National Aeronautics and
Space Administration

Technology Demonstration Mission Program

The Bridge

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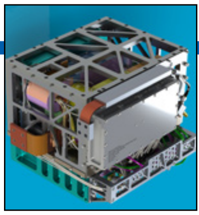


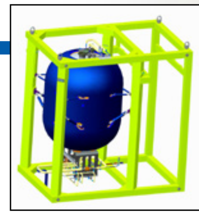


NASA's 'Flying Saucer' in the Spotlight

This artist's concept shows the test vehicle for NASA's Low-Density Supersonic Decelerator, designed to test landing technologies for future Mars missions. (Image: NASA/JPL-Caltech)

2014 proved to be a highly successful year for the NASA Technology Demonstration Mission's "flying saucer" — the Low-Density Supersonic Decelerator project. Last summer, the LDSD project successfully tested a rocket-powered, saucer-shaped vehicle, flying it to near-space from the U.S. Navy's Pacific Missile Range Facility on Kauai, Hawaii.

The innovative LDSD project went on to earn Popular Science magazine's "Best of What's New" award in the aerospace category.

The goal of the flight test — the first of three planned for the project — was to determine if the balloon-launched, rocket-powered, saucer-shaped design could reach the altitudes and airspeeds needed to test two new breakthrough technologies destined for future Mars missions. The first, the Supersonic Inflatable Aerodynamic Decelerator, is a large, doughnut-shaped air brake that deployed during the flight, helping slow the vehicle from nearly Mach 4 — or four times the speed of sound — to about Mach 2. The second, the Supersonic Disksail Parachute, is the largest supersonic parachute ever flown. It has more than double the area of the parachute that was used for the Mars Science Laboratory mission that carried the "Curiosity" rover to the Martian surface.

On June 28, 2014, the LDSD test vehicle was lofted by a helium balloon large enough to fill a football stadium. A little over two hours after launch, as it reached an altitude of 120,000 feet, the vehicle was released and a solid rocket motor fired, boosting it to about 180,000 feet and four times the speed of sound. The SIAD was inflated to slow the vehicle and then a ballute — a blend of balloon-plus-parachute — was deployed to pull out the main parachute, mimicking a Mars-like atmospheric entry.

Recovering the nearly 7,000 pounds of equipment and more than 100-foot-diameter parachute after splashdown in the Pacific Ocean was no easy feat. Three members of the LDSD team — John Gallon, John Luke Wolff and Brant Cook — orchestrated the recovery efforts of a crew of engineers, scientists and partners. It required months of planning and three boats dispatched from Port Allen, near the missile range facility, on a 12-hour and more-than-110-nautical-mile trip to the splashdown area.

Gallon, Wolff and Cook were aboard the boats, as was a Navy Explosive Ordnance Disposal team, which inspected the LDSD test vehicle as it floated before recovery to make sure there were no live pyrotechnics remaining.

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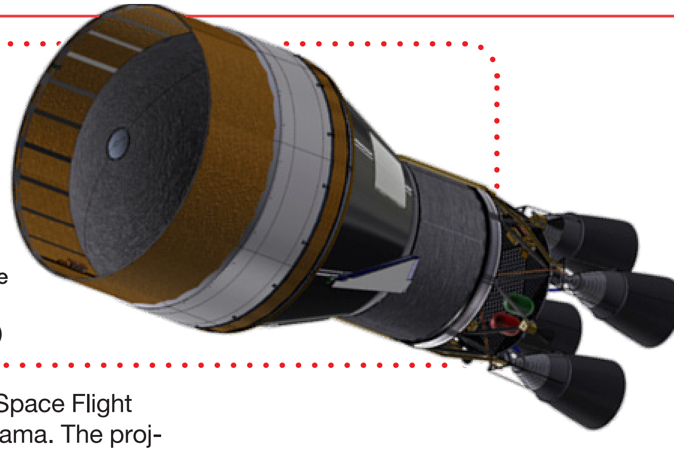
TDM: The Bridge

NASA's Technology Demonstration Missions program bridges the gap between ground demonstration tests and final flight testing to reduce the development risk for future missions and to provide the final infusion of cost-effective, revolutionary new technologies into robust NASA, government and commercial space programs. The TDM program office, managed by NASA's Marshall Space Flight Center in Huntsville, Alabama, is overseeing a portfolio of technology demonstration flight and ground projects led by NASA teams and industry partners across the country. The program is part of NASA's Space Technology Mission Directorate.

