NASA Technical Memorandum 107705

LDEF: A BIBLIOGRAPHY WITH ABSTRACTS

H. GARLAND GOUGER, EDITOR

NOVEMBER 1992

National Aeronautics and Space Administration

Langley Research Center
Hampton, Virginia 23665-5225

FOREWORD

The Long Duration Exposure Facility was a free-flying cylindrical structure that housed self-contained experiments in trays mounted on the exterior of the structure. Launched into orbit from the Space Shuttle Challenger in 1984, the LDEF spent almost six years in space before being recovered in 1990. The 57 LDEF experiments investigated the effects of the low earth orbit environment on materials, coatings, electronics, thermal systems, seeds, and optics. It also carried experiments that measured crystal growth, cosmic radiation, and micrometeoroids.

This bibliography contains 435 selected records from the NASA aerospace database covering the years 1973 through June of 1992. The citations are arranged within subject categories by author and date of publication.

TABLE OF CONTENTS

AEROSPACE ENVIRONMENTS

1 WHITAKER, ANN F., FINCKENOR, MIRIA M., KAMENETZKY RACHEL R., (NASA, Marshall Space Flight Center, Huntsville, AL). "Property changes induced by the space environment in polymeric materials on LDEF" 1992; AIAA-Paper-92-0790.
Note: AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992 8 p.

Property changes that occurred in four groups of polymer-based materials in the Long Duration Exposure Facility (LDEF) due to exposure to the outer space environment for 5.8 yrs are examined. Evaluations of contamination and mass loss are presented along with optical, thermal, and electrical analyses and mechanical property evaluations for TFE Teflon, the fluorinated material Halar the silicone-based material RTV 511, and PEEK resin. (C.D.).
A92-28229.

2 STIEGMAN, A. E., BRINZA, DAVID E., LAUE, ERIC G., ANDERSON, MARK S., LIANG, RANTY H., (JPL, Pasadena CA). "Vacuum ultraviolet radiation/atomic oxygen synergism in fluorinated ethylene propylene Teflon erosion" Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 29, Jan.-Feb. 1992, p. 150, 151 1992,

A micrographic investigation is reported of samples of the fluorinated ethylene propylene (FEP) Teflon thermal-blanketing materials recovered from the Long-Duration Exposure Facility (LDEF) satellite. The samples are taken from the trailing edge and row 8 which correspond to exposures to vacuum UV (VUV) and VUV + atomic O, respectively. Data are taken from SEM and IR- spectra observations, and the LDEF leading-edge FEP shows a high degree of erosion, roughening, and sharp peaks angled in the direction of the flow of atomic O. The trailing edge sample influenced primarily by VUV shows a hard brittle layer and some cracked mosaic patterns. Comparisons to a reference sample suggest that the brittle layer is related to exposure to VUV and is removed by atomic-O impingement. Polymers that are stable to VUV radiation appear to be more stable in terms of atomic oxygen. (C.C.S.).
A92-24669.

3. KINARD, WILLIAM H., MARTIN, GLENNA L., (NASA, Langley Research Center Hampton, VA); O'NEAL, ROBERT L., (Lockheed Engineering and Sciences Co., Hampton VA). "Interactions of the space environments with the Long Duration Exposure Facility (LDEF)" 1992; AIAA-Paper-92-0792.
Note: AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV Jan. 6-9, 1992. 9 p.

The Long Duration Exposure Facility (LDEF) was retrieved from space after 69 months in orbit. Post-retrieval observations of the facility and the 57 experiments that were onboard have revealed unique and valuable observations of the space environments and the interactions of these environments with the LDEF during the prolonged stay. This paper describes the LDEF the onboard experiments, the flight mission, and what some of the post-retrieval LDEF observations have revealed about the radiation, meteoroids, manmade debris, atomic oxygen, and contamination environments and their effects on spacecraft. (Author)
A92-28230.

4 CHRISTIE, ROBERT J., LU, CHENG YI; ARONOFF. IRENE; (Rockwell International Corp., Rocketdyne Div ,. Canoga Park, CA). "Applicability of Long Duration Exposure Facility environmental effects data to the design of Space Station Freedom electrical power system" , 1992; AIAA-Paper-92-0848.
Note: AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

Data defining space environmental effects on the Long Duration Exposure Facility (LDEF) are examined in terms of the design of the electrical power system (EPS) of the Space Station Freedom (SSF). The significant effects of long-term exposure to space are identified with respect to the performance of the LDEF's materials, components, and systems. A total of 57 experiments were conducted on the LDEF yielding information regarding coatings, thermal systems, electronics, optics, and power systems. The resulting database is analyzed in terms of the specifications of the SSF EPS materials and subsystems and is found to be valuable in the design of control and protection features. Specific applications are listed for findings regarding the thermal environment, atomic oxygen, UV and ionizing

radiation, debris, and contamination. The LDEF data are shown to have a considerable number of applications to the design and planning of the SSF and its EPS. (C.C.S.)
A92-29614.

5. BOURASSA, R. J., GILLIS, J. R. "Solar exposure of LDEF experiment trays" , 1992; NASA-CR-189554. 265P
Note: Boeing Co., Seattle, WA. Defense and Space Group.

Exposure to solar radiation is one of the primary causes of degradation of materials on spacecraft. Accurate knowledge of solar exposure is needed to evaluate the performance of materials carried on the Long Duration Exposure Facility (LDEF) during its nearly 6 year orbital flight. Presented here are tables and figures of calculated solar exposure for the experiment rows, longerons, and end bays of the spacecraft as functions of time in orbit. The data covers both direct solar and earth reflected radiation. Results are expressed in cumulative equivalent sun hours (CESH) or the hours of direct, zero incidence solar radiation that would cause the same irradiance of a surface. Space end bays received the most solar radiation, 14,000 CESH; earth end bays received the least, 4,500 CESH. Row locations received between 6,400 CESH and 11,200 CESH with rows facing either eastward or westward receiving the most radiation and rows facing northward or southward receiving the least. (Author)
N92-22499.

6. ZWIENER, JAMES M., WILKES, DONALD R., HUMMER, LEIGH L., (AZ Technology, Huntsville AL). "Unusual materials effects observed on the thermal control surfaces experiment (S0069)" , 1991
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 69 (SEE N91-24972) Abstract Only

A number of unusual effects were observed on the Thermal Control Surface Experiment (TCSE) test samples, front cover and structural components. These include induced UV fluorescence, the migration and degradation of KRS-5 materials, atomic oxygen effects, contamination, texturing, discoloration, and meteoroid/ debris impact. LDEF (Long Duration Exposure Facility) mission induced fluorescence was observed on several TCSE samples. Similar fluorescence was observed on LDEF leading edge materials from Experiment A0114. (Author).
N91-25036.

7 WHITESIDE, J. B., GIANGANO, D., HEUER, R. L., KAMYKOWSKI, E., KESSELMAN, M., ROONEY, W., SCHULTE, R., STAUBER, MICHAEL C. "Effects of space environment on space-based radar phased-array antenna: Status and preliminary observations" 1991
Note: Grumman Aerospace Corp., Bethpage, NY In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 117 (SEE N91-24972) Abstract Only

The overall objective is to evaluate the effect of the space environment on Kapton films considered for the Grumman space based radar (SBR) phased-array antenna. The most striking result is the overall good condition of the Kapton antenna planes and Kapton tensile specimens. This is largely attributable to the orientation of the Kapton (parallel and flush on the space end) and the stability of the LDEF in orbit. Results on elongation and mechanical properties of the plain and fiberglass reinforced Kapton will be described. Stress-dependent permanent deformation and some reductions in strain to failure were observed. Physical property testing of the materials is in progress. Electronic data acquisition and memory systems appeared to operate correctly, but functional tests were not yet performed. An evaluation of the high voltage-plasma interaction data is underway. Some minor systems anomalies (e.g., fastener sheared during removal, strong odor inside electronics container) were noted. Other observations such as radiation, contamination, impacts, and orientation features of atomic oxygen erosion are reported. (Author).
N91-25083.

8. WHITAKER, ANN F., YOUNG, LEIGHTON E. "An overview of the first results on the solar array passive LDEF experiment (sample), AO171" , 1991
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 93 (SEE N91-24972) Abstract Only

Space environmental effects were visibly obvious on components of experiment AO171 which contained solar cells, composites, polymeric thin films, solar reflectors, protective coatings, metals, paints , and elastomers.

Micrometeoroid/space debris impacts were observed on all experiment elements. Luminescence of polyimide, silicone, and polyurethane materials occurred under black light examination. Outgassing of RTV511 occurred mainly as a result of insufficient thermal vacuum bakeout. Solar cell degradation was predominantly below 10 percent. Elastomers lost mass and discolored; composites showed evidence of atomic oxygen attack, and unprotected thin polymer films eroded away (Author).
N91-25059.

9. VALLIMONT, JOHN; HAVEY, KEITH. "Effects of long term exposure on optical substrates and coatings (SOO50-1)" 1991
Note: Eastman Kodak Co., Rochester, NY In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 105 (SEE N91-24972) Abstract Only

The experiment consisted of fused silica and ultra low expansion (ULE(tm)) glass samples which were either uncoated or had high reflectance silver, antireflectance, or solar rejection coatings. A set of duplicate control samples was manufactured and stored in a controlled environment for comparison purposes. Data on the analysis of the contaminate deposited on the samples, micrometeoroid impact, and the environmental effects on the substrate materials and coatings are presented. Some results of particular interest are that the contaminate composition varied between different types of samples, fractures were incurred in the glass at the micrometeoroid impact site, and no darkening of the ULE(tm) glass occurred due to the radiation exposure. (Author).
N91-25071

10. TAYLOR, E. W., PADDEN, R. J., BERRY J. N., SANCHEZ, A. D., CHAPMAN, S. P "Preliminary analysis of WL experiment number 701 Space environment effects on operating fiber optic systems" 1991
Note: Air Force Systems Command, Kirtland AFB, NM. Optoelectronics Section. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 115 (SEE N91-24972) Abstract Only.

A brief overview of the analysis performed on WL Experiment number 701 is presented, highlighting the successful operation of the first know active fiber optic links orbited in space. Four operating fiber optic links were exposed to the space environment for a period exceeding five years, situated aboard and external to the Long Duration Exposure Facility (LDEF). Despite the prolonged space exposure to radiation, wide temperature extremums, atomic oxygen interactions, and micrometeorite and debris impacts, the optical data links performed well within specification limits. Early Phillips Laboratory tests and analyses performed on the experiment and its recovered magnetic tape data strongly indicate that fiber optic application in space will have a high success rate. (Author).
N91-25081

11 STRGANAC, THOMAS; FARROW, ALLAN; LETTON, ALAN. "Preliminary investigation of thin film polymers exposed to low Earth orbit" , 1991
Note: Texas A&M Univ., College Station. Dept. of Aerospace Engineering. In NASA, Langley Research Center, First LDEF Post- Retrieval Symposium Abstracts p 53 (SEE N91-24972) Abstract Only.

Preliminary results of thin film polymers exposed to low-Earth orbit aboard the Long Duration Exposure Facility (LDEF) are discussed. Dynamic testing of a 0.92/0.92 mil. polyester laminate film indicated that the modulus loss of the exposed specimens may be very small. When the storage modulus of the exposed specimen was compared to the storage modulus of a control specimen over a temperature range of minus 150 degrees to 100 degrees, there was very little change. Fourier Transform Spectroscopy performed on the same exposed material indicated crosslinking of the polyethylene, which was verified by an increase in the storage modulus above the glass transition temperature. Optical microscopy of the sample showed micrometeoroid strikes and contamination in spots by what is thought to be silicon outgassed from a nearby experiment. (Author).
N91-25020.

12 STRGANAC, THOMAS W., LETTON, ALAN; (Texas A. &. M. University, College Station)., FARROW, D. A., ROCK, NEIL I., WILLIAMS, KEVIN D. "The investigation of balloon materials exposed to the low earth orbit environment" , 1991, AIAA-Paper- 91-3657
Note: AIAA, International Balloon Technology Conference, Albuquerque, NM, Oct. 8-10, 1991. 9 p.

The results of analyses conducted on balloon materials retrieved from the Long Duration Exposure Facility (LDEF) are presented. LDEF was a satellite put in LEO to examine the effects of the space environment. The purpose of the experiment proposed by Texas A&M University was to determine the effects of long-term exposure of the hostile environment of the upper atmosphere on candidate balloon films, tapes and lines. (R.E.P.).
A92-12745.

13. STEIN, BLAND A., PIPPIN, H., GARY (Boeing Aerospace Co., Seattle WA). "Preliminary findings of the LDEF materials special investigation group " 1991
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 51 (SEE N91-24972) Abstract Only

Presented here are the charter and scope of the Long Duration Exposure Facility's (LDEF) Space Environmental Effects on Materials Special Investigation Group (MSIG) activities, and an overview of of preliminary observations. These observations of low-Earth orbit environmental effects on material were made in space during during LDEF retrieval and during LDEF tray deintegration. Also included are initial findings of laboratory analysis of LDEF materials. (Author).
N91-25018.

14. ROUSSLANG, KEN W., CRUTCHER, E. RUSS; PIPPIN, H. GARY "Results of examination of silvered Teflon from the Long Duration Exposure Facility" 1991
Note: Boeing Aerospace and Electronics Co., Seattle, WA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 65 (SEE N91-24972). Abstract Only

Pieces of silvered Teflon thermal control blanket from seventeen locations on the Long Duration Exposure Facility (LDEF) were studied. Results of the measurements of surface texturing, and mechanical, electrical and thermal properties are presented. Photos of the blankets, scanning electron microscope pictures, infrared spectra, and surface analysis results are presented. Contamination issues relative to performance of the blankets are discussed. The variation in measured properties are reported as a function of exposure conditions. (Author).
N91-25032.

15. ROBERTSON, JAMES B., CLARK, IVAN O. "Effect of space exposure on pyroelectric infrared detectors" 1991
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 107 (SEE N91-24972). Abstract Only.

Twenty pyroelectric type infrared detectors were flown onboard the Long Duration Exposure Facility (LDEF). The detector chips were of three different pyroelectric materials. lithium- tantalate, strontium-barium-niobate, and triglycine-sulfide. The experiment was passive; no measurements were taken during the flight. Performance of the detectors was measured before and after flight. Postflight measurements revealed that detectors made of lithium-tantalate and strontium-barium-niobate suffered no measureable loss in performance. Detectors made of triglycine- sulfide suffered complete loss of performance, but so did the control samples of the same material. Repoling of the triglycine- sulfide failed to revive the detectors. (Author).
N91-25073.

16. PLAGEMANN, W. L. "Condition of chromic acid anodized aluminum clamps flown" 1991
Note: Boeing Aerospace and Electronics Co., Seattle, WA. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 75 (SEE N91-24972) Abstract Only.

A survey of the condition of the chromic acid anodized (CAA) coating on selected LDEF tray clamps was carried out. Measurements of solar absorptance and thermal emittance were carried out at multiple locations on both the space exposed and spacecraft facing sides of the clamps. Multiple clamps from each available angle relative to the ram direction were examined. The diffuse component of the reflectance spectrum was measured for a selected subset of the clamps. The thickness of the CAA was determined for a small set of clamps. Examples of variation in integrity of the coatings from leading to trailing edge will be shown. (Author). N91-25042

17 PETRIE, BRIAN C. "LDEF-space environmental effects on materials: Composites and silicone coatings" 1991
Note: Lockheed Missiles and Space Co., Sunnyvale, CA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 84 (SEE N91-24972). Abstract Only.

The objective of the Lockheed experiment is to evaluate the effects of long term low Earth orbit environments on thermal control coatings and organic matrix/fiber reinforced composites. Two diverse categories are reported: silicone coatings and composites. For composites physical and structural properties were analyzed; results are reported on mass/dimensional loss, microcracking, short beam shear, CTE, and flexural properties. The changes in thermal control properties, mass, and surface chemistry and morphology are reported and analyzed for the silicon coatings. (Author).
N91-25051

18. PARCELIER, MICHEL. "Effect of space environment on composite materials and thermal coatings (AO 138-9)" 1991
Note: Aerospatiale, Les Mureaux (France). In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 87 (SEE N91-24972) Abstract Only

The results are presented of experiments located in one of FRECOPA canister on epoxy-matrix carbon fiber reinforced composite materials, adhesives, and thermal coatings. Only thermal coatings and some composite materials were exposed to direct space environment for the first year, while other materials (for mechanical and expansion tests) were located in the lower levels (subjected to only vacuum and thermal cycling). In order to assess the degradation of materials after space aging, reference specimens were stored in clean room for the duration of LDEF mission and tested at the same time as the aged specimens. (Author).
N91-25054.

19. MOSS, C. E., REEDY R. C. "Measurements of induced radioactivity in some LDEF samples" , 1991
Note: Los Alamos National Lab., NM. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 17 (SEE N91-24972). Abstract Only.

Twenty-six stainless steel trunnion samples, five aluminum end support retainer plate samples, two aluminum keel plate samples, and two titanium clips were analyzed. The shielded high purity germanium detectors used had efficiencies of 33, 54, and 80 pcts. at 1332 keV Detector efficiencies as a function of energy and corrections for self absorption in the samples were determined with calibrated sources, unactivated control samples, and calculations. Several measurements were made on most samples. In the trunnion samples, Mn-54 and Co-57 were seen and limits were obtained for other isotopes. The results agree well with 1-D activation calculations for an anisotropic trapped proton model. In the aluminum samples, Na-22 and Be-7 were seen. Other results are presented. (Author).
N91-24986.

20. MOSS, C. E., REEDY, R. C. "Measurements of induced radioactivity in some LDEF samples" , 1991 24P
Note: Los Alamos National Lab., NM. Presented at the 1st Long Duration Exposure Facility Post-Retrieval Symposium, Kissimmee, FL, 3-8 Jun. 1991

Twenty-six stainless steel trunnion samples, five aluminum end support retainer plate samples, two aluminum keel plate samples, and two titanium clips were analyzed. The shielded high purity germanium detectors used had efficiencies of 33,, 54, and 80 pcts. at 1332 keV Detector efficiencies as a function of energy and corrections for self-absorption in the samples were determined with calibrated sources and unactivated control samples. Several measurements were made on most samples. In the trunnion samples, Mn-54 and Co-57 were seen and limits were obtained for other isotopes. The results agree well with 1-D activation calculations for an anisotropic trapped proton model. In the aluminum and titanium samples, Na-22 was seen. Other results are presented. (DOE).
N91-32882.

21 MOONEY, THOMAS A., SMAJKIEWICZ, ALI. "Transmittance measurements of ultra violet and visible wavelength interference filters flown aboard LDEF " , 1991
Note: Barr Associates, Inc., Westford, MA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 112 (SEE N91-24972). Abstract Only.

A set of ten interference filters for the UV and VIS spectral region were flown on the surface of the Long Duration Exposure Facility (LDEF) Tray B-8 along with earth radiation budget (ERB) components from the Eppley Laboratory. Transmittance changes and other degradation observed after the return of the filters to Barr are reported. Substrates, coatings, and (where applicable) cement materials are identified. In general, all filters except those containing lead compounds survived well. Metal dielectric filters for the UV developed large numbers of pinholes which caused an increase in transmittance. Band shapes and spectral positioning, however, did not change. (Author).
N91-25078.

22 MIRTICH, MICHAEL J., STEVENS, NICHOLAS; MERROW JAMES; (Cleveland State Univ , OH. "Ion beam textured and coated surfaces experiment (IBEX) " 1991
Note: National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 73 (SEE N91-24972). Abstract Only

The IBEX, with 36 samples of various materials, was placed aboard the LDEF Twenty-seven of the samples had surfaces modified using ion beam technology, and nine were made up of commercially available materials. The materials are in some way useful in space power systems. The various types of materials tested included six categories: (1) ion beam structured surfaces suitable for solar thermal (concentrator) or space radiators; (2) ion beam sputtered conductive coatings for thermal and space charge control; (3) solar reflector surfaces; (4) flexible thin film coatings and solar array blanket material for protection of spacecraft polymers; (5) painted and/or state-of-the-art solar thermal materials; and (6) micrometeoroid sensitive detector Data analysis presented include the optical properties of each surface before and after exposure to the space environment and the respective backup surfaces. (Author).
N91-25040.

23. MIGLIONICO, C., STEIN, C., (USAF. Phillips Laboratory ,. Kirtland AFB, NM); MURR, L. E., (Texas, University El Paso). "Effects of space environment on structural materials - A preliminary study and development of materials characterization protocols" Journal of Materials Science (ISSN 0022-2461), vol. 26, Oct. 1 1991 p. 5134-5142. 1991

A preliminary study of materials exposed in space in LEO for nearly six years in the NASA Long-Duration Exposure Facility is presented. It is demonstrated that it will be necessary to isolate surface debris and reaction products from materials exposed in space. Replication techniques originally designed for electron microscopy examination of surfaces can be applied to lift off and isolate such surface features. Debris and reaction products were examined through a variety of analytical techniques, including the surface morphology by SEM, and internal microstructures by STEM and TEM, EDS, and SAD. The results illustrate the role that atomic oxygen and micrometeorites play in surface alteration and reaction in LEO space environments, as well as the role of debris created from other proximate materials. (O.G.)
A92-10527 NAG9-481

24 MESHISHNEK, M. J., GYETVAY S. R., JAGGERS, C. H. "Long Duration Exposure Facility experiment M0003 deintegration/ findings and impacts" 1991
Note: Aerospace Corp., El Segundo, CA. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 79 (SEE N91-24972). Abstract Only

The Aerospace Corporation LDEF Experiment M0003 was designed to study the effect of the space environment on a large variety of spacecraft materials and components, both current and developmental. The experiment was housed in four LDEF trays and contained over 1200 specimens, two data systems, and two environment exposure control canisters. Effects of the space environment such as vacuum, ultraviolet, atomic oxygen, meteoroid and debris, thermal cycling and synergistic effects on various samples are described, and summaries of the board data are presented. (Author).
N91-25046.

25 MAAG, CARL R., LINDER, W. KELLY; (Space Systems Div AFSC Field Office, Houston TX). "Measured space environmental effects to LDEF during retrieval" 1991
Note: Science Applications International Corp., Glendora, CA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 6 (SEE N91-24972). Abstract Only

The Interim Operational Contamination Monitor (IOCM) is an attached shuttle payload to the Long Duration Exposure Facility (LDEF) that was used on 2 earlier flights to quantify the contamination deposited during the course of the missions. The IOCM can characterize by direct measurement the deposition of molecular and particulate contamination during any phase of flight. Also, the IOCM actively measures the optical property changes of thermal control surfaces by calorimetry, the flux of the ambient atomic oxygen environment, the incident solar flux, and the absolute ambient pressure in the payload bay. The IOCM also provides a structure and sample holders for the exposure of passive material samples to the space environment, e.g., thermal cycling, atomic oxygen, and micrometeoroids and/or debris. Some of the more salient results from the flight suggests that the payload bay was slightly contaminated during both the prelaunch phase of the mission and after the deployment of the SYNCOM IV payload. Measurements during the postflight phases, i.e., ferry flight and deintegration processing, show negligible to very low mass deposition. The results of the data are discussed in depth. (Author)
N91-24976.

26. LAIRD, C. E. "Study of activation of metal samples from LDEF- 1 and Spacelab-2. " , 1991, NASA-CR-184171 62P
Note: University of Eastern Kentucky, Richmond. Dept. of Physics and Astronomy. Final Report.

The activation of metal samples and other material orbited onboard the Long Duration Exposure Facility (LDEF) and Spacelab-2 were studied. Measurements of the radioactivities of spacecraft materials were made, and corrections for self-absorption and efficiency were calculated. Activation cross sections for specific metal samples were updated while cross sections for other materials were tabulated from the scientific literature. Activation cross sections for 200 MeV neutrons were experimentally determined. Linear absorption coefficients, half lives, branching ratios and other pertinent technical data needed for LDEF sample analses were tabulated. The status of the sample counting at low background facilities at national laboratories is reported. (Author).
N91-29297

27. LAIRD, C. E. "Activation calculations for trapped protons below 200 MeV. " , 1991, NASA-CR-184170. 192P
Note: University of Eastern Kentucky, Richmond. Dept. of Physics and Astronomy. Appendix Final Technical Report.

Tables are given displaying of the results of the activation calculations of metal samples and other material aboard the Long Duration Exposure Facility-1 (LDEF-1) and Spacelab-2 with the computer program, PTRAP4. The computer printouts give the reaction, the reactant product, the proton reaction cross sections as a function of the energy of the incident protons, and the activation as a function of distance into the sample from the exposed surface. (Author).
N91-29865.

28. KINARD, WILLIAM H. "LDEF space environments overview." 1991
Note: National Aeronautics and Space Administration. Langley Research Center Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 4 (SEE N91-24972). Abstract Only

The Long Duration Exposure Facility (LDEF) was launched into an Earth orbit during a period of minimum solar activity. It was retrieved almost 6 years later during a period of near maximum solar activity. In flight, the LDEF was passively stabilized in three axes and it flew in a near circular orbit having an inclination of 28.5 degs and an initial altitude of approx. 257 nautical miles. When the LDEF was retrieved, the orbit had decayed to an altitude of approx. 180 nautical miles. Specifically, the LDEF flew with one surface always facing the trailing direction, one surface facing Earth, and one surface facing into space. These facts made the LDEF an ideal platform to expose experiments to study the space environments and the effects of these environments on spacecraft materials and systems. An overview is provided of the specific space environments to which the LDEF experiments were exposed. The specific features are also pointed out of the LDEF that allow the effects of different environments to be isolated. (Author).
N91-24974.

29. KESSLER, D. J., (NASA, Johnson Space Center, Houston, TX); ZARNECKI, J. C. (Kent, University, Canterbury, England); MATSON, D. L., (JPL, Pasadena CA), eds. "Space dust and debris. Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B (Meetings B2, B3, and B5) of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990.Meeting sponsored by COSPAR." Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, 207 p. For individual items see A92-18652 to A92-18677 1991,

The present conference on space dust and debris encompasses orbital debris, in situ measurements and laboratory analysis of space-dust particles, comparative studies of comets, asteroids, and dust, the protection and maneuvering of spacecraft in space- debris environments, and the out-of-elliptic distribution of interplanetary dust derived from near-earth flux. Specific issues addressed include asteroid taxonomy, the optical properties of dust from cometary and interplanetary grains, light scattering by rough surfaces on asteroidal/lunar regoliths, and the first results of particulate impacts and foil perforations on the Long Duration Exposure Facility Also addressed are collision probability and spacecraft disposition in the geostationary orbit, a flash on the moon caused by orbital debris, the limits of population growth in low earth orbit due to collisional cascading, and the simulation of cosmic man-made dust effects on space-vehicle elements in rocket and laboratory experiments. (C.C.S.).
A92-18651

30. HUNTER, JERRY L., WORTMAN, JIM J., GRIFFIS, DIETER P., SIMON, CHARLES G., (Institute for Space Science and Technology Inc., Gainesville FL). "Ion microprobe elemental analyses of impact features on interplanetary dust experiment sensor surfaces." 1991
Note: North Carolina State Univ., Raleigh. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 39 (SEE N91-24972). Abstract Only.

Hypervelocity impact features on several of the electro-active dust sensors utilized in the Interplanetary Dust Experiment (IDE) were subjected to elemental analysis using an ion microprobe. The negatively biased dust sensor surfaces acted as ion traps for cations produced in the plasma plumes of impacting particles. Impactor residue surrounds most impact features to two or three feature diameters. After etching away a layer of carbonaceous/ silicaceous surface contamination, low mass resolution elemental survey scans are used to tentatively identify the presence of impactor debris. High mass resolution two-dimensional elemental maps and three dimensional depth profiling of the feature and surrounding area show the distribution and relative composition of the debris. The location of these sensors on the six primary Long Duration Exposure Facility (LDEF) sides provides a unique opportunity to further define the debris environment. Researchers applied the same techniques to impact and contaminant features on a set of ultra-pure, highly polished single crystal germanium wafer witness plates that were mounted on row 12 and exposed to the environment during the entire mission. (Author).
N91-25007

31 HICHWA, BRYANT P., SELEE, STEVEN R., DODDS, JERRY· LONG, GREG S. "Optical performance of exposed solar cell covers." 1991
Note: Optical Coating Lab., Inc., Santa Rosa, CA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 106 (SEE N91-24972). Abstract Only.

The characterization results of samples flown on the Long Duration Exposure Facility (LDEF) are discussed. These samples included both coated and uncoated fused silica and ceria glass substrates used in the manufacture of solar cell covers. The coatings comprised a single-layer magnesium fluoride antireflection coating and an all-dielectric high-reflector multilayer coating centered at 350 nm. Samples were mounted on both the leading and trailing surfaces of the LDEF for exposure to the environment of space. The optical properties of the coatings will be compared to control samples which were stored on the ground during the LDEF Mission. Results of Auger Electron Spectroscopy and Rutherford Backscatter Spectroscopy measurements made on several of the coatings are presented to explain the effects of space on the chemical composition of the coatings. (Author).
N91-25072.

32 HEMMINGER, C. S., STUCKEY, W K., UHT, J. C. "Space environmental effects on silvered Teflon thermal control surfaces. " 1991
Note: Aerospace Corp., El Segundo, CA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 64 (SEE N91-24972). Abstract only.

Cumulative space environment effects on Ag/fluorinated ethylene propylene (FEP) were a function of exposure orientation. Samples from nineteen silvered Teflon (Ag/FEP) thermal control surfaces recovered from the Long Duration Exposure Facility (LDEF) were analyzed to determine changes in this material as a function of position on the spacecraft. Although solar absorptance and infrared emittance of measured thermal blanket specimens are relatively unchanged from control specimen values, significant changes in surface morphology, composition and

chemistry were observed. Researchers hypothesize that the FEP surfaces on LDEF were degraded by ultraviolet radiation exposure at all orientations, but that the damaged material had been removed by erosion from the blankets exposed to atomic oxygen flux and that contamination is masking the damage on trays flanking the trailing edge. (Author).
N91-25031

33. HARVEY, GALE A. "Effects of long-duration exposure on optical system components." , 1991
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 104 (SEE N91-24972). Abstract Only

The optical materials and UV detectors experiment (SOO50-1) was a set of 18 optical windows, filters, and ultraviolet detectors. The optical specimens were all retrieved in excellent condition. No delamination or blistering of the filters occurred. No discoloration of the optical window materials occurred, but the MgF2 window did experience roughing. The most notable degradation of the optics were the deposition of an organic film on the exposed surfaces. The film absorption was measured using a Fourier transform infrared spectrometer and a UV spectrometer. The 6 percent absorption at 3.4 microns corresponds to about 100 mgm/sq ft of organic film. The UV absorption was almost 100 percent at 200 nm and about 50 percent at 380 nm. (Author).
N91-25070.

34. HARMON, B. A., FISHMAN, G. J., PARNELL, T A., LAIRD, C. E. (University of Eastern Kentucky, Richmond.). "Induced radioactivity in LDEF components." , 1991
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 16 (SEE N91-24972). Abstract Only

The systematics of induced radioactivity on the Long Duration Exposure Facility (LDEF) were studied in a wide range of materials using low level background facilities for detection of gamma rays. Approx. 400 samples of materials processed from structural parts of the spacecraft, as well as materials from onboard experiments, were analyzed at national facilities. These measurements show the variety of radioisotopes that are produced with half-lives greater than 2 wks, most of which are characteristic of proton induced reactions above 20 MeV For the higher activity, long lived isotopes, it was possible to map the depth and directional dependences of the activity. Due to the stabilized configuration of the LDEF, the induced radioactivity data clearly show contributions from the anisotropic trapped proton flux in the South Atlantic Anomaly. This effect is discussed, along with evidence for activation by galactic protons and thermal neutrons. The discovery of Be-7 was made on leading side parts of the spacecraft, although this was though not to be related to the in situ production of radioisotopes from external particle fluxes. (Author).
N91-24985.

35. GREGORY, JOHN C. "Analysis of surfaces from the LDEF A0114." , 1991, NASA-CR-188990. 46P
Note: Alabama Univ., Huntsville. Dept. of Chemistry. phase 4 Semiannual Progress Report, 1 Mar - 31 Aug. 1991

Progress made from 1 Mar. to 31 Aug. 1991 is presented. The work concentrated on profilometry measurements of eroded and corroded sample surfaces, optical transmission measurements, analysis of the pinhole camera, and x-ray photoelectron spectroscopic (XPS) analysis of some samples. The following papers are presented: (1) observation of Be-7 on the surface of the Long Duration Exposure Facility (LDEF) Spacecraft; (2) measurement of the passive attitude control performance of a recovered spacecraft; (3) effects on LDEF exposed copper flim and bulk; (4) measurements of erosion characteristics for metal and polymer surfaces using profilometry; (5) the interactions of atmospheric cosmogenic radionuclides with spacecraft surfaces; (6) pinhole cameras as sensors for atomic oxygen in orbit; and (7) interaction of atomic oxygen with solid surfaces in low earth orbit- results from LDEF experiment A0114. For individual titles, see N92-11075 through N92-11078.
N92-11074.

36. DONOVAN, T M., BENNETT, J. M., GYETVAY, S. R., (Aerospace Corp., Los Angeles ,. CA.). "Space environmental effects on coated optics." , 1991
Note: Naval Weapons Center, China Lake, CA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 113 (SEE N91-24972). Abstract Only

Several multilayer coated mirror designs developed for potential space applications were tested on the Long Duration Exposure Facility (LDEF) along with single layer witness coatings deposited on fused silica and a coated CaF2 window. Performance requirements included high mirror reflectivity, low absorption, low scatter, environmental durability, and radiation hardness. The designs were selected in screening tests using combined electron, proton, and simulated solar UV radiation. The purpose of the space test was to validate the above test results and determine the effects of atomic oxygen and contamination on mirror performance. (Author).
N91-25079.

37 CHARLIER, JEAN. "Vacuum deposited optical coatings experiment (AO 138-4)." , 1991
Note: MATRA Service Aerodynamique, Velizy-Villacoublay (France). In NASA, Langley Research Center, First LDEF Post- Retrieval Symposium Abstracts p 108 (SEE N91-24972). Abstract Only.

The aim of this experiment was to test the optical behavior of 20 components and coatings subjected to space exposure. Most of them are commonly used for their reflective or transmittive properties in spaceborne optics. They consist in several kind of metallic and dielectric mirrors designed for the 0.12 to 10 microns spectrum, UV, and NIR bandpass filters, visible, and IR antireflecting coatings, visible/IR dichroic beam splitters, and visible beam splitter The coatings were deposited on various substrates such as glasses, germanium, magnesium fluoride, quartz, zinc selenide, and kanigened aluminum. Several coating materials were used such as Al, Ag, Au, MgF2, LaF3, ThF3, ThF4, SiO2, TiO2, ZrO2, Al2O3, MgO, Ge, and ZnSe. Five samples of each component were manufactured. Two flight samples were mounted in such a way that one was directly exposed to space and the other looking backwards. The same arrangement was used for the spare samples stored on ground in a box identical to the flight one and they were kept under vacuum during the LDEF mission. Finally, one set of reference components was stocked in a sealed box under a dry nitrogen atmosphere. By comparing the preflight and postflight optical performances of the five samples of each component, it is possible to detect the degradations due to the space exposure. (Author).
N91-25074.

38. BRINKER, DAVID J., HICKEY, JOHN R., (Eppley Lab. Inc., Newport RI)., BRASTED, DONALD K. "Advanced photovoltaic experiment, S0014: Preliminary flight results and post-flight findings." , 1991
Note: National Aeronautics and Space Administration. Lewis Research Center. Cleveland, OH. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 95 (SEE N91-24972). Abstract Only

The Advanced Photovoltaic Experiment (APEX) is an LDEF experiment designed to provide reference solar cell standards for laboratory measurements as well as to investigate the solar spectrum and the effects of long term exposure of solar cells to the LEO environment. Silicon and gallium arsenide solar cells were flown with the appropriate instrumentation to periodically measure cell performance and temperature. The experimental objectives, the design employed to realize these objectives and the solar cells and instrumentation selected for the flight are presented. A discussion of the flight data returned are included. Preliminary results from the post flight analysis of the absolute cavity radiometer, the digital solar angle sensor, and the Barr Associates narrow bandpass optical filters are also presented. The initial findings of work to determine the chemical nature of contamination layers on APEX are also presented. (Author).
N91-25061

39. BLAKKOLB, B. K., YAUNG, J. Y., RYAN, L. E., TAYLOR, W. "LEO space environmental effects: TRW LDEF experimental trays." , 1991
Note: TRW Space and Defense Sector, Redondo Beach, CA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 57 (SEE N91-24972). Abstract Only.

Comprised of two identical trays, the TRW Long Duration Exposure Facility (LDEF) experiment (A0054) provided a unique opportunity to study long term space environmental effects on a variety of materials exposed to two different space environments. The leading edge tray saw micrometeors and anthropogenic space debris, ultraviolet radiation, and energetic atomic oxygen. In contrast, the trailing edge tray was exposed to ultraviolet and micrometeors but saw relatively little, if any, space debris fluence and no energetic atomic oxygen. The striking difference in appearance of the two experimental trays is directly attributable to the nonuniformity of the space environment about the LDEF It is estimated that the majority of the erosion to the Kapton polyimide dielectric material occurred during the last month

on orbit due to the sharply nonlinear increase in atomic oxygen number density as orbital altitude decayed over the life of the mission. (Author).
N91-25024.

40. ARMSTRONG, T W., COLBORN, B. L. "Radiation calculations and comparisons with data. " , 1991
Note: Science Applications International Corp., Prospect, TN. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 22 (SEE N91-24972). Abstract Only.

In conjunction with the analysis of data from the Long Duration Exposure Facility (LDEF) ionizing radiation dosimetry, a calculation program was established to aid in data interpretation and to assess the accuracy of current radiation environments and effects models for future mission applications. Initial estimates of LDEF exposure to trapped, galactic, and atmospheric (albedo) radiation sources were made, and the radiation environment (primary and secondary particle spectra) and several radiation effects (induced radioactivity and dose) for varying amounts of LDEF shielding were calculated for a simplified LDEF mass model. Preliminary comparisons of the calculated results were made with the induced radioactivity measurements for several LDEF parts and with preliminary dose data from several experiments (P0004, P0006, and M0004). Predictions were compared with the radioactivity induced in the aluminum clamps holding the experiment trays and in the stainless steel trunnions to test a recently developed theory of trapped proton anisotropy (Author).
N91-24991

41 ANDERSON, B. JEFFREY; SUGGS, RONNIE J., (NASA, Marshall Space Flight Center, Huntsville, AL); SMITH, ROBERT E., HICKEY, MICHAEL, CATLETT, KAREN; (FWG Associates, Inc Huntsville ,. AL). "Recent improvements in atmospheric environment models for Space Station applications" , 1991, AIAA-Paper-91-0452
Note: AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7- 10, 1991 10 p.

The capability of empirical models of the earth's thermosphere must continually be updated if they are to keep pace with their many applications in the aerospace industry. This paper briefly summarizes the progress of several such efforts in support of the Space Station Program. The efforts consists of the development of data bases, analytical studies of the data, and evaluation and intercomparison of thermosphere models. A geomagnetic storm model of Slowey does not compare as well to the MSIS-86 model as does the Marshall Engineering Thermosphere (MET). LDEF orbit decay data is used to evaluate the performance of the MET and MSIS-86 during a period of high solar activity; equal to or exceeding the highest levels that existed during the time of the original data sets upon which these models are based. (Author).
A91-19307

42 STEIN, BLAND A., YOUNG, PHILIP R ,. comps. "Proceedings of the LDEF Materials Data Analysis Workshop" 1990; NASA-CP- 10046.
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. Workshop held at Cocoa Beach, FL, 13-14 Feb. 1990.

The 5-year, 10-month flight of the Long Duration Exposure Facility (LDEF) greatly enhanced the potential value of most LDEF materials, compared to the original 1-year flight plan. NASA recognized this potential by forming the LDEF Space Environmental Effects on Materials Special Investigation Group in early 1989 to address the expanded opportunities available in the LDEF structure and on experimental trays, so that the value of all LDEF materials to current and future space missions would be assessed and documented. The LDEF Materials Data Analysis Workshop served as one step toward the realization of that responsibility and ran concurrently with activities surrounding the successful return of the spacecraft to the NASA Kennedy Space Center A compilation of visual aids utilized by speakers at the workshop is presented. Session 1 summarized current information on analysis responsibilities and plans and was aimed at updating the workshop attendees: the LDEF Advisory Committee, Principle Investigators, Special Investigation Group Members, and others involved in LDEF analyses or management. Sessions 2 and 3 addressed materials data analysis methodology, specimen preparation, shipment and archival, and initial plans for the LDEF Materials Data Base. A complementary objective of the workshop was to stimulate interest and awareness of opportunities to vastly expand the overall data base by considering the entire spacecraft as a materials experiment. (Author).
N90-26075.

43. SHAFFER, BRAD L. "Analysis of space radiation effects in gallium arsenide and cadmium selenide semiconductor samples using luminescence spectroscopic techniques M.S. Thesis" 1990; AD- A230684.
Note: Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

Analysis of space radiation effects in gallium arsenide and cadmium selenide semiconductor samples using luminescence spectroscopic techniques. The M0006 semiconductor samples were placed into a 28.5 degree inclination, 480 km altitude, near- circular orbit aboard the Long Duration Exposure Facility satellite and exposed to direct space environment for a period of 11 months, and were shielded by 0.313 inches of aluminum for another 58 months. The samples were examined for changes using cathodoluminescence and photoluminescence in various wavelength regions from 0.5 to 1.8 microns. Samples were cooled to approximately 10 K in a vacuum of 10-8. (GRA).
N91-20958.

44 SATER, JANET M., BERSCH, CHARLES F., HONG, WILLIAM S. "IDA studies on natural space environmental effects on materials for SDIO " , 1990; AD-A237974. 109P
Note: Institute for Defense Analyses, Alexandria, VA. Final Report, Nov 1987 - Dec. 1990.

The background is provided of IDA's role in the area of space environmental effects (SEE) for Strategic Defense Initiative Organization (SDIO), particularly the Materials and Structures program. Included in these efforts are establishig and co- chairing the NASA/SDIO Workshop on Space Environmental Effects on Materials (June 1988). This workshop, in part, led to the recovery of the NASA Long Duration Exposure Facility (LDEF) after more than 5 years in space as well as to the appointment of the M and S Office as the SDIO focal point for SEE. A technical assessment of the utility of various LDEF experiments to SDI is highlighted. Results of the assessment were presented at an SDIO Workshop in August 1989 and copies were provided to appropriate, interested groups. The study provided the basis for preparation of detailed SDIO sample/analysis information packages for the NASA-LDEF Office. Continuing involvement in LDEF post-retrieval activities is noted as well. (GRA).
N91-29660.

45. HUGHES, P C. "LDEF temperature histories: A simple theory" , 1990; AD-B151978L. 75P
Note: Toronto Univ. (Ontario). Inst. for Aerospace Studies.

The temperature of a particular area (an experimental test patch) on the surface of the Long Duration Exposure Facility (LDEF) varies with time in a manner that depends on a large number of factors. The direct input from the sun depends on whether LDEF is in sunlight; if in sunlight, on whether the test patch can actually see sun; and if it can see sun, on the angle of incidence of the sun's radiation. The heat input to the test patch from the rest of the LDEF vehicle also depends on the average temperature of the LDEF vehicle, which in turn depends on its eclipse history. This report examines all these factors and uses a multiple time scale description (corresponding physically to orbital, precessional and annual time scales) to build an understanding of the chief features observed in the flight data. Geometrical, orbital, and thermal models are developed. Numerical calculations based on these models are shown to be be in qualitative agreement (and usually even in semi quantitative agreement) with flight data. Thus all the salient features of the in-orbit temperature data can be explained in terms of the physical phenomena described. (Author (CISTI)).
N92-13142.

46. HAWKINS, G. J., HUNNEMAN, R., SEELEY J. S., (Reading University, England. "Preliminary results from infrared multilayer filters and materials exposed to the space environment on the NASA LDEF mission" IN: Infrared technology and applications; Proceedings of the Meeting, London, England, June 26-28, 1990 (A91-51506). Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 407-419. , 1990.

The paper addresses an experiment carried out at the Long Duration Exposure Facility (LDEF) launched by the Space Shuttle. High-performance infrared filters, coatings, and materials were exposed to the complete diversity of space radiations and temperature excursions. Transmission measurements obtained and processed from an infrared spectrophotometer both before and after exposure are compared with unexposed control specimens, and the results of detailed microscopic and general visual examinations are analyzed. The degradation mechanisms and

environmental effects are studied, and it is concluded that the infrared filters and materials exposed to the space environment demonstrated the long-term spectral and mechanical stability. (V T).
A91-51519.

47 BRINKER, DAVID J., HICKEY. JOHN R., (Eppley Lab. Inc., Newport RI)., BRASTED, DONALD K. "The effect of the low Earth orbit environment on space solar cells" 1990; NASA-TM-103735. 8P
Note: National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH. Presented at the 5th International Photovoltaic Science and Engineering Conference, Kyoto, Japan, 26-30 Nov. 1990; sponsored in part by Japan Society of Applied Physics, Inst. of Electrical Engineers of Japan and Foundation for Adv of Intern. Science, Kyoto, Japan

The results of a space flight experiment designed to provide reference cell standards for photovoltaic measurements as well as to investigate the solar spectrum and the effect of long-term exposure of solar cells to the space environment are presented. This experiment, the Advanced Photovoltaic Experiment (APEX), was launched into low Earth orbit as part of the Long Duration Exposure Facility in 1984 and retrieved 69 months later. APEX contained over 150 solar cells of a wide variety of materials, designs and coverglasses. Data on cell performance was recorded for the first year-on-orbit. (Author).
N91-19165.

48. BRINKER, DAVID J., HART, RUSSELL E. ,. JR., HICKEY, JOHN R., (Eppley Lab. Inc., Newport RI). "Preliminary results from the advanced photovoltaic experiment flight test" , 1990; NASA-TM- 103269. 12P
Note: National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH. Presented at the 21st Photovoltaic Specialists Conference, Kissimmee, FL, 21-25 May 1990; sponsored in part by IEEE

The Advanced Photovoltaic Experiment is a space flight test designed to provide reference cell standards for photovoltaic measurement as well as to investigate the solar spectrum and the effect of the space environment on solar cells. After a flight of 69 months in low earth orbit as part of the Long Duration Exposure Facility set of experiments, it was retrieved in January, 1990. The electronic data acquisition system functioned as designed, measuring and recording cell performance data over the first 358 days of flight; limited by battery lifetime. Significant physical changes are also readily apparent, including erosion of front surface paint, micrometeoroid and debris catering and contamination. (Author).
N91-11058.

49. BRINKER, DAVID J., HART RUSSELL E. ,. JR., (NASA, Lewis Research Center, Cleveland, OH); HICKEY, JOHN R., (Eppley Laboratory Inc., Newport RI). "Preliminary results from the Advanced Photovoltaic Experiment flight test" IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21- 25, 1990, Conference Record. Vol. 2 (A91-41876). New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1213-1218. , 1990.

The Advanced Phototovoltaic Experiment is a space flight test designed to provide reference cell standards for photovoltaic measurements and to investigate the solar spectrum and the effect of the space environment on solar cells. After a flight of 69 months in low earth orbit as part of the Long Duration Exposure Facility set of experiments, it was retrieved in January 1990. The electronic data acquisition system functioned as designed, measuring and recording cell performance data over the first 358 days of flight, limited by battery lifetime. Significant physical changes are also readily apparent, including erosion of front surface paint, micrometeoroid and debris cratering, and contamination. (I.E.).
A91-41980.

50. BRINKER, DAVID J., (NASA, Lewis Research Center, Cleveland, OH); HICKEY, JOHN R., (Eppley Laboratory, Inc Newport ,. RI). "Preliminary flight test results from the advanced photovoltaic experiment" IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6 (A91-37926). New York, American Institute of Chemical Engineers, 1990, p. 36-41.Previously announced in STAR as N91-11058. , 1990.

The Advanced Photovoltaic Experiment is a space flight test designed to provide reference cell standards for photovoltaic measurement as well as to investigate the solar spectrum and the effect of the space environment on

solar cells. After a flight of 69 months in low earth orbit as part of the Long Duration Exposure Facility set of experiments, it was retrieved in January, 1990. The electronic data acquisition system functioned as designed, measuring and recording cell performance data over the first 358 days of flight, limited by battery lifetime. Significant physical changes are also readily apparent, including erosion of front surface paint, micrometeoroid and debris catering and contamination. (Author).
A91-38163.

51 TENNEY DARREL R. "Structural materials for space applications" , 1989.
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. In its NASA/SDIO Space Environmental Effects on Materials Workshop, Part 1 p 25-52 (SEE N89-23528)

The long-term performance of structural materials in the space environment is a key research activity within NASA. The primary concerns for materials in low Earth orbit (LEO) are atomic oxygen erosion and space debris impact. Atomic oxygen studies have included both laboratory exposures in atomic oxygen facilities and flight exposures using the Shuttle. Characterization of atomic oxygen interaction with materials has included surface recession rates, residual mechanical properties, optical property measurements, and surface analyses to establish chemical changes. The Long Duration Exposure Facility (LDEF) is scheduled to be retrieved in 1989 and is expected to provide a wealth of data on atomic oxygen erosion in space. Hypervelocity impact studies have been conducted to establish damage mechanisms and changes in mechanical properties. Samples from LDEF will be analyzed to determine the severity of space debris impact on coatings, films, and composites. Spacecraft placed in geosynchronous Earth orbit (GEO) will be subjected to high doses of ionizing radiation which for long term exposures will exceed the damage threshold of many polymeric materials. Radiation interaction with polymers can result in chain scission and/or cross-linking. The formation of low molecular weight products in the epoxy plasticize the matrix at elevated temperatures and embrittle the matrix at low temperatures. This affects both the matrix-dominated mechanical properties and the dimensional stability of the composite. Embrittlement of the matrix at low temperatures results in enhanced matrix microcracking during thermal cycling. Matrix microcracking changes the coefficient of thermal expansion (CTE) of composite laminates and produces permanent length changes. Residual stress calculations were performed to estimate the conditions necessary for microcrack development in unirradiated and irradiated composites. The effects of UV and electron exposure on the optical properties of transparent polymer films were also examined to establish the optimum chemical structure for good radiation resistance. Thoughts on approaches to establishing accelerated testing procedures are discussed. (Author).
N89-23530.

52 LEGER, L. J. "Effects of the Low Earth Orbital environment on spacecraft materials" , 1985.
Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex. Materials Branch. In ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 75-80 (SEE N86-22593).

