Extending Ground Segment Products for supporting a large range of In-Orbit Services

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IOS at Telespazio

Objective

- Develop the capability to support a **large portfolio of in-orbit services**, ranging from deorbiting and satellite life extension solutions to the in-orbit replacement of damaged subsystems
- Position Telespazio as a major supplier for ground segment and operations for in-orbit services in Europe

Strength

- Major service provider in Europe
- Fucino Space Centre
- Trusted operator
- Ground Station Network extended via partnerships
- Close relationship to satellite manufacturer in the Space Alliance

Approach

- Follow **market-driven approach** (market analysis, business plan)
- Develop the **required/missing capabilities** in the Group
- Establish (key) **partnerships**

Target Service Porfolio

- **Orbit raising and positioning / Transportation**: satellites injected in the wrong position by the launcher and requiring the in-space transportation / last mile delivery

- **Relocation and positioning**: satellites already in orbit needing orbital parameters correction and/or change unable to execute the task due to anomalies (e.g. propulsion anomalies, attitude control system anomalies, etc.)

- **Station keeping**: EOL satellites and active satellites with propulsion/attitude control systems anomalies unable to perform orbit correction and to maintain their attitude on their own

- **Inspection**: health check-up or look for anomalies of active satellites already in orbit / characterise and secure IOS ops

- **Deorbiting**: EOL satellites in orbit unable to deorbit but due to propulsion anomalies

- **Refuelling***: EOL satellites already in orbit requiring refuelling for either life extension or deorbiting

- **Delivery of units and in-orbit assembly***: substitution, upgrade or addition of further elements to active satellites already in orbit

- **Repair***: repair of one or more elements of active satellites already in orbit due to a malfunction

- **Active Debris Removal**: debris mitigation targeting risk bodies in orbit improving collision avoidance results, particularly in LEO orbit

(*): Require client spacecraft preparation
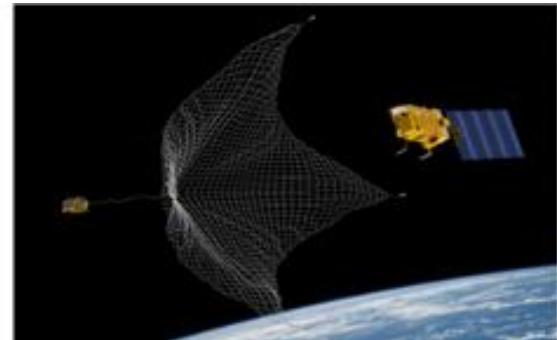
ESA IOS Maturation Phase

Space Alliance contribution to the IOS Mission Maturation Phase ESA Studies, completed end of 2022
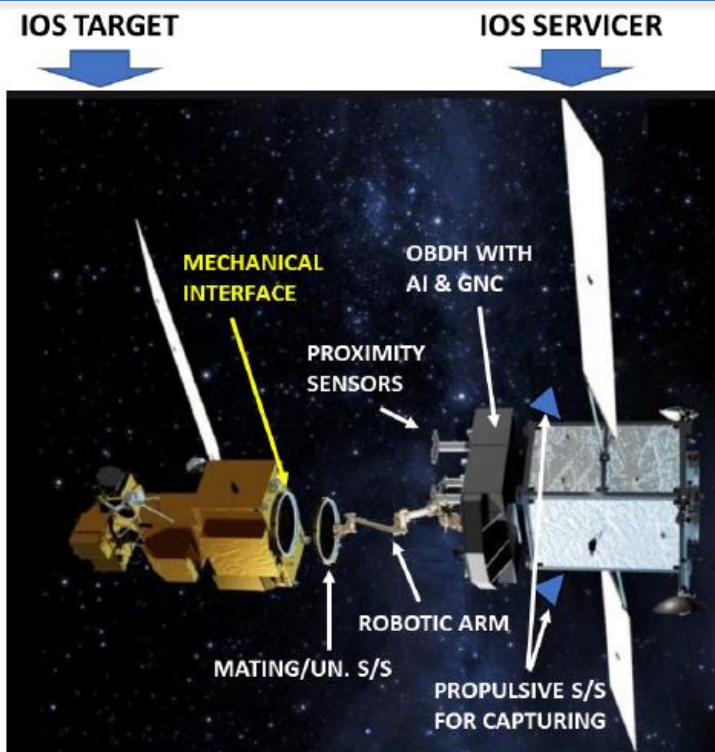
Main maturation elements

