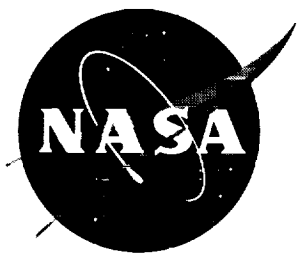


NASA Technical Memorandum 108480



# FY 1994 Scientific and Technical Reports, Articles, Papers, and Presentations

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October 1994



## FOREWORD

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GEORGE C. MARSHALL SPACE FLIGHT CENTER  
Marshall Space Flight Center, Alabama

FY 1994 SCIENTIFIC AND TECHNICAL REPORTS,  
ARTICLES, PAPERS, AND PRESENTATIONS

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precipitation. Grain boundary precipitation and precipitate free zones (PFZ's) were observed in the wrought alloy after exposing to temperatures above 605 °C (1,120 °F). The fine-grained microstructure observed in the laser and electron-beam glazed NARloy-Z was much more stable at elevated temperatures. Microstructural changes correlated well with hardness measurements.

TM-108432 November 1993  
A Simulation Model for Probabilistic Analysis of Space Shuttle Abort Modes. R.T. Hage. Preliminary Design Office. 94N-21859

This report presents a simulation model which has been developed to provide a probabilistic analysis tool to study the various space transportation system abort mode situations. The simulation model is based on Monte Carlo simulation of an event-tree diagram which accounts for events during the space transportation system's ascent and its abort modes. The simulation model considers just the propulsion elements of the shuttle system (i.e., external tank, main engines, and solid boosters). The model was developed to provide a better understanding of the probability of occurrence and successful completion of abort modes during the vehicle's ascent. The results of the simulation runs discussed in this report are for demonstration purposes only, they are not official NASA probability estimates.

TM-108433 December 1993  
Performance Assessment of Low Pressure Nuclear Thermal Propulsion. H.P. Gerrish, Jr., and G.E. Doughty. Propulsion Laboratory. 94N-21860

A low pressure nuclear thermal propulsion (LPNTP) system, which takes advantage of hydrogen dissociation/recombination, has been proposed as a means of increasing engine specific impulse (Isp). This paper examines the effect of hydrogen dissociation/recombination on LPNTP Isp. A two-dimensional computer model was used to show that the optimum chamber pressure is approximately 100 psia (at a chamber temperature of 3,000 K), with an Isp ~ 15 s higher than at 1,000 psia. At high chamber temperatures and low chamber pressures, the increase in Isp is due to both lower average molecular weights caused by dissociation and added kinetic energy from monoatomic hydrogen recombination. Monoatomic hydrogen recombination increases the Isp more than hydrogen dissociation. Variations in the mole fraction of monoatomic hydrogen are similar

to variations in static pressure along the axial nozzle position. Most recombination occurs close to the nozzle throat. Practical variations in nozzle geometry have minimal impact on recombination. Other models, which can simulate a wider range of nozzle designs, should be used in the future. The uncertainty of the hydrogen kinetic reaction rates at high temperatures (~3,000 K) affects the accuracy of the analysis and should be verified with simple bench tests.

TM-108434 December 1993  
Detailed Study of Oxidation/Wear Mechanism in Lox Turbopump Bearings. T.J. Chase and J.P. McCarty. Propulsion Laboratory. 94N-21580

Wear of 440C angular contact ball bearings of the phase II high pressure oxygen turbopump (HPOTP) of the space shuttle main engine (SSME) has been studied by means of various advanced non-destructive techniques (NDT) and modeled with reference to all known material, design, and operation variables. Three modes dominating the wear scenario were found to be the adhesive/shear peeling (ASP), oxidation, and abrasion. Bearing wear was modeled in terms of the three modes. Lacking a comprehensive theory of rolling contact wear to date, each mode is modeled after well-established theories of sliding wear, while sliding velocity and distance are related to microsliding in ball-to-ring contacts. Microsliding, stress, temperature, and other contact variables are evaluated with analytical software packages of SHABERTH™/SINDA™ and ADORE™. Empirical constants for the models are derived from NIST experiments by applying the models to the NIST wear data. The bearing wear model so established precisely predicts quite well the average ball wear rate for the HPOTP bearings. The wear rate has been statistically determined for the entire population of flight and development bearings based on Rocketdyne records to date. Numerous illustrations are given.

TM-108435 January 1994  
MAMS Data for the Convection and Moisture Experiment (CAMEX). A.R. Guillory, G.J. Jedlovec, and R.J. Atkinson. Space Sciences Laboratory. 94N-24080

During the fall of 1993, NASA sponsored a field program called the Convection And Moisture Experiment (CAMEX). The field effort focused on: (1) convective storms in order to investigate their associated electrical properties, precipitation, and

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predictability; and (2) atmospheric moisture studies. This document describes the data collected from the Multispectral Atmospheric Mapping Sensor (MAMS) onboard a NASA ER-2 aircraft which was deployed out of NASA/Wallops Flight Facility, Wallops Island, Virginia, from September 11 through October 7, 1993.

TM-108436 January 1994  
Survey of Visualization and Analysis Tools. P.J. Meyer. Space Sciences Laboratory. 94N-26150

A large number of commercially available visualization and analysis tools are available to the researcher. This document discusses some of the strengths and limitations of some of these tools, from the viewpoint of the Earth sciences discipline. Visualization and analysis tools fall into one of two categories: those that are designed to a specific purpose and are nonextensible, and those that are generic visual programming tools that are extensible. Most of the extensible packages examined incorporate a data flow paradigm.

TM-108437 February 1994  
Development of Infrared Sensors Using Energy Transfer/Energy Upconversion Processes: Study of Laser Excited Fluorescence in Rare Earth Ion Doped Crystals—Final Report: Marshall Space Flight Center Director's Discretionary Fund Project (CDDF) No. 91-10. S.K. Nash-Stevenson, B.R. Reddy, and P. Venkateswarlu. Astrionics Laboratory. 94N-24073

This report presents a summary of the spectroscopic study of three systems:  $\text{LaF}_3:\text{Ho}^{3+}$ ,  $\text{LaF}_3:\text{Er}^{3+}$ , and  $\text{CaF}_2:\text{Nd}^{3+}$ . When the D levels of  $\text{Ho}^{3+}$  in  $\text{LaF}_3$  were resonantly excited with a laser beam of 640 nm, upconverted emissions were detected from J (416 nm), F (485 nm), and E (546 nm) levels. Energy upconverted emissions were also observed from F and E levels of  $\text{Ho}^{3+}$  when the material was excited with an 800 nm near infrared laser. When the D levels of  $\text{Er}^{3+}$  in  $\text{LaF}_3$  were resonantly excited with a laser beam of 637 nm, upconverted emissions were detected from the E (540 nm) and P (320, 400, and 468 nm) levels. Energy upconverted emissions were also observed from F, E, and D levels of  $\text{Er}^{3+}$  when the material was resonantly excited with an 804 nm near infrared laser. When the D levels of  $\text{Nd}^{3+}$  in  $\text{CaF}_2$  were resonantly excited with a laser beam of 577 nm, upconverted emissions were detected from the L (360 and 382

nm), K (418 nm), and I (432 nm) levels. Very weak upconverted emissions were detected when this system was irradiated with a near infrared laser. The numbers in parentheses are the wavelengths of the emissions.

TM-108438 February 1994  
A Survey of Geographical Information Systems Applications for the Earth Science and Applications Division, Space Sciences Laboratory, Marshall Space Flight Center. D. Rickman, K.A. Butler, and C.A. Laymon. Space Sciences Laboratory. 94N-28820

The purpose of this document is to introduce Geographical Information System (GIS) terminology and summarize interviews conducted with scientists in the Earth Science and Applications Division (ESAD). There is a growing need in ESAD for GIS technology. With many different data sources available to the scientists comes the need to be able to process and view these data in an efficient manner. Since most of these data are stored in vastly different formats, specialized software and hardware are needed. Several ESAD scientists have been using a GIS, specifically the Man-computer Interactive Data Access System (McIDAS). McIDAS can solve many of the research problems that arise, but there are areas of research that need more powerful tools; one such example is the multispectral image analysis which is described in this document. Given the strong need for GIS in ESAD, we recommend that a requirements analysis and implementation plan be developed using this document as a basis for further investigation.

