NASA Ares I Crew Launch Vehicle Upper Stage Overview

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Abstract

By incorporating rigorous engineering practices, innovative manufacturing processes and test techniques, a unique multi-center government/contractor partnership, and a clean-sheet design developed around the primary requirements for the International Space Station (ISS) and Lunar missions, the Upper Stage Element of NASA's Crew Launch Vehicle (CLV), the "Ares I," is a vital part of the Constellation Program's transportation system. Constellation's exploration missions will include Ares I and Ares V launch vehicles required to place crew and cargo in low-Earth orbit (LEO), crew and cargo transportation systems required for human space travel, and transportation systems and scientific equipment required for human exploration of the Moon and Mars. Early Ares I configurations will support ISS re-supply missions.

A self-supporting cylindrical structure, the Ares I Upper Stage will be approximately 84' long and 18' in diameter. The Upper Stage Element is being designed for increased supportability and increased reliability to meet human-rating requirements imposed by NASA standards. The design also incorporates state-of-the-art materials, hardware, design, and integrated logistics planning, thus facilitating a supportable, reliable, and operable system.

With NASA retiring the Space Shuttle fleet in 2010, the success of the Ares I Project is essential to America's continued leadership in space. The first Ares I test flight, called Ares 1-X, is scheduled for 2009. Subsequent test flights will continue thereafter, with the first crewed flight of the Crew Exploration Vehicle (CEV), "Orion," planned for no later than 2015. Crew transportation to the ISS will follow within the same decade, and the first Lunar excursion is scheduled for the 2020 timeframe.

