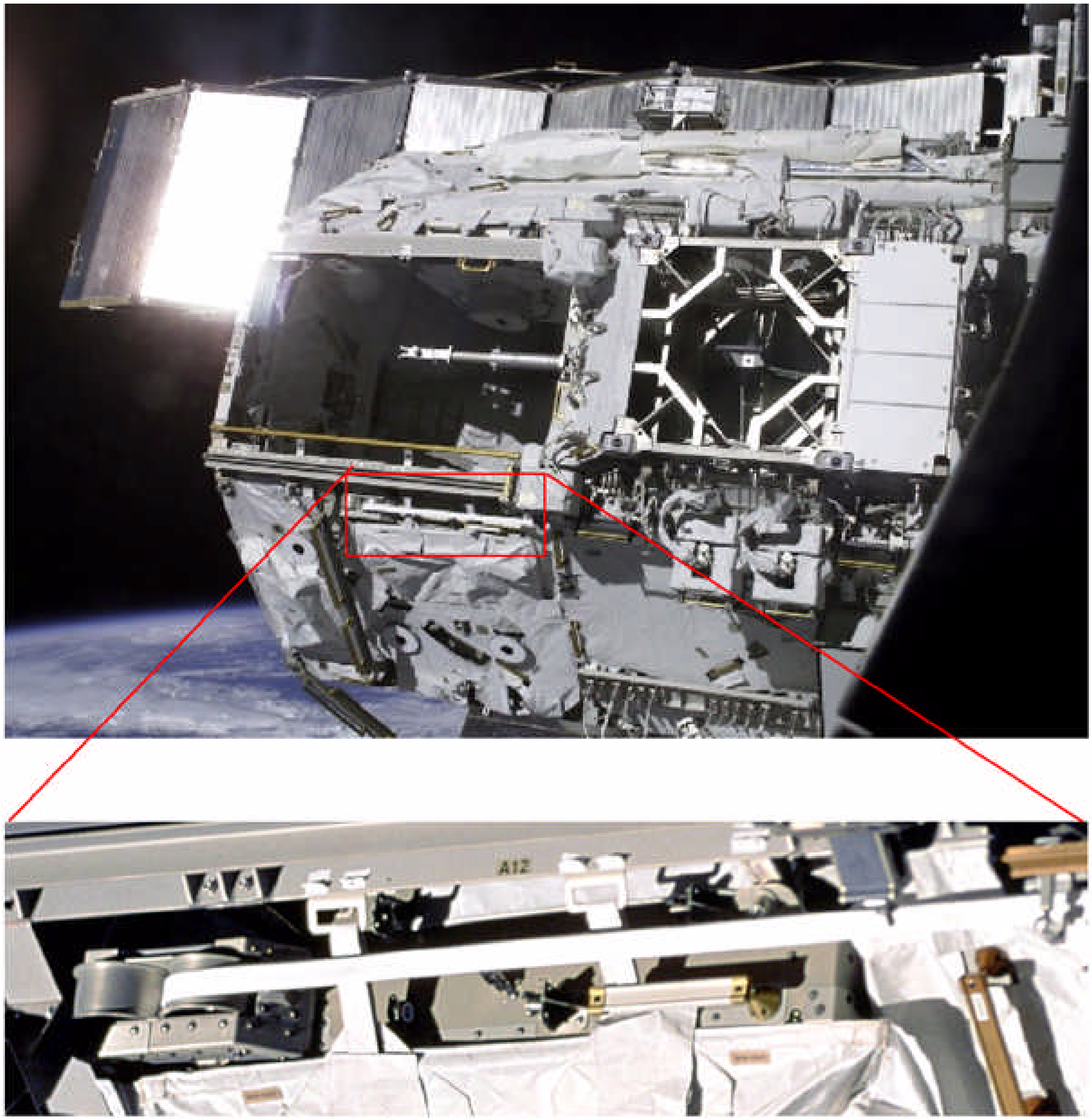
Hubble Space Telescope Degradation Data Used for Ground-Based Durability Projection of Insulation on the International Space Station

