

SLS Navigation Model-Based Design Approach (Emerson)

T. Emerson Oliver, Evan Anzalone PhD., Kevin Geohagan, Bill Bernard, Thomas Park PhD.

The SLS Program chose to implement a Model-based Design and Model-based Requirements approach for managing component design information and system requirements. This approach differs from previous large-scale design efforts at Marshall Space Flight Center where design documentation alone conveyed information required for vehicle design and analysis and where extensive requirements sets were used to scope and constrain the design. The SLS Navigation Team has been responsible for the Program-controlled Design Math Models (DMMs) which describe and represent the performance of the Inertial Navigation System (INS) and the Rate Gyro Assemblies (RGAs) used by Guidance, Navigation, and Controls (GN&C). The SLS Navigation Team is also responsible for the navigation algorithms. The navigation algorithms are delivered for implementation on the flight hardware as a DMM. For the SLS Block 1-B design, the additional GPS Receiver hardware is managed as a DMM at the vehicle design level. This paper provides a discussion of the processes and methods used to engineer, design, and coordinate engineering trades and performance assessments using SLS practices as applied to the GN&C system, with a particular focus on the Navigation components. These include composing system requirements, requirements verification, model development, model verification and validation, and modeling and analysis approaches.

The Model-based Design and Requirements approach does not reduce the effort associated with the design process versus previous processes used at Marshall Space Flight Center. Instead, the approach takes advantage of overlap between the requirements development and management process, and the design and analysis process by efficiently combining the control (i.e. the requirement) and the design mechanisms. The design mechanism is the representation of the component behavior and performance in design and analysis tools. The focus in the early design process shifts from the development and management of design requirements to the development of usable models, model requirements, and model verification and validation efforts. The models themselves are represented in C/C++ code and accompanying data files. Under the idealized process, potential ambiguity in specification is reduced because the model must be implementable versus a requirement which is not necessarily subject to this constraint. Further, the models are shown to emulate the hardware during validation. For models developed by the Navigation Team, a common interface/standalone environment was developed. The common environment allows for easy implementation in design and analysis tools. Mechanisms such as unit test cases ensure implementation as the developer intended. The model verification and validation process provides a very high level of component design insight.

The origin and implementation of the SLS variant of Model-based Design is described from the perspective of the SLS Navigation Team. The format of the models and the requirements are described. The Model-based Design approach has many benefits but is not without potential complications. Key lessons learned associated with the implementation of the Model Based Design approach and process from infancy to verification and certification are discussed.