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Space Exploration

Ares I Upper Stage Backgrounder



Description & Purpose: Ares I is an in-line, two-stage rocket that will carry the crew exploration vehicle Orion to low-Earth orbit. This rocket will succeed the space shuttle as NASA's primary vehicle for human exploration in the next decade. Boeing will produce the Ares I upper stage, with a Pratt & Whitney- Rocketdyne engine and avionics procured separately (Boeing will build the Instrument Unit Avionics and IUA structure and will also provide avionics box integration). The Ares I upper stage is propelled by a single J-2X main engine fueled with liquid oxygen and liquid hydrogen. Boeing is providing producibility engineering support to the NASA Design Team at Marshall Space Flight Center in preparation for production of the upper stage components. Final manufacturing and assembly will be at the NASA Michoud Assembly Facility in New Orleans, La.

Customer: NASA is the customer for the Ares I upper stage. The Marshall Space Flight Center in Huntsville, Ala. is leading the overall design of the Ares I Crew Launch vehicle with Boeing serving as their production partner for the upper stage.

General Characteristics:

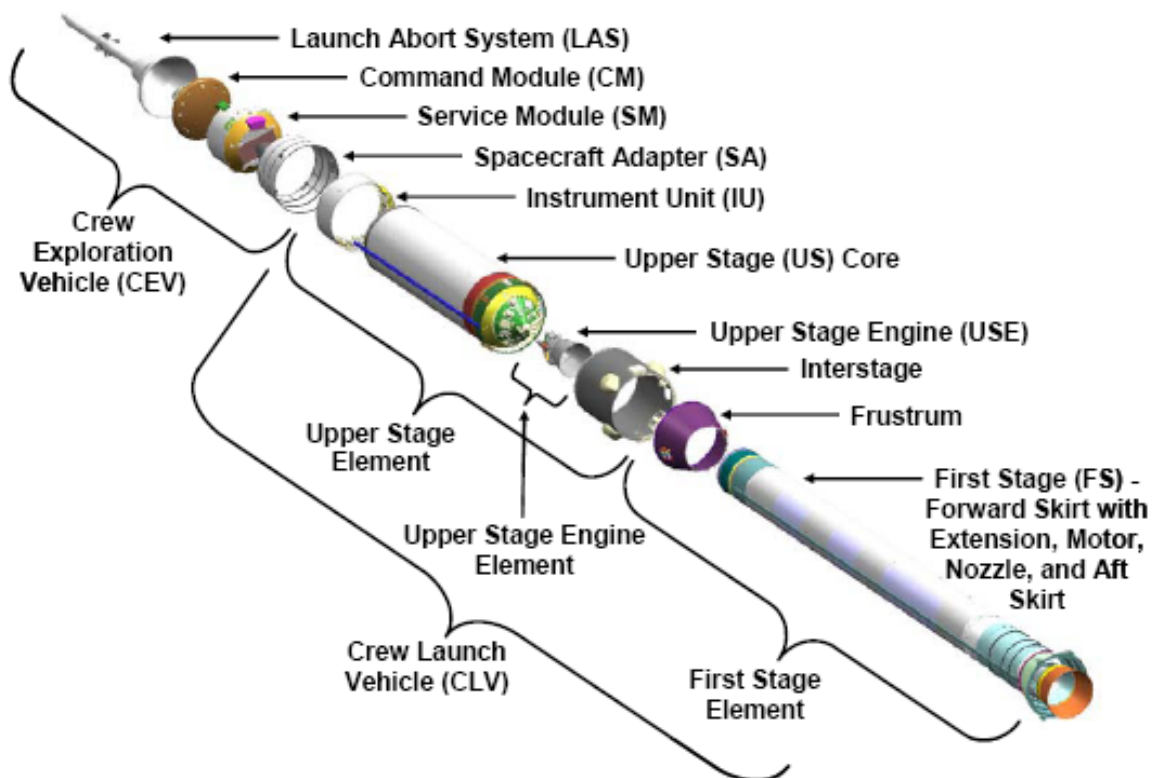
Overall Ares I Crew Launch Vehicle

Diameter:	18 feet (5.5 m) (widest point is at upper stage)
Height:	320 feet
Payload Weight:	~25 metric tons (50,000 pounds)
Liftoff Weight:	1,997,506 lbs.
Liftoff Thrust:	3,186,764
Thrust to Weight Ratio:	1.6
Booster Stage Separation:	125 sec. at 314,000 feet at mach 5.8
Orion & Service Module Separation:	70 nautical miles