Recession of organic-polymer-based surfaces due to oxidation by atomic oxygen, the major component of the LEO environment, was studied in Space Shuttle flights 5, 8, and 41-G to measure reaction rates and the effects of various parameters on reaction rates. Surface recession on the flights indicates reaction rates of 3 x10 to the minus 24th power cc atom for unfilled organic polymers. Application of these rates to Space Station-type exposure for main structural items indicates that as much as 0.075 cm of surface recession occurs in 30 yr. Because of the importance of this effect on Space Station systems, additional experiments are planned to obtain better reaction rate measurements ensuring and adequate data base for Space Station design. (Author (ESA)).
N86-22602.

53. LAIRD, C. E. "Study of proton and neutron activation of metal samples in low Earth orbit." , 1985; NASA-CR-171596. 156P
Note: University of Eastern Kentucky, Richmond. Dept. of Physics and Astronomy Final Technical Report.

The anticipated nuclear activation of metal samples in low Earth orbit for the Spacelab and Long Duration Exposure Facility (LDEF) missions was studied. Compilations were made of scientific data needed in analyzing the samples. These compilations include reaction cross sections, half lives, reaction Q values, gamma ray energies, and competing reactions. Calculations were made of the expected activation given proton and neutron fluxes and target covering

The stability of various vacuum deposited optical coatings exposed to the space environment were analyzed. A wide range of optical components manufactured by vacuum deposition, such as metallic and multidielectric reflective coatings in the UV range, metal dielectric interference filtes in the UV and IR ranges, narrow-bandpass filters int he near-UV and visible ranges, selective metallic mirrors in the range from 1500 to 2500 A. antireflective and reflective IR coatings, beam splitters in the visible and IR ranges, and optical surface reflection (OSR) coatings were developed. Many of these components were incorporated into scientific and technical experiments flown on balloons and rockets as well as on Symphonie, Meteosate, OTS, D2- B, TIROS n, and others. It appears that these components operate successfully in flight. (E.A.K.).
N84-24681

62 DELASI, R. J., ROSSI, M. L., WHITESIDE, J. B., KESSELMAN, M., HEUER, R. L., KUEHNE, F. J. "Effect of space environment on space-based radar phased-array antenna (A0133)" 1984;
Note: Grumman Aerospace Corp., Bethpage, N.Y. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 21-23 (SEE N84-24632).

Kapton polyimide film was selected as the baseline material for the Grumman spce based radar (SBR) concept. To gain the requisite confidence for long-term service durability, it is desirable to subject material specimens as well as a portion of the SBR antenna directly to the combined space environment and compare property degradation to that caused by laboratory simulation. The overall objective of this program is to evauate the effect of the space environment on polymeric materials currently being considered for the Grumman SBR Phased-Array Antenna. Degradation mechanisms caused by thermal cycling, ultraviolet and charged- particle irradiation, applied load, and high-voltage plasma interaction will be evaluated. The experiment occupies a 6-in.- deep end corner tray located on the space end of the Long Duration Exposure Facility and consists of both passive and active parts. The passive part addresses the effect of environment and stress on the dimensional stability spliced and continuous Kapton, both plain and reinforced. The active part will study the interaction of high voltage and low-Earth-orbit plasma. (R.J.F.).
N84-24638.

63. BRADHORST, H. W. ,. JR., FORESTIERI, A. F. "Advanced photovoltaic experiment (S0014)" 1984;
Note: National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 88-90 (SEE N84- 24632).

The advanced photovoltaics-related experiments for investigating a portion of the solar spectrum and the effect of the space environment on photovoltaics. The information will be used to provide correlation between space and ground testing and also to provide for more accurate performance measurement in the laboratory. Specific objectives of these experiments are to provide information on the performance and endurance of advanced and conventional solar cells, to improve reference standards for photovoltaic measurements, and to measure the energy distribution in the extraterrestrial solar spectrum. Data to be obtained will include temperatures and short-circuit current of the samples. Six-point current-voltage (I-V) characteristics will be obtained for selected samples. These data will be recorded once a day during the flight. Orbit data will be correlated with preflight and postflight measurement of the samples. (M.G.).
N84-24657

64 BOURRIEAU, J. "Optical fibers and components experiment (A0138-7)" 1984;
Note: Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 165-166 (SEE N84-24632).

Fiber optics permanent damages induced by ionizing radiation after a long exposure in space and after laboratory tests were examined. Irradiation tests performed with radioactive sources (Sr90 - Y90) were validataed, computer coses used for the fluence and dose profile were verified. The performance of fiber optics waveguides in a low altitude orbit, and the origin of transmission losses in the material were dtermined. High sensitivity to ionizing radiations, however, may be a restriction for optic fiber use on satellites. Irradiation tests on these components using neutrons, gamma rays, and X-rays are carried out. Radiation damage on opticao materials, however, is strongly linked to the test conditions. (E.A.K.).
N84-24683.

65. BLUE, M. D., GALLAGHER, J. J., SHACKELFORD, R. G. "Investigation of the effects of long-duration exposure on active optical system components (S0050)" 1984;
Note: Georgia Inst. of Tech., Atlanta. Engineering Experiment Station. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 176-179 (SEE N84-24632).

The effects of long duration space exposure on the relevant performance parameters of lasers, radiation detectors, and selected optical components, was determined. The results and implications of the measurements indicating real or suspected degradation mechanisms were evaluated and guidelines, based on these results, for selection and use of components for space electro-optical systems are established. (E.A.K.).
N84-24687

66. ANGELO, J. A. ,. JR., MADONNA, R. G., ALTADONNA, L. P., (Perkin-Elmer); DAGOSTINO, M. D., CHANG, J. Y., ALFANO, R. R., CAPLAN, V. L. "Space environment effects (M0006)" 1984;
Note: Grumman Aerospace Corp., Bethpage, N.Y In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 185-187 (SEE N84-24632)

The effects of long term exposure to the near Earth space environment on advanced electrooptical and radiation sensor components were examined. The effect of long duration spaceflight on the germination rate of selected terrestrial plant seeds is observed in exobiological experiments. (E.A.K.).
N84-24690.

67 HEINRICH, W. "Calculated linear energy transfer spectra of HZE particles for the free flyer Biostack experiment on the LDEF- mission" , 1979. 14P
Note: Gesamthochschule, Siegen (West Germany). Dept. of Physics.

The LDEF-mission, scheduled for launch on the Space Shuttle in 1981, will fly for about nine months in a near earth orbit with an inclination angle of 28. During this flight the Free Flyer Biostack experiment will measure biological effects of individual heavy ions from cosmic radiation. The corresponding results of a calculation of linear energy transfer (LET) spectra in free space and inside the experiment are presented. The calculation considers the geomagnetic shielding of the spacecraft against charged particles with low energies and the disintegration of the heavy ions inside the experiment by fragmentation. For this mission the LET spectra will differ significantly from those of previous experiments. Primary particles with high LET are scarce. Inside the experiment the LET spectra change with depth of matter due to the energy loss and fragmentation of the nuclei. (Author (ESA)).
N80-11767

68. VENABLES, J. D., AHEARN, J. S., (Martin Marietta Laboratories, Baltimore Md). "Radiation sensitivity of quartz crystal oscillators experiment for the Long Duration Exposure Facility /LDEF/" 1978; AAS-78-032.
Note: American Astronautical Society and Deutsche Gesellschaft fuer Luft- und Raumfahrt, Goddard Memorial Symposium, 16th, Washington, D.C., Mar. 8-10, 1978, AAS 4 p.

A proposed experiment, which has been selected by NASA for inclusion in the Long Duration Exposure Facility (LDEF), is discussed. The objective of the experiment is to obtain information relevant to predicting and improving the radiation sensitivity of quartz oscillators. Specifically, the effect of exposing various grades of quartz oscillators to an orbital environment will be compared with observations obtained using the transmission electron microscope which suggest that the technique may be used to classify quartz-crystals according to their radiation sensitivity. ((Author)).
A79-11560.

69. KULACKI, F. A., NEREM, R. M. "The identification of scientific programs to utilize the space environment Final Report, Jun. 1975 - Jun. 1976" , 1976; NASA-CR-148455. 206P
Note: Ohio State Univ., Columbus.

A program to identify and develop ideas for scientific experimentation on the long duration exposure facility (LDEF) was completed. Four research proposals were developed: (1) Ultra pure germanium gamma ray radiation detectors in the space environment, intended to develop and demonstrate an X-ray and gamma-ray spectroscopy system incorporating a temperature cyclable high- purity germanium detector and diode heat pipe cryogenic system for

cooling, (2) growth, morphogenesis and metabolism of plant embryos in the zero-gravity environment, to investigate if the space environment induces mutations in the embryogenic cells so that mutants of commercial significance with desirable attributes may be obtained, (3) effect of zero gravity on the growth and pathogenicity of selected zoopathic fungi. It is possible that new kinds of treatment for candidiasis, and tichophytosis could eventuate from the results of the proposed studies, and (4) importance of gravity to survival strategies of small animals. Gravitational effects may be direct or mediate the selection of genetic variants that are preadapted to weightlessness. (Author).
N76-27289.

BENDING VIBRATION

1 EDIGHOFFER, H. "Vibration analysis of the Long Duration Exposure Facility (LDEF) using SPAR" , 1980; NASA-CR-159239. 96P
Note: General Electric Co., Philadelphia, Pa.

The structural modeling of the Long Duration Exposure Facility (LDEF) utilizing the SPAR system of computer programs for vibration analysis is discussed. The technical areas of interest were: (1) development of the LDEF finite element model; (2) derivation of tray effective panel stiffness matrix using finite element tray models; (3) assessment of attachment conditions and end fitting flexibility by comparing SPAR with test static displacements; (4) SPAR grouping; and (5) derivation of the LDEF frequencies and mode shapes and comparing them with tests. Special detailed finite element modeling was required to obtain good agreement between analytical and test vibration modes. An orthotropic panel in the overall model was developed. Orthotropic stiffness for this panel were obtained from finely detailed statically loaded SPAR models which included stiffness and allowed for partial relative sliding of the tray clamping attachments. Sensitivity to LDEF joint boundary conditions was determined, and static test data proved valuable in assessing modeling of local end fittings. (B.D.).
N80-26696.

BERYLLIUM 7

1 TRUSCOTT, P R., DYER, C. S., FLATMAN, J. C. "Surface activation of Concorde by Be-7" , 1991
Note: Royal Aircraft Establishment, Farnborough (England). Space Dept. In NASA, Langley Research Center, First LDEF Post- Retrieval Symposium Abstracts p 14 (SEE N91-24972) Abstract Only.

Activation analysis of two airframe parts from Concorde aircraft has identified te presence of Be-7, a nuclide which was found by other investigators to have been collected on the forward edge of the Long Duration Exposure Facility (LDEF) structure. The results of the Concorde analysis indicate that this phenomenon is very much a surface effect, and that the areal densities of the Be-7 are comparable to those found for LDEF The collection of Be-7 by the aircraft must be greater than in the case of LDEF (since the duration for which Concorde is accumulating the nuclide is shorter) and is of the order of 1.9 to 40 nuclei sq cm/s, depending upon assumptions made regarding the efficiency of the process which removes the radionuclide. (Author).
N91-24983.

2 PHILLIPS, G. W., KING, S. E., AUGUST, R. A., RITTER, J. C., CUTCHIN, J. H. "Discovery of Be-7 Accretion in Low Earth Orbit" 1991,
Note: The 16th Annual AAS Guidance and Control Conference American Astronautical Society, San Diego, CA. Conference held in Keystone, CO, 2-6 Feb. 1991

Strong Be-7 activity was observed on the surface of the Long Duration Exposure Facility (LDEF) during the first complete gamma ray survey of a large spacecraft after its return to earth. This is the first known evidence for accretion of a radioactive isotope onto an orbiting spacecraft. Be-7 is produced by spallation reactions of cosmic rays on nitrogen and oxygen in the upper atmosphere. However, the observed density is much greater than expected due to cosmic ray production in situ; this is significant for models of atmospheric mixing. Be-7 may be a valuable tracer in future studies of the upper atmosphere. Other isotopes seen during the survey, the strongest being Na-22, are due

to activation of spacecraft components while in orbit. The likely accretion is discussed of other cosmic ray produced isotopes and their possible effects on spacecraft in low earth orbit. (GRA).
N91-27195.

3. PETTY, G. W., (Purdue University, West Lafayette , IN). "Equilibrium profiles of atomic Be-7 and Be-10 in the atmosphere above 100 km" Geophysical Research Letters (ISSN 0094-8276), vol. 18, Sept. 1991, p. 1687-1690. 1991,

Theoretical profiles of cosmogenic Be-7 in the atmosphere above 100 km were computed in an effort to explain unexpectedly high accumulations of this radionuclide found on the leading surfaces of the Long Duration Exposure Facility (LDEF) spacecraft. Diffusion calculations suggest that gravitational fractionation is sufficient to explain most, and possibly all, of the observed Be-7 enrichment at the recovery altitude of the spacecraft, provided only that the nuclide exists at and above the turbopause predominantly in the form of free atoms. Upward diffusion of Be-7 atoms through the turbopause appears to occur rapidly enough to largely offset losses at higher altitudes due to radioactive decay. The same model is used to compute cosmogenic Be-10 profiles in order to predict the probable outcome of planned measurements of Be-10 accumulations on LDEF surfaces. (Author).
A91-52764.

4. GREGORY JOHN C., FISHMAN, G. J., HARMON, A., PARNELL, T A., HERZOG, G., KLEIN, J., JULL, A. J. T., (Arizona Univ., Tucson. "The interactions of atmospheric cosmogenic radionuclides with spacecraft surfaces" , 1991.
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 13 (SEE N91-24972) Abstract Only.

The discovery of the cosmogenic radionuclide Be-7 on the front surface of the Long Duration Exposure Facility (LDEF) has opened new opportunities to study several unexplored regions of space science. The experiments have shown that the Be-7 found was concentrated in a thin surface layer of spacecraft material. The only reasonable source of the isotope is the atmosphere through which the spacecraft passed. It is expected that the uptake of Be in such circumstances will depend on the chemical form of the Be and the chemical nature of the substrate. It was found that the observed concentration of Be-7 does differ between metal surfaces and organic surfaces such as PTFE (Teflon). It is noted however, that (1) organic surfaces are etched by the atomic oxygen found under these orbital conditions, and (2) the relative velocity of the species is 8 km/s relative to the surface and the interaction chemistry and physics may differ from the norm. Be-7 is formed by disintegration of O and N nuclei under cosmic ray proton bombardment. Many other isotopes are produced by cosmic ray reactions, and some of these are suited to measurement by the extremely sensitive methods of accelerator mass spectrometry. (Author).
N91-24982.

5. GREGORY, JOHN C., FISHMAN, G. J., HARMON, B. A., PARNELL, T A., (National, Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.). "The interactions of atmospheric cosmogenic radionuclides with spacecraft surfaces" , 1991.
Note: Alabama Univ., Huntsville. In its Analysis of Surfaces from the LDEF A0114, Phase 4 15 p (SEE N92-11074).

The discovery of the cosmogenic radionuclide Be-7 on the front surface (and the front surface only) of the Long Duration Exposure Facility (LDEF) spacecraft has opened opportunities to investigate new phenomena in several disciplines of space science. The experiments performed for this work show that the Be-7 results only if the source of the isotope is the atmosphere through which the spacecraft passed. We should expect that the uptake of beryllium in such circumstances will depend on the chemical form of the Be and the chemical nature of the substrate. It was found that the observed concentration of Be-7 does, in fact, differ between metal surfaces and organic surfaces such as PTFE (teflon). It is noted, however, that: (1) organic surfaces, even PTFE, are etched by the atomic oxygen found under these orbital conditions, and (2) the relative velocity of the species is 8 km(exp -1)s relative to the surface and the interaction chemistry and physics may differ from the norm. The Be-7 is formed by spallation of O and N nuclei under cosmic ray proton bombardment. The principal source region is at altitudes of 12-15 km. While very small quantities are produced above 300 km, the amount measured on the LDEF was 3 to 4 orders of magnitude higher than expected from production at orbital attitude. The most reasonable explanation is that Be-7 is rapidly transported from low altitudes by some unknown mechanism. The process must take place on a time scale similar to the half-life of the isotope (53 days). Many other isotopes are produced by cosmic ray reactions, and some of these are suited to measurement by the extremely sensitive methods of accelerator mass spectrometry. A program was initiated to

search for these isotopes and it is hoped that such studies will provide new methods for studying mixing in the upper atmosphere. (Author).
N92-11075.

6. FISHMAN, G. J., PARNELL, T A., PETERS, P., (NASA, Marshall Space Flight Center, Huntsville, AL); HARMON, B. A., (Universities Space Research Association, Huntsville AL)., GREGORY, J. C., (University of Alabama, Huntsville). "Observation of Be-7 on the surface of LDEF spacecraft" Nature (ISSN 0028- 0836), vol. 349, Feb. 21 1991 p. 678-680. 1991

   Significant quantities of Be-7 have been found on the leading edge of the Long Duration Exposure Facility (LDEF), which was returned to earth after almost six years in space. Although the absolute atmospheric concentration of Be-7 needed to explain this detection is extremely small, its concentration at LDEF's altitude must be several orders of magnitude higher than in the stratosphere below, where it is produced by cosmic-ray reactions with atmospheric nitrogen and oxygen nuclei. The detection may lead to the use of Be-7 as an exoatmospheric tracer as well as to studies of surface interactions in space. (C.D.)
   A91-27291

CHARGED PARTICLES

1. OLMEZ, ILHAN; BURNS, FORREST; SAGALYN, PAUL L., (Army Materials Technology, Lab Watertown ,. MA.). "Charged particle activation studies on the surface of LDEF spacecraft " , 1991
   Note: Massachusetts Inst. of Tech., Cambridge. Nuclear Reactor Lab. In NASA, Langley Research Center, First LDEF Post- Retrieval Symposium Abstracts p 18 (SEE N91-24972). Abstract Only

   High energy proton induced nuclear reaction products are examined using seven elements, namely: Al, Si, Ni, Co, Zr, Ta, and W. Activities were detected due to Na-22 from Al, Co-56 from Ni, Co-58 from Cu, and Y-88 from Zr targets. No induced activity was observed in Si, Ta, and W, most probably due to the long cooling times. Only Zr sample contained a weak Be-7 peak, although Ta and W were also located at the leading edge of the spacecraft. Gamma rays of individual isotopes were measured using high resolution Ge(Li) solid state detector coupled to 4096 multichannel analyzer. Activities were calculated for Co-56 (846 keV) and Co-57 (122 and 136 keV's) at the time of the entry of the spacecraft and found to be 0.014 + or - c/sec g, 0.018 + or - 0.002 c/sec g, and 0.0024 + or - 0.0007 c/sec g, respectively. (Author).
   N91-24987

2. CHILDS, C. B. "Passive particle dosimetry. Final Report, 17 Nov. 1970 - 30 Jun. 1977 silver halide crystal growth" 1977· NASA-CR-150739. 71P
   Note: North Carolina Univ., Chapel Hill Dept. of Physics and Astronomy

   Present methods of dosimetry are reviewed with emphasis on the processes using silver chloride crystals for ionizing particle dosimetry. Differences between the ability of various crystals to record ionizing particle paths are directly related to impurities in the range of a few ppm (parts per million). To understand the roles of these impurities in the process, a method for consistent production of high purity silver chloride, and silver bromide was developed which yields silver halides with detectable impurity content less than 1 ppm. This high purity silver chloride was used in growing crystals with controlled doping. Crystals were grown by both the Czochalski method and the Bridgman method, and the Bridgman grown crystals were used for the experiments discussed. The distribution coefficients of ten divalent cations were determined for the Bridgman crystals. The best dosimeters were made with silver chloride crystals containing 5 to 10 ppm of lead; other impurities tested did not produce proper dosimeters. (A.R.H.).
   N78-27965.

COMPOSITE MATERIALS

1 YOUNG, PHILIP R., SLEMP WAYNE S. "Chemical characterization of selected LDEF polymeric materials" 1991
Note: National Aeronautics and Space Administration. Langley Research Center Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 52 (SEE N91-24972) Abstract Only.

Chemical characterization of selected polymeric materials which received exposure on the Long Duration Exposure Facility (LDEF) is reported. The specimens examined include silvered fluorinated ethylene propylene Teflon thermal blanket material, polysulfone, epoxy, polyimide matrix resin/graphite fiber reinforced composites, and several high performance polymer films. These specimens came from numerous LDEF locations, and thus received different environmental exposures. The results to date show no significant change at the molecular level in the polymer that survived exposure. Scanning electron and scanning tunneling microscopes show resin loss and a texturing of some specimens which resulted in a change in optical properties. The potential effect of a silicon-containing molecular contamination on these materials is addressed. The possibility of continued post- exposure degradation of some polymeric films is also proposed. (Author).
N91-25019.

2 YOUNG, PHILIP R., SLEMP WAYNE S., WITTE, WILLIAM G., JR., (NASA, Langley Research Center Hampton, VA); SHEN, JAMES Y., (Lockheed Engineering and Sciences Co., Hampton VA). "Characterization of selected LDEF polymer matrix resin composite materials" IN: International SAMPE Symposium and Exhibition, 36th, San Diego, CA, Apr 15-18, 1991, Proceedings. Book 1 (A92- 10126) 1991 p. 403-416., 1991

The characterization of selected graphite fiber reinforced epoxy (934 and 5208) and polysulfone (P1700) matrix resin composite materials which received 5 years and 10 months of exposure to the LEO environment on the Long Duration Exposure Facility is reported. Resin loss and a decrease in mechanical performance as well as dramatic visual effects were observed. However chemical characterization including infrared, thermal, and selected solution property measurements showed that the molecular structure of the polymeric matrix had not changed significantly in response to this exposure. The potential effect of a silicon- containing molecular contamination of these specimens is addressed. (Author).
A92-10156.

3. WHITAKER, ANN F., (NASA, Marshall Space Flight Center Huntsville, AL). "Coatings could protect composites from hostile space environment" Advanced Materials and Processes (ISSN 0882- 7958), vol. 139, April 1991, p. 30-32. 1991.

An experiment has been conducted on about 100 different material/process combinations, most of which were candidates for use in solar arrays having high power-to-weight ratios. These substances were exposed to the LEO environment during Long- Duration Exposure Facility Experiment A0171 in order to evaluate the synergistic effects of the LEO environment on the materials' mechanical, electrical; and optical properties. Materials evaluated include solar cells, cover slips having antireflectance coatings, adhesives, encapsulants, reflective materials, mast and harness materials, structural composites, and thermal control thin films. About one-sixth of the experiment tray was devoted to composite-material tensile specimens, which were specifically to be studied for changes in their mechanical properties. Preliminary results of the surface-damage evaluation are presented. These surface effects are dominated by atomic-oxygen erosion and micrometeoroid/space debris impacts. (L.K.S.).
A91-32134.

4. VYHNAL, RICHARD F., WELCH, DOUGLAS W., POWELL, HOWARD J. "Evaluation of long-duration exposure to the natural space environment on graphite-polyimide and graphite-epoxy mechanical properties" , 1991.
Note: Rockwell International Corp., Tulsa, OK. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 89 (SEE N91-24972) Abstract Only.

Experiment AO175 involved passive exposure (on oblique leading and trailing faces of LDEF) of carbon-fiber reinforced laminates of epoxy, bismaleimide, and polyimide resins. Post-flight evaluation included: optical examination of exposed surfaces, panel weight and distortion measurements, ultrasonic c-scan inspection, and conventional mechanical testing of coupons machined from the panel. (Author).
N91-25056.

5. TENNYSON, R. C., MORISON, W. D., (Toronto University, Canada. "Space environmental effects on polymer matrix composite materials" IN: Composites; Proceedings of the 8th International Conference on Composite Materials (ICCM/8), Honolulu, HI, July 15-19, 1991 Section 12-21 (A92-32535). p. 16-I-1 to 16-I-14. , 1991

   Results are presented on the behavior of a variety of fiber reinforced polymer matrix composites that comprised the UTIAS experiment on the NASA-LDEF satellite. LDEF was launched in April 1984 and retrieved in January 1990, thus providing a space exposure of about 70 months. The UTIAS experiment consisted of 62 tubes, a stainless steel calibration tube, and 45 flat samples. A data acquisition system was incorporated to monitor 16 channels of strain and temperature, every 16 hours for the first year in orbit. Data is presented for several epoxy matrix composites with carbon, boron, and Kevlar reinforcements. Results to date show clearly the effect of outgassing on the dimensional changes of these materials and the corresponding coefficients of thermal expansion. In addition, the erosion of these materials due to atomic oxygen is demonstrated as a function of the orientation of the samples relative to the incident O atoms. (Author).
   A92-32656.

6. TENNYSON, R. C., MABSON, G. E., MORISON, W. D., KLEIMAN, J., (Toronto University, Downsview Canada). "LDEF mission update - Composites in space" Advanced Materials and Processes (ISSN 0882-7958), vol. 139, May 1991 p. 33-36. 1991.

   Preliminary results are presented of the NASA Long-Duration Exposure Facility (LDEF) composite-materials experiment. This experiment included samples made of epoxy-matrix composites containing boron, carbon, and aramid fibers. A custom data- acquisition system was designed and built to record the output of 16 thermal/strain gages every 16 hours for 371 days. Results of initial analyses of the composite-material samples are discussed. The thermal-model predictions are in good agreement with test data up to the initial 300 orbital days. The polymer-matrix composites outgassed for 40 to 120 days depending on the material system, and outgassing caused significant permanent dimensional changes that must be factored into the design of low-distortion laminates. Low-incident-angle atomic oxygen eroded the composite- material samples that were located about 80 deg off the ram direction. (R.E.P.)
   A91-36849.

7 TENNYSON, R. C., MABSON, G. E. "Thermal-vacuum effects on polymer matrix composite materials" 1991
   Note: Toronto Univ. (Ontario). Inst. for Aerospace Studies. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 77 (SEE N91-24972) Abstract Only.

   Results are presented on the thermal-vacuum response of a variety of fiber reinforced polymers matrix composites that comprised the UTIAS experiment on the LDEF satellite. Theoretical temperature-time predictions for this experiment are in excellent agreement with test data. Results also show quite clearly the effect of outgassing in the dimensional changes of these materials and the corresponding coefficients of thermal expansion. Finally, comparison with ground-based simulation tests are presented as well. Use of these data for design purposes are also given. (Author).
   N91-25044.

8. STECKEL, GARY L., LE, TUYEN D., (Aerospace Corp., Mechanics and Materials Technology Center El Segundo, CA). "LDEF mission update. III - Composites survive space exposure" Advanced Materials and Processes (ISSN 0882-7958), vol. 140, Aug. 1991, p. 35-38. 1991,

   Numerous specimens of both polymer and metal matrix composite materials are noted to remain in excellent condition after almost six years of LEO space environment exposure aboard NASA's Long Duration Exposure Facility The samples range over graphite fiber-reinforced Mg and Al alloys, and graphite fiber-reinforced epoxy, polysulfone, and polyimide resins, with and without. The properties of major interest in this study were the coefficients of thermal expansion, solar emittance and absorptance, specific heat, and thermal conductivity. Attention was given to the effects of micrometeoroid impact craters and atomic oxygen. (O.C.).
   A91-48675.

9. STECKEL, GARY L., LE, TUYEN D. "Experiment M0003-10: Advanced composites" , 1991
Note: Aerospace Corp., El Segundo, CA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 82 (SEE N91-24972) Abstract Only

The Advanced composites Sub-experiment includes numerous metal matrix composites, primarily graphite fiber reinforced aluminum and magnesium, and several classes of graphite fiber reinforced organic matrix (epoxy, polysulfone, polyimide) composites with and/or without thermal control or protective coatings. The experiment included over 500 flight samples, mounted on the leading and trailing edges of LDEF. and a full complement of the laboratory control samples. Preliminary results are presented reviewing changes in the visual appearance of the samples, atomic oxygen erosion of the organic matrix composites, contamination effects, and the effects of micrometeorite impacts and thermal fatigue on the metal matrix composites. (Author).
N91-25049.

10. SLEMP. WAYNE S., YOUNG, PHILIP R., WITTE, WILLIAM G. ,. JR., SHEN, JAMES Y. (Lockheed Engineering and Sciences Co., Hampton VA). "Effects of LDEF flight exposure on selected polymer matrix resin composite materials" 1991
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 86 (SEE N91-24972). Abstract Only

The characterization of selected graphite fiber reinforced epoxy and polysulfone matrix resin composites which received exposure to the LEO environment on the LDEF is reported. The changes in mechanical properties of ultimate tensile strength and tensile modulus for exposed flight specimens are compared to the three sets of control specimens. Marked changes in surface appearance are discussed, and resin loss is reported. The chemical characterization including IR, thermal, and selected solution property measurements showed that the molecular structure of the polymeric matrix had not changed significantly in response to this exposure. (Author).
N91-25053.

11 HILL, SYLVESTER G., GEORGE, PETE; CRUTCHER, E. RUSS; DURSCH, HARRY; PIPPIN, H. GARY "Results from analysis of Boeing composite specimens flown on LDEF experiment M0003." , 1991
Note: Boeing Aerospace and Electronics Co., Seattle, WA. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 83 (SEE N91-24972). Abstract Only

Specimens of three selected organic/graphite fiber composite materials were flown on both the leading and trailing edges of LDEF Additional sets of compression, tension, flexure, and lap shear specimens were flown on the trailing edge. A large T300/934 panel was flown on the leading edge. One quarter of this specimen was directly exposed to a near ram environment; each of the other three quarters were covered with a different thermal control paint. Results of mechanical, optical, and chemical analysis of the specimens are presented. Recession rates of the fiber and resin under atomic oxygen exposure were estimated and are reported. (Author).
N91-25050.

12. FELBECK, DAVID K. "High-toughness graphite/epoxy composite material experiment." , 1991
Note: Michigan Univ., Ann Arbor In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 85 (SEE N91-24972). Abstract Only

The experiment was designed to measure the effect of near-space exposure on mechanical properties of specially toughened 5208/ T300 graphite-epoxy composites. The properties measured are elastic modulus, strength, and fracture toughness. Specimens were mounted on an external frame during the time of the LDEF mission. Specimen variables include angle of adjacent plies and fraction of interlaminar contact, which is controlled by the fraction of finely spaced holes in Mylar film placed between the prepreg monolayers of the composite. (Author).
N91-25052.

13. TENNYSON, R. C., HANSEN, J. S., MABSON, G. E., MORISON, W D., KLEIMAN, J., (Toronto University, Canada. "Composite materials in space - Results from the LDEF satellite" IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings (A91-34926). Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 405-419. Research supported by CDC and Ontario Centre for Materials Research. , 1990.

Preliminary results will be presented on the behavior of a variety of fiber-reinforced polymer matrix composites that comprised the UTIAS experiment on the LDEF satellite. LDEF was launched in April 1984, and retrieved in January 1990, thus providing a space exposure of about 70 months. The UTIAS experiment consisted of a variety of epoxy-matrix composites with carbon, boron, and aramid (Kevlar) reinforcements. A data- acquisition system was incorporated to monitor 16 channels of strain and temperature every 16 hours for the first year in orbit. Results to date show clearly the effect of outgassing on the dimensional changes of these materials and the corresponding coefficients of thermal expansion. In addition, the erosion of these materials due to atomic oxygen will be demonstrated as a function of the orientation of the samples relative to the incident O atoms. Comparisons with ground-based space simulation studies will also be presented. (Author).
A91-34961

14. WITTE, WILLIAM G. "Baseline tensile tests of composite materials for LDEF (Long Duration Exposure Facility) exposure" 1987, NASA-TM-89069. 62P
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

Tensile specimens of five graphite fiber reinforced composite materials were tested at room temperature to provide baseline data for similar specimens exposed to the space environment in low-Earth orbit on the NASA Long Duration Exposure Facility. All specimens were 4-ply (+ or - 45 deg)s layups; at least five replicate specimens were tested for each parameter evaluated. Three epoxy-matrix materials and two polysulfone-matrix materials, several fiber volume fractions, and two sizes of specimen were evaluated. Stress-strain and Poisson's ratio-stress curves, ultimate stress, strain at failure, secant modulus at 0.004 strain, inplane shear stress-strain curves, and unidirectional shear modulus at .004 shear strain are presented. (Author).
N87-20386.

15. WITTE, W. G., JR. "Manual for LDEF tensile tests" , 1985; NASA-TM-87624. 40P
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

One of the experiments aboard the NASA Long Duration Exposure Facility (LDEF) consists of a tray of approximately one hundred tensile specimens of several candidate space structure composite materials. During the LDEF flight the materials will be subjected to the space environment and to possible contamination during launch and recovery. Tensile tests of representative samples were made before the LDEF flight to obtain baseline data. Similar tests will be made on control specimens stored on earth for the length of the LDEF flight and on recovered flight specimens. This manual codifies the details of testing, data acquisition, and handling used in obtaining the baseline data so that the same procedures andequipment will be used on the subsequent tests. (Author).
N86-11299.

16. TENNYSON, R C., HANSEN, J. S. "The effect of space environment exposure on the properties of polymer matrix composite materials (A0180)" 1984;
Note: Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 41-43 (SEE N84-24632).

The objective of this experiment is to determine the effect of various lengths of exposure to a space environment on the mechanical properties of selected commercial polymer matrix composite materials. Fiber materials will include graphite, boron, S-glass, and PRD-49. The mechanical properties to be investigated are orthotropic elastic constants, strength parameters (satisfying the tensor polynomial relation), coefficients of thermal expansion, impact resistance, crack propagation, and fracture toughness. In addition, the effect of laminate thickness on property changes will also be investigated. (R.J.F.).
N84-24644.

17 SLEMP, W. S. "Space exposure of composite materials for large space structures (A0134)" 1984;
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. In its Long Duration Exposure Facility (LDEF) p 24-26 (SEE N84-24632).

The objective of this experiment is to evaluate the effects of the near-Earth orbital environment on the physical and chemical properties of laminated continuous-filament composites and composites resin films for use in large space structures and advanced spacecraft. The experiment is passive and occupies about one-half of a 6-in.-deep peripheral tray. Specimens of composite materials and polymeric and resin films are arranged above and below the experiment mounting plate to enable both exposure and nonexposure to sunlight. This provides a comparison of the effects of ultraiolet plus vacuum plus thermal cycling and those of vacuum plus thermal cycling on these materials. The experiment tray is thermally isolated from the Long Duration Exposure Facility structure to allow the material specimens to experience a wide range of thermal cycles. Tensile and compression specimens will be used to evaluate the laminated composite materials. A number of the specimens are precut and ready for testing after space exposure, whereas other specimens will be prepared from larger samples. (R.J.F.).
N84-24639.

18. POWELL, J. H., WELCH, D. W. "Evaluation of long-duration exposure to the natural space environment on graphite-polyimide and graphite-epoxy mechanical properties (A0175)" 1984;
Note: Rockwell International Corp., Tulsa, Okla. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 38-40 (SEE N84-24632).

The primary objective of this experiment is to accumulate the needed operational data associated with the exposure of graphite- polyimide and graphite-epoxy material to the environments of space. The experiment will be mounted in two 3-in.-deep peripheral trays. Graphite-polyimide specimens will occupy 1 1/3 trays and the graphite-epoxy specimens will occupy two-thirds of a tray. The experiment approach requires two matched sets of specimens with traceable records that are maintained for materials processing and specimen quality. After fabrication, one set of each test specimen will be sectioned and structurally tested to serve as a data baseline. After the flight, the other set of specimens will undergo extensive measurements of mechanical properties for comparison with the original data baseline. Structural testing of the graphite-polyimide specimens will provide strength and elastic data in tension, compression, and shear. Transverse tension microcracking and crack propagation will be evaluated by photomicroscopy. Structural testing of the graphite-epoxy specimens will include verification of laminate, core, adhesive, and fatigue properties as applied to the design and analysis of the payload bay door. Microcracking and crack propagation will also be analyzed by photomicroscopy. (R.J.F.).
N84-24643.

19. PARCELIER, M. "The effect of the space environment on composite materials (A0138-9)" , 1984.
Note: Aerospatiale Etablissement des Mureaux (France). In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 32-34 (SEE N84-24632).

The objective is to test different types of materials (laminates, thermal coatings, and adhesives) to determine their actual useful lifetime. These experiments will also make is possible to integrate the histories of the thermal and mechanical characteristics into models of the composite structures. The experiment is passive and is located in one of the boxes in a 12- in.-deep peripheral tray with nine other experiments from France. The box will provide protection for the samples from contamination during the launch and reentry phases of the Long Duration Exposure Facility mission. The experiment revolves around four themes of study: thermal coatings, adhesives, dimensional stability, and mechanical characteristics. The various materials will be arranged in six levels within the box, so only the first level will be subjected to direct solar radiation. Each level will consist of plates from which test specimens will be cut after the mission. (R.J.F.)
N84-24641

20. FELBECK, D. K. "Influence of extended exposure in space on mechanical properties of high-toughness graphite-epoxy composite material (A0019)" 1984;
Note: Michigan Univ., Ann Arbor. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 19-20 (SEE N84- 24632).

Graphite-epoxy composites are promising candidates for structural use in space vehicles because of their high strength and elastic modulus properties. The problem of low fracture toughness was solved by use of recently developed techniques of intermittent interlaminar bonding. Before this material can be adapted for space use, however, confidence must be gained that its mechanical properties are not degraded by exposure to the space environment.

The objective of this experiment is to test the effect of extended exposure to a space environment on the mechanical properties of a specially toughened T300/5208 graphite-epoxy composite material. Specimens made by recently developed techniques of intermittent interlaminar bonding will be exposed and afterward tested for fracture toughness, tensile strength, and elastic modulus. The approach of this experiment is to provide a frame on which the specimens can be mounted with their flat sides normal to the Long Duration Exposure Facility radius, each specimen with an unobstructed exposure of about 2 pi sr. The specimens will be mounted so that they neither fracture from high stress nor fail from excessive heating during launch and return. (R.J.F.).
N84-24637.

21 ELBERG, R. "Effect of space exposure of some epoxy matrix composites on their thermal expansion and mechanical properties (A0138-8)" 1984;
Note: MATRA Service Aerodynamique, Le Chesnay (France). Space Div. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 27-31 (SEE N84-24632).

This experiment has three objectives. The first and main objective is to detect a possible variation in the coefficient of thermal expansion of composite samples during a 1-year exposure to the near-Earth orbital environment. A second objective is to detect a possible change in the mechanical integrity of composite products, both simple elements and honeycomb sandwich assemblies. A third objective is to compare the behavior of two epoxy resins commonly used in space structural production. The experimental approach is to passively expose samples of epoxy matrix composite materials to the space environment and to compare preflight and postflight measurements of mechanical properties. The experiment will be located in one of the three FRECOPA (French cooperative payload) boxes in a 12-in.-deep peripheral tray that contains nine other experiments from France. The FRECOPA box will protect the samples from contamination during the launch and reentry phases of the mission. The coefficients of thermal expansion are measured on Earth before and after space exposure. (R.J.F.).
N84-24640.

22. HANSEN, J. S., TENNYSON, R. C., (Toronto University, Toronto Canada). "Polymer matrix composite materials experiment to be flown on the Space Shuttle LDEF mission" COSPAR, Plenary Meeting, 21st, Innsbruck, Austria, May 29-June 10, 1978, Paper. 7 p. , 1978.

There is at present some concern regarding the capability of polymer matrix composite materials to withstand the rigors of long term exposure in space. Thus NASA has recently accepted a proposal to include a materials testing and fracture mechanics experiment on the first Long Duration Exposure Facility (LDEF) mission (presently scheduled for the first operational flight of the orbiter vehicle). LDEF is ideally suited for this type of passive space experiment as it will orbit at about 550 km, and will provide a total exposure time ranging from 6-12 months. The purpose of the experiment is to determine the effect of the space environment on the coefficient of thermal expansion, the material moduli and strength as well as on the fracture toughness. The composite systems being evaluated are graphite/epoxy, Kevlar/ epoxy, boron/epoxy and glass/epoxy. It is anticipated that the combined effects of hard vacuum, solar radiation, and large temperature variations could result in significant material degradation. For comparative purposes, tests will be conducted on the same materials in a space simulator which has been constructed specifically for this experiment. (Author).
A78-48589.

COMPUTER PROGRAMS

1 EADES, J. B. ,. JR., WOLF, H. "Program selection, modification and the demonstration of a baseline trajectory simulation for the LDEF mission" , 1975; NASA-CR-132726. 70P
Note: Analytical Mechanics Associates, Inc., Seabrook, Md.

The selection, conversion, and modification of computer programs to be used for the long duration exposure facility (LDEF) mission analysis studies is described. Selected output from these programs is illustrated and discussed. Program capabilities are demonstrated and a baseline solution typical to the LDEF orbital operation is provided. (Author).
N75-31183.

CONTAMINATION

1 HARVEY GALE A. "Organic contamination of LDEF " , 1991
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 9 (SEE N91-24972). Abstract Only.

A brown stain of varying thickness was present on most of the exterior surface of the retrieved Long Duration Exposure Facility (LDEF). Tape lifts of Earth-end LDEF surfaces taken showed that the surface particle cleanliness immediately after retrieval was very good, but faint footprints of the tape strips on the tested surfaces indicated a very faint film was removed by the tape. Solvent wipes of these surfaces showed that the stain was not amenable to standard organic solvent removal. Infrared spectra of optical windows from tray E5 show that the organic film is hydrocarbon in composition, but is not similar to the oil that seeped from tray C12. Very dark and heavy deposits of the stain is present at openings and vents to the interior of LDEF Heavy brown and blue-green deposits are present in the interior of LDEF where sunlight penetrated through cracks and vent openings. The exterior of LDEF had significant areas painted with a white polyurethane paint for thermal control, and almost all of the interior was painted with a black polyurethane paint. Brown staining is consistent with outgassing of hydrocarbons from these paints by rapid solar UV induced polymerization of the outgassed hydrocarbons when they hit sunlight exposed areas. (Author).
N91-24979.

COSMIC RAYS

1 WATTS, JOHN W. ,. JR., DERRICKSON, JAMES H.; PARNELL, T A., FISHMAN, G. J., HARMON, A., BENTON, E. V., FRANK, A. L., HEINRICH, WOLFGANG; (Siegen Univ., Germany F R.). "The ionizing radiation environment of LDEF prerecovery predictions " , 1991 Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 11 (SEE N91-24972) Abstract Only.

The Long Duration Exposure Facility (LDEF) was exposed to several sources of ionizing radiation while in orbit. The principal ones were trapped belt protons and electrons, galactic cosmic rays, and albedo particles (protons and neutrons) from the atmosphere. Large solar flares in 1989 may have caused a small contribution. Prior to the recovery of the spacecraft, a number of calculations and estimates were made to predict the radiation exposure of the spacecraft and experiments. These were made to assess whether measurable radiation effects might exist, and to plan the analysis of the large number of radiation measurements available on the LDEF. Calculations and estimates of total dose, particle fluences, linear energy transfer spectra, and induced radioactivity were made. The principal sources of radiation is described, and the preflight predictions are summarized. (Author).
N91-24980.

2. PRICE, P BUFORD. "Science requirements for Heavy Nuclei Collection (HNC) experiment on NASA Long Duration Exposure Facility (LDEF) Mission 2 Final Report" , 1991, NASA-CR-187527 77P
Note: California Univ., Berkeley.

The Heavy Nuclei Collection (HNC) is a passive array of stacks of a special glass, 14 sheets thick, that record tracks of ultraheavy cosmic rays for later readout by automated systems on Earth. The primary goal is to determine the relative abundances of both the odd- and even-Z cosmic rays with Z equal to or greater than 50 with statistics a factor at least 60 greater than obtained in HEAO-3 and to obtain charge resolution at least as good as 0.25 charge unit. The secondary goal is to search for hypothetical particles such as superheavy elements. The HNC detector array will have a cumulative collection power equivalent to flying 32 sq m of detectors in space for 4 years. The array will be flown as a free-flight spacecraft and/or attached to Space Station Freedom. (Author).
N91-23887

3. PHILLIPS, G. W., KING, S. E., AUGUST, R. A., RITTER, J. C., CUTCHIN, J. H., HASKINS, P S., MCKISSON, J. E., ELY D. W., WEISENBERGER, A. G., PIERCEY, R. B., (Mississippi State Univ., Mississippi State). "Gamma radiation survey of the LDEF spacecraft" , 1991
Note: Naval Research Lab., Washington, DC. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 12 (SEE N91-24972) Abstract Only

The retrieval of the Long Duration Exposure Facility (LDEF) spacecraft after nearly 6 years in orbit offered a unique opportunity to study the long term buildup of induced radioactivity in the variety of materials on board. The first complete gamma ray survey was conducted of a large spacecraft on LDEF shortly after its return to Earth. A surprising observation was the large Be-7 activity which was seen primarily on the leading edge of the satellite, implying that it was picked up by LDEF in orbit. This is the first known evidence for accretion of a radioactive isotope onto an orbiting spacecraft. Other isotopes seen during the survey, the strongest being Na-22 and Mn-54, are all attributed to activation of spacecraft components in orbit. Be-7 is a spallation product of cosmic rays on nitrogen and oxygen in the upper atmosphere. However, the observed density is much greater than expected due to cosmic ray production in situ. This implies transport of Be-7 from much lower altitudes up to the LDEF orbit. (Author).
N91-24981

4. O'SULLIVAN, D., THOMPSON, A., BOSCH, J., KEEGAN, R., WENZEL, K. P., SMIT, A., DOMINGO, C. (Universidad Autonoma de Barcelona, Bellaterra Spain ,.). "The LDEF ultra heavy cosmic ray experiment " , 1991
Note: Dublin Inst. for Advanced Studies (Ireland). In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 25 (SEE N91-24972) Abstract Only

The Long Duration Exposure Facility (LDEF) Ultra Heavy Cosmic Ray Experiment (UHCRE) used 16 side viewing LDEF trays giving a total geometry factor for high energy cosmic rays of 30 sq m sr. The total exposure factor was 170 sq m sr y. The experiment is based on a modular array of 192 solid state nuclear track detector stacks, mounted in sets of 4 pressure vessels (3 experiment tray). The extended duration of the LDEF mission has resulted in a greatly enhanced potential scientific yield from the UHCRE. Initial scanning results indicate that at least 2000 cosmic ray nuclei with Z greater than 65 were collected, including the world's first statistically significant sample of actinides. Postflight work to date and the current status of the experiment are reviewed. Provisional results from analysis of preflight and postflight calibrations are presented. (Author).
N91-24994.

5. KING, S. E., PHILLIPS, G. W., AUGUST, R. A., RITTER, J. C. (U.S. Navy, Naval Research Laboratory, Washington, DC); CUTCHIN, J. H., (Sachs/Freeman, Associates Landover ,. MD). "Radiation survey of the LDEF spacecraft" IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, April 1991, p. 525-530. 1991,
Note: (1990 Nuclear Science Symposium, Arlington, VA, Oct. 23- 26, 1990, Proceedings. A91-42475).

The authors report the first complete gamma-ray survey of a large spacecraft, the Long Duration Exposure Facility (LDEF). The survey was conducted using an array of germanium detectors from the U.S. Naval Research Laboratory and individual detectors from the Institute for Space Science and Technology to study the accumulation and distribution of radioisotopes induced in the wide variety of materials present on the LDEF. Na-22, Be-7, Mn- 54, and the positron annihilation line were all strongly observed. Traces of Co-56, Co-57, and Co-60 were also observed. The most striking feature of the data was the unexpected distribution of Be-7, which was predominately present on the leading surfaces of the spacecraft. The evidence clearly indicates an accretion of the Be-7 onto the surface of the LDEF. This is the first known observation of the deposition of a radioisotope onto the surface of a spacecraft. Be-7 is a spallation product of cosmic rays on nitrogen and oxygen in the upper atmosphere. To explain the surface density of 5.4 x 10 to the 5th atoms/sq cm, it must be assumed that the light Be-7 atom is transported up from lower altitudes. (I.E.).
A91-42487

6. CSIGE, I., BENTON, E. V., FRANK, A. L., FRIGO, L. A., BENTON, E. R., (San Francisco Univ., CA, PARNELL, T A., WATTS, JOHN W. , JR. "Charged particle LET-spectra measurements aboard LDEF." , 1991
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 20 (SEE N91-24972). Abstract Only.

The linear energy transfer (LET) spectra of charged particles was measured in the 5 to 250 keV/micron (water) interval with CR- 39 and in the 250 to 1000 keV/micron (water) interval with polycarbonate plastic nuclear track detectors (PNTDs) under different shielding depths in the P0006 experiment. The optimal processing conditions were determined for both PNTDs in relation to the relatively high track densities due to the long term exposure in space. The total track density was measured over the selected samples, and tracks in coincidence on the facing surfaces of two detector sheets were selected for measuring at the same position on each sheet. The Short Range (SR) and Galactic Cosmic Ray (GCR) components were measured separately. The integral dose and dose rate spectra of charged particles are also given. The high LET portion of the LET spectra was measured with high statistical accuracy. This is a unique result of this experiment due to the low flux of this type of particle under typical shielding conditions. (Author).
N91-24989.

7 BENTON, E. V , FRANK, A. L., BENTON, E. R., CSIGE, I., (San Francisco Univ., CA, PARNELL, T A., WATTS, JOHN W. , JR. "Radiation exposure of LDEF· Initial results." , 1991.
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 24 (SEE N91-24972). Abstract Only.

Initial results from Long Duration Exposure Facility (LDEF) include radiation detector measurements from four experiments; P0006, P0004, M0004, and A0015. The detectors were located on both the leading and trailing edges of the orbiter and also at the Earthside end. This allowed the directional dependence of the incoming radiation to be measured. Total absorbed doses from thermoluminescent detectors (TLDs) verified the predicted spatial east-west dosedependence of a factor of approx. 2.5, due to trapped proton anisotropy in the South Atlantic Anomaly (SAA). On the trailing edge of the orbiter, a range of doses from 664 to 291 rad were measured under nominal shielding of 0.42 to 8.45 g/ sq cm. A second set of detectors near this locations results are also given. On the leading edge, doses of 258 to 210 rad were found under shielding of 1.25 to 2.48 g/sq cm. Initial charged particle LET (linear energy transfer) spectra, fluxes, doses, and dose equivalents, for LET in H2O greater than or = 5 keV/micron, were measured with plastic nuclear track detectors located in the four experiments. Also, preliminary data on low energy neutrons were obtained from detectors containing (6)LiF foils. (Author).
N91-24993.

8. TARLE, GREGORY "Heavy Nucleus Collector (HNC) project for the NASA Long Duration Exposure Facility (LDEF)." , 1990; NASA- CR-182094. 94P
Note: Michigan Univ., Ann Arbor. Final Report.

