Revolutionizing Aerospace Simulations, HIL & Digital Twins

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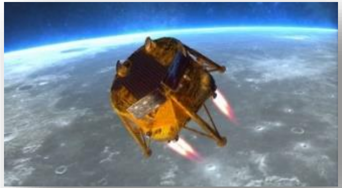
About Sim Dot Space

- Founded in 2019, **SIM.SPACE** is an ISO certified company that consists of team of engineers with decades of hands-on experience in the fields of: simulations, aerospace, physics, real-time, embedded systems, remote sensing, DevOps, large scale SAAS platforms and cloud based micro-services.

- **SIM.SPACE** has developed a globally first-of-its-kind simulations and hybrid labs (HIL) infrastructure for scalable aerospace system-level simulations that harness the power of distributed parallel computing, micro services, and cloud computing architecture (private or public) to enable the capacity necessary for AI and Machine Learning applications, Large scale simulations (e.g. UAV swarms or satellite constellations) and fast performance analysis (i.e. Monte Carlo), and modern simulation DevOps needs.



Beresheet 1 HIL hybrid lab, simulation and AOCS sensors EGSE

F-16 A/B Avionics Software dev. HIL hybrid lab and simulators

ELOP LOROP reconnaissance pod ground station

S/W module for Elbit Hermes 450 UAV

JANES multi-user flight simulator (BlueStar)

Developing system level simulations has become harder

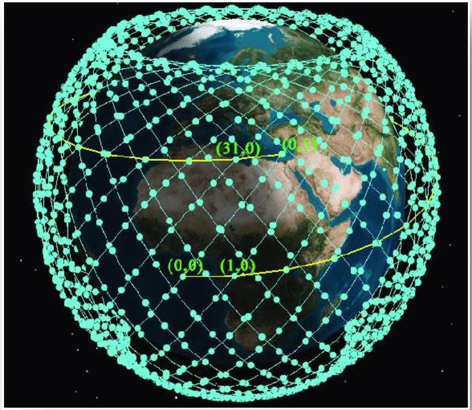
High-fidelity simulations, HIL and Digital Twins are **key to the success of aerospace projects** and are always on the program's critical paths

ispace HAKUTO-R

"The analysis reveals that the cause of the lander's failure […] It was determined that ***simulations of the landing sequence did not adequately*** *incorporate the lunar environment on the navigation route…"*

[Tokyo, May 26, 2023 - ispace, inc.]

- Simulations have become much **more difficult to develop** (complexity, simulation scale, DevOps needs, etc.)
- **Schedules and budgets** required to drastically **decrease**
- Legacy simulation tools (**mostly from the 1990s**)
- **Key personnel** who developed them are **not available**



System-level simulations usage in projects

High-level simulation

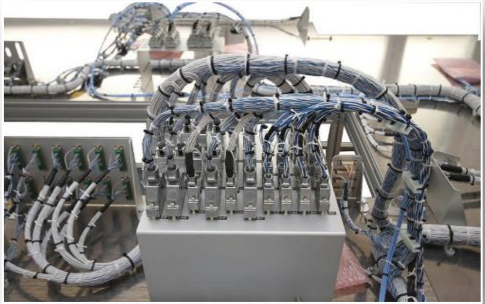
System performance analysis and verification by system engineers, algorithms development by Guidance and Control (G&C) engineers

Integration of Flight and Payload S/W

Development and testing environment for Flight / Payload software developers, integration of specific Hardware ICD

Hardware In the Loop

Real-time dynamic verification of the entire system or specific components with Hardware In the Loop (HIL)



Training Operation and Maintenance (TOMS)

Operators training / Trainers / Simulators, and Digital Twins throughout the life of the system

Sim Dot Space provide a seamless transition from high-level analysis, through flight software testing and HIL verification, reducing training effort for relevant personnel and improving simulation quality

SIM.SPACE

The aerospace related simulations ecosystem

CERTIFIED ISO 9001:2015 COMPANY

Computed aided design & Finite elements analysis

- Ansys
- Dassault Systemes
- Autodesk
- COMSOL
- OpenFOAM
- Siemens
- ptc

Market size: $22.5B (2022)
CAGR: 13.5% (yearly)
Defense & Aerospace: 25-35%

Physics analysis (Thermal, Fluid, RF, Space environment, etc.)

