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Compiled by Joyce E. Turner
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**Author(s)**

Compiled by Joyce E. Turner

**Performing Organization Name and Address**

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

**Sponsoring Agency Name and Address**

National Aeronautics and Space Administration
Washington, DC 20546

**Abstract**

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FOREWORD

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Main Propulsion System Test Requirements for the Two-Engine Shuttle-C. E.E. Lynn and G.K. Platt. Propulsion Laboratory. N90-14282

The Shuttle-C is an unmanned cargo-carrying derivative of the space shuttle with optional two or three space shuttle main engines (SSME's), whereas the shuttle has three SSME's. Design and operational differences between the Shuttle-C and shuttle were assessed to determine requirements for additional main propulsion system (MPS) verification testing. Also, reviews were made of the shuttle main propulsion test (MPT) program objectives and test results and shuttle flight experience.

It was concluded that, if significant MPS modifications are not made beyond those currently planned, then main propulsion system verification can be concluded with an on-pad propellant loading and countdown demonstration test plus a long duration on-pad flight readiness firing.


This report presents results from the comparison study of two computer codes for crack growth analysis—NASCRAC and NASA/FLAGRO. The two computer codes gave compatible conservative results when the part through crack analysis solutions were analyzed versus experimental test data. Results showed good correlation between the codes for the through crack at a lug solution. For the through crack at a lug solution, NASA/FLAGRO gave the most conservative results.


This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY 89. It also includes papers of MSFC contractors.


The JPL has completed a test program, using multisection BATES and 5 × 10-in batch-check motors, with the objectives of measuring the effects of the parameters that were considered to most strongly influence the transition to, or threshold conditions for, erosive burning rate augmentation. A statistical analysis was performed on the test data to explore the possible relationships among the parameters believed to influence the rate of erosive burning. Multivariate methods and simple and multiple regressions were used, and a model for predicting erosive burning rates in small PBAN circular perforated grains was developed.


This report presents a summary of selected atmospheric conditions observed near Space Shuttle STS-28 launch time on August 8, 1989, at Kennedy Space Center, Florida. STS-28 carried a Department of Defense payload and the flight azimuth in this report will be denoted by a reference flight azimuth, since the actual flight azimuth is not known. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of prelaunch Jimsphere-measured vertical wind profiles is given in this report. The final atmospheric tape, which consists of wind and thermodynamic parameters versus altitude, for STS-28
vehicle ascent has been constructed and represents the
best estimate of the launch environment to 400,000 ft
altitude that was traversed by the STS-28 vehicle. The
STS-28 ascent atmospheric data tape has been con-
structed by Marshall Space Flight Center’s Earth Sci-
ence and Applications Division to provide an internally
consistent data set for use in post-flight performance
assessments.

TM-100387 January 1990
Global Nonlinear Optimization of Spacecraft
Protective Structures Design. R.A. Mog, J.N.
Lovett, Jr., and S.L. Avans. Structures and
Dynamics Laboratory. N90-21095

The global optimization of protective structural
designs for spacecraft subject to hypervelocity
meteoroid and space debris impacts is presented. This
nonlinear problem is first formulated for weight
minimization of the space station core module con-
figuration using the Nysmith impact predictor. Next,
the equivalence and uniqueness of local and global
optima is shown using properties of convexity. This
analysis results in a new feasibility condition for this
problem. The solution existence is then shown,
followed by a comparison of optimization techniques.
Finally, a sensitivity analysis is presented to determine
the effects of variations in the systemic parameters on
optimal design. The results show that global optimiza-
tion of this problem is unique and may be achieved by a
number of methods, provided the feasibility condition
is satisfied. Furthermore, module structural design
thicknesses and weight increase with increasing
projectile velocity and diameter and decrease with in-
creasing separation between bumper and wall for the
Nysmith predictor.