The primary goal of the heavy nucleus collector (HNC) experiment was to obtain high resolution composition measurements for cosmic ray nuclei in the platinum-lead and actinide region of the periodic table. Secondary objectives include studies of selected groups of elements of lower charge. These goals were to be realized by orbiting a large area array of dielectric nuclear track detectors in space for several years. In this time sufficient actinide nuclei would be collected to determine the nucleosynthetic age of the cosmic radiation and the relative mix of r- and s-process elements in the cosmic ray source. The detector consists of approximately 50 trays assembled in pressurized canisters. Each tray would contain 8 half-stacks (4 stacks total) and an event thermometer which would record the temperature of each event at the time of exposure. Each stack would contain 7 layers of Rodyne-P, CR-39 and Cronar plastic track detectors interleaved with copper stripping foils. Upon return to Earth, detectors would be removed for analysis. Ultraheavy nuclei would have left tracks through the detector sheets that would be made visible after etching in a hot sodium hydroxide solution. (Author).
N90-30045.

9. O'SULLIVAN, D., THOMPSON, A., (Dublin Institute for Advanced Studies, Ireland; WENZEL, K. P., DOMINGO, V., (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands). "The ultra heavy cosmic ray experiment on LDEF-1" IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings (A86-46851). Baton Rouge, LA, Louisiana State University, 1985, p. 302-309. , 1985.

The DIAS-ESTEC ultraheavy-cosmic-ray experiment was deployed in earth orbit aboard the LDEF by the Space Shuttle on April 6, 1984. A large-area (12-sq m) solid-state nuclear-track-detector array, designed to study the charge spectrum of nuclei with Z = 30 or greater, is to remain in orbit until recovery of the LDEF by a second Shuttle mission

in March 1985. Details of the background to the experiment, its astrophysical significance, analysis, and general expectations are discussed. The impact of recent results on the registration-temperature effect for ultraheavy nuclei on overall charge resolution is assessed. (Author).
A86-46875.

10. O'SULLIVAN, D., (Dublin Institute for Advanced Studies, Dublin Ireland). "LDEF-1 and beyond ultraheavy cosmic ray experiment description" Irish Astronomical Journal (ISSN 0021- 1052), vol. 17, March 1985, p. 40-47 1985;

The cosmic-ray experiment flown on the Long Duration Exposure Facility (LDEF) launched by the Space Shuttle in April 1984 to a circular 250-n.m. 28.5-deg-inclination orbit for a 1-yr mission is characterized and illustrated with photographs, drawings, and graphs. The experiment comprises a set of 16 multiple-layer (polycarbonate/lead) nuclear-track-detector trays occupying 20 sq m of the 100-sq-m LDEF exposure area and is designed to measure the relative abundances of nuclei with Z greater than 65 in cosmic radiation and hence to investigate the processes involved in the synthesis and acceleration of cosmic rays in the Galaxy The range of heavy-nucleus cosmic-ray experiments prior to LDEF is indicated; the LDEF recovery and analysis procedures are explained; the temperature-dependence of track-detector response is discussed; and plans for a second flight of LDEF with a larger detector area (50 sq m), a 55-deg-inclination orbit, and a 2-yr exposure are outlined. (T.K.).
A85-31769.

11 FOWLER, P H., (Bristol, University England). "Ultra heavy cosmic rays" Irish Astronomical Journal (ISSN 0021-1052), vol. 17 Sept. 1985, p. 112-127 1985;

A history of the study of ultra heavy cosmic rays is presented. Data sources include balloon flights of photographic emulsions and Wilson cloud chambers, a HEAO-3 C2 Danish/French experiment, and an Ariel VI cosmic ray Cerenkov radiation detector Attention is given to cosmic ray primaries of low charge (Z not more than 28), ultra heavy nuclei with Z greater than 30, ultra heavy charge spectra (Z not more than 50), and charge spectra for Z greater than 50. It is noted that the Long Duration Exposure Facility (LDEF) at the time of preparation of the paper was still in space and collecting UH cosmic rays, yielding a harvest that should exceed by 20 times the Ariel VI and HEAO 3 total. Such a harvest could contain a significant flux of actinides. (D.H.).
A86-11860.

12 DRACH, J., PRICE, P B., SALAMON, M. H., TARLE, G., (Michigan Univ.); AHLEN, S. P., (Indiana Univ.). "Capabilities of the LDEF- 2 heavy nuclei collection" 1985.
Note: California Univ., Berkeley Dept. of Physics. In NASA. Goddard Space Flight Center 19th Intern. Cosmic Ray Conf., Vol. 2 p 131-134 (SEE N85-34006).

To take the next big step beyond High Energy Astronomy Observatory (HEAO-3) the Heavy Nuclei Collector (HNC), to be carried on an LDEF reflight, has the goals of greatly increased collecting power (30 actinides) and charge resolution sigma sub Z or = 0.25 E for Z up to approximately 100, which will provide abundances of all the charges 40 or Z or = 96 and permit sensitive searches for hypothetical particles such as monopoles, superheavy elements, and quark nuggets. (G.L.C.).
N85-34040.

13. ADAMS, J. H. ,. JR., BEAHM, L. P., STILLER, B., (M and B. Consulting Co., Washington D. C.). "The heavy ions in space experiment" 1985.
Note: Hulburt (E. O.) Center for Space Research, Washington, D.C. In NASA. Goddard Space Flight Center 19th Intern. Cosmic Ray Conf., Vol. 3 p 282-285 (SEE N85-34862).

The Heavy Ions in Space (HIIS) experiment was developed and is currently in orbit onboard the long duration facility (LDEF). The HIIS will record relativistic cosmic ray nuclei heavier than magnesium and stopping nuclei down to helium. The experiment uses plastic track detectors that have a charge resolution of 0.15 charge units at krypton and 0.10 charge units, or better, for nuclei lighter than cobalt The HIIS has a collecting power of 2 square meter steradians and it has already collected more than a year's data. (E.A.K.).
N85-34936.

14. O'SULLIVAN, D., THOMPSON, A., OCEALLAIGH, C., DOMINGO, V ESA)., WENZEL, K. P. (ESA). "A high-resolution study of ultra-heavy cosmic-ray nuclei (A0178)" 1984;
Note: Dublin Inst. for Advanced Studies (Ireland). In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 101-104 (SEE N84-24632).

The main objective of the experiment is a detailed study of the charge spectra of ultraheavy cosmic-ray nuclei from zinc (Z = 30) to uranium (Z = 92) and beyond using solid-state track detectors. Special emphasis will be placed on the relative abundances in the region Z or - 65, which is thought to be dominated by r-process nucleosynthesis. Subsidiary objectives include the study of the cosmic-ray transiron spectrum a search for the postulated long- lived superheavy (SH) nuclei (Z or = 110), such as (110) SH294, in the contemporary cosmic radiation. The motivation behind the search for super-heavy nuclei is based on predicted half-lives that are short compared to the age of the Earth but long compared to the age of cosmic rays. The detection of such nuclei would have far-reaching consequences for nuclear structure theory. The sample of ultraheavy nuclei obtained in this experiment will provide unique opportunities for many tests concerning element nucleosynthesis, cosmic-ray acceleration, and cosmic-ray propagation. (M.G.).
N84-24661

15. "Measurement of heavy cosmic-ray nuclei on LDEF (M0002-2)" 1984;
Note: Kiel Univ. (West Germany). Inst. for Pure and Applied Nuclear Physics. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 113-114 (SEE N84-24632).

The objective of this experiment is to measure the elemental and isotopic abundamces of heavy cosmic-ray nuclei with nuclear charge Z equal to or greater than 3. The chemical and energy spectra will be measured for particles that have energies in the range from 20 to 1000 MeV per atomic mass unit. Two points of great interest are geomagneticaly forbidden cosmic-ray particles and heavy ions of the trapped radiation. (Author).
N84-24664

16. O'SULLIVAN, D., THOMPSON, A., DALY, J. OCEALLAIGH, C., (Dublin Institute for Advanced Studies, Dublin Ireland)., WENZEL, K. P., DOMINGO, V., SMIT A., (ESA, Cosmic Ray Div., Noordwijk, Netherlands). "The ultra heavy cosmic ray experiment on the NASA Long Duration Exposure Facility (LDEF)" IN: International Cosmic Ray Conference, 18th, Bangalore, India, August 22-September 3, 1983, Late Papers. Volume 9 (A85-22801). Bombay, Tata Institute of Fundamental Research, 1983, p. 403-406. 1983.

A large array (about 20 sq m sr) of solid-state nuclear track detectors is being prepared for a twelve month exposure in earth orbit aboard the NASA Long Duration Exposure Facility which is scheduled to be launched by Space Shuttle in 1984. The experiment is designed to study the charge spectrum of cosmic-ray nuclei with Z greater than 30. particulary of those above Z about 70, by collecting a larger sample of events than that obtained in any previous exposure. For the first time, preflight calibration with high-energy ultra heavy nuclei, has been employed. A summary of the astrophysical significance, experimental approach, and current state of implementation of the experiment is presented. Detector development results are reported. (Author).
A85-23017

17 CEALLAIGH, C. O., DALY, J., SULLIVAN, D., THOMPSON, A., (Dublin Institute for Advanced Studies, Dublin Ireland)., DOMINGO, V., SMIT, A., WENZEL, K. P., (ESA, Cosmic Ray Div., Noordwijk, Netherlands). "The ultra heavy cosmic ray experiment on the NASA long duration exposure facility" International Cosmic Ray Conference, 18th, Bangalore, India, Aug. 22-Sept. 3, 1983, Paper. 7 p. 1983;

The experiment is designed primarily to investigate the charge spectrum of cosmic ray nuclei with Z greater than or equal to 30. This is to be done by obtaining a larger sample of events than has hitherto been possible by balloon or satellite exposures. A very large array of solid state nuclear track detectors is to be exposed in space for approximately one year. Special emphasis will be placed on the relative abundances in the region where Z is greater than or equal to 65, which is thought to be dominated by r-process nucleosynthesis. Among the subsidiary objectives of the experiment are the study of the cosmic ray transition spectrum and a search for the postulated long-lived superheavy nucley (Z greater than or equal to 110) in the contemporary cosmic radiation. It is noted that the search for super-heavy nuclei is based on predicted half-lives that are short in comparison with the age of the earth but long

in comparison with the age of cosmic rays. The far-reaching consequences for nuclear structure theory that the detection of such nuclei would have are noted. (C.R.). A84-24076

18. PRICE, P B. "Definition study for an advanced cosmic ray experiment utilizing the long duration exposure facility. Final Report, 17 Jul. 1980 - 30 Sep. 1981" , 1982; NASA-CR-165918. 56P
Note: California Univ., Berkeley. Space Sciences Lab.

To achieve the goals of cosmic ray astrophysics, an ultraheavy cosmic ray experiment on an LDEF reflight should be in an orbit with high inclination (approximately 57 deg) at approximately 230 nm for approximately 2 years near solar minimum (approximately 1986). It should fill 61 trays. Each tray should contain 4 modules of total active area 0.7 sq m, with a thermal blanket, thermal labyrinth mounts, aluminum honeycomb mechanical support, and total weight approximately 100 kg. Each module should contain interleaved CR39, Lexan, and thin copper sheets plus one event-thermometer canned in a thin metal cannister sealed with approximately 0.2 atm dry O2. The CR39 and Lexan should be manufactured to specifications and the sheet copper rolled to specifications. The event-thermometer should be a stiffened CR39 sheet that slides via bimetal strips relative to fixed CR39 sheet so that stack temperature can be read out for each event. The metal cannister can be collapsed at launch and landing, capturing the sliding assembly to prevent damage. An engineering study should be made of a prototype LDEF tray; this will include thermal and mechanical tests of detectors and the event thermometer (Author).
N82-26158.

19. O'SULLIVAN, D., (Dublin Institute for Advanced Studies, Dublin Ireland). "Some recent developments in the study of the elements and isotopes of the cosmic radiation" Vistas in Astronomy (ISSN 0083-6656), vol. 26, pt. 2, 1982, p. 87-105. 1982;

The relative abundances of the charge, mass, and energy spectra of cosmic ray nuclei, whose study has benefited considerably from advances in detector technology and the availability of high altitude balloons and earth-orbiting spacecraft, are useful indicators of the nuclear reactions that occur at their sources and also provide information on interstellar propagation processes. Attention is presently given to experiments in propagation effects, relative abundances for nuclei with Z values lower than 30, C, N, and O abundances, the cosmic ray clock function of radioactive nuclides, ultraheavy nuclei, and composition at very high energies, which have been conducted since the late 1970s. Also noted are the prospective gains in these fields which are expected upon the launching of the Long Duration Exposure Facility by the Space Shuttle in 1984. (O.C.).
A83-42161

20. LAIRD, C E. "Studies of neutron and proton nuclear activation in low-Earth orbit" , 1982.
Note: University of Eastern Kentucky, Richmond. Dept. of Physics and Astronomy. In NASA. Marshall Space Flight Center The 1982 NASA/ASEE Summer Fac. Fellowship Program 16 p (SEE N83- 17359).

The expected induced radioactivity of experimental material in low Earth orbit was studied for characteristics of activating particles such as cosmic rays, high energy Earth albedo neutrons, trapped protons, and secondary protons and neutrons. The activation cross sections for the production of long lived radioisotopes and other existing nuclear data appropriate to the study of these reactions were compiled. Computer codes which are required to calculate the expected activation of orbited materials were developed. The decreased computer code used to predict the activation of trapped protons of materials placed in the expected orbits of LDEF and Spacelab II. Techniques for unfolding the fluxes of activating particles from the measured activation of orbited materials are examined. (E.A.K.).
N83-17382.

21 ADAMS, J. H. ,. JR., SHAPIRO, M. M., SILBERBERG, R., TSAO, C. H., (U.S Navy, Laboratory for Cosmic Ray Physics, Washington, D.C.). "Fast heavy ions in the heliosphere" (COSPAR, IUPAP, IAU, IAGA, and SCOSTEP, Symposium on Cosmic Rays in the Heliosphere, Budapest, Hungary, June 2-14, 1980.) Advances in Space Research, vol. 1, no. 3, 1981, p. 169-172. 1981,

A satellite experiment intended to study the age, nature and propagation of heavy cosmic ray ions in the heliosphere is presented. The experiment, to be carried on the Long Duration Exposure Facility, is made of up eight modules each containing two stacks of plastic track detectors to be maintained at temperatures between 23 and 38 C during the

year-long exposure. Objectives of the mission include a search for medium-energy singly ionized particles predicted by a model of the anomalous component of cosmic rays, the measurement of the composition of cosmic rays heavier than iron, and a search for low-energy ions in the inner magnetosphere. (A.L.W.).
A81-36107

22 THOMPSON, A., O'SULLIVAN, D., DALY, J., OCEALLAIGH, C., (Dublin Institute for Advanced Studies, Dublin Ireland)., DOMINGO, V., SMIT, A., WENZEL, K. P., (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands). "A high resolution study of ultra heavy cosmic ray nuclei using the long duration exposure facility /LDEF/" In: International Cosmic Ray Conference, 16th, Kyoto, Japan, August 6-18, 1979, Conference Papers. Volume 11 (A81-12386) Tokyo, University of Tokyo, 1980, p. 103-108. , 1980.

A large array of nuclear track detectors is being prepared for a twelve month exposure in space aboard the LDEF which is scheduled to be launched by the NASA Space Shuttle in 1981 The experiment is designed to study the charge spectrum of cosmic ray nuclei with Z greater than 30 by obtaining a large and more uniform sample of events than has hitherto been possible by balloon or satellite exposures. A summary of the astrophysical significance of the experiment and its current state of development is given. (Author).
A81-12536.

23. HEINRICH, W., (Seigen Universitaet, Seigen West Germany). "Predicted LET-spectra of HZE-particles for the Free Flyer Biostack Experiment on the Long Duration Exposure Facility mission" In: Life sciences and space research. Volume 18 - Proceedings of the Open Meeting of the Working Group on Space Biology, Bangalore, India, May 29-June 9. 1979 (A80-50051) Oxford and Elmsford, N.Y., Pergamon Press, 1980, p. 143-152 , 1980.

The LDEF (long duration exposure facility) mission, scheduled for a launch on the Space Shuttle in 1981, will fly for about 9 months in a near-earth orbit with an inclination angle of 28 deg. In this flight the Free Flyer Biostack Experiment has the objective of measuring the biological effects of individual heavy ions from cosmic radiation (HZE particles). This paper presents results of a calculation of LET-spectra in free space and within the absorber of the experiment. The calculation considers the geomagnetic shielding of the spacecraft against charged particles with low energies and the disintegration of the heavy ions within the absorbing material by fragmentation. For this mission the LET spectra turn out to differ from those of previous experiments. The steepness of the spectra changes significantly with LET and also with depth of absorber (Author).
A80-50066.

DYNAMIC STRUCTURAL ANALYSIS

1 JONES, T. C., LUCY, M. H., SHEARER, R. L. "Long Duration Exposure Facility (LDEF) structural verification test report" , 1983; NASA-TM-85672. 73P
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

Structural load tests on the Long Duration Exposure Facility's (LDEF) primary structure were conducted. These tests had three purposes: (1) demonstrate structural adequacy of the assembled LDEF primary structure when subjected to anticipated flight loads; (2) verify analytical models and methods used in loads and stress analysis; and (3) perform tests to comply with the Space Transportation System (STS) requirements. Test loads were based on predicted limit loads which consider all flight events. Good agreement is shown between predicted and observed load, strain, and deflection data. Test data show that the LDEF structure was subjected to 1.2 times limit load to meet the STS requirements. The structural adequacy of the LDEF is demonstrated. (E.A.K.).
N83-33221

2 BERMAN, A., NAGY, E. J., (Kaman Aerospace Corp., Bloomfield CT). "Improvement of a large analytical model using test data" (Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 1, p. 301-306) AIAA Journal (ISSN 0001-1452), vol. 21, Aug. 1983, p. 1168-1173. 1983;

A83-40870.

3. BERMAN, A., NAGY, E. J., (Kaman Aerospace Corp., Bloomfield CT). "Improvement of a large dynamic analytical model using ground vibration test data" In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 1 (A82-30076) New York, American Institute of Aeronautics and Astronautics, 1982, p. 301- 306. , 1982.

A method has been developed which uses measured normal modes and natural frequencies to improve an analytical mass and stiffness matrix model of a structure. The method directly identifies, without iteration, a set of minimum changes in the analytical matrices which force the eigensolutions to agree with the test measurements. An application is presented in which the analytical model had 508 degrees of freedom and 19 modes were measured at 101 locations on the structure. The resulting changes in the model are judged to be small compared to expectations of errors in the analysis. Thus the improved model is accepted as a reasonable model of the structure with improved dynamic response characteristics. In addition, it is shown that the procedure may be a useful tool in identifying apparent measured modes which are not true normal modes of the structures. ((Author)).
A82-30108.

4. IBRAHIM, S. R., (Old Dominion University, Norfolk Va)., PAPPA, R. S. (NASA, Langley Research Center, Structural Dynamics Branch, Hampton, Va.). "Large modal survey testing using the Ibrahim time domain /ITD/ identification technique" In: Structures, Structural Dynamics and Materials Conference, 22nd, Atlanta, Ga., April 6-8, 1981, and AIAA Dynamics Specialists Conference, Atlanta, Ga., April 9, 10, 1981, Technical Papers. Part 2. (A81-29428) New York, American Institute of Aeronautics and Astronautics, Inc., 1981, p. 173-186. 1981.

The ability of the ITD identification algorithm in identifying a complete set of structural modal parameters using a large number of free-response time histories simultaneously in one analysis, assuming a math model with a high number of degrees-of-freedom, has been studied. Identification results using simulated free responses of a uniform rectangular plate, with 225 measurement stations, and experimental responses from a ground vibration test of the Long Duration Exposure Facility (LDEF) Space Shuttle payload, with 142 measurement stations, are presented. As many as 300 degrees-of-freedom were allowed in analyzing these data. In general, the use of a significantly oversized math model in the identification process was found to maintain or increase identification accuracy and to identify modes of low response level that are not identified with smaller math model sizes. The concept of a Mode Shape Correlation Constant is introduced for use when more than one identification analysis of the same structure are conducted. This constant quantifies the degree of correlation between any two sets of complex mode shapes identified using different excitation conditions, different user- selectable algorithm constants, or overlapping sets of measurements. ((Author)).
A81-29449.

5. EDIGHOFFER, H. H., (NASA, Langley Research Center, Hampton, Va., General, Electric Co , Fairfield, Conn.); SEWALL, J. L., (NASA, Langley Research Center, Hampton, Va.). "SPAR analysis of LDEF vibration characteristics finite element computer code for Long Duration Exposure Facility structural dynamic modeling" Computers and Structures, vol. 13, Aug. 1981, p. 489-496. 1981.

This paper presents a structural dynamic modeling of the Long Duration Exposure Facility (LDEF), which is a Space Shuttle payload of passive scientific experiments contained in trays mounted on a large cylindrically shaped structure. Special detailed finite element modeling, using the SPAR system of computer programs was required to obtain good agreement between analytical and test vibrations modes. Experimental trays contributed significantly to overall LDEF stiffnesses, and these contributions were realistically represented for each tray by the stiffness matrix of an equivalent orthotropic panel in the overall LDEF SPAR model. Orthotropic stiffnesses for this panel were obtained from finely detailed statically loaded tray SPAR models in which stiffness coupling was accounted for along with partial relative sliding allowed by the tray clamping attachments. Joint boundary conditions were also significant in the structural dynamic modeling of LDEF, and static data proved valuable in assessing modeling of local end fittings. ((Author)).
A81-36624.

ELECTRO-OPTICS

1 CLARK, L. G., DIBATTISTA, J. D., (NASA, Langley Research Center. Hampton, Va.). "Space qualification of optical instruments using the NASA Long-Duration Exposure Facility" In: Optics in adverse environments; Proceedings of the Seminar, San Diego, Calif., August 25, 26, 1977 (A79-12037) Bellingham, Wash., Society of Photo-Optical Instrumentation Engineers, 1978, p. 11-18. , 1978.

The NASA Long-Duration Exposure Facility (LDEF), designed for the in situ testing of optical instrumentation in the space environment is described. The LDEF is basically a reusable structure which is three-axis gravity-gradient stabilized when flying free in space. The structure weighs about 8,000 lbs. and accommodates experiment trays weighing about 10,000 lbs. A vacuum exposure control canister is being designed for controlled exposure experiments. The LDEF will have an experiment power and data system and a shuttle bay environmental measurements system is being designed for measuring parameters such as acoustics, vibration, acceleration. The induced environment contamination monitor will evaluate the contamination levels of shuttle payloads. Experiments currently under development include the evaluation of active optical components and the study of fiber optic data transmission. (S.C.S.).
A79-12039.

EXPERIMENT DESIGN

1 BUECKER, H., HORNECK, G., REITZ, G., (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Institut fuer Flugmedizin, Bonn, West Germany). "The Biostack experiment in the U.S. long exposure duration test program " DFVLR-Nachrichten, June 1979, p. 23-25. In German. 1979;

The Free Flyer Biostack is a biological experiment proposed for the Long Duration Exposure Facility and is intended to study the effects of cosmic rays on biological objects. This paper describes the basic details of the Free Flyer Biostack experiment and gives some attention to possible (i.e., somatic and genetic) effects of cosmic rays in a space environment. (B.J.).
A79-41230.

2 HAYN, D. STEINBERGER, H. "Suggested experiments for momentum-free G-simulation using the Long Duration Exposure Facility (LDEF)." 1978; TUM-LRT-KB-77/18. 18P
Note: Technische Univ., Munich (West Germany). Lehrstuhl fuer Raumfahrttechnik. In German

An experiment is proposed which represents a torque-free simulation of the acceleration values 1 g, 1/3 g and 0 g. These are generated by two contrarotating cylindrical disks. The apparatus will fit in an experiment tray, and will be activated after the unloading of the carrier from the space shuttle.
N80-23360.

3. SHEPPARD, A. P., WOOD, J. M. "Experiment definition using the space laboratory, long duration exposure facility, and space transportation system shuttle. Final Report" , 1976; NASA-CR- 146658. 74p.
Note: Georgia Inst. of Tech., Atlanta.

Candidate experiments designed for the space shuttle transportation system and the long duration exposure facility are summarized. The data format covers: experiment title, Experimenter, technical abstract, benefits/justification, technical discussion of experiment approach and objectives, related work and experience, experiment facts space properties used, environmental constraints, shielding requirements, if any, physical description, and sketch of major elements. Information was also included on experiment hardware, research required to develop experiment, special requirements, cost estimate, safety considerations, and interactions with spacecraft and other experiments. (Author).
N76-20171.

4. FEATHERSTON, F. H., (Universities Space Research Association, Charlottesville Va). "University-generated space experiments for the long duration exposure facility" , 1976; AIAA-Paper-76-782. Note: American Institute of

Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, Calif., Aug. 18-20, 1976, 7 p.

The significance of the Long Duration Exposure Facility (LDEF) and the functions and objectives of the Universities Space Research Association (USRA) are considered. USRA sponsored experiments are to be conducted with the aid of LDEF mission payloads. The LDEF will use a 12-sided cylinder The space missions will take full advantage of the capabilities inherent in the Shuttle system design. (G.R.).
A76-43087

5. DIBATTISTA, J. D. (NASA, Langley Research Center Hampton, Va.). "The Long Duration Exposure Facility - A shuttle transported low cost technology experiment carrier" , 1975; AAS-75-269.
Note: AAS, AIAA, IEEE, ORSA, and IMS, Meeting on Space Shuttle Missions of the 80's, Denver, Colo., Aug. 26-28, 1975, AAS 21 p.

The Long Duration Exposure Facility (LDEF) is a passive spacecraft capable of remaining in space for extended periods. Its primary role is to accommodate advanced spacecraft technology experiments. The LDEF is space-shuttle delivered and retrieved. With retrieval, it offers unique opportunities to study, in ground-based laboratories, results from a wide variety of experiments after exposure in space. ((Author)).
A76-12892.

FIBER OPTICS

1 JOHNSTON, A. R., BERGMAN, L. A., (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA); TAYLOR, E. W., (USAF. Weapons Laboratory ,. Albuquerque, NM). "Fiber optic experiment for the Shuttle long-duration exposure facility" In: Fiber optics in adverse environments; Proceedings of the Seminar. San Diego, CA, August 25-27, 1981 (A83-22475) Bellingham, WA, SPIE - The International Society for Optical Engineering, 1982, p. 125-133. 1982.

The present investigation is concerned with an active fiber- optic data transmission experiment which has been under development for a planned orbital exposure on the Shuttle Long Duration Exposure Facility (LDEF) and subsequent recovery for laboratory evaluation. The LDEF is a space shuttle payload which is designed to carry a large number of independent tray-mounted experiments into low earth orbit for exposure to the space environment. The LDEF is then to be recovered by a later shuttle flight for postflight examination. Data is stored on a tape recorder within the experiment tray; no telemetry is provided. A description is given of two independent experiment trays which are being prepared. The experiments are to be conducted to gain experience in the design of a complete fiber link for the space environment and to confirm that the effects of the critical environments in space, in particular particle radiation and temperature extremes, are not detrimental to satisfactory link operation. (G.R.).
A83-22491

GROUND OPERATIONAL SUPPORT SYSTEM

1 MARKS, D. A., GENDIELLEE, R. E., KELLY T M., GIOVANNELLO, M. A. "Operations planning simulation model extension study. Volume 1 Long duration exposure facility ST-01-A automated payload Final Report" 1974; NASA-CR-120710. 89P
Note: Grumman Aerospace Corp., Bethpage, N.Y Product Support Dept.

Ground processing and operation activities for selected automated and sortie payloads are evaluated. Functional flow activities are expanded to identify payload launch site facility and support requirements. Payload definitions are analyzed from the launch site ground processing viewpoint and then processed through the expanded functional flow activities. The requirements generated from the evaluation are compared with those contained in the data sheets. The following payloads were included in the evaluation: Long Duration Exposure Facility; Life Sciences Shuttle Laboratory; Biomedical Experiments Scientific Satellite; Dedicated Solar Sortie Mission; Magnetic Spectrometer; and Mariner

Jupiter Orbiter The expanded functional flow activities and descriptions for the automated and sortie payloads at the launch site are presented. (J.M.S.).
N75-20432.

HEAT PIPES

1 TILLER, SMITH E., SULLIVAN, DAVID "Long Duration Exposure Facility (LDEF) low-temperature Heat Pipe Experiment Package (HEPP) power system results" 1991
Note: National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 126 (SEE N91-24972) Abstract Only

An overview of a self contained Direct Energy Transfer (DET) Power System which was developed to provide power to the Long Duration Exposure Facility (LDEF) Heat Pipe Experiment Package (HEPP) Experiment. A brief synopsis of the flight characteristics of the power system are presented to illustrate the system's capability to function successfully in alow Earth orbit (LEO) space environment. The successful space flight operations of the battery, solar arrays, and power system electronics during the flight period of almost six years (approximately 32,000 LEO cycles) are discussed. (Author).
N91-25092.

2. SHULAR, DAVID. "Long Duration Exposure Facility: Transverse flat plate heat pipe" , 1991
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 101 (SEE N91-24972) Abstract Only

The Transverse Flat Plate Heat Pipe is a thermal control device that serves the dual function of temperature control and mounting base for electronic equipment. In it's ultimate application, the heat pipe would be a lightweight structural member that could be configured in a platform or enclosure, and provide temperature control for large space structures, flight experiments, and equipment. The purpose of this experiment is to evaluate the zero-G performance of several heat pipe modules. Performance assessment includes: (1) the systems heat transport capability; (2) temperature drop between evaporator and condensor; and (3) the ability to maintain temperature over varying duty cycles and environments. (Author).
N91-25067

3. MCINTOSH, ROY; BRENNAN, PATRICK J., (OAO Corp., Greenbelt MD). "Long Duration Exposure Facility (LDEF) Low-temperature Heat Pipe Experiment Package (HEPP)" , 1991
Note: National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 99 (SEE N91-24972). Abstract Only

The flight test results are discussed obtained with the Heat Pipe Experiment Package (HEPP). The HEPP was designed to demonstrate the performance of an ethane constant conductance heat pipe (CCHP) and an ethane heat pipe diode in microgravity. These heat pipes have a nominal operating temperature range of 140 to 250 K. Also, included in the HEPP is a Phase Change Material (PCM) canister which provides temperature stability through melting and freezing of the n-heptane PCM. A comparison of pre-flight, flight, and post-flight thermal performance is also presented. (Author).
N91-25065.

4. GROTE, MICHAEL G., (McDonnell-Douglas Electronics Systems Co., Laser and Electronic, Systems Div., Saint Louis, MO). "Results from the cascaded variable conductance heatpipe experiment on LDEF" 1991; AIAA-Paper-91-1356.
Note: AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 9 p.

A variable conductance heatpipe experiment (CVCHPE) was successfully flown on the Long Duration Exposure Experiment (LDEF) and demonstrated temperature control better than +/- 0.3 C during 50 days of on-orbit data collection in a widely varying external environment. The experiment used two series connected, dry reservoir variable conductance heatpipes which require no electrical power for operation. The heatpipes used a central artery design

with ammonia working fluid and nitrogen control gas. The LDEF was in orbit for almost six years, and posttest data indicated that the set point drifted upward less than 1 C per year There were significant changes to the appearance of all external thermal control surfaces primarily due to atomic oxygen degradation. These changes, though, had little effect on the CVCHPE performance. (Author)
A91-43422

5. GROTE, MICHAEL G. "Results from the cascaded variable conductance heatpipe experiment on LDEF " , 1991
Note: McDonnell-Douglas Electronics Co., Saint Louis, MO Laser and Electronic Systems Div In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 100 (SEE N91-24972). Abstract Only

A Variable Conductance Heat Pipe Experiment (CVCHPE) was successfully flown onboard the LDEF and demonstrated temperature control better than +/- 0.3 C during 50 days of on-orbit data collection in a widely varying external environment. The experiment used two series connected, dry reservoir variable conductance heat pipes which require no electrical power for operation. The heat pipes used a central artery design with ammonia working fluid and nitrogen control gas. (Author).
N91-25066.

6. OWEN, J. W., EDELSTEIN, F., (Grumman Aerospace Corp.). "Transverse flat-plate heat pipe experiment (S1005)" 1984;
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 74-77 (SEE N84- 24632).

The objective of this experiment is to evaluate the zero-g performance of a number of transverse flat plate heat pipe modules. Performance will include the transport capability of the pipes, the temperature drop, and the ability to maintain temperature over varying duty cycles and environments. Additionally, performance degradation, if any, will be monitored over the length of the Long Duration Exposure Facility (LDEF) mission. This information is necessary if heat pipes are to be considered for system designs where they offer benefits not available with other thermal control techniques. (M.G.).
N84-24653.

7 MCINTOSH, R. JR; OLLENDORF, S., MCCREIGHT C. R., (NASA, Ames Research Center). "Low-temperature heat pipe experiment package (HEPP) for LDEF (S1001)" 1984;
Note: National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 70-73 (SEE N84- 24632).

The principal objectives of the experiment are to determine zero-g start-up performance for conventional and diode low temperature heat pipes, to evaluate heat pipe performance in zero-g for an extended period of time, to determine zero-g transport capability of each heat pipe, and to determine diode operation, including forward conductance, turndown ratio, and transient behavior Two heat pipes, a fixed conductance transporter heat pipe and a thermal diode heat pipe, are coupled with a radiant cooler system. Both pipes are charged with ethane. Also integrated with the radiator is a phase change material (PCM) canister which provides temperature stability during transport tests. N-heptane, which has a melting/freezing point of 182 K, is used as the PCM. The high heat capacity (28 W-hr of latent heat) provided by the canister permits high power heat pipe testing at constant temperature. (M.G.).
N84-24652.

8. GROTE, M. G., CALHOUN, L. D. ,. II. "Cascade variable- conductance heat pipe (A0076)" 1984;
Note: McDonnell-Douglas Astronautics Co., St. Louis, Mo. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 66-69 (SEE N84-24632).

The objective is to verify the capability of a cascade variable conductance heat pipe (CVCHP) system to provide precise temperature control of long life spacecraft without the need for a feedback heater or other power sources for temperature adjustment under conditions of widely varying power input and ambient environment. Solar energy is the heat source and space the heat sink for thermally loading two series connected variable conductance heat pipes. Electronics and power supply equipment requirements are minimal. A 7.5 V lithium battery supplies the power for thermistor type temperature sensors for monitoring system performance, and a 28 V lithium battery supplies power for valve actuation. (M.G.). N84-24651

9. COLLICOTT, H. E., (Boeing Co., Seattle WA)., BAUER, P E., (McDonnell Douglas Astronautics Co., St Louis , MO). "Spacecraft thermal control, design, and operation" New York, American Institute of Aeronautics and Astronautics (Progress in Astronautics and Aeronautics. Volume 86), 1983, 371 p. 1983;

Requirements and challenges concerning military spacecraft thermal management are considered along with a Shuttle Orbiter thermal control postflight evaluation, the orbital test satellite thermal experience after 3 1/2 years in orbit, the thermal design and experiment thermal integration of the long duration exposure facility, and satellite thermal design and analyses for expendable and Shuttle launch environments. Topics related to subsystem and components are discussed, taking into account the thermo-mechanical design and analysis system for a 76-in. parabolic antenna reflector, the thermodynamic optimization of a cryogenic storage system for minimum boiloff, and a molecular absorption cryogenic cooler for liquid hydrogen propulsion system. Subjects concerned with material properties and interfaces are explored along with finite-element analysis techniques. A description of heat pipes is also provided, giving attention to osmotic pumped heat pipes for large space platforms, the development of a double-wall artery high-capacity heat pipe, and the Marangoni effect. No individual items are abstracted in this volume (G.R.).
A84-10224.

10. CALHOUN, L. D., GROTE, M. G., (McDonnell Douglas Astronautics Co., St Louis , MO). "The cascaded variable conductance heat pipe experiment for LDEF Long Duration Exposure Facility" 1981, AIAA-Paper-81-1157
Note: American Institute of Aeronautics and Astronautics, Thermophysics Conference, 16th, Palo Alto, CA, June 23-25, 1981 9 p.

A Cascaded Variable Conductance Heat Pipe (CVCHP) has been assembled to demonstrate vapor temperature control within a 0.6 deg C band (23.6 deg C + or - 0.3 deg C) for nine months in actual space flight conditions. Temperature control will be maintained for heat inputs from 5 to 32 watts and a range of effective space temperatures using no electrical power. Solar energy will be used to generate heat inputs. The cascaded system consists of two series connected dry reservoir variable conductance heat pipes. Previous short term ground tests have demonstrated the desired control capability of this system. The experiment will be flown on NASA Langley Research Center's Long Duration Exposure Facility (LDEF) currently planned for launch in January 1984. ((Author)).
A81-39142.

11 TILLER, S. E. "The LDEF heat pipe experiment power systems" , 1980.
Note: National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md. In its The 1979 Goddard Space Flight Center Battery Workshop p 277-284 (SEE N80-20820).

A heatpipe experiment for a long duration exposure facility is described. The design and configuration of the power system of the spacecraft is reported with emphasis placed on its solar array panels, 12-ampere hour 18-cell nickel battery, and its electronic controller. (R.C.T.).
N80-20843.

12 ROBINSON, G. A. , JR., (NASA, Marshall Space Flight Center Huntsville, Ala.). "LDEF transverse flat plate heat pipe experiment /S1005/ Long Duration Exposure Facility" 1979; AIAA-Paper-79-1077
Note: American Institute of Aeronautics and Astronautics, Thermophysics Conference, 14th, Orlando, Fla., June 4-6, 1979, 7 p.

The paper describes the Transverse Flat Plate Heat Pipe Experiment. A transverse flat plate heat pipe is a thermal control device that serves the dual function of temperature control and mounting base for electronic equipment. In its ultimate application, the pipe would be a lightweight structure member that could be configured in a platform or enclosure and provide temperature control for large space structures, flight experiments, equipment, etc. The objective of the LDEF flight experiment is to evaluate the zero-g performance of a number of transverse flat plate heat pipe modules. Performance will include: (1) the pipes transport capability, (2) temperature drop, and (3) ability to maintain temperature over varying duty cycles and environments. Performance degradation, if any, will be monitored over the length of the LDEF mission. This information is necessary if heat pipes are to be considered for system designs where

they offer benefits not available with other thermal control techniques, such as minimum weight penalty, long- life heat pipe/structural members. ((Author)).
A79-38053.

13. SUELAU, H. J. BRENNAN, P. J., (B & K Engineering, Inc Towson Md.); MCINTOSH, R., (NASA, Goddard Space Flight Center, Systems Div., Greenbelt, Md.). "HEPP - A low temperature Heat Pipe Experiment Package developed for flight on-board the Long Duration Exposure Facility /LDEF/" In: International Heat Pipe Conference, 3rd, Palo Alto, Calif., May 22-24, 1978, Technical Papers. (A78-35576) New York, American Institute of Aeronautics and Astronautics, Inc., 1978, p. 418-425. 1978.

The Heat Pipe Experiment Package (HEPP) is designed to provide a flight evaluation system for low temperature heat pipes. The HEPP will be flown aboard the Long Duration Exposure Facility which will be launched and retrieved as part of the Space Shuttle program. The experiment contains two heat pipes: an axially grooved fixed conductance heat pipe and a liquid blockage thermal diode. A phase change material canister is also integrated with a radiant cooler system. Additional hardware consists of supporting electrical equipment, including electronics for signal conditioning and command functions, a data recorder, and a hermetically sealed battery which powers the experiment. A thermal model was developed to simulate the behavior of the HEPP and a ground test program was conducted to verify the predicted performance of the equipment. ((Author)).
A78-35634.

14. OLLENDORF, S., (NASA, Goddard Space Flight Center Greenbelt, Md.). "Heat pipes in space and on earth" In: International Heat Pipe Conference, 3rd, Palo Alto, Calif., May 22-24, 1978, Technical Papers. (A78-35576) New York, American Institute of Aeronautics and Astronautics, Inc., 1978, p. 312-315. 1978.

The performance of heat pipes used in the thermal control system of spacecraft such as OAO-III and ATS-6 is discussed, and aplications of heat pipes to permafrost stabilization on the Alaska Pipeline and to heat recovery systems are described. Particular attention is given to the ATS-6, launched in 1974, which employs 55 heat pipes to carry solar and internal power loads to radiator surfaces. In addition, experiments involving radiative cooling based on cryogenic heat pipes have been planned for the Long Duration Exposure Facility spacecraft and for Spacelab. The role of heat pipes in Space Shuttle heat rejection services is also mentioned. (J.M.B.).
A78-35619.

15. "Development of cryogenic thermal control heat pipes Final Report of stainless steels" , 1978; NASA-CR-152302. 40P
Note: B & K Engineering Inc., Towson, Md.

The development of thermal control heat pipes that are applicable to the low temperature to cryogenic range was investigated. A previous effort demonstrated that stainless steel axially grooved tubing which met performance requirements could be fabricated. Three heat pipe designs utilizing stainless steel axially grooved tubing were fabricated and tested. One is a liquid trap diode heat pipe which conforms to the configuration and performance requirements of the Heat Pipe Experiment Package (HEPP). The HEPP is scheduled for flight aboard the Long Duration Flight Exposure Facility (LDEF). Another is a thermal switch heat pipe which is designed to permit energy transfer at the cooler of the two identical legs. The third thermal component is a hybrid variable conductance heat pipe (VCHP). The design incorporates both a conventional VCHP system and a liquid trap diode. The design, fabrication and thermal testing of these heat pipes is described. The demonstrated heat pipe behavior including start- up, forward mode transport, recovery after evaporator dry-out, diode performance and variable conductance control are discussed. (F.O.S.).
N79-30499.

16. KROLICZEK, E. J. "Definition of a cryogenic heat pipe experiment LANDSAT C, ATS-F, Tiros-N, and LDEF experiments" 1976.
Note: B & K Engineering, Inc., Towson, Md. In ESA Heat Pipes p 673-682 (SEE N76-32374).

The planning of a flight experiment to verify the performance of cryogenic heat pipes in a zero-g space environment is described. A number of spacecraft were investigated as potential flight opportunities for the Cryogenic Heat Pipe Experiment including ATS-F, LANDSAT 3, and LDEF (Long Duration Exposure Facility). An experiment is being

prepared for the Tiros-N satellite. Experiment package designs together with anticipated results and typical mission profiles required to meet experiment objectives were developed for each spacecraft. Limitations imposed by the spacecraft and its orbit were identified and evaluated. The major design features of each experiment package, including location on the spacecraft, size, weight, temperature, and power profiles, are summarized. (ESA)
N76-32432

HEAVY IONS

1 BEAUJEAN, R., JONATHAL, D., ENGE, W (Kiel Universitaet, Federal Republic of Germany). "Heavy ion measurement on LDEF" (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273- 1177), vol. 12, no. 2-3, 1992, p. 359-362. 1992;

A stack of CR-39 track detectors was exposed on the NASA satellite LDEF and recovered after almost 6 years in space. The quick look analysis yielded heavy ion tracks on a background of low energy secondaries from proton interactions. The detected heavy ions show a steep energy spectrum which indicates a radiation belt origin. (Author).
A92-20919.

2. BEAUJEAN, R., JONATHAL, D., ENGE, W "Heavy ion measurement on LDEF " 1991
Note: Kiel Univ (Germany, F.R.). Inst. fuer Reine und Angewandtd Kernphysik. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 27 (SEE N91-249729) Abstract Only

The Kiel Long Duration Exposure Facility (LDEF) experiment M0002, mounted on experiment tray E6, was designed to measure the heavy ion environment by means of CR-39 plastic solid state track detectors. The detector stack with a size of 40x34x4.5 cu cm was exposed in vacuum covered by thermal protection foils with a total thickness of approx. 14 mg/sq cm. After etching small samples of the detector foils tracks with Z greater than or = 6 could be easily detected on a background of small etch pits, which were probably produced by secondaries from proton interactions. The LDEF orientation with respect to the magnetic field lines within the South Atlantic Anomaly (SAA) is expected to be constant during the mission. Therefore, the azimuth angle distribution was measured on the detector foils for low energy stopping particles. All detected arrival directions are close to a plane perpendicular to the magnetic field line of -20 deg declination and -40 deg inclination at location 34 deg W and 27 deg S. Together with the steep energy spectrum, this spatial distribution close to the mirror plane in the SAA is an evidence that heavy ions were detected from a radiation belt population. (Author).
N91-24996.

3. ADAMS, J. H. ,. JR., SLBERBERG, R., TSAO, C. H. "Heavy ions in space (M0001)" 1984;
Note: Naval Research Lab., Washington, D. C. Lab. for Cosmic Ray Physics. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 105-108 (SEE N84-24632).

The ojectives are to investigate three components of heavy nuclei in space: (1) a recently observed anomalous component of low-energy nuclei of N, O, and Ne, (2) the heavy nuclei in the Van Allen radiation belts; and (3) the UH nuclei (Z 30) of the galactic radiation. The study of the anomalous flux of N, O, and Ne nuclei in the unexplored energy region above 100 MeV/u is expected to provide new insights into the source of this component. Its observation in this experiment will confirm that these ions are singly charged. Knowledge of the energy spectra of the heavy nuclei observed in the Van Allen belts is expected to enhance the understanding of the origin of the belts (e.g., injection and local acceleration pocesses). The observation of these heavy ions could show, for the first time, that low-energy particles of extraterrestrial origin can diffuse to the innermost parts of the magnetosphere. Measurements of the UH component are expected to contribute information concerning its source, interstellar propagation, and the galactic storage time. (M.G.)
N84-24662.

IONIZING RADIATION

1 PARNELL, T A. "Summary of ionizing radiation analysis on the Long Duration Exposure Facility" 1991
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 28 (SEE N91-24972) Abstract Only

The Ionizing Radiation Special Investigation Group (IRSIG) for the Long Duration Exposure Facility (LDEF) was established to perform radiation measurements and analysis not planned in the original experiments, and to assure availability of LDEF analysis results in a form useful to future missions. The IRSIG has organized extensive induced radioactivity measurements throughout LDEF and a comprehensive program to compare the LDEF radiation measurements to values calculated using environment models. The activities and present status of the Group is described. The ionizing radiation results presented is summarized. (Author).
N91-24997

2 BENTON, E. V., HEINRICH, W., (Siegen Univ., Germany F R.), eds. "Ionizing radiation exposure of LDEF" 1990; NASA-CR- 189536, 66P
Note: San Francisco Univ., CA.

The Long Duration Exposure Facility (LDEF) was launched into orbit by the Space Shuttle 'Challenger' mission 41C on 6 April 1984 and was deployed on 8 April 1984. The original altitude of the circular orbit was 258.5 nautical miles (479 km) with the orbital inclination being 28.5 degrees. The 21,500 lb NASA Langley Research Center atellite, having dimensions of some 30x14 ft was one of the largest payloads ever deployed by the Space Shuttle. LDEF carried 57 major experiments and remained in orbit five years and nine months (completing 32,422 orbits). It was retrieved by the Shuttle 'Columbia' on January 11, 1990. By that time, the LDEF orbit had decayed to the altitude of 175 nm (324 km). The experiments were mounted around the periphery of the LDEF on 86 trays and involved the representation of more than 200 investigators, 33 private companies, 21 universities, seven NASA centers, nine Department of Defense laboratories and eight foreign countries. The experiments covered a wide range of disciplines including basic science, electronics, optics, materials, structures, power and propulsion. The data contained in the LDEF mission represents an invaluable asset and one which is not likely to be duplicated in the foreseeable future. The data and the subsequent knowledge which will evolve from the analysis of the LDEF experiments will have a very important bearing on the design and construction of the Space Station Freedom and indeed on other long-term, near-earth orbital space missions. A list of the LDEF experiments according to experiment category and sponsor is given, as well as a list of experiments containing radiation detectors on LDEF including the LDEF experiment number, the title of the experiment, the principal investigator, and the type of radiation detectors carried by the specific experiment. (Author).
N92-18023.

3. ARMSTRONG, TONY W., COLBORN, B. L. "Scoping estimates of the LDEF satellite induced radioactivity " , 1990; NASA-CR-184074, 60P
Note: Science Applications International Corp., Prospect, TN. Final Technical Report.

The Long Duration Exposure Facility (LDEF) satellite was recovered after almost six years in space. It was well-instrumented with ionizing radiation dosimeters, including thermoluminescent dosimeters, plastic nuclear track detectors, and a variety of metal foil samples for measuring nuclear activation products. The extensive LDEF radiation measurements provide the type of radiation environments and effects data needed to evaluate and help resolve uncertainties in present radiation models and calculational methods. A calculational program was established to aid in LDEF data interpretation and to utilize LDEF data for assessing the accuracy of current models. A summary of the calculational approach is presented. The purpose of the reported calculations is to obtain a general indication of: (1) the importance of different space radiation sources (trapped, galactic, and albedo protons, and albedo neutrons); (2) the importance of secondary particles; and (3) the spatial dependence of the radiation environments and effects expected within the spacecraft. The calculational method uses the High Energy Transport Code (HETC) to estimate the importance of different sources and secondary particles in terms of fluence, absorbed dose in tissue and silicon, and induced radioactivity as a function of depth in aluminum. (Y.S.).
N91-16056.

LITHIUM SULFUR BATTERIES

1 REID, MARGARET A. "Impedances of Li/SO2 cells retrieved from the Long Duration Exposure Facility (LDEF satellite) and comparison with cells stored terrestrially" 1991 NASA-TM- 104526, 9P
Note: National Aeronautics and Space Administration, Lewis Research Center, Cleveland, OH.

Impedances were measured on several Li/SO2 cells retrieved from the Long Duration Exposure Facility (LDEF) satellite. These cells were used to power instruments and recorders and had all been partially or fully discharged. Impedances were also measured on several cells that were stored in cold storage since manufacture. Unfortunately, none of the cells stored terrestrially had undergone any discharge, whereas all of the cells on the satellite were at least partially discharged early in the mission and then remained on orbit for about 5 years further. It has been observed by others that storage of an Li/SO2 cell after partial discharge, increases the resistance and thickness of the passive film on the Li electrode, as indicated by an increase in the time for recovery of voltage when a load is applied (voltage lag), or in some cases by an inability of a cell to sustain a normal current after such storage. Since the cells stored terrestrially were not discharged in the same manner as the LDEF cells, a direct comparison cannot be made. Thus, the effects of the space environment cannot be separated from the effects of storage after partial discharge. It is believed that the increases in impedance in the LDEF cells are largely due to the storage upon partial discharge rather than the effects of the space environment. (Author).
N92-13484.

2 JUVINALL, G. L. "NASA lithium cell applications" , 1978.
Note: Jet Propulsion Lab., California Inst. of Tech., Pasadena. In NASA. Goddard Space Flight Center 11th Ann. Battery Workshop p 395-410 (SEE N79-28669).