- Dassault Systemes
- Siemens
- Rockwell Automation
- Ansys
- Keysight Technologies
- ptc
- AGI
- FreeFlyer

Modeling tools, and Algorithms development

- MathWorks
- anylogic
- SolidWorks
- Siemens (SC)
- Ansys
- Altair
- SIMUL8
- FlexSim problem solved.

Rendering engines

- Unity
- Unreal Engine
- octanerender
- D5 Render
- blender

System level & System-of-Systems (SoS) level Simulations

Training, Operations & Maintenance

Hardware In The Loop (HIL) simulation

There is a market need for a modern commercial system-level and HIL simulation infrastructure (similar to other simulation categories that already have such infrastructures) to allow aerospace companies to focus on their core business and avoid the overhead of development and maintenance of in house simulation infrastructures

Aerospace companies current system simulation challenges

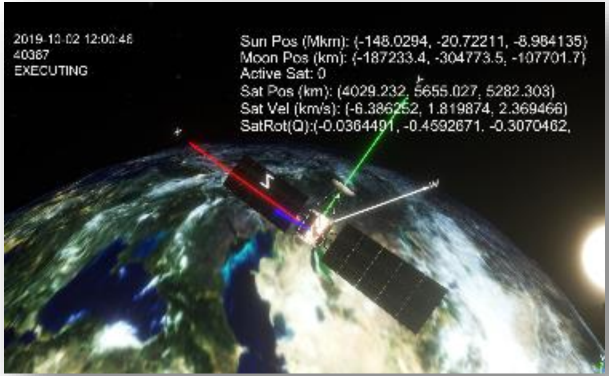
Topic	The problem / challenge faced by aerospace companies
AI / Machine Learning	Legacy system simulations do not meet the performance needs necessary for **Machine Learning and AI** applications as well as complex computational required for large scale performance analysis (i.e Monte Carlo)
Scalability	Legacy system simulation infrastructures are **not built to handle large scale simulations** such as large **satellite constellations, swarms of drones**
Development costs	The development **cost of legacy simulations is too high** and development **duration is too long**, and it is difficult to retain good simulation and HIL infrastructure engineers over time
Open APIs	Legacy infrastructures do not provide an **Open architecture** with **APIs** such as **REST** or **Kafka**
DevOps	Legacy infrastructures are **not suitable for the current operational and DevOps requirements** (Cloud computing, Kubernetes, Dockers, Virtual Machines, Linux/Windows)
IT costs	Legacy infrastructures that run simulations on the developer's workstation require **powerful and expensive workstations** for each developer and impose more complex cyber protection
Knowledge gap	Legacy infrastructures were **mostly written in the 90s, with "old" technology** and architecture, by people who are no longer available in organizations, and have since been copied by Copy & Paste, there is a need for a paradigm shift by simulation engineers.