TM-108439 March 1994  
Intercomparison of Wildfire and High-Resolution Interferometer Sounder (HIS) Data From STORM-FEST: An Investigation of Wildfire Spectral Channel Discrepancies. G.J. Jedlovec and G.S. Carlson. Space Sciences Laboratory. 94N-29553

This simultaneous collection of HIS spectral measurements aboard the ER-2 during STORM-FEST provided a means to explore calibration problems in the infrared bands of the Wildfire instrument. Large discrepancies in brightness temperatures were noted in Wildfire bands designed to sample the "wings" of the strong ozone absorption band centered at 9.6  $\mu\text{m}$ , where the atmospheric transmittance changes rapidly with wavelength. Examination of interchannel relationships in Wildfire data and

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subsequent comparison to Wildfire data synthesized from the HIS measurements suggests that a wavelength shift in the channel spectral response from those determined in the laboratory may have occurred. Based on comparisons from several flights, this spectral shift has been empirically determined to be about  $0.15 \mu\text{m}$ . It is speculated that this problem resulted from a slight misalignment of the spectrometer grating or other optical elements, or was a result of extreme range in temperatures experienced by the instrument throughout the course of an ER-2 flight. A consequence of this temperature fluctuation may be a change in a position of the grating in the optical path and could result in the variations in channel spectral response during flight. These findings for Wildfire may have significant bearing on future use of the MAS because of the similarities to the original Wildfire configuration.

TM-108440 March 1994  
The Effects of Embedded Internal Delaminations on Composite Laminate Compression Strength; An Experimental Review. A.T. Nettles. Materials and Processes Laboratory. 94N-26127

Delaminations in laminated composite materials can degrade the compressive strength of these materials. Delaminations can form as a result of impact damage or processing flaws. In order to better understand the effects of these delaminations on the compressive behavior of laminated composite plates, programs have been conducted to assess the criticality of prescribed delaminations of known size, shape, and location on the compression strength of laminated composites. A review of these programs is presented along with highlights of pertinent findings from each.

TM-108441 March 1994  
Technical Assessment of MIR-1 Life Support Hardware for the International Space Station. K.L. Mitchell, R.M. Bagdigian, R.L. Carrasquillo, D.L. Carter, G.D. Franks, D.W. Holder, Jr., C.F. Hutchens, K.Y. Ogle, J.L. Perry, and C.D. Ray. Structures and Dynamics Laboratory. 94N-31380

NASA has been progressively learning the design and performance of the Russian life support systems utilized in their Mir space station. In 1992 a plan was implemented to assess the benefits of the Mir-1 life support systems to the *Freedom* program. Three primary tasks focused on: (1) evaluating the operational Mir-1 support technologies and under-

standing if specific Russian systems could be directly utilized on the American space station and determine if Russian technology design information could prove useful in improving the current design of the planned American life support equipment, (2) evaluating ongoing Russian life support technology development activities to determine areas of potential long-term application to the U.S. space station, and (3) utilizing the expertise the Russians have gained with the long-term operation of their space station life support systems to evaluate the benefits to the current U.S. space station program which included the integration of the Russian Mir-1 designs with the U.S. designs to support a crew of six.

TM-108442 March 1994  
Extra-Vehicular-Activity (EVA) Glove Evaluation Test Protocol. E.M. Hinman-Sweeney. Astrionics Laboratory. 94N-27952

One of the most critical components of a space suit is the gloves, yet gloves have traditionally presented significant design challenges. With continued efforts at glove development, a method for evaluating glove performance is needed. This paper presents a pressure-glove evaluation protocol. A description of this evaluation protocol and its development is provided. The protocol allows comparison of one glove design to another, or any one design to bare-handed performance. Gloves for higher pressure suits may be evaluated at current and future design pressures to drive out differences in performance due to pressure effects. Using this protocol, gloves may be evaluated during design to drive out design problems and determine areas for improvement, or fully mature designs may be evaluated with respect to mission requirements. Several different test configurations are presented to handle these cases. This protocol was run on a prototype glove. The prototype was evaluated at two operating pressures and in the unpressurized state, with results compared to bare-handed performance. Results and analysis from this test series was provided, as is a description of the configuration used for this test.

TM-108443 March 1994  
Microbiology Report for the Stage 7 and Stage 8 Water Recovery Tests. M.C. Roman and S.A. Minton. Structures and Dynamics Laboratory. 94X-10202

The Water Recovery Test (WRT) Stage 7 and Stage 8 of the Environmental Control and Life

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Support System (ECLSS) test program was conducted at NASA/Marshall Space Flight Center (MSFC). Assessments of the design and operation of a single-loop water recovery system, which combined the potable and hygiene water recovery loops used in previous WRT testing, was performed during the two test stages. Stage 7 operated for 59 days, December 4, 1991, to February 22, 1992. During each day of WRT stage 7, an average of 20 human test subjects generated wastewater from shower, hand wash, oral hygiene, and laundry activities. In addition, test subjects produced humidity condensate (during exercise), and donated urine. Stage 8 operated 84 days, July 14, 1992, to October 7, 1992. This stage was conducted in donor mode operation with no test subject reclaimed water usage. Stage 8 was conducted identically to stage 7 except for one important change in the system configuration. The potable water processor (PWP) feed sterilizer was by-passed throughout stage 8 testing to determine the impact on the subsystem performance and unibed life expectancy.

TM-108444 March 1994  
 Development of a New Seal for Use on Large Openings of Pressurized Spacecraft (Center Director's Discretionary Fund Project No. 92-11). B. Weddendorf. Structures and Dynamics Laboratory. 94N-27560

This report presents the results of the Center Director's Discretionary Fund project "Development of a New Seal for Use on Large Openings of Pressurized Spacecraft." The goal of this project was to design, build, and test an example of the seal invented by the author for use on Space Station *Freedom* and patented in 1991. The seal features a metallic spring core and replaceable elastomeric sealing elements. The metallic spring is designed to retain the sealing force of the elastomeric element against both sides of face seal gland for any specified amount of waviness or separation of the glands. A seal able to tolerate at least 1.3 mm (0.05 in) of flange distortion or separation and a test fixture of this seal which allowed direct comparison testing of O-rings were built. These designs were tested to compare leakage at different amounts of flange deflection. Results of the testing show the development seal exceeded its requirement to seal 1.3 mm of flange separation by 1 mm. This compared with the O-ring leakage increasing dramatically at 0.5 mm of separation. The development seal also leaked at a lower rate than the O-ring seals in all tests.

TM-108445 March 1994  
 Operations Summary for the Convection and Moisture Experiment (CAMEX). V.L. Griffin, A.R. Guillory, M. Susko, and J.E. Arnold. Space Sciences Laboratory. 94N-33004

During the fall of 1993, NASA sponsored a field program called the Convection and Moisture Experiment (CAMEX) at Wallops Island, Virginia. CAMEX was a multidisciplinary experiment design to measure the three-dimensional moisture fields over Wallops Island, and to characterize the multi-frequency radiometric signature of tropical convection over the Gulf Stream and southeastern Atlantic Ocean. This document summarizes the daily CAMEX activities, including ground and aircraft (NASA ER-2) operations, and includes "quick-look" summaries of data acquisition along with data examples provided by the various CAMEX PI's.

TM-108446 March 1994  
 Small Subscale Solid Rocket Combustion Simulator Test Report for O-Ring Tests Conducted During 1993 (P27093002 to P27093011). M. Sullivan. Propulsion Laboratory. 94X-10222

Between June and October 1993, a series of hybrid rocket motor tests were performed using the SSSRCS. A total of 10 tests were performed in-house at Marshall Space Flight Center. These tests exposed ASRM compound 17A O-rings to hot, abrasive combustion gases. RSRM V-1115 O-rings were simultaneously exposed to this severe environment for comparison to historical baseline materials and testing efforts. All of the objectives for these tests were satisfied. Although both materials performed well, the ASRM compound 17A material consistently suffered less total heat effect than did the RSRM baseline. This report documents the results and analyses from the O-ring portion of the testing.

TM-108447 March 1994  
 Space Shuttle Main Engine Turbopump Bearing Assessment Program. B. Spiegel Breithaupt. Propulsion Laboratory. 94N-28265

This report documents the work done on the bearing assessment program over the past 2<sup>1</sup>/<sub>2</sub> years. The objective of the program is to develop a non-destructive evaluation system for the SSME HPOTP's which would be used to detect anomalies in installed bearings without engine disassembly. Data bases of various signatures are obtained by

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slowly turning the pump shafts before and after an engine firing. These signatures are then analyzed and compared to the original signatures to more accurately predict bearing wear.

TM-108448 April 1994  
NASA Marshall Space Flight Center Solar Observatory Report—July–October 1993. J.E. Smith. Space Sciences Laboratory. 94N-29470

This report provides a description of the NASA Marshall Space Flight Center's Solar Vector Magnetograph Facility and gives a summary of its observations and data reduction during June–October 1993. The systems that make up the facility are a magnetograph telescope, an H- $\alpha$  telescope, a Questar telescope, and a computer code.

