

Revolutionizing Aerospace Simulations, HIL & Digital Twins April, 2024

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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 commercial 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 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

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"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





There is a market need for a modern commercial system-level and HIL simulation infrastructure to allow aerospace companies to focus on their core business and avoid the overhead of development and maintenance of in house simulation infrastructures



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

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









<u>Training Operation and</u> <u>Maintenance (TOMS)</u> 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

Examples of problems solved by Sim Dot Space infrastructure

 Need for a significant reduction of development and maintenance costs of system simulations, software development labs, hybrid labs, trainers, and digital twins, and development time

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- Need to unify high level simulation, software development lab, hybrid lab & trainers infrastructures
- Need for a simulation that combines purchased components or that are developed in different technologies (Executables / DLLs / Libraries / Dockers) or that run on different OS (Windows / Linux)
- Need for a simulation that can grow dynamically to any scale (up to tens of thousands of processes in the same simulation) without requiring expensive dedicated hardware (such as HPC)
- Need for integration of the simulation with external systems through open interfaces (e.g. REST API or Kafka messaging interfaces)
- Need to develop a simulation that meets current DevOps needs, while utilizing components previously developed by the organization in their legacy simulations
- Need for the integration of complete existing legacy simulations into a large "super simulation" as well as large as with multiple instances of legacy simulation (e.g. multiple UAVs)
- Need to reduce expensive developer workstation procurement costs for previously developed simulations
- Need to combine a digital system simulation with multiple entities together with a hybrid laboratory







Companies current system simulation challenges

Торіс	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 , or require expensive hardware to scale
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.



Sim Dot Space unique solution for these challenges

Торіс	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 REST API, SDK, CLI, 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



Modern web Simulation Graphical User Interface





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

Example of a Sim.Space HIL Hybrid lab topology



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