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DOMINO-X Multi-Mission and Federation Services

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Abstract

Airbus, a global leader in space systems, is developing state-of-the-art multi-mission capabilities for Earth Observation. Airbus sells systems consisting of S250 optical, S250 radar, S850 and S950 satellite products, which all have complementary strengths. The best combination for each client depends on aimed performance and economics. In addition, Airbus, as a system integrator, also connects these systems to third party systems, giving access in this way to imagery providers or to direct receiving stations for example. In the frame of a project aiming at standardizing EO ground segment architectures, the strategy of Airbus is to provide end users a wide range of imagery products through the same solution using federation services.

The federation is based on a new concept of operations, with the objective to provide users with the best possible reactivity to acquire products as well as the freshest images and actionable information delivered by the system of systems.

Using a modular architecture of a ground segment that includes standardized interfaces, multi-mission building blocks can be assembled together in a custom way that allows answering, at the good level, the customer needs, while enhancing operations.

The paper covers the CONOPS, the functional overview of Airbus' multi-mission capabilities and the modular architecture that allows plugging Airbus' product with multiple imaging systems thanks to standardized interfaces.

Keywords: Federation Services, ground segment architecture, Earth Observation, standardized interfaces, Domino, coverage, site monitoring

Acronyms/Abbreviations

CONOPS: Concept of Operations
EO: Earth Observation
FS: Federation Services
GS: Ground segment
HAPS: High Altitude Pseudo-Satellite
SAR: Synthetic Aperture Radat
UAS: User Access Services
UAV: Unmanned Aerial Vehicle

1. Introduction

Within the DOMINO-X project Airbus works, among many other topics, on standardized architecture and interfaces for EO missions and on a Federation Service product. This Federation capability will become increasingly relevant as more and more EO systems will see the light of day in the future. As these systems will multiply, they will also become more interconnected. The capabilities of heterogeneous systems will be mobilised to address end users' needs for imagery, be they optical, infrared, microwave, super-spectral, hyper-spectral or combinations of these. Fig. 1 illustrates the heterogeneity of EO systems eligible for federation.

Today there are limited number of solutions available on the market to support end users and operators to select the right combination of systems to complete the imaging needs in the most rapid way. The Federation Service brick is the key piece for a smart and reactive exploitation of systems of EO systems.

Since this federation brick would interface with satellite programming functions of multiple system provided or operated by multiple actors, it is important that the interfaces are clear and made public.

