SLS Block 1-B and Exploration Upper Stage Navigation System Design

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The SLS Block 1B vehicle is planned to extend NASA's heavy lift capability beyond the initial SLS Block 1 vehicle. The most noticeable change for this vehicle from SLS Block 1 is the swapping of the upper stage from the Interim Cryogenic Propulsion stage (ICPS), a modified Delta IV upper stage, to the more capable Exploration Upper Stage (EUS). As the vehicle evolves to provide greater lift capability and execute more demanding missions so must the SLS Integrated Navigation System to support those missions.

The SLS Block 1 vehicle carries two independent navigation systems. The responsibility of the two systems is delineated between ascent and upper stage flight. The Block 1 navigation system is responsible for the phase of flight between the launch pad and insertion into Low-Earth Orbit (LEO). The upper stage system assumes the mission from LEO to payload separation. For the Block 1B vehicle, the two functions are combined into a single system intended to navigate from ground to payload insertion. Both are responsible for self-disposal once payload delivery is achieved.

The evolution of the navigation hardware and algorithms from an inertial-only navigation system for Block 1 ascent flight to a tightly coupled GPS-aided inertial navigation system for Block 1-B is described. The Block 1 GN&C system has been designed to meet a LEO insertion target with a specified accuracy. The Block 1-B vehicle navigation system is designed to support the Block 1 LEO target accuracy as well as trans-lunar or trans-planetary injection accuracy. This is measured in terms of payload impact and stage disposal requirements. Additionally, the Block 1-B vehicle is designed to support human exploration and thus is designed to minimize the probability of Loss of Crew (LOC) through high-quality inertial instruments and Fault Detection, Isolation, and Recovery (FDIR) logic. The preliminary Block 1B integrated navigation system design is presented along with the challenges associated with meeting the design objectives. This paper also addresses the design considerations associated with the use of Block 1 and Commercial Off-the-Shelf (COTS) avionics for Block 1-B/EUS as part of an integrated vehicle suite for orbital operations.