Ground-based environmental durability tests have indicated that exposing materials in accelerated tests to known spacecraft mission degradation sources predicted by an environmental model does not simulate the extent of damage that occurs in the space environment. The reasons for this may include the complex nature of the space environment, which is not simulated completely in any ground-based facility, the extreme differences in exposure rates in space and in ground tests, and inaccuracies in environmental models. One approach to overcoming the difficulties in simulating the space environment using ground-based testing is to calibrate the facility using data from actual space-exposed materials to deter-mine exposure levels required to replicate degraded properties observed in space. Research was conducted at the NASA Glenn Research Center to develop a ground-to-space correlation method that determines the durability of Teflon-based insulation for the International Space Station (ISS) by using data obtained in a ground facility and degraded Teflon thermal insulation retrieved from the Hubble Space Telescope.

The mobile transporter (MT), also called the ISS railcar, was installed on the ISS S-Zero (S0) truss during STS-110 in April 2002. The MT trailing umbilical system (TUS) contains two cables that provide redundant power, video, and communication conductors to the MT. Each cable is contained within a mechanical reel assembly that deploys and retracts the cable as the MT translates. The space-exposed TUS cable insulation is made of an outer jacket and inner core of expanded polytetrafluoroethylene (ePTFE). The outer jacket is composed of six layers of ePTFE (a total thickness of 50±10 mils) that is heated and pressed during cable fabrication. After fabrication, the outer jacket ePTFE varies in thickness and is approximately 43±3 mils (0.11±0.008 cm) thick. The inner core is 7 to 10 mils (0.018 to 0.0254 cm) thick. The TUS cable has a mission life of 10 years and is estimated to thermal cycle from -100 to 130 °C on orbit. The bottom photograph shows a closeup of one of the TUS cables, as photographed in June 2002 during STS-111. Polytetrafluoroethylene, from which ePTFE is made, is known to be significantly more susceptible to radiation degradation than fluorinated ethylene propylene (FEP). Hubble Space Telescope Teflon FEP thermal insulation of 2- and 5-mil (0.0051- and 0.0125-cm) thicknesses has become extremely brittle in the space environment. Therefore, we desired to test the durability of the ePTFE for the TUS application on the ISS.



S-Zero (S0) truss on the International Space Station. Top: Mobile transporter (MT) on the S0 truss during shuttle mission STS-110. Bottom: Closeup photograph of the MT trailing umbilical system cable during STS-111.

The ground-to-space correlation method developed uses a multiple-step process to determine the durability of ePTFE for ISS applications based on ground-based x-ray irradiation and heating exposure that simulates the bulk embrittlement that occurs in the 5-mil- (0.0125-cm-) thick FEP thermal insulation covering the Hubble Space Telescope. The method was designed to damage the back surface of equivalent thickness ePTFE to the same amount of scission damage as occurred in FEP retrieved from the Hubble Space Telescope after 9.7 years in space (based on elongation data) and then correct for differences in ground test ionizing radiation versus space radiation effects, temperature variations, space ionizing radiation environment variations (spacecraft altitude, inclination, and duration), and thickness variations.

The analysis for this application indicates that after a 10-year mission, the ISS ePTFE will have an extremely embrittled front surface, with surface cracks induced under any given strain, and a very ductile back surface. This study also found that a thermal-induced strain of 0.1 will develop in the ePTFE, and under this strain condition, microscopic cracks will start developing very early in the mission at the exposed surface and could develop to a depth of • 0.030 cm after 10 years.

The test method developed can be applied to other materials and space flight environments, and thus can improve durability predictions of spacecraft materials based on ground testing.

Find out more about this research: http://www.grc.nasa.gov/WWW/epbranch/

Glenn contacts: Kim K. de Groh, 216-433-2297, Fax: 216-433-2221, Kim.K.deGroh@nasa.gov; Bruce A. Banks, 216-433-2308, Fax: 216-433-2221, Bruce.A.Banks@nasa.gov; and Joyce A. Dever, 216-433-6294, Fax: 216-433-2221, Joyce.A.Dever@nasa.gov
Authors: Kim K. de Groh, Bruce A. Banks, Joyce A. Dever, and Janet C. Hodermarsky
Headquarters program office: OAT
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