Composites Paving the Way for Lighter, More Efficient Launch Vehicles

By Kimberly Newton

Composites for Exploration Upper Stage is a ground-demonstration project that came under the Technology Demonstration Mission Program umbrella in 2014. With CEUS, engineers are looking at new and innovative ways to infuse lightweight composite materials into primary structures for NASA's Space Launch System Exploration Upper Stage, enhancing the stage's performance.



With the Composites for Exploration Upper Stage ground demonstration project, engineers are seeking ways to infuse lightweight composite materials into primary structures for NASA's Space Launch System Exploration Upper Stage. (Image: NASA)

Just as automotive designers look for creative solutions to increase gas mileage, launch vehicle designers look for ways to increase booster efficiency while maximizing payload mass. One way to do this is to reduce the overall weight of an upper stage booster, which translates to nearly a one-for-one increase in payload the vehicle can carry.

The use of composite materials and new manufacturing techniques instead of traditional metallic structures and techniques could reduce the overall weight and cost of a launch vehicle, allow for more cargo mass and improve rocket stage propellant storage.

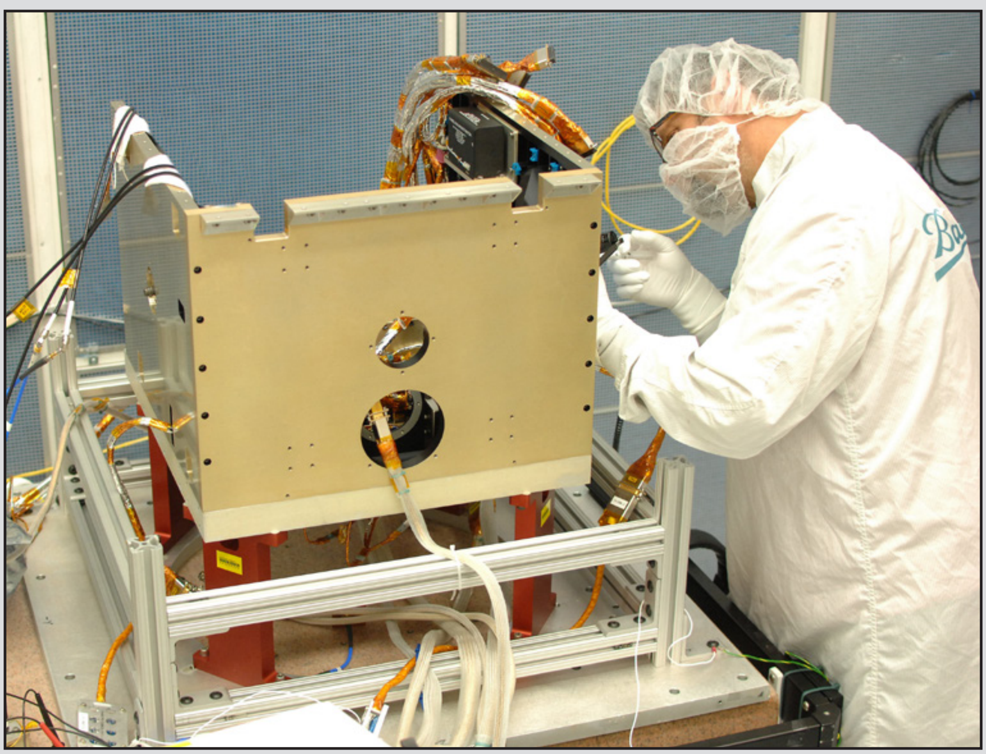
The CEUS project will build upon lessons learned from a prior 5.5-meter-diameter composite cryogenic tank tested last year at NASA's Marshall Space Flight Center in Huntsville, Alabama. The project will go further, designing, developing and testing an 8.4-meter-diameter liquid hydrogen tank skirt. The knowledge gained from these ground tests will be used to measure the advantages of composite materials over their metallic counterparts in the areas of manufacturing costs, thermal conductivity and mass.

