Space It Up!
SPOKE 2

ADVANCED DESIGN AND ANALYSIS OF SPACE MISSIONS AND SYSTEMS AND INNOVATIVE DIGITALIZATION - SYSTEM ENGINEERING AND DIGITAL TWIN

Speaker: Fabrizio Piergentili (Spoke Leader)

SIU! Days 26-28 January 2026, Florence

AGENZIA SPAZIALE ITALIANA

Ministero dell'Università e della Ricerca

The Space It Up! project is funded by the Italian Space Agency (ASI) and the Ministry of University and Research (MUR), under contract no. 2024-5-E.0 – CUP I53D24000060005.

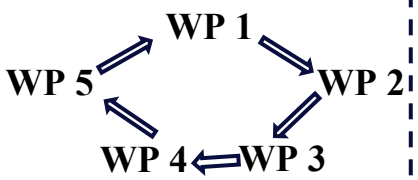
Spoke Leader: UNIROMA1

WORKFLOW TO REACH THE TOOLS DEFINITION

Work based on Tasks

TASK 1
TASK 2
TASK N

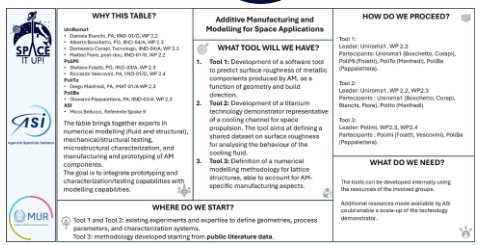
Sinergies inter-WP



Plenary Meeting

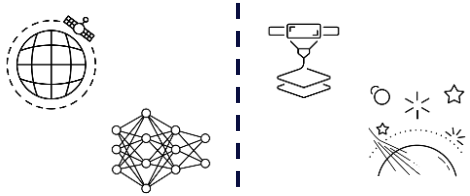
Work based on Tools

1 2 3 4 5 6 7



TASK 1
TASK N
TASK 2

Sinergies intra-WP



4 thematic areas

Tools definition

SPOKE 2 PLENARY MEETING

Working session, Spoke 2

1. **Synergy mapping**
   Across Tasks and Work Packages within the Spoke

2. **4 thematic areas**
   Shared framing and definition of common interests

3. **Plenary meeting: Rome, December 9th**
   Work organized in 4 tables (rooms) to coordinate activities

Keywords

DIALOGUE | SINERGY | UPDATES | TOOL | OBJECTIVES

SPOKE 2 TOOLS OVERVIEW
7 tools, grouped in 4 thematic areas

ID	TOOL	WP	PARTNERS
Digital twins for Space Missions			
TOOL1	STAR: Space mission Twin for Architecture Representation	WP 2.2, WP 2.4, WP 2.5	UNIROMA1, UNIPD, UNIPA, POLIMI, POLITO, TELESPAZIO, INRIM, SITAEL
TOOL2	Digital Twin for Lunar Surface exploration scenario	WP 2.4	TELESPAZIO, UNIROMA1
Additive Manufacturing and Modelling for Space Applications			
TOOL3	Defect Modeling and Fatigue Damage Detection in Lattice Structure	WP 2.3, WP 2.4	POLIMI, POLIBA
TOOL4	SHARPEN: preciSe rougHness lAseR-Powder bEd fabricatioN	WP 2.3	UNIROMA1, POLIMI, POLITO, POLIBA
AI-Driven approaches for Spacecraft Design and Operations			
TOOL5	LLM-Based rag tool for spacecraft preliminary design process	WP 2.4, WP 2.5	TAS-I, UNIROMA1
TOOL6	Software for classification of anthropic areas in Earth Observation images	WP 2.5, WP 2.4	MAPSAT, UNIROMA1
Space Weather impact on Space Missions			
TOOL7	Space Weather Impact on Space Missions	WP 2.2	GSSI+/SISSA, POLITO

SPOKE 2 TOOLS OVERVIEW
7 tools, grouped in 4 thematic areas

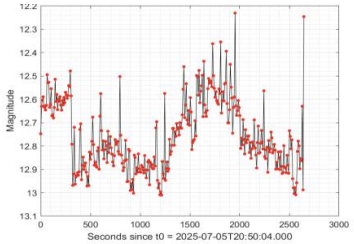
ID	TOOL	WP	PARTNERS
Digital twins for Space Missions			
TOOL1	STAR: Space mission Twin for Architecture Representation	WP 2.2, WP 2.4, WP 2.5	UNIROMA1, UNIPD, UNIPA, POLIMI, POLITO, TELESPAZIO, INRIM, SITAEL
TOOL2	Digital Twin for Lunar Surface exploration scenario	WP 2.4	TELESPAZIO, UNIROMA1
Additive Manufacturing and Modelling for Space Applications			
TOOL3	Defect Modeling and Fatigue Damage Detection in Lattice Structure	WP 2.3, WP 2.4	POLIMI, POLIBA
TOOL4	SHARPEN: preciSe rougHness lAseR-Powder bEd fabricatioN	WP 2.3	UNIROMA1, POLIMI, POLITO, POLIBA
AI-Driven approaches for Spacecraft Design and Operations			
TOOL5	LLM-Based rag tool for spacecraft preliminary design process	WP 2.4, WP 2.5	TAS-I, UNIROMA1
TOOL6	Software for classification of anthropic areas in Earth Observation images	WP 2.5, WP 2.4	MAPSAT, UNIROMA1
Space Weather impact on Space Missions			
TOOL7	Space Weather Impact on Space Missions	WP 2.2	GSSI+/SISSA, POLITO

TOOL1: STAR: SPACE MISSION TWIN FOR ARCHITECTURE REPRESENTATION

A multi-level digital twin framework from mission and constellation design down to satellite's subsystems

REFLECTANCE MODULE

Optical signature of the bus under realistic illumination conditions to predict **light curves** and **brightness**

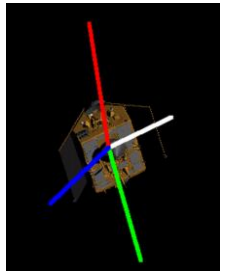


CLOCK ANOMALIES MODULE

Identification of **anomalies** in atomic clocks, and correlation with **environmental parameters** (temperature, humidity, etc.)

ATTITUDE MODULE

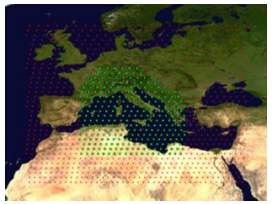
- Support to **what-if analysis**
- **Rotational dynamics** of **tumbling objects**, including the effects of both **external torques and internal perturbations**



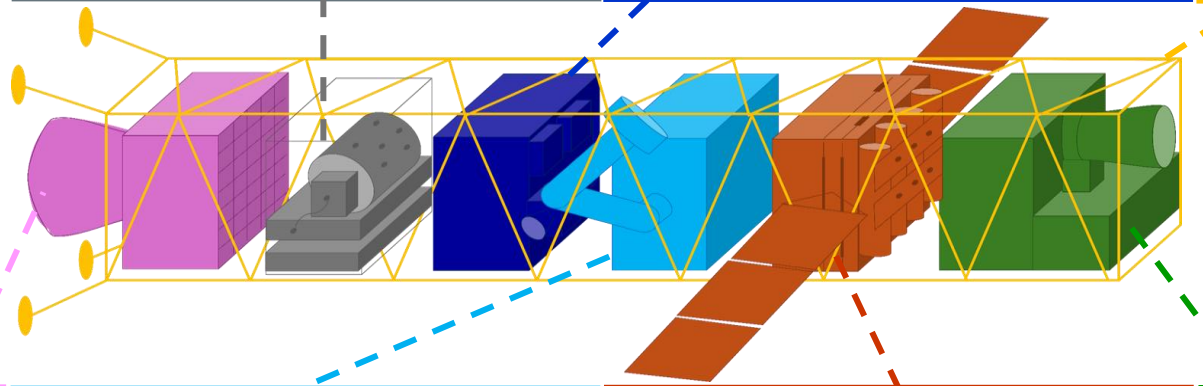
STRUCTURE MODULE

- **Multi-fidelity simulation for analysis of space structures**
- **Degradation of materials and structures** subject to **thermal cycles and radiation**
- **Interaction between with the surface of** a planetary body
- **SHM** tool for monitoring the structural health of **flexible components**

