# NASA Technical Memorandum

NASA TM- 100384

# FY 1989 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

Compiled by Joyce E. Turner
Management Operations Office

October 1989



National Aeronautics and Space Administration

George C. Marshall Space Flight Center

NASA

# Report Documentation Page

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| NASA TM-100384 | | |

**4. Title and Subtitle**

FY 1989 Scientific and Technical Reports, Articles, Papers, and Presentations

**5. Report Date**

October 1989

**6. Performing Organization Code**

**7. Author(s)**

Compiled by Joyce E. Turner

**8. Performing Organization Report No.**

**10. Work Unit No.**

**9. Performing Organization Name and Address**

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

**11. Contract or Grant No.**

**13. Type of Report and Period Covered**

Technical Memorandum

**12. Sponsoring Agency Name and Address**

National Aeronautics and Space Administration
Washington, D.C. 20546

**14. Sponsoring Agency Code**

**15. Supplementary Notes**

Prepared by Management Operations Office, Administrative Operations Office.

**16. Abstract**

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| 17. Key Words (Suggested by Author(s)) | 18. Distribution Statement |
|---|---|
| | Unclassified – Unlimited |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 61 | NTIS |

NASA FORM 1626 OCT 86

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
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# FY 1989 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

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TM-100344 November 1988

STS-26 Solid Rocket Booster Post Flight Structural Assessment. David A. Herda and Charles J. Finnegan. Structures and Dynamics Laboratory. 89N-13494

A post-flight assessment of the space shuttle's solid rocket boosters was conducted at the John F. Kennedy Space Center in Florida after the launch of STS-26. The two boosters were inspected for structural damage and the results of this inspection are presented in this report. Overall, the boosters were in good condition. However, there was some minor damage attributed to splash down. Some of this damage is a recurring problem. Explanations of these problems are provided.

TM-100345 December 1988

Chemseal 3808-A2 Penetration into Small Leak Path. M.R. Carruth, Jr. and R.F. DeHaye. Materials and Processes Laboratory. N89-18608

A possible fix to a leak in the oxidizer system of the space shuttle Discovery's attitude control system was proposed by MSFC. This fix involved the passing of a "shuttlecock" past the leaking Dynaflow fitting and sealing the vent tube containing the fitting with Chemseal 3808-A2. The question of whether the Chemseal 3808-A2 can flow into the leak path and provide a better seal was addressed analytically and by experiment to verify the analytical formula used. The results show that the equations are applicable and that the Chemseal will flow into the expected leak path and seal.

TM-100346 October 1988

FY 1988 Scientific and Technical Reports, Articles, Papers, and Presentations. Compiled by Joyce E. Turner. Management Operations Office. N89-18253

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY88. It also includes papers of MSFC contractors.

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The information in this report may be of value to the scientific and engineering community in determining what information has been published and what is available.

TM-100347 November 1988

Measurements and Calculations of the Coulomb Cross Section for the Production of Direct Electron Pairs by Energetic Heavy Nuclei in Nuclear Track Emulsion – Center Director's Discretionary Fund Final Report. J.H. Derrickson, P.B. Eby, W.F. Fountain, T.A. Parnell, B.L. Dong, J.C. Gregory, Y. Takahashi, and D.T. King. Space Science Laboratory. N89-15692

Measurements and theoretical predictions of the coulomb cross section for the production of direct electron pairs by heavy ions in emulsion have been performed. Nuclear track emulsions were exposed to the 1.8 GeV/amu $Fe^{56}$ beam at the Lawrence Berkeley Laboratory bevalac and to the 60 and 200 GeV/amu $O^{16}$ and the 200 GeV/amu $S^{32}$ beam at the European Center for Nuclear Research Super Protron Synchrotron modified to accelerate heavy ions. The calculations combine the Weizsacker-Williams virtual quanta method applicable to the low-energy transfers and the Kelner-Kotov relativistic treatment for the high-energy transfers. Comparison of the measured total electron pair yield, the energy transfer distribution, and the emission angle distribution with theoretical predictions revealed a discrepancy in the frequency of occurrence of the low-energy pairs ($\leq$10 MeV). The microscope scanning criteria used to identify the direct electron pairs is described and efforts to improve the calculation of the cross section for pair production are also discussed.

