Low Density Supersonic Decelerators

Key Facts

- Current technology for decelerating from the high speed of atmospheric entry to the final stages of landing on Mars dates back to NASA's Viking Program, which put two landers on Mars in 1976. The basic Viking parachute design has been used ever since — and was used again in 2012 to deliver the Curiosity rover to Mars.
- To conduct advanced exploration missions in the future and safely land heavier spacecraft on Mars, NASA must advance the technology of decelerating large payloads traveling at supersonic speeds in thin atmospheres to a new level of performance.
- On rocket sleds and high in Earth's stratosphere, NASA's Low Density Supersonic Decelerator (LDSD) technology demonstration project is testing new full-scale parachutes and inflatable drag devices at high speeds to mature them for future use at Mars. Testing is expected to be conducted from 2012 through 2015.
- These new drag devices are one of the first steps on the technology path to potentially landing humans, habitats, and their return rockets safely on Mars.

Future robotic missions to Mars and eventual human exploration of the Red Planet will require that more massive payloads than the one-ton Curiosity Mars rover be delivered to the surface. NASA is developing new large, sturdy, and lightweight systems to deliver next-generation rovers and landers on Mars. These new technologies would be able to slow larger, heavier landers from the supersonic speeds of Mars atmospheric entry to the subsonic ground-approach speeds necessary for a safe landing.

The new designs borrow from the same technique used by the Hawaiian pufferfish—the ʻoʻopu hue—to increase its size without adding mass: rapid inflation.

These systems, called low density supersonic decelerators, aim to solve the complicated problem of slowing Martian entry vehicles down enough to safely deliver large payloads to the Martian surface without bringing along massive amounts of extra rocket propellant or carrying a large and heavy atmospheric entry shield.

The Red Planet is Different

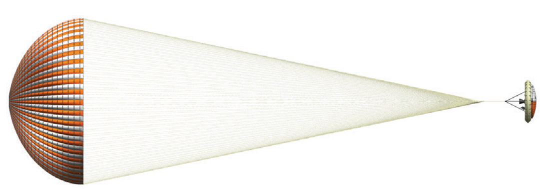
Landing on Mars is not like landing on Earth, which has a dense atmosphere, or on the moon, which has no atmosphere. Mars has a tricky environment somewhere in-between: it has too much atmosphere to allow rockets alone to land heavy vehicles, as is done on the moon, but too little atmosphere to land vehicles from space purely with friction and parachutes, as is done on Earth.

In addition, parachutes for Mars surface-bound craft must be enormous, because the atmosphere is too thin to fill a parachute like those used on Earth. Even with large parachutes, powerful retro rockets or rugged airbags have been required to complete the landing. These are some of the factors that make delivering large payloads to the surface of Mars extremely difficult.

It is not practical to test new, unproven descent technologies at Mars. Instead, NASA intends to use the very thin air found high in Earth's stratosphere as a "local" test space that duplicates many of the most important aspects of Mars' low-density atmosphere.

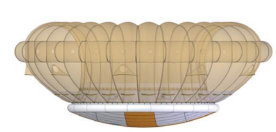
Limits of Viking-Era Deceleration Techniques

NASA's current parachute-based deceleration system has been used since the Viking Program of the 1970s. This system has reached the limit of the amount of mass that it can deliver to Mars. Additionally, because of the extremely thin Martian atmosphere, regions at high elevations—such as mountainous areas and the high-altitude southern plains—will remain inaccessible until a new landing method can be developed and proven to work.



30.5-meter Supersonic Ring Sail Parachute

6-meter SIAD-R



8-meter SIAD-E

The LDSD project aims to develop and test two sizes of inflatable drag devices and a large new, supersonic ringsail parachute.

The new deceleration capabilities provided by NASA's Low Density Supersonic Decelerator (LDSD) project should permit landings at higher altitudes, with greater spacecraft masses and higher precision. A successful LDSD test program would bring these new technologies to sufficient readiness levels allowing them to be infused into potential future robotic and human mission designs.

Developing Crosscutting, Breakthrough Technologies

As one of NASA's Technology Demonstration Missions, the LDSD project seeks to reduce risks to potential future missions by eliminating the need to fly unproven hardware by flight testing a design that can meet the higher-mass payload needs of potential future Mars exploration spacecraft.

NASA's Technology Demonstration Missions aim to bridge the gap between scientific and engineering challenges and the technological innovations needed to overcome them. The program's focus is on bringing cross-cutting technologies to flight-level maturity within two or three years to radically advance NASA's mission in space and enable benefits for science and industry here on Earth.

The LDSD project is sponsored by the NASA Space Technology Mission Directorate and managed by NASA's Jet Propulsion Laboratory in Pasadena, CA.

The Technology Demonstration Mission program is managed by NASA's Marshall Space Flight Center in Huntsville, AL.