TM-108449 April 1994  
Ampoule Failure Sensor Time Response Testing—Experiment 1. M.L. Johnson and D.A. Watring. Astrionics and Space Sciences Laboratory. 94N-30199

The response time of an ampoule failure sensor exposed to a liquid or vapor gallium-arsenide (GaAs) is investigated. The experimental configuration represents the sample/ampoule cartridge assembly used in NASA's Crystal Growth Furnace (CGF). The sensor is a chemical fuse made from a metal with which the semiconductor material reacts more rapidly than it does with the containing cartridge. For the III-IV compound of GaAs, a platinum metal was chosen based on the reaction of platinum and arsenic at elevated temperatures which forms a low melting eutectic. Ampoule failure is indicated by a step change in resistance of the failure sensor on the order of megohms. The sensors will increase the safety of crystal growth experiments by providing an indication that an ampoule has failed. Experimental results indicate that the response times (after a known ampoule failure) for the 0.003 and 0.010 inch ampoule failure sensors are 2.4 and 3.6 minutes, respectively. This ampoule failure sensor will be utilized in the CGF during the second United States Microgravity Laboratory Mission (USML-2) and is the subject of a NASA patent application.

TM-108450 April 1994  
Space Sciences Laboratory Publications and Presentations, January 1–December 31, 1993. Compiled by T.W. Moorehead. Space Sciences Laboratory. 94N-34173

This document lists the significant publications and presentations of the Space Sciences Laboratory during the period January 1–December 31, 1993. Entries in the main part of the document are categorized according to NASA Reports (arranged by report number), Open Literature, and Presentations (arranged alphabetically by title). Also included for completeness is an Appendix (arranged by report number) listing preprints issued by the Laboratory during this reporting period. Some of the preprints have not been published; those already published are so indicated. Most of the articles listed under Open Literature have appeared in refereed professional journals, books, monographs, or conference proceedings. Although many published abstracts are eventually expanded into full papers for publications in scientific and technical journals, they are often sufficiently comprehensive to include the significant results of the research reported. Therefore, published abstracts are listed separately in a subsection under Open Literature. Questions or requests for additional information about the entries in this report should be directed to Tauna W. Moorehead (ES02; 544-7581) or to one of the authors. The organizational code of the cognizant SSL branch or office is given at the end of each entry.

TM-108451 April 1994  
National Aerospace Plane (NASP) X-30 Natural Environment Requirements Document (Rev. 1.0). Dale L. Johnson. Space Sciences Laboratory. 94X-10268

This document defines and summarizes the natural environment design criteria to be used in the design, operational planning, and testing of the proposed, experimental National Aerospace Plane (NASP) X-30 vehicle. Much of the atmospheric design criteria involves climatologies for the Edwards AFB, CA (proposed) launch and landing site, as well as atmospheric design statistics pertaining to flight patterns around the CONUS and orbital/deorbital phases. A design risk of 5 percent or 1 percent is assumed for the proposed flight phases of the X-30 vehicle, as well as pre- and post-launch concerns.

TM-108452 April 1994  
Vulnerability of Manned Spacecraft to Crew Loss From Orbital Debris Penetration. J.E. Williamsen. Structures and Dynamics Laboratory. 94N-30161

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Orbital debris growth threatens the survival of spacecraft systems from impact-induced failures. Whereas the probability of debris impact and spacecraft penetration may currently be calculated, another parameter of great interest to safety engineers is the probability that debris penetration will cause actual spacecraft or crew loss. Quantifying the likelihood of crew loss following a penetration allows spacecraft designers to identify those design features and crew operational protocols that offer the highest improvement in crew safety for available resources.

Within this study, a Manned Spacecraft Crew Survivability (MSCSurv) computer model is developed that quantifies the conditional probability of losing one or more crew members,  $P_{\text{loss/pen}}$ , following the remote likelihood of an orbital debris penetration into an eight module space station. Contributions to  $P_{\text{loss/pen}}$  are quantified from three significant penetration-induced hazards: pressure wall rupture (explosive decompression), fragment-induced injury, and "slow" depressurization. Sensitivity analyses are performed using alternate assumptions for hazard-generating functions, crew vulnerability thresholds, and selected spacecraft design and crew operations parameters. These results are then used to recommend modifications to the spacecraft design and expected crew operations that quantitatively increase crew safety from orbital debris impacts.

TM-108453 April 1994  
Root-Sum-Square Structural Strength Verification Approach. H.M. Lee. Structures and Dynamics Laboratory. 94N-30206

Utilizing a proposed fixture design or some variation thereof, this report presents a verification approach to strength test space flight payload components, electronics boxes, mechanisms, lines, fittings, etc., which traditionally do not lend themselves to classical static loading. The fixture, through use of ordered Euler rotation angles derived herein, can be mounted on existing vibration shakers and can provide an innovative method of applying single axis flight load vectors. The versatile fixture effectively loads protoflight or prototype components in all three axes simultaneously by use of a sinusoidal burst of desired magnitude at less than one-third the first resonant frequency. Cost savings along with improved hardware confidence are shown to be the potential, with the end product being an efficient way to verify experiment hardware for both random vibration and strength.

TM-108454 May 1994  
A Case Study of Analysis Methods for Large Deflections of a Cantilever Beam. L.D. Craig. Structures and Dynamics Laboratory. 94N-32903

A load case study of geometric nonlinear large deflections of a cantilever beam is presented. The bending strain must remain elastic. Closed form solution and finite element methods of analysis are illustrated and compared for three common load cases. A nondimensional monogram for each case is presented in the summary.

TM-108456 April 1994  
A User's Guide to the Trace Contaminant Control Simulation Computer Program. J.L. Perry. Structures and Dynamics Laboratory. 94N-33696

The Trace Contaminant Control Simulation computer program is a tool for assessing the performance of various trace contaminant control technologies for removing trace chemical contamination from a spacecraft cabin atmosphere. The results obtained from the program can be useful in assessing different technology combinations, system sizing, system location with respect to other life support systems, and the overall life cycle economics of a trace contaminant control system. The user's manual is extracted in its entirety from NASA TM-108409 to provide a stand-alone reference for using any version of the program. The first publication of the manual as part of TM-108409 also included a detailed listing of version 8.0 of the program. As changes to the code were necessary, it became apparent that the user's manual should be separate from the computer code documentation and be general enough to provide guidance in using any version of the program. Provided in the guide are tips for input file preparation, general program execution, and output file manipulation. Information concerning source code listings of the latest version of the computer program may be obtained by contacting the author.

TM-108457 May 1994  
Trace Contaminant Control Simulation Computer Program—Version 8.1. J.L. Perry. Structures and Dynamics Laboratory. 94N-33973

The Trace Contaminant Control Simulation computer program is a tool for assessing the performance of various process technologies for

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removing trace chemical contamination from a spacecraft cabin atmosphere. Included in the simulation are chemical and physical adsorption by activated charcoal, chemical adsorption by lithium hydroxide, absorption by humidity condensate, and low- and high-temperature catalytic oxidation. Means are provided for simulating regenerable as well as nonregenerable systems. The program provides an overall mass balance of chemical contaminants in a spacecraft cabin given specified generation rates. Removal rates are based on device flow rates specified by the user and calculated removal efficiencies based on cabin concentration and removal technology experimental data. Versions 1.0 through 8.0 are documented in NASA TM-108409. TM-108409 also contains a source file listing for version 8.0. Changes to version 8.0 are documented in this technical memorandum and a source file listing for the modified version, version 8.1, is provided. Detailed descriptions for the computer program subprograms are extracted from TM-108409 and modified as necessary to reflect version 8.1. Version 8.1 supersedes version 8.0. Information on a separate user's guide is available from the author.

TM-108458 June 1994  
Ampoule Failure Sensor Time Response Testing—Experiments 2 and 3. M.L. Johnson and D.A. Watring. Astrionics and Space Sciences Laboratory. 94N-36822

The response time of an ampoule failure sensor exposed to a liquid or vapor gallium-arsenide (Ga-As) and the corresponding breach time of the containing cartridge is investigated. The experiments were conducted in niobium-hafnium (WC-103) cartridges with an exterior silicide coating. These cartridges were built to flight specifications that were used in NASA's Crystal Growth Furnace during the first United States Microgravity Laboratory (USML-1) mission. The ampoule failure sensor is a chemical fuse made from a metal with which the semiconductor material reacts more rapidly than it does with the containing cartridge. In these experiments, a platinum metal was used for the manufacture of the sensors. This technical report discusses the response time of two different sensor designs. The first design utilizes a helical wrapped wire and the second uses a single bare wire element. Experimental results indicate that both sensors are adequate in sensing the presence of molten or vapor GaAs with the latter having a 2-minute longer response time. In both experiments, the containing cartridge

was breached within 185 minutes after ampoule rupture.

TM-108459 June 1994  
A Programmable Heater Control Circuit for Spacecraft (Center Director's Discretionary Fund Final Report, Project No. 90-19). D.D. Nguyen, J.W. Owen, D.A. Smith, and W.J. Lewter. Structures and Dynamics Laboratory and Astrionics Laboratory.

