Paper ID: 73311
oral
student

IAF SPACE POWER SYMPOSIUM (C3)
Interactive Presentations - IAF SPACE POWER SYMPOSIUM (IPB)

Author: Mr. Saroj Kumar
Propulsion Research Center, University of Alabama in Huntsville, United States

Dr. Dale Thomas
University of Alabama in Huntsville, United States
Dr. Jason Cassibry
Propulsion Research Center, University of Alabama in Huntsville, United States

SPACECRAFT INTEGRATED SYSTEM MODEL FOR NTP POWERED PLANETARY SCIENCE MISSIONS

Abstract

The advantages of Nuclear Thermal Propulsion (NTP) systems have been studied towards the exploration of future human and robotic missions to Mars and beyond. Traditional mission design concept studies for an NTP powered robotic mission have produced promising results by demonstrating NTP capabilities in relation to higher scientific return values. However, realistic concept development for an emerging propulsion technology can be extremely challenging when there is a lack of historical data from multiple systems of systems. Current mission analyses have utilized multiple standalone models to analyze the results such as propulsion system, trajectory, spacecraft design etc. This approach is not only time consuming but also limits the consistency between design and user evaluation scenarios. The mutual dependence of multiple parameters starting from spacecraft design to onboard NTP system and launch vehicle requirements results in an iterative problem. The design problem involves variables which are mix of discrete and continuous in nature which adds to further complexity and optimization difficulties.

In order to optimize the multidisciplinary problem, we propose a model-based framework utilizing Model Based Systems Engineering (MBSE) for trades and optimization, concept visualization from behavior modeling and simulation-based mission validation. The framework utilizes executable architecture to perform requirement analysis and behavioral simulation. The requirement analysis is performed by assessing physical characteristics, verifying requirements and improving traceability by running trade studies against mission environment. The behavioral simulation is performed by identifying emergent behavior and exploring new use cases by executing SysML behavior design in the mission context. This paper will present the spacecraft integrated system model for early mission formulation for NTP powered robotic missions. The models for the NTP system, spacecraft and launch vehicle will be integrated based on the science mission objectives. The interconnection of various system models enables rapid results and selecting the best design. Initial results using the integrated mission design approach have demonstrated the enhanced capability of a NTP powered spacecraft for robotic rendezvous missions to Jupiter and Saturn. With an expendable NTP powered system using a single 15klbf engine, NASA's Europa clipper class spacecraft can be delivered to Jupiter in 2.1 years and Cassini class spacecraft can be delivered to Saturn in 4.7 years using a single high-class commercial launcher. This demonstrates that NTP powered missions can reduce the interplanetary trip times be a factor of two or more for similar class of spacecraft which utilizes traditional chemical propulsion systems.