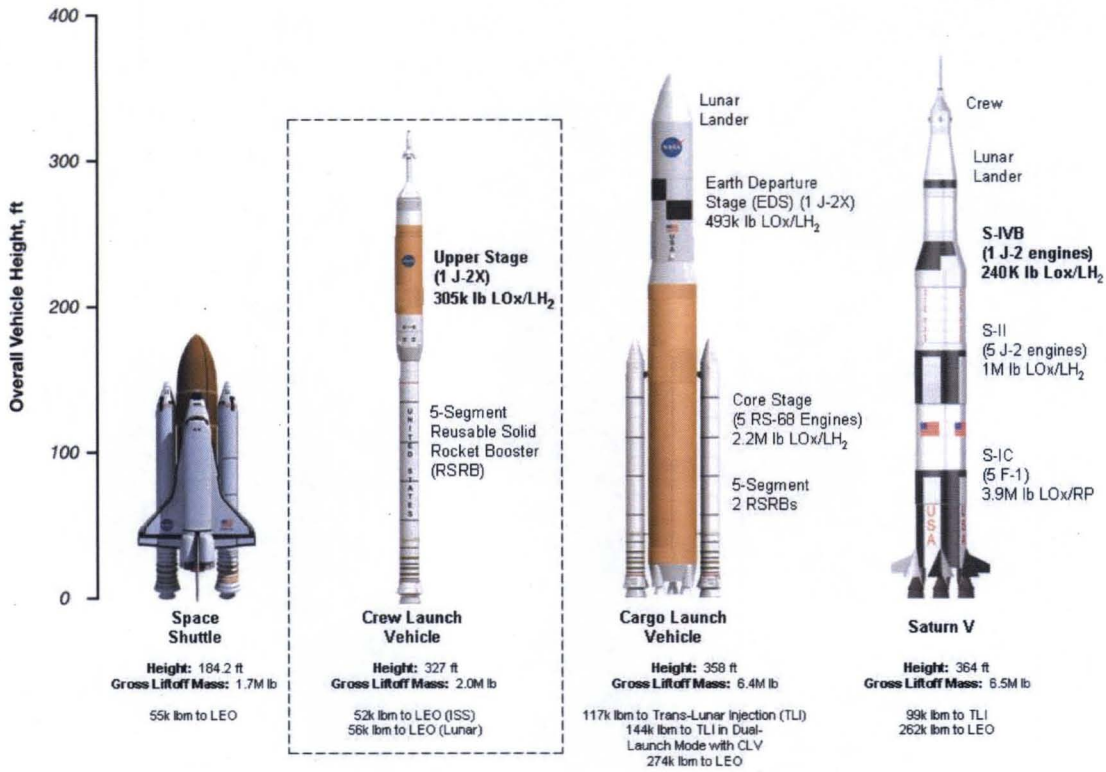

Figure 1. Heritage to Development Comparison

The Ares I Upper Stage is being designed by a NASA Design Team (NDT) and fabricated by the Upper Stage Production Contractor (USPC), The Boeing Company, at the Michoud Assembly Facility (MAF) in New Orleans, Louisiana. NASA awarded this contract to Boeing in August 2007 in a competitive procurement as part of an agreement that includes the assembly, checkout, and delivery of the completed integrated Upper Stage. NASA has also selected an Upper Stage Instrument Unit Avionics Contractor (IUAC), The Boeing Company, to fabricate, assemble, and checkout the avionics hardware and systems into the Instrument Unit (IU). A competitive procurement was completed in December 2007 with the final selection of the IUAC.

The Upper Stage Office (USO) is responsible for the Upper Stage Design, Development, Test, and Evaluation (DDT&E), including project management, development planning, resource planning, tracking, and risk management. The USO is also responsible for the qualification acceptance of flight hardware. NASA will maintain data rights for the design and resulting Upper Stage hardware. The DDT&E period consists of the first five test flights of the Ares I–Ares 1-X, Ares 1-Y, Orion 1, Orion 2 (crewed), and Orion 3 (crewed).

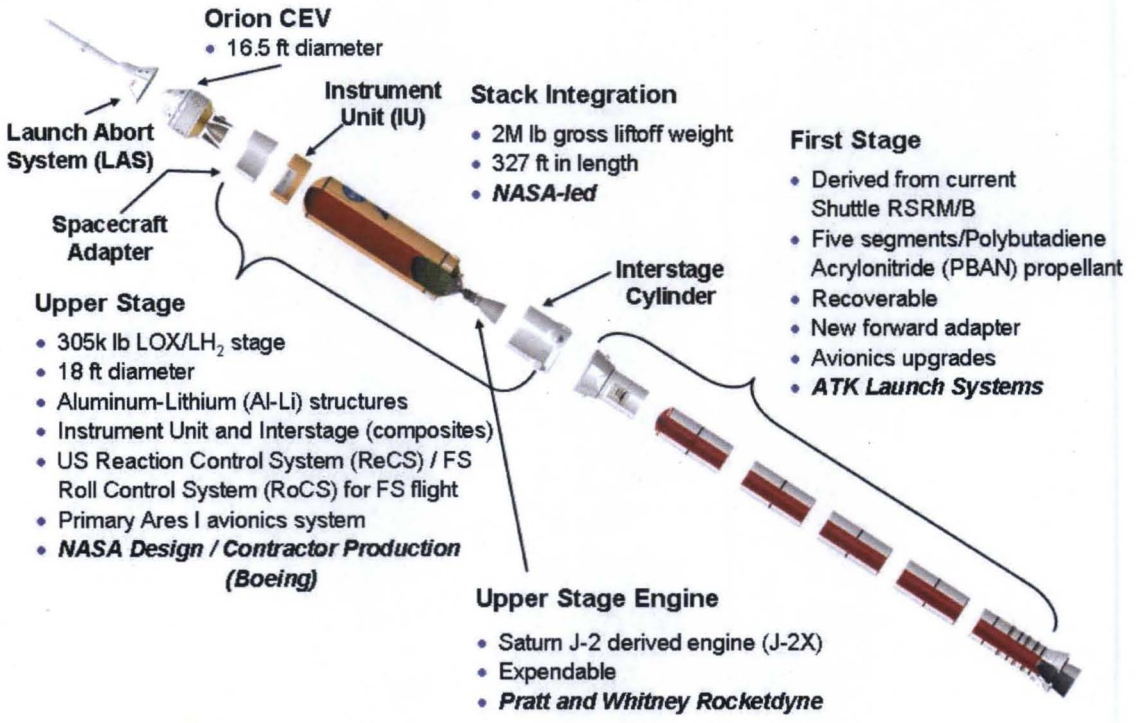

Figure 2. Upper Stage Overview

Upper Stage Element Functional Overview

The Upper Stage will provide the guidance, navigation, and control (GN&C), and the Saturn-derived J-2X Upper Stage Engine (USE) will provide the thrust and propulsive impulse, required for the second stage of the Ares I ascent flight after the First Stage separates from the launch vehicle.