Upper Stage

Diameter:	18 feet (5.5 m)
Length:	84 feet
Dry Weight:	32,500 lbs
Propellant:	305,000 pounds
J-2X Ignition:	133 seconds after liftoff
J-2X engine run time:	465 seconds
Altitude of First Stage Separation:	191,000 (36 miles)
Final Altitude of Upper Stage:	70 miles
*Orbit:	11 by 100 nautical miles

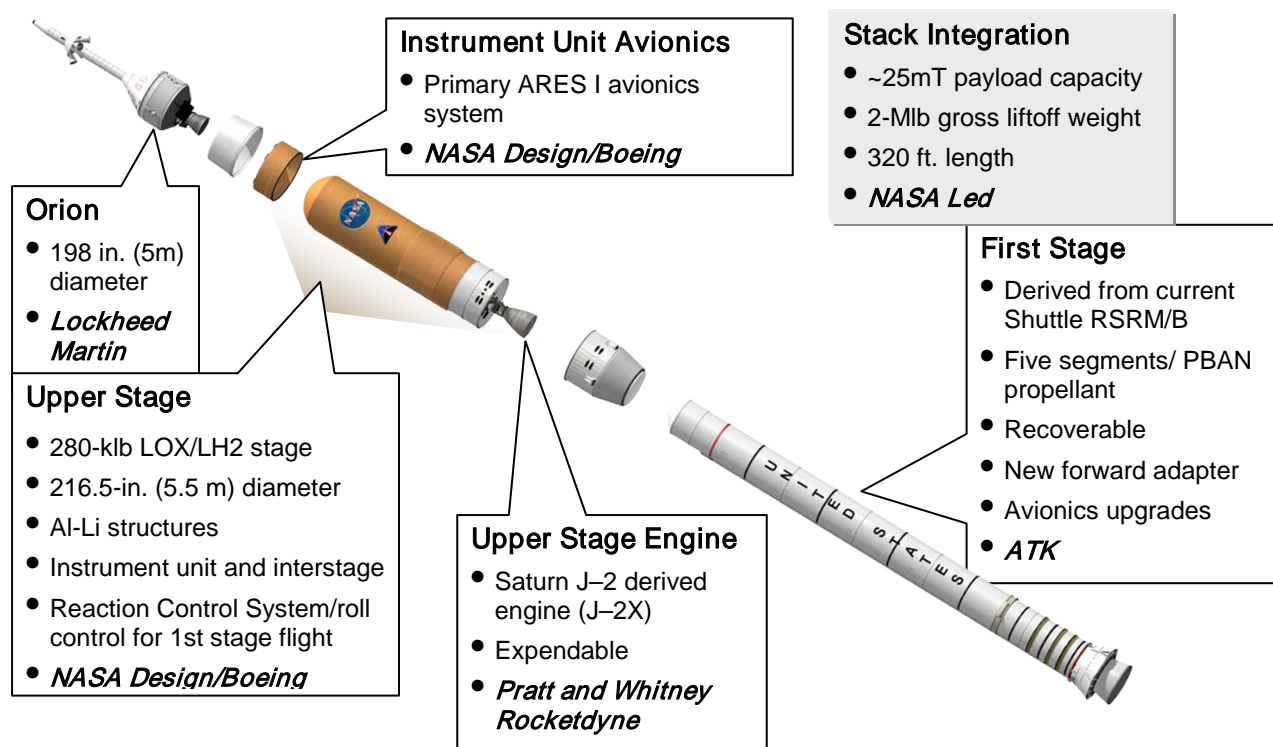
* = ensures upper stage will fall into same areas of the Indian Ocean whether a lunar or space station mission



Background

The Ares I rocket will launch astronauts to the International Space Station and will eventually help return humans to the moon. Ares I, named for the Greek god associated with Mars, is an in-line, two-stage rocket topped by the Orion crew exploration vehicle, its service module and a launch abort system. The launch vehicle's first stage is a single, five-segment reusable solid rocket booster, derived from the Space Shuttle program's four-segment booster. The second stage, or upper stage, is being designed at NASA. Boeing will serve as NASA's production partner. The first Ares I test flight is planned for 2009. Crew transportation to the International Space Station is planned to begin no later than 2015. The first lunar excursion is scheduled for the 2020 timeframe.

