From Paper to Production to Test: an Update on NASA's J-2X Engine for Exploration

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Abstract

The NASA/industry team responsible for developing the J-2X upper stage engine for the Space Launch System (SLS) Program has made significant progress toward moving beyond the design phase and into production, assembly, and test of development hardware. The J-2X engine exemplifies the SLS Program goal of using proven technology and experience from more than 50 years of United States spaceflight experience combined with modern manufacturing processes and approaches. It will power the second stage of the fully evolved SLS Program launch vehicle that will enable a return to human exploration of space beyond low earth orbit.

Pratt & Whitney Rocketdyne (PWR) is under contract to develop and produce the engine, leveraging its flight-proven LH_2/LOX, gas generator cycle J-2 and RS-68 engine capabilities, recent experience with the X-33 aerospike XRS-2200 engine, and development knowledge of the J-2S tap-off cycle engine. The J-2X employs a gas generator operating cycle designed to produce 294,000 pounds of vacuum thrust in primary operating mode with its full nozzle extension. With a truncated nozzle extension suitable to support engine clustering on the stage, the nominal vacuum thrust level in primary mode is 285,000 pounds. It also has a secondary mode, during which it operates at 80 percent thrust by altering its mixture ratio.

The J-2X development philosophy is based on proven hardware, an aggressive development schedule, and early risk reduction. NASA Marshall Space Flight Center (MSFC) and PWR began development of the J-2X in June 2006. The government/industry team of more than 600 people within NASA and PWR successfully completed the Critical Design Review (CDR) in November 2008, following extensive risk mitigation testing. Assembly of the first development engine was completed in May 2011 and the first engine test was conducted at the NASA Stennis Space Center (SSC), test stand A2, on 14 July 2011.

Testing of the first development engine will continue through the autumn of 2011, be paused for test stand modifications to the passive diffuser, and then restart in the spring of 2012. This testing will be followed by specialized powerpack testing intended to examine the design and operating margins of the engine turbomachinery. The development plan beyond this point leads through more system-level, engine testing of several samples, analytical model validation activities, functional and performance verification, and then ultimate certification to support human spaceflight.

This paper will discuss the J-2X development background, provide top-level information on design and development planning, and will explore some of the development challenges and mitigation activities pursued to date.