SEE Bulletin

NASA's Space Environments and Effects Program January 2001

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Satellite Contamination and Materials Outgassing Knowledgebase

By
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Sverdrup Technology, Inc.

The origin of the Satellite Contamination and Materials Outgassing Knowledgebase Program began during a NASA Space Environments and Effects (SEE) Program workshop on neutral contamination held at NASA's Marshall Space Flight Center in Huntsville, Alabama, on April 29-30, 1997. The attendees developed and prioritized potential subject areas for funding as a part of NASA Research Announcement NRA8-20. Top priority items were to 1) establish a material outgassing database based on the ASTM E1559-93 Standard Test Method for Contamination Outgassing Characteristics of Spacecraft Materials; and 2) establish a database consolidating quartz crystal microbalance (QCM) data from previous missions in space. The attendees agreed that the QCM has become the primary instrument for providing materials outgassing property data as well as for characterizing on-orbit real time satellite environments.

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A proposal combining both high priorities for QCM data was submitted by Physical Sciences Inc., as the principal investigator and Johns Hopkins University/Applied Physics Laboratory (JHU/APL) and Sverdrup Technology/AEDC Group as co-investigators. Work on the program began in October 1998 and was completed September 30, 2000, when the database was transferred from JHU/APL to the SEE Program Office at the Marshall Space Flight Center in Huntsville, Alabama.

Satellite Contamination and Materials Outgassing Knowledgebase (Cont'd.)

The goal of this program was to assemble at one site much of the knowledge accumulated about the outgassing properties of aerospace materials based on ground testing, the effects of this outgassing observed on spacecraft in flight and the broader contamination environment measured by instruments on-orbit. The material outgassing data include datasets obtained using the ASTM Standard E-1559 and supplements data obtained previously using the ASTM Standard E-595.

Missions will often test materials of specific interest to their program but not disseminate the results widely. One major challenge was to locate and encourage members of the spacecraft contamination and test community to share ground test and flight observational data taken using QCMs. Several significant repositories of E1559 materials outgassing information volunteered to provide data including Outgassing Services International and Lockheed (80 materials), Goddard Space Flight Center (90 materials), TRW (20 materials), and the European Space Agency/ESTEC (100 materials). A complete list of the contributors is given in the appropriate section of the knowledgebase site. Similarly, contributions of flight data, papers and reports were obtained from about 20 other participants. A part of the knowledgebase is an excerpted collection of data from the Ballistic Missile Defense Organization (BMDO) sponsored Midcourse Space Experiment (MSX) Satellite Program. The MSX Program has been the source of ongoing contamination measurements and experiments from a suite of instruments since April 1996. We are very appreciative of the generosity and efforts of all of these researchers in sharing their data for the benefit of all.

Because the goal of the functional Knowledgebase was to allow researchers around the world remote access to its complete contents, contributions by researchers located around the U.S. provided a motivation for electronic communication and transfer from the start of the effort. While Physical Sciences Inc. was the principal investigator, Sverdrup Technology, Inc. was responsible for collection and review of the materials outgassing data from ground and flight programs, while the role of JHU/APL personnel was to create the website structure, develop the software and search engine and populate the site.

The Internet revolution has enabled this new approach of information exchange. The Knowledgebase allows the user to learn about contamination sources and concerns through reading articles prepared by experts, linking to other websites, observing graphs created to illustrate specific processes and interactive analysis of the actual ground test and flight data. The papers, graphs, and even the entire datasets (in spreadsheet form) can be downloaded to the user's home computer location. While not meant to be a tutorial on contamination, the interested spacecraft engineer will find this combination of expert knowledge and massive data sets to be a extremely valuable resource for space mission design and implementation. Because there is so much more available than just tabular data, we have used the term "knowledgebase" to capture the unique nature and value of this website.

The Satellite Contamination and Materials Outgassing Knowledgebase was developed using the Microsoft InterDev® platform to permit smooth incorporation into the SEE website. The structure was designed to:

- minimize processing time to the user;
- provide quick search and down load capability;
- and provide easy incorporation of new datasets.

Satellite Contamination and Materials Outgassing Knowledgebase (Cont'd.)

