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Building Operations Efficiencies Into NASA's Crew Launch Vehicle Design

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The U.S. Vision for Space Exploration guides NASA's challenging missions of technological innovation and scientific investigation. With the Agency's commitment to complete the International Space Station (ISS) and to retire the Space Shuttle by 2010, the NASA Administrator commissioned the Exploration Systems Architecture Study (ESAS) in mid 2005 to analyze options for a safer, simpler, more cost-efficient launch system that could deliver timely human-rated space transportation capabilities.

NASA's finite resources yield discoveries with infinite possibilities. As the Agency begins the process of replacing the Shuttle with new launch vehicles destined for missions beyond low-Earth orbit to the Moon and Mars, NASA is designing the follow-on crew and cargo systems for maximum operational efficiencies. This mandate is imperative to reduce the \$4.5 billion NASA spends on space transportation each year. This paper gives top-level details of how the follow-on Crew Launch Vehicle (CLV) is being designed for reduced lifecycle costs as a primary catalyst for the expansion of future frontiers.

NASA rolled out its exploration architecture solutions in fall 2005 and established the CLV Project as part of the Constellation Program to design, develop, test, and operate the transportation system for the Crew Exploration Vehicle (CEV) (see Figure 1). The CLV configuration was selected based on figures of merit that included greatly improved safety and reliability, coupled with dramatic decreases in operations costs. A fixed budget and accelerated schedule also were factors against which both Shuttle-derived and expendable launch vehicle options were measured.



Figure 1. The CLV will loft the CEV early next decade (artist's concept).

The follow-on launch vehicle selected is based primarily on re-purposed Shuttle propulsion elements; this approach provides well-understood human-rated hardware upon which to evolve a new system. The CLV uses a single modified 4-segment Solid Rocket Booster (SRB) as the First Stage and a modified Space Shuttle Main Engine (SSME) to power a clean-sheet Upper Stage design (see Figure 2). Though not without risk, this configuration was objectively determined to have the greatest overall probability for improved crew safety, coupled with the best likelihood of meeting technical, budget, and schedule parameters.

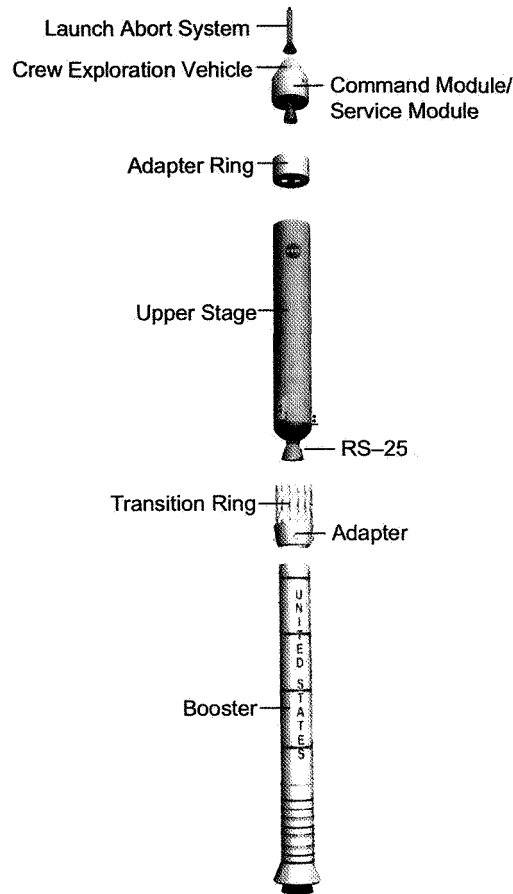


Figure 2. The CLV builds on Shuttle heritage hardware (artist's concept).

The NASA is revitalizing the space fleet and of re-vectoring the way the Agency does business. For example, NASA has released an announcement for orbital transportation service demonstrations, making ISS servicing a viable market for both established and emerging commercial providers. This is one of many facets of achieving efficiencies across the Agency's mission portfolio. Likewise, the CLV Project emphasizes the importance of planning today for efficient operations tomorrow.