The advantages of lithium systems are described and a general summary of their application in present and future NASA programs is presented. Benefits of the lithium systems include an increased payload weight and an increased cost effectiveness to the customer. This also allows for more flexibility in the design of future space transportation systems. (R.E.S.).
N79-28706.

3. BENE, J. "Lithium cell tests at Langley Research Center for the long duration exposure facility" , 1977
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. In NASA. Goddard Space Flight Center The 1977 Goddard Space Flight Center Battery Workshop p 565-580 (SEE N79-21565).

The long duration exposure facility mission places temperature requirements of from -30 F to +150 F on the batteries to be used. A hermetically sealed lithium sulfur dioxide cell was tested to predict what the temperature of the battery would be over a given spectrum of temperatures of operation. Near the end of cell discharge, as the voltage started colapsing, a very high heat output rise due to chemical reaction took place. However, if the cells were thermally insulated, they vented, ignited, and burned if an attempt was made to discharge them all the way. The cells do not go into reversal. It was determined that the root of the problem was probably the chemical reaction between the lithium and the acetonitrite solvent. A redesigned cell is discussed as well as some alternates. (A.R.H.).
N79-21615.

LONG DURATION EXPOSURE FACILITY

1 MAAG, CARL R., JONES, THOMAS M., RAO, SHANKAR M., LINDER, W. KELLY; (Space Systems Div. AFSC Field Office, Houston TX). "A comparison of shuttle vernier engine plume contamination with CONTAM 3.4 code predictions" 1992.
Note: Science Applications International Corp., Glendora, CA. In NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 p 789 (SEE N92-22324) Abstract Only.

In 1985, using the CONTAM 3.2 code, it was predicted that the shuttle Primary Reaction Control System (PRCS) and Vernier Reaction Control System (VRCS) engines could be potential contamination sources to sensitive surfaces located within the shuttle payload bay. Spaceflight test data on these engines is quite limited. Shuttle mission STS-32, the Long Duration Exposure Facility retrieval mission, was instrumented with an experiment that provided the design engineer with evidence that contaminant species from the VRCS engines can enter the payload bay. More recently, the most recent version of the analysis code, CONTAM 3.4, has re-examined the contamination potential of these engines. (Author).
N92-22384.

2 KUSSMAUL, MICHAEL, (Sverdrup Technology Inc., Brook Park OH.); MIRTICH, MICHAEL J., CURREN, ARTHUR. "Ion beam treatment of potential space materials at the NASA Lewis Research Center" , 1992; NASA-TM-105398. 17P
Note: National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH. Presented at the Surface Modification of Metals by Ion Beams, Washington, DC, 15-19 Jul. 1991; sponsored by the Naval Research Lab.

Ion source systems in different configurations, have been used to generate unique morphologies for several NASA space applications. The discharge chamber of a 30 cm ion source was successfully used to texture potential space radiator materials for the purpose of obtaining values of thermal emittance greater than 0.85 at 700 and 900 K. High absorptance surfaces were obtained using ion beam seed texturing, for space radiator materials that were flown on the Long Duration Exposure Facility (LDEF) for 5.8 years in space. An ion source discharge chamber was also used to develop electrode surfaces with suppressed secondary electron emission characteristics for use in collectors in microwave amplifier traveling wave tubes. This was accomplished by sputtering textured carbon onto copper as well as texturing copper using tantalum and molybdenum as sacrificial texture inducing seeding materials. In a third configuration, a dual ion beam system was used to generate high transmittance diamondlike carbon (DLC) films. (Author).
N92-21548.

3. JOHNSON, CHRIS; THALLER, LARRY; BITTNER, HARLIN; DELIGIANNIS, FRANK; TILLER, SMITH; SULLIVAN, DAVID; BENE, JAMES; (SAFT America, Inc Cockeysville ,. MD.). "Summary of LDEF battery analyses" , 1992.
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In its The 1991 NASA Aerospace Battery Workshop p 125-132.

Tests and analyses of NiCd, LiSO2, and LiCf batteries flown on the Long Duration Exposure Facility (LDEF) includes results from NASA, Aerospace, and commercial labs. The LiSO2 cells illustrate six-year degradation of internal components acceptable for space applications, with up to 85 percent battery capacity remaining on discharge of some returned cells. LiCf batteries completed their mission, but lost any remaining capacity due to internal degradation. Returned NiCd batteries tested an GSFC showed slight case distortion due to pressure build up, but were functioning as designed. (Author).
N92-22746.

4 BRAGG, BOBBY J., BOURLAND, DEBORAH S., MERRY, GLENN; PUTT, RON; (MetalAir, Technology Systems International, Inc., Atlanta, GA.). "Primary zinc-air batteries for space power" , 1992.
Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX. In NASA. Marshall Space Flight Center, The 1991 NASA Aerospace Battery Workshop p 151-184 (SEE N92-22740).

Prismatic HR and LC cells and batteries were built and tested, and they performed well with respect to the program goals of high capacity and high rate capability at specific energies. The HR batteries suffered reduced utilizations owing to dryout at the 2 and 3 A rates for the 50 C tests owing to the requirement for forced convection. The LC batteries suffered reduced utilizations under all conditions owing to the chimney effect at 1 G, although this effect would not occur at 0 G. An empirical model was developed which accurately predicted utilizations and average voltages for single cells, although thermal effects encountered during battery testing caused significant deviations, both positive and negative, from the model. Based on the encouraging results of the test program, we believe that the zinc-air primary battery of a flat, stackable configuration can serve as a high performance and safe power source for a range of space applications. (Author).
N92-22748.

5. WINN, WILLARD G. "Gamma ray spectrometry of LDEF samples at SRS" , 1991
Note: Westinghouse Savannah River Co., Aiken, SC. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 19 (SEE N91-24972) Abstract Only

A total of 31 samples from Long Duration Exposure Facility (LDEF), including materials of Al, V, and steel trunnions were analyzed by ultralow level gamma spectrometry. The study quantified particle induced activations of Na-22, Sc-46, Cr-51, Mn-54, Co-56, Co-57, Co-58, and Co-60. The samples of trunnion sections exhibited increasing activity toward the outer end of the trunnion and decreasing activity toward its radial center. The trunnion sections did not include an end piece that collects noticeable Be-7 on its leading surface. No significant Be-7 was detected in the samples analyzed. The most sensitive analyses were performed with a 90 pct. efficient HPGe gamma ray detector which is enclosed in a purged active/passive active shield. (Author).
N91-24988.

6. SPEAR, STEVE; DURSCH, HARRY "LDEF mechanical systems" 1991
Note: Boeing Aerospace and Electronics Co., Seattle, WA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 120 (SEE N91-24972) Abstract Only

Following the Long Duration Exposure Facility (LDEF), the Systems Special Investigation Group (SIG) was involved in a considerable amount of testing of mechanical hardware flown on the LDEF. The primary objectives were to determine the effects of the long term exposure on: (1) mechanisms employed both on the LDEF or as part of individual experiments; (2) structural components; and (3) fasteners. Results of testing the following LDEF hardware are presented: LDEF structure, fasteners, trunnions, end support beam, environment exposure control cannisters, motors, and lubricants. A limited discussion of PI test results is included. The lessons learned are discussed along with the future activities of the System SIG. (Author).
N91-25086.

7 SMITH, ALAN R., HURLEY DONNA L. "Radioactivities of Long Duration Exposure Facility (LDEF) materials: Baggage and bonanzas" 1991
Note: California Univ., Berkeley. Lawrence Berkeley Lab. In NASA, Langley Research Center. First LDEF Post-Retrieval Symposium Abstracts p 15 (SEE N91-24972) Abstract Only

Radioactivities in materials onboard the returned Long Duration Exposure Facility (LDEF) satellite were studied by a variety of techniques. Among the most powerful is low background Ge semiconductor detector gamma ray spectrometry. The observed radioactivities are of two origins: those radionuclides produced by nuclear reactions with the radiation field in orbit and radionuclides present initially as contaminants in materials used for construction of the spacecraft and experimental assemblies. In the first category are experiment related monitor foils and tomato seeds, and such spacecraft materials as Al, stainless steel, and Ti. In the second category are Al, Be, Ti, Va, and some special glasses. Consider that measured peak-area count rates from both categories range from a high value of about 1 count per minute down to less than 0.001 count per minute. Successful measurement of count rates toward the low end of this range can be achieved only through low background techniques, such as used to obtain the results presented here. (Author).
N91-24984.

8. PREUSS, LUDWIG. "Long Duration Exposure Facility (LDEF) results" 1991
Note: Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Space Communications and Propulsion Div. In NASA, Langley Research Center. First LDEF Post-Retrieval Symposium Abstracts p 97 (SEE N91-24972) Abstract Only

Thermal control coatings, solar cells, and micrometeoroid capture cells were flown on the LDEF-Experiment S1002 to investigate the behavior of these components under space conditions and to collect micrometeoroids and debris. The experiment and the components to be investigated are described. The visual inspections, electrical and thermooptical measurements as well as chemical and metallurgical investigations conducted on the complete experiment as well as on single components are described, analyzed and discussed. (Author).
N91-25063.

9 PERRY ARTHUR T "Retrievable Payload Carrier (RPC): Next generation Long Duration Exposure Facility" 1991
Note: American Space Technology, Inc., Santa Monica, CA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 132 (SEE N91-24972). Abstract Only

The Retrievable Payload Carrier (RPC) is described which is a multi-experiment, free-flyer spacecraft being privately developed to make in-space experimentation more accessible and economically feasible for research and development organizations. The carrier concept was derived from NASA's highly successful and flight proven Long Duration Exposure Facility (LDEF). The LDEF capabilities were enhanced to meet new customer requirements. This reusable payload carrier is planned for launch and retrieval by the space shuttle on a regular basis. The RPC's compact design facilitates flexible manifesting of the shuttle cargo bay space, thereby, permitting timely launches and retrievals. The vehicle is designed so that either the entire carrier can be retrieved from orbit, or individual experiment pallets can be removed and replaced in orbit. This gives customers even greater control over their experiment recoveries. A fully operational RPC System consists of: (1) a carrier spacecraft; (2) a ground control station for communication with customer payloads and the carrier; (3) a ground processing facility to provide refurbishment, final checkout, and integration of customer payloads and the carrier; and (4) the personnel required to support both the development and operation phases of the program. Customer payloads will fly 6 to 18 month missions, or longer, as required. Spreading launch, operations, and retrieval costs over multiple experimental payloads results in minimized customer costs. The RPC Program's initial objective is to operate a simple carrier system which meets basic customer service needs. (Author).
N91-25097

10. MASON, JAMES B., DURSCH, HARRY· EDELMAN, JOEL, (Long Duration Exposure Facility Newsletter, Silver Spring ,. MD.). "Systems special investigation group overview" , 1991
Note: National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 118 (SEE N91-24972). Abstract Only

The Systems Special Investigation Group (SIG) has undertaken investigations in the four major engineering disciplines represented in the Long Duration Exposure Facility (LDEF) hardware: electrical, mechanical, thermal, and optical systems. Testing was planned for the highest possible level of assembly, and top level system tests for nearly all systems were performed at this time. To date, testing was performed on a mix of LDEF and individual experimenter systems. No electrical or mechanical system level failures attributed to the spaceflight environment have yet been detected. Some low cost electrical components were used successfully, although relays were a continuing problem. Mechanical galling was observed unexpectedly, but no evidence of cold welding was identified yet. A working index of observed systems anomalies was created and will be used to support the tracking and resolution of these effects. The LDEF hardware currently available to the Systems SIG includes most of the LDEF systems hardware, and some significant experimenter hardware as well. A series of work packages was developed for each of several subsystem types where further testing is of critical interest. The System SIG is distributing a regular newsletter to the greater LDEF community in order to maintain coherence in an investigation which is widely scattered both in subject matter and in geography. Circulation of this informal document has quadrupled in its first year. (Author).
N91-25084.

11 LEVINE, ARLENE S. ,. comp. "First LDEF Post-Retrieval Symposium abstracts" 1991 NASA-CP-10072.
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. Symposium held in Kissimmee, FL, 2-8 Jun. 1991

The LDE facility was designed to better understand the environments of space and the effects of prolonged exposure in these environments on future spacecraft. The symposium abstracts presented here are organized according to the symposium agenda into five sessions. The first session provides an overview of the LDEF, the experiments, the mission, and the natural and induced environments the spacecraft and experiments encountered during the mission. The second session presents results to date from studies to better define the environments of near-Earth space. The third session addresses studies of the effects of the space environments on spacecraft materials. The fourth session addresses studies of the effects of the space environments on spacecraft systems. And the fifth session addresses other subjects such as results of the LDEF life science and crystal growth experiments. For individual titles, see N91-24973 through N91-25098. N91-24972.

12 LERNER, ERIC J. "Bringing back a long look at space" Aerospace America (ISSN 0740-722X), vol. 29, Aug. 1991 p. 28-31 1991

The delayed return of the Long Duration Exposure Facility (LDEF) satellite, designed to study in depth the LEO environment and its effects on systems, space materials, and organisms is reviewed. The plants, materials, and microorganisms on board LDEF got through six years in good shape, including a variety of plant seeds that were exposed on the outside of the LDEF still having 40-50 percent germination rates when returned to earth. Two puzzling features were the discovery of some mysterious heavy ion cosmic rays and, possibly, the main component of interplanetary dust in the solar system. Many graphite composite materials, optical components, and whole systems ranging from solid rockets to fiber optic devices survived their six years in space without any major degradation in function. (R.E.P.).
A91-47878.

13. KINARD, WILLIAM H. (NASA, Langley Research Center Hampton, VA); O'NEAL, ROBERT L., (Lockheed Engineering and Sciences Co., Hampton VA) "Long Duration Exposure Facility (LDEF) results" 1991, AIAA-Paper-91-0096. Note: AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7- 10, 1991 11 p.

This paper presents an overview of the initial observations of the Long Duration Exposure Facility and the 57 onboard experiments which were retrieved from space on January 12, 1990, during the Space Shuttle STS Mission 32. The facility and the 57 science, technology, and applications experiments had remained in space for almost 6 years. The initial and the continuing observations of this retrieved hardware have provided, and will continue to provide for a number of years in the future, a wealth of basic science data on the environments of near-earth space and a unique opportunity to observe and study long duration synergistic effects of these space environments on a large array of typical spacecraft materials and systems. (Author).
A91-21367

14 COLBORN, B. L., ARMSTRONG, T. W. "LDEF geometry/mass model for radiation analyses." , 1991
Note: Science Applications International Corp., Prospect, TN. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 23 (SEE N91-249729). Abstract Only.

A 3-D geometry/mass model of Long Duration Exposure Facility (LDEF) was generated to aid in the interpretation of ionizing radiation experiments relative to the influence of varying shielding distributions around the dosimetry, and to allow more definitive calculations and comparisons with the measured data. This model takes into account the major individual structural members of the LDEF spacecraft, the mass in each experiment tray, and, for selected tras containing ionizing radiation dosimetry, major parts within the tray are modeled. The geometry/mass model, together with a ray tracing algorithms, was programmed for use both as a stand alone code in determining 3-D shielding distributions at dosimetry locations, and as a geometry module that can be interfaced with radiation transport codes. (Author).
N91-24992

15. "Systems special investigation group" . 1991, NASA-CR- 187355. 196P
Note: Boeing Co., Seattle, WA. Long Duration Exposure Facility. Interim Report.

An interim report concerning the Long Duration Exposure Facility (LDEF) is presented by a Boeing Systems special investigation group (SIG). The SIG activities were divided into five engineering disciplines: electrical, mechanical, optics, thermal, and batteries/solar cells. The responsibilities of the SIG included the following areas: support de-integration at Kennedy Space Center (KSC); testing of hardware at Boeing; review of principal investigator (PI) test plans and test results; support of test activities at PI labs; and collation of all test results into the SIG database. (D.R.D.).
N92-17728.

16. "Abstracts for the 54th Annual Meeting of the Meteoritical Society; Abstracts Only" , 1991, NASA-CR-188934.
Note: Lunar and Planetary Inst., Houston, TX Meeting held in Monterey, CA, 21-26 Jul. 1991

Abstracts of the papers presented at 54th Annual Meeting of the Meteoritic Society are compiled. The following subject areas are covered: Antarctic meteorites; nebula and parent body processing; primary and secondary SNC parent planet processes; enstatite chondrites and aubrites; achondrite stew; refractory inclusions; meteorite exposure ages and sizes; interstellar/ meteorite connections; lunar origins, processes and meteorites; craters, cratering and tektites; cretaceous-tertiary impact(s); IDPs (LDEF stratosphere, Greenland and Antarctica); chondrules; and chondrites. For individual titles, see N92-12902 through N92-12932.
N92-12901

17. WEHRLE, VICTOR A., ED., (Canadian Space Agency, Ottawa Canada). "CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov 19-21, 1990, Proceedings" Ottawa, Canadian Aeronautics and Space Institute, 1990, 521 p. In English and French. For individual items see A91-34927 to A91-34969. 1990.

The present conference on the developing status and future prospects of astronautics technologies discusses space commercialization in the 1990s, the Canadian Solar Sail Project, cooperative control of multiple space manipulators, a neural- network paradigm for robotic control, in situ lunar oxygen extraction, photovoltaic power for a lunar base, Radarsat payload technologies, and the development of an educational infrastructure for the study of outer space. Also discussed are spacecraft thermal design and verification, noncontact modal measurement in large space structure testing, a robotic vision system for the evolutionary MSS, the Limb imaging spectrograph for airglow, the remote sensing of temperature and composition in the middle atmosphere, the LDEF satellite's results on composite materials in space, a large and flexible Radarsat SAR antenna, and a Ku-band antenna design for the M-Sat mission. (O.C.).
A91-34926.

18. STEVENSON, TIM; (Kent University, Canterbury England). "LDEF comes home" Space (ISSN 0267-954X), vol. 6, Mar -Apr 1990, p. 8-10, 12. 1990;

The Space Shuttle STS-32 mission is discussed, including retrieval of the Long Duration Exposure Facility (LDEF) and the repair and reorbiting of the Solar Maximum Mission spacecraft. The use of the Remote Manipulator System to retrieve the LDEF and the process of placing the LDEF in the payload bay are examined. Consideration is given to the experiments included on the LDEF, including studies of atomic oxygen erosion and micrometeoroid/ space debris impact. (R.B.).
A90-29680.

19. STEVENSON, TIM; (Kent University, Canterbury England). "LDEF comes home" Aerospace Composites and Materials (ISSN 0954- 5832), vol. 2, May-June 1990, p. 8-10, 13. 1990;

This paper describes the Long Duration Exposure Facility (LDEF), the technological studies carried out on the LDEF mission, and the retrieval of LDEF The LDEF, which, in particular, provided a platform for the exposure of conventional and innovative aerospace materials, is a twelve-sided structure with flat ends, with each of these sides carrying six trays comprising one or more experiments, and more trays at the two ends. The technological studies included the exposure of thermal control surfaces, structural materials, dielectrics, holographic data storage crystals, fiber optics materials, advanced solar cells, balloon materials, filters, optics, detectors, advanced heat pipes, a study of crystal growth, and several million plant seeds. The retrieval, which was successfully carried by the the STS-32 mission, is described in detail. (I.S.).
A90-36671

20. RUFFA, GREGORY HESS, RONALD; DOBYNS, ALAN; FISCHER, NORMAN; HALL, CHARLES. "Space sciences and astronomy" Aerospace America (ISSN 0740-722X), vol. 28, Dec. 1990, p. 10-78. 1990;

A review of space sciences missions and their contributions to astronomy over the course of 1990 is presented. It is noted that the Shuttle Orbiter Columbia recovered the Long Duration Exposure facility, Japan undertook the first lunar mission in 14 years with the launch of the Muses-A on an M3S-2 booster, Voyager 1 transmitted over 60 images to create a mosaic with the sun, Venus, earth, Jupiter, Saturn, Uranus, and Neptune from the edge of the solar system.

The first launch of a payload employing a three-stage Pegasus rocket was also successfully conducted. Also mentioned are the launch of the joint American-German-British spacecraft Rosat, the first commercial Atlas I launch which carred the Combined Release of Radiation Experiment, and the injection of Magellan into the desired orbit around Venus to conduct the synthetic-aperture radar mapping of the planet's surface. The launch of the ESA Ulysses and flybys of Jupiter by Galileo are also mentioned, together with the problems of the Hubble Space Telescope. (L.K.S.).
A91-16560.

21 LITTLE, S. A., (NASA, Space Station Freedom Program Office, Reston, VA); KINARD, W. H., (NASA, Langley Research Center Hampton, VA); WHITESIDE, J. B., (Grumman Corporate Research Center, Bethpage NY). "The role of the Long Duration Exposure Facility in the design of the Space Station Freedom" 1990; IAF-Paper-90-080.
Note: IAF International Astronautical Congress, 41st, Dresden, Federal Republic of Germany. Oct. 6-12, 1990. 6 p.

The Long Duration Exposure Facility (LDEF) satellite retrieved this year by the U.S. Space Shuttle offers spacecraft designers an unprecedented opportunity to examine synergistic, long-term space environmental effects on systems and materials. This paper discusses the strategy for data development and the role its implementation will play in the design of the Space Station Freedom. Examples are provided from three key areas (environments definition, protection of external surfaces, and verification of system components) to illustrate LDEF's potential contribution. (Author).
A91-13786.

22 DREHER, P. E., LYONS, A. T "Long-term orbital lifetime predictions" 1990; NASA-TP-3058. 26P
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

Long-term orbital lifetime predictions are analyzed. Predictions were made for three satellites: the Solar Max Mission (SMM), the Long Duration Exposure Facility (LDEF), and the Pegasus Boiler Plate (BP). A technique is discussed for determining an appropriate ballistic coefficient to use in the lifetime prediction. The orbital decay rate should be monitored regularly. Ballistic coefficient updates should be done whenever there is a significant change in the actual decay rate or in the solar activity prediction. (Author).
N91-10092.

23. BADHWAR, GAUTAM D., (NASA, Johnson Space Center, Houston, TX). "Exospheric temperatures during solar cycle 22" Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 38, July-Sept. 1990, p. 369-375. 1990;

An analysis is conducted of the orbital decay of the Long Duration Exposure Facility (LDEF) satellite in order to develop an empirical model of the solar radio flux at 10.7 cm and of the exospheric temperature driving current atmospheric-density models at high radio fluxes. The Jacchia-Lineberry (1982) atmospheric model is used to fit a set of orbit semimajor axis observations to a predicted set whose only free variable was the exospheric temperature. A comparison of the exospheric temperatures with those predicted by the Jacchia (1977) model indicates increasing divergences above 1100 K, suggesting needed modifications to the model. (O.C.).
A91-10404.

24. "STS-32 mission report" Spaceflight (ISSN 0038-6340), vol. 32, March 1990, p. 88-95. 1990;

A summary is made of the principal accomplishments of STS-32. Most notable is the successful retrieval of the Long Duration Exposure Facility and loading into the payload bay, breaking the record for the largest Shuttle landing weight. Other achievements included the successful deployment of the last Syncom IV satellite and numerous experiments which benefitted from the mission's extended duration. A description of the crew's achievements from launch to landing almost eleven days later is presented. (R.E.P.).
A90-25493.

25 "Sixty-nine months in space: A history of the first LDEF (Long Duration Exposure Facility)" 1990; NASA-NP-149. 15P
Note National Aeronautics and Space Administration, Washington, DC. Original contains color illustrations

The LDEF project is summarized from its conception, through its deployment, to the return of the experiments. A LDEF chronology and a fact sheet is included. The experiments carried more than 10,000 specimens to gather scientific data and to test the effects of long term space exposure on spacecraft materials, components, and systems. Results will be invaluable for the design of future spacecraft such as Space Station Freedom. (Author).
N92-19727

26. SMITH, E A., WARD, D. T., SCHMITT M. W., PHENNEGER, M. C., (Computer Sciences Corp., Silver Spring ,. MD.); VAUGHN, F J., LUPISELLA, M. L. "Lifetime predictions for the Solar Maximum Mission (SMM) and San Marco spacecraft" , 1989.
Note: National Aeronautics and Space Administration. Goddard Space Flight Center Greenbelt, MD. In its Flight Mechanics/ Estimation Theory Symposium, 1989 p 459-476 (SEE N90-13413)

Lifetime prediction techniques developed by the Goddard Space Flight Center (GSFC) Flight Dynamics Division (FDD) are described. These techniques were developed to predict the Solar Maximum Mission (SMM) spacecraft orbit, which is decaying due to atmospheric drag, with reentry predicted to occur before the end of 1989. Lifetime predictions were also performed for the Long Duration Exposure Facility (LDEF), which was deployed on the 1984 SMM repair mission and is scheduled for retrieval on another Space Transportation System (STS) mission later this year Concepts used in the lifetime predictions were tested on the San Marco spacecraft, which reentered the Earth's atmosphere on December 6, 1988. Ephemerides predicting the orbit evolution of the San Marco spacecraft until reentry were generated over the final 90 days of the mission when the altitude was less than 380 kilometers. The errors in the predicted ephemerides are due to errors in the prediction of atmospheric density variations over the lifetime of the satellite. To model the time dependence of the atmospheric densities, predictions of the solar flux at the 10.7-centimeter wavelength were used in conjunction with Harris- Priester (HP) atmospheric density tables. Orbital state vectors, together with the spacecraft mass and area, are used as input to the Goddard Trajectory Determination System (GTDS). Propagations proceed in monthly segments, with the nominal atmospheric drag model scaled for each month according to the predicted monthly average value of F10.7 Calibration propagations are performed over a period of known orbital decay to obtain the effective ballistic coefficient. Progagations using plus or minus 2 sigma solar flux predictions are also generated to estimate the despersion in expected reentry dates. Definitive orbits are compared with these predictions as time expases. As updated vectors are received, these are also propagated to reentryto continually update the lifetime predictions. (Author).
N90-13440.

27 "Syncom 4 deploy, LDEF retrieval highlight 10-day Columbia flight" , 1989; NASA-NEWS-RELEASE-89-180. 32P
Note: National Aeronautics and Space Administration, Washington, DC.

The objectives of Space Shuttle Mission STS-32 are described along with major flight activities, prelaunch and launch operations, trajectory sequence of events, and landing and post- landing operations. The primary objectives of STS-32 are the deployment of a Navy synchronous communications satellite (Syncom 4) and the retrieval of the Long Duration Exposure Facility (LDEF) launched from the Challenger in April 1984. Secondary STS- 32 payloads include a protein crystal growth experiment, the Fluids Experiment Apparatus (FEA) for the investigation of microgravity materials processing, the Mesoscale Lighting Experiment, the Latitude-Longitude Locator Experiment, the Americal Flight Echocardiograph, and an experiment to investigate neurospora circadian rhythms in a microgravity environment. (M.G.).
N90-13448.

28. LEVINE, JACK. "Flight projects overview" 1988.
Note: National Aeronautics and Space Administration, Washington, D.C. In its Technology for Future NASA Missions: Civil Space Technology Initiative (CSTI) and Pathfinder p 357-377 (SEE N89-11760).

Information is given in viewgraph form on the activities of the Flight Projects Division of NASA's Office of Aeronautics and Space Technology. Information is given on space research and technology strategy, current space flight experiments, the Long Duration Exposure Facility, the Orbiter Experiment Program, the Lidar In-Space Technology

Experiment, the Ion Auxiliary Propulsion System, the Arcjet Flight Experiment, the Telerobotic Intelligent Interface Flight Experiment, the Cryogenic Fluid Management Flight Experiment, the Industry/University In-Space Flight Experiments, and the Aeroassist Flight Experiment. (R.J.F.).
N89-11777

29. DERYDER, L. (NASA, Langley Research Center Hampton, VA); KELLY, G. M., HECK, M., (Analytical Mechanics Associates, Inc Hampton ,. VA). "Orbit lifetime characteristics for Space Station" 1988; AIAA-Paper-88-2490.
Note: IN: AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988, Technical Papers (A88-31376). Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 187-195.

The factors that influence the orbital lifetime characteristics of the NASA Space Station are discussed. These include altitude, attitude, launch date, ballistic coefficient, and the presence of large articulating solar arrays. Examples from previous program systems studies are presented that illustrate how each factor affects Station orbit lifetime. The effect of atmospheric density models on orbit lifetime predictions is addressed along with the uncertainty of these predictions using current trajectory analysis of the Long Duration Exposure Facility spacecraft. Finally, nominal reboost altitude profiles and fuel requirement considerations are presented for implementing a reboost strategy based on planned Shuttle Orbiter rendezvous strategy and contingency considerations. (C.D.).
A88-31399.

30. BOUDREAULT RICHARD; (Canadian Astronautics, Ltd Ottawa , Canada). "Economics and rationale for material processing using free-flying platforms" IN: Commercial opportunities in space; Symposium, Taipei, Republic of China, Apr 19-24, 1987, Technical Papers (A89-26376). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 161-176. Research supported by Canadian Astronautics, Ltd. , 1988.

The use of space platforms for the production of materials in a microgravity production is reviewed. The platforms considered include the Space Shuttle, the Space Station, and existing unmanned free-flying platforms. The economics of each type of platform is summarized and the minimum breakeven price for products is discussed in terms of production volume, initial investment, and space platforms. This cost is compared to the price of the different materials. It is concluded that the free- flying platform provides the most economically viable microgravity environment. (R.B.).
A89-26386.

31 POWELL, JOEL W., (Space Information Canada, Calgary. "The Space Test Programme - An update" British Interplanetary Society. Journal (ISSN 0007-084X), vol. 40, Nov. 1987, p. 513- 518. 1987;

The Space Test Program (STP) is a USAF R&D effort, established in 1967, which has accomplished 48 missions in its 20-year history. Attention is presently given to the 15 payloads launched in the 1981-1987 period; these encompass add-on STP payloads on USAF Agena-boosted reconnaissance satellite launches, the 'Teal Ruby' experiment demonstrating IR detection of subsonic aircraft from orbit, the Auroral Imaging Remote Sensor, the P78-1 astrophysical satellite (destroyed by an experimental USAF ASAT weapon in 1985), the Combined Release and Radiation Effects Satellite, and the Solar Activity Measurement Experiment. (O.C.).
A88-20068.

32 DAHL, FERDINAND. "The role of the DFVLR project management life sciences in the space program of the Federal Republic of Germany" , 1987
Note: Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). In its Proceedings and Program Draft in Gravitational Biology in the Federal Republic of Germany (DFVLR-Mitt-85-16) p 10-16 (SEE N88-15363) Transl. into from Gravitationsbiologie in der Bundesrepublik Deutschland- Vortraege und ein Programmentwurf, DFVLR, Cologne, Rept. DFVLR- MITT-85-16, Oct. 1985 p 9-20.

The West German space program in cooperation with ESA and NASA is focused on the Spacelab 1 mission, on the Eureca mission, the Long Duration Exposure Facility, the International Microgravity Laboratory, Spacelab D2 mission, as well as on bioracks, European Radiation Assembly and Human Physiology Laboratory. Experiments are carried out in radiobiology, exobiology, physiology, botany, microbiology, rhythmic processes, and biotechnology. The DFVLR

project management and the experiment/project selection procedure by the scientific advisory committees are presented. (ESA).
N88-15364.

33. ANDERSON, E C., (Lockheed Electronics Co. Inc Information Engineering Div , Plainfield, NJ). "Lockheed tape recorders in space exploration" Lockheed Horizons (ISSN 0459-6773), Dec. 1987 p. 2-11 1987.

Tape recorders for capturing and storing the excess data collected by spacecraft instruments are discussed. Gaps as small as 10 millionths of an inch, with the recorders operating within a range of one to 100 inches/second with four to eight tracks on quarter-inch tape and nine to 16 tracks on half-inch tape, are described. Advances such as negator springs helping to provide constant torque to ensure smooth tape motion, ball bearings keeping rotating elements in precise alignment with minimum friction, introduction of high-purity vacuum melt steel, and bearing spacers matched to within 50 millionths of an inch, are discussed. The tape recorders for the Long Duration Exposure Facility are analyzed. (A.S.).
A88-26417

34. MURRAY ROBERT C., (PRC Kentron, Inc Hampton ,. Va.); WALSH, ROBERT F., KINARD, WILLIAM H. "A precision, thermally-activated driver for space application" , 1986.
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. In NASA. Lewis Research Center The 20th Aerospace Mechanics Symposium p 231-239 (SEE N87-16321)

A space qualified, precision, large force, thermally-activated driver that has been developed jointly by the NASA Langley Research Center and PRC Kentron is described. The driver consists of a sealed hydraulic cylinder containing a metal bellows, a bellows plug, a coil spring, a spring retainer, and output shaft, a shaft guide, and a quantity of silicone oil. Temperature changes cause the silicone oil to expand or contract thus contracting or expanding the bellows/spring assembly thereby extending or retracting the output shaft. (Author).
N87-16337

35 SCHOONHOVEN, C. B. "The space station and human productivity: An agenda for research" 1985.
Note: San Jose State Univ., Calif. Dept. of Organization and Management. In NASA. Johnson (Lyndon B.) Space Center R and D Productivity: New Challenges for the US Space Program p 352-367 (SEE N86-15157).

Organizational problems in permanent organizations in outer space were analyzed. The environment of space provides substantial opportunities for organizational research. Questions about how to organize professional workers in a technologically complex setting with novel dangers and uncertainties present in the immediate environment are examined. It is suggested that knowledge from organization theory/behavior is an underutilized resource in the U.S. space program. A U.S. space station will be operable by the mid-1990's. Organizational issues will take on increasing importance, because a space station requires the long term organization of human and robotic work in the isolated and confined environment of outer space. When an organizational analysis of the space station is undertaken, there are research implications at multiple levels of analysis: for the individual, small group, organizational, and environmental levels of analysis. The research relevant to organization theory and behavior is reviewed. (E.A.K.).
N86-15188.

36. JONES, JAMES L., (NASA, Langley Research Center, Hampton, VA). "Continual LDEF program" IN: Space Station: Gateway to space manufacturing; Proceedings of the Conference, Orlando, FL, Nov. 7, 8, 1985 (A87-25451). Arlington, VA, Pasha Publications, 1985, 34 p. , 1985.

The long-duration-exposure-facility (LDEF) experiment underway as of November 1985 is presented in drawings, diagrams, photographs, and tables and briefly characterized. The 57 LDEF experiments include studies of diffusion crystal growth; photovoltaic degradation of solar cells; thermal-coating performance; heat pipes; and cosmic-ray effects on seeds, spores, and eggs. Also included are answers to questions about LDEF retrieval posed at the conference. (T.K.).
A87-25458.

37 WEST M. L "Space Shuttle inflatable training articles. Final Report" , 1984; NASA-CR-171761 102P
Note: Raven Industries, Inc., Sioux Falls, S. Dak. Applied Technology Div

The design, development, construction, and testing of the Long Duration Exposure Facility inflatable and the space telescope training articles are discussed. While these articles are of similar nature, materials, and construction, they vary in size and present different problems with regards to size, shape, gross/net lift, and balance. (A.R.H.)
N84-20618.

38. SANDY M. L., CARTER, D., (NASA, Langley Research Center Hampton, VA); GRIGSBY D. K., (NASA, Education Service Branch, Washington, DC). "A new dimension in space experimentation" AIAA Student Journal (ISSN 0001-1460), vol. 21, Winter 1983/84, p. 18-21 30. 1984;

Based on the Space Shuttle's ability to place the Long Duration Exposure Facility (LDEF) in space and later retrieve it, a new opportunity for scientific exploration in space is studied. The LDEF which is scheduled to be placed in orbit in 1984 and returned to earth after one year in space is described. It is a large unmanned facility 9 m in length and 4 m in diameter and flying at an 482 km orbit. It is pointed out that the LDEF allows investigators to have their experiments returned to them for in- depth analysis, eliminates the need for complex systems to transmit data to earth, does not require propulsion equipment, and increases the kinds of experiments that can be performed. A description is given for each of the five categories of the experiments provided by the LDEF: (1) evaluation of the impact of space environments on materials used for thermal coatings on polymer-matrix composites, on optics, and on quartz-crystal oscillators; (2) experiments with unique heat pipe systems having the goal to achieve temperature control of + or - 6 F; (3) evaluation of solar array materials; (4) growth of single crystals of lead sulfite, calcium carbonate, and synthetic metals; and (5) scientific experiments to determine the chemistry of micrometeoroids and to identify isotopes in interstellar gas and ultra-heavy cosmic ray nuclei. Finally, the project SEEDS (Space Exposed Experiment Developed for Students) which experiments with tomato seeds behavior in zero gravity is discussed. (I.R.).
A84-43898.

39 MAGNUSSON, H. G., GOFF. M. F "Ku-Band rendezvous radar performance computer simulation model. Final Report" 1984. NASA-CR-171804 90P
Note: Hughes Aircraft Co., El Segundo, Calif Radar Systems Group.

All work performed on the Ku-band rendezvous radar performance computer simulation model program since the release of the preliminary final report is summarized. Developments on the program fall into three distinct categories: (1) modifications to the existing Ku-band radar tracking performance computer model; (2) the addition of a highly accurate, nonrealtime search and acquisition performance computer model to the total software package developed on this program; and (3) development of radar cross section (RCS) computation models for three additional satellites. All changes in the tracking model involved improvements in the automatic gain control (AGC) and the radar signal strength (RSS) computer models. Although the search and acquisition computer models were developed under the auspices of the Hughes Aircraft Company Ku-Band Integrated Radar and Communications Subsystem program office, they have been supplied to NASA as part of the Ku-band radar performance comuter model package. Their purpose is to predict Ku-band acquisition performance for specific satellite targets on specific missions. The RCS models were developed for three satellites: the Long Duration Exposure Facility (LDEF) spacecraft, the Solar Maximum Mission (SMM) spacecraft, and the Space Telescopes. (S.B.).
N84-32650.

40. KUCZERA, H., (Muenchen, Technische Universitaet ,. Munich, West Germany). "Examples of current cooperative projects in space flight LDEF and Giotto " (Hermann-Oberth-Gesellschaft, Raumfahrtkongress, 32nd, Coblenz, West Germany, Sept. 15-18, 1983) Astronautik (ISSN 0004-6221), vol. 21, no. 2, 1984, p. 38- 43. In German. 1984;

The long-duration-exposure facility (LDEF) to be placed in orbit by STS-41-C for a 10-month mission and the ESA Giotto spacecraft to be Ariane launched in July 1985, for rendezvous with Comet Halley are characterized, with a focus on dust-detection instruments. LDEF carries 86 experiment trays containing 48 experiments, of which seven (occupying 37 trays) are to investigate cosmic dust. The 240 10 x 10-cm dust detectors consist mainly of a 2.5-micron-thick mylar foil coated with 100 nm of Ta and 5 nm of Au/Pd (on the underside and external surface, respectively) and Ge target plates. The overall plan of the Giotto mission and the history of Halley observations are

reviewed; the spacecraft (based on the GEOS satellite) is described; and the instruments and experiments are listed. The impact-plasma monitor, particle-impact analyzer (a mass spectrograph), and dust-impact detector are discussed in detail and illustrated with photographs. (T.K.).
A84-40049.

41 KINARD, W H. "Introduction to Long-Duration Exposure Facility" 1984;
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 1-5 (SEE N84-24632).

A description of the structure and uses of the Long Duration Exposure Facility (LDEF) is given. The LDEF was designed to provide a large number of economical opportunities for science and technology experiments that require modest electrical power and data processing while in space and which benefit from postflight laboratory investigations with the retrieved experiment hardware. Like the Shuttle, the LDEF is reusable, and repeat missions are planned, each with a new complement of experiments. The LDEF is essentially a free-flying cylindrical structure. The experiments on LDEF are totally self-contained in trays mounted on the exterior of the structure. LDEF can accommodate 86 experiment trays, 72 around the circumference and 14 on the two ends. The LDEF is delivered to Earth orbit by the Shuttle. In orbit, the Shuttle remote manipulator system removes the LDEF from the Shuttle payload bay and places it in a gravity- gradient-stabilized attitude. After an extended period in orbit, which is set by experiment requirements, the LDEF is retrieved on a subsequent Shuttle flight. (R.J.F.).
N84-24633.

42 GREENE, R. F ,. JR. "LDEF thermal measurements system (P0003)" 1984;
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. In its Long Duration Exposure Facility (LDEF) p 78-81 (SEE N84-24632).

Many of the passive experiments flying on LDEF will be significantly enhanced if data are available postflight to indicate the temperature time histories of test materials and other specimens exposed in the experiments. The baseline LDEF approach was to provide postflight calculated temperature histories of experiment boundaries and solar flux data for the mission, which can in turn be used by each investigator to calculate the temperature time histories for critical experiment components. Without in-flight temperature measurements, a substantial uncertainty will exist in the calculated temperatures. The data measured by the thermal measurement system (THERM) will significantly improve postflight knowledge of temperatures experienced by LDEF experiments. The THERM data will also be valuable in validating the LDEF thermal design concept and in providing better design data for experimenters on future LDEF missions. The objectives of this experiment are to determine the history of the interior average temperatures of the LDEF for the total orbital mission and to measure the temperatures of selected components and thermal boundary conditions. (M.G.).
N84-24654.

43. COLLINS, M. A. , JR., ALDRICH, A. D., LUNNEY G. S. "National Space Transportation Systems Program mission report" 1984; NASA-TM-87455 18P
Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

The STS 41-C National Space Transportation Systems Program Mission Report contains a summary of the major activities and accomplishments of the eleventh Shuttle flight and fifth flight of the OV-099 vehicle, Challenger Also summarized are the significant problems that occurred during STS 41-C, and a problem tracking list that is a complete list of all problems that occurred during the flight. The major objectives of flight STS 41-C were to successfully deploy the LDEF (long duration exposure facility) and retrieve, repair and redeploy the SMM (Solar Maximum Mission) spacecraft, and perform functions of IMAX and Cinema 360 cameras.
N85-23900.

44 "Statement of Captain Robert L. Crippen, USN, Commander of Space Shuttle Flight 41-C; Francis R. Scobee, pilot; Doctor George D. Nelson, Mission Specialist; Terry J. Hart, Mission Specialist; and Doctor James D. Van Hoften, Mission Specialist; accompanied by Frank Cepollina, Solar Maximum Repair Mission Project Manager" , 1984.
Note: Committee on Science and Technology (U. S. House). In its Results of Space Shuttle Flight 41-C p 3-10 (SEE N85-12928).

The performance of the space shuttle Challenger, its direct insertion into orbit, and the deployment of the long duration exposure facility with its 57 experiments are described by the crew of the eleventh space transportation system flight. Other features of the mission discussed include the rendezvous, capture, and repair of the solar maximum mission spacecraft; operations of the manned maneuvering unit and the mechanical arm; and problems encountered when using the T-pad. Cameras and other equipment employed during the mission are also considered. (A.R.H.).
N85-12929.

45. "Space Shuttle inflatable training articles. Appendices D and I: Drawings Final Report" , 1984; NASA-CR-171762. 732P
Note: Raven Industries, Inc., Sioux Falls, S. Dak. United States

Drawings are presented for the Long Duration Exposure Facility inflatable and for the space telescope training articles. (A.R.H.).
N84-20619.

46. DIGIACOMO, A. F., BURNS, W. C., SCHALL, P "Environmental qualification tests, signal conditioning unit, SD802 materials experiment" 1983; AD-A138910. 53P
Note: Aerospace Corp., El Segundo, Calif. Materials Sciences Lab.

The vibration qualification test described within this report completes the vibration qualification requirements as established by the LDEF Project Office for flight hardware association with the SD802 materials experiment. The combined environment temperature altitude test described was completed to establish the operating stability of electronic components within the signal conditioning electronic units (SCUs). (Author (GRA)).
N84-22897

47 DIGIACOMO, A. F., BURNS, W C., SCHALL, P "Certification vibration tests, SD802 materials experiment" 1983; AD-A138547 136P
Note: Aerospace Corp., El Segundo, Calif. Materials Sciences Lab.

The SD802 materials experiment has been subjected to a certification vibration test as a Space transportation system flight safety completion requirement. The test described within this report verifies the structural integrity and demonstrates the ability to satisfy functional requirements of the experiment. The final flight weight and center of gravity of each experiment tray were also determined. (GRA).
N84-22982.

48. JOELS, K. M., KENNEDY G. P "The Space Shuttle operator's manual" New York, Ballantine Books, 1982. 178 p; 1982.

The book provides a layman's guide to Space Shuttle operations. Topics covered include launch and landing procedures, including simplified chronological checklists detailing crew and ground control actions; environmental control and crew hygiene; operation of the Remote Manipulator System (RMS) and EVA equipment. Various payloads are described including mission profiles for Spacelab and the Space Telescope deployment mission. All major STS subsystems are diagrammed and described, and foldout flight deck console facsimiles are included. (D.M.G.).
A83-11501

49. IGENBERGS, E "Applying space flight technology at universities. Final Report, Jul. 1981" 1982; BMFT-FB-W-82- 019. 78P
Note: Technische Univ., Munich (West Germany). Inst. fuer Luft und Raumfahrt. Sponsored by Bundesministerium fuer Forschung und Technologie. In GERMAN.

Universities conduct experimental investigations which are rather simple concerning their configuration and space flight requirements. A continuous program which is self supporting and in agreement with the utilization program of the BMFT and independent from the budget of the BMFT is assessed. Astronautical Institutes can support other faculties and are especially helpful to groups which have no contact with astronautics. The development of a university operated information system where the astronautical institutes act as information and support centers for other

faculties is assessed. In the framework of practical tests of the suggested approach experiments were proposed for the Spacelab, the LDEF and the GETAWAY SPECIAL. (E.A.K.).
N83-17563.

50. "Making space work for mankind; Proceedings of the Nineteenth Space Congress, Cocoa Beach, FL, April 28-30, 1982" Congress sponsored by the Canaveral Council of Technical Societies. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1982. 360 p. (For individual items see A82-47252 to A82-47283). 1982.
Topics in the practical applications of space are discussed. General subjects considered include: space power systems; future Shuttle cargo programs; international Shuttle users; expendable vehicle payloads; space manufacturing operations; commercial space applications; energy choices of the future; special interest topics; space communications. Specific topics addressed include; the EUropean REtrievable CArrier; future military spacecraft power systems; Space Platform solar array; European use of the Space Shuttle; Japanese satellites; the expendable launch vehicle and satellite development; space manufacturing; space manufacturing and the Space Operations Center· the Long Duration Exposure Facility; commerce and remote sensing; robots, progress in renewables; artificial intelligence in space missions; life support system considerations for space station. (C.D.).
A82-47251

51 WILLIAMSON, N. G., (Rockwell International Corp. Space Operations and Satellite, Systems Div., Downey, CA). "Space transportation system payload carriers - An overview" In: Material and process applications - Land, sea, air space; Proceedings of the Twenty-sixth National Symposium and Exhibition, Los Angeles, CA, April 28-30, 1981 (A81-44326) Azusa, CA, Society for the Advancement of Material and Process Engineering, 1981, p. 543-551 , 1981

The Space Shuttle payload bay capabilities are described, and an overview is presented of various payload carriers currently planned for use with payloads on the Space Shuttle. It is noted that these carriers range from the small, self-contained payload canister to upper stages, the Long-Duration Exposure Facility, Spacelab, and the Multimission Modular Spacecraft. The STS carriers relating to materials and processes research are thought to be of primary interest. The various components of the Multimission Modular Spacecraft are shown. (C.R.).
A81-44370.

52 TURNER, D. N., (NASA, Washington DC). "Space Shuttle utilization characteristics with special emphasis on payload design, economy of operation and effective space exploitation" , 1981, IAF-81-23.
Note: International Astronautical Federation, International Astronautical Congress, 32nd, Rome, Italy, Sept. 6-12, 1981 12 p.

The reusable manned Space Shuttle has made new and innovative payload planning a reality and opened the door to a variety of payload concepts formerly unavailable in routine space operations. In order to define the payload characteristics and program strategies, current Shuttle-oriented programs are presented: NASA's Space Telescope, the Long Duration Exposure Facility. the West German Shuttle Pallet Satellite, and the Goddard Space Flight Center's Multimission Modular Spacecraft. Commonality of spacecraft design and adaptation for specific mission roles minimizes payload program development and STS integration costs. Commonality of airborne support equipment assures the possibility of multiple program space operations with the Shuttle. On-orbit maintenance and repair was suggested for the module and system levels. Program savings from 13 to over 50% were found obtainable by the Shuttle over expendable launch systems, and savings from 17 to 45% were achievable by introducing reuse into the Shuttle-oriented programs. (J.F.).
A81-47299.

53 SINGER, S. F., (University of Virginia, Charlottesville VA). "Halley's Comet should shower earth with submicron particles" Astronautics and Aeronautics, vol. 19, Sept. 1981, p. 60, 74. 1981,

Background considerations are presented for the Halley's Comet observation experimental program that will be implemented by the Space Shuttle Orbiter's Long Duration Exposure Facility (LDEF), scheduled to fly in 1984. The LDEF will incorporate an interplanetary dust experiment for the detection of submicron particles. The characteristics of the LDEF are predicated on analyses of readings made aboard the Explorer 46 satellite by solid-state capacitors. Attention is given alternative interpretations of the submicron particles, which may be produced by collisions, comets, or interstellar dust penetration of the solar system. (O.C.) A81-46342.

54. LONG, M. J. "The long duration exposure facility structural interface" , 1981
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. In NASA. Marshall Space Flight Center The 15th Aerospace Mech. Symp. p 423-439 (SEE N81-22388).

The development of an efficient structural interface between the Long Duration Exposure Facility (LDEF) and the space shuttle orbiter is discussed. Thermal gradients and manufacturing tolerances restrict the number of retention points in the shuttle to four with no more than three in one plane. Loads during the powered exit, high drag reentry, and landing are also critical factors in the location of retention points. A LDEF design is described that meets all requirements while avoiding the structural weight penalties associated with an asymmetrical arrangement. The ground handling and assembly problems are resolved in an economical and effective manner. (M.G.).
N81-22415.

55. IGENBERGS, E. "Use of space flight by Universities spaceborne experiment technology transfer" , 1981 78P
Note: Technische Univ., Munich (West Germany). Inst. fuer Luft- und Raumfahrt Sponsored by Bundesministerium fuer Forschung und Technologie In GERMAN.

Spaceborne experiments, planned and designed at the university level, are discussed. Small self-contained payloads of simple configuration that pose minimal space flight requirements are considered for inclusion in Spacelab, the Long Duration Exposure Facility, and for the Getaway Special (NASA). Astronautics technical support of university projects and information flow are treated. A university operated information dissemination system is proposed in order to strengthen contact with astronautical institutes. Information exchange procedures are demonstrated for three experimental designs. (Author (ESA)).
N82-26045.

56. GIGUERE, R. P "SD/LDEF technical User's Manual" , 1981, AD-A113504. 117P
Note: Aerospace Corp., El Segundo, Calif. Operations Lab.