TM-100348 January 1989

Protein Crystal Nucleation Kinetics Using Relative Light-Scattering Techniques – Center Director's Discretionary Fund Final Report. Marc Lee Pusey. Space Science Laboratory. N89-17535

Light-scattering intensity measurements are a sensitive method for following changes in the hydrodynamic radius of particles in solution. The approach used in this report utilizes the light-scattering intensity ratios of a polydisperse to a monodisperse system. By numerically modeling the process, and fitting the model curves to the data, estimates have been obtained

for the dimerization equilibrium constant, the dimer + dimer ⇌tetramer equilibrium constant, and the association rate constant for the dimerization process.

TM-100349 January 1989

Ideal Black Hole Fluid. Larry L. Smalley. Space Science Laboratory. N89-17558

The concept of a primordial black hole fluid is introduced and its consequence for supercluster-sized (i.e., large scale voids) and the missing mass question are discussed.

TM-100350 January 1989

Processing of Strong Flux Trapping High $T_c$ Oxide Superconductors – Center Director's Discretionary Fund Final Report. M.K. Wu, C.A. Higgins, P.T. Leong, H. Chou, B.H. Loo, P.A. Curreri, P.N. Peters, R.C. Sisk, C.Y. Huang, and Y. Shapira. Space Science Laboratory. N89-17530

Magnetic suspension effect was first observed in samples of $YBa_2Cu_3O_7$/AgO (Y-123/AgO) composites. Magnetization measurements of these samples show a much larger hysteresis which corresponds to a large critical current density. In addition to the Y-123/AgO composites, recently similar suspension effects in other RE-123/AgO, where RE stands for rare-Earth elements, were also observed. Some samples exhibit even stronger flux pinning than that of the Y-123/AgO sample. An interesting observation was that in order to form the composite which exhibits strong flux trapping effect the sintering temperature depends on the particular RE-123 compound used. This paper presents the detailed processing conditions for the formation of these RE-123/AgO composites, as well as the magnetization and critical field data.

TM-100351 February 1989

Material Selection Guidelines to Limit Atomic Oxygen Effects on Spacecraft Surfaces. J.T. Visentine and A.F. Whitaker. Materials and Processes Laboratory. X89-10321

Many materials comprising the exposed surfaces of spacecraft orbiting in the low-Earth orbit environment are subject to significant mass erosion and changes in surface properties due to interactions with ambient atomic oxygen, the predominant gaseous species at LEO altitudes. The suprathermal (5 eV) interactions are energized by the collision of ambient oxygen atoms with a spacecraft at an orbital velocity of 8 km/s.

Guidelines for selecting materials resistant to the effects of atomic oxygen are provided for application to satellites and space platforms designed to operate in the low-Earth orbit environment. A nomograph incorporating the influence of spacecraft altitude, attitude, orbital inclination, mission duration, and solar activity conditions is included for estimating atomic oxygen fluence (total integrated flux) and, consequently, the degree of surface erosion a spacecraft will experience over its lifetime. Existing laboratory and flight experiments results are comprehensively reviewed, and the applicability and limitations of these data are discussed in the context of guidelines for suggested screening techniques.

TM-100352 January 1989

Improved Capabilities of the Multispectral Atmospheric Mapping Sensor (MAMS). G.J. Jedlovec, K.B. Batson, R.J. Atkinson, C.C. Moeller, W.P. Menzel, and M.W. James. Space Science Laboratory. N89-20430

NASA maintains a number of aircraft instruments in support of future flight programs. Scientific findings from data collected with these instruments have been particularly important over the last few years as the scientific justification of new instrumentation for NASA's Earth observing system (Eos) was being formulated. The Multispectral Atmospheric Mapping Sensor (MAMS) is one such instrument which has made an impact on Eos instrumentation. This document serves as a follow-on report to NASA TM-86565 entitled "The Multispectral Atmospheric Mapping Sensor (MAMS): Instrument Description, Calibration, and Data Quality" and discusses changes to the instrument which have led to new capabilities and improved data quality through better signal-to-noise and more accurate calibration methods. This report summarizes the capabilities which will exist with MAMS through the next 3 to 5 years.