Spacecraft thermal control is accomplished for many components through use of multilayer insulation systems, electrical heaters, and radiator systems. The heaters are commanded to maintain component temperatures within design specifications. The programmable heater control circuit (PHCC) was designed to obtain an effective and efficient means of spacecraft thermal control. The hybrid circuit provides use of control instrumentation as temperature data, available to the spacecraft central data system, reprogramming capability of the local microprocessor during the spacecraft's mission, and the elimination of significant spacecraft wiring. The hybrid integrated circuit has a temperature sensing and conditioning circuit, a microprocessor, and a heater power and control circuit. The device is miniature and housed in a volume which allows physical integration with the component to be controlled. Applications might include alternate battery-powered logic-circuit configurations. A prototype unit with appropriate physical and functional interfaces was procured for testing. The physical functionality and the feasibility of fabrication of the hybrid integrated circuit were successfully verified. The remaining work to develop a flight-qualified device includes fabrication and testing of a Mil-certified part. An option for completing the PHCC flight qualification testing is to enter into a joint venture with industry.

TM-108460 August 1994  
Portable Color Multimedia Training Systems Based on Monochrome Laptop Computers (CBT-in-a-Briefcase), With Spinoff Implications for Video Uplink and Downlink in Spaceflight Operations (Center Director's Discretionary Fund Final Report, No. 91-16). D.W. Scott. Structures and Dynamics Laboratory. 94N-37556

This report describes efforts to use digital motion video compression technology to develop a highly portable device that would convert 1990-91

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era IBM-compatible and/or MacIntosh notebook computers into full-color, motion-video capable multimedia training systems. An architecture was conceived that would permit direct conversion of existing laser-disk-based multimedia courses with little or no reauthoring. The project did not physically demonstrate certain critical video keying techniques, but their implementation should be feasible. This investigation of digital motion video has spawned two significant spaceflight projects at MSFC: one to downlink multiple high-quality video signals from Spacelab, and the other to uplink video conference-quality video in real-time and high quality video offline, plus investigate interactive, multimedia-based techniques for enhancing onboard science operations. Other airborne or spaceborne spinoffs are possible.

TM-108461 June 1994  
Effect of Microgravity on Crystallization of ZBLAN Fibers. D.S. Tucker. Materials and Processes Laboratory.

ZrF<sub>4</sub>-BaF<sub>2</sub>-LaF<sub>3</sub>-AlF<sub>3</sub>-NaF (ZBLAN) optical fiber was flown onboard the NASA's KC-135 microgravity aircraft to determine the effects of microgravity on crystal growth in this material. Fiber samples were placed in evacuated quartz ampoules and heated to the crystallization temperature in 0, 1, and 2g. The 1 and 2g samples were observed to slump and crystallize. The 0g samples showed no evidence of crystallization.

TM-108462 July 1994  
Dynamics Explorer 1, Retarding Ion Mass Spectrometer Summary Spectrograms—81/280 to 81/365 Spin-Time Spectrograms for H<sup>+</sup>, He<sup>+</sup>, O<sup>+</sup>, N<sup>+</sup>, O<sup>++</sup>, M/Z = 2, and Molecular Ions. DE 1/RIMS Investigators. Space Sciences Laboratory.

The Retarding Ion Mass Spectrometer (RIMS) experiment onboard the Dynamics Explorer 1 (DE 1) satellite was designed to perform energy and mass-per-charge analysis on low-energy ions (<50 eV) with mass/charge ratios ranging from 1 to 40 amu/Z. The DE 1 satellite, carrying the RIMS experiment, was launched into an elliptical polar orbit on August 3, 1981. The ~7.5 hour orbit has perigee of 675 km altitude and apogee of 24,875 km altitude. This document, and those that follow in this series, contains summary RIMS data spectrograms for each orbit for which RIMS data are available.

The RIMS instrument began returning science data on day 280 of 1981 and continued to return usable data until the end of the DE mission in March 1991. It should be noted that studies of the RIMS data set should be conducted only with a thorough awareness of the material described in the introduction section presented here, or in collaboration with a scientist familiar with RIMS data analysis.

TM-108463 August 1994  
Finite Element Analysis of a Composite Wheelchair Wheel Design. R. Ortega. Structures and Dynamics Laboratory.

The finite element analysis of a composite wheelchair wheel design is presented. The design is the result of a technology utilization request. The designer's intent is to soften the riding feeling by incorporating a mechanism attaching the wheel rim to the spokes that would allow considerable deflection upon compressive loads. A finite element analysis was conducted to verify proper structural function. Displacement and stress results are presented and conclusions are provided.

TM-108464 August 1994  
Inner Magnetosphere Imager (IMI) Solar Terrestrial Probe Class Mission Preliminary Design Study Report. M. Herrmann and L. Johnson. Program Development Directorate.

For three decades, magnetospheric field and plasma measurements have been made by diverse instruments flown on spacecraft in many different orbits, widely separated in space and time, and under various solar and magnetospheric conditions. Scientists have used this information to piece together an intricate, yet incomplete view of the magnetosphere. A simultaneous global view, using various light wavelengths and energetic neutral atoms, could reveal exciting new data and help explain complex magnetospheric processes, thus providing us with a clear picture of this region of space.

The George C. Marshall Space Flight Center (MSFC) is responsible for defining the IMI mission which will study this region of space. NASA's Space Physics Division of the Office of Space Science placed the IMI third in its queue of Solar Terrestrial Probe missions for launch in the 1990's. A core instrument complement of three imagers (with the potential addition of one or more mission enhancing instruments) will fly in an elliptical, polar Earth orbit with a apogee of 44,600 km and a perigee of 4,800 km. This paper will address the



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mission objectives, spacecraft design considerations, interim results of the MSFC concept definition study, and future plans.

TM-108465 August 1994  
Statistical Design Study of Lunar Ceramic. M. Effinger and D. Tucker. Materials and Processes Laboratory.

Fabrication of a lunar ceramic was conducted according to a statistically designed experiment. The method of cold pressing was used since the consumption of electrical energy is kept to a minimum, a priority in the lunar environment. This traditional fabrication technique also provides an initial data source on which further investigations can be based. Results obtained from using 2 percent binder, a cold pressing pressure of 276 MPa, and 24 hours sintering time yielded the greatest compressive strength of 247 MPa. Analysis of each variable's influence on the compressive strength is also presented.

TM-108466 September 1994  
New Directions in Phthalocyanine Pigments (Center Director's Discretionary Fund Final Report No. 90-25). D.V. Trinh. Materials and Processes Laboratory.

Phthalocyanines have been used as a pigment in coatings and related applications for many years. These pigments are some of the most stable organic pigments known. The phthalo blue and green pigments have been shown to be ultraviolet (UV) stable and thermally stable to over 400 °C. These phthalocyanines are both a semiconductor and photoconductor, exhibiting catalytic activity and photostabilization capability of polymers. Many metal free and metallic phthalocyanine derivatives have been prepared. Development of the new classes of phthalocyanine pigment could be used as coating on NASA spacecraft material such as glass to decrease the optical degradation from UV light, the outside of the space station modules for UV protection, and coating on solar cells to increase lifetime and efficiency.

TM-108467 September 1994  
STS Propellant Densification Feasibility Study Data Book. M.M. Fazah. Propulsion Laboratory.

The feasibility of using densification or subcooling with respect to standard temperature propellants on the Space Transportation System (STS) in order to achieve a payload gain is discussed in this report.

The objective is to determine the magnitude of the payload gain and to identify any system impacts to the space shuttle on either flight systems or ground systems. Results show that a payload benefit can be obtained by subcooling the liquid hydrogen (LH<sub>2</sub>) from a nominal temperature of 36.4 to 28.5 °R and by subcooling the liquid oxygen (LO<sub>2</sub>) from a nominal temperature of 164 °R to either 132.1 or 141.4 °R. When the propellants are subcooled to 28.5 and 132.1 °R for the LH<sub>2</sub> and LO<sub>2</sub>, respectively, a maximum payload gain of 7,324 lb can be achieved, and when the propellants are subcooled to 28.5 and 141.5 °R for the LH<sub>2</sub> and LO<sub>2</sub>, respectively, a maximum payload gain of 6,841 lb can be achieved. If the LH<sub>2</sub> is subcooled to 28.5 °R while the LH<sub>2</sub> and LO<sub>2</sub> remains at the nominal conditions, a maximum payload gain of 1,303 lb can be achieved.

