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Architecture Patterns for Digital Twins in Space Applications

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Introduction

The concept of twin has been practised in space industry since the 1960s, where twinning ideas were used for space programming at NASA. Appollo 13 [1] rescue mission used a twin on ground which allowed engineers to test possible solutions. Since then, Twins have become predominantly virtual than physical.

Digital twins can improve system design , manufacturing, operations and maintenance in many other domains than space: for example, transportations (air, rail, maritime) industries have announced digital twin as one of the top strategic technology trend, yet many definitions of digital twins can be found in literature.

The concept was mentionned early 2002 for the development of a product management center: it contained basic elements of digital twins: real space, virtual space, and the data and information flows between real and virtual spaces. May be the most recent definition of digital twins, as provided at INCOSE 2020 [2], explains why it is predicted that digital twins will enable billions savings in engineering, manufacturing, maintenance and operations by 2025 "The Digital Twin is the virtual, state -full representation of a physical product and the system behind across its life using operational real - time data and other sources to enable understanding, learning, reasoning and dynamically recalibrating for improved decision making".

Internet of things (IOTs) as well as OT and IT technologies enabled digital twins to become cost-effective and easily deployable. In particular, IOT sensors can deliver data on how both real entities and virtual twins are operated and behave within the environment.

Beyond technologies, this paper aims to share with the space industry, different architecture patterns to demonstrate operational benefits of digital twins, and the impact of this trend on concurrent system engineering and life cycle management. Standardisation topics are then highlighted.

References

[1]: C. Mikinis, The history and creation of the digital twin concept, Challenge Advisory Insights, March 2019.
[2]: G. Bleakley, "The role of Simulation and AI in the implementation of a Digital Twin", INCOSE Workshop, 2020.