TM-100353 January 1989

Reexamination of Radiofrequency Mass Spectrometers – Center Director's Discretionary Fund Final Report. M.R. Carruth, Jr. Materials and Processes Laboratory. N89-18672

The three-stage, two-cycle, Bennett mass spectrometer in use in space and ground experiments today is of the same physical configuration as developed by Bennett in 1950. Sine-wave radiofrequency (RF) is also still used. The literature indicated that the electronics and physical manufacturing capabilities of 1950 technology may have limited the use of other improvements at that time. Therefore, a study, experimental and analytical, was undertaken to examine previously rejected RF approaches as well as new ones. The results of this study indicate there are other approaches which use fewer grids and square wave of a combination of square-wave and sine-wave RF. In regard to suppression of harmonics, none performed better than the three-stage, two-cycle, Bennett mass spectrometer. Use of square-wave RF in the Bennett approach can provide a slightly more compact configuration but no increase in throughput.

TM-100356 February 1989

Automatic Mathematical Modeling for Real Time Simulation Program. C. Wang and S. Purinton. Information and Electronic System Laboratory. N89-18147

This report describes a methodology for automatic mathematical modeling and generating simulation models. The major objective was to create a user-friendly environment for engineers to design, maintain, and verify their models; to automatically convert the mathematical models into conventional code for computation; and finally, to document the model automatically.

TM-100357 February 1989

NASA/MSFC FY88 Global Scale Atmospheric Processes Research Program Review. Edited by G.S. Wilson, F.W. Leslie, and J.E. Arnold. Space Science Laboratory.

This document describes the research supported by NASA's Global Atmospheric Processes Research Program at the Marshall Space Flight Center. There has been much interest recently in environmental issues such as the ozone hole, the global warming of the atmosphere, etc. Debate about the magnitude of these environmental changes continues. One problem is that measurements of the atmosphere are concentrated near large cities or airports of which virtually all are located on land representing only a small part of the Earth's surface. One way to gain more understanding of the atmosphere is to make measurements on a global scale from space. One of NASA's new initiatives is the Earth observation system, a series of new sensors to measure globally atmospheric parameters such as temperature, moisture, wind, lightning, etc. Analysis of satellite data by developing algorithms to interpret the radiance information improves our understanding and also defines requirements for these new sensors. One measure of our knowledge of the atmosphere lies in our ability to predict its behavior. In order to predict future states of the atmosphere, one must know not only the current state but also the physics which govern change. Use of numerical and experimental models provides a better understanding of these processes. This work describes these efforts in the context of satellite data analysis and fundamental studies of atmospheric dynamics which examine selected processes important to the global circulation.

TM-100358 January 1989

Oblique Hypervelocity Impact Response of Dual-Sheet Structures. W.P. Schonberg and R.A. Taylor. Materials and Processes Laboratory. N89-21246

This report describes the results of a continuing investigation of the phenomena associated with the oblique hypervelocity impact of spherical projectiles onto multisheet aluminum structures. A series of equations that quantitatively describes these phenomena is obtained through a regression of experimental data. These equations characterize observed ricochet and penetration damage phenomena in a multisheet structure as functions of geometric parameters of the structure and the diameter, obliquity, and velocity of the impacting projectile. Crater damage observed on the ricochet witness plates is used to determine the sizes and speeds of the ricochet debris particles that caused the damage. It is observed that the diameter of the most damaging ricochet debris particle can be as large as 40 percent of the original particle diameter and can travel at speeds between 24 percent and 36 percent of the original projectile impact velocity. The equations necessary for the design of shielding panels that will protect external systems from such ricochet debris damage are also developed. The dimensions of these shielding panels are shown to be

strongly dependent on their inclination and on their circumferential distribution around the spacecraft. It is concluded that obliquity effects of high-speed impacts must be considered in the design of any structure exposed to the meteoroid and space debris environment.