- Service specifications
- Roles and responsibilities for operations and service
- Cost estimates and Business Plan
- CONOPS elements
  - Mission description
  - Interactions and coordination with customers during different phases
  - Ground station redundancy
  - Operations roles definition
  - Nominal/backup centres strategy
  - Manning according to phases
- Ground segment elements
  - Flight Dynamics Centre product maturation including Proximity Operations Monitoring
  - Mission Simulator supporting payload operation team during proximity operations
  - Payload/Robotic Simulator supporting payload operation team during capture operations

Segment	Service
Life extension	Orbit raising and positioning
	Relocation and positioning
	Station keeping
Decommission	Deorbiting
Life enhancement	Refuelling
	Delivery of units
	Repair

Italy PNRR IOS

IOS TARGET   IOS SERVICER

MECHANICAL INTERFACE
OBDH WITH AI & GNC
PROXIMITY SENSORS
ROBOTIC ARM
MATING/UN. S/S
PROPULSIVE S/S FOR CAPTURING

- Demo mission enabling key functionalities, technologies and system capabilities to develop a portfolio of in orbit services
  - ✓ De-orbiting/Debris removal
  - ✓ Re-location/Re-orbiting/Life extension
  - ✓ Refuelling
  - ✓ Repairing / Refurbishment
  - ✓ Assembling
- ASI implementing entity
- Launch and subsequent operations not included
- QR and AR in 2026, potential launch would follow

Space Alliance proposition and industrial value chain

**Consortium:** TAS-I (leader), AVIO, Leonardo, TPZ, D-Orbit (co-contractors)

Industrial Role:

- **TAS-I:** design authority and servicer spacecraft (avionics and robotic platform)
- **AVIO:** servicer spacecraft (orbital support and propulsion module)
- **LDO:** robotics payload
- **TPZ:** ground segment (GSN, MCC) and operations preparation and validation
  - **ALTEC** as subco
- **D-Orbit:** target spacecraft and refueling service design

Ground Segment Architecture for IoS

- **Mission Control Center (MCC)**

  - **Mission Control System (MCS):** control system implemented by EASE-MISSION control centre, a solution developed by Telespazio SPA (Italy)

  - **Mission Planning System (MPS):** creation and management of main mission operations: inspection rendezvous, docking, de-orbiting, relocation, refuelling, repairing and assembling

  - **Flight Dynamics System (FDS):** all functionalities required to support orbit determination and prediction, manoeuvre planning and estimation, FD related command preparation, events prediction, pointing data generation.

  - **Network Control Centre (NCC):** communications control including station network scheduling

  - **IOS Proximity and Robotics Management Centre:** covering near RT functionality of absolute & relative navigation and Payload Operation for both Servicer and Target satellite

