NASA Facts

National Aeronautics and
Space Administration

Marshall Space Flight Center
Huntsville, Alabama 35812

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Hypersonics

Research and Development

An artist's rendering of the X-43C hypersonic flight demonstrator, scheduled to take wing for flight testing by 2008.

Imagine being able to take off from a U.S. airport and travel to space at a price comparable to flying aboard the Concorde jet. Technology now being developed by NASA and its partners might achieve such highly reliable and low cost access to space in less than two decades, yielding limitless possibilities for space travel, such as space commerce and tourism.

NASA's hypersonics investment, part of the Next Generation Launch Technology Program, is intended to develop enabling technologies to support creation of third-generation reusable launch vehicles. This research is expected to yield cheaper, safer, more routine access to space in coming decades.

The Next Generation Launch Technology Program is part of the Space Launch Initiative, NASA's research and development effort intended to enable routine access to and from the International Space Station, and to spearhead development of key technologies that will support the needs of future space launch systems.

NASA expects to spend about $800 million on its hypersonics program over the next six years. This intensive research and development effort is expected to yield, within the next 15-18 years, a fleet of vehicles powered by air-breathing rocket- or turbine-based engines, and capable of launching from most ordinary airport runways.

And because these craft will be capable of sustaining atmospheric travel speeds well in excess of Mach 5 — or about 3,750 mph, the point at which "supersonic" flight becomes "hypersonic" flight — they also promise to open up unprecedented new opportunities for international commerce and trade.

Overhauling the propulsion paradigm

It is commonly held that conventional rocket propulsion technologies have reached the limit of their power and performance capabilities. To advance our flight capabilities to the next level and retain America's leadership in space, NASA requires new, improved means of propelling craft to Earth orbit.

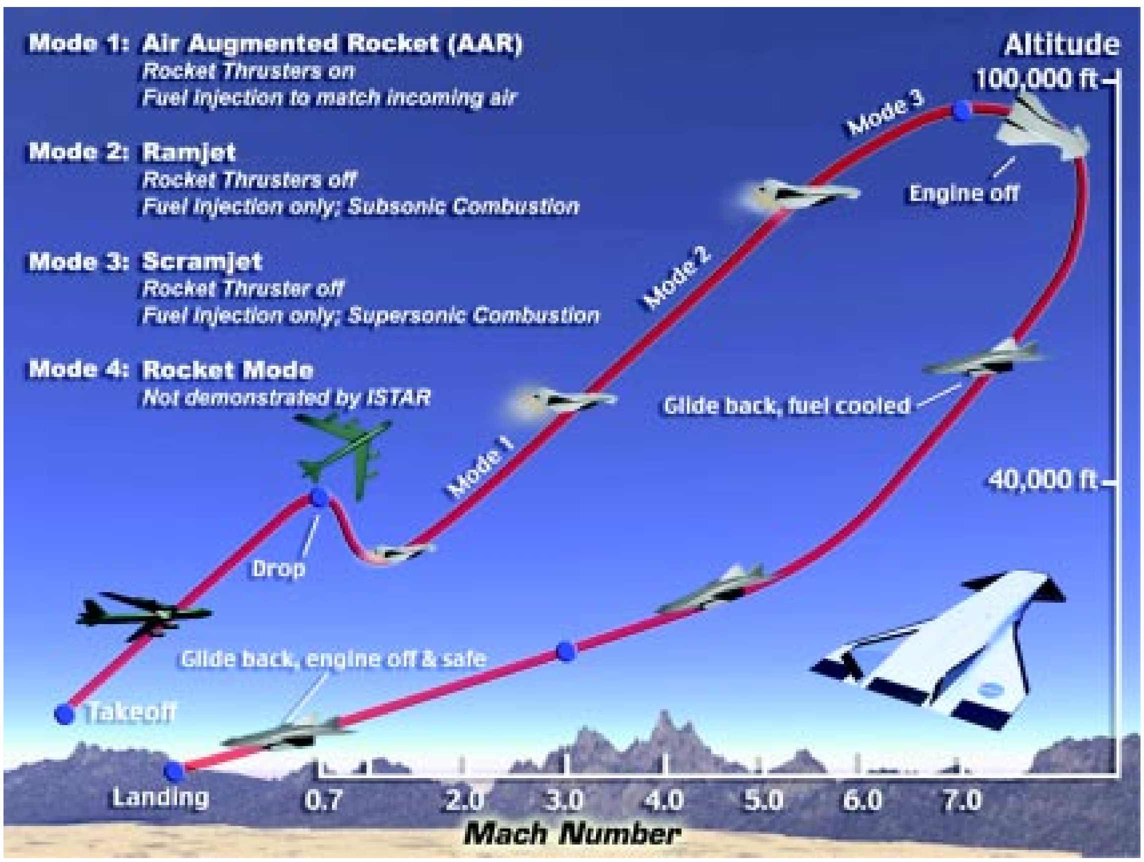
Takeoff weight also remains a critical factor in any space launch. More than 80 percent of the Space Shuttle's weight at takeoff is its propellant — hydrogen and oxygen. NASA seeks to do away with that heavy propellant load, reducing the need to carry large amounts of heavy oxidizer. Such a move will enable horizontal takeoff vehicles with higher reliability, lower operational costs and airline-type operations — advances necessary to enable civilian passengers to go to space.