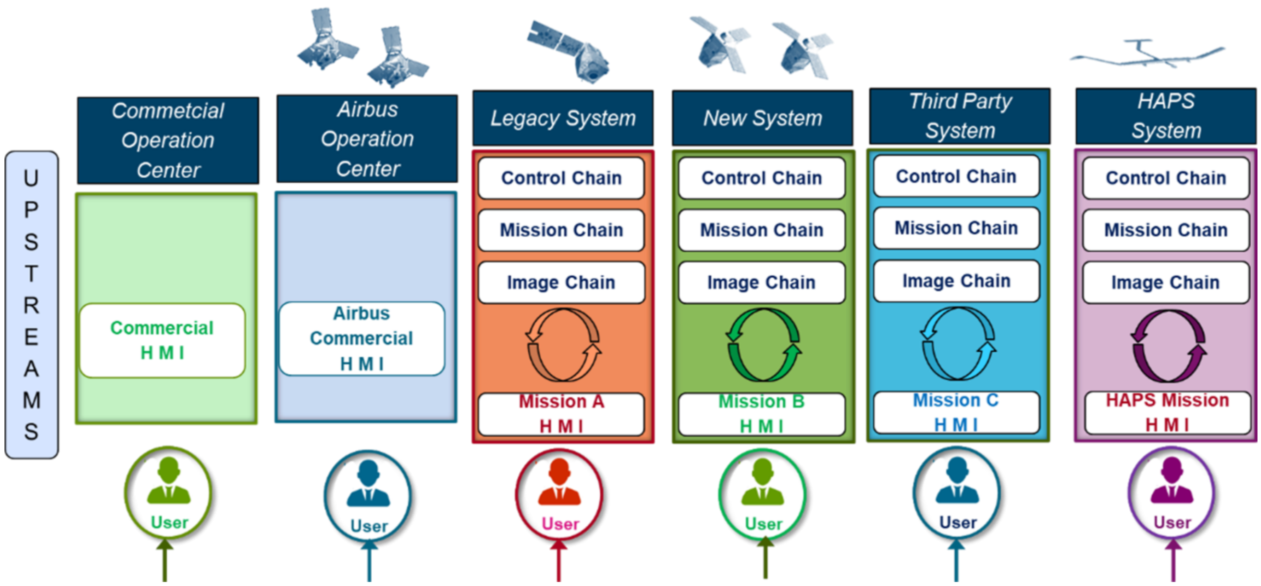

Fig. 1 Illustration of the heterogeneity of EO systems that may need to be federated

2. Concept of operations

The concept of operations corresponding to our federation approach relies on:

- The capacity to task first our customers' own systems/satellites, sometimes working in a constellation, with the shortest delay between the user request and the acquisition of images, and the shortest processing time, and whenever possible, using streaming capabilities.
- The capacity to harvest, when required, external data providers, whether public or commercial data, to complete the user request in the best timeframe. Such a capacity requires to be open to the external world, with interoperability capabilities and standard interfaces.
- The capacity to automatize the operations, even when mixing or dispatching activities between different missions.
- The capacity to supervise the operations and to provide the user with a good level of standardized information using for instance notification mechanisms.

Each time a user wants to have a new image product, including time series or smart products based on AI detection, the ground segment will use the multi-mission features to improve reactivity and/or to find the best match corresponding to user needs. The submission of imaging requests is supported by advanced feasibility analyses which take into account the system's work load and possible climate and weather forecasts for optical acquisition.

The federation service applies the right strategy with respect to the nature of the request. Indeed, the acquisition strategy is different depending on whether the request is for imaging small theatres of operations or for mapping of larger areas. Indeed, the first one needs reactivity and revisit, the second one needs preferably homogeneous instruments, viewing angles or illumination conditions. There are also the cases in between that require specific approaches. The federation product supports the automatic decision making for optimal performance.

3. Federation Service functions

The Federation Service is composed of ten key functions that are described in this section.

3.1 Get Systems Capabilities

This function manages the capabilities of all the federated systems, owned and external ones. It retrieves the external systems capabilities using the Interoperability services capabilities providing function (system name, list of satellites, orbital data…).

Concerning image processing capabilities, owned systems ones or upper levels processing ones, the function retrieves them from corresponding dominoes using the domino capabilities providing function.

The function provides the system's HMI the capabilities of all the federated systems (owned and external ones). The list of provided capabilities could be limited to those really needed by the user.

3.2 Perform Intrinsic Feasibility

This function performs the intrinsic feasibility of a Programming Request on all the systems that are addressed at request level. It is called when the end-user asks for it. The results of an intrinsic feasibility consists in a splitting of the request geographical area into meshes, and of satellite accesses on the meshes over the request validity period.

For owned systems, the function relies on the intrinsic feasibility provided by the systems themselves, i.e. on the "Analyse Programming Request" function of the Mission Planning domino.

For external systems, the function relies on an internal generic model that is based on the systems capabilities provided by interoperability functions in the GS.

3.3 Activate User Request

This function performs the activation of a User Request. It is called when the end-user asks for it. The User Request is stored in the database.

For a mono system User Request the function performs the activation of the corresponding Programming Request on the chosen system.

For a multi-system User Request, the "Dispatch Site Monitoring Acquisitions" function is used for submitting a request.

3.4 Cancel User Request

This function performs the cancellation of a User Request. It is called when the end-user asks for it.