TM-100388 February 1990
PATRAN–STAGS Translator (PATSTAGS).
Neil Otte. Structures and Dynamics Laboratory. N90-21125

This document presents a computer program used
to translate PATRAN finite element model data into
STAGS (Structural Analysis of General Shells) input
data. The program supports translation of nodal, nodal
constraints, element, force, and pressure data. The
subcategory UPRESS required for the readings of live
pressure data into STAGS is also presented.
The specimens were cut with a diamond wheel wafering saw through the impacted area perpendicular to the outer fibers. Photographs at 12 x magnification were taken of these cross-sections and examined. The results on the bidirectional samples show little damage until 1.13 J, at which point delaminations were seen in the epoxy specimens. The PEEK specimens showed less delamination than the epoxy specimens for a given impact energy level. The unidirectional specimens displayed more damage than the bidirectional samples for a given impact energy, with the PEEK specimens showing much less damage than the epoxy material.

A comprehensive description of the structural and instrumentation hardware and the experimental capabilities of the 105-meter Marshall Space Flight Center Drop Tube Facility is given. This document is to serve as a guide to the investigator who wishes to perform materials processing experiments in the Drop Tube. Particular attention is given to the Tube's hardware to which an investigator must interface to perform experiments. This hardware consists of the permanent structural hardware (with such items as vacuum flanges), and the experimental hardware (with the furnaces and the sample insertion devices). Two furnaces, an electron-beam and an electromagnetic levitator, are currently used to melt metallic samples in a process environment that can range from 10 Torr to 1 atmosphere. Details of these furnaces, the processing environment gases/vacuum, the electrical power, and data acquisition capabilities are specified to allow an investigator to design his/her experiment to maximize successful results and to reduce experimental "setup" time on the Tube. Various devices used to catch samples while inflicting minimum damage and to enhance turnaround time between experiments are described. Enough information is provided to allow an investigator who wishes to build his/her own furnace or sample catch devices to easily interface it to the Tube. The experimental instrumentation and data acquisition systems used to perform pre-drop and in-flight measurements of the melting and solidification process are also detailed. Typical experimental results are presented as an indicator of the type of data that is provided by the Drop Tube Facility. A summary bibliography of past Drop Tube experiments is provided, and an appendix explaining the noncontact temperature determination of free-falling drops is provided. This document is to be revised occasionally as improvements to the Facility are made and as the summary bibliography grows.

This report presents fracture mechanics analysis results from the following structures/components analyzed at Marshall Space Flight Center (MSFC) between 1982 and 1989: space shuttle main engine (SSME), Hubble Space Telescope (HST), external tank attach ring, B-1 stand lox inner tank, and solid rocket booster (SRB). Results from the SSME high pressure fuel turbopump (HPFTP) second stage blade parametric analysis determined a critical flaw size for a wide variety of stress intensity values. The engine 0212 failure analysis was a time-dependent fracture life assessment. Results indicated that the disk ruptured due to an overspeed condition. Results also indicated that very small flaws in the curvic coupling area could propagate and lead to failure under normal operating conditions. It was strongly recommended that a nondestructive evaluation inspection schedule be implemented. The main ring of the HST, scheduled to launch in 1990, was analyzed by safe-life and fail-safe analyses. First safe-life inspection criteria curves for the ring inner and outer skins and the fore and aft channels were derived. Afterwards the skins and channels were determined to be fail-safe by analysis. A conservative safe-life analysis was done on the 270 redesign external tank attach ring. Results from the analysis were used to determine the nondestructive evaluation technique required. A leak before burst analysis of the B-1 stand lox inner tank indicated that leakage would be detected well before burst conditions developed.

The corrosion protection of 6061-T6 anodized aluminum afforded by a newly patented polyurethane seal has been studied using the ac impedance technique. Values of the average corrosion rates over a 27-day exposure period in 3.5% NaCl solutions at pH 5.2 and pH 9.5 compared very favorably for Lockheed-prepared polyurethane-sealed and dichromate-sealed coats of the same thickness. Average corrosion rates for both specimens over the first 7 days of exposure compared well with those for a hard anodized, dichromate-sealed coat, but rose well above those for the hard anodized coat over the entire 27-day period. This is attributed both to the greater thickness of the hard anodized coat, and possibly to its inherently better corrosion protective capability.