TM-100359 March 1989

Atmospheric Environment for Space Shuttle (STS-26) Launch. G.L. Jasper, D.L. Johnson, and G.W. Batts. Space Science Laboratory. N89-21819

This report presents a summary of selected atmospheric conditions observed near space shuttle STS-26 launch time on September 29, 1988, 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-26 vehicle ascent has been constructed. The STS-26 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.

TM-100360 March 1989

NASA Marshall Space Space Flight Center Solar Observatory Report – January–December 1987. J.E. Smith. Space Science Laboratory. N89-21712

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 1987. 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-100361 February 1989

A Noncontacting Scanning Photoelectron Emission Technique for Bonding Surface Cleanliness Inspection. R.L. Gause. Materials and Processes Laboratory. N89-24623

Molecular contamination of bonding surfaces can drastically affect the bond strength that can be achieved and therefore the structural integrity and reliability of the bonded part. The presence of thin contaminant films on bonding surfaces can result from inadequate or incomplete cleaning methods, from oxide growth during the time between cleaning (such as grit blasting) and bonding, or from failure to properly protect cleaned surfaces from oils, greases, fingerprints, release agents, or deposition of facility airborne molecules generated by adjacent manufacturing or processing operations.

Required cleanliness levels for desired bond performance can be determined by testing to correlate bond strength with contaminant type and quantity, thereby establishing the degree of contamination that can be tolerated based on the strength that is needed. Once the maximum acceptable contaminant level is defined, a method is needed to quantitatively measure the contaminant level on the bonding surface prior to bonding to verify that the surface meets the established cleanliness requirement.

This paper describes a unique photoelectron emission technique for the nondestructive inspection of various bonding surfaces, both metallic and nonmetallic, to provide quantitative data on residual contaminant levels. The technique can be used to scan surfaces at speeds of at least 30 ft/min using a servo system to maintain required sensor to surface spacing. The fundamental operation of the photoelectron emission sensor system, which is commercially available, is explained and the automated scanning system and computer data acquisition hardware and software, which was developed by MSFC, are described. Illustrative data are provided relative to sensor and system performance for both bonding test specimens and full scale hardware (SRM) inspection applications. Current capabilities and limitations of the use of this methodology are addressed and plans for future development and application are summarized.

TM-100362 March 1989

Space Station CMIF Extended Duration Metabolic Control Test Final Report. R.G. Schunk, R.M. Bagdigian, R.L. Carrasquillo, K.Y. Ogle, and P.O. Wieland. Structures and Dynamics Laboratory. N89-23503

This report contains a discussion of the space station extended duration metabolic control test (EMCT)

that was conducted at the MSFC Core Module Integration Facility in November of 1987. The primary objective of the EMCT was to gather performance data from a partially-closed regenerative environmental control and life support (ECLS) system functioning under steady-state conditions. Included in the report is a description of the EMCT configuration, a summary of events, a discussion of anomalies that occurred during the test, and detailed results and analysis from individual measurements of water and gas samples taken during the test. A comparison of the physical, chemical, and microbiological methods used in the post test laboratory analyses of the water samples is included. The report also details the preprototype ECLS hardware used in the test, providing an overall process description and theory of operation for each hardware item. Analytical results pertaining to a system level mass balance and selected system power estimates are also included in the report.

TM-100363 March 1989

Space Station ECLSS Simplified Integrated Test Final Report. R.G. Schunk, R.O. Bagdigian, R.L. Carrasquillo, K.Y. Ogle, and P.O. Wieland. Structures and Dynamics Laboratory. N89-24044

This report contains a discussion of the space station simplified integrated test (SIT) which was conducted at the MSFC Core Module Integration Facility in June of 1987. The first in a series of three integrated ECLS system tests, the primary objectives of the SIT were to verify proper operation of ECLS subsystems functioning in an integrated fashion as well as to gather preliminary performance data for the partial ECLS system used in the test. Included in this report is a description of the SIT configuration, a summary of events, a discussion of anomalies that occurred during the test, and detailed results and analysis from individual measurements and water and gas samples taken during the test. The report also details the preprototype ECLS hardware used in the test, providing an overall process description and theory of operation for each hardware item.

