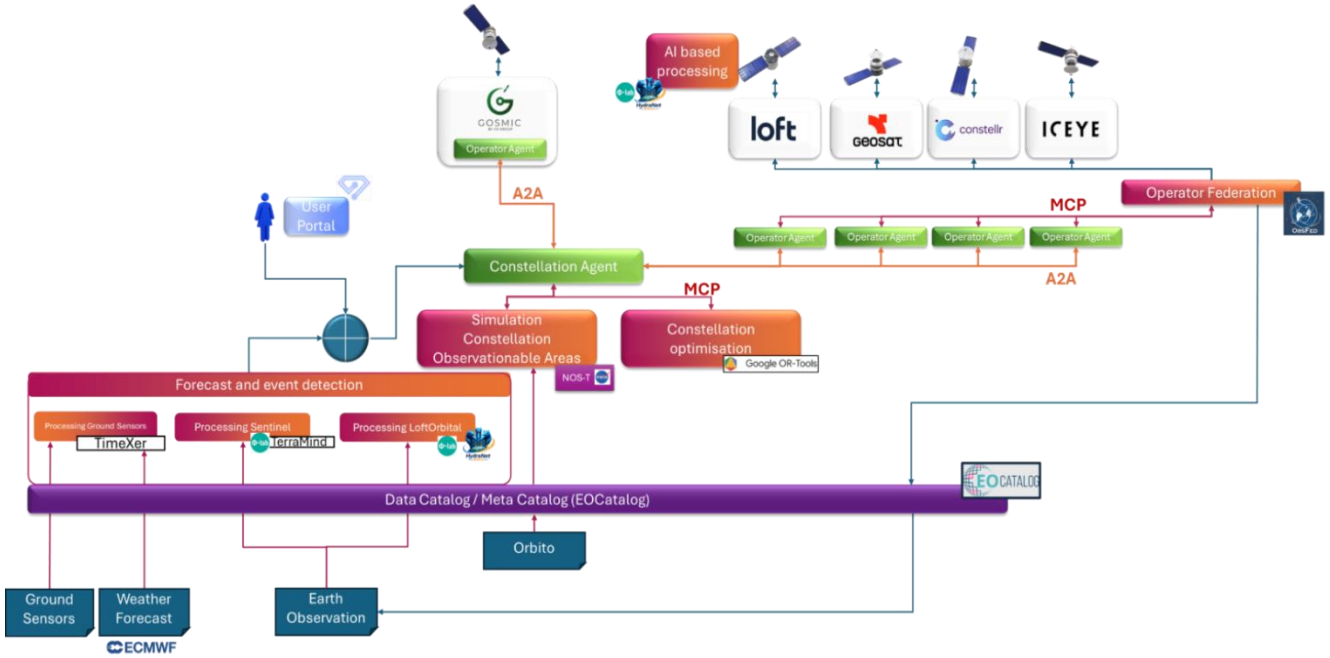


*Figure 1 Current implementation of EO Virtual Constellation*

## 2.3. Scope of the First Demonstration and Outlook for Future Use Cases

The initial demonstration phase of the EO Virtual Constellation initiative will focus on flood monitoring over selected European river basins, with particular emphasis on the Danube River and the French national river network. This first use case is chosen to validate the ability of task-able EO assets and agentic interfaces to support low-latency, responsive observations, including adaptive tasking, rapid data delivery, and near-real-time information generation in an operationally relevant context.

While this first demonstration will concentrate on specific European Areas of Interest (AOIs), it should be clearly understood that this focus is illustrative rather than restrictive. Subsequent phases or follow-on activities may extend to:

- other geographical regions, both within and outside Europe,
- additional river basins or hydrological systems,
- and more broadly, non-flood-related use cases.

In particular, future use cases are expected to explore scenarios where low latency, rapid response, and adaptive sensing are critical, such as:

- disaster and emergency response (e.g. wildfires, earthquakes, landslides),
- maritime surveillance and safety,
- environmental hazards and extreme weather events,
- infrastructure monitoring and resilience,
- or other time-critical Earth observation applications requiring dynamic tasking and fast decision loops.

## 3. OPPORTUNITY FOR COLLABORATION

This opportunity for collaboration is currently open to identify and engage with stakeholders capable of contributing to the evolution of the EO Virtual Constellation. This initiative does not constitute a tender action, nor it implies any form of binding commitment, contractual obligation, or selection outcome for either the responding entities or the EO Virtual Constellation or the European Space Agency. This initiative targets two key categories of contributors, listed in order of priority:

- High-level priority: Operators of task-able EO assets offering on-demand acquisition capabilities, optionally with associated advanced event detection and forecasting algorithms.
- Medium-level priority: Providers of ground-based data, including IoT networks, in situ measurement systems, and crowd-sourced information streams that can enrich situational awareness and act as real-time triggers, optionally with associated advanced event detection and forecasting algorithms.