Boeing was selected by NASA to build the upper stage for the Ares I crew launch vehicle on Aug 28, 2007, primarily for its innovative lean manufacturing practices. The basic cost-plus-award-fee contract is valued at \$514.7 million for design team support and the manufacture of the test units and six production flight units.



The contract also includes provisions for a possible additional \$275 million for "as needed" support (called Indefinite Delivery Indefinite Quantity tasks) and \$335 million in options for 12 additional units, bringing the potential total contract value to \$1.125 billion. The contract period of performance is Sept. 1, 2007 through Dec. 31, 2016.

Boeing will support NASA during the design phase and will be responsible for production of the Ares I upper stage. Final assembly of the upper stage will take place at NASA's Michoud Assembly Facility (MAF) in New Orleans, La. If all options of the cost-plus

performance contract are exercised through 2016, Boeing could produce as many as 23 upper stages, which includes test and qualification units. NASA can order up to four additional flight units a year along with the two under contracts. Boeing will start production work at MAF in mid-2010, and by the end of that year will have 150 – 200 employees supporting production activities. Boeing is assisting NASA with facility upgrades which are expected to begin in early 2009.

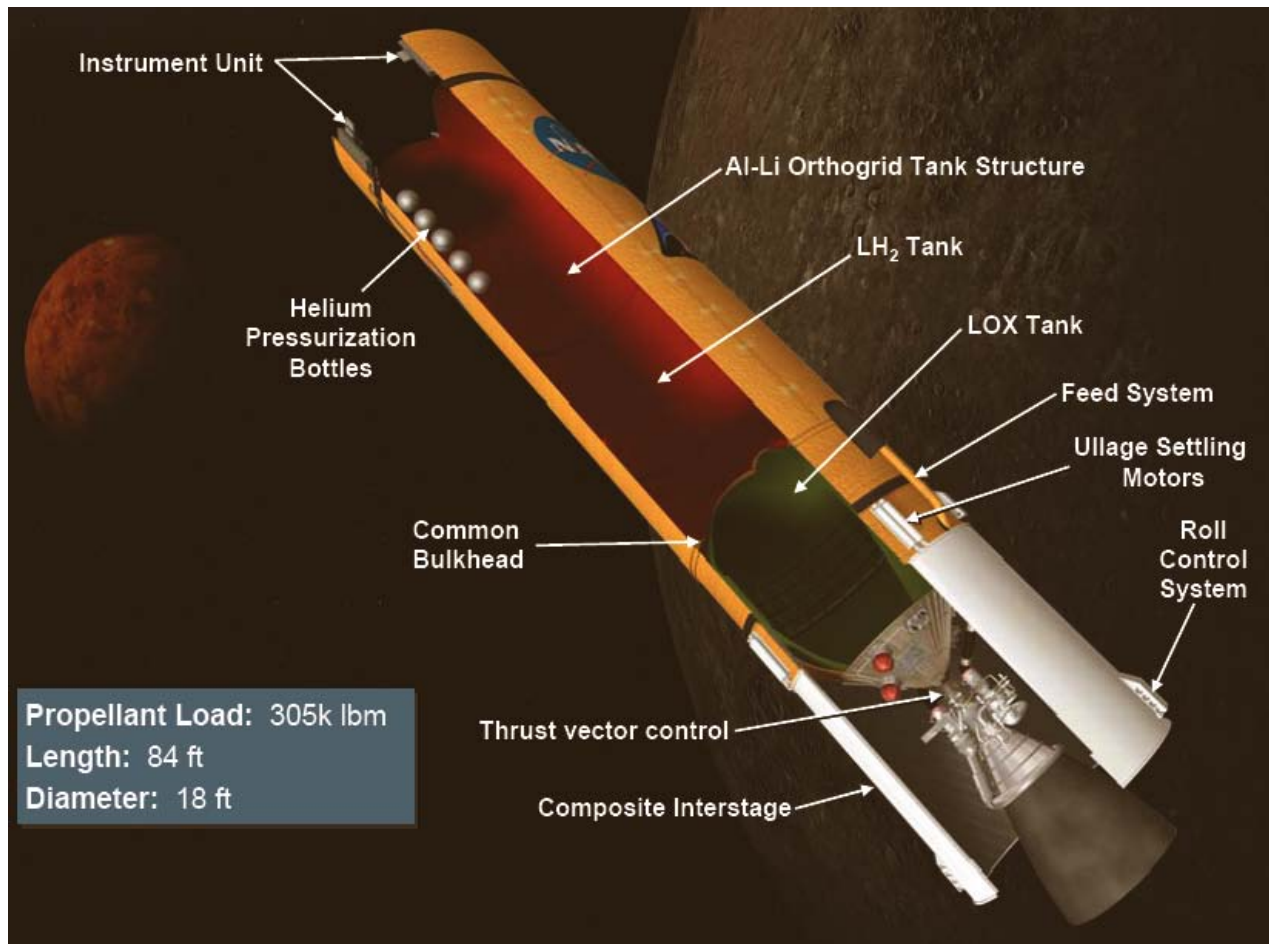
NASA's Ares I approach is similar to that used for procuring the Saturn rockets, with a NASA-led design and an industry production partner. NASA will follow the same approach for the Instrument Unit Avionics procurement, which Boeing was also selected to produce. The Ares I upper stage is about six times larger than any upper stage that flies today, but is along the scale and size of what was flown in the Saturn rocket era. During the Apollo era, Boeing worked on the Saturn first stage booster at MAF in the 1960s. Parts for the booster were shipped to Michoud from the company's Wichita, Kan. plant, as well as from subcontractors around the country.