TM-4511 August 1993  
Terrestrial Environment (Climatic) Criteria Guidelines for Use in Aerospace Vehicle Development, 1993 Revision. D.L. Johnson, Editor. Space Sciences Laboratory. 94N-14824

This document provides guidelines on terrestrial environment data specifically applicable in the development of design requirements/specifications for NASA aerospace vehicles and associated equipment development. The primary geographic areas encompassed are the John F. Kennedy Space Center, FL; Vandenberg AFB, CA; Edwards AFB, CA; Michoud Assembly Facility, New Orleans, LA; John C. Stennis Space Center, MS; Lyndon B. Johnson Space Center, Houston, TX; and the White Sands Missile Range, NM. In addition, a section has been included to provide information on the general distribution of natural environmental extremes in the conterminous United States that may be needed to specify design criteria in the transportation of space vehicle subsystems and components. A summary of climatic extremes for worldwide operational needs is also included. Although not considered as a specific vehicle design criterion, a section on atmospheric attenuation has been added since sensors on certain Earth orbital experiment missions are influenced by the Earth's atmosphere. This document presents the latest available information on probable climatic extremes and supersedes information presented in TM X-64589, TM X-64757, TM X-78118, and TM-82473. Information is included on atmospheric chemistry, seismic criteria, and on a mathematical model to predict atmospheric dispersion of

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aerospace engine exhaust cloud rise and growth. There is also a section on atmospheric cloud phenomena. The information in this report is recommended for use in the development of aerospace vehicle and associated equipment design and operational criteria, unless otherwise stated in contract work specifications. The environmental data in this report are primarily limited to information below 90 km.

TM-4527 June 1994  
Natural Orbital Environment Definition Guidelines for Use in Aerospace Vehicle Development. B.J. Anderson, Editor, and R.E. Smith, Compiler. Systems Analysis and Integration Laboratory. 94N-36175

This document provides definitions of the natural near-Earth space environment suitable for use in the initial development/design phase of any space vehicle. The natural environment includes the neutral atmosphere, plasma, charged particle radiation, electromagnetic radiation (EMR), meteoroids, orbital debris, magnetic field, physical and thermal constants, and gravitational field. Communications and other unmanned satellites operate in geosynchronous-Earth orbit (GEO); therefore, some data are given for GEO, but emphasis is on altitudes from 200 to 1,000 km (low-Earth orbit (LEO)). This document does not cover the induced environment or other effects resulting from presence of the space

vehicle. Manmade factors are included as part of the ambient natural environment; i.e., orbital debris and radio frequency (RF) noise generated on Earth, because they are not caused by the presence of the space vehicle but form part of the ambient environment that the space vehicle experiences.

TM-4594 April 1994  
Lunar Ultraviolet Telescope Experiment (LUTE) Phase A Final Report. R.O. McBrayer, et al. Preliminary Design, Science and Engineering, and Safety and Mission Assurance Office. 94N-34920

The Lunar Ultraviolet Telescope Experiment (LUTE) is a 1-meter telescope for imaging from the lunar surface of the ultraviolet spectrum between 1,000 and 3,500 angstroms. There have been several endorsements of the scientific value of a LUTE. In addition to the scientific value of LUTE, its educational value and the information it can provide on the design of operating hardware for long-term exposure in the lunar environment are important considerations.

This report provides the results of the LUTE phase A activity begun at the George C. Marshall Space Flight Center in early 1992. It describes the objective of LUTE (science, engineering, and education), a feasible reference design concept that has evolved, and the subsystem trades that were accomplished during the phase A.

## NASA TECHNICAL PAPERS

TP-3421 October 1993  
Prioritization Methodology for Chemical Replacement. W. Cruit, S. Schutzenhofer, B. Goldberg, and K. Everhart. NASA Operational Environment Team. 94N-15723

This project serves to define an appropriate methodology for effective prioritization of efforts required to develop replacement technologies mandated by imposed and forecast legislation. The methodology used is a semiquantitative approach derived from quality function deployment techniques (QFD Matrix). This methodology aims to weigh the full environmental, cost, safety, reliability, and programmatic implications of replacement technology development to allow appropriate identification of viable candidates and programmatic alternatives. The results are being implemented as a guideline for consideration for current NASA propulsion systems.

TP-3432 November 1993  
Total Systems Design Analysis of High Performance Structures. V. Verderaime. Structures and Dynamics Laboratory. 94N-20141

Designer-control parameters were identified at interdiscipline interfaces to optimize structural systems performance and downstream development and operations with reliability and least life-cycle cost. Interface tasks and iterations are tracked through a matrix of performance disciplines integration versus manufacturing, verification, and operations interactions for a total system design analysis. Performance integration tasks include shapes, sizes, environments, and materials. Integrity integrating tasks are reliability and recurring structural costs. Significant interface designer control parameters were noted as shapes, dimensions, probability range factors, and cost. Structural failure concept is presented, and first-order reliability and deterministic methods, benefits, and limitations are discussed. A deterministic reliability technique combining benefits of both is proposed for static structures which is also timely and economically verifiable. Though launch vehicle environments were primarily considered, the system design process is applicable to any surface system using its own unique filed environments.

TP-3434 November 1993  
Review of the Probabilistic Failure Analysis Methodology and Other Probabilistic Approaches for Application in Aerospace Structural Design. J.S. Townsend, C. Meyers, R. Ortega, J. Peck, M. Rheinfurth, and B.

Weinstock. Structures and Dynamics Laboratory. 94N-23342

Probabilistic structural analyses and design methods are steadily gaining acceptance within the aerospace industry. The safety factor approach to design has long been the industry standard, and is believed by many to be overly conservative, and thus costly. A probabilistic approach to design may offer substantial cost savings. This report summarizes several probabilistic approaches; the probabilistic failure analysis (PFA) methodology developed by Jet Propulsion Laboratory, fast probability integration (FPI) methods, the NESSUS finite element code, and response surface methods. Example problems are provided to help identify the advantages and disadvantages of each method.

TP-3442 December 1993  
Analysis and Test of Low Profile Aluminum Aerospace Tank Dome. R. Ahmed and J.M. Wilhelm. Structures and Dynamics Laboratory. 94N-23294

In order to increase the structural performance of cryogenic tanks, the aerospace industry is beginning to employ low-profile bulkheads in new generation launch vehicle designs. This report details the analysis and test of one such dome made from 2219 aluminum. Such domes have two potential failure modes under internal pressure, general tensile failure and hoop compression buckling (in regions near the Equator). The test determined the buckling load and ultimate tensile load of the hardware and showed that both compared well with the analysis predictions. This effort was conducted under the auspices of NASA and the General Dynamics Cryogenic Tank Technology Program (CTTP).

TP-3457 January 1994  
CORSS: Cylinder Optimization of Rings, Skin, and Stringers. J. Finckenor, P. Rogers, and N. Otte. Structures and Dynamics Laboratory. 94N-24727

Launch vehicle designs typically make extensive use of cylindrical skin stringer construction. Structural analysis methods are well developed for preliminary design of this type of construction. This report describes an automated, iterative method to obtain a minimum weight preliminary design.

Structural optimization has been researched extensively, and various programs have been written for this purpose. Their complexity and ease of use depends on their generality, the failure modes

considered, the methodology used, and the rigor of the analysis performed. This computer program employs closed-form solutions from a variety of well-known structural analysis references and joins them with a commercially available numerical optimizer called the "Design Optimization Tool" (DOT).

Any ring and stringer stiffened shell structure of isotropic materials that has beam type loading can be analyzed. Plasticity effects are not included. It performs a more limited analysis than programs such as PANDA, but it provides an easy and useful preliminary design tool for a large class of structures.

This report briefly describes the optimization theory, outlines the development and use of the program, and describes the analysis techniques that are used. Examples of program input and output, as well as the listing of the analysis routines, are included.

TP-3458 January 1994  
 Results of a Laboratory Experiment That Tests Rotating Unbalanced-Mass Devices for Scanning Gimbaled Payloads and Free-Flying Spacecraft (CDDF Final Report No. 92-02). D.C. Alhorn and M.E. Polites. Astrionics Laboratory and Structures and Dynamics Laboratory. 94N-23574

Rotating unbalanced-mass (RUM) devices are a new way to scan space-based, balloon-borne and ground-based gimbaled payloads, like x-ray and gamma-ray telescopes. They can also be used to scan free-flying spacecraft. Circular scans, linear scans, and raster scans can be generated. A pair of RUM devices generates the basic scan motion and an auxiliary control system using torque motors control moment gyros, or reaction wheels keeps the scan centered on the target and produces some complementary motion for raster scanning. Previous analyses and simulation results show that this approach offers significant power savings compared to scanning only with the auxiliary control system especially with large payloads and high scan frequencies. However, these claims have never been proven until now. This paper describes a laboratory experiment which tests the concept of scanning gimbaled payload with RUM devices. A description of the experiment is given and test results that prove the concept are presented. The test results are compared with those from a computer simulation model of the experiment and the differences are discussed.