The separate ground, flight datasets and online bibliographic publication references (~ 100) are searchable by keywords that link to the actual files. The plot routines allow the user to select specific data, manipulate the plot axes and print the results at their location. All plots and files are contained in MS Excel spreadsheets and image files (.jpg or .gif) that have compressed versions (in "zip" format) that permit rapid download. Navigation through the website is compatible with both Internet Explorer and Netscape Communicator. The user follows a menu driven response to find data within the site. The papers, text and figures represent a clear illustrative summary of the effects observed and conclusions reached through analysis by the responsible researchers. It is the intent of the SEE Program to manage the introduction of new material to maintain this philosophy.

We believe that this website will help move contamination a step forward -away from anecdotal folklore - toward engineering discipline. Our hope is that the website will form a nucleus for information exchange; that is, users will not only take information from our Knowledgebase, but also provide new information from ground testing and space missions - expanding and increasing the value of this site to all. We urge government and industry users to endorse this approach that will ultimately reduce redundant testing and unnecessary delays, permit uniform comparisons, and allow informed decisions. Finally, we hope the Knowledgebase will not be a static entity. It is our intent that as new information is added, the Knowledgebase in its present form will grow and become even more comprehensive. We have endeavored to create a structure that will permit continued growth to occur in a logical fashion so that the user will notice new materials and new information folders as they revisit the site in the future.

Past presentations describing this effort have created a significant interest in the US and international community concerning access to this operational Knowledgebase (especially those involved with the International Space Station). The Knowledgebase is governed by US Federal Government export control laws; however, as with all databases and models offered by the SEE Program, requests for access may be directed to:

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SEE Program Office
Marshall Space Flight Center, Huntsville, AL 35812
Telephone: 256-544-2342
Email: donna.hardage@msfc.nasa.gov

Space Technology Research Vehicle (STRV)

On the evening of November 15, Arianespace successfully launched the STRV-1d satellite on an Ariane 5 launch vehicle from the Guiana Space Center in Kourou, French Guiana. The spacecraft was successfully deployed approximately 34 minutes into the mission as planned and is in a highly elliptical orbit exposing it to the severe radiation environment. On board this spacecraft is the NASA Radiation & Electronics Testbed (NASRET), comprised of six experiments evaluating the effects of space radiation on the electronics. The SEE Program will follow the progress of the NASRET experiments and provide future updates as to their progress. NASRET is sponsored by NASA's Space Environments & Effects (SEE) Program.

The Living With A Star Program
NASA's Role In Assuring Performance In Space And Atmospheric Environments

BY

Janet L. Barth , NASA/Goddard, Greenbelt, MD

NASA has initiated the Living with a Star (LWS) Program to develop the scientific understanding to address the aspects of the Connected Sun-Earth system that affect life and society. A goal of the program is to bridge the gap between science, engineering, and user application communities. This will enable future science, operational, and commercial objectives in space and atmospheric environments by improving engineering approaches to the accommodation and/or mitigation of the effects of solar variability on technological systems. A pre-formulation study determined the optimum combination of science missions, modeling, and technology infusion elements to accomplish this goal.

The LWS Program is designed to address environment accommodation issues for future spacecraft. The program architecture, illustrated in Fig. 1, consists of the following elements:

- Science Missions to collect data,
- Theory and Modeling to define the external environment,
- Space Environment Testbeds (SET) to define the environment interaction with spacecraft components, and
- Evolution of established and expanded partnerships.

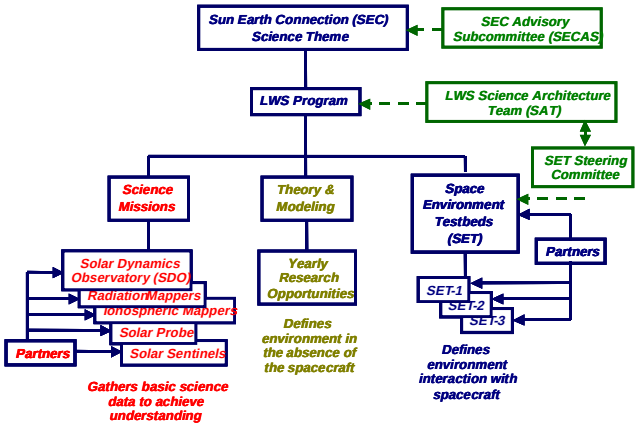

Fig. 1: This figure illustrates the program architecture of the LWS program.