- **Ground Station Network (GSN):** GS Network to access Space Segment in RF (payload configuration + TM/TC)
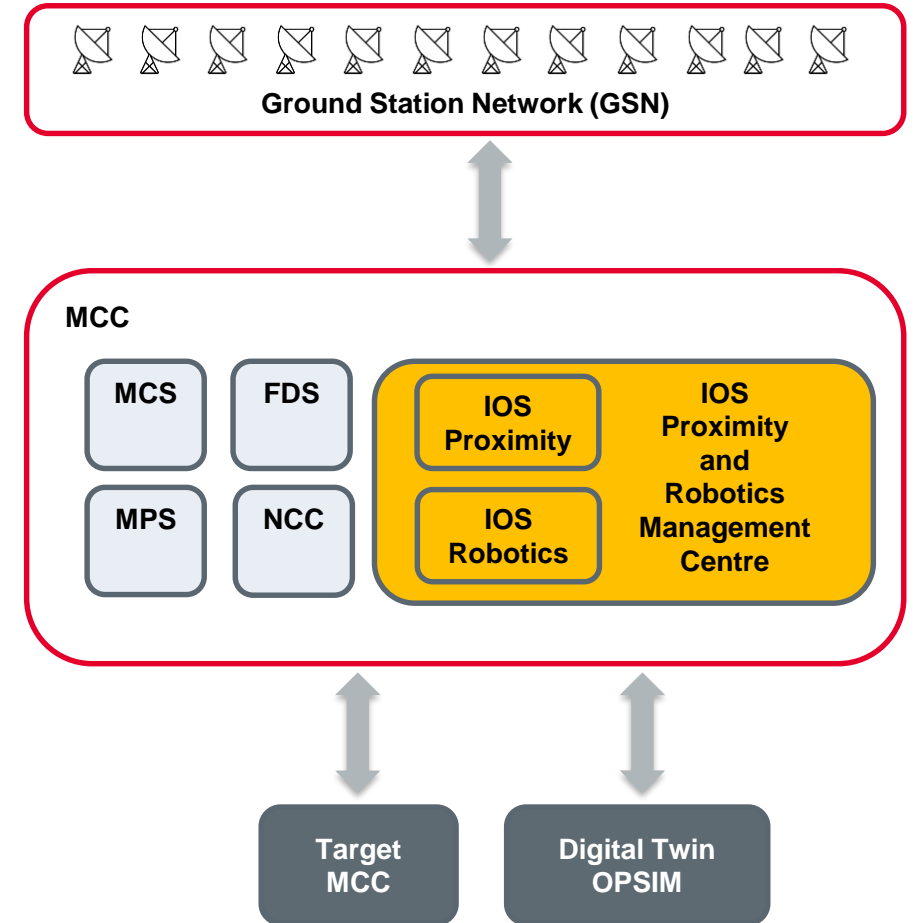
Ground Station Network (Integrated Map)

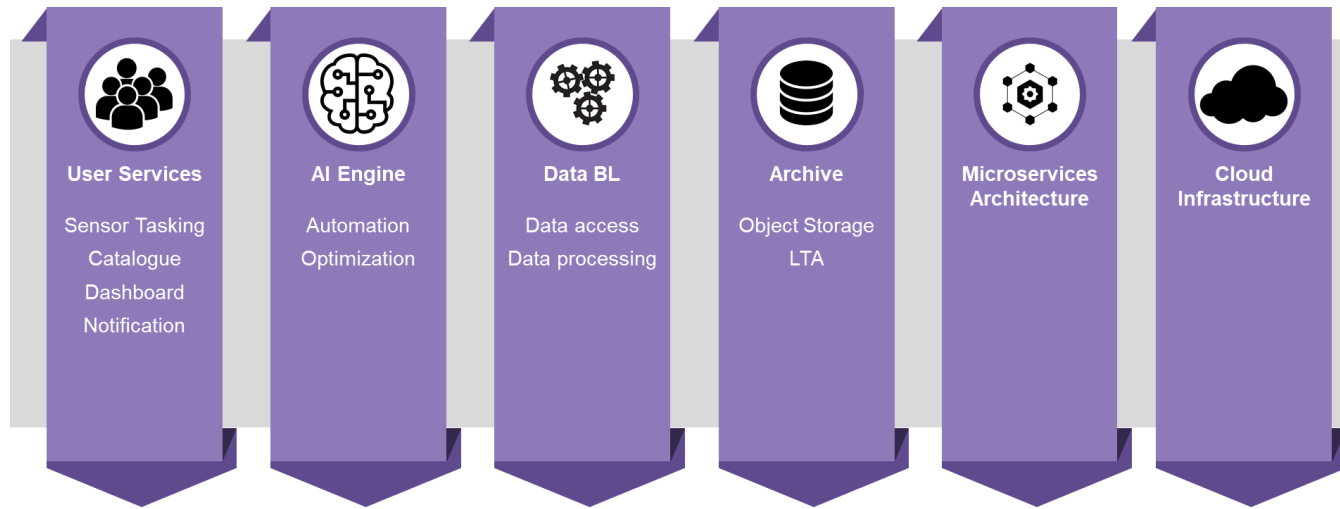*N.B.: Possible additional partners antenna facility could be added in the Ground Station Network*