TP-3463 February 1994  
 Thermocapillary Flow With Evaporation and Condensation and Its Effect on Liquid Retention

in Low-G Fluid Acquisition Devices, MSFC Center Director's Discretionary Fund Final Report, Project No. 91-15. G.R. Schmidt. Propulsion Laboratory. 94N-27639

The steady motion, thermal and free surface behavior of a volatile, wetting liquid in microgravity are studied using scaling and numerical techniques. The objective is to determine whether the thermocapillary and two-phase convection arising from thermodynamic nonequilibrium along the porous surfaces of spacecraft liquid acquisition devices could cause the retention failures observed with liquid hydrogen and heated vapor pressurant. The study also examines why these devices seem immune to retention loss when pressurized with heated helium or heated directly through the porous structure. Results show that highly wetting fluids exhibit large negative and positive dynamic pressure gradients toward the meniscus interline when superheated and subcooled, respectively. With superheating, the pressure variation and recoil force arising from liquid/vapor phase change exert the same influence on surface morphology and promote retention. With subcooling, however, the pressure distribution produces a suction that degrades mechanical equilibrium of the surface. This result indicates that thermocapillary-induced deformation arising from subcooling and condensation is the likely cause for retention loss. In addition, increasing the level of nonequilibrium by reducing accommodation coefficient suppresses deformation and explains why this failure mode does not occur in instances of direct screen heating or pressurization with a heated inert gas.

TP-3488 May 1994  
 Aerodynamic Characteristics of the National Launch System (NLS) 1<sup>1/2</sup> Stage Launch Vehicle. A.M. Springer and D.C. Pokora. Structures and Dynamics Laboratory. 94N-37577

The National Aeronautics and Space Administration (NASA) is studying ways of assuring more reliable and cost effective means to space. One launch system studied was the NLS which included the 1<sup>1/2</sup> stage vehicle. This document encompasses the aerodynamic characteristics of the 1<sup>1/2</sup> stage vehicle. To support the detailed configuration definition, two wind tunnel tests were conducted in the NASA Marshall Space Flight Center's 14x14-Inch Trisonic Wind Tunnel during 1992. The tests were a static stability and a pressure test, each utilizing 0.004 scale models. The static stability test resulted in the forces and moments acting on the vehicle. The

aerodynamics for the reference configuration with and without feedlines and an evaluation of three proposed engine shroud configurations were also determined. The pressure test resulted in pressure distributions over the reference vehicle with and without feedlines including the reference engine shrouds. These pressure distributions were integrated and balanced to the static stability coefficients resulting in distributed aerodynamic loads on the vehicle. The wind tunnel tests covered a Mach range of 0.60 to 4.96. These ascent flight aerodynamic characteristics provide the basis for trajectory and performance analysis, loads determination, and guidance and control evaluation.

TP-3490 June 1994  
The Corrosion Protection of Several Aluminum Alloys By Chromic Acid and Sulfuric Acid Anodizing. M.D. Danford. Materials and Processes Laboratory. 94N-37578

The corrosion protection afforded 7075-T6, 7075-T3, 6061-T6, and 2024-T3 aluminum alloys by chromic acid and sulfuric acid anodizing was examined using electrochemical techniques. From these studies, it is concluded that sulfuric acid anodizing provides superior corrosion protection compared to chromic acid anodizing.

TP-3499 July 1994  
Universal First-Order Reliability Concept Applied to Semistatic Structures. V. Verderaime. Structures and Dynamics Laboratory.

A reliability design concept was developed for semistatic structures which combines the prevailing deterministic method with the first-order reliability method. The proposed method surmounts deterministic deficiencies in providing uniformly reliable structures and improved safety audits. It supports risk analyses and reliability selection criterion. The method provides a reliability design factor derived from the reliability criterion which is analogous to the current safety factor for sizing structures and verifying reliability response. The universal first-order reliability method should also be applicable for air and surface vehicles semistatic structures.

TP-3501  
Illustrated Structural Application of Universal First-Order Reliability Method. V. Verderaime. Structures and Dynamics Laboratory.

The general application of the proposed first-order reliability method was achieved through the

universal normalization of engineering probability distribution data. The method superimposes prevailing deterministic techniques and practices on the first-order reliability method to surmount deficiencies of the deterministic method and provide benefits of reliability techniques and predictions. A reliability design factor is derived from the reliability criterion to satisfy a specified reliability and is analogous to the deterministic safety factor. Its application is numerically illustrated on several practical structural design and verification cases with interesting results and insights. Two concepts of reliability selection criteria are suggested. Though the method was developed to support affordable structures for access to space, the method should also be applicable for most high-performance air and surface transportation systems.

TP-3506 September 1994  
Damage Tolerance of Candidate Thermoset Composites for Use on Single Stage to Orbit Vehicles. A.T. Nettles, D. Lance, and A. Hodge. Materials and Processes Laboratory.

Four fiber/resin systems were compared for resistance to damage and damage tolerance. One toughened epoxy and three toughened bismaleimide (BMI) resins were used, all with IM7 carbon fiber reinforcement. A statistical design of experiments technique was used to evaluate the effects of impact energy, specimen thickness, and tup diameter on the damage area as computed by C-scans, and residual compression-after-impact (CAI) strength. Results showed that two of the BMI systems sustained relatively large damage zones, yet had an excellent retention of CAI strength.

TP-3507 September 1994  
Development of Homotopy Algorithms for Fixed-Order Mixed  $H_2/H_\infty$  Controller Synthesis. M. Whorton, H. Buschek, and A.J. Calise. Structures and Dynamics Laboratory.

A major difficulty associated with  $H_\infty$  and  $\mu$ -synthesis methods is the order of the resulting compensator. Whereas model and/or controller reduction techniques are sometimes applied, performance and robustness properties are not preserved. By directly constraining compensator order during the optimization process, these properties are better preserved, albeit at the expense of computational complexity. This paper presents a novel homotopy algorithm to synthesize fixed-order mixed  $H_2/H_\infty$  compensators. Numerical results are presented for a four-disk

flexible structure to evaluate the efficiency of the algorithm.

TP-3508 September 1994

An Inelastic Analysis of a Welded Aluminum Joint. R.E. Vaughan. Structures and Dynamics Laboratory.

Butt-weld joints are most commonly designed into pressure vessels which then become as reliable as the weakest increment in the weld chain. In practice, weld material properties are determined from tensile test specimen and provided to the stress analyst in the form of a stress versus strain diagram. Variations in properties through the thickness of the weld and along the width of the weld have been suspect but not explored because of inaccessibility and cost.

The purpose of this study is to investigate analytical and computational methods used for analysis

of welds. The weld specimens are analyzed using classical elastic and plastic theory to provide a basis for modeling the inelastic properties in a finite-element solution. The results of the analysis are compared to experimental data to determine the weld behavior and the accuracy of prediction methods. The weld considered in this study is a multiple-pass aluminum 2219-T87 butt weld with thickness of 1.40 in.

The weld specimen is modeled using the finite-element code *ABAQUS*. The finite-element model is used to produce the stress-strain behavior in the elastic and plastic regimes and to determine Poisson's ratio in the plastic region. The value of Poisson's ratio in the plastic regime is then compared to experimental data. The results of the comparisons are used to explain multipass weld behavior and to make recommendations concerning the analysis and testing of welds.



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- HAMAKER, J.W. PP03  
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- HOWARD, R.T. EB62  
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Measurements of Solar Differential Rotation From Cross-Correlation Tracking of Supergranulation. For presentation at the Annual AGU/SPD Meeting, Baltimore, MD, July 23-27, 1994.

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- NESMAN, T.E. ED33  
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 HOOVER, R.B.  
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- PERKEY, D.J. ES42  
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- PETTIGREW, P.J. ES75  
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 GREGORY, J.C.  
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- PIMPERL, M.M. ES84  
 RAMSEY, B.D.  
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 MINIMATANI, T.  
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- POLETTO, G. ES82  
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- KHAN, J.  
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 HARVEY, K.  
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- POLLOCK, C.J. ES83  
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- POLLOCK, C.J. ES83  
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 ARNOLDY, R.L.  
 KINTNER, P.M.  
 CAHILL, L.J., JR.  
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- PORTER, J. ES52  
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- POWERS, W.T. EB22  
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 ET AL.  
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- PRESTWICH, A.H. ES84  
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LUGINBUHL, C.  
JOY, M.  
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- PRINCE, T.A. ES66  
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- QUATTROCHI, D.A. ES42  
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- QUATTROCHI, D.A. ES44  
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- QUATTROCHI, D.A. ES42  
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- QUATTROCHI, D.A. ES42  
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- RAMSEY, B.D. ES84  
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FULTON, A.  
MIR, J.  
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- RAMSEY, B.D. ES65  
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- RAO, P.A. ES43  
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- REDDY, B.F. EB22  
NASH-STEVENSON, S.K.  
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- REIFF, P.H. ES53  
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- RHODES, P.H. ES76  
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Preparation of N-(4-Nitrophenyl)-N-Methylaminoacetonitrile (NPAN) Derivatives for Non-linear Optics. For presentation at the Society for Advancement of Chicanos and Native Americans in Science (SACNAS), Chicago, IL.

