Time in space exposes materials to the test of time

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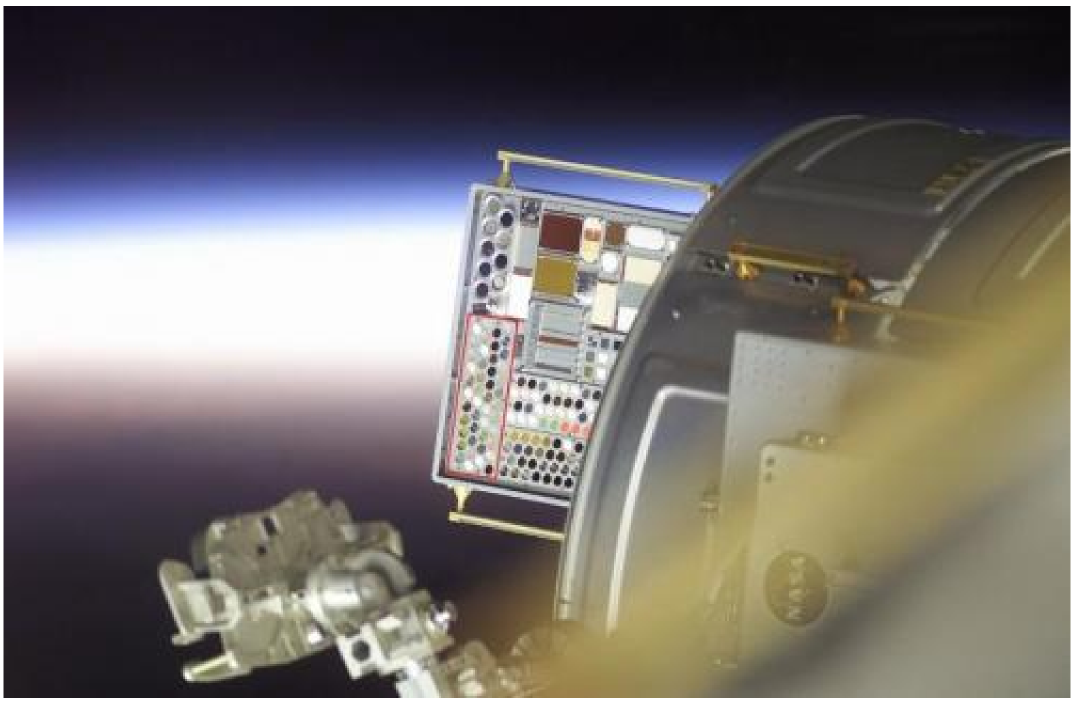


The MISSE 2 outside the Quest Airlock on the International Space Station. The Polymer Erosion and Contamination Experiment (PEACE) experiment is outlined in red. Credit: NASA

Much like that pickup truck rusting in your backyard thanks to time, rain and the elements, extended stays in the brutal environment of space can take its toll on spacecraft, satellites and space stations. In fact, anything outside the protective blanket of our atmosphere can be assaulted by orbital debris, temperature extremes, micrometeoroids, direct sunlight and, when spacecraft are in low-Earth orbit (LEO) or orbiting near another planet like Mars, atomic oxygen. Over time this relentless hammering by the space environment degrades many spacecraft materials.

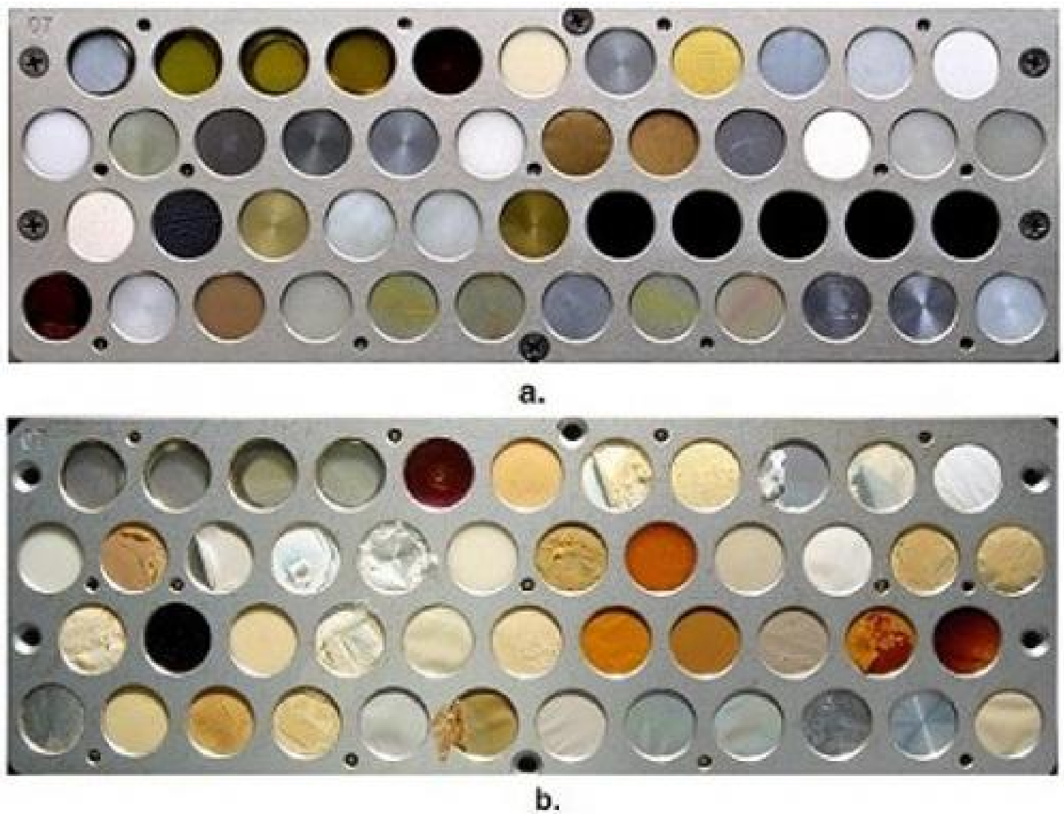
To understand how different materials perform in LEO, researchers designed the Materials International Space Station Experiment (MISSE), a series of flight investigations mounted to the exterior of the International Space Station.

