Space Launch System Accelerated Booster Development Cycle

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With the retirement of the Space Shuttle, NASA is seeking to reinvigorate the national space program and recapture the public's interest in human space exploration by developing missions to the Moon, near-earth asteroids, Lagrange points, Mars, and beyond. The would-be successor to the Space Shuttle, NASA's Constellation Program, planned to take humans back to the Moon by 2020, but due to budgetary constraints was cancelled in 2010 in search of a more "affordable, sustainable, and realistic"[1] concept[2]. Following a number of studies, the much anticipated Space Launch System (SLS) was unveiled in September of 2011. The SLS core architecture consists of a cryogenic first stage with five Space Shuttle Main Engines (SSMEs), and a cryogenic second stage using a new J-2X engine[3]. The baseline configuration employs two 5-segment solid rocket boosters to achieve a 70 metric ton payload capability, but a new, more capable booster system will be required to attain the goal of 130 metric tons to orbit. To this end, NASA's Marshall Space Flight Center recently released a NASA Research Announcement (NRA) entitled "Space Launch System (SLS) Advanced Booster Engineering Demonstration and/or Risk Reduction." The increased emphasis on affordability is evident in the language used in the NRA, which is focused on risk reduction "leading to an affordable Advanced Booster that meets the evolved capabilities of SLS" and "enabling competition" to "enhance SLS affordability."[4]

The purpose of the work presented in this paper is to perform an independent assessment of the elements that make up an affordable and realistic path forward for the SLS booster system, utilizing advanced design methods and technology evaluation techniques. The goal is to identify elements that will enable a more sustainable development program by exploring the trade space of heavy lift booster systems and focusing on affordability, operability, and reliability at the system and subsystem levels[5]. For this study, affordability is defined as lifecycle cost, which includes design, development, test, and engineering (DDT&E), production and operational costs (P&O). For this study, the system objectives include reducing DDT&E schedule by a factor of three, showing 99.9% reliability, flying up to four times per year, serving both crew and cargo missions, and evolving to a lift capability of 130 metric tons.[3]

After identifying gaps in the current system's capabilities, this study seeks to identify non-traditional and innovative technologies and processes that may improve performance in these areas and assess their impacts on booster system development. The DDT&E phase may be improved by incorporating incremental development testing and integrated demonstrations to mitigate risk. To further reduce DDT&E, this study will also consider how aspects of the booster system may have commonality with other users, such as the Department of Defense, commercial applications, or international partners; by sharing some of the risk and investment, the overall development cost may be reduced. Consideration is not limited to solid and liquid rocket boosters. A set of functional performance characteristics, such as engine thrust, specific impulse (I_{sp}), mixture ratio, and throttle range are identified and their impacts on the system are evaluated. This study also identifies how such characteristics affect overall life cycle cost, including DDT&E and fixed and variable P&O.

Investigation of innovative technologies and processes will be evaluated through the Technology Identification, Evaluation, and Selection (TIES)[6] methodology, this study seeks to identify an affordable and realistic path forward for the SLS booster system. The results will include identification of booster system architectures that are most likely to succeed on an affordable budget, as well as key drivers of DDT&E cost and schedule. Performance requirements must be met while significantly reducing acquisition and development costs in order to create a program that is sustainable enough to achieve its mission goals.

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