Unified Simulation and Analysis Framework for Deep Space Navigation Design

As the technology that enables advanced deep space autonomous navigation continues to develop and the requirements for such capability continues to grow, there is a clear need for a modular expandable simulation framework. This tool's purpose is to address multiple measurement and information sources in order to capture system capability. This is needed to analyze the capability of competing navigation systems as well as to develop system requirements, in order to determine its effect on the sizing of the integrated vehicle. The development for such a framework is built upon Model-Based Systems Engineering techniques to capture the architecture of the navigation system and possible state measurements and observations to feed into the simulation implementation structure. These models also allow a common environment for the capture of an increasingly complex operational architecture, involving multiple spacecraft, ground stations, and communication networks. In order to address these architectural developments, a framework of agent-based modules is implemented to capture the independent operations of individual spacecraft as well as the network interactions amongst spacecraft. This paper describes the development of this framework, and the modeling processes used to capture a deep space navigation system. Additionally, a sample implementation describing a concept of network-based navigation utilizing digitally transmitted data packets is described in detail. This developed package shows the capability of the modeling framework, including its modularity, analysis capabilities, and its unification back to the overall system requirements and definition.