RINCON, C.D. EH23  
ARWOOD, R.  
NUNES, A.C., JR.  
Plastic Flow, Strain-Hardening, and Strength of Butt Welds in 2219-T87 Aluminum. For publication in the Welding Journal, Miami, FL.

ROTHERMEL, J. ES43  
HARDESTY, R.M.  
MENZIES, R.T.  
Characterizing Subgrid Scale Processes and Assessing Satellite Doppler Wind Lidar With MACAWS. For presentation at the Sixth Symposium on Global Change Studies, Dallas, TX, January 15-20, 1995.

ROBERTS, F.E. EH34  
Relation of Processing Parameters to Tensile Strength and Surface Finish in Materials for Fused Deposition Modeling and Stereolithography. For presentation at the American Ceramic Society 96 Annual Meeting and Exposition, Indianapolis, IN, April 24-27, 1994.

RUBIN, B.C. (USRA)  
KOUVELIOTOU, C.K.  
PARADIJS, J.V. (University of Amsterdam)  
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HARMON, B.A. ES66  
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MEEGAN, C.A.  
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PACIESAS, W.S. (UAH)  
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ROBERTSON, F.R. ES42  
McCAUL, W.E.  
Diagnostics of Macroscale Cloud Systems and Their Relationships to Kinematic and Thermodynamic Forcing. For presentation at The Royal Society European Conference on the Global Energy and Water Cycle, London, United Kingdom, July 18-22, 1994.

RUPP, C.C. PS02  
Small Expendable Deployer System First Flight (SEDS-1) Features and Dynamics During Deployment. For presentation at the International Round Table on Tethers in Space, Noordwijk, The Netherlands, September 28-30, 1994.

ROBINSON, J.H. ED52  
NOLEN, A.M. EH15  
An Investigation of Metal Matrix Composites as Shields for Hypervelocity Orbital Debris Impacts. For presentation at the 1994 Hypervelocity Impact Symposium, Santa Fe, NM, October 17-19, 1994, and for publication in the Proceedings of the International Journal of Impact Engineering.

RUSSELL, C.K. EH25  
Evaluation of the Paton and United States Developed Tools for Materials Processing in Space. For presentation at the Second International Conference on Welding in Space and Construction of Space Vehicle by Welding, Kiev, Ukraine, May 17, 1994.

ROGERS, J. ES74  
DOWNEY, J.  
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FACEMIRE, B.  
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Coarsening of Three-Dimensional Droplets by Two-Dimensional Diffusion, Part I—Experiment. For publication in the Journal of Electronic Materials, Lexington, MA.

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| <p>SAFIE, F.M.</p>   | <p>CT31</p>                                   | <p>A Risk Assessment Methodology for the Space Shuttle External Tank Welds. For presentation at the 1994 Annual Reliability and Maintainability Symposium, Anaheim, CA, January 25-27, 1994.</p>   |  |
| <p>SCARBRO, H.D.<br/>HO, C.W.<br/>HORWITZ, J.L.<br/>WILSON, G.R.<br/>MOORE, T.E.</p>                                 | <p>(UAH)<br/><br/><br/><br/>ES53</p>          | <p>Centrifugal Acceleration of the Polar Wing. For publication in the Journal of Geophysical Research, Washington, DC.</p>   |  |
| <p>SCHILLER, S.<br/>LUVALL, J.</p>   | <p>ES42</p>                                   | <p>A Portable Ground-Based Atmospheric Monitoring System (PGAMS) for the Calibration and Validation of Atmospheric Correction Algorithms Applied to Satellite Images. For presentation at the International Society of Optical Engineering (SPIE), Orlando, FL, April 4-8, 1994.</p> |  |
| <p>SCHMIDT, G.R.<br/>NADARAJAH, A.<br/>CHUNG, T.J.<br/>KARR, G.R.</p>  | <p>EP25<br/>(UAH)</p>                         | <p>Influence of Two-Phase Thermocapillary Flow on Cryogenic Liquid Retention in Microscopic Pores. For presentation at the 32nd AIAA Aerospace Science Meeting and Exhibit, Reno, CA, January 10-13, 1994.</p>   |  |
| <p>SCHRAMM, F.<br/>ROXBY, D.</p>   | <p>LA20<br/>(Rockwell)</p>                    | <p>Beginning the 21st Century With Advanced Automatic Part Identification (API). For presentation at NASA/SPIE, San Diego, CA, July 25-28, 1994.</p>   |  |
| <p>SCHRAMM, F.<br/>ROXBY, D.</p>   | <p>AT01<br/>(Rockwell)</p>                    | <p>Beginning the 21st Century With Advanced Automatic Parts Identification (API). For presentation at Technology 2003, Anaheim, CA, December 7-9, 1993.</p>  |  |
| <p>SCHUMANN, R.S.<br/>TAYLOR, G.E.<br/>SMITH, S.A.<br/>WINFONG, T.L.</p>   | <p>ES42</p>                                   | <p>Application of 50 MHz Doppler Radar Wind Profiler to Launch Operations at Kennedy Space Center and Cape Canaveral Air Station. For presentation at the AMS Conference on Weather Analysis and Forecasting, Dallas, TX, January 15-20, 1995.</p>                                   |  |
| <p>SHA, Y.-G.<br/>SU, C.-H.<br/>PALOSZ, W.<br/>VOLZ, M.P.<br/>GILLIES, D.C.<br/>SZOFRAN, F.R.<br/>LEHOCZKY, S.L.</p> | <p>ES75</p>                                   | <p>Mass Flux and Crystal Growth of Zn-Se by PVT. For presentation at the Eighth International Conference on Vapor Growth and Epitaxy, Germany, July 24-29, 1994.</p>   |  |
| <p>SHA, Y.-G.<br/>VOLZ, M.P.<br/>LEHOCZKY, S.L.</p>  | <p>ES75</p>                                   | <p>Electrical Properties and Compositional Distributions of CVT and PVT Grown <math>Hg_{1-x}Cd_xTe</math> Epilayers. For publication in the Journal of Electronic Materials, Warrendale, PA.</p>   |  |
| <p>SHAPIRO, R.G.<br/>BEITH, B.<br/>GOLDBERG, J.H.<br/>HALE, J.<br/>KELLEY, J.F.</p>                                  | <p>EO23</p>                                   | <p>I'm Graduating, Now What? A Comparison of Work in Academics, Consulting, Government, Industrial Research, and Industrial Development. For presentation at the Human Factors and Ergonomics Annual Meeting, Nashville, TN, October 24-28, 1994.</p>                                |  |
| <p>SHEALY, D.L.<br/>WANG, C.<br/>HOOVER, R.B.</p>  | <p>ES82</p>                                   |  |  |

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SHELL, M.Q. ES37  
 COLLIER, M.D.  
 Adaptation of Control Center Software to Commercial Real-Time Display Applications. For presentation at the Dual Use Space Technology Transfer Conference and Exhibition, Houston, TX, February 1-4, 1994.

SHENG, W. ES74  
 HE, K.  
 KORNFELD, D.  
 PENN, B.  
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 ET AL.  
 Lasing and Fluorescence From BIS-MSB-Dye-Doped Polystyrene Microspheres. For presentation at the 1993 OSA, Toronto, Canada, October 3-8, 1993.

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 PUSEY, M.  
 Investigation of Nucleating Lysozyme Solutions. For publication in Acta Crystallographica D, Munksgaard, Noerre Soegade 35, DK-1370, Copenhagen, Denmark.

SILVA, A.V. (University of California-Berkeley)  
 DE PATER, I.  
 LIN, R.P. ES52  
 MCTIERNAN, M.M. (UC-Berkeley)  
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 Multiwavelength Coverage of the 7 January 1992 Flare. For presentation at the Annual AGU-SPD Meeting, Baltimore, MD, May 23-27, 1994.

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 ELSNER, R.  
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 X-Ray Performance of the Engineering Prototype Stellar X-Ray Polarimeter. For presentation

SINGH, J. EH25  
 JERMAN, G.  
 POORMAN, R.  
 BHAT, B.  
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SINGH, N.B.  
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 HENNINGSSEN, T.  
 HOPKINS, R.H.  
 MAZELSKY, R.  
 HOPKINS, F.K. (Wright Lab)  
 FRAZIER, D.O. ES01  
 SINGH, O.P. (Gyanpur, UP)  
 Growth of Binary Organic NLO Crystals: m.Na-p.NA and m.NA-CNA System. For publication in the Journal of Materials Research, Pittsburgh, PA.

SMELTZER, S.S., III ED52  
 LAWSON, S.W.  
 Composite Redesign of Obstetrical Forceps. For presentation at the Fourth National Technology Transfer Conference (Technology 2003), Anaheim, CA, December 7-9, 1993.

SNYDER, R.S. ES71  
 RHODES, P.H.  
 The NASA Electrophoresis Program. For presentation at the International Aerospace Congress, Moscow, Russia, August 15-19, 1994.