The baseline Design Reference Mission calls for the Upper Stage to provide active thrust via the USE for approximately 463 seconds after First Stage burnout and separation. Shortly after USE cut-off, the Orion CEV separates from the Upper Stage and ignites for insertion into LEO. The Upper Stage is dormant after safe shut-down of the USE and re-enters for disposal in the Indian Ocean. The two Design Reference Mission trajectories envisioned for the Ares I launch vehicle are a 28.5° flight profile to support Lunar missions and a 51.6° flight profile to support ISS missions.

Figure 3 illustrates the primary products of the Upper Stage Element.

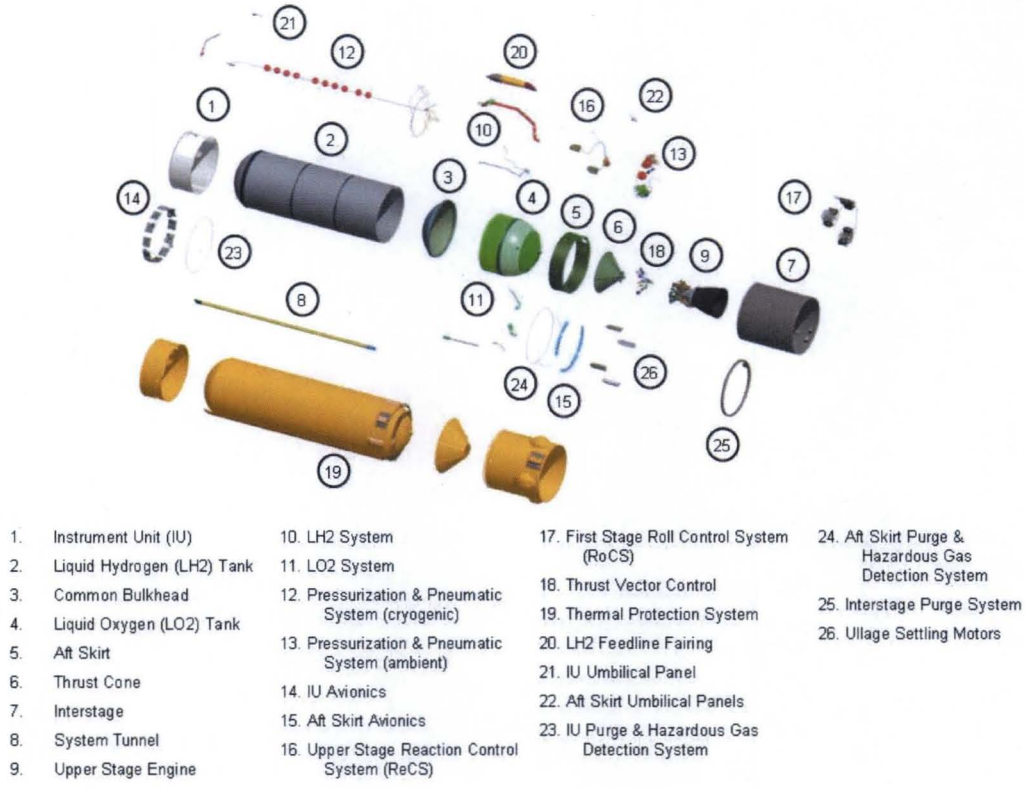

Figure 3. Upper Stage Element

The final integrated Ares I Upper Stage will be the product of numerous partnerships among industry participants, the Upper Stage Production Contractor (USPC), and multiple NASA Centers. The development process begins with component tests and advances to more integrated testing as the design matures. The design is managed in Design Analysis Cycles (DACs) that provide coordinated decomposition, detailed design at the component level, and reintegration of the system. The DACs are scheduled to support design reviews.

