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ENHANCING MISSION EFFICIENCY: ADVANCED FLIGHT DYNAMICS AUTOMATION WITH *FOCUSSUITE*

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Abstract

Automation and hands-off operations are becoming indispensable for modern missions, which are growing in complexity to deliver superior services. To keep pace with these advancements, every component, including flight dynamics, must evolve. GMV's flight dynamics solution, ***Focussuite***, has been at the forefront of this evolution, continuously innovating to meet the demands of today's missions.

We are excited to introduce our latest breakthrough: FOCAS (***Focus*** Aggregation Service). This cutting-edge component is designed to enhance mission support by integrating advanced automation and operational capabilities. With FOCAS, we are setting a new standard in flight dynamics, providing our clients with the tools they need to achieve mission success in an increasingly complex space environment

FOCAS is the service responsible for triggering jobs based on external events. Its aim is to fully automate the operations converting ***Focussuite*** in a reactive system. These events can be of any nature, such as the availability of new satellite information, the completion of another process, or an error that requires recovery. To handle scalability, all external events are fed into a message queue, allowing horizontal scaling when the volume of incoming messages is huge. Any external element can be integrated as we provide a Rest API that they can use to publish messages.

This new tool has been integrated in our product ***Autofocus***, the peace of our software in charge of the automation of the operations to give it more capabilities and a better way to define the operations.

Acronyms/Abbreviations

API: Application Programming Interface
CDMs: Conjunction Data Message
SSA: Space Situational Awareness
EUSST: European Union Space Surveillance and Tracking

1. Introduction

The ***Focus Aggregation Service (***FOCAS) is a service that is continuously listening for events from different sources like ***Focus EventsLogger***, a GraphQL server (subscription query) or Apache Kafka (Topics Consumer) or RabbitMQ and it is able to execute actions (Python Scripts) according to the information of these events.

The design provides an extensible framework at all levels: Event Sources, Trigger Conditions and Actions (aka. scripts).

The triggers, scripts and sources can be configured. The FOCAS provides a REST API. The different components can be modified without need of restarting the system. It will also be integrated into the web HMI so users can configure them in a user-friendly way.

The python scripts are extended to ease the generation of the trigger actions. It contains a library developed by GMV for extracting useful information like the event information of the event that triggered the configuration or libraries to connect to ***Focussuite*** API and perform operations.

1.1 FOCAS Architecture

The following components can be identified:

- **Event Source Subscribers**: This component is composed of different services that connect to different streams like Kafka, GraphQL, RabbitMQ or ***Focus Eventslogger***. This element is expected to be an independent element.

- **Scheduler**: This component simulates the arrival of events from the server, defined by cron jobs. Internally it uses Quartz Job Scheduling Library and read all the available jobs from an external database. The cron jobs are user configurable. This component is integrated within previous component.
- **Event broker:** Internal queue to manage all the event and its processing. This queue is an embedded ActiveMQ. It will evolve to use Kafka and therefore external to the service. A component for interfacing to insert events in the queue is provided for simplifying the Event Source generation.
- **Trigger Processor/Action Executor** (aka. **Event Processor**): These components are responsible for reading all the information from the event and execute a specific script according to the triggers in case of occurrence of a trigger condition. The triggers and scripts are loaded from an external database. These scripts can be used to connect to external components such as Kafka, RabbitMQ, ***Focussuite*** API…

The following picture shows a high-level architecture of the system.