TM-100395 April 1990
Definition of Large Components Assembled On-Orbit and Robot Compatible Mechanical Joints.
J. Williamsen, F. Thomas, J. Finckenor, and B. Spiegel. Structures and Dynamics Laboratory. N90-22043

One of four major areas of project Pathfinder is in-space assembly and construction. The task of in-space assembly and construction is to develop the requirements and the technology needed to build elements in space.

This paper identifies a 120-ft diameter tetrahedral aerobrake truss as the focus element. A heavily loaded mechanical joint is designed to robotically assemble the defined aerobrake element. Also, typical large components such as habitation modules, storage tanks, etc., are defined, and attachment concepts of these components to the tetrahedral truss are developed.

TM-100396 December 1989

This report presents a summary of selected atmospheric conditions observed near space shuttle STS-34 launch time on October 18, 1989, at Kennedy Space Center, Florida. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of pre-launch Jimsphere-measured vertical wind profiles is given in this report. The final atmospheric tape, which consists of wind and thermodynamic parameters versus altitude, for STS-34 vehicle ascent has been constructed. The STS-34 ascent atmospheric data tape has been constructed by Marshall Space Flight Center's Earth Science and Applications Division to provide an internally consistent data set for use in post-flight performance assessments and represents the best estimate of the launch environment to the 400,000-ft altitude that was traversed by the STS-34 vehicle.

TM-100397 April 1990
The Temperature Variation of Hydrogen Diffusion Coefficients in Metal Alloys. M.D. Danford. Materials and Processes Laboratory. N90-21836

Hydrogen diffusion coefficients have been measured as a function of temperature for a few metal alloys using an electrochemical evolution technique. Results from these measurements are compared to those obtained by the time-lag method. In all cases, diffusion coefficients obtained by the electrochemical method are larger than those by the time-lag method by an order of magnitude or more. These differences are attributed mainly to hydrogen trapping.

TM-100398 April 1990

Gamma-ray bursts display a wide range of temporal and spectral characteristics, but typically last several seconds and emit most of their energy in the low-energy, gamma-ray region. The burst sources appear to be isotropically distributed on the sky. Several lines of evidence suggest magnetic neutron stars as sources for bursts. A variety of energy sources and emission mechanisms have been proposed.

TM-100399 March 1990

This report presents a summary of selected atmospheric conditions observed near space shuttle STS-33 launch time on November 22, 1989, at Kennedy Space Center, Florida. STS-33 carried a Department of Defense payload and the flight azimuth in this report will be denoted by a reference flight azimuth, since the
actual flight azimuth is not known. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of pre-launch Jimsphere-measured vertical wind profiles is given in this report. The final atmospheric tape, which consists of wind and thermodynamic parameters versus altitude, for STS-33 vehicle ascent has been constructed. The STS-33 ascent atmospheric data tape has been constructed by Marshall Space Flight Center’s Earth Science and Applications Division to provide an internally consistent data set for use in postflight performance assessments and represents the best estimate of the launch environment to the 400,000-ft altitude that was traversed by the STS-33 vehicle.

TM-100400 March 1990

This report presents a summary of selected atmospheric conditions observed near space shuttle STS-32 launch time on January 9, 1990, at Kennedy Space Center, Florida. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of pre-launch Jimsphere-measured vertical wind profiles is given in this report. The final atmospheric tape, which consists of wind and thermodynamic parameters versus altitude, for STS-32 vehicle ascent has been constructed. The STS-32 ascent atmospheric data tape has been constructed by Marshall Space Flight Center’s Earth Science and Applications Division to provide an internally consistent data set for use in postflight performance assessments and represents the best estimate of the launch environment that was traversed by the STS-32 vehicle.

TM-100401 June 1990

This memorandum develops approaches for forecasting the cost of major hardware development programs while these programs are in the design and development C/D phase. Three approaches are developed: a schedule assessment technique for bottom-line summary cost estimation, a detailed cost estimation approach, and an intermediate cost element analysis procedure. The schedule assessment technique was developed using historical cost/schedule performance data.