TM-100364 May 1989

A Methodology for Commonality Analysis, with Application to Selected Space Station Systems. L.D. Thomas. Space Station Project Engineering Office. N89-24421

The application of commonality in a system represents an attempt to reduce costs by reducing the number of unique components. A formal method for conducting commonality analysis has not been established. In this dissertation, commonality analysis is characterized as a partitioning problem. The cost impacts of commonality are quantified in an objective function, and the solution is that partition which minimizes this objective function. Clustering techniques are used to approximate a solution, and sufficient conditions are developed which can be used to verify the optimality of the solution. This method for commonality analysis is general in scope. It may be applied to the various types of commonality analysis required in the conceptual, preliminary, and detail design phases of the system development cycle.

TM-100365 May 1989

Pressure-Volume Properties of Metallic Bellows. L. Kiefling. Structures and Dynamics Laboratory. N89-24422

Metallic bellows are commonly used as segments of propellant feedlines for rocket-propelled vehicles to accommodate temperature-induced length variations, manufacturing tolerances, and gimbaling of the engines. These bellows sections deform radially and change volume when internal pressure varies, and the magnitude of such deformation is much higher than that for the straight, cylindrical segments of the line. The greater flexibility, or lesser stiffness, of the bellows, decreases the frequency of acoustic oscillations in the line. These acoustic oscillations are a major factor in the so-called POGO phenomena which have plagued most of the larger liquid rocket-propelled vehicles for many years.

A method is developed to calculate the change in volume of a bellows due to a change in internal pressure. Results of an experiment are also presented along with a test-analysis comparison. The computer code is included.

TM-100366 April 1989

The Corrosion Protection of Aluminum by Various Anodizing Treatments. M.D. Danford. Materials and Processes Laboratory. N89-26079

Corrosion protection to 6061-T6 aluminum, afforded by both Teflon-impregnated anodized coats

(Polylube and Tufram) and hard-anodized coats (water sealed and dichromate sealed), was studied at both pH 5.5 and pH 9.5, with an exposure period of 28 days in 3.5% NaCl solution (25 °C) for each specimen. In general, corrosion protection for all specimens was better at pH 9.5 than at pH 5.5. Protection by a Tufram coat proved superior to that afforded by Polylube at each pH, with corrosion protection by a hard-anodized, water-sealed coat at pH 9.5 providing the best protection. Electrochemical work in each case was corroborated by microscopic examination of the coats after exposure. Corrosion protection by Tufram at pH 9.5 was most comparable to that of the hard-anodized samples, although pitting and some cracking of the coat did occur.

TM-100367 May 1989

An Evaluation of the General Dynamics 20 kHz 5 kW Breadboard for Space Station Electrical Power at MSFC. D.K. Hall and R.E. Kapustka. Information and Electronic Systems Laboratory. N89-25278

This report discusses the results and observations of tests made on the General Dynamics 20 kHz breadboard for space station electrical power. This study considers the General Dynamics 20 kHz system only, and not the issue of the use of 20 kHz ac power for spacecraft applications.

TM-100368 June 1989

Rapid Fitting of Particle Cascade Development Data from X-Ray Film Densitometry Measurements. E. Roberts, C.M. Benson, and W.F. Fountain. Space Science Laboratory. N89-24260

This report describes a semiautomatic method of fitting transition curves to x-ray film optical density measurements of electromagnetic particle cascades. Several hundred singly and multiply interacting cosmic ray events from the JACEE 8 balloon flights were analyzed using this procedure. In addition to greatly increased speed compared to the previous manual method, the semiautomatic method offers increased accuracy through maximum likelihood fitting.