Due to space constraints and customer focus, the rest of this article will concentrate on describing the SET and its future opportunities. For more information on the Science Missions and Theory and Modeling Project, please visit the following website: http:sec.gsfc.nasa.gov/lws.htm and reference AIAA paper number AIAA-2001-0235.

LWS Space Environment Testbeds

The Space Environment Testbeds (SETs) concept is being defined to complete the transition from science to applications with the objective of improving the engineering approach to accommodate and/or mitigate the effects of solar variability on spacecraft design and operations. The SET has three goals. The first is to enhance the technical and scientific capability of satellite systems by enabling easy, low cost, and fast access to space for technology validation in the relevant environment. The second goal is to function as a pathfinder for future spacecraft deployment in space environments for commercial, government, and science interests by improving environment definitions and effects models and guidelines. The last goal is to infuse the improved predictive capability and validation results in space and atmospheric environments to government and industry users for space weather prediction, spacecraft design and operations, and terrestrial/aircraft operations. These goals will be discussed in more detail in the next sections.

The Living With A Star Program
NASA's Role In Assuring PEerformance In Space And Atmospheric Environments (Cont'd.)

A concept study for space environment testbeds that would achieve these goals and provide data to improve the environment models was developed under the Orbiting Technology Testbed Initiative (OTTI) before the LWS Program began. Because the LWS science missions and the Theory and Modeling Project now have the responsibility to define the environment, the trade space for the testbeds has changed significantly. As a result, new concept studies are now underway to refine a testbed concept for the LWS/SET Program.

Goal 1: Technology Validation in the Relevant Environment

The capability to use COTS and emerging technologies in harsher space environments does not exist at the present time. Enabling the capability requires:

- Defining the environment and its effects on spacecraft performance;
- Defining a sequence of testbeds and orbits that expose new technologies to the appropriate environment in a stepwise approach;
- Determining issues associated with on-orbit validations of new technologies;
- Defining the launch options and mission operations architectures; and,
- Identifying potential customers.

Environments Requirements

An OTTI environments requirements trade study was performed to define orbits that provide the desired level of radiation effects on electronic systems and to define the level of measurements of the environment needed to interpret and model radiation effects and to improve performance prediction methods. These requirements are directly applicable to the SET. Components of the environment that are desirable exposures for SET experiments are:

- Plasma to characterize surface charging;
- Trapped protons for single event effects and degradation from total ionizing dose and displacement damage;
- Trapped electrons for internal charging, dose, and degradation; and,
- Transient protons and heavier ions from galactic cosmic rays (GCRs) and solar events for single event effects, dose, and degradation.

The ideal complement of environment measurement devices to provide adequate correlation of environment effects for the SET experiments includes:

- Electron, proton, and cosmic ray detection at to be determined energy levels;
- Dosimetry distributed throughout the spacecraft;
- High and low linear energy transfer spectra;
- Electrostatic discharge;
- Micrometeoroid measurements.

Goal 2: Improvement in Environment and Effects Models and Guidelines

Uncertainties in spacecraft performance are derived from sources that can be reduced. Natural variations in the space environment such as variations in solar activity cannot be reduced and must be accommodated or mitigated in the spacecraft design and/or operations. Uncertainties due to lack of accurate information about the definition of the environment or the performance of the spacecraft hardware in the environment can be reduced by:

- Obtaining more accurate environment definitions;
- Developing design and operations models and guidelines that better characterize the environment;

- Developing better definitions of the performance of the hardware in the environment; and,
- Developing better test and analysis capabilities to verify the hardware's performance in the spacecraft design and operations.

The LWS Program seeks to reduce all four sources of uncertainty due to lack of accurate information and thus retire risk for using emerging technology. These reductions will permit improvements in the margin for uncertainty in the environment definition and in the project manager's reserve, thus reducing cost. In the Theory and Modeling element, it will use existing science data and data from the LWS Science missions that define the environments to improve the engineering environments definitions, particularly for plasma and ionizing radiation.