TM-100402 June 1990
Equivalent Circuit Models for ac Impedance Data Analysis. M.D. Danford. Materials and Processes Laboratory. N90-25277

A least-squares fitting routine has been developed for the analysis of ac impedance data. It has been determined that the checking of the derived equations for a particular circuit with a commercially available electronics circuit program is essential. As a result of the investigation described in this report, three equivalent circuit models have been selected for use in the analysis of ac impedance data at this laboratory.

TM-100403 May 1990

This report presents a summary of selected atmospheric conditions observed near space shuttle STS-36 launch time on February 28, 1990, at Kennedy Space Center, Florida. STS-36 carried a Department of Defense payload, and the flight azimuth in this report will be denoted by a reference flight azimuth, since the actual flight azimuth is not known. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of pre-launch Jimsphere-measured vertical wind profiles is given in this report. The final atmospheric tape, which consists of wind and thermodynamic parameters versus altitude, for STS-36 vehicle ascent has been constructed. The STS-36 ascent atmospheric data tape has been constructed by Marshall Space Flight Center’s Earth Science and Applications Division to provide an internally consistent data set for use in postflight performance assessments and represents the best estimate of the launch environment to the 400,000-ft altitude that was traversed by the STS-36 vehicle.

TM-100404 June 1990
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 January–December 1989. The systems that make up the facility are a magnetograph telescope, an H-alpha telescope, a Questar telescope, and a computer code. The data are represented by longitudinal contours with azimuth plots.

The Advanced X-Ray Astrophysics Facility (AXAF) will be subject to several sources of charged particle radiation during its 15-year orbital lifetime: geomagnetically-trapped electrons and protons, galactic cosmic ray particles, and solar flare events. The purpose of this report is to estimate these radiation levels for the AXAF orbit for use in the design of the observatory’s science instruments.

A proposed transient response method is formulated for the liftoff analysis of the space shuttle vehicle. The proposed method uses a power series approximation with unknown coefficients for the interface forces between the space shuttle and mobile launch platform. This allows the equations of motion of the two structures to be solved separately with unknown coefficients at the end of each time step. The unknown coefficients are obtained by enforcing the interface compatibility conditions between the two structures. Once the unknown coefficients are determined, the total response is computed for that time step. The method is validated by a numerical example of a cantilevered beam and by the liftoff analysis of the space shuttle vehicle. The proposed method is compared to an iterative transient response analysis method used by Martin Marietta for their space shuttle liftoff analysis. It is shown that the proposed method uses less computer time than the iterative method and does not require as small a time step for integration. The space shuttle vehicle model is reduced using two different types of component mode synthesis (CMS) methods, the Lanczos CMS method and the Craig and Bampton CMS method. By varying the cutoff frequency of the Craig and Bampton method it was shown that the space shuttle interface loads can be computed with reasonable accuracy. Both the Lanczos CMS method and Craig and Bampton CMS method give similar results. A substantial amount of computer time is saved using the Lanczos CMS method over that of the Craig and Bampton method. However, when trying to compute a large number of Lanczos vectors, input/output computer time increased and increased the overall computer time. The application of several liftoff release mechanisms that can be adapted to the proposed method are discussed.

A test bed for a large space power system breadboard for the Hubble Space Telescope (HST) was designed and built to test the system under simulated orbital conditions. A discussion of the data acquisition and control subsystems designed to provide for continuous 24-hour per day operation and a general overview of the test bed is presented. The data acquisition and control subsystems provided the necessary monitoring and protection to assure safe shutdown with protection of test articles in case of loss of power or equipment failure over the life of the test (up to 5 years).
frequency components of a given data window. Transformation of data into different coordinate axes is useful in the analysis of experiments with different orientations and can be achieved by the use of a transformation matrix. Application of such analysis techniques to residual acceleration data provides additional information than what is provided in a time history and increases the effectiveness of post-flight analysis of low-gravity experiments.

**TM-103508**
**June 1990**

This report presents a summary of selected atmospheric conditions observed near space shuttle STS-31 launch time on April 24, 1990, at Kennedy Space Center, Florida. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of pre-launch Jimsphere-measured vertical wind profiles is given in this report. The final atmospheric tape, which consists of wind and thermodynamic parameters versus altitude, for STS-31 vehicle ascent has been constructed. The STS-31 ascent atmospheric data tape has been constructed by Marshall Space Flight Center’s Earth Science and Applications Division to provide an internally consistent data set for use in postflight performance assessments and represents the best estimate of the launch environment to the 400,000-ft altitude that was traversed by the STS-31 vehicle.