CONSTELLATION OPTIMIZER AND MISSION DESIGNER

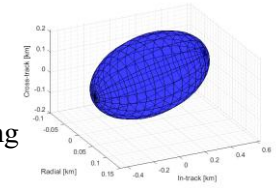


Optimization and **Design** of **satellite constellations** based on customizable mission parameters and sensors benchmarking



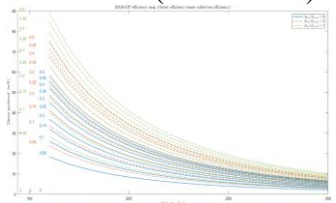
COLLISION AVOIDANCE MODULE

Assessment of conjunction events through covariance-based **collision probability estimation**, supporting the definition of collision avoidance **manouvers**



ABEP MODULE

Performance and operation of an Air-Breathing Electric Propulsion system for applications in VLEO (160-300 km)

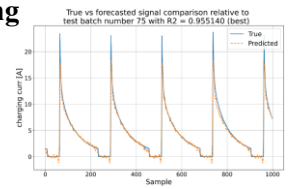


MANIPULATOR MODULE

Design, remote control and training in Manufacturing, Assembly, Integration and Testing activities and **in On-orbit Servicing, Assembly, and Manufacturing** operations

EPS MODULE

- **Batteries State Of Health (SOH) monitoring**
- **Solar array wing cells degradation monitoring**



OBSERVATION MODULE

Simulating the **full observation process** of a space sensor, enabling **performance assessment, trade-off analysis, and synthetic dataset production**

LEGGE SPAZIO ITALIA, GIUGNO 2025

Requisiti oggettivi per l'esercizio di attivita' spaziali

Sicurezza delle attivita' spaziali in tutte le loro fasi e i loro aspetti, dalla **progettazione dell'oggetto spaziale e delle sue componenti** alla gestione delle attivita' spaziali

Requisiti soggettivi generali

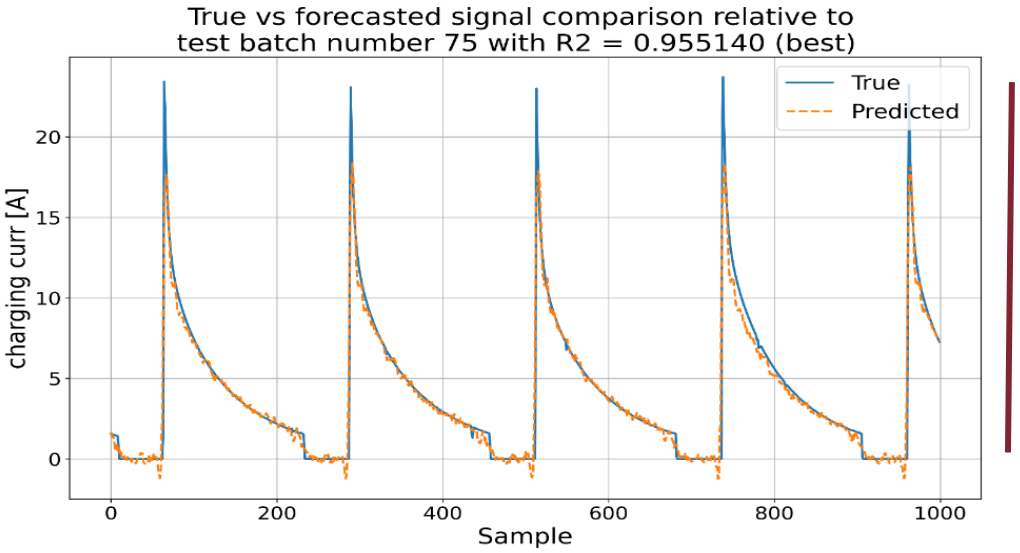
Disponibilita' di un servizio di prevenzione delle collisioni, in proprio o provvisto da un fornitore abilitato

Requisiti oggettivi per l'esercizio di attivita' spaziali

Valutazione relativa all'inquinamento luminoso e radioelettrico prodotto dagli oggetti spaziali e alla mitigazione degli effetti dei detriti spaziali

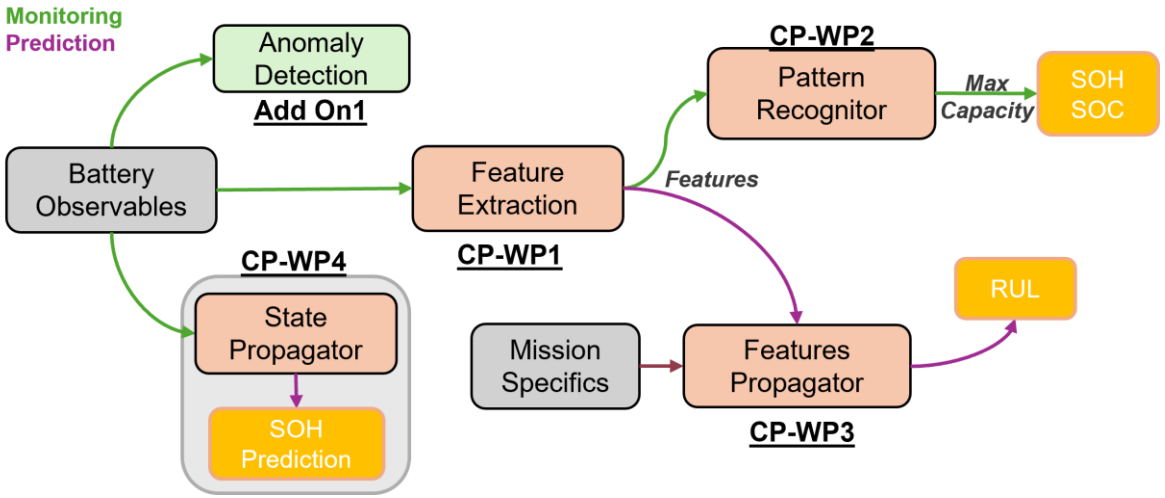
EPS MODULE

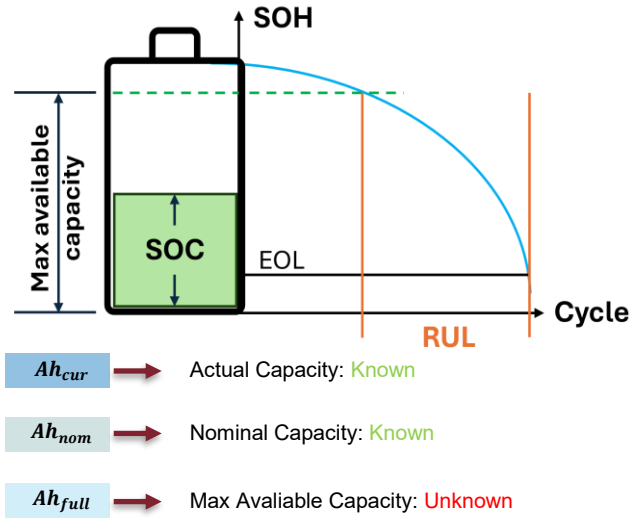
Digital Twins for Space Battery Management Systems



Develop a **data-driven framework** to predict Health and **Useful Life**, using **historical telemetry** and **mission requirements**.

This involves linking degradation trends with operational and environmental conditions to **optimize battery sizing, improve energy management** and extend the service life of satellites.



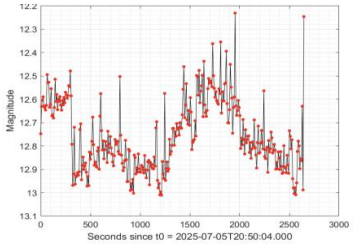


TOOL1: STAR: SPACE MISSION TWIN FOR ARCHITECTURE REPRESENTATION

A multi-level digital twin framework from mission and constellation design down to satellite's subsystems

REFLECTANCE MODULE

Optical signature of the bus under realistic illumination conditions to predict **light curves** and **brightness**

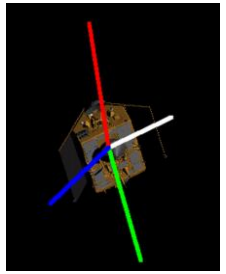


CLOCK ANOMALIES MODULE

Identification of **anomalies** in atomic clocks, and correlation with **environmental parameters** (temperature, humidity, etc.)