The benefits of Sim Dot Space infrastructure

Topic	Sim Dot Space solution
AI / Machine Learning	Sim Dot Space infrastructure harnesses the power of **parallel computing**, **micro services**, and **cloud computing** architecture (private or public) to enable the capacity necessary for **AI and Machine Learning** applications and large scale performance analysis (i.e Monte Carlo)
Extreme Scalability	Sim Dot Space infrastructure implements **multi-level distributed parallel processing using micro-services** that can scale up to thousands of simulated entities (e.g. Satellites, UAVs, etc.)
Development cost reduction	Sim Dot Space reduces development costs with our **simulation generation tool**, extensive library of **reusable generic space related models**, and simple reuse, seamless integration, migration, and orchestration of **customer existing simulation assets**
Open APIs	Sim Dot Space implements an **Open architecture** with full support for **REST API** and **Kafka** messaging
Robust DevOps	Sim Dot Space infrastructure allows writing a simulation once, and **running it in any topology/architecture**: single process, distributed parallel computation, micro-services, Docker, Kubernetes, HPC, Virtual Machines, supporting both **Linux & Windows** environments
IT cost reduction	Sim Dot Space infrastructure reduces IT costs of developer's workstation allowing **running simulations and HIL via any web browser** using centralized simulation servers (or private/public cloud server), and simplifies cyber security with centralized cyber protection
Reduce overheads	Using Sim Dot Space infrastructure **aerospace companies focus on their core business** and avoid the overhead of development and maintenance of in house simulation infrastructures

Revolutionizing Aerospace Simulations, HIL & Digital Twins

- Modern commercial aerospace hi-fidelity simulation framework
- Pioneering **M**odeling & **S**imulation **as a S**ervice paradigm
- Harnessing the power of **cloud computing and parallel processing** – scalability, IT saving, cyber security, versions
- Smooth transition from a small scale simulation to large scale simulations of **huge satellite constellations**
- Rapid simulation development:
  - **Simulation generation tool** – automatic code generation
  - Extensive library of **reusable** generic space related models
- **Unified environment:** S/W simulation, HIL, Training and Operation simulator and Digital Twin
- Seamless integration, migration, and orchestration of customer **existing simulation assets** (purchased or in house developed models and even complete simulations)



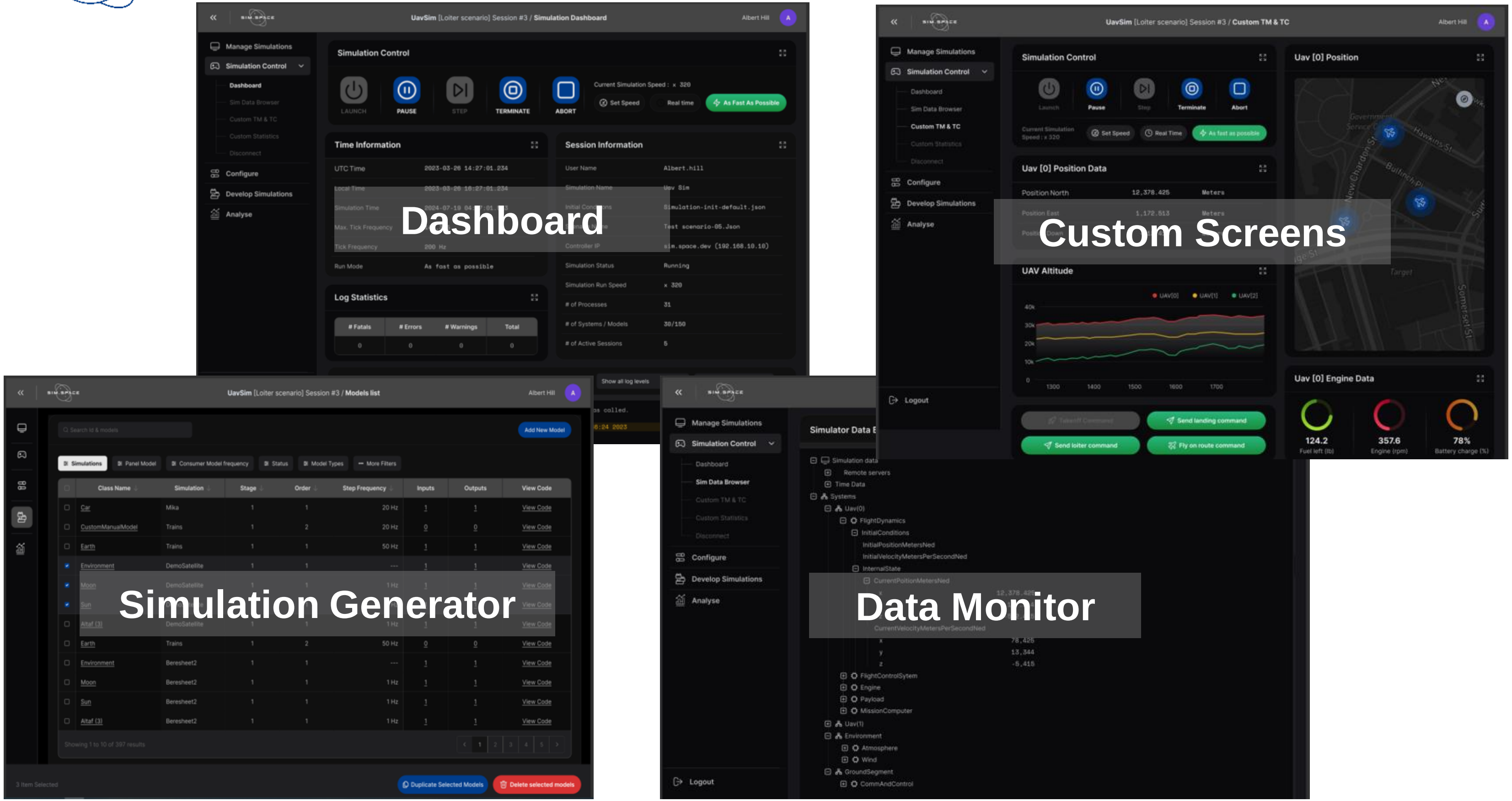
Sim.Space cloud architecture design highlights