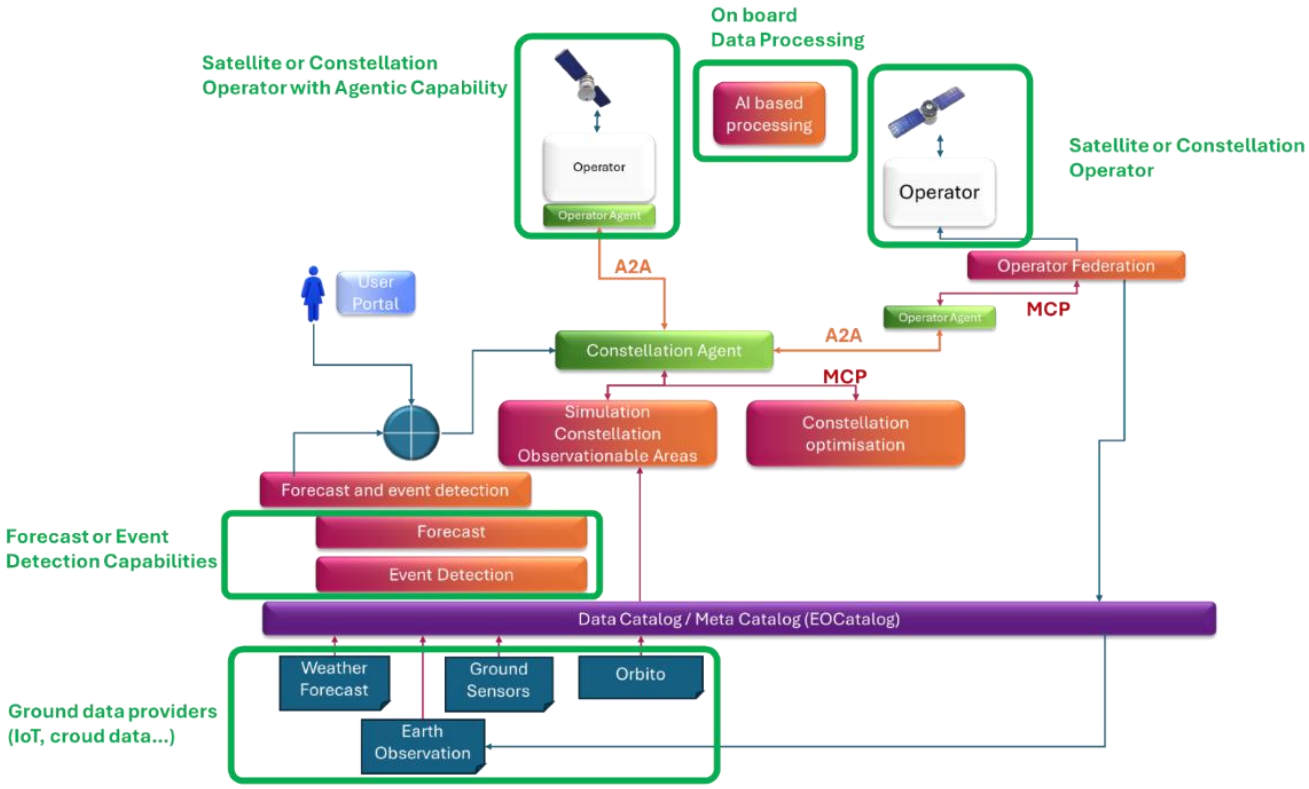


**FIGURE 2 SCOPE OF THE CALL FOR INTEREST**

## 3.1. Task-able EO space assets

The integration of task-able EO spacecraft from commercial or institutional providers introduces a decisive layer of flexibility and responsiveness into geospatial intelligence workflows, complementing the systematic acquisition strategies of public missions such as Sentinel-1 and Sentinel-2 under the Copernicus Program. Beside the predefined observation schemes from Copernicus missions, other spacecrafts and constellations can offer complementing and on-demand tasking capabilities that allow to request acquisitions over specific areas of interest with tailored parameters such as spatial resolution, revisit frequency, and viewing geometry. Some space assets could also perform dedicated processing on board (including AI based processing) and low latency transmission capacity. Traditionally, this interaction has been mediated through web interfaces, including RESTful APIs, secure web portals, or even email-based request systems, enabling integration into

automated pipelines where triggers derived from analytics or external signals initiate new image capture requests. However, a more advanced paradigm is emerging with the introduction of agentic interfaces, Agent-to-Agent (A2A) architectures.

In the EO Virtual Constellation framework, we are looking for space asset owners and operators who can support on demand or semi on demand tasking via API, beyond static acquisition plans, and/or provide transparency on feasibility constraints (orbit, capacity, latency, conflicts) and/or participate in automated or machine mediated tasking workflows. Participation is particularly encouraged from operators whose platforms support, or plan to support 1) onboard processing, including AI/ML based inference (e.g. detection, classification, quality filtering), 2) event driven or priority based downlink, or 3) low latency data delivery, suitable for near real time applications or 4) interest A2A-like enable capabilities.

## 3.2. Ground-based assets

Ground-based data has traditionally played a complementary role to spaceborne observations, providing in situ measurements enabling the calibration, validation, and fusion of local ground-truth information with spaceborne observations. However, the rapid proliferation of IoT devices and crowd-sourced signals is fundamentally expanding this paradigm into a more dynamic, event-driven ecosystem. Integrating heterogeneous terrestrial data streams, ranging from environmental sensors and smart infrastructure to mobile devices and participatory reporting platforms enables the detection of transient phenomena with far greater temporal granularity.

These signals can act as low-latency triggers for adaptive tasking or prioritized processing pipelines, allowing ground segments to shift from static, pre-planned workflows toward responsive architectures where processing is initiated based on real-world conditions rather than orbital schedules alone. For example, anomalous readings from hydrological IoT networks, traffic sensors, or even aggregated user-generated content can flag emerging events such as floods, wildfires, or infrastructure disruptions, prompting immediate retrieval and accelerated processing of relevant satellite data takes. This fusion not only improves

situational awareness but also optimizes resource allocation (e.g. downlink capacity, storage, and compute) by focusing efforts on high-value observations. Moreover, the incorporation of crowd-based signals introduces a semantic layer that is often absent from classic remote sensing, enabling more nuanced interpretation and validation of satellite-derived products.

In the EO Virtual Constellation framework, ground-based data becomes not just a validation tool but a primary driver of intelligent orchestration, unlocking innovative use cases such as real-time environmental monitoring, predictive maintenance of critical assets, and adaptive disaster response systems that operate at the intersection of edge sensing and spaceborne intelligence.