The project will take advantage of structural testing planned for the baseline SLS Exploration Upper Stage components at the Marshall Center. Skirt assemblies will be subjected to load test environments similar to those the SLS upper stage will encounter upon launch. The composite material test data will be compared and contrasted to the performance predictions developed for similar metallic skirts.

The final ground test is planned for 2017 and will provide key data, allowing for consideration of the development and use of these and additional composite components on SLS and other NASA human-rated space vehicles.

The Composites for Exploration Upper Stage Project is led by NASA's Marshall Space Flight Center in Huntsville, Alabama, in participation with NASA's Glenn Research Center in Cleveland, Ohio, and Langley Research Center in Hampton, Virginia.

Newton is a public affairs officer at NASA's Marshall Space Flight Center in Huntsville, Alabama.



GPIM Bus Complete

The Ball Aerospace & Technologies Corp. Green Propellant Infusion Mission satellite team in Boulder, Colorado, integrated spacecraft bus components and completed the bus in September 2014 after just 54 days of assembly. In addition to the primary propulsion payload that is testing the new non-toxic propellant, the GPIM spacecraft will carry three experimental payloads. Ball Aerospace is leading the GPIM team and providing the spacecraft bus. Aerojet Rocketdyne of Sacramento, California, has developed the thruster and catalyst technologies which enable practical applications for space missions. Government partners include NASA's Glenn Research Center in Cleveland, Ohio; NASA's Goddard Space Flight Center in Greenbelt, Maryland; NASA's Kennedy Space Center, Florida; and the U.S. Air Force Research Laboratory, with additional mission support from the Air Force Space and Missile Systems Center at Kirtland Air Force Base, New Mexico. (Image: Ball Aerospace)

Deep Space Atomic Clock Set for Flight

By Elizabeth Landau

Some of most accurate clocks essential for spacecraft navigation are large, bulky and located on Earth. Having an ultra-stable clock small enough to fly on a spacecraft could have many benefits.

The Deep Space Atomic Clock, a technology project led by scientists at NASA's Jet Propulsion Laboratory in Pasadena, California, could do wonders for navigation, gravity science and communications between spacecraft and Earth. This atomic clock is compact enough to fly on a spacecraft, and could be useful for both deep space navigation and the GPS services that we use here on Earth.

In 2014, the DSAC team received confirmation that its demonstration unit will be flying on the Orbital Test Bed, a spacecraft being built by Surrey Satellite Technology US of Englewood, Colorado. The team also got the go-ahead for launch on the Air Force's STP-2 mission -- a SpaceX Falcon Heavy -- scheduled for May 2016. DSAC's year-long flight demonstration will pave the way for development of a final version usable by a mission.

"We're building a demonstration unit that is suitable for spaceflight, but we have been focusing our attention on solving key technology issues," said Todd Ely, principal investigator for the DSAC demonstration unit at JPL.