Testing Need: A Supersonic Deceleration System for a Low-Density Atmosphere

NASA's LDSD project will need to conduct full-scale tests of potential breakthrough technologies in Earth's stratosphere before possibly sending the technologies to space for use in a Mars atmospheric entry, descent and landing.

For the LDSD project, three devices will be developed. All three are planned to be demonstrated at speeds greater than the speed of sound and will be the largest of their kind ever flown at these speeds.

The new devices under development include two balloon-like pressure vessels, called Supersonic Inflatable Aerodynamic Decelerators (SIADs). One 20 feet (six meters) in diameter, sized for future robotic missions and called SIAD-R, would be inflated with pressurized hot gas, and one 26 feet (eight meters) in diameter, sized for payloads related to human missions and called SIAD-E, would be inflated with ram air pressure. These drag devices, which are attached to the outer rim of a capsule-like atmospheric entry vehicle, will inflate when the test vehicle is flying at Mach 3.5 or greater and decelerate the vehicle to Mach 2, where it becomes safe to deploy a supersonic parachute.

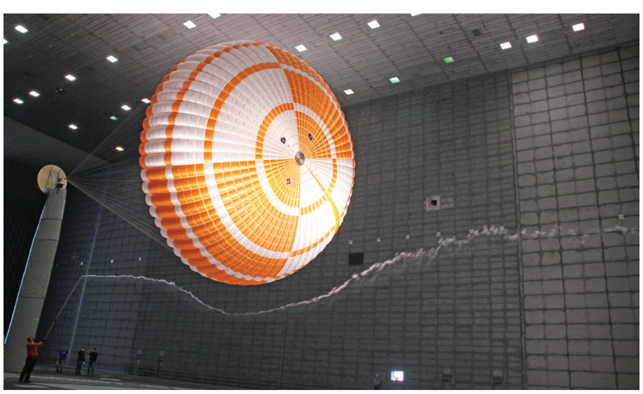


Image credit: Eric James/NASA ARC

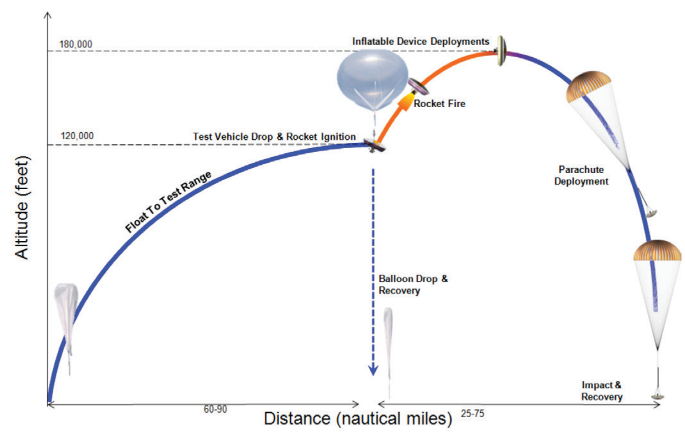
A one-third scale prototype LDSD ringsail parachute undergoes flow testing in the 80 x 120-foot test section of the National Full-scale Aerodynamics Complex operated by the U.S. Air Force at NASA Ames Research Center; a full-scale version would envelope the entire test section when fully inflated.

A new parachute with a modified design, approximately 100 feet (30.5 meters) in diameter—more than twice the area of the most recent Viking-based parachute used to land Curiosity—also will be developed to further slow the entry vehicle from Mach 2 to subsonic speeds.

The test campaigns include wind tunnel tests of parachute designs and rocket sled tests of various parts of the system at the U.S. Navy's China Lake Naval Air Weapons Station in California from 2012 through 2014.

Initial LDSD tests are being conducted using rocket sleds to accelerate the hardware to high speed. This test shows a successful deployment of the SIAD-R decelerator.

Stratospheric tests of the LDSD will be conducted in 2014 and 2015 at the Pacific Missile Range Facility operated by the U.S. Navy on Kauai, Hawaii. A large scientific balloon provided by NASA Wallops Flight Facility and the Columbia Scientific Balloon Facility will lift a solid-rocket powered test vehicle to an altitude of about 120,000 feet (37 kilometers). Within the stratosphere, the LDSD payload will undergo a rocket-powered trajectory to reach supersonic speeds and then test the deployment and function of the inflatable decelerators, followed by recovery of the balloon and test vehicle in the ocean.



Planned flight profile for four high-altitude LDSD tests in Earth's stratosphere.

For more information about the Low Density Supersonic Decelerator project, please see:
www.nasa.gov/mission_pages/tdm/ldsd/index.html

The Final Environmental Assessment for the supersonic flight tests and the signed Finding of No Significant Impact is available at:
www.govsupport.us/nasaldsdea/Default.aspx