Air-breathing engine technologies are generally considered, among NASA propulsion researchers, to hold the best potential for meeting these Earth-to-orbit launch requirements.

Built on the foundation of hypersonics research conducted over the last few decades, NASA's efforts initially call for incremental ground and flight tests focusing on hypersonic propulsion and airframe technologies, to be integrated with additional technology requirements as development progresses. The program is built on a 25-year roadmap, complete with planned milestones and "decision gates," or points at which informed program decisions may be made based on accomplishments and lessons learned. In coming decades, NASA hopes to:

- dramatically reduce the cost of access to space;
- dramatically reduce trip time between destinations;
- cut turnaround time between flights from weeks to mere hours; and
- maintain aircraft-like levels of safety and reliability.

The key challenge facing the program in accomplishing these goals is twofold: first, NASA's Hyper-X series flight demonstrators must validate the performance of its test engines and airframes; and second, those proven technologies must be integrated successfully into a complete, low-weight flight system — one that is fully operable and maintainable.



Anticipated Performance of a future hypersonic flight demonstrator powered by the ISTAR engine system.

The X-43A flight demonstrator, scheduled to be tested in flight in 2003.

Ramjet/scramjet engines provide propulsion at speeds greater than Mach 5, using air drawn from the atmosphere during flight to ignite and burn on-board fuel. While mechanically simple, both are much more aerodynamically complex than conventional jet engines — yet they provide much greater efficiency, permitting long-duration hypersonic flight.

Invented in 1913 by French researcher Rene Lorin, the ramjet is the simplest form of an air-breathing propulsion engine, containing no moving parts. Once a vehicle has reached speeds of at least 400 mph, the force of inertia "rams" a continuous stream of cold, fast-moving air through an interior engine chamber. This air is compressed, slowed to subsonic speed, mixed with on-board fuel and ignited, providing thrust. A scramjet, in comparison, requires a propulsive boost to speeds in excess of Mach 5 in order to ignite. Scramjet engines operating at speeds greater than Mach 8 are typically fueled with liquid hydrogen.

Air-breathing technologies

Air-breathing engines are known as "combined cycle" systems because they use a graduating series of propulsion systems to reach optimum travel speed, or to leave the atmosphere altogether. These systems capture air from the atmosphere during a large portion of their flight — an arrangement that improves efficiency 5-10 times beyond that of conventional chemical rockets. The result is a dramatic weight reduction, enabling greater flexibility in vehicle design and performance.

Multiple air-breathing engine configurations are being developed and tested, including rocket-based combined cycle (RBCC) and turbine-based combined cycle (TBCC) engines, as well as ramjet/scramjet.

In RBCC and TBCC configurations, a conventional rocket or turbine engine is paired with a dual-mode ramjet engine, which scoops air from the atmosphere during flight by way of an inlet. The turbine or rockets power flight until the ramjet achieves enough compression of ingested air to produce positive thrust, typically at about Mach 3. Then, at some point between Mach 5 and Mach 7 (approximately 3,750 mph to 5,300 mph), the operating ramjet switches to supersonic combustion ramjet — or "scramjet" — mode, as it climbs into the upper reaches of the atmosphere. In an RBCC configuration, the on-board rocket is then reignited around Mach 12 for the final boost to low Earth orbit. A TBCC configuration also would require an on-board rocket system to reach orbit.

ISTAR

The Integrated System Test of an Air-breathing Rocket or "ISTAR" project is NASA's first flight-type system development and ground test of a rocket-based, combined cycle propulsion system.

The primary ISTAR industry development team, the Rocket-Based Combined Cycle Consortium, or RBC3, includes the Rocketdyne Propulsion & Power business unit of The Boeing Co., of Canoga Park, Calif.; the Pratt & Whitney Space Propulsion business unit of United Technologies Corp., of West Palm Beach, Fla.; and the Aerojet Missile and Space Propulsion business unit of GenCorp, Inc., of Sacramento, Calif.

Dubbed "ARGO" by its design team, the prototype engine system is named for the mythical Greek ship that bore Jason and the Argonauts on their epic voyage of discovery. The ISTAR contract calls for completion of the conceptual system design by November 2002. Testing of the flight-weight, fuel-cooled engine flowpath is scheduled to begin in 2008.

The project, funded by NASA, is managed by the Marshall Space Flight Center in Huntsville, Ala.