

**technology opportunity**

Reusable Ram Booster Launch Design Emphasizes Use of Existing Components to Achieve Space Transport for Satellites and Spacecraft

Using off-the-shelf technology to make space transport more affordable



Engineers at NASA's Armstrong Flight Research Center have designed a partially reusable launch system to propel a payload-bearing spacecraft into a low Earth orbit (LEO). The concept design for the three-stage Ram Booster employs existing turbofan engines, ramjet propulsion, and an already operational third-stage rocket to achieve LEO for satellites and other spacecraft. Excluding payload (which stays in orbit), over 97 percent of the Ram Booster's total dry weight (including three stages) is reusable. As the design also draws upon off-the-shelf technology for many of its components, this novel approach to space transport dramatically lowers the cost of access to space. The technology has applications for NASA, the military, and the commercial aerospace sectors.

Benefits

- **Economical:** Lowers the cost of space access, with use of reusable components and a simplified propulsion system
- **Efficient:** Maximizes use of already operational components by using off-the-shelf technology
- **Effective:** Enables fast turnaround between missions, with reuse of recoverable first and second stages
- **Safer:** Operates with jet fuel in lower stages, eliminating the need for hazardous hypergolic or cryogenic propellants and complex reaction control systems
- **Simpler:** Offers a single fuel type for air-breathing turbofan and ramjet engines
- **Novel:** Approaches space launch complexities in a new way, providing a conceptual technical breakthrough for first and second stage boost and recovery

Applications

Satellite and spacecraft launches for:

- NASA
- Military
- Commercial aerospace firms

Licensing and Partnering Opportunities

This technology is part of NASA's Innovative Partnerships Office, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider opportunities for licensing the Ram Booster technology (DRC-010-039).

Technology Details

Reusable launch systems are the key to reducing the high cost of lofting cargo and humans to space and making the exploration of deep space more feasible. By some estimates, reusable rockets would reduce the cost of running space missions many-fold. Similarly, as all commercial transport industries use reusable vehicles, so too must the commercial space transport industry in order to thrive. With its use of off-the-shelf technology and a simplified propulsion system, this innovative Armstrong design isn't just setting a course for more affordable space access but for safer space launches as well.

How It Works

The Ram Booster operates in three stages. Launching and landing vertically, the first stage is recoverable, reusable, has 18 turbofan jet engines, and can be turned around in a short timeframe for the next mission. The estimated maximum temperature seen by reusable components during launch and recovery is 1,350° Rankine, which means that little refurbishment should be required. Depending on second-stage maintenance (and second- and third-stage readiness for assembly and check-out), the turnaround-time should range from a few weeks to a few days.

The engines have characteristics of production F-100-229 turbofans and carry the system to an altitude of 40,000 feet and Mach 2.6 before separating. Each engine has a fixed inlet and custom cowling shaped for low drag, high thrust, and the capability to prevent engine stall during the turnaround maneuver. Navigation, flight control, and guidance systems are fully autonomous and contained in the first- and third-stage onboard computers.

The second stage separates at 100,000 feet and is recovered from the ocean for re-use. Its 15 reusable ramjet engines are evenly spaced around the second-stage cylinder and operate from Mach 2 to Mach 4. Discounting vehicle stage integration, the most significant Ram Booster development challenge will be significant weight reduction in the (currently) metallic second-stage ramjet engines through use of ceramic and composite materials. The first stage's turbofan and second stage's ramjet engines both burn jet fuel, so there is no need for hazardous hypergolic or cryogenic propellants for either lower stage, which operate with one propellant tank each. This simplified propulsion system enhances safety and further eliminates the need for complex reaction control systems. The third stage of the Ram Booster is an expendable, payload-bearing rocket with characteristics of the Centaur III. Powered by two RL10A-4-2 engines, propellants are cryogenic hydrogen and oxygen.

Why It Is Better

The cost of transporting one pound of payload to LEO using conventional technology ranges from \$2,000 to \$10,000 per pound. The Ram Booster seeks to reduce these costs with a new technical concept for launch systems. The design employs reusable components, maximizes the use of already operational components, and provides new methods for first and second stage cost and recovery efforts. A simplified propulsion system and use of off-the-shelf technology, such as the turbofan and ramjet engines as well as a proven third-stage rocket, are expected to reduce costs and shorten launch system development time.

Patent

Armstrong has one patent issued (U.S. Patent No: 8,047,472) for this technology.

For more information about this technology, please contact:

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