ATTITUDE MODULE

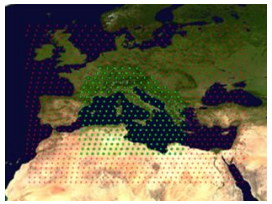
- Support to **what-if analysis**
- **Rotational dynamics** of **tumbling objects**, including the effects of both **external torques and internal perturbations**



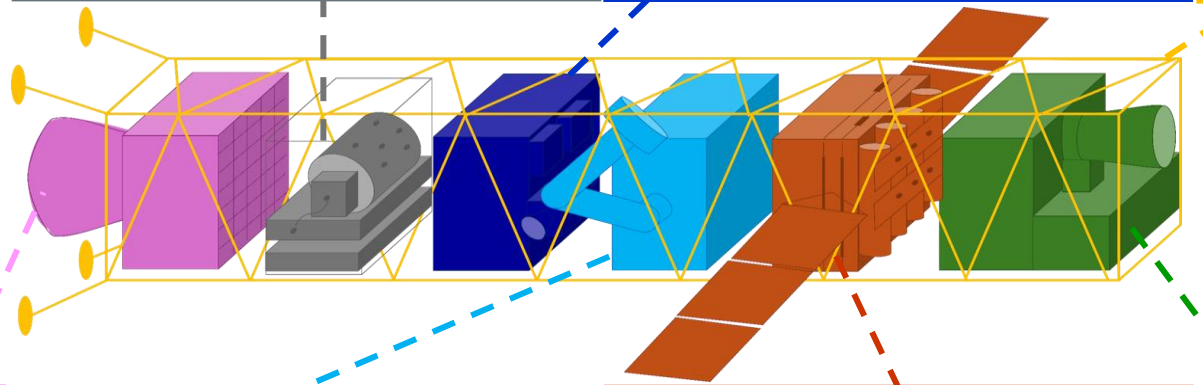
STRUCTURE MODULE

- **Multi-fidelity simulation for analysis of space structures**
- **Degradation of materials and structures** subject to **thermal cycles and radiation**
- **Interaction between with the surface of** a planetary body
- **SHM** tool for monitoring the structural health of **flexible components**

CONSTELLATION OPTIMIZER AND MISSION DESIGNER

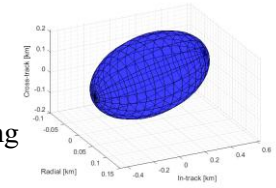


Optimization and **Design** of **satellite constellations** based on customizable mission parameters and sensors benchmarking



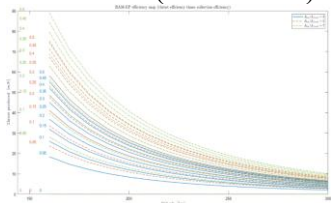
COLLISION AVOIDANCE MODULE

Assessment of conjunction events through covariance-based **collision probability estimation**, supporting the definition of collision avoidance **manouvers**



ABEP MODULE

Performance and operation of an Air-Breathing Electric Propulsion system for applications in VLEO (160-300 km)

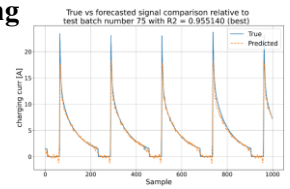


MANIPULATOR MODULE

Design, remote control and training in Manufacturing, Assembly, Integration and Testing activities and **in On-orbit Servicing, Assembly, and Manufacturing** operations

EPS MODULE

- **Batteries State Of Health (SOH) monitoring**
- **Solar array wing cells degradation monitoring**



OBSERVATION MODULE

Simulating the **full observation process** of a space sensor, enabling **performance assessment, trade-off analysis, and synthetic dataset production**

LEGGE SPAZIO ITALIA, GIUGNO 2025

Requisiti oggettivi per l'esercizio di attivita' spaziali

Sicurezza delle attivita' spaziali in tutte le loro fasi e i loro aspetti, dalla **progettazione dell'oggetto spaziale e delle sue componenti** alla gestione delle attivita' spaziali

Requisiti soggettivi generali

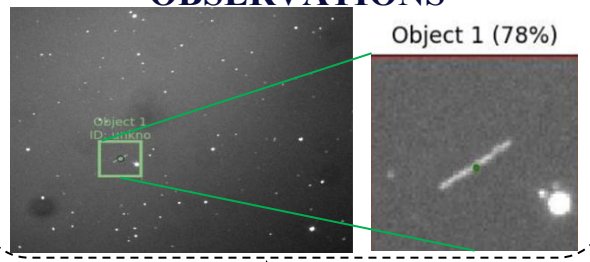
Disponibilita' di un servizio di prevenzione delle collisioni, in proprio o provvisto da un fornitore abilitato

Requisiti oggettivi per l'esercizio di attivita' spaziali

Valutazione relativa all'inquinamento luminoso e radioelettrico prodotto dagli oggetti spaziali e alla mitigazione degli effetti dei detriti spaziali

COLLISION AVOIDANCE MODULE

OBSERVATIONS

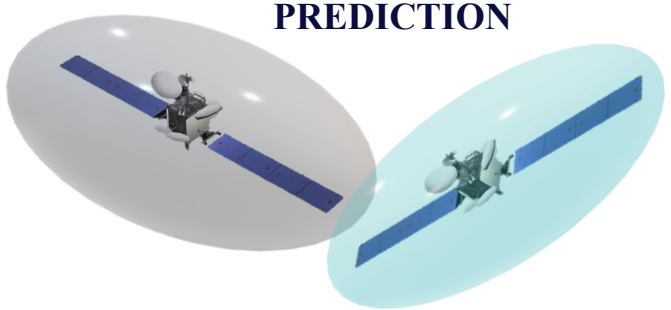


CATALOGUED TLEs

REAL ORBITAL DATA

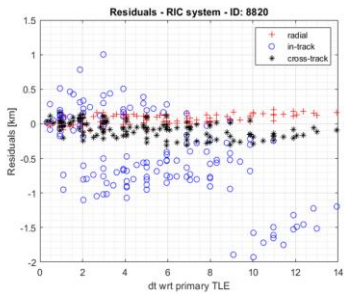
COLLISION PROBABILITY PREDICTION

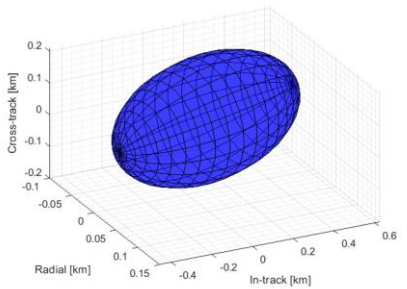
ALERT MESSAGE



Example of Covariance Ellipsoid Estimation for a LEO object

Name: LAGEOS 1
SSN: 8820
Orbit: LEO
Eccentricity: 0.004
Inclination: 109°
Period: 3.7h



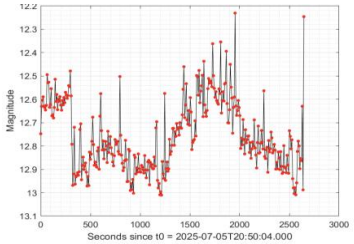


TOOL1: STAR: SPACE MISSION TWIN FOR ARCHITECTURE REPRESENTATION

A multi-level digital twin framework from mission and constellation design down to satellite's subsystems

REFLECTANCE MODULE

Optical signature of the bus under realistic illumination conditions to predict **light curves** and **brightness**

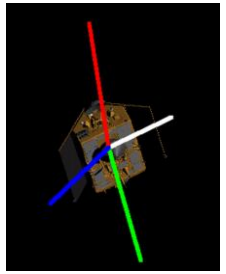


CLOCK ANOMALIES MODULE

Identification of **anomalies** in atomic clocks, and correlation with **environmental parameters** (temperature, humidity, etc.)