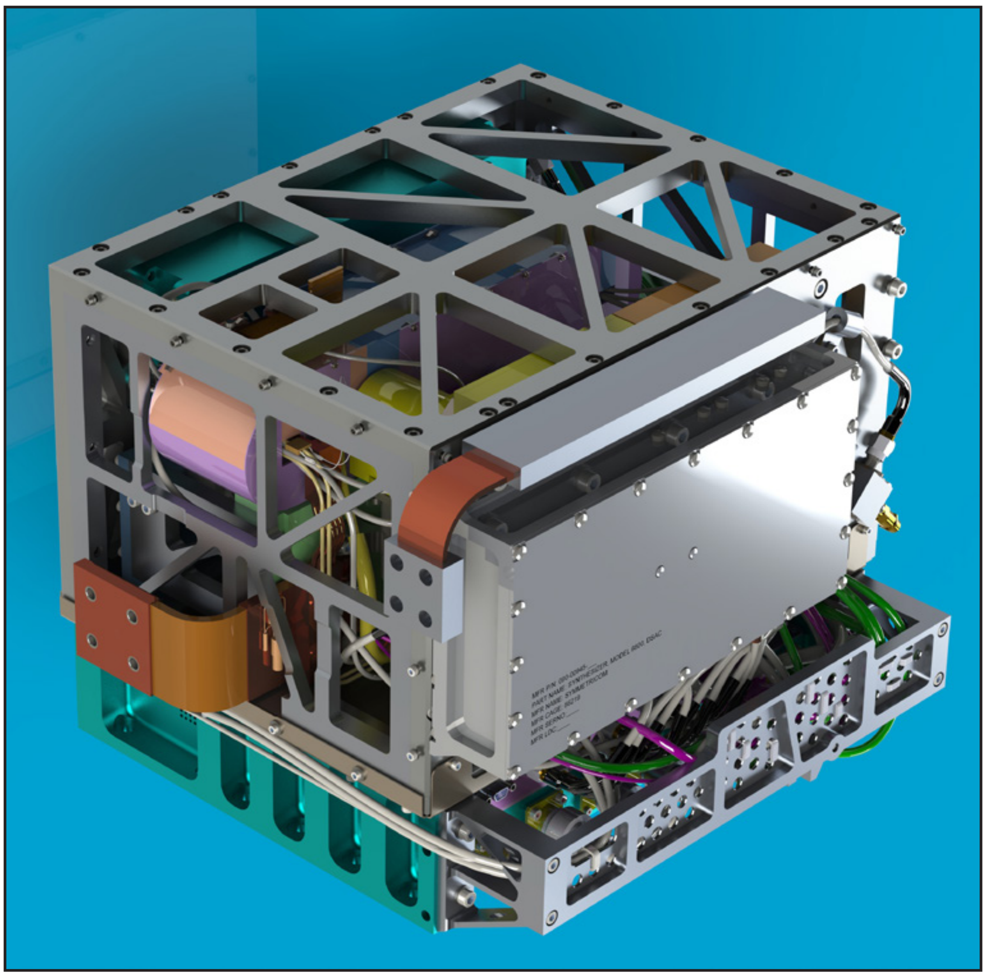
Currently, tracking a spacecraft on Earth is a two-way process. Antennas in NASA's Deep Space Network send tracking signals to a spacecraft which it "turns around" and sends back to Earth. A navigation team processes this data to determine the spacecraft's trajectory, and any needed spacecraft navigation commands. This two-way process eliminates measurement errors that the spacecraft's clock would introduce over time. But with an ultra-stable atomic clock on board, these errors would be minimized, and the tracking could switch to being one-way: In other words, the spacecraft would calculate its own timing for navigation purposes.

"One-way tracking with DSAC enables more precise tracking, and the ability to get more data using the existing Deep Space Network," Ely said.

At destinations such as Mars, DSAC would enable a single antenna of the Deep Space Network to get tracking data from two spacecraft at the same time. This could nearly double the amount of tracking information for a space mission. If DSAC were on a spacecraft flying by Jupiter's moon Europa, more data about its gravity – indicating the presence of an underwater ocean – could be collected using the spacecraft's low gain antennas and one-way tracking on uplink instead of the traditional two-way tracking.

The DSAC demonstration unit is fairly compact, measuring 11 inches by 10 inches by 9 inches (28 centimeters by 25 centimeters by 23 centimeters). In late 2014, the DSAC project team was engaged in testing the ion traps that would be incorporated into the demonstration unit, to see which ones will be best for flight, and determining the "secret sauce" of neon and mercury to charge the tube.

Landau is a media relations specialist at NASA's Jet Propulsion Laboratory in Pasadena, California.



The Deep Space Atomic Clock project is scheduled for launch into space as part of a May 2016 Air Force mission. (Image: NASA/JPL)

http://www.nasa.gov/mission_pages/tdm/main

"Everyone worked together so well," said Wolff, mechanical team and black box project lead. "If we had only been able to retrieve some of the components of the vehicle and recording systems we would have considered it a good day. But because of the dedication of this team and collaboration among everyone, we were able to retrieve the vehicle, the data recorder, the ballute and the parachute. The data we received is invaluable and we will be able to use it to better the vehicle for the next flight."

"The video we got from the black box recordings was just incredible," said Ian Clark, principal investigator for LDSD at NASA's Jet Propulsion Laboratory in Pasadena, California. "Because of the great efforts of the recovery team, we were able to get the data from the flight recorders and see the flight as it was recorded by the GoPro cameras. This was invaluable in understanding how the parachutes worked and what we need to adjust."