This report provides a complete review of the flight and ground support electronics with an emphasis on documenting the electronics programming particular to this mission. The electronics fabricated by MSL and the test plan for the hardware flight qualification tests from component to system levels are documented. Appendix A gives a breakdown of the transducers used and their locations so that these data can be easily shared among the many experimenters. (Author (GRA)).
N82-28324.

57 DAVID, L. W., (National Space Institute, Washington DC)., IRONS, J. J., (U.S. House of Representatives, Science and Technology Committee, Washington, DC). "Space Shuttle educational programs update and plans for the future" 1981; IAF-81-287
Note: International Astronautical Federation, International Astronautical Congress, 32nd, Rome, Italy, Sept. 6-12, 1981, 14 p.

The use of the Space Shuttle as an educational tool is considered, taking into account the value to students, educators, and NASA. An update of the European Space Agency student program is provided, giving attention to an educational physics experiments project and the Access to Spacelab for Young Europeans Program. Spacelab 1 is to be launched in late 1983. The areas aboard the Orbiter which could accommodate student experiments during a Spacelab flight include the mid-deck area, Spacelab module/racks, the Spacelab pallet, and the Orbiter bay. The Long Duration Exposure Facility offers a unique opportunity for student space experimentation. Attention is given to student built satellites, taking into account the Orbiting Satellite Carrying Amateur Radio series, an amateur space telescope project, and a solar sail project. Proposed future student space education programs are also discussed. (G.R.).
A81-47437

58. WERNER, K. E. "Drawer drive for space shuttle vacuum canister long duration exposure facility" , 1980.
Note; General Electric Co., Philadelphia, Pa. Reentry Systems Div In NASA. Langley Res. Center Proc. of the 14th Aerospace Mech. Symp. p 279-288 (SEE N80-23495).

A sliding drawer type canister was designed to contain long duration exposure facility experiments which require vacuum storage before and after space exposure. The elastomeric seals require high closing loads which are generated through camming levers and transmitted through a spring loaded pressure plate. Lubrication was provided by various dry surface coatings. Higher than expected friction required some redesign after which the assembly functioned well and provided good sealing. (Author).
N80-23518.

59. PAYNE, K. R. "An impedance technique for determining low frequency payload environments Space Transportation System" , 1979.
Note: Martin Marietta Corp., Denver, Colo. In Shock and Vibration Inform. Center The Shock and Vibration Bull., Pt. 2 p 1-14 (SEE N80-16211).

An approximation method for determining low frequency payload environments is developed and compared to state of the art coupling/response routines. Problems in signal conditioning techniques and frequency domain analysis are discussed. Results from analytical simulations with a spring mass system and a mathematical model of the Space Transportation System and Long Duration Facility are presented. (K.L.).
N80-16212.

60. HAMON, W. J., (NASA, Washington D. C.). "The space transportation system" In: Spacelab: Utilization and experimental design; Course on Space Technology, Toulouse, France, May 22-June 2, 1978, Proceedings. (A79-40701) Toulouse, Centre National d'Etudes Spatiales, 1979, p. 11-23. , 1979.

Design features of the Space Shuttle orbiter vehicle, main engine, solid rocket booster, external tank, and inertial and spinning solid upper stages are presented. Space Shuttle facilities at Kennedy Space Center are discussed, together with the long duration exposure facility, a reusable, unmanned gravity-gradient stabilized, free-flying structure which can accomodate both active and passive experiments requiring long- term space exposure. Standard and optional Shuttle services are outlined, and preliminary flight assignments are described. (C.K.D.).
A79-40703.

61 GOURLEY, H., LOVOI, P A., (International Technical Associates, Menlo Park ,. Calif.). "Testing of antireflection coatings using the NASA long-duration exposure facility /LDEF/" In: Space optics; Proceedings of the Seminar, Huntsville, Ala., May 22-24, 1979. (A80-17432) Bellingham, Wash., Society of Photo- Optical Instrumentation Engineers, 1979, p. 182-185. , 1979.

Optics for spacecraft presently use antireflection (AR) coatings whose space environment performance has only been measured indirectly via overall system performance. New AR coating techniques, chemically prepared coatings, are not readily accepted for use due to a lack of qualifying space environment data. An experiment to be carried out on the NASA Long Duration Exposure Facility (LDEF) is described. The experiment will utilize multiple samples, both coated and uncoated, with nonflight samples being maintained as controls. Conventional vacuum deposited coatings will be utilized as well as the new chemically prepared coatings. The present LDEF mission will provide 6 to 9 months of low earth orbit environment with future missions providing several years of exposure both in low earth orbit and in higher orbits. ((Author)).
A80-17454.

62. CHANGEART, F. J., CADARS, J. "A container for conditioning space experiments" , 1979.
Note: Centre National d'Etudes Spatiales, Toulouse (France). In ESA Mater. Sci. in Space p 189-199 (SEE N80-13069) In FRENCH and English.

A modular facility for scientific and technological experiments requiring protection against pollution and degradation hazards before and after their exposure to space environment is presented. The device was designed for a package of French experiments (FRECOPA) to be flown on the NASA Long Duration Exposure Facility (LDEF). The unit is described, consisting of an airtight canister, a support structure, an opening and closing mechanism, and a electronic control unit. Complete equipment specifications are provided and application of FRECOPA on the LDEF is outlined. (Author ESA). N80-13093.

63. JORDAN, K. L. , JR., (USAF, Washington D. C.). "The Department of Defense role in the Shuttle/Spacelab system" 1978; AAS-78-014.
Note: American Astronautical Society and Deutsche Gesellschaft fuer Luft- und Raumfahrt, Goddard Memorial Symposium, 16th, Washington, D.C., Mar. 8-10, 1978, AAS 23 p.

A summary is provided of the overall role of the DoD in the Space Transportation System (STS). The development of the Inertial Upper State (IUS) is described as well as the planning for an STS launch and landing capability at Vandenberg AFB, California. DoD requirements of the STS and operations planning are addressed. DoD plans for the utilization of STS include mission operations, cargo manifesting, mission control of the IUS and payloads, and exploiting the potential payload benefits. Utilization of the Long Duration Exposure Facility is also discussed. Finally, Spacelab Utilization by the DoD is described, including in-house study efforts and study contracts, both planned and completed. Some potential DoD/Spacelab experiments are described.
A79-11556.

64. CLARK, L. G., DIBATTISTA, J. D., (NASA, Langley Research Center, Long Duration Exposure Facilities Projects Office, Hampton, Va.). "LDEF/Shuttle capabilities for environmental testing in space" , 1978.
Note: In: The industrialization of space; Proceedings of the Twenty-third Annual Meeting, San Francisco, Calif., October 18- 20, 1977 Part 1 (A78-36701) San Diego, Calif., American Astronautical Society; Univelt, Inc., 1978, p. 297-308.

The Long Duration Exposure Facility (LDEF) is being developed to accommodate experiments which require a free-flying exposure in space and which benefit from postflight laboratory analysis of the retrieved experiment hardware. The first LDEF mission, which is planned for a 6- to 12-month stay in space is scheduled in the late 1970s during the Shuttle Orbital Flight Test Program. The LDEF is a simple reusable structure which is three-axis gravity gradient stabilized when free flying in space. The experiments on the LDEF are totally self-contained in trays mounted to the structure. After the LDEF is either revisited or retrieved by the Shuttle, the trays with experiments will be returned to the experimenters for postflight inspection. Attention is given to the fabrication of a second LDEF for a long-term mission planned in 1979, aspects of LDEF orbit life time, the radiation environment, questions of solar exposure, the thermal environment, and the vacuum (atomic particle) environment. (G.R.).
A78-36713.

65. CHANGEART F. J., (Centre National d'Etudes Spatiales, Centre Spatial deToulouse, France). "Presentation on 'FRECOPA' FRench COoperative passive PAyload - Grouping of French experiments installed on board the L.D.E.F Long Duration Exposure Facility" , 1978; IAF-78-212.
Note: International Astronautical Federation, International Astronautical Congress, 29th, Dubrovnik, Yugoslavia, Oct. 1-8, 1978, 26 p.

The payload FRECOPA proposed by France for the first flight of the LDEF (Long Duration Exposure Facility) is a group of two experiments on cosmic dust and five on the behavior of materials and components exposed to a space environment. The first experiment consists in exposing various targets to the space environment and studying the morphology of craters. The second consists in collecting cosmic dust and determining its nature and chemical composition. The materials experiments will test the effects of space environment on thin film products, diffraction gratings, optical fibers, and thermal control coatings. Information relating to the packaging and integration of the experiments is given. (P.T.H.).
A79-11293.

66. "New experiments selected for 1980 operational shuttle flight" , 1978; NASA-NEWS-RELEASE-78-1 17P
Note: National Aeronautics and Space Administration, Washington, D. C.

Experiments selected for NASA's Long Duration Exposure Facility mission are described. Technical areas represented by the experiments include materials, thermal control coatings, detectors, power, micrometeoroids, electronics, lubrication, optics, and space debris detection. (J.M.S.).
N78-15063.

67 MERRILL, R. L., DAVIS, B. W., (Battelle Memorial Institute, Columbus Ohio) "Shuttle payloads - Opportunities to expand ground-based research" Astronautics and Aeronautics, vol. 15, Apr 1977 p. 38-43. 1977;

The capabilities of the upcoming Shuttle flights include: accommodation of very large payloads in both weight (up to 65,000 lb) and size (60 by 15 ft); stay in orbit for extended periods (7 to 30 days); launching and retrieving objects in space (free flyers); returning payloads to earth unharmed; frequent flight schedules (one flight per week by 1985); relatively low cost. These capabilities will enable the earth-bound researchers to move their laboratories to space and take advantage of the properties of the space environment. The cost of space research must be measured in terms of the cost per useful data point, and not the cost per flight. The space research is and will be used in mapping, mineral exploration, land use planning, agricultural crop measurements and forecasting, water-resource management, and environmental monitoring. The exploitation of research opportunities based on the properties of the space environment can potentially contribute to a broad spectrum of physical, biological, chemical, and engineering sciences as well as a very large number of industrial processes. (A.Y.).
A77-29029.

68. KINARD. W H., (NASA, Langley Research Center Hampton, Va.). "Long Duration Exposure Facility - A unique mode of Shuttle utilization" (NASA Ames Research Center and American Vacuum Society, Symposium on the Use of the Space Shuttle for Science and Engineering, Moffett Field, Calif., May 9-11, 1977.) Journal of Vacuum Science and Technology, vol. 14, Nov.-Dec. 1977 p. 1258-1262. 1977

The Long Duration Exposure Facility (LDEF) is a Shuttle- transported, reusable, essentially passive facility with accommodations for a wide variety of experiments which require a free-flying carrier for exposure in space. Specifically, the LDEF is tailored to provide low-cost accommodations for experiments which have modest requirements for electrical power and data systems, and for experiments which benefit from postflight laboratory investigations with the retrieved experiment hardware. Each experiment for LDEF will be totally self-contained in a tray As the interface with the facility has been minimized, the LDEF experimenters will be freed from many of the requirements which have complicated development of space experiments in the past. ((Author)).
A78-19467

69 IGENBERGS, E., (Muenchen, Technische Universitaet , Munich, West Germany). "LDEF /Long Duration Exposure Facility/ A new experiment carrier used in Space Shuttle" Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, 10th, Berlin, West Germany Sept. 13-15, 1977 Paper 28 p. In German. , 1977

The LDEF which is being developed by NASA, is to be placed into orbit by the Space Shuttle for the conduction of technological, scientific, and application-oriented experiments in space. It is intended to use the LDEF as a basis for carrying out comparatively simple experiments with low-level requirements with respect to energy and data processing. The results of the experiments can be studied afterwards in ground-based laboratories when the LDEF has been brought back again to earth by the Space Shuttle. In the first mission, which is to begin in July 1979, the LDEF is to remain in orbit for a time period lasting from 6 to 12 months. A second mission, which is to begin in summer 1980 will have a duration of 10 years. The LDEF consists of a cylindrical aluminum frame. It is intended that the LDEF is to be used by experimenters who will design, construct, and mount their own experiments. Experiments selected for the first flight are related to the study of meteorites, investigations of the effectiveness of new coatings for the thermal control of spacecraft, the long-term behavior of solar cells in space, and the study of the behavior of optical components in space. (G.R.).
A78-24450.

70. IGENBERGS, E "Long Duration Exposure Facility (LDEF): A new multipurpose free-flying experiment carrier" , 1977 27P
Note: Technische Univ , Munich (West Germany). Lehrstuhl fuer Raumfahrttechnik. Presented at Ann. DGLR Meeting, Berlin, 13-15 Sep. 1977 In German.

The construction, launch, and return environment of the long duration exposure facility (LDEF) are described. Possible long- term experiments are discussed. (Author (ESA)).
N80-23359.

71 DIBATTISTA, J. D., CLARK, L. G., (NASA, Langley Research Center, Hampton, Va.). "The long duration exposure facility - A test bed for space technology development" 1977: AIAA-Paper- 77-561
Note: American Institute of Aeronautics and Astronautics and Princeton University, Conference on Space Manufacturing Facilities, 3rd, Princeton, N.J., May 9-12, 1977 6 p.

The long duration exposure facility (LDEF) is being developed by NASA to accommodate, using the Shuttle, a class of technology, science, and applications experiments which require a free-flying exposure in space. The LDEF offers an attractive approach to experiments which require long-term exposure in space. LDEF missions up to 10 years duration are possible and requested by researchers. Attention is given to the LDEF concept and the operations, plans for technology testing in space, and aspects of investigator participation. (G.R.).
A77-32073.

72 DIBATTISTA, J. D., (NASA, Langley Research Center, Hampton, Va.). "Long duration exposure facility - A free-flying experiment carrier" In: Space research XVII; Proceedings of the Open Meetings of Working Groups on Physical Sciences, June 8-19, 1976 and Symposium on Minor Constituents and Excited Species, Philadelphia, Pa., June 9, 10, 1976. (A78-18101) Oxford and New York, Pergamon Press, 1977 p. 847-853. 1977

The Long Duration Exposure Facility (LDEF) will complement and extend Shuttle operations with Spacelab and pallets. The LDEF is a passive stabilized structure which can accommodate a wide variety of users who have experiments which require a free-flying carrier for exposure in space. The experiments are contained in trays which are attached to the LDEF. This paper describes the LDEF concept and operation, the facility, mission characteristics, and plans for the selection of experiments to fly on LDEF ((Author)).
A78-18190.

73. KINARD, W. H., (NASA, Langley Research Center, Hampton, Va.). "Long duration exposure facility - A multipurpose free-flying experiment carrier" Raumfahrtforschung, vol. 20, Sept.-Oct. 1976, p. 225-231. 1976;

The Long Duration Exposure Facility (LDEF) is being developed to accommodate, using the Shuttle, a class of technology, science, and applications experiments which do not require a sophisticated or dedicated satellite. The LDEF is a simple reusable structure approximately 4.3 m in diameter and 9 m in length. The basic LDEF consists of a structural framework whose cross section is a 12- sided regular polygon. A facility description is provided, taking into account the structure, aspects of attitude stabilization, the experiment trays, the experiment exposure control canister, the environment monitoring system, and Shuttle bay environment measurements. Missions and questions of experiment selection are discussed, giving attention to orbits, dynamic motions, a space debris damage experiment, thermal coating experiments, the solar cells and arrays experiment, and the active optical components experiment. (G.R.)
A77-11816.

74 KINARD, W. H., (NASA, Langley Research Center, Hampton, Va.). "Long Duration Exposure Facility - A multipurpose free-flying experiment carrier" American Astronautical Society and Deutsche Gesellschaft fuer Luft- und Raumfahrt, International Meeting on Utilization of Space Shuttle and Spacelab, Bonn, West Germany, June 2-4, 1976, Paper 26 p. 1976.
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

The Long Duration Exposure Facility (LDEF) is being developed by NASA to accommodate, using the Space Shuttle, a class of technology, science and applications experiments which require a free-flying exposure in space, but which do not require a sophisticated or dedicated satellite. The facility is a simple reusable structure about 14 ft in diameter and 30 ft long, which is three-axis gravity-gradient stabilized when free flying in space. Various aspects of the LDEF are examined, including the attitude stabilization system, the experiment trays, the experiment exposure control canister,and the environment monitoring system. LDEF mission plans are considered, as is experiment selection - the space debris damage experiment, the thermal coating experiment, the solar cells and arrays experiment, and the active optical components experiment. (B.J.).
A76-42359.

75. HEISS, K., (Econ Inc., Princeton N. J.). "Space Shuttle economics and US defence potentialities" Interavia, vol. 31 Nov 1976, p. 1071-1073. 1976;

Cost and organization aspects of the space transportation system (STS) incorporating the Space Shuttle system are surveyed, with some recommendations on back-up launch sites, payload effects, funding, fleet size, and discontinuing the use of expendable launch vehicles. Payload effects contemplated include: relaxed constraints on mass and volume of STS vehicles, on-orbit checkout-refurbishment-retrieval capability, payload sharing of shuttle flights, and new expanded payload capabilities. Risk stemming from 'single acts of sabotage, blackmail or unilateral interventions of groups opposed to U.S. interests' is invoked in support of diversification of STS launch area siting. A Shuttle- ferried long duration exposure facility (LDEF) for extended unmanned in-orbit experiments is described. (R.D.V).
A77-13332.

MANIPULATORS

1 CORNILS, KARIN; GOODE, PLESENT W "Location of planar targets in three space from monocular images" , 1987 NASA-TM-101868. 13P
Note: National Aeronautics and Space Administration. Langley Research Center. Hampton, VA. Presented at the 1987 Conference on Space Applications of Artificial Intelligence (AI) and Robotics, Greenbelt, MD, 13-14 May 1987

Many pieces of existing and proposed space hardware that would be targets of interest for a telerobot can be represented as planar or near-planar surfaces. Examples include the biostack modules on the Long Duration Exposure Facility, the panels on Solar Max, large diameter struts, and refueling receptacles. Robust and temporally efficient methods for locating such objects with sufficient accuracy are therefore worth developing. Two techniques that derive the orientation and location of an object from its monocular image are discussed and the results of experiments performed to determine translational and rotational accuracy are presented. Both the quadrangle projection and elastic matching techniques extract three-space information using a minimum of four identifiable target points and the principles of the perspective transformation. The selected points must describe a convex polygon whose geometric characteristics are prespecified in a data base. The rotational and translational accuracy of both techniques was tested at various ranges. This experiment is representative of the sensing requirements involved in a typical telerobot target acquisition task. Both techniques determined target location to an accuracy sufficient for consistent and efficient acquisition by the telerobot. (Author).
N89-29991

2 "Shuttle manipulator design reviewed" Aviation Week and Space Technology, vol. 105, Nov. 1, 1976, p. 38, 39. 1976;

The paper deals with the Canadian-built remote manipulator system that will deploy and retrieve space shuttle payloads in orbit. The first manipulator flight is planned on the third shuttle orbital flight when the long-duration exposure facility is expected to be deployed. The manipulator system will be 50 ft long and have six degrees of freedom. The shoulder joint (the point which attaches to the orbiter payload bay about 7 ft aft of the main cabin bulkhead) will have pitch and yaw capability. The unit's elbow joint that connects the two boom sections will have a pitch capability, while the RMS wrist joint that joins the end effector will have pitch, roll, and yaw. Design capability is for maneuvering payloads on the orer of 32,000 lb. Shuttle free- flying payload deployment simulations, currently under way, are discussed, along with some aspects of manipulator control. (V.P.).
A77-11899.

MICROMETEOROIDS

1 MCDONNELL, J. A. M., (Kent University, Canterbury England). "Impact cratering from LDEF's 5.75-year exposure - Decoding of the interplanetary and earth-orbital populations" IN: Proceedings of Lunar and Planetary Science, Volume 22; Conference, Houston, TX, Mar. 18-22, 1991 (A92-30851 12-91). Houston, TX, Lunar and Planetary Institute, 1992, p. 185-193. , 1992.

Penetration records from exposure of the LDEF multiple-foil microabrasion experiment (MAP) in five pointing directions have been obtained in order to decode the possible contribution from earth orbital (bound) components and hyperbolic (unbound) particles of extraterrestrial origin. A preliminary flux redistribution is derived for the nominal east- (ram), west- (trailing) and space-pointing detector surfaces. Orbital dynamics and collisional probabilities are used to demonstrate a high anisotropy in the flux rate for the different detector locations. The east-to-west flux ratio for the MPA data is 34 +/- 7 for the penetration of aluminum at 5 microns and 7.3 +/- 1.7 at 30 microns; the space-to-west ratio is 4.9 +/- 1.0 at 5 microns. These data demonstrate that LDEF impacts on all detectors are dominated by unbound and hence extraterrestrial particulates above particulate masses of 6.4 x 10 exp -10 g mass. However, for small particulates an orbital component is clearly identified on the east and side faces that exceeds the interplanetary flux distribution by a factor of about four on the east face. (C.D.).
A92-30868.

2 ZWIENER, JAMES M. "Meteoroid/space debris impacts on MSFC LDEF experiments" 1991
Note: National Aeronautics and Space Administration. Marshall Space Flight Center Huntsville, AL. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 33 (SEE N91-24972) Abstract Only

A number of unusual effects are presented that were observed on the TCSE test samples, front cover, and structural components. These include induced UV fluorescence in some materials, the migration and degradation of KRS-5 materials, atomic oxygen (AO), and contaminant texturing and discoloration, and meteoroid and debris impacts. These effects and their causes are discussed. (Author).
N91-25001

3. ZOOK, HERBERT A. "Deriving the velocity distribution of meteoroids from the measured meteoroid impact directionality on the various LDEF surfaces" , 1991
Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 44 (SEE N91-24972) Abstract Only

Because of spacecraft motion, a much higher flux of meteoroids is expected to strike the leading (apex) surface of a spacecraft than is expected to strike the trailing (antapex) surface. The ratio of fluxes (apex to antapex) depends on the velocity distribution of meteoroids entering the Earth's atmosphere. The ratio ranges from 5.7 to 9.2 at constant meteoroid mass for the three velocity distributions examined. The velocity of impact is also greater on average, on the apex surface than on the antapex surface, and the impacts tend to be more normal to the surface. This means that the meteoroids that make a crater of a given diameter are less massive than those that strike the antapex surface. These effects further increase the apex-antapex abundance ratio at constant crater diameter compared to that at constant mass. For craters 100 microns in diameter on 6061 T6 aluminum on the Long Duration Exposure Facility. the ratios obtained on various surfaces are given in tabular form. (Author).
N91-25012

4. ZOLENSKY MIKE; SEE, THOMAS H., SIMON, CHARLES G., ALLBROOKS, MARTHA K., ATKINSON, DALE R., (POD Associates, Inc Albuquerque , NM.). "Meteoroid and orbital debris record of the Long Duration Exposure Facility" 1991
Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 35 (SEE N91-24972) Abstract Only

The Long Duration Exposure Facility (LDEF) was recovered in January 1990 following 5.7 years exposure of approx. 130 square meters of surface area in low-Earth orbit (250-179 miles). Kennedy Space Center acquired data are currently being reduced to yield accurate impact crater depths and diameters. Presented here is a preliminary accounting of the impact record based on the approx. 15.4 square meter surface area of LDEF's 6061-T6 aluminum frame, which was exposed in 26 different directions. (Author).
N91-25003.

5. ZOLENSKY, MICHAEL, (NASA, Johnson Space Center Houston, TX); ATKINSON, DALE; (POD Associates, Albuquerque NM)., SEE, THOMAS; (Lockheed Engineering and Sciences Co., Houston TX)., ALLBROOKS, MARTHA; (Systems Science and Software, Albuquerque NM)., SIMON, CHARLES; (Washington University, Saint Louis ,. MO); FINCKENOR, MIRIA; (NASA, Marshall Space Flight, Center, Huntsville, AL). "Meteoroid and orbital debris record of

the Long Duration Exposure Facility's frame" Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991 p. 204-209. 1991,

The gravity stabilization feature of the NASA Long Duration Exposure Facility (LDEF), which was recovered in January 1990 after 5.7 years of continuous exposure to the LEO environment, has allowed the resolution of the flux and trajectories of impacting meteoroids and space-debris particulates. Attention is presently given to the stereoscopic video imaging results obtained for the large impact features on the LDEF's aluminum frame. Extreme directionalities appear to typify impacting particulates larger than 0.1 mm in diameter; this is not explainable in light of current models. Recommendations for further LDEF analyses to ensure the safe design of future spacecraft are presented. (O.C.).
A91-42637

6. STELLA, PAULM. "Leo micrometeorite/debris impact damage" , 1991
Note: Jet Propulsion Lab., California Inst. of Tech., Pasadena. In NASA. Lewis Research Center, Space Photovoltaic Research and Technology Conference 7 p (SEE N91-30203).

The school bus sized Long Duration Exposure Facility (LDEF) was retrieved in 1990, after nearly six years of 250 nautical mile altitude low earth orbit environmental exposure. The recovery of LDEF experiments has provided extensive information on space interactions, including micrometeorite, debris, atomic oxygen, ultraviolet, and particulate radiation. The Jet Propulsion Laboratory provided a test plate as part of Solar-Array-Materials Passive LDEF (SAMPLE) Experiment. The test plate contained thirty thin silicon solar cell/cover assemblies. The cover samples included a variety of materials such as Teflon and RTV silicones, in addition to conventional microsheet. The nature of the approximately 150 micrometeorite/debris impacts on the cell/cover samples, cell interconnects, and aluminum test plate is discussed. (Author).
N91-30237

7 SINGER, S. F., STANLEY, J. E., KASSEL, P. C., KINARD, W. H., WORTMAN, J. J., WEINBERG, J. L., MULHOLLAND, J. D., EICHHORN, G., COOKE, W. J., MONTAGUE, N. L. "First spatio-temporal results from the LDEF Interplanetary Dust Experiment" (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 115-122. 1991

The LDEF Interplanetary Dust Experiment is unique in providing a time history of impacts of micron-sized particles on six orthogonal faces of the vehicle over a span of nearly a full year. Over 15,000 hits were recorded, representing a mix of zodiacal dust, meteor-stream grains, orbital debris, perhaps beta-meteoroids, and possibly interstellar matter. Although the total number was higher than predicted, the relative panel activity distribution was near expectations. Detailed deconvolution of the impact record with orbital data is underway, to examine each of these populations. Very preliminary results of the fairly crude 'first-look' analysis suggest that debris is the major particle component at 500 km. The data show clear evidence of some known meteor streams as sharp, tightly-focused events, unlike their visible counterparts. Some apparent debris events show similar signatures. Data from the leading and trailing edges suggest a detection of beta-meteoroids, but the analysis is not yet conclusive. Absolute fluxes and flux ratios are not yet known, since the detector status analysis is yet incomplete. (Author).
A92-18666.

8. SINGER, S. F., OLIVER, J. P., WEINBERG, J. L., COOKE, W. J., MONTAGUE, N. L., (Institute for Space Science and Technology, Gainesville FL)., MULHOLLAND, J. D., (Institute for Space Science and Technology, Gainesville FL and Grasse, France); WORTMAN, J. J., (North Carolina State University, Raleigh; KASSEL, P. C., KINARD, W. H., (NASA Langley Research Center, Hampton VA). "LDEF Interplanetary Dust Experiment - Techniques for identification and study of long-lived orbital debris clouds" . 1991, IAF-Paper-91-285.
Note: IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991 12 p.

The Long Duration Exposure Facility (LDEF) is a 12-sided, 4.3-m- diameter, 9.1-m-long cylinder designed and built by NASA Langley to carry experiments for extended periods in space. The LDEF was first placed in orbit by the Shuttle Challenger on 7 April 1984 and recovered by the Shuttle Columbia in January 1990, only days before it was expected to burn up in the earth's atmosphere. The Interplanetary Dust Experiment (IDE) was designed to detect

impacts of extra-terrestrial particles and orbital debris. The IDE detectors (which covered about 1 sq m of the surface of LDEF) were sensitive to particles ranging in size from about 0.2 to 100 microns. Data were recorded for 11.5 months before the supply of magnetic tape was exhausted. Examination of the LDEF IDE dataset shows that impacts often occurred in 'bursts', during which numerous impacts occurred in a short time (typically 3-5 min) at a rate much greater than the average impact rate. In several cases, such events reoccurred each time the LDEF returned to the same point in its orbit. Such multi-orbit event sequences were found to extend for as many as 25 or more orbits. (Author).
A92-14713.

9. RADICATIDIBROZOLO, F., HARRIS, D. W., CHAKEL, J. A., FLEMING, R. H., (Evans, Charles and Associates, Redwood City, CA)., BUNCH, T E. "Imaging analysis of LDEF craters" , 1991
Note: National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA. In Lunar and Planetary Inst., Abstracts for the 54th Annual Meeting of the Meteoritical Society p 194 (SEE N92-12901) Abstract Only

Two small craters in Al from the Long Duration Exposure Facility (LDEF) experiment tray A11E00F (no. 74, 119 micron diameter and no. 31, 158 micron diameter) were analyzed using Auger electron spectroscopy (AES), time-of-flight secondary ion mass spectroscopy (TOF-SIMS), low voltage scanning electron microscopy (LVSEM), and SEM energy dispersive spectroscopy (EDS). High resolution images and sensitive elemental and molecular analysis were obtained with this combined approach. The result of these analyses are presented. (Author).
N92-12927

10. PARKER, IAN. "Simulating space impacts" Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Sept. 1991 p. 14, 15, 17 1991,

The need for simulating space debris impacts in the laboratory, in order to develop spacecraft protection systems, has led to the development of a hypervelocity impact-generation facility using both light gas gun and electromechanical accelerator techniques to reach muzzle velocities of the order of 7.5 and 9.0 km/sec. Firings can be conducted at the rate of two per day. New launchers are under development which will be capable of accelerating particles to 20 km/sec. (O.C.).
A91-52999.

11 OLSSON-STEEL, DUNCAN; (Adelaide University, Spaceguard Pty Ltd., Australia). "Face-dependent impact probabilities, velocities and angles upon LDEF by space debris and natural meteoroids" (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B / Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 85-88. 1991,

For specified geocentric orbits the impact probabilities, velocities, and angles upon the different faces of the Long Duration Exposure Facility are calculated, and it is found that quite different distributions of microcratering are to be expected. In particular the flux to the east (leading) face exceed that to the west (trailing) face by a very large ratio. The north and south faces receive exposures slightly in excess of the east face for lower-velocity impacts from low-inclination orbits, but much lower exposures than the east face for high- velocity impacts from high-inclination orbits. The space face (pointing directly away from the earth) and the earth face (pointing directly toward the earth) is subject to very few impacts from geocentric orbits. Therefore, while three sides (the east, north and south) are hit many times by artificial space debris, the other three (the west, space and earth) are impacted almost solely by natural meteoroids from heliocentric orbits, and can be used to determine the flux of such particles in the vicinity of the earth. The ratios of impacts upon the east, west and space faces are useful indicators of the velocity/orbit distribution of meteoroids. (Author).
A92-18661

12. MULHOLLAND, J. DERRAL, SINGER, S. FRED; OLIVER, JOHN P., WEINBERG, JERRY L., COOKE, WILLIAM J., KASSEL, PHILIP C., WORTMAN, JIM J., MONTAGUE, NANCY L., KINARD, WILLIAM H., (North Carolina State Univ., Raleigh. "IDE spatio-temporal impact fluxes and high time-resolution studies of multi-impact events and long- lived debris clouds" , 1991

Note: National Aeronautics and Space Administration. Langley Research Center Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 41 (SEE N91-24972). Abstract Only

During the first 12 months of the Long Duration Exposure Facility (LDEF) mission, the Interplanetary Dust Experiment (IDE) recorded over 15,000 total impacts on six orthogonal faces with a time resolution on the order of 15 to 20 seconds. When combined with the orbital data and the stabilized configuration of the spacecraft, this permits a detailed analysis of the micro- particulate environment. The functional status of each of the 459 detectors was monitored every 2.4 hours, and post-flight analyses of these data has now permitted an evaluation of the effective active detection area as a function of time, panel by panel and separately for the two sensitivity levels. Thus, total impacts were transformed into areal fluxes, and are presented here for the first time. Also discussed are possible effects of these fluxes on previously announced results: apparent debris events, meteor stream detections, and beta meteoroids in observationally significant numbers. (Author)
N91-25009.

13. MCKNIGHT, D. S., DUEBER, R. E., (U.S. Air Force Academy, Colorado Springs ,. CO); TAYLOR, E. W., (USAF Phillips Laboratory , Kirtland AFB, NM). "Space debris and micrometeorite events experienced by WL experiment 701 in prolonged low earth orbit" Journal of Geophysical Research (ISSN 0148-0227), vol. 96, June 1 1991, p. 9829-9833. 1991,

Air Force Systems Command Weapons Laboratory experiment 701 (Space Environment Effects on Fiber Optic Systems) was housed aboard the Long Duration Exposure Facility and placed into orbit on April 6, 1984, by the Shuttle Challenger. It was retrieved 69 months later by the Shuttle Columbia on January 12, 1990. During this period in orbit, the experiment experienced numerous debris or micrometeorite impacts. Impact flux values, crater characteristics, and shock phenomena on the experiment's space- exposed surfaces were observed to be similar to returned materials of the Solar Max satellite. This paper presents the analysis of preliminary data, describes data reduction techniques, and outlines areas of future study. (Author)
A91-40413.

14 MCDONNELL, TONY "Space debris. Orbital microparticulates impacting LDEF experiments favour a natural extraterrestrial origin" 1991
Note: Kent Univ., Canterbury (England). Physics Lab. In Lunar and Planetary Inst., 22nd Lunar and Planetary Science Conference p 45-48 (SEE N91-19995).

The results of work carried out at the Unit for Space Sciences at the University of Kent at Canterbury, United Kingdom, on the micrometeoroid and space debris environment of near Earth space are described. The primary data for the research program is supplied by an examination of several types of exposed surface from the NASA Long Duration Exposure Facility (LDEF), including an experiment dedicated to the detection of micrometeoroids and space debris provided by the University (Author)
N91-20008.

15 MCDONNELL, J. A. M. SULLIVAN, K. "Foil perforation particulate impact records on LDEF MAP AO023: Incident mass distributions" 1991
Note: Kent Univ., Canterbury (England) Team Unit for Space Sciences. In NASA, Langley Research Center, First LDEF Post- Retrieval Symposium Abstracts p 34 (SEE N91-24972). Abstract Only

An array of multiple foils varying from 1.5 to 3.0 microns exposed on Long Duration Exposure Facility's (LEDF's) geocentrically stabilized exposure platform provides perforation distributions which relate to particulate flux mass distributions and impact velocity in LDEF's orbital reference frame. The application of physical modeling enables a preliminary separation into orbital and interplanetary components, both of which have differing velocities and hence penetration effectiveness. Thin foil hypervelocity calibration data and parametric penetration formulae developed to relate target hole diameter to projectile dimensions are critically examined and a new formula offered for the ballistic limit situation. Incorporating projectile density, target density, and target strength and dimensional scaling from submicron particulates to centimeter scale data, it contrast very significantly with previous formulae in the interpretation of space impact data. Perforation flux distributions for the leading, trailing, and space pointing faces and associated mass distributions for the two populations are presented. (Author) N91-25002

16. MCDONNELL, J. A. M., SULLIVAN, K. "Dynamic (computer) modelling of the particulate environment: Transformations from the LDEF reference frame to decode geocentric and interplanetary populations" , 1991
Note: Kent Univ., Canterbury (England). Unit for Space Sciences. In NASA, Langley Research Center, First LDEF Post- Retrieval Symposium Abstracts p 42 (SEE N91-24972).

The Long Duration Exposure Facility's impact signature record and the size frequency distribution of craters and perforations offers a unique record of environmental data referenced conveniently to the geocentric reference frame. Chemical analysis of residues can offer only limited assistance. Hence, flux modelling has been developed to transform from both geocentric orbital distributions and geocentrically unbounded interplanetary source distributions. This is applied to the foil and crater penetration records in the Ram (E), Trailing (W), and Space Pointing directions to offer the means of decoding the records. It shows that the mix of the components is size dependent. Parametric forms of the modelling transformations are presented for the orbital and unbound populations. (Author).
N91-25010.

17. MCDONNELL, J. A. M., DESHPANDE, S. P., GREEN, S. F., NEWMAN, P. J., PALEY M. T., RATCLIFF P. R., STEVENSON, T. J., SULLIVAN, K. (Kent University. Canterbury England). "First results of particulate impacts and foil perforations on LDEF" (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991 p. 109-114. 1991.

The interpretation of the Long Duration Exposure Facility (LDEF) Microabrasion Package (MAP) is considered in the light of both natural and artificial particulate impacts. The use of attitude stabilization is described emphasizing its role in the collection of a broader range of direct penetration data that confirm near- earth data. Expected north/south symmetry is not observed, and a distinct feature is noted in the penetration spectrum of all the faces in the form of a steep distribution at the 25-30-micron foil thickness. (C.C.S.)
A92-18665.

18. MANDEVILLE, JEAN CLAUDE. "Study of meteoroid impact craters on various materials (AO 138-1). Attempt at dust debris collection with stacked detectors (AO 138-2) " 1991
Note: Centre d'Etudes et de Recherches, Toulouse (France). In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 31 (SEE N91-24972). Abstract Only.

Part of the Long Duration Exposure Facility (LDEF) tray allocated to French experiments, known as FRECOPA payload, was devoted to the study of dust particles. Two passive experiments were flown: one composed of a set of glass and metallic samples and one composed of multilayer thin foils detectors. In addition to these experiments, a broad variety of materials were exposed to the bombardment of microparticles and provide more data. Thick target experiment comprises selected metallic (Al, Au, Cu, W, Stainless Steel) 250 microns thick and glass surfaces 1.5 mm thick. Crater size distribution from these thick target experiments enable, with the aid of lab calibrations by solid particle accelerators, the evaluation of the incident microparticle flux in the near earth environment. The aim of the multiple foil penetration and collection experiment is primarily to study the feasibility of multilayer thin film detectors acting as energy sorters in order to collect micrometeoroids, if not in their original shape, at least as 'breakup' fragments suitable for chemical analysis. Foil thicknesses range from 0.75 to 5 microns of Al. (Author).
N91-24999.

19. HUMES, DONALD H. "Large craters on the meteoroid and space debris impact experiment " , 1991
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 30 (SEE N91-24972). Abstract Only

The distribution around the Long Duration Exposure Facility (LDEF) of 532 large craters in the Al plates from the Meteoroid and Space Debris Impact Experiment (S0001) is discussed along with 74 additional large craters in Al plates donated to the Meteoroid and Debris Special Investigation Group by other LDEF experimenters. The craters are 0.5 mm in diameter and larger. Crater shape is discussed. The number of craters and their distribution around

the spacecraft are compared with values predicted with models of the meteoroid environment and the manmade orbital debris environment. (Author).
N91-24998.

20 HORZ, FRIEDRICH; BERNHARD, R. P., SEE, THOMAS H. ATKINSON, DALE R., ALLBROOKS, MARTHA K., (POD Associates, Inc Albuquerque NM.). "M and D SIG progress report Laboratory simulations of LDEF impact features." 1991
Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 45 (SEE N91-24972). Abstract Only.

Reported here are impact simulations into pure Teflon and aluminum targets. These experiments will allow first order interpretations of impact features on the Long Duration Exposure Facility (LDEF), and they will serve as guides for dedicated experiments that employ the real LDEF blankets, both unexposed and exposed, for a refined understanding of the Long Duration Exposure Facility's collisional environment. (Author).
N91-25013.

21 FINCKENOR, MIRIA. "Meteoroid/space debris impacts on MSFC LDEF experiments." 1991
Note: National Aeronautics and Space Administration. Marshall Space Flight Center Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 32 (SEE N91-24972). Abstract Only.

The numerous meteoroid and space debris impacts found on AO171, AO034, S0069, and other MSFC experiments are examined. Besides those impacts found by the Meteoroid and Debris Special Investigative Group at KSC, numerous impacts of less than 0.5 mm were found and photographed. The flux and size distribution of impacts are presented as well as EDS analysis of impact residue. Emphasis is on morphology of impacts in the various materials, including graphite/epoxy composites, polymeric materials, optical coatings, thin films, and solar cells. (Author).
N91-25000.

22 BROWNLEE, D. E., HORZ, FRIEDRICH; LAURANCE, M., BERNHARD, R. P., WARREN, J., BRADLEY J. P., (McCrone Associates, Inc Westmont , IL.). "The composition of meteoroids impacting LDEF " 1991 Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX. In Lunar and Planetary Inst., Abstracts for the 54th Annual Meeting of the Meteoritical Society p 38 (SEE N92-12901). Abstract Only.

So far we have completed an initial scanning electron microscopy (SEM) survey of craters on the exterior of the Long Duration Exposure Facility (LDEF) in the 100 micron to 1mm size range and done some quantitative analysis. In typical craters, the residue appears to be a mixture of glass and FeNi and sulfide beads with an overall chondritic elemental composition. In less than 10 percent of the craters, there is a substantial amount of meteoroid debris that also contains unmelted mineral grains. The relatively high abundance of forsterite and enststite among these irregular grains suggests that a high melting point probably plays a role in surviving impact without melting. (Author).
N92-12910.

23 AMARI, S., FOOTE, J., JESSBERGER, E. K., SIMON, C., STADERMANN, F. J., (Max-Planck-Inst. fuer Kernphysik, Heidelberg Germany , F.R.)., SWAN, P., WALKER, R., ZINNER, E. "SIMS analysis of extended impact features on LDEF experiment." 1991
Note: Washington Univ., Saint Louis, MO. Center for the Space Sciences. In NASA, Langley Research Center First LDEF Post- Retrieval Symposium Abstracts p 38 (SEE N91-24972). Abstract Only.

Discussed here are the first Secondary Ion Mass Spectroscopy (SIMS) analysis of projectile material deposited in extended impact features on Ge wafers from the trailing edge. Although most capture cells lost their plastic film covers, they contain extended impact features that apparently were produced by high velocity impacts when the plastic foils were still intact. Detailed optical scanning of all bare capture cells from the trailing edge revealed more than 100 impacts. Fifty-eight were selected by scanning electron microscope (SEM) inspection as prime candidates for SIMS analysis. Preliminary SIMS measurements were made on 15 impacts. More than half showed substantial enhancements of Mg, Al, Si, Ca, and Fe in the impact region, indicating micrometeorites as the projectiles. (Author).
N91-25006.

24 ALLBROOKS, MARTHA K., ATKINSON, DALE R., SEE, THOMAS H., (Lockheed Engineering and Sciences Co., Houston TX). HORZ, FRIEDRICH. "Preliminary micrometeoroid and debris effects on LDEF thermal control surfaces." 1991
Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 45 (SEE N91-24972) Abstract Only

Thermal control surfaces on the Long Duration Exposure Facility (LDEF) were exposed to 5.75 years of low-Earth orbit environments. Since LDEF was gravity gradient stabilized and directionally stable, the effects of each of the environments can be distinguished via changes in material responses to hypervelocity impacts. The extent of these effects are being visually and microscopically characterized using thermal control surfaces archived at Johnson Space Center in order to determine the the relationship between environment exposure and resulting ring sizes, delamination areas, and penetration diameters. The characterization of these affected areas will provide spacecraft system designers with the information they require to determine degradation of thermal control systems during satellite lifetimes. (Author).
N91-25014

25. SEE, T., ALLBROOKS, M., ATKINSON, D., SIMON, C., (Washington Univ., Saint Louis ,. MO.); ZOLENSKY M. comps. "Meteoroid and debris impact features documented on the long duration exposure facility: A preliminary report" 1990; NASA-TM-105463. 583P
Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center Houston, TX.

The Long Duration Exposure Facility (LDEF) was host to several individual experiments designed to characterize aspects of the meteoroid and space-debris environment in low-Earth orbit. It was realized from the very start, however, that the most complete way to accomplish this goal was to exploit the meteoroid and debris record of the entire LDEF The Meteoroid and Debris Special Investigation Group (M&D SIG) was organized to achieve this end. Two dominant goals of the M&D SIG are the documentation of the impact record of the entire LDEF. and the dissemination of this information to all interested workers. As a major step towards the accomplishment of these goals, we have prepared this publication describing the M&D SIG observations of impact features made during LDEF deintegration activities at KSC in the spring of 1990. It is hoped that this report will serve as a useful guide for spacecraft designers as well as for meteoroid and space-debris workers, and that it will spur further work on the LDEF impact-laden surfaces collected by the M&D SIG and now available for allocation to qualified investigators. An important aim is to present all data and descriptions of impact features in a form which, though terse, remains comprehensible to the wider community. There is a deliberate minimum of interpretations. Thus, this catalog is intended to serve as a guide to the impact features found on LDEF and is not intended to stand as a definitive interpretive work. (Author).
N92-18270

26. MCKNIGHT D. S., DUEBER, R. E. (U.S. Air Force Academy. Colorado Springs , CO); TAYLOR, E. W., (USAF. Weapons Laboratory , Kirtland AFB, NM) "Space debris and micrometeorite events experienced by WL Experiment 701 in prolonged low earth orbit" 1990; AIAA-Paper-90-3905.
Note: AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27 1990. 17 p.

WL Experiment 701 (Space Environment Effects on Fiber Optic Systems) was housed aboard the Long Duration Exposure Facility (LDEF) and placed into orbit on April 6, 1984, by the Shuttle Challenger. It was retrieved sixty-nine months later by the Shuttle Columbia on January 12, 1990. During this period in orbit, the experiment experienced numerous debris or micrometeorite impacts. Impact flux values, crater characteristics and shock phenomena on the experiment's space exposed surfaces were observed to be similar to returned materials of the Solar Max satellite. This paper presents the analysis of preliminary data, describes data reduction techniques and outlines areas of future study. (Author).
A91-10227

27 SINGER, FRED S. "Particles injected by comets" 1987
Note: George Mason Univ., Fairfax, Va. In ESA, Proceedings of the International Symposium on the Diversity and Similarity of Comets p 433-434 (SEE N88-21884)

Submicron sized particles released by comets into interplanetary (IP) space are discussed. Sensitive impact detectors on Explorer 46 satellite show large increases in flux during certain meteor streams. The total mass and lifetime of

these particles were determined and their electric potential deduced. Space debris, which, in principle, could affect the observations, is shown to be unimportant. A more refined experiment on the Long Duration Exposure Facility (LDEF) to settle crucial problems ragarding IP particles is mentioned. (ESA).
N88-21944.

28. LANGE, G. JESSBERGER, E. K., (Max-Planck-Institut fuer Kernphysik, Heidelberg West Germany); AIGNER, S., IGENBERGS, E., KUCZERA, H., (Muenchen, Technische Universitaet ,. Munich, West Germany). "Chemical fractionation effects during high velocity impact" (COSPAR and IAF, Plenary Meeting, 26th, Topical Meetings and Workshop on Cosmic Dust and Space Debris, 6th, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 6, no. 7, 1986, p. 9-12. 1986;

Dust capture cells on board the LDEF (Long Duration Exposure Facility) satellite were designed to enable the study of the elemental and isotopic composition as well as the size distribution and flux of interplanetary dust particles (IDPs), destructively collected at 500 km altitude over a period of several years. This is a report on simulation experiments of high velocity impacts on the capture cells which have been performed in order to investigate the relationship of the particle's chemical composition before the impact to the composition of the residue on the cell. To that end, both the projectile material and the impact residues have been analyzed with secondary ion mass spectrometry (SIMS). It is found that elemental fractionation occurs during the impact and that the magnitude of fractionation is related to the volatility of the elements. (Author).
A87-44378.

29. KUZCERA, H., IGLSEDER, H., WEISHAUPT, U., IGENBERGS, E. "Acoustic penetration and impact detector for micrometeoroid and space debris application" , 1986.
Note: Technische Univ., Munich (West Germany). Institut fuer Luft-und Raumfahrt. In Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 64-66 (SEE N86-30584)

The Two-Stage Acoustic Penetration and Impact Detector is a simple device for measuring the impact event time, the projectile velocity, the flight path direction and the momentum. The results of laboratory tests have shown that this detector can be used in a wide range of projectile size and velocity. According to measurement purposes the size of the detection area, the distance between the front foil and the target plate and the number of microphones as well as the evaluation procedure can easily be adjusted. The target plate area can also be replaced by another foil detector, if two penetration stages are preferred. This active detector is suitable for a variety of applications in meteoroid and space debris exploration. It can also be supplied with capture cell properties for chemical analysis of inside- deposits. Therefore, this measurement principal has been taken into consideration as a possible flight experiment for instance for a later Longer Duration Exposure Facility (LDEF) flight or future space station activities. (Author).
N86-30594

30. HOERZ, F. ed. "Trajectory determinations and collection of micrometeoroids on the space station." , 1986; NASA-CR-177303.
Note: Lunar and Planetary Inst., Houston, Tex. Workshop held in Houston, Tex., 16-18 Dec. 1985. Report of the Workshop on Micrometeorite Capture Experiments.

Summaries of papers presented at the Workshop on Micrometeorite Capture Experiments are compiled. The goals of the workshop were to define the scientific objectives and the resulting performance requirements of a potential Space Station facility and to identify the major elements of a coherent development program that would generate the desired capabilities within the next decade. Specific topics include cosmic dust and space debris collection techniques, particle trajectory and source determination, and specimen analysis methods. For individual titles see N86-30585 through N86-30607.
N86-30584.

31. SINGER, S. F., (George Mason University, Fairfax VA)., STANLEY, J. E., (Virginia University, Charlottesville; KASSEL, P., (NASA, Langley Research Center, Hampton, VA). "The LDEF interplanetary dust experiment Long Duration Exposure Facility" IN: Properties and interactions of interplanetary dust; Proceedings of the Eighty-fifth Colloquium, Marseille, France, July 9-12, 1984 (A86-42326). Dordrecht, D. Reidel Publishing Co., 1985, p. 117-120. , 1985.

Explorer 46 data and the Long Duration Exposure Facility (LDEF) interplanetary dust experiment are examined. Analysis of the Explorer 46 data reveals the existence of particles of 0.1 micron and a mass of 1 x 10 to the -16th gm, the injection of the submicron particles directly by a comet (injection mass of about 5000 tons), and a submicron particle lifetime of about three years. The applications of LDEF data to particles in hyperbolic orbits, particle swarms, morning-to-evening asymmetry, the effects of the earth's orbit eccentricity, and the presence of interstellar dust are discussed. The effects of space debris on data collection are considered. (I.F.)
A86-42345.

32. KUCZERA, H. (Muenchen, Technische Universitaet , Munich, West Germany). "Dust collectors in space - An experiment of the Technical University of Munich aboard the NASA LDEF long-term mission Staubfaenger im Weltraum - Ein Experiment der Technischen Universitaet Muenchen an Bord der NASA-Langzeitmission LDEF" Luft- und Raumfahrt (ISSN 0173-6264), vol. 6, 3rd Quarter 1985, p. 67-70. In German. 1985.

