

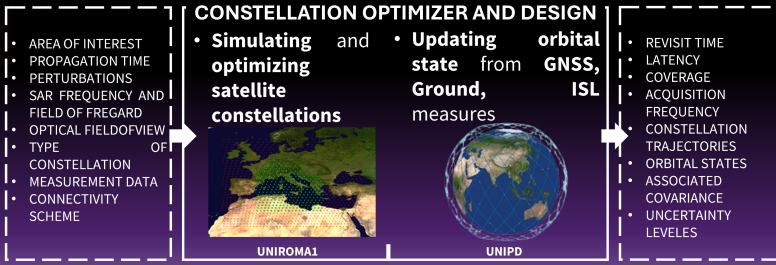
STAR: Space mission Twin Architecture Representation

A MULTI-LEVEL DIGITAL TWIN FRAMEWORK FROM MISSION AND CONSTELLATION DESIGN DOWN TO SATELLITE'S SUBSYSTEMS



Spoke 2

Advanced Design and Analysis of Space Missions and Systems and Innovative Digitalization - System Engineering and Digital Twin



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- GEOMETRY
- MATERIAL PROPERTIES
- BOUNDARY CONDITIONS
- ENVIRONMENTAL CONDITIONS (TEMPERATURE CYCLE AT SITE AND RADIATION TYPES)
- DATA ABOUT STRUCTURAL ELEMENTS PRONE TO THERMAL CYCLE DEGRADATION
- INSTRUMENT DESIGN
- PRIOR SURFACE PROPERTIES DISTRIBUTION

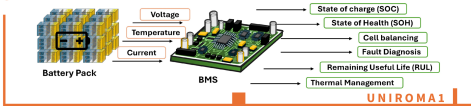
Multi-fidelity simulation for analyses of space structures

- Analysis of degradation of materials and structure subject to thermal cycles and radiation
- Modelling of the interaction with the surface of a planetary body
- SHM tool for monitoring the structural health of flexible components

- 3D STRESS AND STRAIN FIELDS
- FAILURE ONSET
- PREDICTION OF DAMAGE INITIATION
- QUALITATIVE/QUANTITATIVE DESCRIPTION OF DAMAGE PATTERNS
- FATIGUE LIFE ESTIMATION
- PREDICTION OF FORCES AND TORQUE BETWEEN THE S/C AND THE PLANETARY SURFACE
- ESTIMATED SURFACE PROPERTIES AND HEALTH STATUS OF THE SPACECRAFT

- ASSET CONFIGURATION
- BATTERY DATA FOR TRAINING AND FORECASTING
- MISSION-SPECIFIC INFORMATION REQUIRED FOR THE DESIGN
- REAL-TIME TELEMETRY FOR OPERATIONAL SCENARIOS

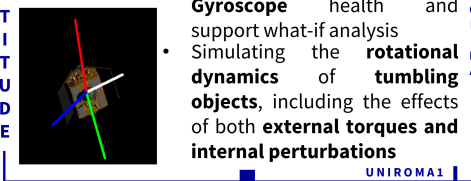
- Semantics-enhanced simulation to monitor solar array wing cells degradation
- High-fidelity representation of batteries, continuously synchronized with real-time data for State Of Health (SOH) monitoring and Remaining Useful Life (RUL) prediction



- LIVE SYNCHRONIZED STATE
- DIAGNOSTICS (SOH)
- PREDICTIONS (RUL)
- DESIGN EXPLORATION AND VALIDATION

- SATELLITE GEOMETRY
- SATELLITE INERTIA
- PERTURBATIONS
- EXTERNAL TORQUES
- PROPAGATION TIME
- REAL-TIME TELEMETRY FOR OPERATIONAL SCENARIOS

- Semantics-enhanced simulation to predict Control Momentum Gyroscopes health and support what-if analysis
- Simulating the rotational dynamics of tumbling objects, including the effects of both external torques and internal perturbations



- ATTITUDE EVOLUTION OVER PROPAGATION TIME
- DIAGNOSTICS
- PREDICTIONS

REFLECTANCE MODULE

Optical signature of the bus to predict light curves and brightness

COLLISION AVOIDANCE MODULE

Assessment of conjunction events through covariance-based collision probability estimation

- SCENARIO DEFINITION
- ORBIT CONFIGURATION
- SENSOR SPECIFICATIONS
- ACQUISITION TIMELINE AND SETTINGS
- POINTS OR AREAS OF INTEREST
- PERSONALIZED TERRAIN DATA
- 3D MODELS OF OBJECTS OF INTEREST

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

- ACQUISITION GEOMETRY
- ACQUIRED DATA
- SEGMENTATION MASKS
- PIXEL-LEVEL METADATA
- OBJECT LEVEL ANNOTATIONS
- GROUND TRUTH DATASETS FOR ML ALGORITHMS

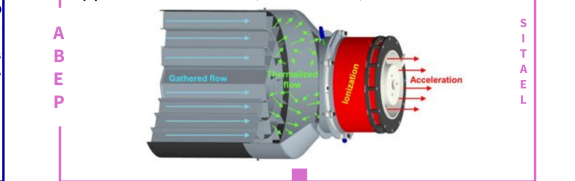
- ASSET DEFINITION
- MODELS
- REAL-TIME TELEMETRY
- COMMANDS AND PROCEDURES
- TRAINING SCENARIOS

High-fidelity representation of the physical asset continuously synchronized with real-time data for design, remote control and training in on-ground Manufacturing, Assembly, Integration and Testing (MAIT) activities as well as in On-orbit Servicing, Assembly, and Manufacturing (OSAM) operations

- LIVE SYNCHRONIZED STATE
- DIAGNOSTICS
- PREDICTIONS
- VALIDATED CONTROL
- TRAINING ASSESSMENT
- ENGINEERING VALIDATION

- ORBITAL STATE
- MISSION TIME
- GUARANTEED ALIGNMENT BETWEEN ABEP SUBSYSTEM AND S/C
- VELOCITY VECTOR
- POWER AVAILABLE

Simulating performance and operation of an air-breathing electric propulsion system for applications in VLEO (160-300 km)



- ESTIMATED THRUST
- ESTIMATED POWER CONSUMPTION

- FREQUENCY/PHASE DATA FROM RB CLOCKS ON BOARD OF GALILEO SATELLITES AND FROM TIME LAB OF INRIM

Identification of different kind of anomalies (frequency jumps, variance enhancement, drift). Correlation with environmental parameters

- CLASSIFICATION AND PREDICTION OF CLOCK ANOMALIES THROUGH ML ALGORITHMS
- CORRELATION TO ENVIRONMENTAL PARAMETERS, LASER POWER FLUCTUATIONS