"The LDSD project is special because it encourages risk and technology development, and learning from challenges," said Gallon. "There are technologies on this vehicle that have never been tested or flown or even developed until this flight, and being a part of that has really just been an amazing experience."

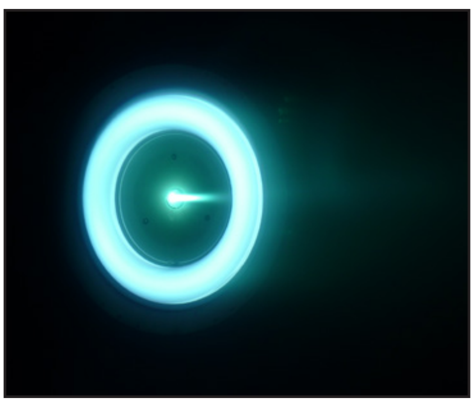
This winter, parachute testing took place at the Supersonic Naval Ordnance Research Track at the Naval Air Weapons Station China Lake in California. A new supersonic parachute design is expected to be ready in time for the next round of flight tests, scheduled for this summer.

The LDSD mission is a cooperative effort led by NASA's Jet Propulsion Laboratory in Pasadena, California. NASA's Wallops Flight Facility in Wallops Island, Virginia, coordinated support with the Pacific Missile Range Facility and provided the balloon systems for the LDSD test.

Navy Explosive Ordnance Disposal team divers retrieve the test vehicle for NASA's Low-Density Supersonic Decelerator, which was launched from the Navy's Pacific Missile Range Facility in Kauai, Hawaii, last summer. The vehicle was lifted to near-space with the help of a balloon and then a rocket in order to test new Mars landing technologies. (Image: NASA/JPL-Caltech)

LDSD parachute testing continues on a rocket sled, right, at the Supersonic Naval Ordnance Research Track at the Naval Air Weapons Station China Lake in California.
(Image: NASA/JPL-Caltech)

Hani Kamhawi is design and test lead of the 12.5kW Hall thruster team for the Solar Electric Propulsion Technology Demonstration Mission. (Image: NASA/GRC)



A Hall thruster in operation during a test. (Image: NASA/GRC)

Editor's Note: TDM Bridge Builders are team members at NASA centers and partner organizations who are helping bridge the gap, bringing one or more of our cutting-edge TDM technologies to flight readiness. Got a suggestion for a team member worthy of a place in the limelight? Email: **Kimberly.D.Newton@nasa.gov**

Dr. Hani Kamhawi is the design and test lead for the development of a 12.5 kW Hall thruster engine as part of TDM's Solar Electric Propulsion project, led by NASA's Glenn Research Center in Cleveland, Ohio, with team members at NASA's Jet Propulsion Laboratory in Pasadena, California. He spoke with us about the team's progress and how electric propulsion may enable human exploration of space.

How do you hope your thruster work will impact NASA's TDM goals?

Our NASA Glenn and JPL team is developing an electric propulsion 12.5 kW Hall thruster technology development unit. Our TDU is designed to operate at three times the power level of a state-of-the-art flight Hall thruster and is capable of long operating lifespan. Both attributes are needed for a number of NASA's proposed Solar Electric Propulsion Technology Demonstration Missions. The performance and lifetime-enhancing features in the TDU are extensible to higher-power Hall thrusters, which is commensurate with the need for efficient and cost-effective human exploration of space. What is interesting about electric propulsion is that its higher specific impulse capability, when compared to chemical propulsion, results in reduced propulsion system costs and fuel requirements for in-space missions. These thrusters have a high specific impulse because they eject the propellant at very high speeds -- a chemical rocket can exhaust it out at 4,500 meters per second, while an electric propulsion device exhausts it out at 20,000 to 40,000. The big difference is that the flow rate is so low you don't need as much propellant mass. You're exhausting propellant out a lot faster, but you're exhausting a lot less. In essence, their fuel efficiency is higher. And less fuel means you can potentially step down in launch vehicle size, increase payload and reduce the overall mission cost. But, there is a big catch: It takes these engines much longer to achieve the same spacecraft velocity when compared to a chemical rocket. For the proposed NASA Asteroid Redirect Mission, we're predicting each thruster will have to operate at full power for almost 55,000 hours. Our TDU thruster has wide throttling range capability. It can operate at high thrust-to-power and high specific impulse (equivalent to high gas mileage) throttling conditions. This means that the thruster will be capable of meeting the mission performance needs of a wide variety of SEP TDM options, some proposed Air Force missions, and the future mission performance needs of the commercial sector as they transition to higher power spacecraft.