**TM-103509**
**July 1990**

This report documents a computer program that generates strain transformations and on-axis stresses in composites given the initial strains and the transformation angles.

**TM-103511**
**August 1990**
Reliability Growth Modeling Analysis of the Space Shuttle Main Engines Based Upon the Weibull Process. J.T. Wheeler. Structures and Dynamics Laboratory. N90-28098

The Weibull process, identified as the non-homogeneous Poisson process with the Weibull intensity function, is used to model the reliability growth assessment of the space shuttle main engine test and flight failure data. Additional tables of percentage-point probabilities for several different values of the confidence coefficient have been generated for setting $(1-\alpha)100$-percent two-sided confidence interval estimates on the mean time between failures. The tabled data pertain to two cases: (1) time-terminated testing and (2) failure-terminated testing. The critical values of the three test statistics, namely Cramér-von Mises, Kolmogorov-Smirnov, and chi-square, have been calculated and tabled for use in the goodness-of-fit tests for the engine reliability data. Numerical results are presented for five different groupings of the engine data that reflect the actual responses to the failures.

**TM-103512**
**August 1990**

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 January–June 1990. The systems that make up the facility are a magnetograph telescope, an H-alpha telescope, a Questar telescope, and a computer code. The data are represented by longitudinal contours with azimuth plots.

**TM-103513**
**July 1990**
Mesoscale Lightning Experiment (MLE): A View of Lightning as Seen From Space During the STS-26 Mission. O.H. Vaughan, Jr. Space Science Laboratory.

This report provides information on the data obtained from the Mesoscale Lightning Experiment (MLE) flown on STS-26. The experiment used onboard TV cameras and a 35-mm film camera to obtain data. Data from the 35-mm film camera are presented. During the mission, the crew had difficulty locating the various targets of opportunity with the TV cameras. To obtain as much data as possible in the short observational timeline allowed due to other commitments, the crew opted to use the hand-held 35-mm camera.

This report presents an updated NASA atmospheric turbulence model, from 0- to 200-km altitude, which was developed to be more realistic and less conservative when applied to space shuttle reentry engineering simulation studies involving control system fuel expenditures. The prior model used extreme turbulence (3σ) for all altitudes, whereas in reality severe turbulence is patchy within quiescent atmospheric zones. The updated turbulence model presented in this report is designed to be more realistic. The prior turbulence statistics (σ and L) have been updated and have been modeled accordingly.


Large solid rocket motors release large quantities of hydrogen chloride and aluminum oxide exhaust during launch or testing. This report summarizes measurements and analysis of the interaction of this material with the deluge water spray and other environmental factors in the near field (within 1 km of the launch or test site). Measurements of mixed solid and liquid deposition (typically 2 normal HCl) following space shuttle launches and 6.4 percent scale model tests are described. Hydrogen chloride gas concentrations measured in the hours after the launch of STS 41D and STS 51A are reported. Concentrations of 9 ppm, which are above the 5 ppm exposure limits for workers, were detected an hour after STS 51A. A simplified model which explains the primary features of the gas concentration profiles is included.


This report is a description of the phase III simplified integrated test (SIT) conducted at the Marshall Space Flight Center (MSFC) Core Module Integration Facility (CMIF) in 1989. This was the first test in the phase III series integrated environmental control and life support systems (ECLSS) tests. The basic goal of the SIT was to achieve full integration of the baseline air revitalization (AR) subsystems for Space Station Freedom. Included in this report is a description of the SIT configuration, a performance analysis of each subsystem, results from air and water sampling, and a discussion of lessons learned from the test. Also included in this report is a full description of the preprototype ECLSS hardware used in the test.