For a mono system User Request, the Programming Request is cancelled on the addressed system.

For a multi-system User Request, the cancellation will be taken into account later on by the "Dispatch Site Monitoring Acquisitions" function.

3.5 Update User Request

This function performs the modification of a User Request after request submission. It is called when the end-user asks for it. The modified User Request is stored in the request database. This modification only concerns request parameters, the modification of request status is not concerned, as it addressed by the "Cancel User Request" function.

For a Programming Request, the list of modifiable parameters is limited to those that do not have impact on the splitting of the geographical area. For instance validity period, angular constraints or cloud cover threshold can be modified.

For a mono system User Request activated on a sovereign system, the function performs the modification of the corresponding Programming Request by using the appropriate function in the Mission Planning services of the corresponding system. For a external systems, the function performs the modification by first cancelling the Programming Request submitted on the external system and then by submitting a new Programming Request corresponding to the modified request.

For a multi-system User Request, the modification is done by the "Dispatch Site Monitoring Acquisitions" function.

3.6 Follow-Up User Request

This function can be called when the end-user asks for it. The follow-up can consist in getting the list of requests matching a given criteria, and/or retrieving the detailed parameters of a given request including the Programming Request progress and status.

3.7 Perform Coverage Feasibility

This function performs the global feasibility of a Coverage Programming Request on each system that is addressed at request level. The goal of this request is to cover a large area. The function can consider or not, depending on the end-user choice, the workload of the systems.

The function relies on an internal model based on the systems capabilities.

If workload has to be considered, the function retrieves the orders book of the owned before performing the calculation.

The results of a Coverage global feasibility consist in a curve of completion progress along the time, and a final completion date.

3.8 Automatic reassessment of coverage end time

This function performs, for each Coverage Programming Request and on the chosen system, a reassessment of the completion progress along the time and of the final completion date, taking into account the already programmed acquisitions, and the workload evolution.

It has to be triggered automatically and periodically, so that up-to-date progress information is always available for the end-user.

The results of this function consist in a reassessed curve of completion progress along the time, in the future, and a final completion date.

3.9 Compute Site Monitoring Allocation Projection

This function performs the system/satellite allocation projection for a Site Monitoring User Request. The goal of this request is to monitor periodically a small area of interest using multiple satellite systems. The function is called when the end-user asks for it. It can consider or not, depending on the end-user choice, the workload of the owned systems.

This function relies on an internal model based on the systems capabilities.

The result of a monitoring Allocation Projection is the first Programming Order system/satellite allocations to ensure the periodicity of the Site Monitoring User Request. It offers the end-user with an estimation of the systems that could be used the complete the Site Monitoring User Request.

3.10 Dispatch Site Monitoring Acquisition

This function performs the dispatch of the Site Monitoring User Request. It considers the workload of the owned systems.

It is triggered automatically and periodically, so that Site Monitoring User Request dispatch is performed taking into account the most updated workload.

The result of a Site Monitoring Acquisition Dispatch is a list of Programming Requests with a specific system/satellite that the Federation Services activates in the mission planning services.

4. Federation Services Interfaces with other parts of the GS

The Federation Services are part of larger GS comprised of multiple services, as depicted in Fig. 2. These services are lumped into so-called dominos that are loosely coupled and that will have standardized interfaces enabling easy integration into a full GS. In the DOMINO-X project the interfaces are being defined.

The loose coupling between the dominoes implies that the Ground Segment is mainly data driven:

- There is no centralized orchestration. Each component has to wait for its inputs. The monitoring of the dominoes is in the meantime continuous.
- A process starts when all the inputs are available, there is no synchronous exchange after the start of a process.

The exception to this concept is the Federation component which has the task to orchestrate the processing at multi-mission level, by ordering each process necessary to fulfil the end-user request as soon as the inputs are ready. For instance: start a detection job as soon as the input image product is archived with the desired level.