What is the "payoff" you are most excited to see with this project?

What is most exciting about my work is having the opportunity to research and invent new ideas, then getting the opportunity to further develop the technology for infusion in NASA missions. The payoff I am most excited about is being part of the team implementing new technologies that will ultimately enable the expanded human exploration of space. Our team's work will continue on the success that electric propulsion has recently achieved in NASA's DAWN mission and on the Air Force's Advanced Extremely High Frequency Satellite. The thruster being developed by this Glenn and JPL team will be a big step toward our goal of using electric propulsion for human exploration of space.

When did you join NASA? What was your first job for the agency?

I started working at the Glenn Center as a graduate student from Ohio State University, conducting work on my doctorate and researching pulsed plasma thrusters. I joined NASA in the summer of 2000. My first job was researching and performing experiments on rocket-based combined cycle engines. The objective was to demonstrate a new propulsion technology that would greatly reduce the cost of access to space. After three years, I joined the In-Space Propulsion Branch, where my focus was the development of Hall thrusters for use in NASA science and exploration missions.

What's one thing most people would be surprised to learn about you?

People are often surprised by my love for soccer. I love to play and watch, and am very happy that both of my boys are really into playing soccer. Though I am still working on them being able to watch a full game without complaining about how boring it is.

LDSD: Hawaii Was the Place to be in 2014

From the TDM Program Manager

McDougal manages the TDM Program Office at the Marshall Space Flight Center in Huntsville, Alabama.

By John McDougal

Our program achieved a critical milestone in 2014 with the Low Density Supersonic Decelerator project's test flight in Kauai, Hawaii. When you're testing an enormous doughnut-shaped Supersonic Inflatable Aerodynamic Decelerator and the largest Supersonic Disksail Parachute ever flown — which will aid in landing larger payloads on Mars — you learn to be patient with weather delays, especially unfavorable winds. The test flight was finally conducted after several weeks of waiting for the right wind conditions, and provided us not only a demonstration of the drag device technologies, but also the first successful flight of the balloon-launched supersonic test bed.

Testing hardware at supersonic speeds is highly complex and the team knew there was a high chance that not all the test objectives would be met. The decelerator performed flawlessly. The parachute, on the other hand, failed. Even so, the team gained the first-ever high-speed, high-resolution video of the parachute's deployment and inflation. The small community of parachute experts is ecstatic in acquiring this data. They realize there is still much to be learned about designing parachutes for deployment under supersonic conditions, despite having flown multiple, successful parachutes which dropped precious cargo safely upon the surface of Mars.

The lessons learned in the test are being captured and utilized as the LDSD team redesigns the supersonic parachute. The new configuration will most likely be a Ringsail. Other tweaks are being made to the hardware and operational procedures which will improve the chances for a fully successful demonstration of all of the technologies on the next two balloon flights scheduled for this summer in Kauai.

This wouldn't be the TDM program if it weren't dynamic and constantly changing. We added a new project that you'll be hearing more about as it gets into full swing this year. The Composites for Exploration Upper Stage will build upon lessons learned from previous composite tank programs at Marshall Space Flight Center to determine if lightweight composites can be used in launch vehicle structures, offering potential weight savings over traditional metallic structures. If successful, this technology could increase cargo capabilities for the launch vehicle. The project will begin fabricating a non-flight, Space Launch System-sized Exploration Upper Stage skirt and begin testing to SLS launch requirements in late 2017.

I welcome this new project under the TDM umbrella and want to thank all the people who work daily to solve difficult problems. It's their commitment to excellence that makes us successful.

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George C. Marshall Space Flight Center
Huntsville, AL 35812
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