The global optimization trends of protective honeycomb structural designs for spacecraft subject to hypervelocity meteoroid and space debris impacts are presented. This nonlinear problem is first formulated for weight minimization of the orbital maneuvering vehicle (OMV) using a generic monomial predictor. Five problem formulations are considered, each dependent on the selection of independent design variables. Each case is optimized by considering the dual geometric programming problem. The dual variables are solved for in terms of the generic estimated exponents of the monomial predictor. The primal variables are then solved for by conversion. Finally, parametric design trends are developed for ranges of the estimated regression parameters. Results specify nonmonotonic relationships for the optimal first and second sheet mass per unit areas in terms of the estimated exponents.


A linear elastic solution to the problem of minimum weight design of cantilever beams with variable width and depth is presented. The solution shown
is for the specific application of the Hubble Space Telescope maintenance mission hardware. During these maintenance missions, delicate instruments must be isolated from the potentially damaging vibration environment of the space shuttle cargo bay during the ascent and descent phases. The leaf springs are designed to maintain the isolation system natural frequency at a level where load transmission to the instruments is a minimum.

Nonlinear programming is used for the optimization process. The weight of the beams is the objective function with the deflection and allowable bending stress as the constraint equations. The design variables are the width and depth of the beams at both the free and the fixed ends.

Space Station Freedom environmental control and life support system testing has been conducted at Marshall Space Flight Center since 1986. The phase III simplified integrated test (SIT) conducted from July 30, 1989, through August 11, 1989, tested an integrated air revitalization system. During this test, the trace contaminant control subsystem (TCCS) was directly integrated with the bleed stream from the carbon dioxide reduction subsystem. The TCCS performed as expected with minor anomalies. The test set the basis for further characterizing the TCCS performance as part of advance air revitalization system configurations.
This paper presents a new method for determining the transient response of a discrete coordinate model of a linear structural system composed of substructures. The method is applicable to systems consisting of any number of substructures, both determinate and indeterminate interface boundaries, and any topological arrangement of the substructures. The method is simple to implement from a computational point of view because the equations of motion of each of the substructures are solved independently, and the interface boundary compatibility conditions are enforced at each integration time step by a matrix multiplication. The method is demonstrated for a structural system consisting of two beam segments and acted upon by a time dependent force. The numerical results from the demonstration problem validates the accuracy of the method. The application of this method to structural systems with changing interface boundary conditions between substructures is discussed.

El Niño is conventionally defined as an anomalous and persistent warming of the waters off the coasts of Ecuador and Peru in the eastern equatorial Pacific, having onset usually in southern hemispheric summer/fall. Examined here are some of the statistical aspects of El Niño occurrences, especially as they relate to the normal distribution and to possible associations with volcanic, solar, and geomagnetic activity.

With regard to the “very strong” El Niño of 1982–83, it is noted that, although it may very well be related to the 1982 eruptions of El Chichón, the event occurred essentially “on time” (with respect to the past behavior of elapsed times between successive El Niño events; a moderate-to-stronger El Niño was expected during the interval 1978 to 1982, assuming that El Niño occurrences are normally distributed, having a mean elapsed time between successive onsets of 4 years and a standard deviation of 2 years and a last known occurrence in 1976). Also, although not widely recognized, the whole of 1982 was a record year for geomagnetic activity (based on the aa geomagnetic index, with the aa index registering an all-time high in February 1982), perhaps, important for determining a possible “trigger” for this and other El Niño events.

A major feature of this study is an extensive bibliography (325 entries) on El Niño and volcanic-solar-geomagnetic effects on climate. Also, included is a tabular listing of the 94 major volcanic eruptions of 1835 to 1986.
carbon/epoxy coupons. Four different material systems with various eight-ply lay-up configurations were tested. Specimens were placed over a 10.3-mm diameter hole and impacted with a smaller tup (4.2-mm diameter) than those used in previous studies. Force-time plots as well as data on absorbed energy and residual tensile strength were gathered and examined. It was found that a critical impact energy level existed for each material tested, at which point tensile strength began to rapidly decrease with increasing impact energy.

TP-3013 May 1990

This paper describes a general-purpose balloon-borne pointing system for accommodating a wide variety of solar scientific instruments. It is designed for precise pointing, low cost, and quick launch. It offers the option of three-axis control, pitch-yaw-roll, or two-axis control, pitch-yaw, depending on the needs of the solar instrument. Simulation results are presented that indicate good pointing capability at Sun elevation angles ranging from 10 degrees to 80 degrees.