- Everything can run anywhere! (on a local PC, virtual machines, Linux/Window, Kubernetes, Openshift, HPC)
- Extreme simulation scalability:
  - All elements (REST server, ReactJS Web server, Simulations) can be clustered
  - Simulations, Systems, and Models use parallel distributed processing
  - All internal simulation communication runs within the cloud
- Development and debug is done using any IDE (Visual Studio, Eclipse, other…)
- Responsive web simulation user interface running on a web browser
- Open REST API for running, controlling and scripting the simulation
- Command line interface (CLI) for batch running the simulation
- Test automation and scenario editing
- Support Node locked, Network, Per user, and Floating licensing
- Published data via Kafka for simple integration with analysis tools

Sim.Space generic high-fidelity aerospace models library

Sensors / Payload	Actuators	Bus Elements	Ground Segment	Environment (continued)	Mathematics
Laser Range Finder	Propulsion (Thrusters & Tanks)	Satellite Antenna	TM parser & Tele-command composer	Orbit Propagation	3D vectors mathematics
IMU	Magnetorquer	Transceiver	Ground Antenna	Aerodynamics drag	Quaternion mathematics
Star Tracker	Reaction Wheel	Battery	Satellite Database (SDB)	Solar Radiation drag	Matrix mathematics
Sun Sensor	Aircraft Engine	PCDU	**Environment**	3^{rd} body gravity	Numeric Integration methods
GNSS	UAV catapult	Thermistors	Earth rotation model	Digital Terrain Model	Direction Cosine Matrixes (DCM)
Payload Gimbals		Heaters	Lunar rotation model	Solar illumination flux	Euler rotations
Air data sensor		Thermostats	Atmosphere and Wind model	Radio communication LOS & link margin	6-DOF equations of motion
Magnetometer		Solar Panels	Earth magnetic field	Lunar gravity models	Two body separation
Camera		Autopilot	Earth gravity models	Moon position	Touchdown detection
Camera storage unit (CSU)		Airframe	Earth and Lunar Eclipse	Sun position	Flight Dynamics

Modern web Simulation Graphical User Interface



Example of a Sim.Space HIL Hybrid lab topology