TM-100370 July 1989

Atmospheric Environment for Space Shuttle (STS-27) Launch. G.L. Jasper, D.L. Johnson, and G.W. Batts. Space Science Laboratory. N89-27316

This report presents a summary of selected atmospheric conditions observed near space shuttle STS-27 launch time on December 2, 1988, at Kennedy Space Center, Florida. STS-27 carried a Department of Defense payload and the flight azimuth in this report will be denoted by 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-27 vehicle ascent has been constructed. The STS-27 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.

TM-100371 June 1989

Development of New Techniques for the Characterization of Crystals and Their Growth Solutions – Center Director's Discretionary Fund Final Report. R.L. Kroes and D.A. Reiss. Space Science Laboratory. N89-26741

The solubility measurement system and the laser scattering microscope system were designed, built, and utilized for the study of crystal growth solutions and crystal characterization measurements. With these instruments we have been able to make solubility measurements and crystal defect maps for a number of new materials. In some cases, where there have been published solubility data (i.e., TGS), we have been able to make more accurate measurements and resolve discrepancies in the published data. The design of these instruments is presented along with a description of their use and some typical data generated using them.

TM-100373 August 1989

Static and Dynamic Deflection Studies of the SRM Aft Case/Nozzle Joint. D.C. Christian, L.D. Kos, and I. Torres. Structures and Dynamics Laboratory. N89-28568

The redesign of the joints on the solid rocket motor (SRM) have prompted the need for analyzing the behavior of the joints using several different types of analyses.

The types of analyses performed include modal analysis, static analysis, transient response analysis, and base driving response analysis. The forces used in these analyses to drive the mathematical model include SRM internal chamber pressure, nozzle blowout and side forces, shuttle vehicle lift-off dynamics, SRM pressure transient rise curve, gimbal forces and moments, actuator gimbal loads, and vertical and radial bolt preloads.

The math model represented the SRM from the aft base tangent point (1,823.95 in) all the way back to the nozzle, where a simplified, tuned nozzle model was attached. The new design used the radial bolts as an additional feature to reduce the gap opening at the aft dome/nozzle fixed housing interface.

TM-100374 August 1989

The Effects of Temperature Gradient and Growth Rate on the Morphology of Fatigue Properties of MAR-M246(Hf) – Center Director's Discretionary Fund Final Report. D.D. Schmidt, W.S. Alter, W.D. Hamilton, and R.A. Parr. Materials and Processes Laboratory.

MAR-M246(Hf) is a nickel-based superalloy used in the turbopump blades of the space shuttle main engines. This study considers the effect of temperature gradient (G) and growth rate (R) on the microstructure and fatigue properties of this superalloy. The primary dendrite arm spacings were found to be inversely proportional to both temperature gradient and growth rate. Carbide and $\gamma$-$\gamma'$ morphology trends were related to the G/R ratios. Weibull analysis of fatigue results shows the characteristic life to be larger by a factor of 10 for the low gradient/fast rate pairing of G and R, while the reliability ($\beta$) was lower.

TM-100375 August 1989

Wind Models for the NSTS Ascent Trajectory Biasing for Wind Load Alleviation. O.E. Smith, S.I. Adelfang, G.W. Batts, and C.K. Hill. Space Science Laboratory. N89-28551

This technical report presents new concepts for aerospace vehicle ascent wind profile biasing. The purpose for wind biasing the ascent trajectory is to provide ascent wind loads relief and thus decrease the probability for launch delays due to wind loads exceeding critical limits. Wind biasing trajectories to the profile of monthly mean winds have been widely used for this purpose. The wind profile models presented in this report give additional alternatives for wind biased trajectories. They are derived from the properties of the bivariate normal probability function using the available wind statistical parameters for the launch site. The analytical expressions are presented to permit generalizations. Specific examples are given to illustrate the procedures. The wind profile models can be used to establish the ascent trajectory steering commands to guide the vehicle through the first state. For the National Space Transportation System (NSTS) program these steering commands are called I-loads.

TM-100376 July 1989

Atmospheric Environment for Space Shuttle (STS-29) Launch. G.L. Jasper and G.W. Batts. Space Science Laboratory.

This report presents a summary of selected atmospheric conditions observed near space shuttle STS-29 launch time on March 13, 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-29 vehicle ascent has been constructed. The STS-29 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.

