



X-43A Hyper-X Booster

Demonstrating Air-Breathing Hypersonic Flight



Hyper-X booster and X-43 research vehicle mated under the wing of NASA's B-52

Mission Description

The NASA X-43A Hyper-X program tested propulsion technologies that promise to increase payload capacity on future reusable space launchers and hypersonic aircraft, defined as faster than Mach 5. While vehicles with conventional rocket engines carry oxygen on board, the air-breathing X-43A scramjet engines use oxygen from the atmosphere, a technique that increases payload capacity.

The small, unmanned X-43A vehicle was carried aboard a modified Pegasus® booster launched from NASA's B-52B aircraft off the coast of California. Once a predetermined altitude and velocity was achieved, the X-43A separated from the booster and flew under its own power at seven to ten times the speed of sound.

Launch Vehicle

The Hyper-X launch vehicle built on technology and operational methods developed on Orbital's space and suborbital rocket programs. A derivative of Orbital's Pegasus space launch vehicle, the rocket's second and third stages were eliminated, as was the fairing, which is normally used to protect satellite payloads. The X-43A research vehicle and its adapter rode atop the front end of a specially-configured Orion 50S first stage solid rocket motor. A newly-developed thermal protection system protected the Pegasus composite structures against severe heating loads associated with lower-altitude hypersonic operations. Other modifications included upgraded first stage guidance and an avionics repackaging that permitted ballasting for hypersonic flight conditions.

QUICK FACTS:

Key Mission Partners:

NASA Langley Research Center
Hampton, VA - Program management and research vehicle lead

NASA Dryden Flight Research Center
Edwards, CA - Flight research lead and contracting agency

ATK, Inc.
Tullahoma, TN - Research vehicle design and fabrication

Orbital Sciences Corporation
Chandler, AZ; Vandenberg AFB, CA; Dulles, VA - Launch vehicle design and fabrication



X-43A vehicle

X-43A Hyper-X Booster

Specifications

Hyper-X Launch Vehicle

Length:	49 ft.
Diameter:	50 in.
Wingspan:	22 ft.
Weight:	37,300 lb. (including X-43A)
Propulsion:	Alliant Techsystems Orion 50S solid rocket motor with 109,000 lb. average thrust
Airframe:	Composite with aluminum ballast/avionics module
Control System:	Electromechanically actuated fins
Avionics System:	GPS/INS navigation, 32-bit flight computer with RS-422 digital serial datalinks, Orbital MACH power and ordnance switching, 2 Mb/secs PCM data system
Performance:	Separation conditions between Mach 7 and 10 at 95,000 to 110,000 ft.

X-43A Research Vehicle

Length:	12 ft.
Wingspan:	5 ft.
Weight:	Approx. 3,000 lb.
Propulsion:	Dual-mode ramjet/scramjet
Downlink:	S-band (approx. 700 parameters were measured and transmitted)

X-43A Mission Update

The second flight of the X-43A Scramjet Demonstrator occurred on March 27 and was fully successful. The second launch attempt incorporated several design improvements over the first flight launch vehicle, including an upgraded control system, redesigned autopilot, off-loaded rocket motor, and improved analytical models. The second flight was launched at 40,000 feet (instead of F1's 25,000 ft) to reduce transonic aerodynamic loads and improve structural and control system margins. An off-loaded Orion 50S solid rocket motor was employed featuring a thrust profile that reduced maximum dynamic pressure ("max-Q") during the flight.

The third X-43A flight broke the records set on Flight 2 demonstrating air-frame integrated scramjet performance at speeds approaching Mach 10. Changes to the launch vehicle for Flight 3 included high-temperature thermal protection system tiles on the wing and fin leading edges for performance to Mach 10, elimination of all ballast and a full propellant load on the ATK Orion 50S booster, lightweight aluminum structures, and updated control laws and aerodynamics. Flight 3 used the same drop conditions as Flight 2, and the early transonic phase of the trajectory mimicked Flight 2 to minimize risk.

Mission Profile

Following takeoff from Edwards Air Force Base, CA, the B-52B aircraft flew to a predetermined launch point over the ocean and released the Hyper-X launch vehicle and research vehicle "stack." After a five-second free-fall, the Orion 50S rocket motor ignited and quickly accelerated the 37,300-pound stack to supersonic speeds. Mach 1 was achieved at eight seconds and Mach 5 at 60 seconds. The first 20 seconds of the boost trajectory resembled a normal Pegasus first stage flight. Afterward, severe structural and aerodynamic heating stresses were encountered. A "pull-down" maneuver was initiated at approximately 35 seconds that placed the stack on a straight and level flight path in preparation for X-43A separation at approximately 89 seconds.