A dust collecting experiment aboard the NASA Long Duration Exposure Facility (LDEF) is discussed. The LDEF mission is reviewed, and the design and function of the experimental detectors is described. The significance of the experiment for the understanding of micrometeorites and for future comet-related missions is addressed. (C.D.)
A86-12494.

33. FECHTIG, H., JESSBERGER, E., (Max-Planck-Institut fuer Kernphysik, Heidelberg West Germany); HOERZ, F., (NASA, Johnson Space Center Houston, TX); IGENBERGS, E., KUCZERA, H., (Muenchen, Technische Universitaet , Munich, West Germany). "Measurements of the elemental and isotopic composition of interplanetary dust collected on LDEF-Long Duration Exposure Facility" IN: Properties and interactions of interplanetary dust; Proceedings of the Eihty-fifth Colloquium, Marseille, France, July 9-12, 1984 (A86-42326) Dordrecht, D. Reidel Publishing Co., 1985, p. 121-126. 1985.

A passive interplanetary dust collection experiment, currently in orbit aboard the Long Duration Exposure Facility, is described. The collectors, germanium target plates covered by metallized Mylar foils, are designed for secondary ion mass spectrometry measurements of the elemental and isotopic compositions of residues resulting from micrometeoroid (greater than 10 to the -10th grams) impacts. Impact simulation experiments have demonstrated the validity of the collection concept. Quantitative elemental analyses are complicated by the nonuniform distribution of projectile-derived elements. (Author)
A86-42346.

34. SINGER, S. F., (Virginia Univ.); STANLEY J. E., (Virginia Univ); KASSEL, P C. , JR., WORTMAN, J. J., (North Carolina Univ.). "Interplanetary dust experiment (A0201)" 1984.
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. In its Long Duration Exposure Facility (LDEF) p 134-135 (SEE N84-24632).

The objective of this experiment is to study interplanetary dust, variously referred to as cosmic dust, cometary dust, zodiacial dust, or meteoric dust particles. Specific objectives are to obtain information regarding particle mass and velocity, and to undertake correlative analyses with other experiments, both on LDEF or near the time of the LDEF flight. (Author)
N84-24671

35. MCDONNELL, J. A. M., CAREY, W C., DIXON, D G., (Kent, University Canterbury , England). "Cosmic dust collection by the capture cell technique on the Space Shuttle" Nature (ISSN 0028- 0836), vol. 309, May 17, 1984, p. 237-240. 1984.

Results of the Microabrasion Foil Experiment (MFE) to collect cosmic dust on board the Space Shuttle are reported. The experiment used a capture cell to collect microparticles by avoiding selection effects introduced by the deceleration of the particles in the earth's atmosphere. Four hypervelocity impact events were recorded over the eight days of the experiment, yielding one large (23 microns in diameter), and three near- marginal perforations (5.1, 6.5, and 5.7 microns in diameter, respectively). The evidence confirmed the effectiveness of the capture cell technique as a method for the assessment of the near-earth particulate environment. A meteroid bumper to dissipate particle energy

was also found to be effective. The morphology of the perforations are discussed, and it is concluded that the current near-earth microparticle influx model should be revised to account for unexplained morphologies. (I.H.).
A84-34797

36 MCDONNELL, J. A. M., ASHWORTH, D. G., CAREY W. C., FLAVILL, R. P., JENNISON, R. C. "Multiple-foil microabrasion package (A0023)" 1984;
Note: Kent Univ., Canterbury (England). In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 117- 120 (SEE N84-24632).

The specific scientific objectives of this experiment are to measure the spatial distribution, size, velocity, radiance, and composition of microparticles in near-Earth space. The technological objectives are to measure erosion rates resulting from microparticle impacts and to evaluate thin-foil meteor 'bumpers' The combinations of sensitivity and reliability in this experiment will provide up to 1000 impacts per month for laboratory analysis and will extend current sensitivity limits by 5 orders of magnitude in mass. (Author)
N84-24666.

37 MANDEVILLE, J. C. "Study of meteoroid impact craters on various materials (A0138-1)" 1984;
Note: Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 121-123 (SEE N84-24632).

Interplanetary dust particles (micrometeoroids) are expected to form well-defined craters upon impacting exposed mterial in space. Studying the frequency and features of these craters will provide data on the mass-flux distribution of micrometeoroids and, to a lesser extent, on the velocity magnitude and direction. This experiment will study impact craters produced by micrometeoroids on selected materials (metals and glasses in the form of thick targets) to obtain valuable technological and scientific data. Specifically, the studies will focus on determining micrometeoroid composition and mass-flux distribution. Analyses will also be made on the distribution of impact velocity vectors. (B.W.).
N84-24667

38 MANDEVILLE, J. C. "Attempt at dust debris collection with stacked detectors (A0138-2)" 1984;
Note: Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 124-126 (SEE N84-24632).

The primary objective of this experiment is to investigate the feasibility of future missions of multilayer thin-film detectors acting as energy sorter to collect micrometeoroids, if not in their original shape, at least as fragments suitable for chemical analysis. It is expected that this kind of particle collector will help in solving one of the most puzzling topics in cosmic- dust studies: the mineralogical and chemical composition of the particles. This is a matter of great interest in the study of the origin and evolution of the solar system. (Author).
N84-24668.

39. HUMES, D. H. "Space debris impact experiment (S0001)" 1984; Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. In its Long Duration Exposure Facility (LDEF) p 136-137 (SEE N84-24632).

The specific objectives of this experiment are to establish the population and size distribution of meteoroids in the mass range from 10 to the minus 10 power to 10 to the minus 4 power G, to establish the current population of man-made debris in the same mass range, and to obtain data on the physical properties (composition and density) of meteoroids. (Author)
N84-24672.

40 HOERZ, F., MCKAY D. S., MORRISON, D. A., BROWNLEE, D. E., (Washington Univ.); HOUSLEY, R. M., (Rockwell International). "The chemistry of micrometeoroids (A0187-1)" 1984;
Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 127-130 (SEE N84-24632).

The prime objective of this experiment is to obtain chemical analyses of a statistically significant number of micrometeoroids. These data will then be compared with the chemical composition of meteorites. Secondary objectives of the experiment relate to density, shape, mass frequency, and absolute flux of micrometeorids as deduced from detailed crater geometrics (depth) diameter and plane shape, and number of total events observed. (Author).
N84-24669.

41 FOOTE, J. H. SWAN, P D., WALKER, R. M., ZINNER, E. K., BAHR, D., FECHTIG, H., JESSBERGER, E., IGENBERGS, E. KREITMAYR, U., KUCZERA, H. "Chemical and isotopic measurements of micrometeoroids by secondary ion mass spectrometry (A0187-2)" 1984;
Note: McDonnell Center for Space Sciences, St. Louis, Mo. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 131-134 (SEE N84-24632) Prepared in cooperation with Max-Planck-Inst. fuer Kernphysik, Heidelberg and Technische Univ , Munich and Ernst-Mach Inst., Freiburg and Dornier-Werke G.m.b.H., Friedrichshafen (West Germany)

The objective of this experiment is to measure the chemical and isotopic composition of interplanetary dust particles of mass greater than 10 to the minus 10 power G for most of thermator elements expected to be present. (Author).
N84-24670.

42 "Meteoroid damage to spacecraft" 1984;
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. In its Long Duration Exposure Facility (LDEF) p 138 (SEE N84-24632).

The objective of this experiment is to obtain examples of meteoroid impact damage to typical spacecraft components, and by so doing to help establish design approaches to minimize meteoroid damage effects to future spacecraft. The results of the complete inspection of the LDEF will complement and extend the data obtained from specific meteoroid experiments flying in LDEF trays. (Author).
N84-24673.

43. SCHROEDER, B., IGENBERGS, E., KUCZERA, H. (Muenchen, Technische Universitaet ,. Munich, West Germany). "Measurement of velocity and shape of small hypervelocity projectiles in a plasma accelerator" IN: International Congress on High Speed Photography and Photonics, 15th, San Diego, CA, August 21-27 1982, Proceedings. Part 2 (A84-45451). Bellingham, WA, SPIE The International Society for Optical Engineering, 1983, p. 991-995. 1983.

A technique has been developed to measure the velocity and shape of small projectiles accelerated to velocities between 10 and 20 km/s in a plasma accelerator as part of a micrometeoroid simulation. The system consists of a light barrier generated by the multiple reflection of a laser beam between two mirrors. The light reflected by the projectiles when these cross the laser beams is detected by a photomultiplier The time needed for the projectile to reach the position of a laser shadowgraph device and the trigger signal for the camera are provided by a computer. The development of this photographic system as well as experimental results are discussed. (Author).
A84-45521

44 ZINNER, E., (Washington University. St Louis ,MO; Wien, Technische Universitaet ,. Vienna, Austria); PAILER, N., (Washington University, St Louis , MO; Max-Planck-Institut, fuer Kernphysik ,. Heidelberg, West Germany); KUCZERA, H., (Muenchen, Technische Universitaet ,. Munich, West Germany). "LDEF - Chemical and isotopic measurements of micrometeoroids by SIMS Secondary Ion Mass Spectroscopy from Long Duration Exposure Facility" (COSPAR, IUTAM, IAU, and IUGS, Topical Meeting and Symposium on Recent Researches into Solid Bodies and Magnetic Fields in the Solar System, Ottawa, Canada, May 16-June 2, 1982) Advances in Space Research (ISSN 0273-1177), vol. 2, no. 12, 1982, p. 251-253. 1982;

Described is a passive experiment for LDEF (Long Duration Exposure Facility) to measure the chemical and isotopic composition of interplanetary dust particles greater than 10 to the -10th g for most of the major elements expected to be present. The detector consists of Ge targets covered with a metallized plastic film. During impact micrometeoroid vapor and melt are deposited on the underside of the foil which can be analyzed by secondary ion mass spectroscopy (SIMS) after the return of the LDEF Additional information on projectile mass, velocity and density can be obtained from the study of the penetration hole and the impact crater. Criteria for the choice of materials are given and first

results of impact simulation experiments are reported which demonstrate the viability of the basic concept and show that isotopic data can be obtained from the deposits. (Author)
A83-35031

45 SINGER, S. F., STANLEY J. E., (University of Virginia, Charlottesville VA). "Comets produce submicron particles in the solar system" In: Cosmology and astrophysics: Essays in honor of Thomas Gold. (A83-20401 07-90) Ithaca, NY, Cornell University Press, 1982, p. 130-136. 1982;

Observational evidence for the existence of submicron particles issuing from meteor streams and comets is examined. The MTS Explorer 46 carried a meteoroid detector which measured the rate of impact of particles with masses on the order of 10 to the - 16th gram. Particle enhancements were observed in association with meteor streams, such as the Taurid and Orionids. The ratio of radiation pressure to gravity is employed to examine the effects of radiation pressure on the particles. When the ratio is higher than one, particles become smaller unless they are dielectrics. Particles with radii less than 0.1 micron, having a potential of +3.3 V are projected to have a lifetime of about 3 yr Several thousands of tons of submicron particles are expected to be produced during a cometary perihelion passage. Launch of a long duration exposure facility with the Shuttle is recommended for studies of the decay of the particles over time. (M.S.K.).
A83-20409.

46. MANDEVILLE, J. C., (ONERA, Centre d'Etudes et de Recherches de Toulouse, Toulouse, France); MCDONNELL, J. A. M., (Kent University, Canterbury England). "Micrometeoroid multiple foil penetration and particle recovery experiments on board Space Shuttle's Long Duration Exposure Facility /LDEF/" In: Solid particles in the solar system; Proceedings of the Symposium, Ottawa, Canada, August 27-30, 1979. (A81-27751) Dordrecht, D. Reidel Publishing Co., 1980, p. 395-400. 1980.

Four experiments, examining the near-earth micrometeoroid flux for about 12 months, and taking place on the Space Shuttle Long Duration Exposure Facility (LDEF), in 1982, are presented. Crater size distributions and the chemical composition of the impacting particles will be determined through the two thick target experiments. The aim of the Frecopa experiment will be mainly to investigate the feasibility of multilayer thin film detectors to collect micrometeoroids. The microabrasion package (MAP) will provide meter-dimensioned surfaces with micrometer dimensioned sensitivity. It is expected that the double foil penetration on the Frecopa and MPA experiments will yield more information than thick targets because of the evidence of the successive degradation of the particle. It is concluded that particle collection experiments will remain generally difficult at high meteoritic velocities. The lower velocity window for multiple layer foil deceleration proves to be sufficient to expect the retention of material, which is at least partially intact. (K.S.)
A81-27810.

47 IGENBERGS, E., FECHTIG, H., (Max-Planck Inst. fuer Kernphysik). "Investigations of micrometeorite impacts on large surfaces and during long-term missions." 1980; TUM-RT-TB-80/ 12. 73P
Note: Technische Univ., Munich (West Germany) Lehrstuhl fuer Raumfahrttechnik. Sponsored by Bundesministerium fuer Forschung und Technology In German

The number of dust particle impacts expected during space missions was investigated and a long-term experiment is presented in order to study the suitability of Spacelab as a micrometeorite detector. A detailed inventory was made of available information on the dust environment. The dust particle expectancy values are given for several planetary and interplanetary missions mentioned in the Lunar and Planetary Mission Handbook. The heat shield surface of Spacelab modules is not suited for micrometeorite detection due to the relatively short flight time. An experiment is proposed for the second mission of the Long Duration Exposure Facility. This experiment is to obtain information on the dust environment close to the Earth and is to contribute to the development of interplanetary dust measuring devices. (Author (ESA)).
N82-15090.

MISSION PLANNING

1 BRUCE, T N., (NASA, Johnson Space Center Houston, TX). "STS retrieval of satellites" IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 (A86-34951). Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 1-1 to 1-14. , 1985.

The Space Transportation System (STS) provides the capability to retrieve satellites from space. This capability was demonstrated on flights STS 41-C and STS 51-A, and will be demonstrated again on a future flight with the retrieval of the Long Duration Exposure Facility (LDEF) This paper describes the activity required to ensure a successful retrieval from initial flight planning to actual flight operations Attention is given to retrieval hardware necessary for success and manifest. Discussion of flight design to meet all constraints placed on the manifested cargo is included. Flightcrew and flight control team training are addressed. Flight rules, techniques, and procedures development are described and examples given. Mission Control Center (MCC) and Payload Operations Control Center (POCC) operations for integrated testing and actual flight support will be presented. (Author).
A86-34952.

2. YOUNG, K A., (NASA, Johnson Space Center, Houston, TX). "Satellite drag prediction effects on Shuttle mission planning" IN: Conference on Aerospace and Aeronautical Meteorology, 9th, Omaha, NE, June 6-9. 1983, Preprints (A83-38701) Boston, MA, American Meteorological Society, 1983, p. 274-276. , 1983.

Long-term factors, along with Shuttle performance limitations, are considered in order to illustrate the need for more reliable long-term drag (meaning 'solar cycle') prediction techniques. Such techniques would make it possible to confidently plan dual- objective Shuttle flights, which maximize Shuttle cargo loadings and thus reduce costs. In describing the coupled mission concept, it is pointed out that by deploying one payload while retrieving or servicing another, the Space Transportation System can maximize the usefulness of the Shuttle and reduce the cost per customer. It is shown here that the proposed mission coupling LDEF (Long Duration Exposure Facility) with ST (Space Telescope) must be rejected since the Shuttle performance limitations prohibit deployment of the ST at even 315 n mi with a subsequent LDEF retrieval. If, however, it were possible to predict solar cycles, then, depending on the prediction, a mission of this type could be feasible. (C.R.).
A83-38756.

3. BULLOCH, C. "Space Shuttle progress - Nearing the end of the tunnel" Interavia, vol. 35, Oct. 1980, p. 899-906. 1980;

Recent progress in the development of the Space Shuttle is reviewed. Attention is given to the Shuttle propulsion system, noting features such as throttling and vectoring and the use of preburners. Work on the external tank which will result in a possible weight reduction of up to 7,500 lbs is described and the solid rocket boosters and the thermal protection system are discussed. In addition, consideration is given to the electronic systems structure including onboard systems, displays, and launch processing systems. Finally, the STS upper stages, LDEF (long duration exposure facility), and NASA Shuttle plans for the next 20 years are covered. (M.E.P.).
A80-52698.

4. NATHAN, C. A., (Grumman Aerospace Corp., Bethpage N. Y.). "Manned remote work station - Safety and rescue considerations" International Astronautical Federation, International Astronautical Congress, 30th, Munich, West Germany, Sept. 17-22, 1979, 20 p. 1979.
Note: Grumman Aerospace Corp., Bethpage, N.Y

It is noted that due to restrictions of payload and volume limitations of current and projected launch systems, space construction of ultralarge space structures is essential. The present paper discusses the concepts of a key piece of construction equipment needed to support assembly of such large structures. Attention is given to the manned remote work station (MRWS), a universal crew cabin to be used as a construction cherry picker, space crane turret, work station on a construction base rail system, or a free flyer. Concepts and safety and rescue requirements for this spacecraft are delineated for early applications in support of Shuttle operations, as well as applications in support of a mid to late 1980's space construction base. Finally, applications in support of constructing and maintaining a solar power satellite system are covered. (M.E.P.).
A79-53421.

5 LEE, C M. "Planning for STS operations" American Astronautical Society, Annual Rocky Mountain Guidance and Control Conference, Keystone, Colo., Feb. 24-28, 1979. 24 p. 1979

The paper stresses the need for adequate long range planning to ensure successful operation of the Space Transportation System (STS). The STS, built around the Space Shuttle, represents a breakthrough to low cost, large capacity spacecraft from high cost, low capacity expendable launch vehicles. Five major success factors are addressed in particular. These are: new management concepts, new applications, STS enhancement, new space research tools, and new users. Under management concepts, the necessary planning and the automated management information systems to implement it are covered. Enhancement of the STS includes a thrust augmentation option to enable carrying of greater payloads. New tools such as the Long Duration Exposure Facility being developed by NASA, the Multi-Mission Satellite, and the 'Get-Away Special' (GAS) payload cannister are investigated. Also stressed is the need to reach new customers who have previously not participated in space projects due to the high cost and lack of know-how. (M.E.P.).
A79-36547

6. STAEHLE, R. L., (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). "Space experiments and the small-scale investigator" , 1978; AAS-78-132
Note: American Astronautical Society, Anniversary Conference, 25th, Houston, Tex., Oct. 30-Nov. 2, 1978, 18 p.

The paper counsels the small-scale investigator who wishes to conduct experiments in space. Discussed topics include opportunities with existing spacecraft, feasible objectives for experiments conducted in space, procedures for obtaining access to a space program, and the organization of an experimental project. The Space Transportation System, Skylab, Getaway Specials, and the Long Duration Exposure Facility are considered. (M.L.).
A79-21251

7 RAYL, G. J. "Conceptual approach study 200 watt per kilogram solar array, phase 3 Final Report" 1978; NASA-CR-158046. 51P Note: General Electric Co., Philadelphia, Pa. Space Div. Prepared for JPL

Activities are described that were directed by JPL to support the earlier conceptual design work with proof of concept models on the one hand, and laboratory test and evaluation of alternate designs and materials that hold promise for further mass economies, on the other. In support of this advanced solar blanket technology the following work was accomplished: (1) preparation of an 80 cell solar module for a 1000 cycle thermal test (2) fabrication of a 660 cell solar panel and performance evaluation of this article after a '0' g flight test, (3) design improvement of the cell interconnect for further mass reduction, (4) completion of UV exposure and thermal cycle tests for a variety of cell cover material and adhesives and (5) preparation of a quantity of representative solar array test specimens for space flight on NASA's Long Duration Exposure Facility (LDEF). (Author).
N79-14551

8 JOHNSON, R. W., JUND, C. S., NIEMANN, W. J., (USAF Space and Missile Systems Organization, Vandenberg AFB ,. Calif.). "Advanced space programs - Transition to the Space Shuttle" Astronautics and Aeronautics, vol. 14, Sept. 1976, p. 32-39. 1976;

The missions planned by the Space Test Program (a tri-service activity under the management of the U.S. Air Force which provides space test platforms for Department of Defense-sponsored experiments) for the Shuttle Era are discussed. The program will emphasize the use of existing space-vehicle designs and off-the- shelf, space-qualified hardware whenever possible. A Standard Spacecraft with either on-orbit spin or three-axis control is being designed for use with the Space Shuttle. The Standard Spacecraft will consist of four basic modules: core, orientation, propulsion, and payload cluster. A payload structure is designed separately for each experiment group, and the propulsion subsystem is tailored to fit the orbit-insertion requirements of each mission. The Long Duration Exposure Facility, a passive structure to be released from the orbiter for one year stay in orbit, will serve as a platform for some STP experiments. (C.K.D.).
A76-42877

9. DIBATTISTA, J. D., (NASA, Langley Research Center, Hampton, Va.). "Long-duration exposure facility - A new capability for space testing and basic research satellite-borne experiments" , 1976; IAF-76-197
Note: International Astronautical Federation, International Astronautical Congress, 27th, Anaheim, Calif., Oct. 10-16, 1976, 12 p

The reusable Long-Duration Exposure Facility (LDEF), which can accommodate experiments requiring large exposure surface areas, large volumes and/or massive hardware, offers to researchers a new inexpensive opportunity to conduct extended technology and basic research testing in the space environment. Many researchers with interest varying from medical research to astrophysics research will have their experiments performed in the 80 large experiment trays on the first LDEF flight. This paper describes the LDEF and a number of experiments now being developed for the first mission. In particular, this paper illustrates the value of the LDEF features which allow the return of the experiment hardware and repeated flights. ((Author)).
A76-46142.

10. "The space shuttle payload planning working groups. Volume 10: Space technology Final Report" 1973; NASA-TM-X-69457 96P
Note: National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

The findings and recommendations of the Space Technology group of the space shuttle payload planning activity are presented. The elements of the space technology program are: (1) long duration exposure facility, (2) advanced technology laboratory, (3) physics and chemistry laboratory, (4) contamination experiments, and (5) laser information/data transmission technology. The space technology mission model is presented in tabular form. The proposed experiments to be conducted by each test facility are described. Recommended approaches for user community interfacing are included. (Author).
N74-15527

ORBITAL RENDEZVOUS

1 HALL, W. M. "An introduction to shuttle/LDEF retrieval operations: The R-bar approach option orbital mechanics and braking schedule" , 1978; NASA-TM-78668. 180P
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

Simulated orbiter direct approaches during long duration exposure facility (LDEF) retrieval operations reveal that the resultant orbiter jet plume fields can significantly disturb LDEF. An alternate approach technique which utilizes orbital mechanics forces in lieu of jets to brake the final orbiter/LDEF relative motion during the final approach, is described. Topics discussed include: rendezvous operations from the terminal phase initiation burn through braking at some standoff distance from LDEF, pilot and copilot activities, the cockpit instrumentation employed, and a convenient coordinate frame for studying the relative motion between two orbiting bodies. The basic equations of motion for operating on the LDEF radius vector are introduced. Practical considerations of implementing an R-bar approach, namely, orbiter/LDEF relative state uncertainties and orbiter control system limitations are explored. A possible R-bar approach strategy is developed and demonstrated. (Author).
N78-18105.

OXYGEN ATOMS

1 YOUNG, PHILIP R., SLEMP, WAYNE S. "An analysis of LDEF- exposed silvered FEP teflon thermal blanket material" , 1991, NASA-TM-104096. 28P
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

The characterization of selected silvered fluorinated ethylene propylene (FEP) teflon thermal blanket material which received 5 years and 9 months of exposure to the LEO environment on the Long Duration Exposure Facility is reported. X-ray photoelectron spectroscopy, infrared, and thermal analyses did not detect a significant change at the molecular level as the result of this exposure. However, various microscopic analyses revealed a roughening of the

coating surface due to atomic oxygen erosion which resulted in some materials changing from specular reflectors of visible radiation to diffuse reflectors. The potential effect of silicon-containing molecular contamination on these materials is addressed. (Author).
N92-15189.

2. TENNYSON, R. C., KLEIMAN, J., MORISON, W. D. "Atomic oxygen erosion of polymer matrix composites" , 1991.
Note: Toronto Univ. (Ontario). Inst. for Aerospace Studies. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 78 (SEE N91-24972) Abstract Only.

Results are presented on atomic oxygen erosion of circular tubes and flat plates fabricated from different epoxy matrix composites containing, boron and Kevlar fiber reinforcements. The UTIAS experiment was located at station D-12, at 90 deg to the LDEF leading edge which was yawed about approximately 8 to 10 deg relative to the velocity vector. This resulted in enhanced atomic oxygen exposure at D-12, providing a total fluence of about 4 x 10(exp 20) atoms/sq cm. Thickness loss measurements were obtained for both flat plates and cylindrical tubes. The effect of reflected atomic oxygen on erosion yield and surface morphology on back surfaces (not directly exposed to AO) are graphically demonstrated. Erosion yields are also compared with other space flight data for similar materials, and ground-based tests in the UTIAS AO simulator. The effect of angle of incidence on surface morphology, erosion profiles and thickness losses are presented and the results correlated with simulator tests as well. (Author).
N91-25045.

3. TENNYSON, R. C., (Toronto, University Downsview ,. Canada). "Atomic oxygen effects on polymer-based materials" Canadian Journal of Physics (ISSN 0008-4204), vol. 69, Aug.-Sept. 1991, p. 1190-1208. 1991;

This paper describes the operation and performance of an atomic- oxygen (AO) beam facility capable of providing ground-state neutral oxygen atoms at about 2.2 eV for flux levels as high as about 10 exp 16 atoms/(sq cm - s). Results are presented on the AO erosion of polymer thin films and composite materials containing graphite and aramid fibers in epoxy matrices. Comparisons with space flight tests are also given, including studies of samples recently retrieved from a composite-materials experiment on the NASA Long Duration Exposure Facility after 70 months exposure in low earth orbit. Parameters that have been investigated include synergistic effects of UV radiation, surface-morphology changes, and accelerated testing. (Author).
A92-17560.

4. PETERS, PALMER N., (National Aeronautics and Space Administration Marshall, Space Flight Center, Huntsville, AL.); GREGORY, JOHN C. "Pinhole cameras as sensors for atomic oxygen in orbit; application to attitude determination of the LDEF" , 1991.
Note: Alabama Univ., Huntsville. In its Analysis of Surfaces from the LDEF A0114, Phase 4 9 p (SEE N92-11074).

Images produced by pinhole cameras using film sensitive to atomic oxygen provide information on the ratio of spacecraft orbital velocity to the most probable thermal speed of oxygen atoms, provided the spacecraft orientation is maintained stable relative to the orbital direction. Alternatively, as it is described, information on the spacecraft attitude relative to the orbital velocity can be obtained, provided that corrections are properly made for thermal spreading and a co-rotating atmosphere. The LDEF orientation, uncorrected for a co-rotating atmosphere, was determined to be yawed 8.0 minus/plus 0.4 deg from its nominal attitude, with an estimated minus/plus 0.35 deg oscillation in yaw. The integrated effect of inclined orbit and co-rotating atmosphere produces an apparent oscillation in the observed yaw direction, suggesting that the LDEF attitude measurement will indicate even better stability when corrected for a co-rotating atmosphere. The measured thermal spreading is consistent with major exposure occurring during high solar activity, which occurred late during the LDEF mission. (Author).
N92-11078

5. LINTON, ROGER C., REYNOLDS, JOHN M. "Atomic oxygen stimulated outgassing" , 1991.
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 59 (SEE N91-24972). Abstract Only.

The passive Long Duration Exposure Facility (LDEF) Experiment A0034, Atomic Oxygen Simulated Outgassing, consisted of two identical one-sixth tray modules, exposing selected thermal control coatings to atomic oxygen and

the combined space environment on the leading edge and, for reference, to the relative wake environment on the trailing edge. Optical mirrors were included adjacent to the thermal coatings for deposition of outgassing products. Ultraviolet grade windows and metal covers were provided for additional assessment of the effects of the various environmental factors. Preliminary results indicate that orbital atomic oxygen is both a degrading and a optically restorative factor in the thermo-optical properties of selected thermal coatings. There is evidence of more severe optical degradation on collector mirrors adjacent to coatings that were exposed to the RAM-impinging atomic oxygen. This evidence of atomic oxygen stimulated outgassing is discussed in relation to alternative factors that could affect degradation. The general effects of the space environment on the experiment hardware as well as the specimens are discussed. (Author).
N91-25026.

6. GREGORY JOHN C. (University of Alabama, Huntsville); PETERS, P N. "LDEF attitude measurement using a pinhole camera with a silver/oxygen atom detector " , 1991
Note: National Aeronautics and Space Administration. Marshall Space Flight Center Huntsville, AL. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 3 (SEE N91-24972). Abstract Only

A small device designed to measure the orbital attitude stability of the Long Duration Exposure Facility (LDEF) spacecraft is examined. The device used the reaction of Ag with O atoms, which convert the metal to a nonconducting black appearing oxide with high efficiency. The atmosphere at LDEF altitudes consists of more than 90 pct. atomic O. The device is a small hemispheric Ag surface facing a pinhole in a metal plate on the front surface of the satellite. It was expected that the stream of O atoms, travelling at a relatively velocity of 8 km/s would pass through the pinhole and strike the Ag surface at the geometric center producing a circular black spot. In fact, the position of the spot has clearly shown that the LDEF was rotated by 8.0 + or - 0.4 deg from its nominal attitude, but that it was remarkably stable about this offset. The ellipticity of the recorded spot was attributed to a yaw oscillation of + or - 0.2 deg, however it was previously noted, that the co-rotation of the Earth's atmosphere should produce a sweeping of the atom beam vector of ca. + or - 1.5 deg about the surface normal. Such an effect was not visible in this experiment (Author).
N91-24973.

7 GOLDEN, JOHNNY L. "Results of examination of the A-276 white and Z-306 black thermal control paint discs flown on LDEF " 1991
Note: Boeing Aerospace and Electronics Co., Seattle, WA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 72 (SEE N91-24972). Abstract Only

Measurements of optical properties and surface characterization of paint discs on selected tray clamps were carried out and are reported. Analysis shows the loss of organic binder for those specimens exposed to atomic oxygen. A visibly darkened layer up to 2 microns thick exists on the outer surfaces of specimens exposed only to solar radiation. Properties of ground control specimens and flight control specimens, as a function of spacecraft location are reported. Representative examples from a photomicrograph survey and SEM examination are shown. (Author).
N91-25039.

8. FREDERICKSON, A. R., FILZ, R. C., RICH, F J., SAGALYN, PAUL L., (Army Materials, Technology Lab ,. Watertown, MA.). "Patterns of discoloration and oxidation by direct and scattered fluxes, especially oxygen on silicon." 1991
Note: Air Force Geophysics Lab., Hanscom AFB, MA. Space Physics Div. In NASA, Langley Research Center First LDEF Post- Retrieval Symposium Abstracts p 76 (SEE N91-24972). Abstract Only

A number of interesting discoloration patterns are clearly evident on M0002-1 which resides on three faces of LDEF: front face, rear face, and earth face. Most interesting is the pattern of blue oxidation on polished single crystal silicon apparently produced by once-scattered ram oxygen atoms along the earth face. Most of the other patterns are seen in the Thermal Control Paint. Also, severe oxidation of CR-39 polycarbonate occurred on the front face of LDEF. as expected. A complete explanation for the patterns has not yet been obtained. (Author).
N91-25043.

9. FRANZEN, W., BRODKIN, JUDY; SAGALYN, PAUL L. "Ellipsometric study of metal samples." , 1991
Note: Army Materials Technology Lab., Watertown, MA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 74 (SEE N91-24972). Abstract Only.

Exposed and unexposed (shielded) portions of the surfaces of six different metal samples (Al, Cu, Ni, Ta, W, and Zr) that had been mounted on LDEF were studied by variable angle spectroscopic ellipsometry. The change in the optical constants of the metals caused by exposure to the space environment was measured. The measured optical constants reflect changes in the morphology and stoichiometry of a surface layer to a depth of this order of magnitude. For all the samples examined in this manner the exposed and unexposed portions exhibited dramatically different optical properties. In order to determine whether the observed changes were caused by the impact of oxygen atoms encountered in flight an experiment was set up in which samples identical to the original metal samples are exposed to a low-energy oxygen plasma in a microwave discharge chamber. Results of this experiment are reported, as well as an analysis of the observed data in terms of surface layers of different composition. (Author).
N91-25041

10. DEGROH, KIM K. "Atomic oxygen undercutting of LDEF aluminized Kapton multilayer insulation." , 1991.
Note: National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 60 (SEE N91-24972). Abstract Only.

Atomic oxygen undercutting is a potential threat to vulnerable spacecraft materials which have been shielded with an atomic oxygen protective coating. This is due to atomic oxygen attack of oxidizable materials at the point of microscopic defects in the protective coatings which occur during fabrication and handling, or from micrometeoroid and debris bombardment in space. An aluminized Kapton multilayer insulation sample which was flown on the leading edge of the Long Duration Exposure Facility (LDEF) was used to study low Earth orbit (LEO) directed ram oxygen undercutting. Cracks in the aluminized coatings around the vent holes provided excellent locations for evaluation of atomic oxygen undercutting. The undercutting profiles were compared to Monte Carlo models which predict LEO ram atomic oxygen attack. The shape of the undercurrent profile was found to vary with crack width, which is proportional to the number of atomic oxygen atoms entering the crack. The resulting atomic oxygen undercut profiles which occurred on LDEF indicated wide undercut cavities in spite of the fixed ram orientation. Potential causes of the observed undercutting profiles will be presented. Implications of the undercutting profiles relevant to Space Station Freedom will also be discussed. (Author).
N91-25027

11. CHRISTL, LIGIA C., GREGORY, JOHN C., PETERS, PALMER N., (National Aeronautics, and Space Administration. Marshall Space Flight Center, Huntsville, AL.). "Measurements of erosion characteristics for metal and polymer surfaces using profilometry" , 1991.
Note: Alabama Univ., Huntsville. In its Analysis of Surfaces from the LDEF A0114, Phase 4 12 p (SEE N92-11074).

The surfaces of many materials exposed in low earth orbit are modified due to interaction with atomic oxygen. Chemical changes and surface roughening effects can occur which alter optical and other properties. The experiment A0114 contained 128 solid surface samples, half of which were exposed on the front and half on the rear of Long Duration Exposure Facility. Each sample was subjected to many analyses, but only the methods and techniques are described which were used to measure the changes in roughness, erosion depths, and material growth using profilometry. (Author).
N92-11077

12. BRINZA, DAVID E., LIANG, RANTY H., STIEGMAN, ALBERT E. "VUV- induced degradation of FEP Teflon aboard LDEF " , 1991
Note: Jet Propulsion Lab., California Inst. of Tech., Pasadena. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 63 (SEE N91-24972). Abstract Only.

Examination of fluorinated ethylene propylene (FEP) copolymer materials recovered from the Long Duration Exposure Facility (LDEF) reveals differing damage characteristics on leading edge (ram-facing) versus trailing edge (wake-facing surfaces). Silver/ Teflon (Ag/FEP) thermal control materials on ram facing surfaces of the LDEF exhibited obvious degradation, with an apparent increase in diffuse light scattering, whereas identical materials on the wake facing

surfaces showed little apparent damage with cursory inspection. Microscopic examination of both types of surfaces reveals the nature and extent of environment induced degradation of materials. The ram facing surfaces were clearly eroded by atomic oxygen impingement, while the wake facing material developed a thin, highly embrittled surface layer (Author).
N91-25030.

13. BOURASSA, ROGER J., GILLIS, JAMES R. Atomic oxygen flux and fluence calculation for Long Duration Exposure Facility (LDEF). 1991, NASA-CR-187418. 267P
Note: Boeing Co., Seattle, WA. Defense and Space Group.

The LDEF mission was to study the effects of the space environment on various materials over an extended period of time. One of the important factors for materials degradation in low earth orbit is the atomic oxygen fluxes and fluences experienced by the materials. These fluxes and fluences are a function of orbital parameters, solar and geomagnetic activity, and material surface orientation. Calculations of atomic oxygen fluences and fluxes for the LDEF mission are summarized. Included are descriptions of LDEF orbital parameters, solar and geomagnetic data, computer code FLUXAV, which was used to perform calculations of fluxes and fluences, along with a discussion of the calculated fluxes and fluences. (Author).
N92-17215.

14. BOURASSA, R. J., GILLIS, J. R., ROUSSLANG, KEN W. "Atomic oxygen and ultraviolet radiation mission total exposures for LDEF experiments." , 1991
Note: Boeing Aerospace and Electronics Co., Seattle, WA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 48 (SEE N91-24972). Abstract Only

An analytical treatment of the effect of thermal molecular velocity on spacecraft atomic oxygen (AO) flux is presented. The analysis leads to a closed form equation that incorporates the effect of atmospheric temperature, number density, spacecraft velocity, and incidence angle on AO flux. The effects of atmospheric rotation, solar activity, and geomagnetic index on AO flux are also inluded on the computer model. Data developed with the model are presented for the Long Duration Exposure Facility (LDEF). The results incorporate variations in the defining environmental and orbital parameters of the spacecraft over its six year orbital flight. Cumulative ultraviolet solar and albedo exposures were calculated (Author).
N91-25016.

15. BANKS, BRUCE A., RUTLEDGE, SHARON K., DEGROH, KIM K. "Low Earth orbital atomic oxygen, micrometeoroid, and debris interactions with photovoltaic arrays" , 1991
Note: National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH. In its Space Photovoltaic Research and Technology Conference 10 p (SEE N91-30203).

Polyimide Kapton solar array blankets can be protected from atomic oxygen in low earth orbit if SiO sub x thin film coatings are applied to their surfaces. The useful lifetime of a blanket protected in this manner strongly depends on the number and size of defects in the protective coatings. Atomic oxygen degradation is dominated by undercutting at defects in protective coatings caused by substrate roughness and processing rather than micrometeoroid or debris impacts. Recent findings from the Long Duration Exposure Facility (LDEF) and ground based studies show that interactions between atomic oxygen and silicones may cause grazing and contamination problems which may lead to solar array degradation. (Author)
N91-30248.

16. BANKS, BRUCE A., GEBAUER, LINDA; (Cleveland State Univ., OH. "Atomic oxygen interactions with FEP Teflon and silicones on LDEF " , 1991
Note: National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 62 (SEE N91-24972).Abstract Only.

The Long Duration Exposure Facility (LDEF) spacecraft represents the first controlled unidirectional exposure of high-fluence atomic oxygen on fluorinated ethylene propylene (FEP Teflon) and silicones. The atomic oxygen erosion yield for FEP Teflon was found to be significantly in excess of previous low fluence orbital data and is an order of

magnitude below that of polyimide Kapton. LDEF FEP Teflon erosion yield data as a function of angle of attack is presented. Atomic oxygen interaction with silicon polymers results in crazing of the silicones as well as deposition of dark contaminant oxidation products on adjoining surfaces. Documentation of results and possible mechanistic explanations are presented. (Author).
N91-25029.

17 LEE, ALECK L., (Lockheed Missiles and Space Co., Inc Sunnyvale ,. CA). "An expert system for atomic oxygen effect analysis" , 1990; SAE-Paper-901410.
Note: SAE, Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990. 7p.

An atomic-oxygen (AO) fluence expert system (AOxpert) designed as a user-friendly software package emulating the way the problem is approached by human experts is presented. In a problem- formulation phase, it is shown that the human expert draws his expertise from an available database compiled from previous flight experiences and test results and makes appropriate decisions. The AOxpert system consists of knowledge bases and inference algorithm, while the analytical power of the system comes from an orbit model and a neutral atmospheric model. The output provides a report of the total AO fluence and the predicted mass loss; a pass or fail flag is available if a threshold value is specified. Fluence calculations performed for the Space Station Freedom and Long Duration Exposure Facility are presented. (V T.).
A90-49419.

18. GREGORY, J. C. "Surface interaction mechanisms of 5eV atomic oxygen: Data analysis from the UAH experiment on STS-8." , 1987; NASA-CR-181141 23P
Note: Alabama Univ., Huntsville. Dept. of Chemistry. Final Report.

The University of Alabama in Huntsville (UAH) experiment which flew on the STS-8 mission had several objectives which were mostly of a speculative nature since so little was known of the processes of interest. The experiment provided original, if limited, data on: (1) oxidation of metal surfaces, (2) reaction rates of atomic oxygen with carbon and other surfaces and the dependence of these rates on temperature, and (3) the angular distribution of 5eV atoms scattered off a solid surface. Provided is a review of the results, with reference given to fuller published accounts where these are available. (Author).
N87-25447

19. GREGORY, J. C. "Partial analysis of experiment LDEF A-0114." 1986; NASA-CR-179236. 6P
Note: Alabama Univ., Huntsville. Dept. of Chemistry. Annual Report for period ending 31 May 1986.

Due to delays in manifesting the return of the Long Duration Exposure Facility from space, attention was concentrated on extracting the maximum information from the EIOM-2 (oxygen interaction with materials experiment) flown on STS-8 in September 1983. An analysis was made of the optical surfaces exposed during that flight and an assessment made of the effect of the 5 eV atomic oxygen upon their physical and chemical properties. The surfaces studied were of two types: high-purity thin films sputtered or evaporated onto 2.54-cm diam lambda/20 fused silica optical flats, and highly polished bulk samples. Rapid etching of carbon and carbonaceous surfaces was observed with polycarbonate CR-39 showing the largest etch of any substrate flown and measured. Of the metals tested, only osmium and silver showed large effects, the former being heavily etched and the later forming a very thick layer of oxide. The first measurable effects on iridium, aluminum, nickel, tungsten and niobium thin films are reported. (M.G.).
N88-14787

20. GREGORY, J. C., (Alabama Univ., Huntsville; PETERS, P N. "The production of glow precursors by oxidative erosion of spacecraft surfaces" , 1985.
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala. In its 2d Workshop on Spacecraft Glow p 174-179 (SEE N86-13239).

Erosion rates of organic materials are measured during a recent flight of the shuttle (STS-8). Several forms of carbon and a variety of thermosetting and thermoplastic polymers are exposed to the ram beam of atomic oxygen. Arrhenius energies of about 1000 to 2000 cal/mole were measured from the rate dependencies on temperature. If some simple assumptions are made about the chemical nature of the desorbed species, the data can be used to estimate

production rates at surfaces in orbit under different conditions of temperature, oxygen atom flux, and material surface conditions. (Author).
N86-13257

21 SCOTT R. L. ,. JR., (Southern Univ.); LINTON, R. C. "Atomic- oxygen stimulated outgassing (A0034)" 1984;
Note: National Aeronautics and Space Administration. Marshall Space Flight Center Huntsville, Ala. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 11-13 (SEE N84- 24632).

The objective of this experiment is to determine if the impingement of atomic oxygen in near-Earth orbit is a major factor in producing optically damaging outgassed products. The expected results will be to obtain samples which have been exposed to atomic oxygen for long durations. Analysis of these samples will determine if the impingement of atomic oxygen on the thermal control surfaces stimulates a significant amount of outgassed products. This experiment will give a clearer picture of the contamination problem and will assist in assuring that future Shuttle payloads, such as the Space Telescope and High- Energy Astronomy Observatory, will not experience Skylab contamination levels. Selected thermal control surfaces will be exposed to the atomic oxygen in near-Earth orbit. Passive collecting samples will collect any induced outgassing resulting from oxygen impingement. The optical condition of the passive samples will be measured using a ground-based integrating sphere reflectometer and a directional reflectometer (R.J.F.).
N84-24635.

22 GREGORY, J. C., (Alabama Univ.); PETERS, P N. "Interaction of atomic oxygen with solid surfaces at orbital altitudes (A0114)" 1984;
Note: National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 14-18 (SEE N84- 24632).

The basic approach to this experiment is to expose a wide variety of material surfaces to the atomic flux in orbit. The experiment is passive and depends on preflight and postflight measurements of the test surfaces in the laboratory. The experiment will also include a reflectometer device to measure atomic beam reflection angles and thus momentum accommodations, and a unique passive spacecraft attitude sensor. Samples consisting of solid disks or thin film coatings on substrate disks will be mounted in a panel. The face of this panel will be flown on Long Duration Exposure Facility normal to the incident stream of oxygen atoms. Each disk will have part of its front surface masked so exposure to the atomic-oxygen reaction will be limited to selected areas, the shadowed areas being used as control surfaces in the measurements. A typical sample is an optically flat quartz disk overcoated with a film of the material of interest. These include Ag, Au, Pt, Nb, Ni, Al, C, Si, Ge, LiF, and a few engineering materials. Some materials for which the expected removal rate is high, such as carbon, will be solid disks rather than thin films. (R.J.F.).
N84-24636.

PROPELLANT STORAGE

1 LESTER, DEAN M., JONES, LEON L., SMALLEY, R. B. ,JR., ORD, R. NEIL. "Space aging of solid rocket materials." 1991
Note: Thiokol Corp., Brigham City, UT In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 92 (SEE N91-24972). Abstract Only

Solid rocket propellant and rocket motor components were aged in a vented container on the interior of the LDEF. The results of aging IPSM-II/PAM-DII space motor components are presented. Ballistic and mechanical properties of the space aged main propellant, igniter propellant, and ignition system were compared with similar data from preflight and ground aged samples. Mechanical properties of the composite materials and bonded joints used in the motor case, insulation, liner, nozzle, exit cone, and skirt were similarly evaluated. The space aging results are compared to data collected in a ground based vacuum aging program on similar components. (Author).
N91-25058.

2 CHEN, OLIVER T., HARTWELL, JAMES A., (Thiokol Corp., Elkton MD). "Long-Duration-Exposure Facility space aging of Star motor components" , 1991, AIAA-Paper-1854.
Note: AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, SaCA, June 24-26, 1991. 8 p.

The performance characteristics of Star solid rocket propellant and related motor materials are described with respect to the NASA Long-Duration Exposure Facility (LDEF) experiment. Real-time space aging results are compared to vacuum studies conducted on the ground in terms of weight loss, propellant hardening, bondline strength decay, and nozzle material properties. Results of the space environment exposure of 5.75 years correspond to those of the vacuum studies. Weight loss and bondline strength decay are found to be negligible, propellant hardening is normal, and nozzle material properties are unchanged. An increase in binder-filler bonding in propellant specimens is the only reported change that is characterized as important. Ground-based vacuum testing is shown to be an effective method for evaluating the effects of space exposure on space motor materials. (C.C.S.).
A91-41635.

3. JONES, L. L., SMALLEY R B. ,. JR. "Space aging of solid rocket materials (P0005)" 1984;
Note: Morton Thiokol, Brigham City. Utah. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 94-96 (SEE N84-24632).

The objective of this experiment is to determine the effects of long-term orbital exposure on the materials used in solid-rocket space motors. Specifically, structural materials and propellants from the STAR/PAM-D series motors and the PAM DII/IPSM-II motors will be tested, as well as advanced composite case and nozzle materials planned for future use. The experiment approach is to expose samples of solid-rocket propellant, liner, insulation, case, and nozzle specimens to the space environment and to compare preflight and postflight measurements of various mechanical, chemical, and ballistic properties. (M.G.).
N84-24659.

4. UDLOCK, D. E. "Storage of solid propellants in a dry environment mechanical properties resulting from long term exposure to aerospace environments" 1978; NASA-CR-158073. 21P
Note: Jet Propulsion Lab., California Inst. of Tech., Pasadena.

Storage of solid propellants in either a dry or a vacuum environment causes a significantly greater increase in the propellants' modulus and maximum tensile strength than does ambient storage. It is postulated that these physical property changes can be attributed to the effect trace amount of moisture has on the bond between the propellants' binder and oxidizer (Author).
N79-15200

5. UDLOCK, D. E. "Storage of solid propellants in space" 1977
Note: Jet Propulsion Lab., California Inst. of Tech., Pasadena. In APL JANNAF Struct. and Mech. Behavior Working Group, Vol. 1 p 13-22 (SEE N78-13220).

A test program is described which determines the extent of physical property changes that result from extended space exposure. Primary emphasis was placed on determining the effects of space vacuum. Solid propellants were stored and their physical properties tested in a vacuum and in a dry environment. The storage caused significantly greater increases in the propellants' modulus and maximum tensile strength than occurred in parallel ambient stored samples. The data indicate that the loss of trace amounts of residual moisture from cured propellant is the apparent cause of the observed propellant property changes. Therefore, initial screening tests were carried out under dry storage conditions. Upon completion of the dry storage tests, appropriate propellant samples are exposed to an actual space environment using the Long Duration Exposure Facility (LDEF). (Author).
N78-13222.

SEEDS

1 GRIGSBY, DORIS K. "Space Exposed Experiment Developed for Students (SEEDS) P-0004-2" 1991
Note: Oklahoma State Univ., Stillwater. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 130 (SEE N91-24972). Abstract Only

This cooperative endeavor of NASA Headquarters, the NASA Langley Research Center, and the George W. Park Seed Company, resulted in the distribution, by the end of March, 1990, of approximately 132,000 space exposed experiment developed for students (SEEDS) kits to 64,000 teachers representing 40,000 classrooms and 3.3 million kindergarden through university students. Kits were sent to every state, as well as to 30 foreign countries. Preliminary radiation data indicates that layer A received 725 rads, while layer D received 350 rads. Germination rate was reported to be 73.8 percent for space exposed seeds and 70.3 percent for earth based control seeds. Tests conducted within the first six months after retrieval indicated space exposed seeds germinated in an average of 8.0 days, while earth based control seeds' average germination rate was 8.3 days. Some mutations (assumed to be radiation induced) reported by students and Park Seed include plants that added a leaf instead of the usual flower at the end of the flower front and fruit produced from a flower with a variegated calyx bore seeds producing albino plants, while fruit from a flower with a green calyx from the same plant bore seeds produced green plants. (Author).
N91-25095.

2. ALSTON, JIM A. "Seeds in space experiment results." 1991
Note: Park (George W.) Seed Co., Inc., Greenwood, SC. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 129 (SEE N91-24972). Abstract Only.

Two million seeds of 120 different varieties representing 106 species, 97 genera, and 55 plant families were flown aboard the Long Duration Exposure Facility (LDEF). The seeds were housed on the space exposed experiment developed for students (SEEDS) tray in sealed canister number six and in two small vented canisters. The tray was in the F-2 position. The seeds were germinated and the germination rates and development of the resulting plants compared to the control seed that stayed in Park Seed's seed storage facility. The initial results are presented. There was a better survival rate in the sealed canister in space than in the storage facility at Park Seed. At least some of the seeds in each of the vented canisters survived the exposure to vacuum for almost six years. The number of observed apparent mutations was very low. (Author).
N91-25094.