Telespazio Ground Segment Products

Service Platform	Description	Applicability for the Domain
ease-mission	Multi-mission operations system especially designed to support large and complex spacecraft with strong security requirements. Access its different modules for mission monitoring & control, mission planning and flight dynamics, all from the cloud.	MCS
ease-rise	End-to-end platform for satellite Multi-constellation & multi-asset management . Access all the elements in your mission from a single dashboard and have a clear overview of your service status at a glance. Detect anomalies quickly and receive notifications to take appropriate actions right when needed.	MCS, Network Management
ease-access	Central platform to dynamically manage the ground station network and establish links towards satellites. It natively supports multiple protocols conversion, flexible ground station brokering, monitor and control of antenna subsystems and WAN status. It interfaces with proprietary and third party ground stations in dierent bands.	GS & Net Mgmt
ease-ground	Multi-mission and multi-sensor system, implementing big data by design and supporting from simple to high performance payload data computing. It enhances your user experience and data usability by generating predictive patterns on your preferences and data insights. The right data for your mission and your users.	OTT, Hosted-Payload mgmt, Hosted GS

Telespazio Space Domain Awareness Platform

Main features and functionalities of SDA Platform are based on the **ease-ground**

User Services	AI Engine	Data BL	Archive	Microservices Architecture	Cloud Infrastructure
Sensor Tasking Catalogue Dashboard Notification	Automation Optimization	Data access Data processing	Object Storage LTA		

Building block concept to easily provide tailoring of functions thanks to **architecture based on micro-services**;

Cloud native (IaaS and PaaS support) to provide **Scalability** and **Reliability**;

Web-based User Interface to enhance and lighten the User Experience.