ATTITUDE MODULE

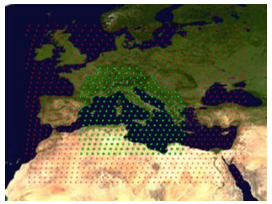
- Support to **what-if analysis**
- **Rotational dynamics** of **tumbling objects**, including the effects of both **external torques and internal perturbations**



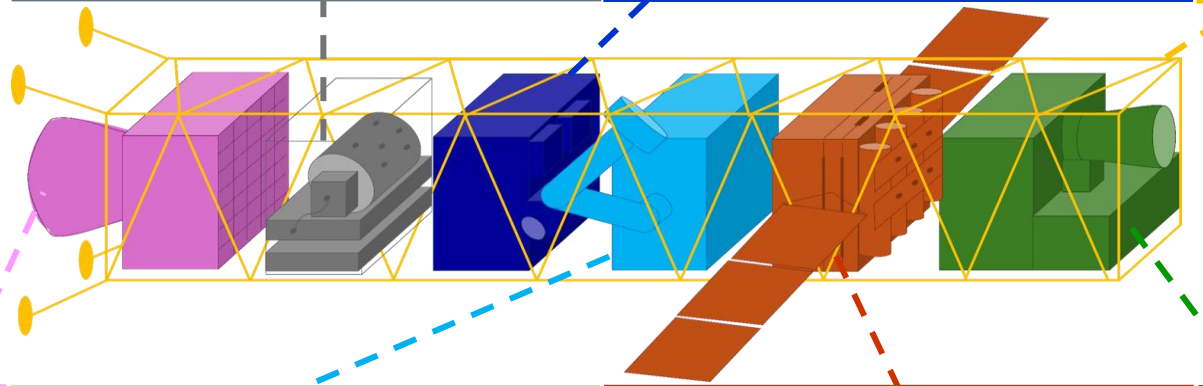
STRUCTURE MODULE

- **Multi-fidelity simulation for analysis of space structures**
- **Degradation of materials and structures** subject to **thermal cycles and radiation**
- **Interaction between with the surface of** a planetary body
- **SHM** tool for monitoring the structural health of **flexible components**

CONSTELLATION OPTIMIZER AND MISSION DESIGNER

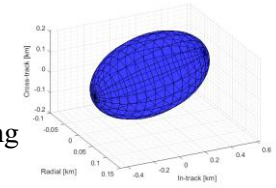


Optimization and **Design** of **satellite constellations** based on customizable mission parameters and sensors benchmarking



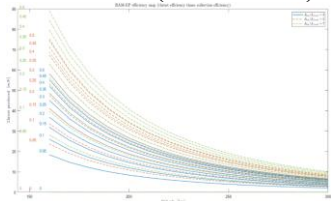
COLLISION AVOIDANCE MODULE

Assessment of conjunction events through covariance-based **collision probability estimation**, supporting the definition of collision avoidance **manouvers**



ABEP MODULE

Performance and operation of an Air-Breathing Electric Propulsion system for applications in VLEO (160-300 km)

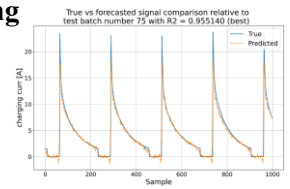


MANIPULATOR MODULE

Design, remote control and training in Manufacturing, Assembly, Integration and Testing activities and **in On-orbit Servicing, Assembly, and Manufacturing** operations

EPS MODULE

- **Batteries State Of Health (SOH) monitoring**
- **Solar array wing cells degradation monitoring**



OBSERVATION MODULE

Simulating the **full observation process** of a space sensor, enabling **performance assessment, trade-off analysis, and synthetic dataset production**

LEGGE SPAZIO ITALIA, GIUGNO 2025

Requisiti oggettivi per l'esercizio di attivita' spaziali

Sicurezza delle attivita' spaziali in tutte le loro fasi e i loro aspetti, dalla **progettazione dell'oggetto spaziale e delle sue componenti** alla gestione delle attivita' spaziali

Requisiti soggettivi generali

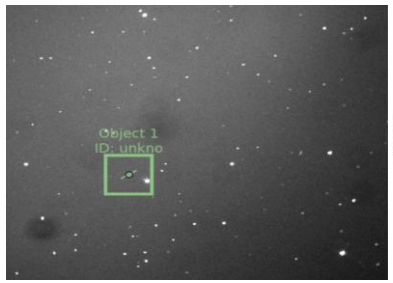
Disponibilita' di un servizio di prevenzione delle collisioni, in proprio o provvisto da un fornitore abilitato

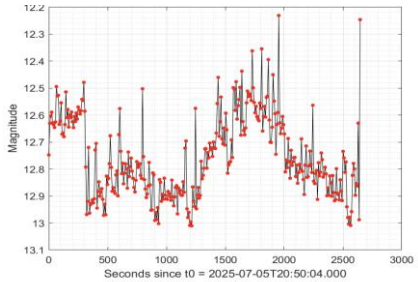
Requisiti oggettivi per l'esercizio di attivita' spaziali

Valutazione relativa all'inquinamento luminoso e radioelettrico prodotto dagli oggetti spaziali e alla mitigazione degli effetti dei detriti spaziali

REFLECTANCE MODULE

OPTICAL OBSERVATION DATA



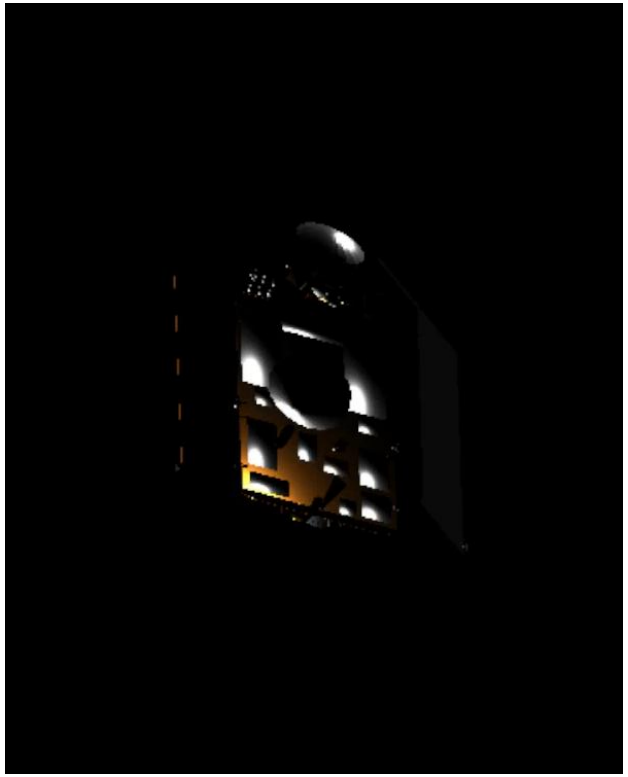


SAPIENZA S5LAB TELESCOPES NETWORK

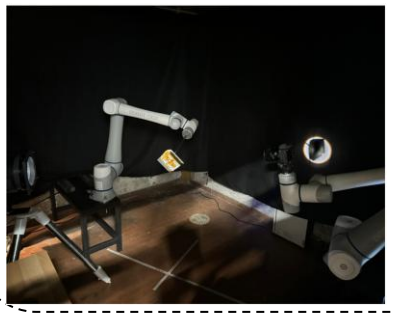
DIGITAL TWIN with BRIGHTNESS PREDICTION CAPABILITIES

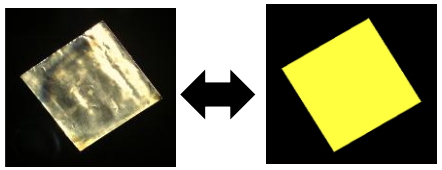
Support to:

- In-orbit objects, for trackability enhancement
- To-be-launched objects for brightness characterization and models calibration
- Design phase of spacecraft, for better compliance to guidelines



