6DOF Testing of the SLS Inertial Navigation Unit

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The Navigation System on the NASA Space Launch System (SLS) Block 1 vehicle performs initial alignment of the Inertial Navigation System (INS) navigation frame through gyrocompass alignment (GCA). Because the navigation architecture for the SLS Block 1 vehicle is a purely inertial system, the accuracy of the achieved orbit relative to mission requirements is very sensitive to initial alignment accuracy. The assessment of this sensitivity and many others via simulation is a part of the SLS Model-Based Design and Model-Based Requirements approach. As a part of the aforementioned, 6DOF Monte Carlo simulation is used in large part to develop and demonstrate verification of program requirements. To facilitate this and the GN&C flight software design process, an SLS-Program-controlled Design Math Model (DMM) of the SLS INS was developed by the SLS Navigation Team. The SLS INS model implements all of the key functions of the hardware—namely, GCA, inertial navigation, and FDIR (Fault Detection, Isolation, and Recovery)—in support of SLS GN&C design requirements verification.

Despite the strong sensitivity to initial alignment, GCA accuracy requirements were not verified by test due to program cost and schedule constraints. Instead, the system relies upon assessments performed using the SLS INS model. In order to verify SLS program requirements by analysis, the SLS INS model is verified and validated against flight hardware. In lieu of direct testing of GCA accuracy in support of requirement verification, the SLS Navigation Team proposed and conducted an engineering test to, among other things, validate the GCA performance and overall behavior of the SLS INS model through comparison with test data.

This paper will detail dynamic hardware testing of the SLS INS, conducted by the SLS Navigation Team at Marshall Space Flight Center's 6DOF Table Facility, in support of GCA performance characterization and INS model validation. A 6-DOF motion platform was used to produce 6DOF pad twist and sway dynamics while a simulated SLS flight computer communicated with the INS. Tests conducted include an evaluation of GCA algorithm robustness to increasingly dynamic pad environments, an examination of GCA algorithm stability and accuracy over long durations, and a long-duration static test to gather enough data for Allan Variance analysis. Test setup, execution, and data analysis will be discussed, including analysis performed in support of SLS INS model validation.