The upper stage will require about 18,000 inches of welds required to assemble the stage. The upper stage will take advantage of friction stir welding, which forces the materials together without melting the components and provides a more reliable, high-strength weld. The upper stage production work will consist of the tanks, feedlines that take the propellants from the tank to the J-2X engine, and all of the structure that carries the loads (forces) between the first stage and the payload. The tanks will be a self-reacted, friction-stir-welded, aluminum-lithium, orthogrid structure. The upper stage design will use a common bulkhead, which separates the liquid oxygen and liquid hydrogen tanks. Three quarters of the volume would be dedicated to the liquid hydrogen. The liquid hydrogen tank is much larger than the oxygen tank due to hydrogen's lower density. The engine burns six pounds of oxygen for every pound of hydrogen. The upper stage will include the thrust vector control system, which will steer the J-2X engine, as well as a reaction control system, which contains small thrusters to control the roll of the vehicle and the attitude of the second stage after the first stage drops off. There are also a number of smaller cryogenic tanks for pressurization and power.

Boeing, in manufacturing the components of the upper stage, will follow a build a little, test a little approach. This approach has the advantage of building up and then testing the subsystems early to avoid passing on any defects in the production flow. Boeing's Lean manufacturing approach will rely upon kitting of key parts so that production workers are efficient, much like an operating room surgeon who has everything that is needed within easy reach. The same concept will be applied to the production shop floor at MAF and is currently used extensively in Boeing manufacturing operations.

The upper stage is powered by a single J-2X engine which will start about 133 seconds after liftoff following separation of the first stage booster at an altitude of 191,000 feet (36 miles). The engine will run for about 465 seconds, burning some 102,600 gallons (302,200 pounds) of propellant. The engine will shut down as the upper stage reaches an altitude of about 70 miles. Shortly after, the Orion capsule will separate from the upper stage. After separation, Orion's engine will ignite to insert the capsule into low-Earth orbit. There, Orion will rendezvous with the International Space Station or with the Earth departure stage of the Ares V rocket for missions to the moon. The Ares I upper

stage will reenter Earth's atmosphere and splash down into the Indian Ocean and will not be reused like the first stage.



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