MISSE research has resulted in several improvements to spacecraft. For example, the results from MISSE 7, which concluded in 2011, improved the performance of a satellite antenna that launched in 2014 as part of a meteorological satellite.

Begun in 2001 and building on earlier degradation studies, MISSE is a multi-organizational effort that includes NASA centers, U.S. Air Force and Naval research laboratories, universities and private industry. MISSE has flown during six different missions to test a variety of samples, ranging from materials to help develop an atomic oxygen erosion predictive tool to a new satellite antenna coating.

More than 4,000 samples and devices, such as solar cells, have flown throughout MISSE's 13-year history. The samples fit into the suitcase-sized Passive Experiment Container (PEC). The container is two-sided so that samples are exposed to the space environment on both sides.

"We often use trays that have a series of openings for one-inch diameter samples," said Kim de Groh, senior materials research engineer and MISSE investigator at NASA's Glenn Research Center in Cleveland. "Imagine you have a piece of cling wrap from your kitchen, and you punch out a one-inch diameter disk. We then ask, 'Will that survive for one year or more years in space?' Probably not. So we stack layers of the material on top of each other and fly that stack in space."



The MISSE 2 PEACE Polymers experiment: a.) before flight, and b.) after four years of space exposure on the exterior of the International Space Station. Credit: NASA

Samples are left in space for extended periods. For example, MISSE 1 and 2 left materials exposed to space during a four-year stretch from 2001 to 2005. MISSE 7 flew in the LEO environment for 18 months. The most recent test, MISSE 8, flew for two years. Those extended stays have helped researchers identify ways to improve materials for use in space and on Earth.

"We flew several antenna coatings for the Aerospace Corporation and they used that for the Defense Meteorological Satellite Program (DMSP)," said Miria Finckenor, materials engineer at NASA's Marshall Space Flight Center in Huntsville, Alabama. "The results that came from MISSE 7 made enough of a difference that they stripped off the coatings from their last two satellites to replace it with the new coating because it worked that much better."

Finckenor did the pre-flight and post-flight measurements of the coating at Marshall. The coating, developed by a team led by Donald J. Boucher, principal engineer and scientist at Environmental Satellite Systems, Aerospace Corporation, El Segundo, California, solved an antenna performance problem.

"We had coated our main reflectors with a material that turned out to be sensitive to water over time. It changes its properties if you have it in a humid environment," said Boucher. "We decided to remove the coating from all our remaining flight units and design a new coating that was very stable with respect to water."

On April 3, an Atlas V rocket launched from Vandenberg Air Force Base in California carrying the DMSP-19 satellite into orbit. The DMSP-19 antenna employed the new, MISSE 7-tested coating.

NASA materials engineer Miria Finckenor prepares to use a spectroreflectometer to analyze the reflectivity of coating samples. Credit: NASA

"We were far less capable of describing vertical distribution of the moisture in the atmosphere with this old antenna coating," said Boucher. "And now we are much, much more capable. We fixed an entire distribution issue with this new antenna coating. All of our satellites have this new reflector coating."

The years-long testing of different materials yields answers for both the aerospace community and those wanting to optimize materials for use in

Earth applications. MISSE has played a role in numerous advances, including NASA Glenn's Atomic Oxygen Erosion Predictive Tool that helps in designing new spacecraft, a coating for the Mars Curiosity Rover, a snow white thermal protective coating for the Dragon spacecraft and contributions to art restoration.

All of this MISSE data is now available online through a Materials and Processes Technical Information System (MAPTIS) account. When filling out the application for access, users simply indicate in the justification field that they want to view this MISSE database.

New databases, new materials and new predictive tools lead to better, longer-lived spacecraft and satellites as well as to improvements to our daily lives here on Earth. With such wide ranging influence, the value of MISSE data could prove to be timeless.

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