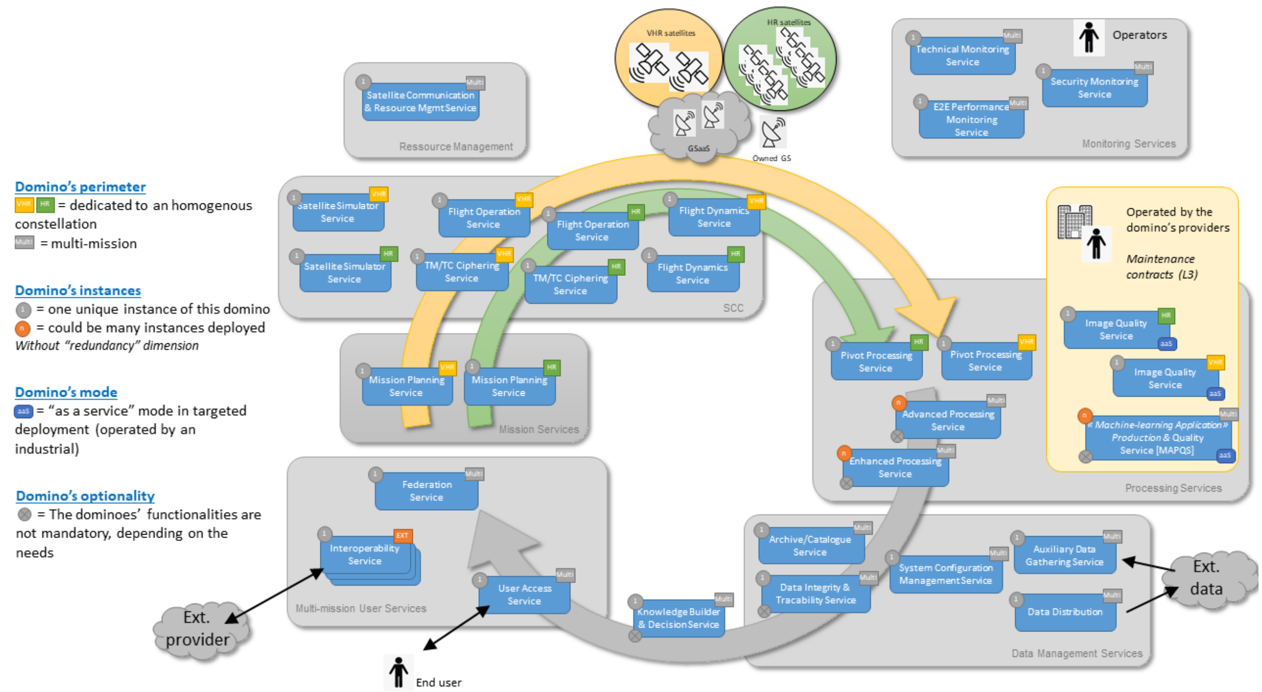

Fig. 2 Diagram representing all the various services that the EO ground segment is comprised of

The Federation Services interfaces, just like for other dominoes, are modelled in a free and publicly available tool called Capella. Fig. 3 is an extract from the model provided here as an illustration of the modelling, focusing on the interfaces between the Federation Services and the User Access Services.

The Federation Services interfaces use web services HTTPS / REST protocol with JSON data format encoding for all Federation interfaces. The OGC API processes applicable standard is applied when possible for capabilities interfaces. STAC API applicable standard is applied when possible for requests consultation interfaces. OpenAPI 3.0 is applied in other cases.