Artificial Intelligence (Machine Learning / Deep Learning), capable of generating Data Analytics and insights derived from the analysis of a large amount of measurements and observations.
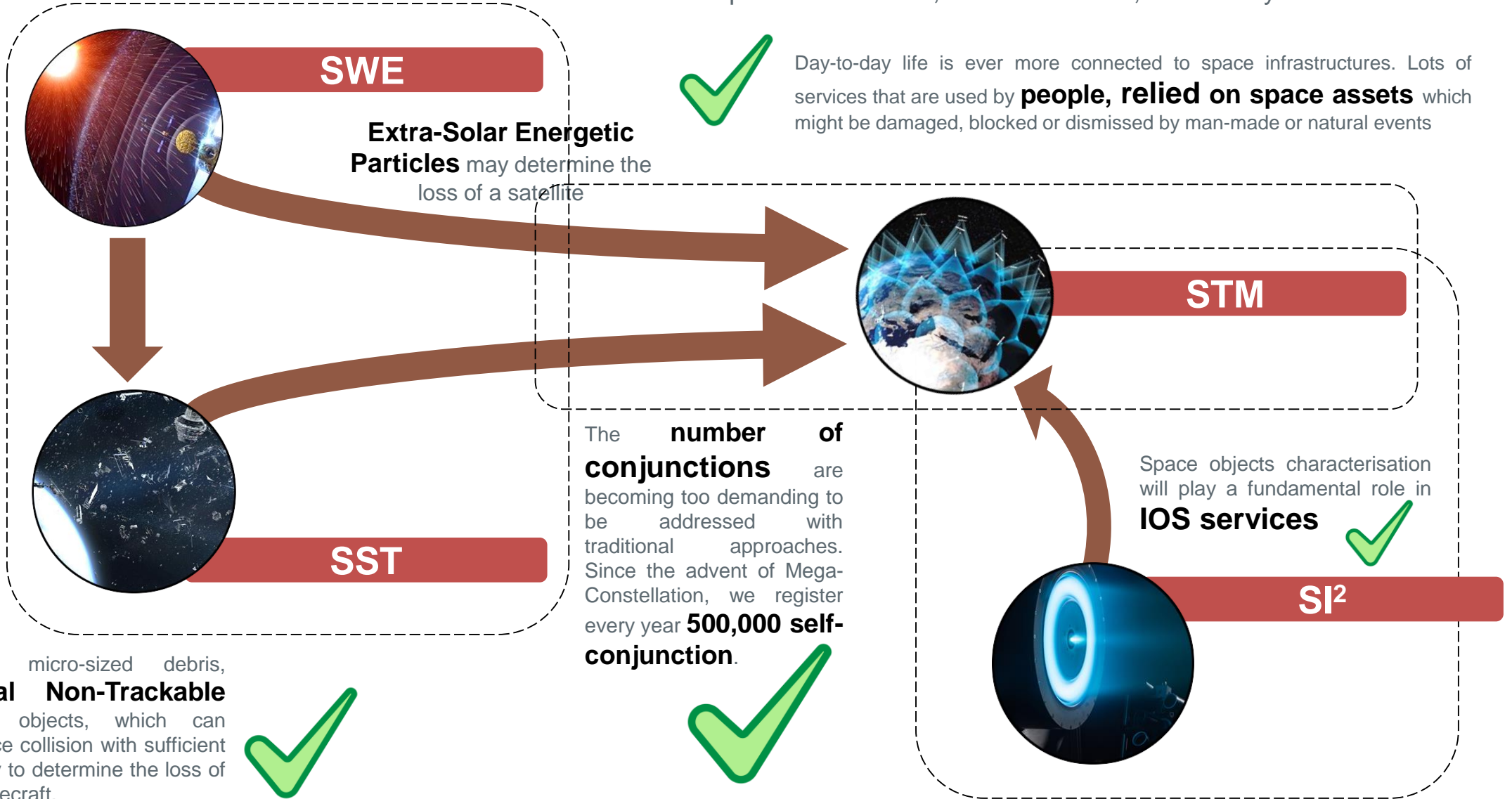
Scalable and flexible ICT infrastructures (Cloud) able to guarantee sufficient **storage** and **calculation** capacity to enable efficient **data exploitation** and **visualisation**;

Telespazio SDA & IOS services

By **exploiting different type of data**, the Platform will be able to address problems that are, most of the time, intrinsically correlated.

✓ Day-to-day life is ever more connected to space infrastructures. Lots of services that are used by **people, relied on space assets** which might be damaged, blocked or dismissed by man-made or natural events

SWE

Extra-Solar Energetic Particles may determine the loss of a satellite

A significant solar activity may increase the **perturbing effects** induced on the satellite

STM

SST

The **number of conjunctions** are becoming too demanding to be addressed with traditional approaches. Since the advent of Mega-Constellation, we register every year **500,000 self-conjunction**.

Detect micro-sized debris, **Lethal Non-Trackable** space objects, which can produce collision with sufficient energy to determine the loss of a spacecraft.

