IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
The Apollo program and the rockets that took humanity to the moon (9-D6.2)

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EVOLUTION AND IMPACT OF SATURN V ON SPACE LAUNCH SYSTEM FROM A GUIDANCE, NAVIGATION, AND MISSION ANALYSIS PERSPECTIVE

Abstract

The Saturn V laid the groundwork for large payload to orbit launch vehicles. This legacy has endured and had a significant impact on the advancement of the current generation of ascent stages, particularly the Space Launch System (SLS). The SLS is designed to provide an initial 70 metric tons of payload to Low Earth Orbit with an evolutionary plan to upgrade to 130 metric tons of payload capability via its Block 2 iteration. Although the new vehicle takes advantage of high performance, state of the art, Liquid Oxygen and Hydrogen propellants, its foundational trajectory optimization process, mission aborts, and ascent flight design are very similar. This paper provides an overview of the approach to Saturn V trajectory design, analysis, aborts design, and verification to compare and contrast with that being done for SLS. Descriptions of the original development and analysis will be provided as well as the evolution of these approaches to current launch vehicle design efforts. Similar to the trajectory optimization and flight approaches, the algorithms used for flying the vehicle along an optimized path share a common heritage. The Saturn V program utilized a new guidance method, the Iterative Guidance Mode. This algorithm is a calculus of variations approach to meet the desired orbit parameters with minimal fuel usage. Over time, this formed the basis of the Powered Explicit Guidance (PEG) algorithm, which is used for the Space Transportation System and the SLS. The navigation system, though, heavily takes advantage of key technological advances in the area of inertial sensor technology and electronic components due to its reliance on specific hardware. Instead of the hand-tuned, platform-based navigation system of Saturn V, the SLS utilizes a strap-down inertial navigation system, providing direct observation of the vehicle's motion in both rotational and translational axes via acceleration and angular rate. Although the measurements are different, the fundamental equations of motion are very similar and both systems provide position and attitude estimate. The two systems will be compared to show the performance capabilities and relative algorithms of the two approaches. Altogether, this work will describe how the experience and technology developed for the Saturn V launch vehicle has played an important role in the development and operational approach of NASA's current heavy lift rocket, SLS.