Transfer initiatives are the following:

- Always User Access Services initiative for UAS / FS interfaces
- Always FS initiative for FS / other domino interfaces

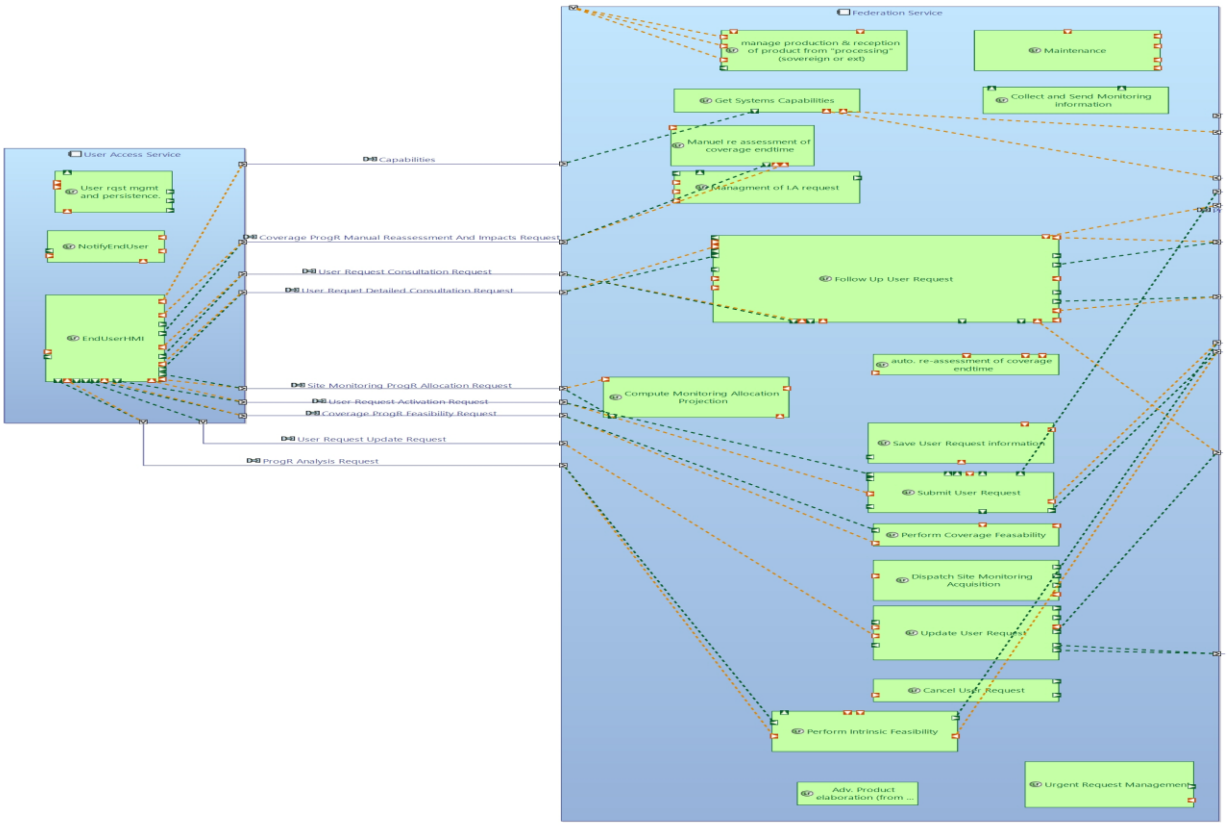

Fig. 3 Interfaces between Federation Services and User Access Services, as modelled in Capella

5. Conclusions

Federation of EO systems is becoming an increasingly important topic as the number of such system increases over time. We are heading towards a systems of systems world. Airbus, via its historic experience of ever more complex systems, is working actively on this topic with the aim to pioneer the next generation of hybrid systems, comprised of optical, infrared or SAR missions. Airbus's solution enables high reactivity in order to fulfil end users' request as fast as possible, be it for large area coverage or for site monitoring applications.

Since federation services may be connected to multiple systems, its interfaces are deliberately public. Model Based System Engineering has been applied and the resulting model is public and the modelling tool is also free and publicly available.

This solution from Airbus is the base for federating other types of EO missions than satellites, typically HAPS and UAV equipped with cameras that will enable more persistency on given zones.

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