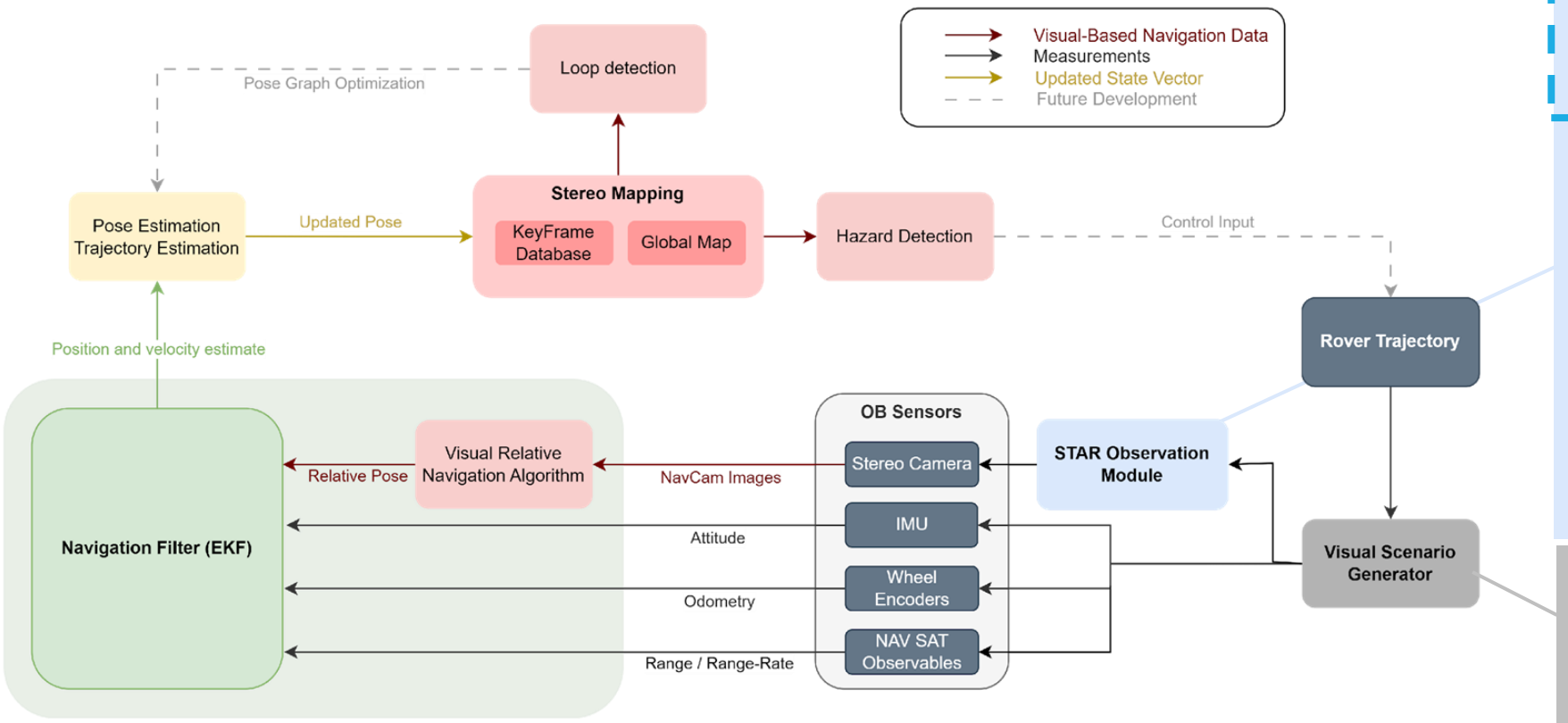
TEST-DERIVED BRIGHTNESS



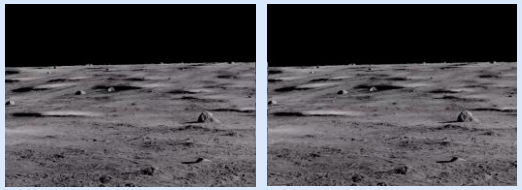


SAPIENZA S5LAB ROBOTIC ARMS FACILITY

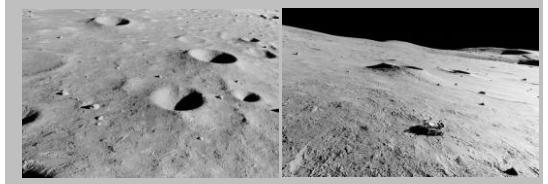
TOOL 2: **DIGITAL TWIN FOR LUNAR SURFACE EXPLORATION SCENARIO**
Extension to the STAR Observation Module – Lunar Rover Use Case



STAR Observation module exploited for generating **synthetic images from the stereo camera sensor**, which are **input to the optical navigation module**

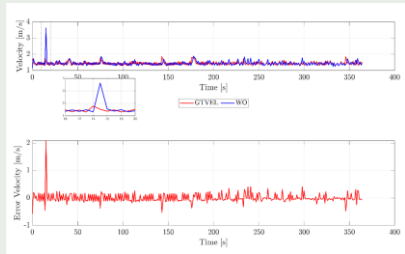


Generation of a **terrain tile with enhanced terrain resolution** (down to cm/px) and **added synthetic terrain features** (rocks, boulders, craters)



Reliable **state estimation in long-range autonomous navigation** cannot rely on a single sensing modality

Optical navigation, inertial and wheel-encoder data are **combined** in the EKF
Ephemeris from a lunar navigation constellation can be integrated within the navigation filters radio-navigation observables



Wheel Odometry readout and rover Ground-Truth velocity

SPOKE 2 TOOLS OVERVIEW
7 tools, grouped in 4 thematic areas

ID	TOOL	WP	PARTNERS
Digital twins for Space Missions			
TOOL1	STAR: Space mission Twin for Architecture Representation	WP 2.2, WP 2.4, WP 2.5	UNIROMA1, UNIPD, UNIPA, POLIMI, POLITO, TELESPAZIO, INRIM, SITAEL
TOOL2	Digital Twin for Lunar Surface exploration scenario	WP 2.4	TELESPAZIO, UNIROMA1
Additive Manufacturing and Modelling for Space Applications			
TOOL3	Defect Modeling and Fatigue Damage Detection in Lattice Structure	WP 2.3, WP 2.4	POLIMI, POLIBA
TOOL4	SHARPEN: preciSe rougHness lAseR-Powder bEd fabricatioN	WP 2.3	UNIROMA1, POLIMI, POLITO, POLIBA
AI-Driven approaches for Spacecraft Design and Operations			
TOOL5	LLM-Based rag tool for spacecraft preliminary design process	WP 2.4, WP 2.5	TAS-I, UNIROMA1
TOOL6	Software for classification of anthropic areas in Earth Observation images	WP 2.5, WP 2.4	MAPSAT, UNIROMA1
Space Weather impact on Space Missions			
TOOL7	Space Weather Impact on Space Missions	WP 2.2	GSSI+/SISSA, POLITO

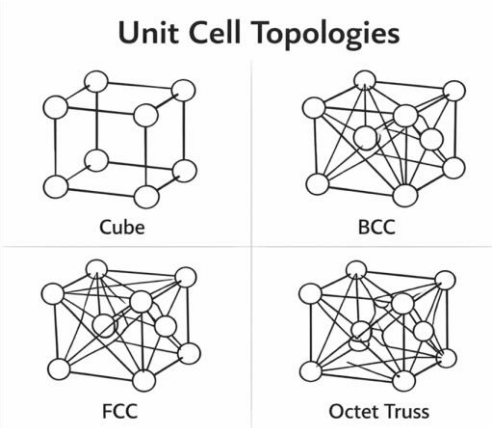
TOOL3: **DEFECT MODELING AND FATIGUE DAMAGE DETECTION IN LATTICE STRUCTURES**

OBJECTIVES:

1. Develop a numerical framework to model the **mechanical response of lattice** accounting for **geometrical and material imperfections**
2. Assess an acoustic-based **Non-Destructive Testing** method **to detect, locate and quantify damage**

Lattice structures

Lattice structures are cellular materials organized in a repetition of a unit cell



Properties and applications

The **tunable topology** of lattice structures enables tailored stiffness, energy absorption, damping, permeability and thermal transport for the target application.

- **Isostatic mounting devices** with minimal thermal conductivity
- **Heat pipes** featuring porous lattice wicks to enhance capillary
- **Damping panels** for improved vibration attenuation.
- **Lightweight structural components** with tailored stiffness-to-weight

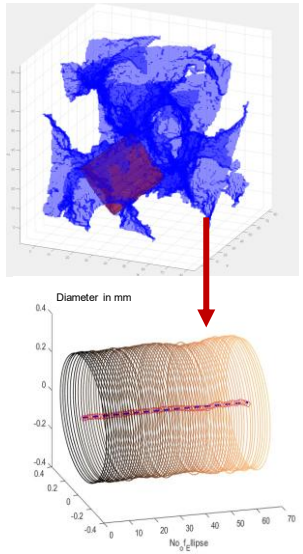
Challenges

Because lattice structures contain **hundreds of unit cells**, two key issues arise:

- **high computational cost** for modeling and simulation
- increased demands on **inspection**, including quality control and damage detection, to reliably assess the manufactured part

Modelling of defects and FE model

Identification of defects from CT scan

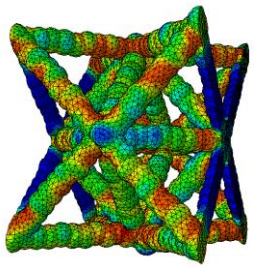


Single strut extracted from the lattice

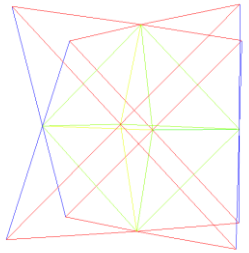
Struts are represented as the **union of multiple spheres,** whose **radius**, **offset**, and **spacing** vary randomly according to statistical distributions derived from CT scans.