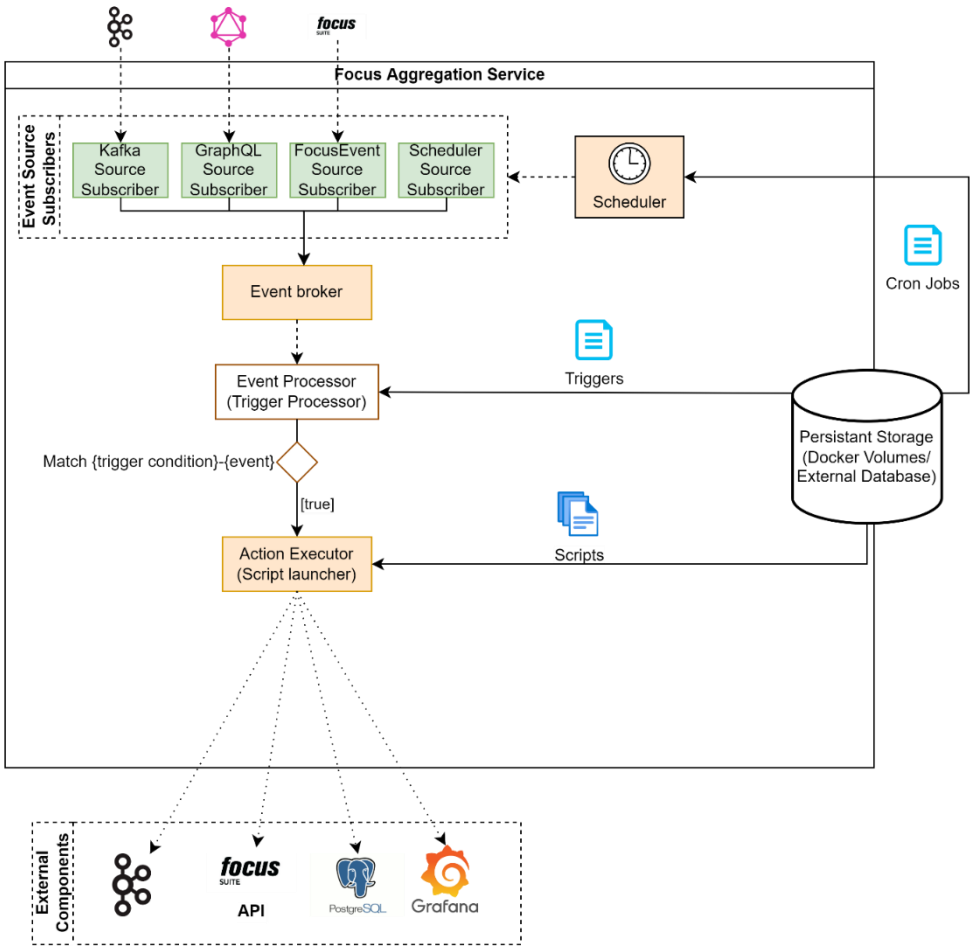

Fig. 1. FOCAS Architecture

2. Application examples

Two different operational applications have been developed already that rely on this component to automate the operations.

In Earth observation missions, the areas targeted for observation may not be predefined or may undergo changes throughout the mission's duration. This presents a unique challenge in improving the use of these missions for data collection. To address this challenge GMV has developed an autonomous service that is capable of computing future imaging opportunities.

This service is designed to work with a user-defined area or point over Earth and takes into consideration various operational constraints.
The operation of this service requires an autonomous Flight Dynamics System, that is able to determine the current orbit of the satellite, propagating it into the future, considering planned manoeuvres, and computing potential image opportunities that arise. And this is reached by using the new version of ***Autofocus*** with FOCAS.
This service is therefore a powerful tool able to maximize the payload use during a mission in a flexible and user-driven manner.
Another use case has been developed capable of calculating the radio frequency resource allocation for each satellite to optimize the routing and performance of a SATCOM constellation. To achieve this, it is necessary to know the evolution of the constellation's topology. This tool exemplifies the need for a service that provides FDS data automatically and autonomously. Given a constellation configuration, which includes the number of satellites, plane configuration, and orbital regimes, ***Focussuite*** is responsible for providing all event data. This data includes station visibility, geographic areas, satellite visibility, collinearities with the Sun, and eclipses, necessary for routing calculation, including meteorological data.
By using ***Autofocus*** with FOCAS, all the necessary logic to trigger these event calculations is established. This setup reacts to both external events, such as a request via an API, and scheduled events, like scheduled periodic execution. The information generated from these calculations is then published through an API, allowing it to be consumed by other subsystems. This integration of automated data provision and reactive calculations is an example of a cutting-edge solution for operational automation, significantly reducing the need for human intervention

3. Future developments

The subsequent phase involves developing an automated system for collision risk assessments utilizing external data sources such as Space-Track, EUSST, or our proprietary service, ***Focusoc***. Recently, GMV has initiated a Flight Dynamics service for SATELIOT, a pioneering New Space operator deploying a 5G NB-IoT constellation in Low Earth Orbit (LEO).
The evolving New Space paradigm necessitates that collision risk assessment becomes a critical and time-intensive task for operators, given the exponential increase in the number of satellites in LEO. This necessitates the automation of this process to the greatest extent possible. With this new version of ***Autofocus***, our system will be capable of responding to Conjunction Data Messages (CDMs) generated by any Space Situational Awareness (SSA) providers, facilitating the generation of new manoeuvre plans that account for these collision risks. This will result in a fully automated process, from the detection to the mitigation of collision risks within our solution.
The process could be described by the following diagram:

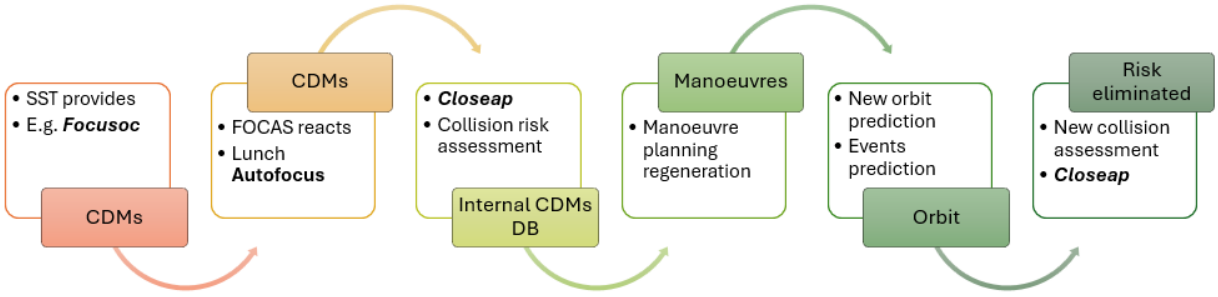

Fig. 4. Risk assessment automation

Withing the SATELIOT mission, this solution will be designed and fully validated.

6. Conclusions

The latest ***Autofocus*** iteration, integrated with FOCAS, is capable of responding to external messages and data files from various subsystems and external providers. This enhancement significantly elevates the automation capabilities of Flight Dynamics Operations. Within the evolving New Space paradigm, this feature is of paramount importance, as collision risk assessment is poised to become one of the most time-consuming tasks for operators. Our solution ensures that this task is fully automated.