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PROTOTYPE OF A WORKFLOW FOR A DIGITAL TWIN IN SMALL SATELLITE OPERATIONS

Abstract

Satellite constellations are increasingly launched into space. Examples of this are Europe's plans to establish two LEO constellations with IRIS^2 and LEO-PNT. It is key to have a high level of automation to operate such large constellations cost effectively. One way to implement this is the so-called "Digital Twin" concept. There is no standardized definition what a Digital twin is. It is rather a collection of ideas for various use cases in the different product lifecycle phases. What they all have in common is the use of a digital model to represent a physical object and its properties. Furthermore, what distinguishes a Digital Twin in this paper from a simple digital model is the automated coupling between the real world object and its digital object. For a Digital Twin in satellite operations, this means the telemetry of a satellite is automatically analyzed and corresponding actions are triggered, i.e. commands are executed. The analysis of the telemetry can involve machine learning techniques to detect outliers, anomalies and perform health monitoring. In this paper we present a first prototype of such a set-up including its simulation and results.

Our prototype is using the NASA Operational Simulator for Small Satellites (NOS3). NOS3 is an open source software, with which the operation of small satellites can be simulated in real time. It is shipped with the different building blocks of a small satellite and connection to the ground.

Using NOS3, the developed prototype in this paper demonstrates the entire workflow of a digital twin for satellite operations: From the onboard generation of telemetry, downlinking the telemetry to the ground, automated analysis of the telemetry using machine learning and sending back a command if required. As a use case for this workflow, we selected the monitoring of the onboard power system. Therefore, a solar panel model and a battery model for power generation and storage are developed. Due to the power consumption of various satellite subsystems and the position of the satellite with respect to the sun, the battery is subjected to a high number of charging cycles. By artificially injecting failures into the battery model it is possible to change the telemetry. This telemetry is then analyzed by the automated machine learning workflow, where countermeasures are automatically initiated.

This first prototype shows how the automation workflow with a Digital Twin can be implemented and

tested for small satellite operations.