3. PARK, G. B. , JR., ALSTON, J. A. "Seeds in space experiment (P0004-1)" 1984;
Note: Park (George W.) Seed Co., Inc., Greenwood, S.C. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 146-147 (SEE N84-24632).

The specific objectives of this experiment are to evaluate the effects of space radiation on the survivability of seed stored in space under sealed and vented conditions and to determine possible resulting mutants and changes in mutation rates. (Author).
N84-24675.

4. GRIGSBY D. K. "Space-exposed experiment developed for students" 1984;
Note: National Aeronautics and Space Administration, Washington, D. C. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 148-150 (SEE N84-24632).

This experiment will offer students the opportunity to evaluate the survivability of seeds stored in the space environment and to determine possible mutants and changes in the mutation rate which may occur. The objectives of this experiment are to involve a very large number of students in a national project to generate interest in science and related disciplines; to offer students from the elementary through the university level an opportunity to participate in a first-hand experiment with materials flown in space; to permit active involvement in classroom experiment design, decision making, data gathering, and comparison of results; and to emphasize a multidisciplinary approach to the project involving subject areas other than science. (B.W.).
N84-24676.

SOLIDIFICATION

1 BAILEY J. A., WHITFIELD, J. K. "Solidification under zero gravity· A Long Duration Exposure Facility (LDEF) experiment for an early space shuttle mission. Semiannual Report" 1976; NASA-CR-146338. 28P
Note: North Carolina State Univ , Raleigh. Dept. of Mechanical and Aerospace Engineering.

The preliminary design of two series of simple experiments the objectives of which are to determine the effect of an absence of gravity on (1) the general morphology of the structure, (2) location of ullage space, and (3) magnitude of surface tension driven convection, during the solidification of several metallic and nonmetallic systems is described. Details of the investigative approach, experimental procedure, experimental hardware, data reduction and analysis, and anticipated results are given. (Author).
N76-18182.

SPACE DEBRIS

1 DITTBERNER, GERALD J., (Kaman Sciences Corp., Alexandria VA)., ELDER, JEFF: (Kaman Sciences Corp. Huntsville AL)., STEEL, DUNCAN; (Spaceguard Pty. Ltd., Adelaide University ,. Australia). "Orbital debris damage estimates using coupled pre- and post- impact calculations" 1991 AIAA-Paper-91-0302.
Note: AIAA, Aerospace Sciences Meeting, 29th, Reno, NV Jan. 7- 10, 1991 11 p.

This paper describes results of a joint effort to couple an orbital-debris collision probability model with an impact damage model. Collision probabilities are produced as a function of velocity and angle of impact on a sample satellite. Damage produced by such an incoming projectile is estimated with semiempirical software called KNAPP (Kaman New Analytic Penetration Program) originally developed for SDI. For purposes of illustration, the orbit of the Long Duration Exposure Facility is used for collision probability calculations, and a generic satellite structure is used for impact damage computations. Results indicate that the two methodologies can be successfully coupled together to provide likely damage as a function of impact velocity and orientation of specific surfaces of a satellite. (Author).
A91-21448.

2 BUNCH, T E., DIBROZOLO, F RADICATI; FLEMING, RONALD H., HARRIS, DAVID W., BROWNLEE, DON E., REILLY TERRENCE W., (Hitachi Scientific Instruments, Mountain View ,. CA.). "LDEF impact craters formed by carbon-rich impactors." , 1991.
Note: National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 40 (SEE N91-24972). Abstract Only.

Two small craters (number 74, 119 microns, and number 31 158 microns in diameter) with depth to diameter ratios of about 0.59 and 0.8, respectively, were found in Al from the Long Duration Exposure Facility (LDEF) experiment tray A11EOOF). Both craters have residues concentrated in the crater bottoms, along the walls, and on top of the overturned rims. Low voltage scanning electron electron microscopy, Auger electron spectroscopy. time of flight secondary ion mass spectroscopy and energy dispersive x-ray spectroscopy were used to obtain high resolution imagery and elemental analysis. Analyses indicate that the impactor for both craters was carbon-rich, as the residues contain mostly C. Silicon, S, and F in low concentrations are present on the Al surface away from the craters and may be, in part, contaminants. (Author).
N91-25008.

3. BROPHY, THOMAS G., (Tokyo University. Japan. "Does debris from the formation of other planetary systems impact earth?" Icarus (ISSN 0019-1035), vol. 94, Nov. 1991, p. 250-254. 1991,

Model size distributions for the ejected debris from extrasolar planet formation are used to calculate the small and large particle fluxes impacting earth, on the assumption that the framework of the standard solar system formation scenario can be applied to other planetary systems. Long Duration Exposure Facility-detected and Kharkov radar-detected impactors with extrasolar velocities are interpretable along these lines, as are several recovered meteorites. (O.C.). A92-15771

4. ATKINSON, DALE R., ALLBROOKS, MARTHA K., WATTS, ALAN J. "LDEF data correlation to existing NASA debris environment models. " , 1991
Note: POD Associates, Inc., Albuquerque, NM. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 43 (SEE N91-24972) Abstract Only

Since the Long Duration Exposure Facility was gravity gradient stabilized and did not rotate, the directional dependence of the flux can be easily distinguished. During the deintegration of LDEF, all impact features larger than 0.5 mm into aluminum were documented for diameters and locations. In addition, all diameters and locations of all impact features larger than 0.3 mm into Scheldahl G411500 thermal control blankets were also documented. This data, along with additional information collected from LDEF materials archived at NASA Johnson Space Center (JSC) on smaller features, will be compared with current meteoroid and debris models. This comparison will provide a validation of the models and will identify discrepancies between the models and the data. (Author).
N91-25011

SPACE PROCESSING

1 TENNYSON, R. C., SALANSKY, N., MORISON, W. D., FISHBEIN, G. "Materials processing in space" , 1989.
Note: Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies. In its Activities of the University of Toronto Institute for Aerospace Studies p 90-91 (SEE N92-13975)

Several programs are currently underway at the University of Toronto Institute for Aerospace Studies (UTIAS) in the area of materials processing in space, including: (1) the design and development of some hardware components for a NASA space-based molecular beam epitaxy facility for growing thin films; (2) a continued evolution of a multipurpose test bed, capable of supporting a range of demonstration experiments on NASA's KC-135 microgravity aircraft, designed to prepare a television program on microgravity science; (3) the development and testing of atomic oxygen, temperature, vacuum, and ultraviolet resistant thermal control materials and coatings for spacecraft applications; and (4) evaluation of material degradation of composite samples recovered from the Long Duration Exposure Facility. (CISTI).
N92-13984.

2. NIELSEN, KJELD FLEMMING; (Danmarks Tekniske Hojskole, Lyngby Denmark)., LIND, M. DAVID; (Rockwell International Science Center, Thousand Oaks ,. CA). "Solution crystal growth on the Apollo-Soyuz, the Spacelab, the LDEF, and the EURECA missions" IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 2 (A87- 32276). Tokyo, AGNE Publishing, Inc., 1986, p. 2111-2116. , 1986.
Room temperature crystal growth from solution in microgravity may potentially offset the convection-driven instabilities that degrade the process on earth. The process of interest, opposite oriented diffusion (OOD), comprises allowing two or more reactant solutions to diffuse toward each other. The crystalline material precipitates in the central region. Calcium tartrate, calcium carbonate and lead sulfide crystals were grown on the Apollo- Soyuz mission. Spacelab missions have featured 12 attempts to grow tetrathiafulvalene-tetracyanoquinodimethane (TTF-TCNQ) crystals, and improvements made with experience are summarized. The reactor employed to grow TTF-TCNQ on the Long Exposure Duration Facility is described, as is the apparatus to be used on the EURECA free-flyer to carry out three trials in OOD (synthetic alloys and CaCO crytals). (M.S.K.).
A87-32558.

3. BOUDREAULT, RICHARD; ESCHER, RICK; CATERALL, CHRIS; (Canadian Astronautics Ltd., Space Systems Div., Ottawa, Canada). "Present and future scenarios for Canadian materials processing in space" IN: Space Station: Gateway to space manufacturing; Proceedings of the Conference, Orlando, FL, Nov. 7, 8, 1985 (A87-25451). Arlington, VA, Pasha Publications, 1985, 25 p. , 1985.

Technological and economic aspects of space materials processing are reviewed, with an emphasis on Canadian scientific and commercial programs. The useful properties of the space environment are described; the effects of microgravity disturbances on materials processing are considered; the payload, power availability, altitude, and

duration of current and planned microgravity support systems such as Shuttle GAS and Hitchhiker, Space Station, Eureca, Leasecraft, and LDEF are listed in a table and discussed; Canadian activities are outlined; and cost analyses of the available options are presented graphically. It is concluded that specialized unmanned free flyers are the most viable commercial space-processing option (combining low cost and a high-quality microgravity environment), but that manned missions are essential for performing basic research and R&D work. (T.K.).
A87-25454.

4. NIELSEN, K. F., (Danmarks Tekniske Hojskole, Lyngby Denmark). "Crystal growth in the microgravity environment" IN: Symposium on Industrial Activity in Space, Stresa, Italy, May 2- 4, 1984, Proceedings (A85-38901). Paris, Eurospace, 1984, p. 308- 320. , 1984.

The designs of space experiments on crystal growth from aqueous solutions are presented, and some preliminary results are briefly characterized. One potential application of microgravity crystal growth, the production of high-purity low-dimensional-conductor organic crystals such as tetrathiafulvene- tetracyanoquinodimethane (TTF-TCNQ) by opposite-orientation diffusion, is discussed. Of the 12 experiments flown on the first Spacelab mission (STS-9), only the four involving calcium tartrate were successful; these results demonstrate the need for teflon filters at the valve openings to protect the growth chamber Experiments on TTF-TCNQ are underway on the Long- Duration-Exposure Facility and planned for the European Recoverable Carrier Drawings and photographs of typical crystals and the experiment modules are provided. (T.K.).
A85-38912.

5. LIND, M. D., NIELSEN, K. F., (Technical Univ. of Denmark). "Growth of crystals from solutions in low gravity (A0139A)" 1984;
Note: Rockwell International Corp., Thousand Oaks, Calif. Science Center. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 8-10 (SEE N84-24632).

The objective of the low gravity crystal growth experiments is to develop a novel solute diffusion method for growing single crystals. The experiments will utilize specially designed reactors with three or more compartments separated by valves to keep the reactant solutions and solvent separated until the apparatus reaches low gravity There will be a mechanism for opening the valves automatically to initiate the diffusion and growth processes. The reactant reservoirs will be large enough to take advantage of the time provided by the Long Duration Exposure Facility (LDEF) flight. An array of several reactors will be mounted in a 12-in.-deep end center tray located on the Earth- facing end of the LDEF. Several reactors operating simultaneously will allow experimentation with more than one crystal growth system and/or variations of conditions for each. The reactors will be enclosed in a vacuum tight container and will be surrounded by thermal insulation. The temperature (approximately 35 deg C) will be regulated and any departures from the desired temperature will be recorded. Power requirements will be provided by LiSO2 batteries. (R.J.F.).
N84-24634.

6. THOMSEN, S. "Solution growth facility, phase A design study. executive summary EURECA" , 1983; ESA-CR(P)-1946. 23P
Note: Terma Elektronisk Industri A/S, Lystrup (Denmark). Space Group.

The technical layout of the EURECA Solution Growth Facility (SGF) was derived from similar facilities developed for Spacelab First Payload and Long Duration Exposure Facility. The SGF system is a multiuser modular facility using qualified hardware and software where cost effective. Each SGF oven module consists of a chamber containing the multiuser reactor vessels. This gives equipment flexibility for other types of experiments which require stable temperature in the range 20 to 80C, e.g., vapor phase epitaxy. (Author (ESA)).
N85-20006.

7 LIND, M. D., NIELSEN, K. F., (Technical Univ. of Denmark, Lyngby. "LDEF experiments: Crystal growth by a solute diffusion process" , 1983.
Note: In ESA Mater Sci. under Microgravity p 167-174 (SEE N83-31637) Sponsored by Space Flight Corporation of Denmark Ltd.

An LDEF investigation of the diffusion of two reactant solutions toward each other through a region of pure solvent in which they react chemically to form single crystals is outlined. Calcium carbonate, lead sulfide and TTF-TCNQ are used. The experiments are expected to yield crystals superior in size and in structural and compositional perfection to those obtained on Earth. The crystal growth reactors, reactor enclosure, process controller, and electric power supply system are described. Thermal design requirements are discussed. (Author (ESA)).
N83-31664.

8. RICHMAN, D. W. "Electrophoresis operations in space" 1982
Note: McDonnell-Douglas Corp., St. Louis, Mo. In NASA. Johnson Space Center Satellite Serv. Workshop, Vol. 1 p 307-319 (SEE N83-11175).

Application of electrophoresis in space processing is described. Spaceborne experiments in areas such as biological products and FDA approved drugs are discussed. These experiments will be carried on shuttle payloads. (B.W.).
N83-11191

9. LIND, M. D., TAYLOR, N. G., (Rockwell International Corp., Thousand Oaks , CA). "LDEF experiment - Crystal growth by solute diffusion processes Long Duration Exposure Facility" In: Material and process applications - Land, sea, air, space; Proceedings of the Twenty-sixth National Symposium and Exhibition, Los Angeles, CA, April 28-30, 1981 (A81-44326) Azusa, CA, Society for the Advancement of Material and Process Engineering, 1981, p. 738-747 , 1981

Certain kinds of single crystals, which are slightly soluble in a particular solvent, can be grown from solutions by solute diffusion processes. In such processes, two or more reactant solutions diffuse together and react chemically at controlled rates. In these processes, a gel separates the two reactant solutions. When the gravitational force is small enough to make convection and sedimentation negligible, as in an orbiting space laboratory, the gel is not needed and can be replaced by a region of pure solvent. The first Long Duration Exposure Facility (LDEF) flight will provide the first opportunity for fully exploring the potential of the process. Accordingly, in cooperation with a Danish group, a solute diffusion crystal growth experiment package to be carried in the first LDEF flight has been built. (G.R.).
A81-44387

10. MOORE, R. G., (Thiokol Corp., Ogden Utah). "Materials research opportunities in the Space Shuttle small self-contained payload program" In: Selective application of materials for products and energy; Proceedings of the Twenty-third National Symposium and Exhibition, Anaheim, Calif., May 2-4, 1978. (A79- 20801) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1978, p. 21-33. , 1978.

NASA's Space Transportation System will make it possible to conduct materials research under microgravity conditions in a much more rigorous and comprehensive fashion than heretofore possible. Space Shuttle Orbiters carrying Spacelab cylindrical modules and attached pallets will provide opportunities for complex, man-attended materials experiments in dedicated missions ranging from seven to thirty days in duration. Attention is given to Spacelab and Long Duration Exposure Facility experiments, small self-contained payloads, operational procedures, the payload interface vibration environment, materials experiment possibilities, and educational opportunities. Several hundred immiscible metallic combinations can be solidified under microgravity conditions and tested for unusual semiconducting and superconducting properties. (G.R.).
A79-20804.

11 BAILEY J. A. "Solidification under zero gravity: A Long Duration Exposure Facility (LDEF) experiment for an early space shuttle mission. Final Report project planning" 1976; NASA- CR-148160. 91P
Note: North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering.

Project planning for two series of simple experiments on the effect of zero gravity on the melting and freezing of metals and nonmetals is described. The experiments will be performed in the Long Duration Exposure Facility, and their purpose will be to study· (1) the general morphology of metals and nonmetals during solidification, (2) the location of ullage space (liquid-vapor interfaces), and (3) the magnitude of surface tension driven convection during solidification of metals and nonmetals. The preliminary design of the experiments is presented. Details of the investigative approach, experimental procedure, experimental hardware, data reduction and analysis, and anticipated results are given. In addition a work plan and cost analysis are provided. (Author). N76-28242.

SPACEBORNE EXPERIMENTS

1 STRGANAC, THOMAS W., FARROW D A., LETTON, ALAN; WILLIAMS, KEVIN D., ROCK, NEIL I., (Texas A&M University, College Station). "Analysis and simulation of polymers exposed to low earth orbit (LEO) environments" , 1992; AIAA-Paper-92-0849.
Note: AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV Jan. 6-9, 1992 8 p.

Several analytical and mechanical tests have been conducted on the exposed specimens and control specimens placed in LEO by NASA's Long Duration Exposure Facility Satellite to differentiate relative changes in mechanical behavior Tests including dynamic mechanical analysis (DMA), DSC, size-exclusion chromatography, FTIR, and SEM have also been conducted to identify chemical and morphological properties. The results of the DMA studies, i.e., the viscoelastic characterization of the polymeric samples, are discussed. (R.E.P.).
A92-29615.

2 REITZ, G., (DLR, Institut fuer Flugmedizin, Cologne, Federal Republic of Germany). "Preliminary total dose measurements on LDEF" (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5. F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 369-373. 1992;

Data are presented on the measurements of absorbed dose of cosmic rays with the lithium fluoride thermoluminescence dosimeters (TLDs) that are part of the Free Flyer Biostack Experiment which is part of the NASA Long Duration Exposure Facility (LDEF). The twenty stacks of the Biostack are back on earth after spending nearly 6 yrs in the earth orbit. The paper discusses the major objectives of the Free Flyer Biostacks attached to the surface of the LDEF, the Biostack experimental units, and the flight parameters of the LDEF. Absorbed dose measurements are presented for three TLDs behind different shieldings in front of the dosimeters. Since most of the exposure time was spent during a period of minimal solar activity, the results can be regarded as representative for a solar minimum situation. (I.S.).
A92-20921

3. YAUNG, J. Y., WONG, W. C., BLAKKOLB, B. K., RYAN, L. E., (TRW Inc., Redondo Beach ,. CA. Space and Technology Group). "LDEF SP- HVDE (space plasma-high voltage drainage experiment) post-flight data on spacecraft leakage current and discharge" , 1991
Note: In NASA, Langley Research Center, First LDEF Post- Retrieval Symposium Abstracts p 98 (SEE N91-24972) Abstract Only

Two identical SP-HVDE (Space Plasma-High Voltage Drainage Experiment) trays were designed and fabricated and were flown in the NASA LDEF in the LEO environment. The trays were placed with one near the leading edge and one near the trailing edge, and investigation was performed to compare the environmental interactions on the dielectric samples of the two trays. The original objective was successfully achieved by measuring the first in-flight long term average leakage current through 156 coulometers. Less than 5 percent anomalous behavior of the coulometers were found in the post flight analysis. (Author)
N91-25064.

4. STAUBER, MICHAEL C., CHANG, J., KANTORCIK, T "Thermoluminescent dosimeter measurements and analysis for LDEF experiment M0006" , 1991
Note: Grumman Aerospace Corp., Bethpage, NY In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 21 (SEE N91-24972) Abstract Only

Glow curve measurements are reported up to 600 C of (Thermoluminescent Dosimeter Measurement) TLD-100 (LiF) samples deployed on Long Duration Exposure Facility (LDEF) and retained as ground control. Lab exposure simulations are also reported with Co-60 radiation, low energy light ions and high energy protons in an effort tc

replicate the glow curves, especially the high temperature peaks observed in the LDEF TLD specimens. The evidence to date clearly shows the effect of inflight anneal on the low temperature part of the glow curve. It also shows that the high temperature part of the glow curve appears due to ion dose deposition. Initial correlations between high temperature glow peaks and effective LET of the registered dose is given. (Author).
N91-24990.

5. SEELEY J. S., HAWKINS, G. J., HUNNEMAN, R. "Exposure to space radiation of high-performance infrared multilayer filters" 1991
Note: Reading Univ (England). Infrared Multilayer Lab. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 110 (SEE N91-24972) Abstract Only

The University of Reading experiment exposed IR interference filters and crystal substrates on identical earth facing and leading-edge sites of the Long Duration Exposure Facility (LDEF). Filters mostly comprised multilayer coatings of lead telluride (PbTe)/II-IV on germanium (Ge) and other substrates: crystals comprised CdTe, MgF2, sapphire, quartz, silicon, and some softer materials. Identical control samples were maintained in the laboratory throughout the experiment. The filters were novel in their design, construction and manufacture, and categorized high- performance because of their ability to resolve emission spectra of the important atmospheric gases for various purposes in remote sensing. No significant changes were found in the spectra of the hard-coated filters or in the harder crystals (the softer materials were degraded to an extent). By virtue of this well- documented and long exposure in LDEF, the qualification of the filter type is significantly improved for its future requirements. (Author).
N91-25076.

6. SCHUERGER, ANDREW C., NORMAN, BRET L., ANGELO, JOSEPH A. , JR., (Science Applications, International Corp , Melbourne, FL.). "Survival of epiphytic bacteria from seed stored on the Long Duration Exposure Facility (LDEF)" , 1991
Note: In NASA, Langley Research Center, First LDEF Post- Retrieval Symposium Abstracts p 133 (SEE N91-24972) Abstract Only

This study was designed to determine the survival of microorganisms exposed to the relatively harsh conditions found in low Earth orbit (LEO). Seed of corn, sunflower, canteloupe, zucchini, bean, pea, and pumpkin cultivars were packaged in two 18 x 2.5 cm aluminum tubes; wall thickness for each tube was 1.33 mm. One seed tube was attacked to payload M0006, tray C-2; a second tube was stored at room temperature in a lab on Earth. Five lithium fluoride thermoluminescent dosimetry wafers (TLD-100 wafers) were placed in each aluminum tube. The total mean dosages for flight and ground-control TLD wafers were 210.0 and 0.9 rads, respectively. Seeds were washed for 2 hrs in a phosphate buffered saline solution. Bacteria were isolated by plating samples of the seed-washings onto dilute tryptic soy agar. Pure isolates of morphologically distinct bacteria were obtained by standard microbiological procedures. Bacteria were grouped according to colony-type and preliminary identification was completed using a fatty-acid analysis system. Bacillus spp. were the primary microoganisms that survived on seed during the experiment. Bacterial diversity and relative abundance were similar for the ground flight seed. Bacillus subtilus, B. pumilus, B. licheniformis, B. polymyxa, B. megaterium, and B. pabuli were isolated most frequently. Members of the genera Kurthia, Listeria, Micrococcus, and Arthrobacter were also isolated from flight and ground control seed. Results support the hypothesis that terrestrial microorganisms can survive long periods of time in the relatively harsh LEO environment. (Author).
N91-25098.

7 SAGALYN, PAUL L. "Measurement of the O18 to O16 isotope ratio for characterizing oxide surface layers on LDEF samples " , 1991
Note: Army Materials Technology Lab., Watertown, MA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 49 (SEE N91-24972) Abstract Only.

Calculations indicate that measurement of the O-16 to O-18 isotope ratio in oxide layers formed on the surfaces of the Long Duration Exposure Facility (LDEF) samples would provide a powerful tool for distinguishing between layers formed at high altitudes and layers formed at low altitudes, as for example during the retrieval of a satellite. In principle, this ratio may be used to date the formation of the oxide layers. (Author).
N91-25017

8. RUTLEDGE, SHARON K., OLLE, RAYMOND M., (Cleveland State Univ., OH. "Durability evaluation of photovoltaic blanket materials exposed on LDEF tray S1003" , 1991
Note: National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 96 (SEE N91-24972) Abstract Only.

Several candidate protective coatings on Kapton and uncoated Kapton were exposed to the LEO environment on the LDEF in order to determine whether the coatings could be used to protect polymeric substrates from degradation in the LEO environment. These materials are used for flexible solar array panels in which the polymer is the structural member that supports the solar cell and current carriers. Arrays such as these are used on the Hubble Space Telescope and will be used on Space Station Freedom. The results of the experiments are presented. (Author).
N91-25062.

9. REITZ, G., BUECKER, H., FACIUS, R., HORNECK, G., SCHAEFFER, M., SCHOTT J. U., BAYONOVE, J., BEAUJEAN, R., BENTON, E. V , DELPOUX, M., (Toulouse Univ , France. "First biological and dosimetric results of the free flyer biostack experiment AO015 on LDEF" 1991
Note: Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.). Biophysics Div. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 131 (SEE N91-24972) Abstract Only.

The main objectives of the Biostack Experiment are to study the effectiveness of the structured components of the cosmic radiation to bacterial spores, plant seeds, and animal cysts for a long duration spaceflight and to get dosimetric data such as particle fluences and spectra and total doses for the Long Duration Exposure Facility orbit. The configuration of the experiment packages allows the localization of the trajectory of the particles in each biological layer and to correlate the potential biological impairment or injury with the physical characteristics of the responsible particle. Although the Biostack Experiment was designed for a long duration flight of only nine months, most of the biological systems show a high hatching or germination rate. Some of the first observations are an increase of the mutation rate of embryonic lethals in the second generation of Arabidopsis seeds, somatic mutations, and a reduction of growth rates of corn plants and a reduction of life span of Artemia salina shrimps. The different passive detector systems are also in a good shape and give access to a proper dosimetric analysis. The results are summarized, and some aspects of future analysis are shown. (Author).
N91-25096.

10. PIPPIN, H. GARY; MULKEY, OWEN; VERZEMNIEKS, JURIS; MILLER, EMMETT; HILL, SYLVESTER G., DURSCH, HARRY "Survey of results from the Boeing modules on the M0003 experiment on LDEF " , 1991
Note: Boeing Aerospace and Electronics Co., Seattle, WA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 81 (SEE N91-24972) Abstract Only.

The Boeing modules on the M0003 experiment included fiber optics, ceramic materials, a variety of electronic piece parts, composites and thermal control paints, fasteners, thin film lubricants, anodized surfaces, and adhesives. These materials were flown on the leading and trailing edge exteriors, and on the interior portion of LDEF M0003 providing exposure under three distinct environments. The condition of each of these material types is described. Results of optical, surface, and mechanical properties are presented. (Author).
N91-25048.

11. PETERS, PALMER N., (National Aeronautics and Space Administration Marshall, Space Flight Center, Huntsville, AL.); GREGORY, JOHN C., CHRISTL, LIGIA C., RAIKAR, GANESH N. "Effects on LDEF exposed copper film and bulk" , 1991
Note: Alabama Univ., Huntsville. In its Analysis of Surfaces from the LDEF A0114, Phase 4 8 p (SEE N92-11074).

Two forms of copper were exposed to the Long Duration Exposure Facility (LDEF) Mission 1 environment: a copper film, initially 74.2 plus or minus 1 1 nm thick sputter coated on a fused silica flat an a bulk piece of oxygen-free, high conductivity (OFHC) copper. The optical density of the copper film changed from 1.33 to 0.70 where exposed, and the film thickness increased to 106.7 plus or minus 0.5 nm where exposed. The exposed area appears purple by reflection and green by transmission for the thin film and maroon color for the bulk copper piece. The exposed areas increased in thickness, but only increase in the thickness of the thin film sample could be readily measured. The

increase in film thickness is consistent with the density changes occurring during conversion of copper to an oxide. However, we have not been able to confirm appreciable conversion to an oxide by x-ray diffraction studies. We have not yet subjected the sample to e- beams or more abusive investigations out of concern that the film might be modified. (Author).
N92-11076.

12 NIELSEN, KJELD FLEMMING; LIND, M. DAVID; (Rockwell International Science Center, Thousand Oaks , CA.). "Results of the TTF-TCNQ- and the calcium carbonate-crystallization on the Long Duration Exposure Facility" 1991
Note: Technical Univ of Denmark, Lyngby Physics Lab. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 128 (SEE N91-24972). Abstract Only

Experiment AO139A on the Long Duration Exposure Facility (LDEF) carried four large containers into orbit for five years with crystal growth solutions for lead sulfide, calcium carbonate, and tetra thiafulvalene- tetra cyanoquino methane (TTF-TCNQ). The LDEF was in excellent condition after the long orbital stay, and although the temperature data was lost, the experiment program had been working since the valves in all containers were opened. All four experiments produced crystals; however they were of varying quality The calcium carbonate crystals had the best appearance. The TTF-TCNQ crystals were packed together near the valve openings of the container When taken apart, the single crystals showed some unusual morphological properties. X-ray investigations as well as conductivity measurements on the long duration space grown TTF-TCNQ crystals are presented, and pictures of the calcium carbonate are shown. Comparisons are made with previous space solution growth experiments on the European Spacelab Mission and the Apollo-Soyuz Test Project. (Author).
N91-25093.

13. MILLER, EMMETT; PORTER, DAVE; SMITH, DAVE; BROOKS, LARRY; LEVORSEN, JOE; MULKEY OWEN. "LDEF electronic systems: Successes, failures, and lessons" 1991
Note: Boeing Aerospace and Electronics Co., Seattle, WA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 119 (SEE N91-24972). Abstract Only

Following the Long Duration Exposure Facility (LDEF) retrieval, the Systems Special Investigation Group (SIG) participated in an extensive series of tests of various electronic systems, including the NASA provided data and initiate systems, and some experiment systems. Overall, these were found to have performed remarkably well, even though most were designed and tested under limited budgets and used at least some nonspace qualified components. However, several anomalies were observed, including a few which resulted in some loss of data. The postflight test program objectives, observations, and lessons learned from these examinations are discussed. All analyses are not yet complete, but observations to date will be summarized, including the Boeing experiment component studies and failure analysis results related to the Interstellar Gas Experiment. Based upon these observations, suggestions for avoiding similar problems on future programs are presented. (Author).
N91-25085.

14. MANDEVILLE, J. C., (ONERA, Centre d'Etudes et de Recherches de Toulouse, France). "Study of cosmic dust particles on board LDEF - The FRECOPA experiment" (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 101-107 1991;

A French experiment partly devoted to the detection of cosmic dust has been flown on the Long Duration Exposure Facility (LDEF), launched in April 1984, and retrieved in January 1990. A variety of sensors and collecting devices will make possible the study of cosmic particles after recovery of exposed material. Remnants of particles, suitable for chemical identification are expected to be found within the stacked foil detectors. Discrimination between true cosmic particles and man-made orbital debris is expected. (Author).
A92-18664.

15. LIND, DON. "The Interstellar Gas Experiment (IGE)" , 1991
Note: Utah State Univ., Logan. Dept. of Physics. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 47 (SEE N91-24972). Abstract Only.

The Interstellar Gas Experiment (IGE) exposed thin metallic foils in order to collect neutral particles from the interstellar gas. These particles were entrapped in the foils along with precipitating magnetospheric and ambient atmospheric particles. Seven of these foils collected particles arriving from seven different directions as seen from the spacecraft for the entire duration of the Long Duration Exposure Facility (LDEF) mission. The authors' mass spectroscopy analysis of the noble gas component of these interstellar particles detected isotopes of helium and neon. These preliminary measurements suggest that the various isotopes are occurring in approximately the expected amounts and that their distribution in direction of arrival is close to what models predict. The analysis to subtract the background fluxes of magnetospheric and atmospheric particles is still in progress. The hope of this experiment is to investigate the noble gas isotopic ratios of this interstellar sample of matter which originated outside the solar system. (Author).
N91-25015.

16. JOHNSTON, ALAN R., BERGMAN, LARRY A., HARTMAYER, RON. "LDEF fiber optic exposure experiment." , 1991
Note: Jet Propulsion Lab., California Inst. of Tech., Pasadena. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 114 (SEE N91-24972). Abstract Only.

Ten fiber optic cable samples of different types were exposed in low Earth orbit for over 5.5 years on the Long Duration Exposure Facility (LDEF). Four of the samples were mounted externally, and the remaining six were internal, under approximately .5 gc/sq m of aluminum. The experiment was recovered in January of 1990, and laboratory evaluation of the effects of the exposure has continued since. An increase in loss, presumed to be from radiation darkening, aging effects on polymer materials used in cabling, unique contamination effects on connector terminations, and micrometeoroid impacts were observed on some of the samples. In addition, the dependence of sample loss was measured as a function of temperature before and after the flight. All cable samples were functional, and the best exhibited no measurable change in performance, indicating that conventional fiber optic cables can perform satisfactorily in spacecraft. Experimental results obtained to date will be presented and discussed. (Author).
N91-25080.

17 HODGSON, RANDALL R., HOLSEN, JAMES N., DRERUP ROBERT A. ,. JR., (Air Force, Wright Aeronautical Labs., Wright-Patterson AFB, OH.). "Post-flight characterization of optical system samples, thermal control samples, and detectors from LDEF experiment M0003, sub-experiments 6 and 13." , 1991
Note: McDonnell-Douglas Electronics Co., Saint Louis, MO. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 102 (SEE N91-24972). Abstract Only.

Flight samples and control samples of optical and thermal control coatings were measured for hemispheric reflectance and transmission. The samples were exposed directly to the orbital environment, but were on the trailing edge of the LDEF satellite. Preliminary analysis shows no significant change in the reflectance of transmission values of most of the samples. Post- flight tests of avalanche photodiodes is also discussed. (Author).
N91-25068.

18. HICKEY JOHN R. "Passive exposure of Earth radiation budget experiment components LDEF experiment AO-147· Post-flight examinations and tests." . 1991
Note: Eppley Lab., Inc., Newport, RI. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 111 (SEE N91-24972) Abstract Only

The Passive Exposure of Earth Radiation Budget Experiment Components (PEERBEC) experiment of the Long Duration Exposure Facility (LDEF) mission was composed of sensors and components associated with the measurement of the earth radiation budget (ERB) from satellites. These components included the flight spare sensors from the ERB experiment which operated on Nimbus 6 and 7 satellites. The experiment components and materials as well as the pertinent background and ancillary information necessary for the understanding of the intended mission and the results are described. The extent and timing of the LDEF mission brought the exposure from solar minimum between cycles 21 and 22 through the solar maximum of cycle 22. The orbital decay, coupled with the events of solar maximum, caused the LDEF to be exposed to a broader range of space environmental effects than were anticipated.

The mission spanned almost six years concurrent with the 12 year (to date) Nimbus 7 operations. Preliminary information is presented on the following: (1) the changes in transmittance experienced by the interference filters; (2) the results of retesting of the thermopile sensors, which appear to be relatively unaffected by the exposure; and (3) the results of the recalibration of the APEX cavity radiometer. The degradation and recovery of the filters of the Nimbus 7 ERB are also discussed relative to the apparent atomic oxygen cleaning which also applies to the LDEF (Author).
N91-25077

19 GYETVAY, S. R., FISHMAN, LAANA, MESHISHNEK, M. J. "Long Duration Exposure Facility experiment M0003 deintegration observations." , 1991
Note: Aerospace Corp., El Segundo, CA. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 80 (SEE N91-24972) Abstract Only

The four trays of the M0003 materials experiment on LDEF contained over 1200 test articles from 19 subexperiments. The complete tests article complement represented a broad range of materials, including thin film optical coatings, paints, polymer sheets and tapes, adhesives, and composites, for use in various spacecraft applications including thermal control, structures, optics, and solar power. All of the test articles were examined individually using bright field, dark field, and Nomarski light microscopy techniques. The condition of the test articles were photo-documented and observed global and anomalous effects were recorded for the benefit of the subexperimenters. (Author).
N91-25047

20. DURSCH, HARRY; SPEAR, STEVE. "On-orbit coldwelding." 1991 Note: Boeing Aerospace and Electronics Co., Seattle, WA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 121 (SEE N91-24972). Abstract Only.

Spacecraft mechanisms are required to operate in the space environment for extended periods of time. A significant concern to the spacecraft designer is the possibility of metal to metal coldwelding or significant increases in friction. Coldwelding can occur between atomically clean metal surfaces when carefully prepared in a vacuum chamber on earth. The question is whether coldwelding occurs in orbit service conditions. The results of the System Special Investigation Group's (SIG's) investigation into whether coldwelding had occurred on any Long Duration Exposure Facility (LDEF) hardware are presented. The results of a literature search into previous ground based anomalies is also presented. Results show that even though there have been no documented on-orbit coldwelding related failures, precautions should be taken to ensure that coldwelding does not occur in the space environment and that seizure does not occur in the prelaunch or launch environment. (Author).
N91-25087

21 DURIN, CHRISTIAN. "Post flight system analysis of FRECOPA (AO 138)." 1991
Note: Centre National d'Etudes Spatiales, Toulouse (France). In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 123 (SEE N91-24972). Abstract Only.

The unexpected duration for the flight of the Long Duration Exposure Facility (LDEF) conducted CNES to create a special investigation group in order to analyze all the materials and systems which compose the French Cooperative Payload (FRECOPA) except the experiments especially prepared for the flight. The FRECOPA tray was on the trailing face (V-) of the LDEF and protected from the atomic oxygen flux during all the flight. However, the solar irradiation was very important with solar flux quite perpendicular to the experiment once an orbit. There was also a good vacuum environment. The objectives are to test the effects of the combined space environment on materials and components like: structure, thermal control coatings and blankets, electronic unit, motors, and mechanical fixtures. When the LDEF returned to Kennedy Space Center, a visual inspection showed the very good behavior of the materials used and it was noted that the three mechanisms to open and close the experiment canisters worked completely. Many impacts of micrometeoroids or space debris on the structure and on the thermal protections were observed. After FRECOPA was brought back to Toulouse, many tests were performed and include: working order tests, mechanical tests (tension), optical and electronic microscopy (SEM), surface analysis (ESCA, SIMS, RBS, AUGER, etc.), thermal analysis, pressure measurements, and gas analysis (outgassing tests). The results of these experiments are discussed. (Author).
N91-25089.

22. DUNBAR, BONNIE J., (NASA, Washington DC). "A materials scientist in space - 1990 MRS Fall Meeting Plenary Address" MRS Bulletin (ISSN 0883-7694), vol. 16, May 1991 p. 36-41 1991,

An edited version of astronaut Bonnie J. Dunbar's Plenary Address at the 1990 MRS Fall Meeting is presented. The Shuttle program is briefly reviewed with emphasis on the microgravity environment experiments conducted aboard the Columbia in January 1991 In particular, protein crystal growth experiments resulted in growing morphologically uniform crystals with sizes in the 400-500 micron range are discussed. The Long-Duration Exposure Facility intended to study the effects of atomic oxygen and the ultraviolet light environment in low earth orbit on materials has been successfully retrieved. Some research areas of future flights are noted. (O.G.).
A91-37028.

23. CHRISTI, L., GREGORY, JOHN C., RAIKAR, G. N., WEIMER, J. J., WISER, R. "Chemical analysis of metal and polymer surfaces on the front and rear LDEF " , 1991
Note: Alabama Univ., Huntsville. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 56 (SEE N91-24972). Abstract Only

The University of Alabama in Huntsville experiment AO114 contained 128 solid surface samples, half of which were exposed on the front and half on the rear of the Long Duration Exposure Facility (LDEF). Each sample is being subject to a battery of analysis methods. In poster form, details of the x-ray photoelectron spectra, Auger electron spectra, Fourier Transform Infrared and ATR infrared spectra, high resolution profilometry, and scanning electron microscope imagery will be presented from a selection of metal and non-metal surfaces. (Author).
N91-25023.

24. BUNCH, T E., RADICATLDIBROZOLO, F., FITZGERALD, RAY (Diafin, La Jolla ,. CA.). "LDEF post-retrieval evaluation of exobiology interests." , 1991
Note: National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA. In NASA, Washington, Fourth Symposium on Chemical Evolution and the Origin and Evolution of Life p 110 (SEE N92-13588). Abstract Only

Cursory examination of the Long Duration Exposure Facility (LDEF) shows the existence of thousands of impact craters of which less than 1/3 exceed 0.3 mm in diameter the largest crater is 5.5 mm. Few craters show oblique impact morphology and, surprisingly, only a low number of craters have recognizable impact debris. Study of this debris could be of interest to exobiology in terms of C content and carbonaceous materials. All craters greater that 0.3 mm have been imaged and recorded into a data base by the preliminary examination team. Various portions of the LDEF surfaces are contaminated by outgassed materials from experimenters trays, in addition to the LDEF autocontamination and impact with orbital debris not of extraterrestrial origin. Because interplanetary dust particles (IDP's) nominally impacted the LDEF at velocities greatr than 3 km/s, the potential for intact survival of carbonaceous compounds is mostly unknown for hypervelocity impacts. Calculations show that for solid phthalic acid (a test impactor), molecular dissociation would not necessarily occur below 3 km/s, if all of the impact energy was directed at breaking molecular bonds, which is not the case. Hypervelocity impact experiments (LDEF analogs) were performed using the Ames Vertical Gun Facility. Grains of phthalic acid and the Murchison meteorite (grain diameter = 0.2 for both) were fired into an Al plate at 2.1 and 4.1 km/s respectively. The results of the study are presented, and it is concluded that meaningful biogenic elemental and compound information can be obtained from IDP impacts on the LDEF (Author).
N92-13664.

25. BONNEMASON, FRANCIS. "Ruled and holographic gratings experiment (AO 138-5). " , 1991
Note: Instruments Service Aerodynamique, Longjumeau (France). Grating Dept. In NASA, Langley Research Center First LDEF Post- Retrieval Symposium Abstracts p 109 (SEE N91-24972). Abstract Only

Experiments on the the Long Duration Exposure Facility involving the study of the behavior of diffraction gratings, ruled replica, holographic, and ion etched masters with a long exposure to the space environment are discussed. To separate the metallic coatings compartment, some mirrors were added to the experiment. In order to be free from grating senescence on ground, one set of reference compounds was stored. Two sets of compounds were loaded,

exposed, and shaded typed, in order to differentiate vacuum influences and sun illuminatio, cosmic dust, and radiation incidences. The investigation of possible damages was operated according to the fundamental triple point of view of wavefront flatness, absolute efficiency, and stray light level. (Author).
N91-25075.

26. BLUE, M. D. "LDEF active optical system components experiment." 1991
Note: Georgia Tech Research Inst., Atlanta. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 103 (SEE N91-24972). Abstract Only.

A preliminary report on the Active Optical System Components Experiment is presented. This experiment contained 136 components in a six-inch deep tray including lasers, infrared detectors and arrays, ultraviolet light detectors, light-emitting diodes, a light modulator, flash lamps, optical filters, glasses, and samples of surface finishes. The experimental results for those component characteristics appear as much related to the passage of time as to the effects of the space environment, but organic materials and extreme-infrared reflectivity of black paints show unexpected changes. (Author).
N91-25069.

27 ASSIE, JEAN PIERRE; PEROTTO, ALFRED. "Effects of ultravacuum and space environment on contact ohmic resistance (AO 138-11)" , 1991
Note: Aerospatiale, Cannes (France). In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 124 (SEE N91-24972). Abstract Only

The experiment was aimed at checking compatibility of the aluminum conductors with conventional conductors and contacts under different conditions of manufacturing (mechanical or magnetostrictive crimping) and storage in laboratory or in long- duration space environment. The electrical characteristics of connections built from nickel-plated conductors and glided copper contacts were noted to vary over the duration of the experiment. These variations are unrelated with the crimping or storage conditions or with metal pairing (nickel-plated aluminum/tinned or silver copper). Such evolutions, even slight, are detrimental to connection quality The same observations hold for some like connections subjected to long-duration thermal cycles. Therefore, work on aluminum technology was reoriented toward a silver aluminum conductor/ golded aluminum contact solution. The first evaluation test performed according to this definition have yielded satisfactory results. (Author).
N91-25090.

28 ASSIE, JEAN PIERRE; CONDE, ERIC; (Centre National d'Etudes Spatiales, Toulouse France). "Microwelding of various metallic materials under ultravacuum (AO 138-10) " 1991
Note: In NASA, Langley Research Center First LDEF Post- Retrieval Symposium Abstracts p 125 (SEE N91-24972) Abstract Only.

The first finding from the AO 138-10 is that cold welding never occurred, and that microwelds didn't even affect the reference (presumably microweld prone) pairs of metals consisting of gold, silver, and chromium. The scientific disappointment from these results must be tempered by the notion of a static AO 138-10 experiment, reflecting the passive character of the global Long Duration Exposure Facility (LDEF) flight. Thus far, it has been theorized that cold welding results from the peeling of the oxide layer that is formed in an earth environment, by the space environment since such a layer no longer grows in space. In fact, such stripping of the oxide layer supposes relative motion of the contacting materials. In the absence of such motion, as in this experiment, oxidation will preserve its integrity and continue to prevent microwelding. More bewildering is that there was no microwelding of the reference pairs. Even though AO 138-10 failed scientific expectations, as did the LDEF structure with cold welding, the positive, functional aspect to keep in mind is the safe operation of single-shot (appendage releasing and/or latching) mechanisms unhindered by microwelding in a space vacuum, as now demonstrated by the statically representative pairs of materials. Other aspects of the experiment are discussed. (Author).
N91-25091

29. AHEARN, J. S., VENABLES, J. D. "Study of factors determining the radiation sensitivity of quartz crystal oscillators (AO189). " , 1991
Note: Martin Marietta Labs., Baltimore, MD. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 116. (SEE N91-24972). Abstract Only

Quartz resonators fabricated from two different grades of quartz material and selected for their susceptibility to radiation damage as determined by transmission electron microscopy (TEM), were tested prior to the LDEF flight. These resonators were then flown on the LDEF mission where they were exposed to the radiation environment of low Earth orbit. Post-flight tests were then conducted to determine any differences in resonator performance caused by the space exposure. Results of the TEM analysis of the quartz material and preflight and postflight measurements of the flight resonators and of the space and ground based control resonators are presented. Further planned work on the TEM analysis of the quartz materials will also be outlined. (Author).
N91-25082

30. "LDEF Experiment P0006 Linear Energy Transfer Spectrum Measurement (LETSME) quick look report. " 1990: NASA-CR- 184115. 49P
Note: Eril Research, Inc., Corte Madera, CA. Final Report.

A preliminary analysis of the various passive radiation detector materials included in the P0006 LETSME experiment flown on LDEF (Long Duration Exposure Facility) is presented. It consists of four tasks: (1) readout and analysis of thermoluminescent detectors (TLD); (2) readout and analysis of fission foil/mica detectors; (3) readout and analysis of (6)LiF/CR-39 detectors; and (4) preliminary processing and readout of CR-39 and polycarbonate plastic nuclear track detectors (PNTD). (Author).
N91-19223.

31 MCDONNELL, J. A. M., STEVENSON, T J., TULLOCH, S. M., GREEN, S. F., (Kent University, Canterbury England). "In-situ studies of cosmic dust and primordial bodies - The plan ahead" British Interplanetary Society, Journal (ISSN 0007-084X), vol. 42, July 1989, p. 315-322. 1989;
Note:

Multinational projects undertaken for the study of cosmic dust and primordial bodies are described. Consideration is given to the Long Duration Exposure Facility, the Timeband Capture Cell Experiment, and the Space Station Freedom facilities. Also discssed are the Mir space station, Ulysses, Cassini, the Comet Rendezvous and Asteroid Flyby mission, and Rosetta. (K.K.).
A89-48147

32 KINARD. WILLIAM H., JONES, JAMES L. , JR. "The Long Duration Exposure Facility material experiments" 1989.
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. In its NASA/SDIO Space Environmental Effects on Materials Workshop, Part 1 p 101-105 (SEE N89-23528)

In the early 1970s, the NASA Office of Aeronautics and Space Technology (OAST) approved the Long Duration Exposure Facility (LDEF) Project. The LDEF project provided NASA and other U.S. and foreign research organizations with opportunities to perform critical technology and science experiments in space using the LDEF and the Space Shuttle. Many of the experiments which were developed and are flying on the first LDEF mission are experiments to investigate the effects of the space environment on materials. An overview is provided for these materials experiments. The LDEF was placed in orbit by the shuttle orbiter Challenger in April 1984, and it was to have been retrieved approximately 1 year later. The Challenger accident, however, has delayed the retrieval more than 4 years. The LDEF retrieval is now manifested on Flight 32 in July 1989. Since the facility and experiments will have been in space almost 5-1/4 years when they are retrieved, they will be a national trove of science and technology data. (Author).
N89-23534.

33. ROTHGEB, T M., (PRC Kentron, Inc Hampton , VA). "Determination of density and coefficient of thermal expansion of a liquid at low temperature" 1986; AIAA-Paper-86-1280.
Note: AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 5p.

This paper presents the results of an experiment used to determine the density and coefficients of thermal expansion of two silicone oils in the temperature range of 25 C to -57 C. The experimental procedure is described, which is simple, yet accurate (approximately two percent error in the density) and can be constructed at low cost with readily available materials. The results are compared with manufacturer's data, and suggestions are made as to ways that the experiment could be modified to obtain better accuracy at a slightly higher cost. (Author).
A86-39893.

34. LIND, DON. "Instellar Gas Experiment (IGE): Testing interstellar gas particles to provide information on the processes of nucleosynthesis in the big bang stars and supernova. " , 1985; NASA-CR-186713. 19P
Note: Utah State Univ., Logan. Dept. of Physics Final Report.

The Interstellar Gas Experiment (IGE) is designed to collect particles of the interstellar gas - a wind of interstellar media particles moving in the vicinity of the solar system. These particles will be returned to earth where the isotopic ratios of the noble gases among these particles will be measured. IGE was designed and programmed to expose 7 sets of six copper-beryllium metallic collecting foils to the flux of neutral interstellar gas particles which penetrate the heliosphere to the vicinity of the earth's orbit. These particles are trapped in the collecting foils and will be returned to earth for mass-spectrographic analysis when Long Duration Exposure Facility (LDEF) on which IGE was launched, is recovered. (Y.S.).
N91-14097

35. DELABOUDINIERE, J. P., CHAUVINEAU, J. P., MARIOGE, J. P., (CNRS Laboratoire, de Physique Stellaire et Planetaire, Verrieres-le-Buisson, France). "Space qualification of multilayered optics" IN: Applications of thin-film multilayered structures to figured X-ray optics; Proceedings of the Meeting, San Diego, CA, August 20-22, 1985 (A87-10956). Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 44- 48. CNRS-CNES-supported research. , 1985.

The feasibility for the ESA SOHO mission, of spectrally selected normal incidence telescopes in the XUV wavelength range is demonstrated in an evaluation of multilayered mirrors illuminated by the sun. Worst case solar vacuum tests of unprotected telescopes illuminated by a xenon arc lamp simulator indicate less than 10 percent decrease in reflectivity of the exposed section of the Hf/Si sample for the secondary mirrors. Primary mirror tests are currently being performed aboard the NASA Long Duration Exposure Facility. Results of protecting filter tests suggest a growth from 40-100 A in the thickness of the two aluminum oxide layers protecting the aluminum, in contradiction to previous findings (Hunter et al., 1973). (R.R.).
A87-10957

36. DAHL, F "The role of the DFVLR project management life sciences in the space program of the Federal Republic of Germany" , 1985.
Note: Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Bereich fuer Projekttraegerschaften. In its Proceedings and Program Draft in Gravitational Biology in the Federal Republic of Germany (DFVLR- Mitt-85-16) p 9-20 (SEE N86-29514) In GERMAN;

The German space program in cooperation with ESA and NASA is focussed on Spacelab 1 mission, on Eureca mission, the Long Duration Exposure Facility, the International Microgravity Laboratory, Spacelab D2 mission, as well as on bioracks, European Radiation Assembly and Human Physiology Laboratory. Experiments are carried out in radiobiology, exobiology, physiology, botany, microbiology, rhythmic processes, and biotechnology. The DFVLR project management and the experiment/project selection procedure by scientific advisory committees are presented. (ESA).
N86-29515.