Modelling strategy based on:

- 1D elements
- homogenized material including the effect of defects



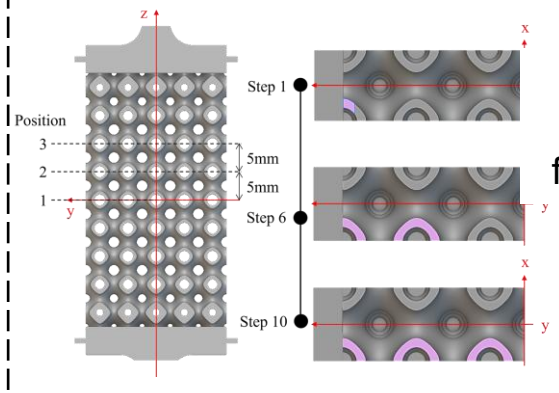
3D octet cell model



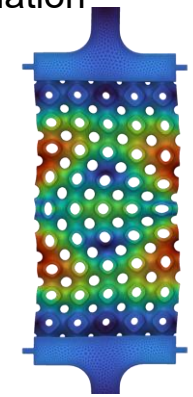
1D octet cell model

Damage Detection

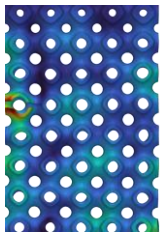
Artificial Neural Network training and validation



Numerical natural frequences



Integer



Damaged

Experimental Dataset

ART (Acustic Resonant Testing) for natural frequences

Pre-fatigue test → Post-fatigue test

Related presentation: Simplified Defect Modeling and Fatigue Damage Detection in Lattice Structures

Related poster: 1) Simplified approach for modeling of defects in lattice structures, 2) Damage Detection in lattice structures using Acoustic Resonance Testing and Numerically-Informed Neural Networks

Davide Lorenzo Cappa, Riccardo Vescovini, Alessandro Levati, Stefano Foletti, Poiitecnico di Milano

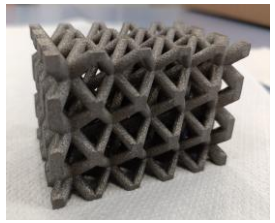
TOOL 4: **SHARPEN: preciSe rougHness lAseR-Powder bEd fabricatioN**

Why L-PBF?

- Complex geometries
- Strength-to-weight ratio
- Performance enhancement

In the aerospace sector:

- Engine and turbine components
- Optimized structural components and satellite antennas

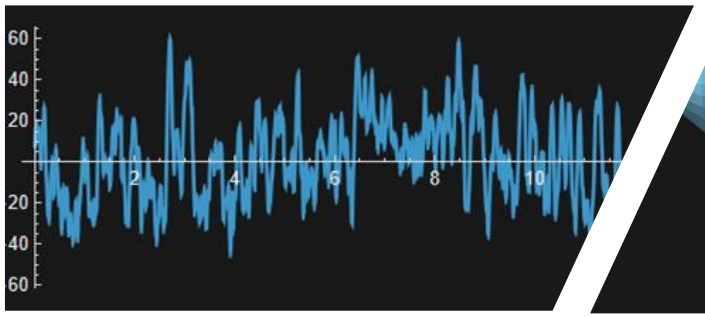


Limitations:

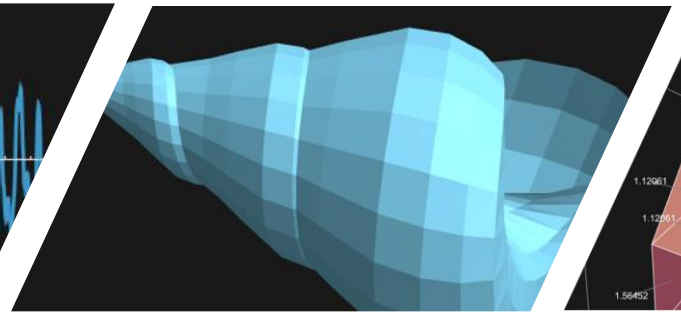
- High surface roughness (generally Ra>10 μm)
- Lack of roughness predictive models
- No help tool for visualizing how component design affects the surface quality
- Hard to control metallurgic process which leads to coarse roughness
- Intrinsic surface quality anisotropy
- Low geometrical accuracy

OBJECTIVE: Detailed graphical map of attainable **surface roughness** on **complex geometries** fabricated by L-PBF through experimental activities and **prediction modelling**

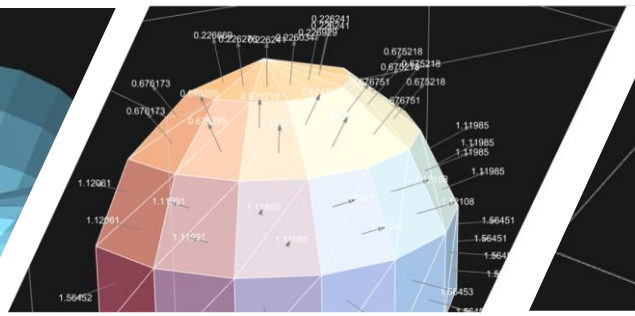
WORKFLOW



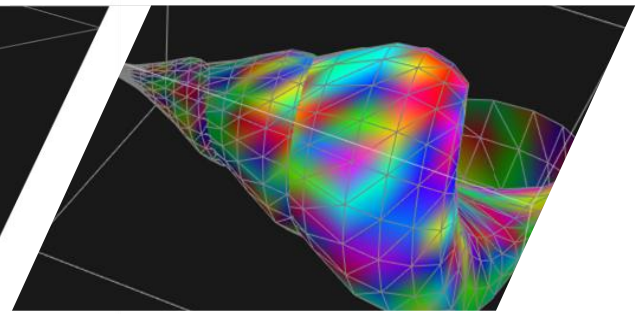
Roughness data



Original 3D model



Vectors calculation



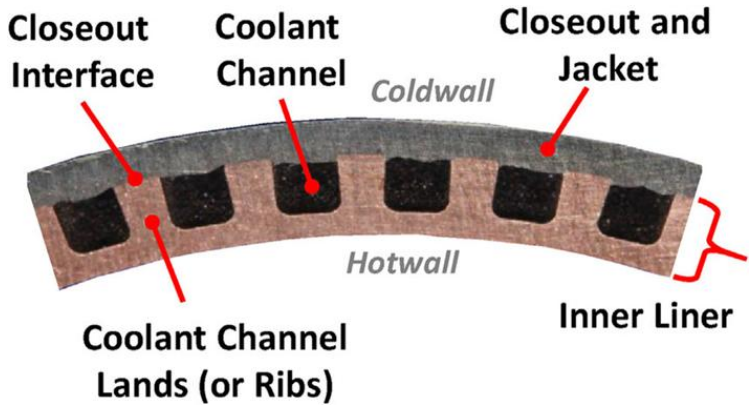
Roughness mapping

Critical example: Thrust Conformal cooling channels

- No support allowed in fabrication

Why L-PBF?

- Internal conformal cooling channels
- Complex paths and cross-sections (variable rib thickness)
- Heat transfer maximization (high roughness may enhance heat transfer)
- Assembly consolidation (elimination of brazing, welding and bolted joints for higher reliability)
- Combustion chamber/nozzle/ cooling channels all integrated possibly in one part
- Reduction of manufacturing steps and costs and procurement times
- Machinability of difficult materials (Nickel, Titanium, Tungsten alloys)

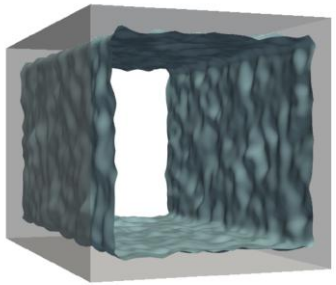


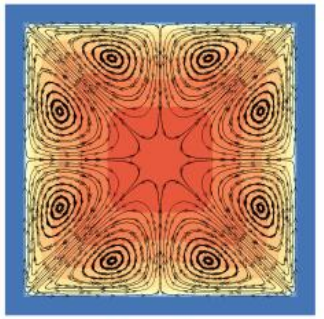
Cooling channel current design

L-PBF Cooling channel example

OBJECTIVES:

- Fabrication of **artifacts** for a measurement campaign to **characterize surfaces quality** produced using L-PBF
- Definition of an experimental activity aimed at creating a **shared database** to be **integrated into CFD codes for cooling channels simulations**