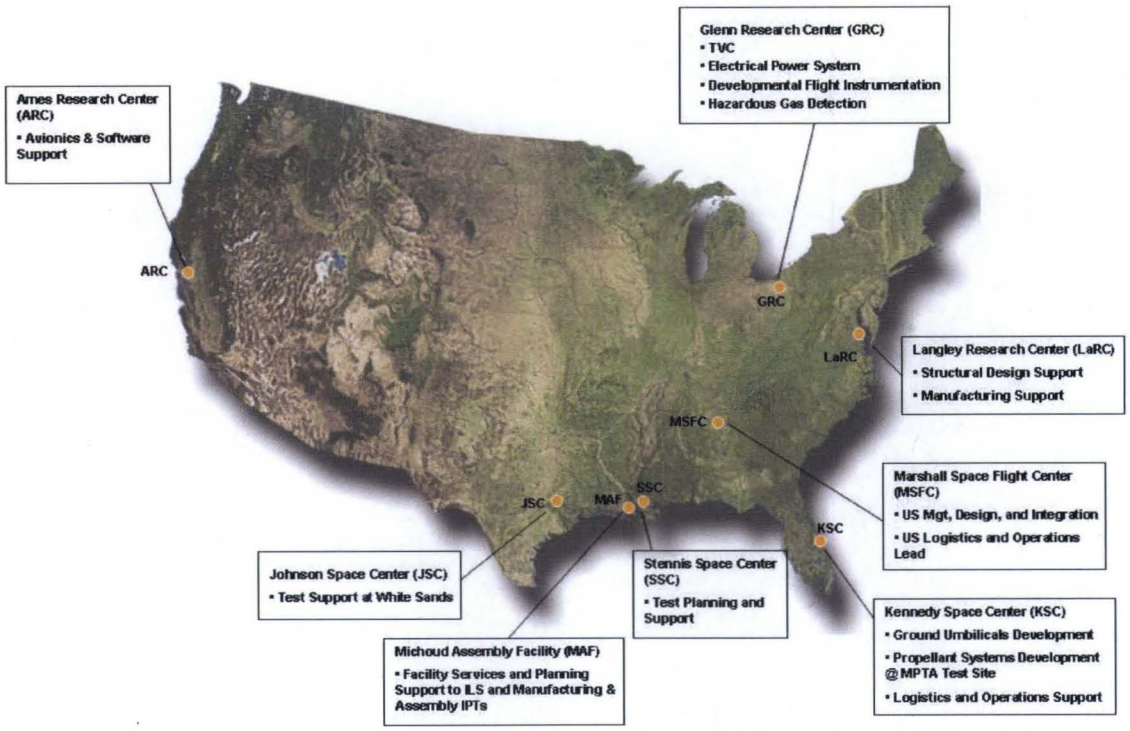

Figure 4. Upper Stage Development Approach

Successful Reviews

In 2007, the Upper Stage Element successfully completed a System Requirements Review (SRR) and System Definition Review (SDR). The SRR, completed in April 2007, confirmed that 1) the Upper Stage Element requirements were complete, verifiable, properly flowed down and traceable, validated, allocated to the subsystem level, and ready to be placed under configuration control; 2) associated risks were identified with mitigations; 3) the requirements were responsive to mission requirements and the architecture/design concept could fulfill the mission objectives within imposed constraints; and 4) the Upper Stage Element was of sufficient maturity to warrant moving forward to the next phase of development and the SDR. Upper Stage Subsystems, including Avionics & Software and Main Propulsion System (MPS), have also successfully completed their respective Subsystem SRRs.

The SDR, completed in October 2007, evaluated the element-level design against the current set of baseline element requirements. The Upper Stage Team openly presented and discussed actions and forward work to close out all Upper Stage SDR Pre-Board findings, with the Board concurring on proceeding to Upper Stage Preliminary Design Review (PDR).

The requirements phase will be followed by the preliminary design phase, which will be completed in June 2008 with the PDRs for the Upper Stage Element and each of the Upper Stage subsystems. Subsystem components will be fabricated and procured during this phase to support the development phase design and test activities.

Upon completion of the PDRs, the Element will enter the final flight design phase, culminating with the Critical Design Reviews (CDRs) in November 2009, at which point the Upper Stage flight configuration design will be baselined. After completion of the CDRs, flight configuration hardware fabrication to support component-level design qualification testing, systems-level design qualification, and flight system fabrication and assembly will begin. All flight configuration hardware, including all qualification hardware, will be fabricated to released drawings.