37. VENABLES, J. D., AHEARN, J. S. "Study of factors determining the radiation sensitivity of quartz crystal oscillators (A0189)" 1984;
Note: Martin Marietta Labs., Baltimore, Md. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 173- 175 (SEE N84-24632)

The correlation between defect cluster concentrations observed for different grades of quartz examined by transmission electron microscopy (TEM) and the electrical stability of quartz resonators exposed to complex radiation

in an orbital LDEF was determined. It is demonstrated that the technique TEM provides a powerful method for studying the effect of radiation on crystalline quartz. Two factors suggest that the observed clusters may be responsible for the radiation-induced frequency drift and acoustic absorption effects associated with irradiated quartz resonators: (1) the clusters are expected to be very effective in modifying the piezoelectric properties of quartz because of the large strain fields associated with them; (2) both phenomena appear to be sensitive to the impurity concentration. It is suggested that TEM can be used to classify grades of quartz according to their suitability for use in radiation-hard resonators. This technique may identify the impurities that are responsible and thereby effect an improvement in the stability of quartz oscillators. (E.A.K.).
N84-24686.

38. TAYLOR, W. W. L., KOMATSU, G. K. "Space plasma high-voltage drainage experiment (A0054)" 1984;
Note: TRW Space Technology Labs., Redondo Beach, Calif. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 82-85 (SEE N84-24632).

The objectives of this experiment are to place large numbers of dielectric samples under electric stress in space; to determine their in-space current drainage behavior; to recover inspect, and further test these samples in laboratory facilities; and finally to specify allowable electric stress levels for these materials as applied to solar-array and thermal control coatings for prolonged exposure in space. These findings, in turn, will pace the design of encapsulated, lightweight, high-voltage solar arrays as well as the development of coating materials for spacecraft operation in energetic charged-particle environments such as that experienced at geosynchronous altitudes during magnetic substorms. (M.G.).
N84-24655.

39. SEELEY, J. S., HUNNEMAN, R., WHATLEY, A., LIPSCOMBE, D. R., (British Aerospace Corp.). "Exposure to space radiation of high- performance infrared multilayer filters and materials technology experiments (A0056)" 1984;
Note: Reading Univ. (England). Dept. of Cybernetics. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 154-157 (SEE N84-24632).

Infrared multilayer interface filter which were used in satellite radiometers were examined. The ability of the filters to withstand the space environment in these applications is critical. An experiment on the LDEF subjects the filters to authoritative spectral measurements following space exposure to ascertain their suitability for spacecraft use and to permit an understanding of degradation mechanisms. The understanding of the effects of prolonged space exposure on spacecraft materials, surface finishes, and adhesive systems is important to the spacecraft designer. Materials technology experiments and experiment on infrared multilayer filters are discussed. (E.A.K.).
N84-24678.

40. RICH, F. J. (AFGL); MICHAEL, I. AFGL)., FISHMAN, G. J., SEGALYN, P. L., (Army, Materials and Mechanics Research Center); MCNULTY, P. J., (Clarkson College of Technology); RAO, Y. V., (Emmanuel College); LAIRD, C. E., (Univ. of Eastern Kentucky). "Trapped-proton energy spectrum determination (M0002-1)" 1984;
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 109-112 (SEE N84-24632).

The objective of this experiment is to measure the flux and energy spectrum of protons with energies of 1 to MeV. These protons are trapped on the Earth's magnetic field lines as part of the inner radiation belt, or Van Allen zone. The proton will be encountered predominantly in the South Atlantic anomaly at a 90 deg pitch angle. (Author).
N84-24663.

41. MULLIN, J. P., LORIA, J. C., BRANDHORST, H. W., JR., (NASA, Lewis Research , Center). "The NASA photovoltaic technology program" , 1984. 12P
Note: Presented at the 17th Photovoltaic Specialists Conf., Kissimmee, Fla., 1-4 May 1984; sponsored by IEEE

The NASA Office of Aeronautical and Space Technology OAST Program in space photovoltaics is reviewed. From the perspective of national landmark mission requirements and five year and 25- year long range plans, the texture of the program is revealed. Planar silicon and concentrator GaAs array technology advances are discussed. Advances in lightweight (50 micro cell) arrays and radiation tolerance research are presented. Recent progress in cascade cells

and ultralightweight GaAs planar cells is noted. Progress in raising silicon cell voltage to its theoretical maximum is detailed. Advanced concepts such as plasmon converters and the Long Duration Exposure Facility LDEF flight experiments pertaining to solar cell and array technology are also shown. (M.A.C.).
N84-32426.

42. MULLIN, J. P. LORIA, J. C., (NASA, Washington DC)., BRANDHORST, H. W ,. JR., (NASA, Lewis Research Center, Cleveland, OH). "The NASA photovoltaic technology program" IN: Photovoltaic Specialists Conference, 17th, Kissimmee, FL, May 1- 4, 1984, Conference Record (A85-35601). New York, Institute of Electrical and Electronics Engineers, 1984, p. 12-16. 1984.

The NASA Office of Aeronautical and Space Technology OAST Program in space photovoltaics is reviewed. From the perspective of national landmark mission requirements and five year and 25- year long range plans, the texture of the program is revealed. Planar silicon and concentrator GaAs array technology advances are discussed. Advances in lightweight (50 micro cell) arrays and radiation tolerance research are presented. Recent progress in cascade cells and ultralightweight GaAs planar cells is noted. Progress in raising silicon cell voltage to its theoretical maximum is detailed. Advanced concepts such as plasmon converters and the Long Duration Exposure Facility LDEF flight experiments pertaining to solar cell and array technology are also shown. (M.A.C.).
A85-35604.

43. MOREAU, G. "Ruled and holographic gratings experiment (A0138- 5)" 1984;
Note: Instruments Service Aerodynamique, Longjumeau (France). In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 163-164 (SEE N84-24632).

The behavior of ruled and holographic gratings with various coatings after extended exposure to the space environments was examined. The coatings and differentiating between the influences of vacuum and solar illumination were examined. In the past, several ruled and holographic gratings with various coatings were successfully flown on rocket experiments. Future utilizations of such gratings are considered for the Space Telescope and for various Spacelab projects under development. The techniques which is used to replicate gratings can also be used to obtain a wide range of lightweight optical components, including sophisticated aspherical, highly polished mirrors. (E.A.K.).
N84-24682.

44. LIND, D. L., GEISS, J., (Bern Univ.); BUEHLER, F. "Interstellar-gas experiment (A0038)" 1984;
Note: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 98-100 (SEE N84-24632).

The objectives of this experiment are to collect and isotopically analyze interstellar gas atoms around the orbit of the Earth for the purpose of obtaining new data relevant to understanding nucleosynthesis, and to study the dynamics of the interstellar wind inside the heliosphere and the isotopic composition of the interstellar medium outside the heliosphere. The experiment hardware will act as a set of simple cameras with high-purity copper-beryllium collecting foils serving as the film. The experiment housing will mount and thermally control the foils, establish the viewing angles and viewing direction, provide baffling to reject ambient neutral particles, provide a voltage grid to reject ionospheric charged particles, sequence collecting foils, control exposure times, and protect the foils from contamination during the deployment and retrieval of the LDEF After being returned to Earth, the entrapped atoms can be analyzed by mass spectroscopy to determine the relative abundance of the different isotopes of helium and neon. An attempt will also be made to detect argon. (M.G.).
N84-24660.

45. LAIRD, C. E. "Study of proton and neutron activation of metal samples in low Earth orbit. Quarterly Technical Report, 18 Apr. - 18 Jul. 1984" , 1984; NASA-CR-171113. 6P
Note: University of Eastern Kentucky, Richmond. Dept. of Physics and Astronomy.

Progress in the following activities has been made: the analysis of the gamma ray spectra taken from samples flown in Spacelab 2; the search for and review of neutron and proton activation cross sections needed to analyze the results of the Long Duration Exposure Facility (LDEF) activation measurements; the consideration given to data analysis of the LDEF and Spacelab 2 samples; the plan to measure relevant cross sections with nuclear accelerator

measurements; and the preparation of an extended gamma ray calibration sources continues through planning and direct measurement of gamma ray efficiency for a Ge(Li) as a function of position along the surface of the detector housing. (E.R.).
N84-31763.

46. LAIRD, C. E. "Study of proton and neutron activation of metal samples in low Earth orbit. Quarterly Technical Report" 1984; NASA-CR-171183. 5P
Note: University of Eastern Kentucky, Richmond. Dept. of Physics and Astronomy

The analysis of the gamma-ray spectra taken from samples flown in Spacelab 1, the search for and review of neutron and proton activation cross-sections needed to analyze the results of the Long Duration Exposure Facility (LDEF) activation measurements; additional calculations of neutron induced activation for the LDEF samples; the data analysis plan for the LDEF and Spacelab 2 samples; the measurement of relevant cross-sections with activation of samples of V, Co, In, and Ta at the Indiana University Cyclotron Facility: and the preparation of an extended gamma-ray calibration source through the development of a proper technique to accurately deposit equal quantities of radioactive material onto a large number of point on the source are discussed. (R.J.F.).
N85-10164

47 JOHNSTON, A. R., BERGMAN, L. A. "Fiber optic data transmission experiment (S0109)" 1984;
Note: Jet Propulsion Lab., California Inst. of Tech., Pasadena. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 180-181 (SEE N84-24632).

Fiber optic components in the space environment were examined. The ability to operate over long periods of time without degradation of performance are determined. (E.A.K.).
N84-24688.

48. HICKEY J. R., GRIFFIN, F. J. "Passive exposure of Earth radiation budget experiment components (A0147)" 1984;
Note: Eppley Lab., Inc., Newport, R.I. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 167- 169 (SEE N84-24632).

In-flight calibration for the solar and Earth flux channels was examined. Earth Radiation on Budget (ERB) channel components were exposed to the space environment and then retrieved and resubmitted to radiometric calibration after exposure. It is suggested that corrections may be applied to ERB results and information will be obtained to aid in the selection of components for future operational solar and Earth radiation budget experiments. To assure that these high accuracy devices are measuring real variations and are not responding to changes induced by the space environment, it is desirable to test such devices radiometrically after exposure to the best approximation of the orbital environment. (E.A.K.).
N84-24684.

49. DELABOUDINIERE, J. P., BERSET, J. M. "Thin metal film and multilayers experiment (A0138-3)" 1984;
Note: Centre National de la Recherche Scientifique, Verrieres- le-Buisson (France). In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 159-160 (SEE N84-24632).

The sources of degradation of in state of the art and newly developed components and testing the usefulness of the concept of storing experiment samples in dry nitrogen under launch and space vacuum conditions during reentry mission phase were investigated. Ultraviolet (UV) and extreme ultraviolet (EUV) experiments suffer degradations during space missions of even 1 month duration. It is suggested that the degradation is due to condensation of outgassing products, followed by solar induced polymerization, however, penetrating charged particles are also known to produce volume effects. Degradation may also start immediately after manufacturing of the component due to oxidation, moisture, or chemical corrosion by atmospheric constituents such as CO2 and SO2. When the filters are used as windows for gas absorption cells or gas filters, or when they define the instrumental bandwidth by themselves. The effects of mechanical degradation by thermal cycling and/or dust may cause a dramatic impact. (E.A.K.).
N84-24680.

50. DAVID, L. W., (National Space Institute, Washington DC). "Space as motivational propulsion Shuttle Orbiter related projects as educational tools" 1984; IAF-84-407
Note: International Astronautical Federation, International Astronautical Congress, 35th, Lausanne, Switzerland, Oct. 7-13, 1984. 12 p.

Several student activities for motivating continued intellectual efforts directed at space-related fields are described. The long duration exposure facility, deployed from the Orbiter in 1984 and due to be retrieved in 1985, contained bags containing a total of 9 million tomato seeds shielded from radiation to varying degrees. The seeds will be distributed to students from grades 5 to university level for experimentation. An amateur space telescope is being constructed by 700 participants in 15 countries under the guidance of university faculty and optics engineers. Test components will be flown in Getaway Special cannisters and then used in the flight hardware. Reception of images from the 175 lb. telescope will be possible anywhere on the planet for $400-500 worth of equipment. The Solar Mesosphere Explorer is monitored by university students interfacing with NASA tracking network. NASA has initiated a Young Astronauts program to encourage interest in space and participation in science projects and math. Finally, discussions are underway between NASA and an entrepreneur to devise a module that will permit dozens of tourists to fly on a 3 day mission at the same time at a cost of $2-3 million per seat (M.S.K.).
A85-13259.

51. CLARK, L. G., KINARD, W. H., CARTER, D. L. , JR., JONES, J. L. ,. JR., eds. "Long Duration Exposure Facility (LDEF), Mission 1 Experiments" 1984;
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

Spaceborne experiments using the space shuttle payload known as the Long Duration Exposure Facility are described. Experiments in the fields of materials, coatings, thermal systems, power and propulsion, electronic, and optics are discussed. For individual titles, see N84-24633 through N84-24690.
N84-24632.

52. CALLEN, W. R., GAYLORD, T. K. "Holographic data storage crystals for LDEF (A0044)" 1984;
Note: Georgia Inst. of Tech., Atlanta. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 152- 153 (SEE N84-24632).

Electro-optic holographic recording systems were developed. The spaceworthiness of electro-optic crystals for use in ultrahigh capacity space data storage and retrieval systems are examined. The crystals for this experiment are included with the various electro-optical components of LDEF experiment. The effects of long-duration exposure on active optical system components is investigated. The concept of data storage in an optical-phase holographic memory is illustrated. (E.A.K.).
N84-24677

53. BUECKER, H. "Free-flyer biostack experiment" 1984;
Note: Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. for Flight Medicine. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 139-145 (SEE N84-24632).

The free-flyer biostack experiment is part of a radiobiological space research program that includes experiments in space as well as in accelerators on Earth. The program has been specially designed to increase knowledge concerning the importance, effectiveness, and hazards of the structured components of cosmic radiation to man and to any biological specimen in space. Up to now, our understanding of the ways in which HZE particles might affect biological matter is based on a few spaceflight experiments from the last Apollo missions and on the limited data available from heavy-ion irradiation from accelerators. In the near future, accelerators capable of accelerating particles up to higher atomic numbers and higher energies will promote increased activity in ground-based studies on biological effects of HZE particles. Comparison of data from such irradiation experiments on Earth with those from an actual spaceflight experiment will show any potential influence of the inevitably attendant spaceflight factors (e.g., weightlessness) on the radiobiological events. (B.W.).
N84-24674.

54. BENTON, E V., (San Francisco Univ.); PARNELL, T A. "Linear energy transfer spectrum measurement experiment (P0006)" 1984;
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 115-116 (SEE N84-24632).

The linear energy transfer (LET) is the energy deposited per unit path length of charged particle traversing matter For estimating the rate of damage from single-hit phenomena, the quantity that best combines the radiation environment, orbital situation, and spacecraft shielding is the linear energy transfer (LET) spectrum at the device location. This experiment will measure the LET spectrum behind different shielding configurations for approxmately 1 year The shielding will be increased in increments of approximately 1 G/sq cm up to a maximum shieldng of 16 G/sq cm. In addition to providing critical information to future spacecraft designers, these measurements will also provide data that will be extremely valuable to other experiments on LDEF (B.W.).
N84-24665.

55. ASSIE, J. P "Microwelding of various metallic materials under ultravacuum (A0138-10)" 1984;
Note: Societe Nationale Industrielle Aerospatiale, Cannes (France). In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 35-37 (SEE N84-24632).

In the space vacuum environment, the spacecraft mechanisms are liable to sustain damaging effects from microwelds due to molecular diffusion of the spacecraft constituent metals. Such microwelds result in a continuing increase in the friction factors and are even liable to jam the mechanisms altogether The object of this experiment is to check the metal surfaces representative of the mechanism constituent metals (treated or untreated, lubricated or unlubricated) for microwelds afater an extended stay in the space environment. The experimental approach is to passively expose inert metal specimens to the space vacuum and to conduct end-of-mission verification of the significance of microwelds between various pairs of metal washers. The experiment will be located in one of the FRECOPA boxes in a 12-in. -deep peripheral tray that contains nine other experiments from France. (R.J.F.).
N84-24642.

56. ALLEN, D. H. "Balloon materials degradation (S1006)" 1984;
Note: Texas A&M Univ., College Station. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 49-51 (SEE N84-24632).

The objective of this experiment is to assess the effects of long-term exposure of candidate balloon films, tapes, and lines to the hostile environment above the Earth's atmosphere. Degradation of mechanical and radiometric properties will be observed by a series of tests on exposed materials. The experiment is passive and will test candidate balloon films, tapes, and lines. The experiment will occupy one-third of a 3- in.-deep peripheral tray. Two additional identical sets of material will be prepared. The first set will be tested immediately and the second will be held in a controlled environment until the recovery of the samples placed on orbit. Tests will then be performed on this second set to determine any effects of aging. The specimens that are recovered from the Long Duration Exposure Facility will also be tested and the effects of long-duration exposure noted. In addition to these specimens, another set of specimens will be exposed at an accelerated exposure facility and the results will be compared with those of specimens exposed in situ. (R.J.F.).
N84-24646.

57 KINARD, W. H., (NASA, Langley Research Center, Hampton, VA). "The LDEF benefits planned experiments" In: Making space work for mankind; Proceedings of the Nineteenth Space Congress, Cocoa Beach, FL, April 28-30, 1982. (A82-47251) Cape Canaveral, FL, Canaveral Council of Technical Societies, 1982, p. 6-1 to 6-6. , 1982.

The Long Duration Exposure Facility (LDEF) is described, and experiments planned for the first LDEF mission are discussed. Four of the eight involve scientific studies of interstellar gas, micrometeoroids, cosmic rays, and crystal growth in zero gravity, and four involve technology studies of the space environmental effects on solar cells, composite materials, thermal coatings, fiber optics, and electronic instruments. For each experiment, the objectives and methods are discussed. (C.D.).
A82-47271.

58 IGENBERGS, E., (Muenchen, Technische Universitaet ,. Munich, West Germany). "The capture-cell experiment for the first LDEF mission Long Duration Exposure Facility" 1982; IAF-Paper-82- 24.
Note: International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 6 p.

A description is presented of experiments to be performed by the long duration exposure facility (LDEF), which will be placed in LEO in 1984 by the Shuttle and retrieved a year later The LDEF will gather data on the chemical and isotopic compositions of interplanetary dust, serve as a data base for the follow-up spacecraft in the series, and aid in distinguishing cosmic dust particles from particles generated by spacecraft. The 30-ft long, 14-ft diameter LDEF will feature experimental trays, a viscous magnetic motion dampler and grappler and ground handler fittings. Targets in the experiment trays will be covered with a thin foil vellum, which dust particles will breach to become imbedded in the Ge target. Spectroscopy will allow chemical analysis of the collected particles. A hypervelocity accelerator will be employed to model the impacts of reference particles for comparison purposes. (M.S.K.).
A82-46917

59 FILZ, R. C. "Long Duration Exposure Emulsion Package (LDEEP). Interim Report" , 1979; AD-A077362 15P
Note: Air Force Geophysics Lab., Hanscom AFB, Mass. Space Physics Div

An exposure package has been designed to obtain measurements of trapped proton fluxes utilizing the NASA Long Duration Exposure Facility. The techniques are similar to those used in the 1960's to obtain trapped proton fluxes from Air Force recoverable satellites. The main novelty consists in the development of proton sensitive plastic detectors capable of withstanding the six month exposure planned for LDEF At the planned LDEF altitude of 450 km, unshielded nuclear emulsion would become grossly over- exposed in six months. Early designs for LDEEP consisted of shielded emulsions with narrow cylindrical openings to allow trapped protons to enter. The discovery of the CR39 plastic detector by Cartwright et al opens up a new solution to this problem. The potential for obtaining the first reliable measurements of inner zone trapped protons of 1 to 10 Mev energy is discussed. Earlier electronic counter measurements are quite uncertain, and the NERV emulsion results covered are far too brief a time interval and were spatially limited. (GRA).
N80-18914

SPACECRAFT CONTAMINATION

1 CRUTCHER, E. RUSS; WARNER, K. J., WASHER, W. W., NISHIMURA, L. S. "LDEF contaminants analysis data." , 1991

Note: Boeing Co., Washington, DC. Defense and Space Group. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 8 (SEE N91-24972). Abstract Only

Modification of surface texture for Ram Facing FEP Teflon on the Long Duration Exposure Facility (LDEF) satellite is documented. Photos of changes in surface texture if thermal blanket material with position on tray C-08 are presented. Infrared spectra and photographic documentation of molecular film deposits on LDEF surfaces by location is reported. Results of a survey of the functional groups and elemental composition of the brown film found widely distributed on the surface of LDEF is shown. A partial photographic catalog of LDEF particulate contaminants is included. A set of photos of particles collected or photographed in place on the surface of LDEF is shown. Particle counts and surface obscuration data for the LDEF satellite are reported. The surface data in tables and charts is presented for the LDEF satellite by location. (Author).
N91-24978.

2 CRUTCHER, E. RUSS; NISHIMURA, L. S., WARNER, K. J., WASCHER, W. W. "Migration and generation of contaminants from launch through recovery: LDEF case history." 1991;
Note: Boeing Aerospace and Electronics Co., Seattle, WA. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 7 (SEE N91-24972). Abstract Only.

The migration of contaminants to and between Long Duration Exposure Facility (LDEF) surfaces reveals new information relevant to all future space missions. The surface of the LDEF satellite closely paralleled over seven

meters of the shuttle during one launch and one reentry Transfer of contaminants from the shuttle bay to the payload were documented and partially quantified for both the launch and recovery separately. LDEF carried a load of volatile silicones and hydrocarbons into orbit which were then polymerized by UV radiation into tough, dark brown stains on exposed surfaces. The distribution of these stains is providing new information on deposition mechanisms that should be studied on future missions. Electrostatic effects, diffusional flow. and effects due to small surface temperature differences at the time of UV exposure are suggested. The types of functional groups present in the LDEF deposit it nearly identical to stains recovered from other spacecraft. These stains were remarkably stable in low Earth orbit even with atomic oxygen exposure if the amount of silicones present was sufficient to create a sealing layer of silicon dioxide over the dark brown stain beneath. (Author).
N91-24977

SPACECRAFT STABILITY

1 GREGORY J. C., (Alabama University. Huntsville; PETERS, P N., (NASA, Marshall Space Flight Center Huntsville. AL) "Measurement of the passive attitude control performance of a recovered spacecraft" Journal of Guidance. Control and Dynamics (ISSN 0731-5090) vol. 15. Jan.-Feb. 1992, p. 282-284. 1992

A novel silver detector incorporated in the Long Duration Exposure Facility (LDEF) has been used to measure the attitude stability of the vehicle. It is thereby established that the LDEF spacecraft maintained a very stable attitude during its nearly 6- year-long flight, notwithstanding a small offset yaw of 8.0 +/- 0.4 deg clockwise from nominal attitude (as viewed from space) and a +/- 0.2-deg oscillation about this offset yaw LDEF experiments which depend on orientation relative to the forward direction may need to be corrected for the angular offset. (O.C.)
A92-21190.

2 SIEGEL. S H., VISHWANATH, N. S. "Analysis of the passive stabilization of the long duration exposure facility Final Report" 1977· NASA-CR-159023. 146P
Note: General Electric Co., Philadelphia. Pa

The nominal Long Duration Exposure Facility (LDEF) configurations and the anticipated orbit parameters are presented. A linear steady state analysis was performed using these parameters. The effects of orbit eccentricity solar pressure. aerodynamic pressure, magnetic dipole, and the magnetically anchored rate damper were evaluated to determine the configuration sensitivity to variations in these parameters. The worst case conditions for steady state errors were identified, and the performance capability calculated. Garber instability bounds were evaluated for the range of configuration and damping coefficients under consideration. The transient damping capabilities of the damper were examined, and the time constant as a function of damping coefficient and spacecraft moment of inertia determined. The capture capabilities of the damper were calculated, and the results combined with steady state. transient and Garber instability analyses to select damper design parameters. (S.E.S.).
N79-17882

3. HUCKINS, E K. . III; (NASA, Langley Research Center Hampton, Va.); BREEDLOVE, W J . JR. HEINBOCKEL. J H. (Old Dominion University Norfolk Va). "Passive three-axis stabilization of the Long Duration Exposure Facility gravity gradient stabilized satellite" 1975; AAS-75-030.
Note: American Astronautical Society and American Institute of Aeronautics and Astronautics, Astrodynamics Specialist Conference, Nassau, Bahamas, July 28-30. 1975. AAS 33 p.

This paper presents an analysis of the attitude dynamics of the Long Duration Exposure Facility (LDEF) LDEF is a large cylindrical gravity gradient stabilized earth satellite which is planned to be delivered to a 270-n mi circular orbit by the space shuttle. The fundamental linear stability capture requirements, and pitch bias constraints generated by the Garber instability are discussed Numerical simulations, based on the full nonlinear equations for the coupled orbital and attitude motion of the vehicle and the viscous magnetic damper show stable behavior of the spacecraft and a damping time constant of 30 to 70 orbits. ((Author))
A76-11329.

4. DAS, A. "Passive stabilization of the Long Duration Exposure Facility (LDEF) Final Report" , 1974; NASA-CR-132566. 164P
Note: General Electric Co., Philadelphia, Pa. Space Div

The results of a study on the application of the magnetically anchored rate damper to gravity gradient stabilization of the Long Duration Exposure Facility (LDEF) are presented. The analyses and simulations required to investigate the use of an existing viscous magnetic rate damper for rate stabilizing the LDEF spacecraft were performed. The following tasks were included: linear performance estimates, capture and damper requirements, and performance prediction. Each of these tasks was performed for two gravity gradient stabilization configurations; an axisymmetric configuration for two-axis (pitch and roll) stability; and a non-axisymmetric configuration for three-axis stability. The results are presented by stabilization configuration. (Author).
N75-17397

THERMAL CONTROL COATINGS

1 LINTON, ROGER C., (NASA, Marshall Space Flight Center, Huntsville, AL). "Effects of space exposure on thermal control coatings" 1992; AIAA-Paper-92-0795.
Note: AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV Jan. 6-9, 1992. 11 p National Aeronautics and Space Administration. Marshall Space Flight Center. Huntsville, AL.

Optical degradation of selected thermal control coatings exposed on LDEF Experiment A0034, 'Atomic Oxygen Stimulated Outgassing', attributable to effects of solar radiation, was significantly changed for specimens whose exposure included orbital atomic oxygen impingement. This LDEF experiment consisted of two passive modules, one exposed to the total space environment on the Leading Edge (RAM) and another exposed to the relative wake of the Trailing Edge. Evidence of atomic oxygen stimulated outgassing and the interrelated effects of the natural environment based on evaluation of the flight specimens will be discussed. (Author).
A92-28232

2. WILKES, DONALD R., HUMMER, LEIGH L., BROWN, M. JOHN; (AZ Technology, Huntsville AL)., ZWIENER, JAMES M. "Thermal control surfaces experiment (S0069) initial materials evaluation " 1991
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL. In NASA, Langley Research Center. First LDEF Post-Retrieval Symposium Abstracts p 68 (SEE N91-24972) Abstract Only

The behavior of materials in the space environment and our understanding of this behavior continues to be a limiting technology for spacecraft and experiments. The Thermal Control Surfaces Experiment (TCSE) aboard the Long Duration Exposure Facility (LDEF) is the most comprehensive experiment flown to study the effects of the space environment on thermal control surfaces. Selected thermal control surfaces were exposed to the LDEF orbital environment and the effects of this exposure measured. The TCSE combined in-space optical measurements with pre- and post-flight analyses of flight materials to determine the effects of long term space exposure. Many of the samples underwent significant changes in appearance as well as optical and mechanical properties. (Author).
N91-25035.

3. WILKES, DONALD R., HUMMER, LEIGH L "Thermal control surfaces experiment (SOO69) flight systems performance " , 1991.
Note: AZ Technology, Huntsville, AL In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 122 (SEE N91-24972) Abstract Only.

The thermal control surfaces experiment (TCSE) was the most complex hardware system aboard the Long Duration Exposure Facility (LDEF). The TCSE system consists of a scanning spectroreflectometer that measured test samples mounted on a rotatable carousel assembly A microprocessor based data system controlled all aspects of TCSE system operation. Power was provided by four primary batteries. Flight measurement and housekeeping data were stored on a tape recorder for postflight analysis. The TCSE is a microcosm of complex electro-optical payloads being developed by NASA, DoD, and the aerospace community. The TCSE provides valuable data on the performance of these systems in space. The TCSE flight system and its excellent performance on the LDEF mission are described.

A few operational anomalies were encountered and are discussed. Initial post-flight tests show that the TCSE system remains functional although some degradation in the optical measurements were observed. Te results of these tests are also presented. (Author).
N91-25088.

4 WILKES, DONALD R., HUMMER, LEIGH L "Thermal control surfaces experiment: Initial flight data analysis" 1991
NASA-CR- 188600. 123P
Note: Final Report. Cockerham (John M.) and Associates, Inc., Huntsville, AL. Prepared in cooperation with AZ Technology Huntsville, AL

The behavior of materials in the space environment continues to be a limiting technology for spacecraft and experiments. The thermal control surfaces experiment (TCSE) aboard the Long Duration Exposure Facility (LDEF) is the most comprehensive experiment flown to study the effects of the space environment on thermal control surfaces. Selected thermal control surfaces were exposed to the LDEF orbital environment and the effects of this exposure were measured. The TCSE combined in-space orbital measurements with pre and post-flight analyses of flight materials to determine the effects of long term space exposure. The TCSE experiment objective, method, and measurements are described along with the results of the initial materials analysis. The TCSE flight system and its excellent performance on the LDEF mission is described. A few operational anomalies were encountered and are discussed. (Author).
N91-25156

5. WILKES, DONALD R., HUMMER, LEIGH L., (AZ Technology, Huntsville AL)., ZWIENER, JAMES M. Thermal control surfaces experiment flight system performance 1991 NASA-TM-105036. 45P
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

The Thermal Control Surfaces Experiment (TCSE) is the most complex system, other than the LDEF, retrieved after long term space exposure. The TCSE is a microcosm of complex electro- optical payloads being developed and flow by NASA and the DoD including SDI. The objective of TCSE was to determine the effects of the near-Earth orbital environment and the LDEF induced environment on spacecraft thermal control surfaces. The TCSE was a comprehensive experiment that combined in-space measurements with extensive post flight analyses of thermal control surfaces to determine the effects of exposure to the low earth orbit space environment. The TCSE was the first space experiment to measure the optical properties of thermal control surfaces the way they are routinely measured in a lab. The performance of the TCSE confirms that low cost, complex experiment packages can be developed that perform well in space. (Author).
N91-30194.

6. SLEMP WAYNE S., YOUNG, PHILIP R. SHEN, JAMES Y , (Lockheed Engineering and Sciences Co., Hampton VA). "Effects of LDEF flight exposure on selected polymeric films and thermal control coatings" 1991
Note: National Aeronautics and Space Administration. Langley Research Center Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 67 (SEE N91-24972) Abstract Only.

The characterization of polymeric films and thermal control coatings which were exposed for five years and ten months to the low-Earth environment is reported. Changes in solar absorptance, thermal emittance, and transmission are compared to laboratory control specimens. Sputter-deposited metallic coatings are shown to eliminate atomic oxygen erosion of resin matrix composite materials. The effects of long-term atomic oxygen exposure to metallized FEP Teflon film is characterized. Chemical characterization of polymeric films indicates that although surface erosion occurs, the molecular structure of the basic polymeric film has not changed significantly in response to this exposure. (Author).
N91-25034.

7 PAILLOUS, ALAIN; GUILLAUMON, JEAN CLAUDE, (Centre National d'Etudes Spatiales, Toulouse France). "Spacecraft thermal control coatings (AO 138-6)" 1991
Note: Centre d'Etudes et de Recherches, Toulouse (France). In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 70 (SEE N91-24972). Abstract Only

The experiment A0 138-6 was located on the trailing edge of LDEF as part of the Experiment FRECOPA. Material specimens 2 x 2 cm, independently mounted in sample-holders with their surface in the same reference plane, were exposed to space. Materials include paints (conductive or not), SSMs, polymeric films, surface coatings, composite materials, and metals. The results show that for some materials the degradation was higher for samples in the canister than for those directly mounted on the tray; contamination problems were ruled out, the higher temperature experienced by the samples inside the canister probably explains this phenomenon. (Author).
N91-25037

8. LETTON, ALAN; ROCK, NEIL I., WILLIAMS, KEVIN D., STRGANAC, THOMAS. "Study of balloon and thermal control material degradation aboard LDEF " 1991
Note: Texas A&M Univ., College Station. Polymer Science and Engineering Program. In NASA, Langley Research Center First LDEF Post-Retrieval Symposium Abstracts p 54 (SEE N91-24972). Abstract Only

The initial results of analysis performed on a number of polymeric materials which were exposed aboard the Long Duration Exposure Facility (LDEF) are discussed. These materials include two typical high altitude balloon films (a polyester and a polyethylene) and silver-backed Teflon from thermal control blanket samples. The techniques used for characterizing changes in mechanical properties, chemical structure and surface morphology include Fourier Transform Infrared (FTIR) spectroscopy scanning electron microscopy. and dynamic mechanical analysis. (Author).
N91-25021

9. KAUDER, LON. "Preliminary results for LDEF/HEPP thermal control samples. " , 1991
Note: National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 61 (SEE N91-24972). Abstract Only

Sixty-five one inch by twelve inch strips of Kapton coated with various black paints, clear coatings, and thin film oxides were placed at three locations on the Long Duration Exposure Facility Two sets were flown in the ram direction on top of the MLI blanket of the Cascade Variable Conductance Heat Pipe Experiment. Two other sets were flown on top of the MLI blanket of the Low Temperature Heat Pipe Experiment perpendicular to the ram direction. The last thirteen samples were taped to the perimeter of the HEPP power tray on the space end of the satellite. The solar absorptance and normal emittance measurements made on the 52 remaining samples are presented, as well as data on the above mentioned samples. (Author).
N91-25028.

10. HURLEY C. "Thermal control materials." 1991
Note: Dayton Univ., OH. In NASA, Langley Research Center, First LDEF Post-Retrieval Symposium Abstracts p 71 (SEE N91- 24972). Abstract Only

The LDEF M0003-5 Thermal Control Materials Experiment contains numerous thermal control coatings, metallized and nonmetallized polymeric films, adhesives, OSR's, and metallic foils. The materials were located on the leading and trailing edges of the satellite, therefore exposed to two different low earth orbital environments. Many specimens received a total exposure of 5.75 years and other received a limited exposure of 0.9 years to the complete environment. On-orbit and post flight photographic records are presented. The material's physical and optical performance are discussed as a function of location and duration of exposure. Data concerning specimen condition, degradation, contamination, optical reflectance and transmittance are discussed. The effect of atomic oxygen erosion on specific materials is also presented, The performance of adhesive bonds with polymeric films is reviewed. (Author).
N91-25038.

11 WILKES, D. R., KING, H. M. "Thermal control surface experiment (S0069)" 1984;
Note: National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala. In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 57-61 (SEE N84- 24632).

The objectives of this LDEF experiment are to determine the effects of the near Earth orbital environment and the Shuttle induced environment in spacecraft thermal control surfaces. Spectral reflectance measurements will be obtained and used to differentiate between different solid state damage mechanisms of environmental damage to

separate the effects of contamination from those of natural environment damage, and for comparison and correlation with laboratory test data. (M.G.).
N84-24649.

12 SLEMP, W S. "Exposure of spacecraft coatings (S0010)" 1984.
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. In its Long Duration Exposure Facility (LDEF) p 54-56 (SEE N84-24632).

The objectives of this LDEF experiment are to determine the effects of both the Shuttle-induced environment and the space radiation environment on selected sets of spacecraft thermal control coatings. The experimental approach is to passively expose samples of thermal control coatings to Shuttle-induced and space radiation environments and to return the samples for postflight evaluation and comparison with preflight measurements to determine the effects of the environmental exposure. Optical measurements of the samples will include total normal emittance and spectral reflectance. The experiment will utilize a 6 in. deep peripheral tray and an experiment exposure control canister (EECC). The EECC will provide protection for some of the samples against exposure to the launch and reentry environments. The EECC will be programmed to open about 2 weeks after LDEF deployment and close pior to LDEF retrieval by the Shuttle and reentry Some samples will not be housed in the EECC and will be exposed to the Shuttle-induced environment during launch and reentry. Comparison of the data from these samples with data from samples in the EECC will yield information about possible contamination induced degradation effects. (M.G.).
N84-24648.

13. PAILLOUS, A., GUILAUMON, J. C., (CNES). "Thermal control coatings experiment (A0138-6)" 1984.
Note: Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). In NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 52-53 (SEE N84-24632).

The objectives of this LDEF experiment are to verify the validity of space environment simulation performed in the laboratory in order to measure the stability of the thermo- optical properties of thermal control coatings, and to compare the behavior in space of some materials for which the available ultraviolet solar simulation is inadequate (especially in the far ultraviolet). The experimental approach is to passively expose samples of the thermal coatings of interest. These coatings include black paint, aluminum paint, white paint, a solar absorber, an optical surface reflector, second surface mirrors, metal coatings, and silica fabrics. Preflight and postflight measurements of thermo-optical properties will be compared to determine the effects of space environment exposure. (M.G.).
N84-24647

14. BAUER, H., GOEDTKE, P., GROH, K., HUSMANN, O. K. PREUSS, L., SCHAEFER, W., WITA, C., ZWIEGEL, J. "Testing of coatings in space, Long Duration Exposure Facility (LDEF). Final Report, Oct. 1981" , 1984; BMFT-FB-W-84-017 326P
Note: Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Space Div. Sponsored by Bundesministerium fuer Forschung und Technologie In GERMAN.

Thermal coatings of the flexible second surface mirrors type, and conductive coatings on solar cell covers were qualified for operation in 24 hr orbit. The coatings are exposed to the low Earth orbit space environment for a longer period by means of the LDEF Accompanying laboratory experiments supplement the flight experiment. The flight experiment was developed, especially the establishment of test and functional specifications, materials and weight lists, temperature prediction for thermal tests, the defined stowage, and the completion of three accompanying ground experiments (near UV solar simulation, contamination experiment, and charging experiment). (Author (ESA)).
N84-31269.

15. GREENE, R. F. ,JR., (NASA, Langley Research Center, Systems Engineering Div., Hampton, VA). "Thermal design and experiment thermal integration of the Long Duration Exposure Facility Shuttle-transported reusable spacecraft" 1982; AIAA-Paper-82- 0829.
Note: American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, 3rd, St. Louis, MO, June 7-11, 1982

The Long Duration Exposure Facility (LDEF) is a large (14 feet diameter by 30 feet long) Shuttle transported, reusable spacecraft. The LDEF can accommodate up to 13,000 pounds of experiments mounted in 86 standard trays. This paper describes the philosophy and approach used for the passive thermal design of the LDEF. Also discussed are the standardized guidelines and techniques used in the thermal design and integration of approximately 50 different thermally passive experiments. A technique for reducing multinode thermal models of experiments to 2 nodes is also presented. This approach allows the efficient thermal integration of large numbers of experiments with the LDEF spacecraft. ((Author)).
A82-31857

16. WILKES, D. R., (NASA, Marshall Space Flight Center, Space Sciences Laboratory, Huntsville, Ala.); BROWN, M. J. (Aerojet Electrosystems Co., Azusa Calif). "An active thermal control surfaces experiment spacecraft temperature determination" , 1979; AIAA-Paper-79-1073.
Note: American Institute of Aeronautics and Astronautics, Thermophysics Conference, 14th, Orlando, Fla., June 4-6, 1979, 7 p.

An active flight experiment is described that has the objectives to determine the effects of the low earth natural environment and the Shuttle induced environment on selected thermal control and optical surfaces. The optical and thermal properties of test samples will be measured in-situ using an integrating sphere reflectrometer and using calorimetric methods. This experiment has been selected for the Long Duration Exposure Facility (LDEF) flight which will be carried to orbit by the NASA Space Shuttle. The LDEF will remain in orbit to be picked up by a later Shuttle mission and returned for postflight evaluation. (Author).
A79-38051

17 PREUSS, L., SCHAEFER, W. "Coating and contamination experiment on LDEF long duration exposure facility" , 1979.
Note: Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). In ESA Spacecraft Mater in Space Environ. p 71-80 (SEE N80-21420).

The lifecycle of geosynchronous satellites was examined in terms of reliable thermal control based on stable second surface mirrors (SSM). Flight measurements showed higher solar absorptance-degradation than measured on the ground. By means of a flight experiment on the long duration exposure facility (LDEF) and additional ground experiments, degradation of thermal coatings (SSMETC) was investigated. The flight experiment as well as the ground experiment test samples and values to be measured are presented. (Author (ESA)).
N80-21427

THERMAL ENVIRONMENTS

1 HUGHES, P C., TENNYSON, R. C., (Toronto University, Downsview Canada). "Long Duration Exposure Facility surface temperatures" Journal of Spacecraft and Rockets (ISSN 0022- 4650), vol. 29, Jan.-Feb. 1992, p. 96-101 1992;

Temperatures on the surface of the Long Duration Exposure Facility (LDEF) depend on a number of factors. The LDEF is sometimes in sunlight, sometimes in eclipse; even when the LDEF is in sunlight, a particular surface area (e.g., a test patch) may not be able to see the sun; and, finally, even if it can see the sun, the angle of incidence of the sun's radiation on the test patch is important. The heat input to the test patch from the rest of the LDEF vehicle depends on the average vehicle temperature, which in turn depends on its eclipse history. This paper examines all of these factors and uses a multiple-time- scale description (corresponding to orbital, precessional, and annual time scales) to build an understanding of the chief features observed in the flight data. Geometrical, orbital, and thermal models are developed. Numerical calculations based on these models are shown to be in general agreement with the characteristics of flight data. Thus, all of the salient features of the in-orbit temperature data can be explained in terms of the physical phenomena described. (Author).
A92-24662.

2. BERRIOS, WILLIAM M., SAMPAIR, THOMAS R., (Lockheed Engineering and Sciences Co., Hampton VA). "Long duration exposure facility post-flight thermal analysis, part 1" 1992; NASA-TM-104208-PT-1 534P
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

Results of the post-flight thermal analysis of the Long Duration Exposure Facility (LDEF) mission are presented. The LDEF mission thermal analysis was verified by comparing the thermal model results to flight data from the LDEF Thermal Measurements System (THERM). Post-flight calculated temperature uncertainties have been reduced to under +/- 18 F from the pre-flight uncertainties of +/- 40 F. The THERM consisted of eight temperature sensors, a shared tape recorder, a standard LDEF flight battery, and an electronics control box. The temperatures were measured at selected locations on the LDEF structure interior during the first 390 days of flight and recorded for post-flight analysis. After the LDEF retrieval from Space on 12 Jan. 1990, the tape recorder was recovered from the spacecraft and the data reduced for comparison to the LDEF predicted temperatures. The LDEF mission temperatures were calculated prior to the LDEF deployment on 7 Apr. 1980, and updated after the LDEF retrieval with the following actual flight parameter data: including thermal fluxes, spacecraft attitudes, thermal coatings degradation, and contamination effects. All updated data used for the calculation of post-flight temperatures is also presented in this document. (Author).
N92-19670.

3. BERRIOS, WILLIAM M., SAMPAIR, THOMAS R., (Lockheed Engineering and Sciences Co., Hampton VA). "Long duration exposure facility post-flight thermal analysis, part 2" , 1992; NASA-TM-104208-PT-2. 455P
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

Results of the post-flight thermal analysis for the Long Duration Exposure Facility (LDEF) mission are presented. The LDEF mission thermal analysis was verified by comparing the thermal model results to flight data from the LDEF Thermal Measurements System (THERM). Post-flight calculated temperature uncertainties have been reduced to under +/- 18 F from the pre-flight uncertainties of +/- 40 F. The THERM consisted of eight temperature sensors, a shared tape recorder, a standard LDEF flight battery, and an electronics control box. The temperatures were measured at selected locations on the LDEF structure interior during the first 390 days of flight and recorded for post-flight analysis. After the LDEF retrieval from Space on 12 Jan. 1990, the tape recorder was recovered from the spacecraft and the data reduced for comparison to the LDEF predicted temperatures. The LDEF mission temperatures were calculated prior to the LDEF deployment on 7 Apr. 1980, and updated after the LDEF retrieval with the following actual flight parameter data: thermal fluxes, spacecraft attitudes, thermal coatings degradation, and contamination effects. All updated data used for calculation of post-flight temperatures is also presented in this document. (Author).
N92-19671

4. BERRIOS, WILLIAM M. "Use of the Long Duration Exposure Facility's thermal measurement system for the verification of thermal models." , 1991.
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. In its First LDEF Post-Retrieval Symposium Abstracts p 5 (SEE N91-24972). Abstract Only.

Results are presented of the comparison between the Long Duration Exposure Facility (LDEF) Thermal Measurements Systems (THERM) recorded temperature data and the predicted values as calculated prior to the LDEF deployment. The postflight thermal model was verified and calculated temperature uncertainties were reduced to under + or - 18 F from the preflight uncertainties of + or - 40 F. The THERM consisted of 8 temperature sensors, a shared tape recorder, a standard LDEF flight battery, and an electronics control box. The temperatures were measured at selected locations on the LDEF structure interior during the first 490 days of flight and recorded for postflight analysis. After the recorder was recovered from space, the tape recorder was recovered and the data reduced for comparison to the LDEF predicted temperatures. By comparing the calculated values to the measured data, a verified thermal model that presents the best agreement with the THERM data was obtained. The THERM experiment provided an economical way of performing a postflight verification of the LDEF Thermal Model by recording a limited number of flight temperatures on typical locations of the LDEF structure. (Author).
N91-24975.

5. BERRIOS, WILLIAM M.; SAMPAIR, THOMAS; (Lockheed Corp., Hampton VA). "Long duration exposure facility solar illumination data package" , 1990; NASA-CR-189873. 168P
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A post flight solar illumination data package was created by the LDEF thermal analysis data group in support of the LDEF science office data group. The data presented was prepared with the Thermal Radiation Analysis System (TRASYS) program. Ground tracking data was used to calculate daily orbital beta angles for the calculation of resultant fluxes. This data package will be useful in calculation of solar illumination fluent for a variety of beta angle orbital conditions encountered during the LDEF mission. (Author).
N92-17335.

6. BERRIOS, WILLIAM M. "Long duration exposure facility post- flight thermal analysis: Orbital/thermal environment data package" 1990; NASA-CR-189872 211P
Note: National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A post flight mission thermal environment for the Long Duration Exposure Facility was created as part of the thermal analysis data reduction effort. The data included herein is the thermal parameter data used in the calculation of boundary temperatures. This boundary temperature data is to be released in the near future for use by the LDEF principal investigators in the final analysis of their particular experiment temperatures. Also included is the flight temperature data as recorded by the LDEF Thermal Measurements System (THERM) for the first 90 days of flight. (Author).
N92-17334.

WAKES

1 ORAN, W. A., NAUMANN, R. J., (NASA, Marshall Space Flight Center, Space Sciences Laboratory, Huntsville, Ala.). "Vacuum in the wake of space vehicles" *Vacuum*, vol. 28, Feb. 1978, p. 73, 74. 1978;

Vacuum conditions to be encountered in the wakes of high altitude unmanned space vehicles are calculated in order to demonstrate possibilities for conducting experiments using the high pumping speeds and very high vacuum (down to 10 to the -15th torr) attainable. The flux of ambient particles backscattered by emissions from spacecraft surfaces is modelled for an idealized Long Duration Exposure Facility spacecraft structure in an orbit of 550 km altitude. The total backscattered fluxes are found to be between 3 x 10 to the 4th and 3 x 10 to the 5th per sq cm sec for H and between 10 to the 6th and 10 to the 7th per sq cm sec for He and O, depending on the angle with respect to the wake axis. It is found that the direct ambient hydrogen flux is an order of magnitude greater than the backscattered flux, while the backscattered fluxes of He and O are greater than the direct fluxes. It is pointed out that care should be taken in designing space experiments to enable these theoretical conditions to be met. (A.L.W.).
A79-33750.

2. ORAN, W. A., NAUMANN, R. J., (NASA, Marshall Space Flight Center Huntsville, Ala.). "Utilization of the vacuum developed in the wake zone of space vehicles in the LDEF class Long Duration Exposure Facility" (NASA Ames Research Center and American Vacuum Society, Symposium on the Use of the Space Shuttle for Science and Engineering, Moffett Field, Calif., May 9-11, 1977.) Journal of Vacuum Science and Technology, vol. 14, Nov.-Dec. 1977, p. 1276-1278. 1977;

Contaminating fluxes from upper atmospheric molecules found in the wake of a typical spacecraft of the Long Duration Exposure Facility class are studied with the aim of determining vacuum levels which may be employed by experiments mounted on the vehicle. A simplified representation for the spacecraft, the velocity-shifted Maxwellian distribution (to evaluate ambient flux which has a velocity sufficient to overtake the spacecraft), and a calculation for the backscattered contribution to the flux density of the wake figure in the study are presented. Results indicate that direct and backscattered fluxes of about 10 to the seventh power molecules per sq cm can be expected in the wake of a spacecraft at 550 km altitude. (J.M.B.).
A78-19470.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 1992	Technical Memorandum

4. TITLE AND SUBTITLE

LDEF: A Bibliography with Abstracts

5. FUNDING NUMBERS

6. AUTHOR(S)

H. Garland Gouger, editor

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

NASA Langley Research Center
Hampton, Va. 23681-0001

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Aeronautics and Space Administration
Washington, D. C. 20546-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

NASA TM-107705

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

unclassified-unlimited

Subject Category 12

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The Long Duration Exposure Facility was a free-flying cylindrical structure that housed self-contained experiments in trays mounted on the exterior of the structure. Launched into orbit from the Space Shuttle Challenger in 1984, the LDEF spent almost six years in space before being recovered in 1990. The 57 experiments investigated the effects of the low earth orbit environment on materials, coatings, electronics, thermal systems, seeds, and optics. It also carried experiments that measured crystal growth, cosmic radiation, and micrometeoroids.

This bibliography contains 435 selected records from the NASA aerospace database covering the years 1973 through June of 1992. The citations are arranged within subject categories by author and date of publication.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Long Duration Exposure Facility, Aerospace environments, micrometeoroids, low earth orbit	118
	16. PRICE CODE: A06

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
unclassified	unclassified	unclassified	unlimited