National Aeronautics and Space Administration

Using Digital Twin for V&V of Autonomous Systems

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Program: FY22 R&TD Strategic Initiative
Strategic Focus Area: Model Based Assurance of Autonomy - Strategic Initiative Leader: Harald Schone

Objectives:

Investigation of automated approaches to test the safety and liveness requirements of an autonomous spacecraft cruising towards and approaching a small body.

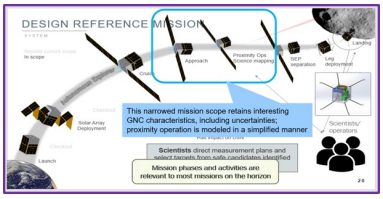

Figure 1. Case Study Mission

Background

Adoption of autonomy in flight software hinges on the ability to trust in their liveliness properties–supporting the accomplishment of mission objectives, and safety properties-avoiding harm to the asset(s) they control.

Approach and Results:

In year 1 we developed a test bed (in *ROS* using *MATLAB*) for the spacecraft consisting of a low-fidelity simulator of the physical environment (including hardware) and an autonomous flight software. The latter consists of a deliberative layer (implemented with *MEXEC*) that receives high level goals (as commands from Mission Ops), elaborates them into executable goals on-board, and schedules their execution by a reactive layer that interfaces with the physical environment to perform state estimation and control. We also developed a system model of the test bed components in the *Ontological Modeling Language (OML)* using the *State Analysis* method. The model was used to drive the implementation of the testbed this year. It will also be used to drive the automated testing effort next year.

Significance/Benefits to JPL and NASA:

V&V of autonomy through automated system testing allows JPL to trust it more in future ambitious NASA missions.

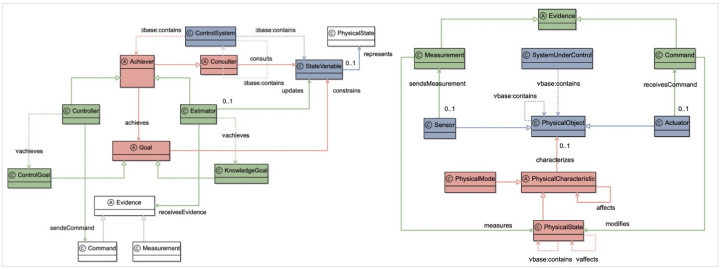

Figure 2. State Analysis Vocabulary in OML

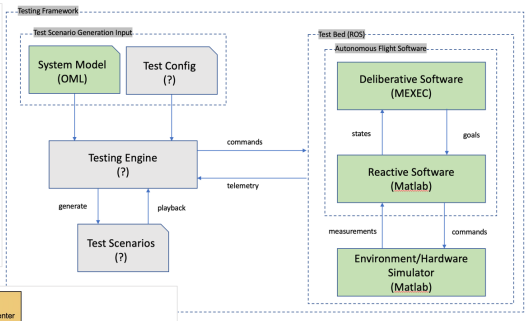

Figure 3. Digital Twin Framework Architecture

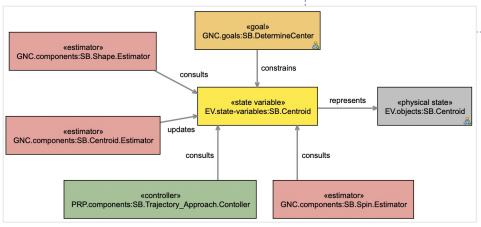

Figure 4. State Variable Description in OML

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