TP-3023 June 1990

A high power CO$_2$ laser beam is known to deteriorate after a few microseconds due to a mode-medium instability (MMI) which results from an intensity dependent heating rate related to the vibrational-to-translational decay of the upper and lower CO$_2$ lasing levels. An iterative numerical technique is developed to model the time evolution of the beam as it is affected by the MMI. The technique is used to study the MMI in an unstable CO$_2$ resonator with a hard-edge output mirror for different parameters like the Fresnel number and the gas density. The results show that the mode of the hard-edge unstable resonator deteriorates because of the diffraction ripples in the mode. We use a Gaussian-reflectivity mirror to correct the MMI. This mirror produces a smoother intensity profile which significantly reduces the effects of the MMI. Quantitative results on peak density variation and beam quality are presented.

TP-3028 June 1990

This report details the loads testing on in-house-fabricated flight configuration SRM outer boot ring segments. The tests determined the bending strength and bending stiffness of these beams and showed that they compared well with the hand analysis. The bending stiffness test results compared very well with the finite element data.

TP-3029 July 1990

Low velocity drop weight instrumented impact testing was utilized to examine the damage resistance of four recently developed carbon fiber/epoxy resin systems. A fifth material, T300/934, for which a large data base exists, was also tested for comparison purposes. A 16-ply quasi-isotropic lay-up configuration was used for all the specimens. Force/absorbed energy-time plots were generated for each impact test. The specimens were cross-sectionally analyzed to record the damage corresponding to each impact energy level. Maximum force of impact versus impact energy plots were constructed to compare the various systems for impact damage resistance. Results show that the four new damage tolerant fiber/resin systems far outclassed the T300/934 material. The most damage tolerant material tested was the IM7/1962 fiber/resin system.

TP-3030 June 1990
This paper presents a new method for scanning balloon-borne experiments, free-flying spacecraft, and gimballed experiments mounted to the space shuttle or the space station. It uses rotating-unbalanced-mass (RUM) devices for generating circular, line, or raster scan patterns and an auxiliary control system for target acquisition, keeping the scan centered on the target, and producing complementary motion for raster scanning. It is ideal for applications where the only possible way to accomplish the required scan is to physically scan the entire experiment or spacecraft as in x-ray and gamma-ray experiments. In such cases, this new method should have advantages over prior methods in terms of either power, weight, cost, performance, stability, or a combination of these.

TP-3031 July 1990
Forbidden Tangential Orbit Transfers Between Intersecting Keplerian Orbits. R.E. Burns. Systems Analysis and Integration Laboratory.
N90-26028

The classical problem of tangential impulse transfer between coplanar Keplerian orbits is addressed. A completely analytic solution which does not rely on sequential calculation is obtained and this solution is used to demonstrate that certain initially chosen angles can produce singularities in the parameters of the transfer orbit. A necessary and sufficient condition for such singularities is that the initial and final orbits intersect.

TP-3042 August 1990
N90-27876

An examination of low velocity impact damage to glass/phenolic and aluminum core honeycomb sandwich panels with carbon/epoxy facesheets is presented. An instrumented drop weight impact test apparatus was utilized to inflict damage at energy ranges between 0.7 and 4.2 Joules. Specimens were checked for extent of damage by cross-sectional examination. The effect of core damage was assessed by subjecting impact-damaged beams to four-point bend tests. Skin-only specimens (facings not bonded to honeycomb) were also tested for comparison purposes. Results show that core buckling is the first damage mode, followed by delaminations in the facings, matrix cracking, and finally fiber breakage. The aluminum honeycomb panels exhibited a larger core damage zone and more facing delaminations than the glass/phenolic core, but could withstand more shear stress when damaged than the glass/phenolic core specimens.

TP-3058 August 1990

This study analyzed long-term orbital lifetime predictions. 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.
NASA CONFERENCE PUBLICATIONS

CP-3085 July 1990

CP-3088 August 1990
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C.D. BROWN
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