The performance of the hardware in the environment will be better defined by combining hardware testing in the space environment and correlative testing on the ground. The goal of the correlative testing is to reduce spacecraft risk and verification costs by developing a better ground test capability instead of always relying on the more costly testing in space. Models to characterize the hardware's performance in space and atmospheric environments will also be developed.

GOAL 3: INFUSION OF RESULTS TO SPACECRAFT DESIGN AND OPERATIONS

The last goal, to infuse the results to spacecraft designers and operators, will be accomplished by sharing the results of the partner experiments with all participants and disseminating the results using publications. The improvement in the capability to predict spacecraft performance with reduced uncertainty margins will provide better, less costly, and more capable spacecraft than at the present time.

The Space Environment Testbeds will be designed to address issues related to rapid technological changes. The goal is to enable the use of COTS and emerging technologies to enhance system performance and decrease risk with reduced cost.

UPCOMING!!

TEST AND GUIDELINES FOR SPACECRAFT CABLE CHARGING

Jet Propulsion Laboratory (JPL) has completed the initial tests to study the charging and discharging of spacecraft cables under high-energy electron irradiation. This report will soon be in hardcopy form and will be featured in the next SEE Bulletin.

COMING SOON!!

The Interactive Spacecraft Charging Handbook Technical Reports will soon be available on our website. These reports provide in-depth knowledge as to how the Interactive Spacecraft Charging Handbook works. The website address is: http://see.msfc.nasa.gov

Hubble Space Telescope (HST) Uses SEE Program Electromagnetic Interference (EMI) Data

To: Tony Clark / MSFC ***26 January 2001***

From: Mark Stanton / USA JSC

Subject: Hubble Space Telescope (HST) Application of the MSFC On-Orbit Radio Frequency Environment Handbook, Document No. CR4776-97-242

The HST SM3B servicing mission (STS-109) will install both an active and passive cooling system to the HST Aft Shroud area. The purpose of these systems is to revive the NICMOS Science Instrument (SI) which has a depleted Cryogenics tank and reduce SI generated heat in the HST Aft Shroud. The design of this cooling system utilizes two externally mounted radiators containing imbedded Capillary Pump Lines (CPL) and heaters. The radiators are attached to non-conductive handrails and the CPL and heater lines are fed through a conduit assembly and enter the aft shroud via vent rings in the rear bulkhead. Once inside the HST Aft Shroud, the CPL's lines connect to thermal interface assemblies which have a non-electrical bond to the SI's. The heater lines are connected to the cooling system electronics.

Because the cooling system radiators are isolated from the HST Structure ground and the CPL lines are isolated at the SI's, concerns were raised regarding the potential to conduct on-orbit radiated noise into the aft shroud compartment and degrade the extremely sensitive (<4 -e) SI detector background levels. In particular, the HST Science Institute at Johns Hopkins University requested an audit of the HST environments and analysis and testing were performed to determine SI performance in the known environments. Data extracted from The On-Orbit Radio Frequency Environment Handbook (referenced in the subject) was used to determine the RF environments. The results of the audit indicated a potential to degrade SI performance based on the handbook data, and modified designs of the radiator and conduit assemblies were implemented to minimize the effects of intentional RF fields on HST.

The MSFC Handbook clearly identified the environments at both the HST Altitude and Inclination. The use of this data was critical in modifying the assemblies.

This effort was funded by the SEE Program through a NASA Research Announcement in 1994.

Miscellaneous

REMINDER!

7th Spacecraft Charging Technology Conference

2001: A Spacecraft Charging Odyssey

ESTEC Conference Center
Noordwijk, The Netherlands
April 23-27, 2001

Sponsored by:

ESA, NASA's SEE Program, CNES, BNSC, DERA, and AFRL

Registration Fee: 250 Euro (approximately $236 USD) before March 1, 2001
300 Euro (approximately $283 USD) after March 1, 2001

Conference web site: http://www.estec.esa.nl/CONFANNOUN/sctc2001/index.html
Technical content, hotel reservations and conference registration information now available from the conference website.

This conference occurs only once every three years. Contact Jody Minor at 256-544-4041 (jody.minor@msfc.nasa.gov) or the conference website for more information.
April is prime tourist season for The Netherlands. Don't wait too late to make hotel reservations!

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