SPOKE 2 TOOLS OVERVIEW
7 tools, grouped in 4 thematic areas

ID	TOOL	WP	PARTNERS
	Digital twins for Space Missions		
TOOL1	STAR: Space mission Twin for Architecture Representation	WP 2.2, WP 2.4, WP 2.5	UNIROMA1, UNIPD, UNIPA, POLIMI, POLITO, TELESPAZIO, INRIM, SITAEL
TOOL2	Digital Twin for Lunar Surface exploration scenario	WP 2.4	TELESPAZIO, UNIROMA1
	Additive Manufacturing and Modelling for Space Applications		
TOOL3	Defect Modeling and Fatigue Damage Detection in Lattice Structure	WP 2.3, WP 2.4	POLIMI, POLIBA
TOOL4	SHARPEN: preciSe rougHness lAseR-Powder bEd fabricatioN	WP 2.3	UNIROMA1, POLIMI, POLITO, POLIBA
	AI-Driven approaches for Spacecraft Design and Operations		
TOOL5	LLM-Based rag tool for spacecraft preliminary design process	WP 2.4, WP 2.5	TAS-I, UNIROMA1
TOOL6	Software for classification of anthropic areas in Earth Observation images	WP 2.5, WP 2.4	MAPSAT, UNIROMA1
	Space Weather impact on Space Missions		
TOOL7	Space Weather Impact on Space Missions	WP 2.2	GSSI+/SISSA, POLITO

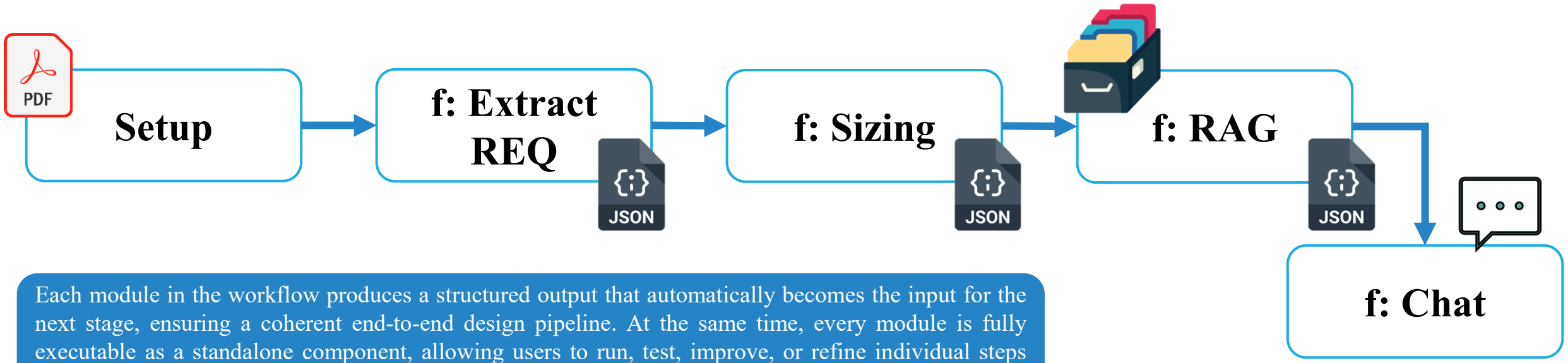
TOOL5: **LLM-BASED RAG TOOL FOR SPACECRAFT PRELIMINARY DESIGN PROCESS**

OBJECTIVES:

1. **Automatically extract requirements variables and constraints** from technical PDF documents
2. **Retrieve** commercially available components **using the sizing-derived requirements** as queries
3. **Provide an interactive chat** for accessing both datasheet information and extracted requirements

Retrieval Augmentation Generation (RAG)-BASED REASONING SYSTEM

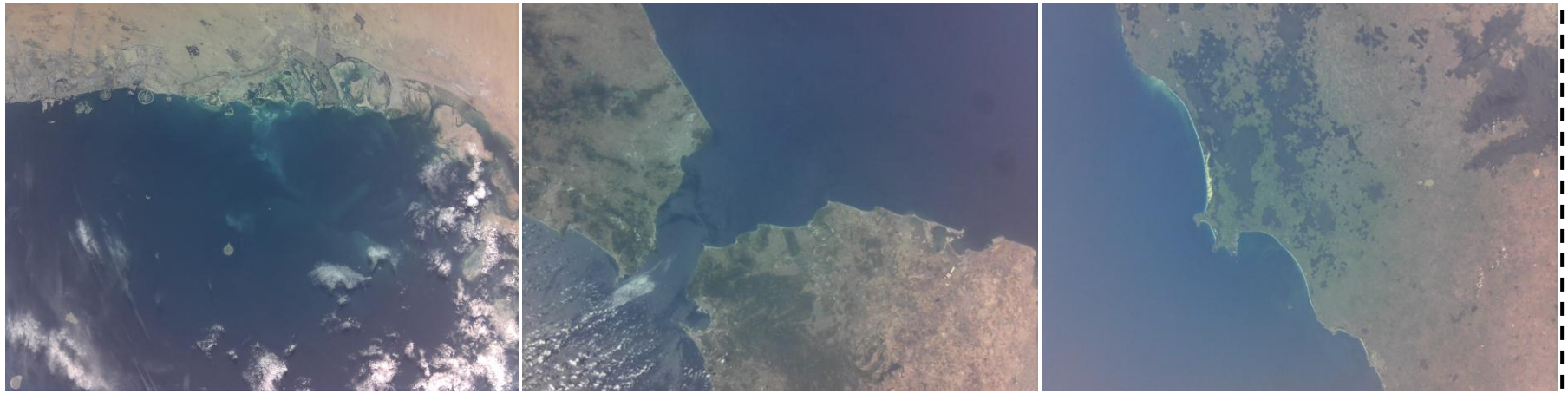
ADVANTAGE: the model is based on updated and specific data, other than the internal knowledge reached through the training



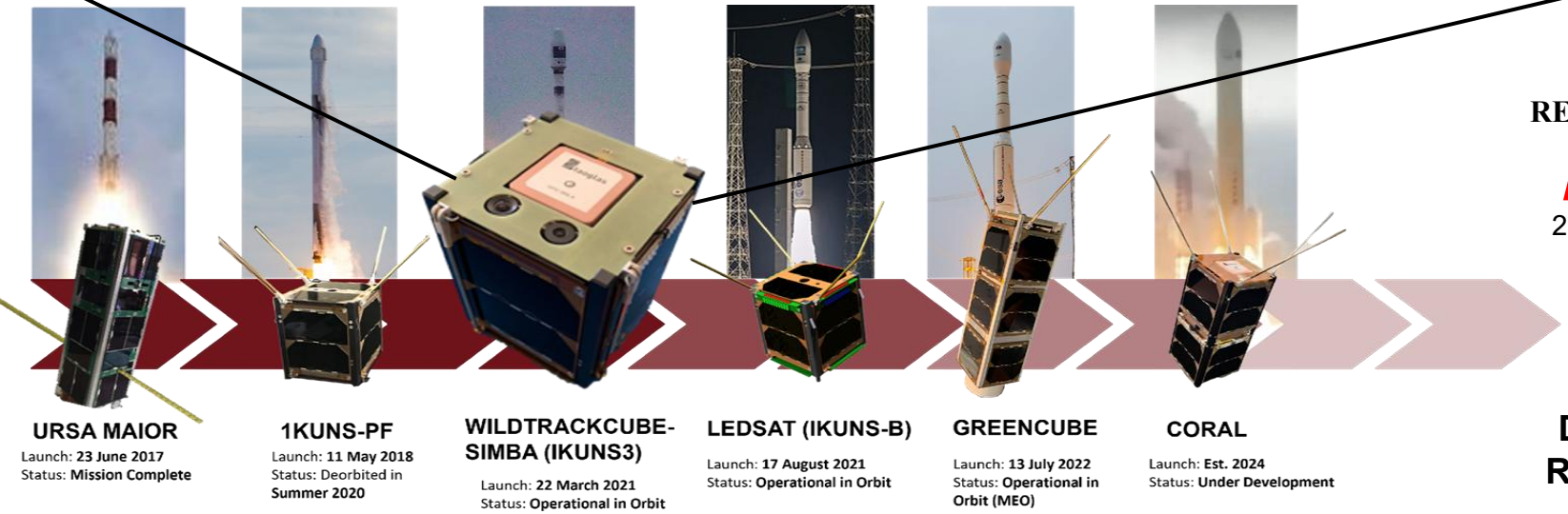
Each module in the workflow produces a structured output that automatically becomes the input for the next stage, ensuring a coherent end-to-end design pipeline. At the same time, every module is fully executable as a standalone component, allowing users to run, test, improve, or refine individual steps independently without affecting the rest of the chain.