The concept of operations is key to the decision-making process in terms of reduced non-recurring costs and recurring costs. The Constellation Program with its long-term implementation, requires increased operational efficiencies throughout the Program. At this early stage, the requirements being developed and the management of these requirements across the Program and Project will drive success.

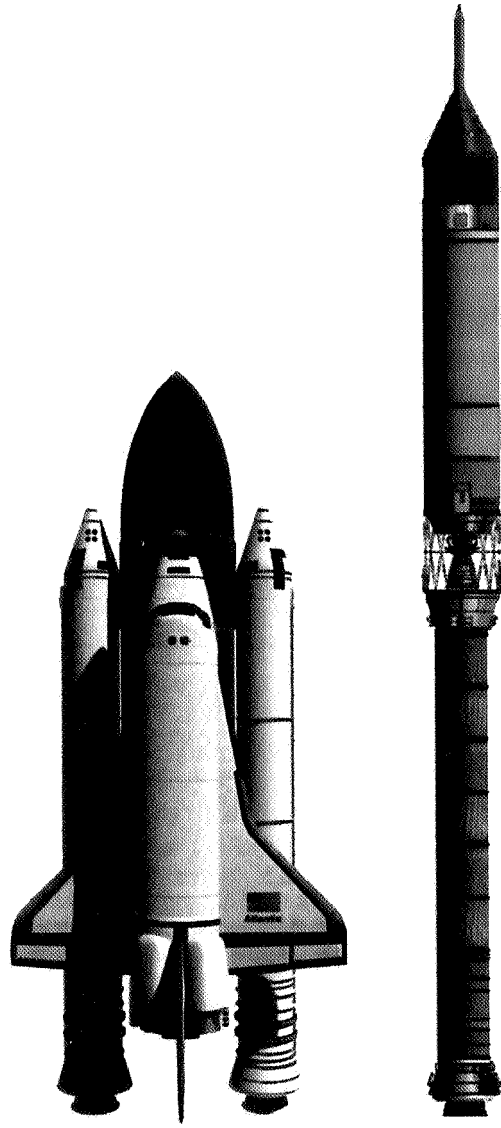


Figure 3. Comparison of the Shuttle and the CLV (vehicles are shown to scale).

The CLV Project's implementation tenets include utilizing current and proven technology to the maximum extent possible. Areas of potential recurring cost savings include designing a robust system with automated processing for reduced-touch labor, easy access for maintenance, commonality among ground support equipment, and the ability to perform standard automated mission profiles without undue operator intervention. Sample requirements that address such issues include launch-on-time probability and launch availability in relation to weather constraints.

At the CLV System Requirements Review, slated for mid 2006, the Constellation Program and CLV Project requirements will be baselined, forming a foundation upon which further operations trade studies will be performed, leading to specific designs that will be baselined at the CLV Preliminary Design Review, currently planned for mid 2008. These configuration-controlled requirements provide statements of **what** the Agency wants and needs; they do not, however, tell its contractors **how** to do the job, an approach that is emblematic of NASA's new business paradigm.

Requirements "creep" can skew budget and schedule to the point that the effort collapses under its own weight. Learning from past experiences, the CLV Project judiciously manages requirements through control boards and its checks-and-balances organizational network. For example, the Project's Vehicle Integration element performs extensive systems engineering functions across the hardware elements (First Stage, Upper Stage, and Upper Stage Engine), while Safety and Mission Assurance representatives and chief engineers are embedded for independent insight. A CLV working group comprised of senior rocket engineers and operations experts recommends the best course of action to transition the aging NASA launch infrastructure for a new era of space operations, while identifying the level of effort that will be necessary for efficiency. Rigorous risk assessments are conducted against validated requirements in trade spaces that include cost as an independent variable, where budget is analyzed against schedule and technical performance.

From the CLV Project's standpoint, the most immediate and persistent action it can take to reduce operations and lifecycle costs is to manage requirements in an accountable manner, delivering the required launch capability on time and within budget. The CLV Project team is focused on the outcome, ensuring that precious time and energy are expended on value-added activities that drive strategies into measurable results.