SPANN, J.F. ES83  
 KEFFER, C.E.  
 ZUKIC, M.  
 A Vacuum Ultraviolet Spectrophotometric System. For publication in Applied Optics, Washington, DC.

SPANN, J.F. ES55  
 The Ultraviolet Imager. For presentation at the Colloquium to Physics Department, University of Arkansas, Fayetteville, AR, November 19, 1993.

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SMITH, E.  
PLATT, R.  
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GRIFFIN, V.  
LOBL, E.  
High Resolution Imaging of Rain Systems With the Advanced Microwave Precipitation Radiometer. For publication in the Journal of Atmospheric and Oceanic Technology, Boston, MA.
- SPENCER, R.W. ES43  
GRIFFIN, V.L.  
Research Opportunities With the Pathfinder MSU Daily Temperature Data Sets. For presentation at the Seventh AMS Satellite Conference, Monterey, CA, June 6-10, 1994.
- SPENCER, R.W. ES43  
GRIFFIN, V.L.  
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- SPENCER, S. (Sverdrup)  
CLAR, D.  
PARNELL, T.A. ED63  
The Design and Analysis of the Thermal Control System for the JACEE High Altitude Long Duration Balloon Flight. For presentation at the 30th COSPAR Scientific Assembly, Hamburg, Germany, July 11-21, 1994.
- SPRINGER, A.M. ED34  
Project Adam: The Army's Man in Space Program. For publication in Quest Magazine, Grand Rapids, MI.
- SPRINGER, A.M. ED34  
Experimental Determination of the Discharge Coefficients for the Advanced Solid Rocket Motor (ASRM) Ignitor Discharge Ports. For presentation at the AIAA Space Programs and Technologies Conference, Huntsville, AL, September 27-29, 1994.
- SPRINGER, A.M. ED35  
Experimental Investigation of Plume Induced Flow Separation for the National Launch System (NLS) 1<sup>1/2</sup> Stage Launch Vehicle. For presentation at the 32nd Aerospace Sciences Meeting, Reno, NV, January 10-13, 1994.
- SPRINGER, A.M. ED35  
The George C. Marshall Space Flight Center's 14x14-Inch Trisonic Wind Tunnel: A Historical Perspective. For presentation at the 32nd Aerospace Sciences Meeting, Reno, NV, January 10-13, 1994.
- SPRINGER, A.M. ED35  
POKORA, D.C.  
Ascent Flight Aerodynamic Characteristics of the National Launch System (NLS) 1<sup>1/2</sup> Stage Launch Vehicle: NLS-2. For presentation at the 32nd Aerospace Sciences Meeting, Reno, NV, January 10-13, 1994.
- SRINIVAS, R. (Teledyne Brown)  
HAMBRIGHT, G.  
AINSWORTH, M.  
FISKE, M.  
SCHAEFER, D. JA83  
Crystal Growth Furnace System Configuration and Planned Experiments on the Second United States Microgravity Laboratory Mission. For presentation at the AIAA 32nd Aerospace Sciences Meeting, Reno, NV, January 10-13, 1994.
- SRINIVASAN, R. ES74  
HE, K.  
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ET AL.  
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- STOKES, E.H. (SRI)  
UPTON, C.G. EH34  
Selection of Improved Acceptance Tests for Cured Carbon Phenolic Composites, Phase II. For presentation at JANNAF, Redstone Arsenal, AL, October 19-21, 1993.
- STOLLBERG, M.T. ES66  
FINGER, M.H.  
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| STONE, N.H.<br>CHANDLER, M.O.<br>Applications of Electrodynamic Tethers to Investigations in Ionospheric, Thermospheric, and Mesospheric Physics. For presentation at the Space Tether Workshop, Ann Arbor, MI, July 5, 1994.                      | ES83 | the 1994 Fall AGU Meeting, San Francisco, CA, December 5-9, 1994.  |
| STUHLINGER, E.<br>TRUMPER, J.<br>WEISSKOPF, M.<br>Rontgenstrahlen Aus Dem Universum (X-Rays From the Universe). For publication in Forschung mit Rontgestrahlen, Heidelberg, Germany.  | ES01 | SUESS, S.T.<br>WU, S.T.<br>WANG, A.-H.<br>POLETTO, G.<br>Magnetohydrodynamic Simulation of a Streamer Beside a Realistic Coronal Hole. For publication in the Space Science Review, The Netherlands.   |
| SUESS, S.T.<br>Modulation in the Heliosheath. For presentation at the Second Pioneer-Voyager Symposium, Durham, NH, May 31-June 3, 1994.   | ES52 | SULLIVAN, R.M.<br>The Effect of Water on Thermal Stresses in Polymer Composites. For publication in the Journal of Applied Mechanics.  |
| SUESS, S.T.<br>MCCOMAS, D.J.<br>BAME, S.J.<br>GOLDSTEIN, B.E.<br>Solar Wind Eddies and the Heliospheric Current Sheet. For publication in the Journal of Geophysical Research, The Netherlands.  | ES52 | SULLIVAN, R.M.<br>A Thermodynamic Model for Hygrothermal Behavior in Polymer Composites. For presentation at the 35th SDM, Hilton Head, SC, April 18-20, 1994.   |
| SUESS, S.T.<br>MCCOMAS, D.J.<br>BAME, S.J.<br>GOLDSTEIN, B.E.<br>Solar Wind Eddies and the Heliospheric Current Sheet. For publication in the Journal of Geophysical Research, Chicago, IL.  | ES82 | SUSKO, M.<br>HERMAN, L.<br>Spatial/Temporal Variability of Wind Fields for Design of Remote Sensors. For presentation at the 32nd Aerospace Science and Exhibits Meeting, Reno, NV, January 10-13, 1994.   |
| SUESS, S.T.<br>NEUGEBAUER, M.<br>GOLDSTEIN, B.E.<br>POLETTO, G.<br>The Solar Origin of, and Mass Flux in the High Speed Streams at Ulysses, December 1992-August 1993. For presentation at the Annual SPD Meeting, Baltimore, MD, May 23-27, 1994. | ES52 | SWARTZ, D.A.<br>Charge Transfer in Helium-Rich Supernova Plasma. For publication in the Astrophysical Journal, Chicago, IL.  |
| SUESS, S.T.<br>POLETTO, G.<br>NEUGEBAUER, M.<br>GOLDSTEIN, B.E.<br>ET AL.<br>Coronal Bright Points and High Speed/High Latitude Solar Wind Streams. For presentation at  | ES82 | SWARTZ, D.A.<br>O'DELL, S.L.<br>SULKANEN, M.E.<br>TENNANT, A.F., Jr.<br>Statistical Uncertainties in Temperature Diagnostics for Hot Coronal Plasma Using the ASCA SIS. For publication the Astrophysical Journal, Chicago, IL.                    |
|  |      | SWARTZ, D.A.<br>SULKANEN, M.E.<br>O'DELL, S.L.<br>TENNANT, A.F.<br>Temperature Diagnostics in Hot Plasma Statistical Uncertainties for ASCA SIS. For presentation at the 184th Astronomical Society Meeting, Minneapolis, MN, May 29-June 3, 1994. |
|  |      | SZOFRAN, F.R.<br>VOLZ, M.P.  |

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| COBB, S.D.<br>LEHOCZKY, S.L.<br>MOTAKEF, S.<br>Bridgman-Magnetic Field Growth of Dilute and Concentrated Semiconductors. For presentation at the 11th International Conference on Crystal Growth, The Hague, The Netherlands, June 18-23, 1995.               |               | TORR, M.R.<br>CHANG, T.<br>TORR, D.G.<br>RICHARDS, P.G.<br>Thermospheric and Mesospheric Nitric Oxide Measured by the Imaging Spectrometric Observatory From ATLAS-1 and Spacelab 1. For publication and presentation at the American Geophysical Union, Baltimore, MD, May 23-27, 1994. | JA01 |
| TALIA, G.E.<br>NUNES, A.C., JR.<br>Cracking During Welding of 2195 Aluminum-Lithium Alloy: Experimental Approaches Towards Mechanism. For presentation at the Aluminum-Lithium Conference, MSFC, AL, May 17-19, 1994.   | EH23          | TORR, M.R.<br>TORR, D.G.<br>A Compact Imaging Spectrograph for Broadband Spectral Simultaneity. For publication in Applied Optics, August 1994.  | JA01 |
| TARIK, K.<br>HINMAN-SWEENEY, E.<br>New ISU Master of Space Studies Programme. For presentation at the International Space University Alumni Conference, Barcelona, Spain, August 5, 1994.   | EB62          | TORR, M.R.<br>TORR, D.G.<br>CHANG, T.<br>RICHARDS, P.<br>SWIFT, W.<br>LI, N.<br>Thermospheric and Mesospheric Nitric Oxide From the ATLAS-1 and Spacelab 1 Missions. For publication in the Journal of Geophysical Research.   | JA01 |
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