Space objects characterisation will play a fundamental role in **IOS services**

SI²

SDA Services Platform (SPADA)

Running the AI

- A Sandbox environment can be generated for each user on the SDA platform

- It can be created both **for expert users that would like to develop**

- The sandbox will generate algorithms and applications, able to exploit the platform resources **with direct access to the data lake**

- Resources are directly assigned to each user based on its privileges
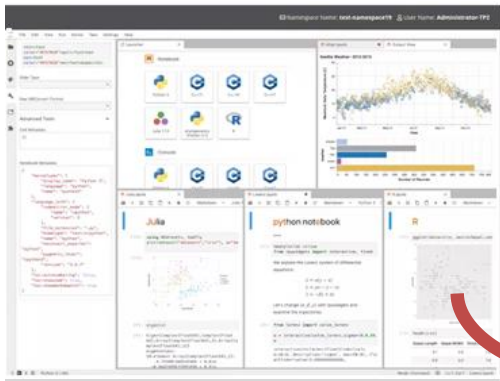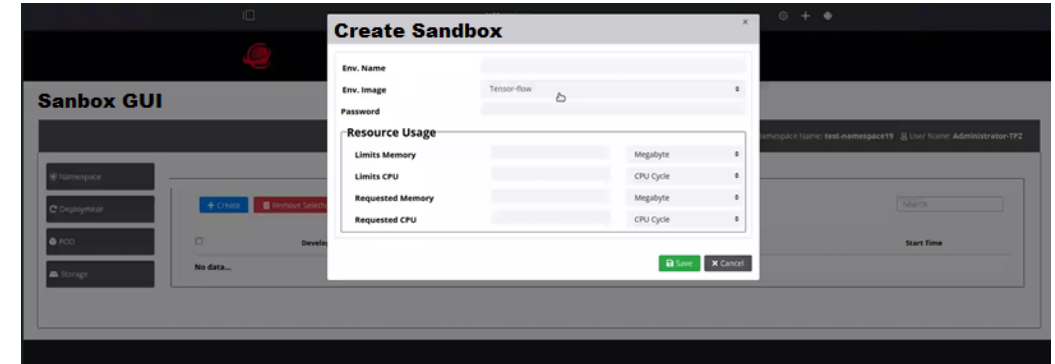
- Sandbox provides template environment images, e.g. **Jupyter Notebook**

- Possibility to **debug the algorithms directly** on the platform close to the data
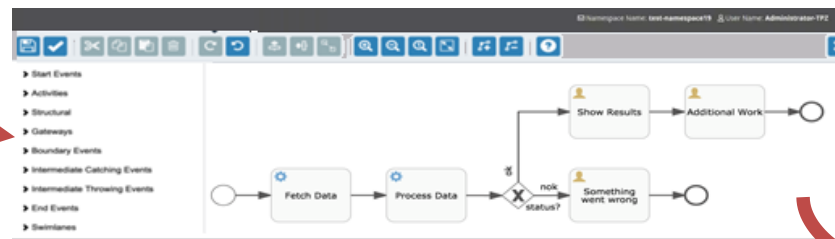
- Directly build and deploy of the algorithm/application
- Configure execution workflows
- **Exploitation and monitoring of the running algorithms** and applications

Products Evolution

- Integration of Proximity and Robotics Management Centre

- Cyber and physical security specific to type of service/mission, handling of classified data

- Closed loop planning driven by telemetry and situation assessment

- Evolution of product lines to integrate Ground Segment products with Space Domain Awareness platform and create environment where IOS missions' elements are fused together, spanning from management of space assets to management of information (observations, manoeuvres chaser / target, etc.)

- Artificial intelligence for automation and autonomous operations improving IOS activities planning and reaction timings:

  - Development of Vision Based Navigation techniques implemented thanks to the integration of Simulink providing space asset physical behaviour as input to the Digital Twin

  - Physics informed neural network to realize a digital twin for accurate simulation of system behaviour (target + servicer) required for guidance and effective operations

  - Statistical Learning, Time Series regression, Random Forest classifiers to predict and recommend automated operational procedures, telecommands and housekeeping of the space assets

- Future evolutions would benefit from further standardization of interfaces of space and ground components

![TELESPAZIO - a LEONARDO and THALES company]

THANK **YOU**
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