TOOL6: **SOFTWARE FOR CLASSIFICATION OF ANTHROPIC AREAS IN EARTH OBSERVATION IMAGES**

Comparison among three **supervised classification methods** for **detection and classification of anthropic areas**



EARTH IMAGES FROM SIMBA



URSA MAIOR
Launch: **23 June 2017**
Status: **Mission Complete**

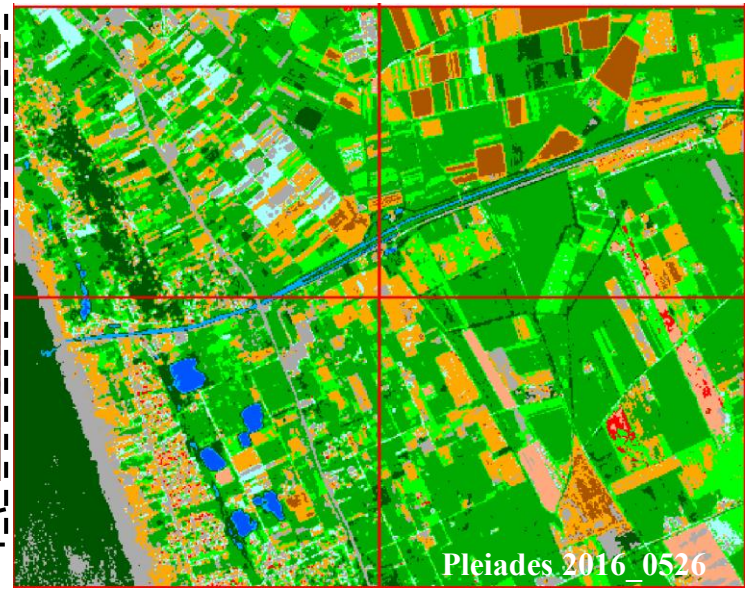
1KUNS-PF
Launch: **11 May 2018**
Status: Deorbited in **Summer 2020**

WILDTRACKCUBE-SIMBA (IKUNS3)
Launch: **22 March 2021**
Status: **Operational in Orbit**

LEDSAT (IKUNS-B)
Launch: **17 August 2021**
Status: **Operational in Orbit**

GREENCUBE
Launch: **13 July 2022**
Status: **Operational in Orbit (MEO)**

CORAL
Launch: **Est. 2024**
Status: **Under Development**



REAL CROPS

2.078 sqkm

	Random Forest	**Support Vector Machine**	**Minimum Distance**
	RF	SVM	MD
	2.149 sqkm	2.240 sqkm	1.811 sqkm
DELTA WITH REAL CROPS:	0.710 sqkm	0.162 sqkm	0.267 sqkm

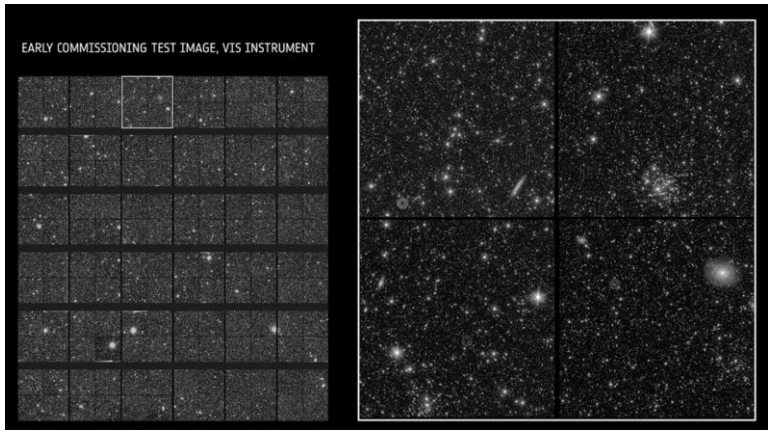
SPOKE 2 TOOLS OVERVIEW
7 tools, grouped in 4 thematic areas

ID	TOOL	WP	PARTNERS
	Digital twins for Space Missions		
TOOL1	STAR: Space mission Twin for Architecture Representation	WP 2.2, WP 2.4, WP 2.5	UNIROMA1, UNIPD, UNIPA, POLIMI, POLITO, TELESPAZIO, INRIM, SITAEL
TOOL2	Digital Twin for Lunar Surface exploration scenario	WP 2.4	TELESPAZIO, UNIROMA1
	Additive Manufacturing and Modelling for Space Applications		
TOOL3	Defect Modeling and Fatigue Damage Detection in Lattice Structure	WP 2.3, WP 2.4	POLIMI, POLIBA
TOOL4	SHARPEN: preciSe rougHness lAseR-Powder bEd fabricatioN	WP 2.3	UNIROMA1, POLIMI, POLITO, POLIBA
	AI-Driven approaches for Spacecraft Design and Operations		
TOOL5	LLM-Based rag tool for spacecraft preliminary design process	WP 2.4, WP 2.5	TAS-I, UNIROMA1
TOOL6	Software for classification of anthropic areas in Earth Observation images	WP 2.5, WP 2.4	MAPSAT, UNIROMA1
	Space Weather impact on Space Missions		
TOOL7	Space Weather Impact on Space Missions	WP 2.2	GSSI+/SISSA, POLITO

TOOL7: **SPACE WEATHER IMPACT ON SPACE MISSIONS**

OBJECTIVES:

1. **JOINT SIMULATIONS:** Simulation framework linking spacecraft to interactions with the environment, including space debris, surface charging, material response
2. **SHARED DATA:** Cosmic radiation properties in terms of energy distributions, spatial density, particle types, temporal variability, and dependence on orbit or trajectory
3. **METODOLOGIES:** Documented impact of Space Weather on advanced on-board electronics; Focus on AI-based architectures developed in intra-Spoke synergy



Examples of Data: VIS first-light mosaic with highlighted CR streaks, before/after stack showing CR masking efficiency (>99 % pixel recovery)

INTEGRATED APPROACH

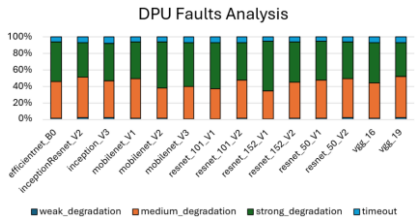
OBSERVATION DATA → Information collection and environment control

\+

ADVANCED DATA-PROCESSING → Experimental validation and AI training

\+

HARDWARE-LEVEL STUDIES → Electronics survey and data structuring



SPOKE 2 TOOLS OVERVIEW
7 tools, grouped in 4 thematic areas

ID	TOOL	WP	PARTNERS
Digital twins for Space Missions			
TOOL1	STAR: Space mission Twin for Architecture Representation	WP 2.2, WP 2.4, WP 2.5	UNIROMA1, UNIPD, UNIPA, POLIMI, POLITO, TELESPAZIO, INRIM, SITAEL
TOOL2	Digital Twin for Lunar Surface exploration scenario	WP 2.4	TELESPAZIO, UNIROMA1
Additive Manufacturing and Modelling for Space Applications			
TOOL3	Defect Modeling and Fatigue Damage Detection in Lattice Structure	WP 2.3, WP 2.4	POLIMI, POLIBA
TOOL4	SHARPEN: preciSe rougHness lAseR-Powder bEd fabricatioN	WP 2.3	UNIROMA1, POLIMI, POLITO, POLIBA
AI-Driven approaches for Spacecraft Design and Operations			
TOOL5	LLM-Based rag tool for spacecraft preliminary design process	WP 2.4, WP 2.5	TAS-I, UNIROMA1
TOOL6	Software for classification of anthropic areas in Earth Observation images	WP 2.5, WP 2.4	MAPSAT, UNIROMA1
Space Weather impact on Space Missions			
TOOL7	Space Weather Impact on Space Missions	WP 2.2	GSSI+/SISSA, POLITO

Space It Up!

SPOKE 2

ADVANCED DESIGN AND ANALYSIS OF SPACE MISSIONS AND SYSTEMS AND INNOVATIVE DIGITALIZATION - SYSTEM ENGINEERING AND DIGITAL TWIN

Speaker: Fabrizio Piergentili (Spoke Leader)

SIU! Days 26-28 January 2026, Florence

AGENZIA SPAZIALE ITALIANA

Ministero dell'Università e della Ricerca

The Space It Up! project is funded by the Italian Space Agency (ASI) and the Ministry of University and Research (MUR), under contract no. 2024-5-E.0 – CUP I53D24000060005.

Spoke Leader: UNIROMA1