TM-100377 September 1989

The Initiation and Propagation of Detonation in Solid Propellants. W.W. Brandon. Program Development Directorate.

Detonation is a potential hazard in the manufacture and use of solid rocket propellants. Extensive studies of detonation in solid propellants were carried out by the Redstone Arsenal Research Division of Rohm and Haas Company from about 1956 to 1970, when the Redstone Division closed. Although the

problem of detonation was not resolved, many aspects of the problem were examined, and the results appear to be of current interest. To facilitate access to this information, relevant documentation has been identified by a participant in the original studies, and selected documentary excerpts, memoranda, and correspondence have been compiled in this NASA Technical Memorandum.

Organizational comments by the author are interspersed throughout sections describing deflagration-to-detonation transition, detonation failure diameter and gap sensitivity to shock initiation, detonation testing, and rudimentary inspection and gas-phase suppression methods. The section on detonation testing includes evaluations of personnel shielding, safety devices, and structures for explosives handling.

TM-100378 September 1989

Concepts for Microgravity Experiments Utilizing Gloveboxes. R.L. Kroes, D.A. Reiss, and B. Facemire. Space Science Laboratory.

The need for glovebox facilities on spacecraft in which microgravity materials processing experiments are performed is discussed. At present such facilities are being designed, and some of their capabilities are briefly described. A list of experiment concepts which would require or benefit from such facilities is presented.

TM-100379 September 1989

Highly Automated Optical Characterization with FTIR Spectrometry. G.L.E. Perry and F.R. Szofran. Space Science Laboratory.

The procedure for evaluating the characteristics of II-VI semiconducting infrared sensor materials with a Fourier transform infrared (FTIR) spectrometer system will be discussed. While the method of mapping optical characteristics with a spectrometer has been employed previously, this system is highly automated compared to other systems where the optical transmission data are obtained using a FTIR system with a small stationary aperture in the optical path and moving the specimen behind the aperture. The hardware and software, including an algorithm developed for extracting cut-on wavelengths of spectra, as well as several example results, will be described to illustrate the advanced level of the system. Additionally, data from transverse slices and longitudinal wafers of the aforementioned semiconductors will be used to show the accuracy of the system in predicting trends in materials such as shapes of growth interfaces and compositional uniformity.

TM-100380 September 1989

Characterizations of Electrical Properties with High $T_c$ Superconducting Materials – Center Director's Discretionary Fund Final Report. R.C. Sisk and P.N. Peters. Space Science Laboratory.

This report describes the automated data acquisition system developed in the Space Science Laboratory at Marshall Space flight Center for measuring electrical properties of high temperature superconductors. The acquisition system, consisting of a computer and computer-controlled hardware, allows large numbers of voltage, current, temperature, and magnetic measurements to be performed on bulk and thin film samples. Typical results are shown characterizing transition temperature ($T_c$), critical current density ($J_c$), and magnetic properties of bulk high $T_c$ materials as a function of temperature.

TM-100381 July 1989

Atmospheric Environment for Space Shuttle (STS-30) Launch. G.L. Jasper and G.W. Batts. Space Science Laboratory.

This report presents a summary of selected atmospheric conditions observed near space shuttle STS-30 launch time on May 4, 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 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-30 vehicle ascent has been constructed. The STS-30 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.

TM-4091 August 1989

Superconducting Gravity Gradiometer Mission – Volume I: Study Team Executive Summary. Edited by S.H. Morgan and H.J. Paik. Program Development Office.

This report is an executive summary based upon the scientific and engineering studies and developments performed or directed by a study team composed of various Federal and university activities involved with the development of a three-axis superconducting gravity gradiometer integrated with a six-axis superconducting accelerometer. This instrument is being developed for a future orbital mission to make precise global gravity measurements. The scientific justification and requirements for such a mission are discussed. This includes geophysics, the primary mission objective, as well as secondary objectives, such as navigation and tests of fundamental laws of physics, i.e., a null test of the inverse square law of gravitation and tests of general relativity. The instrument design and status along with mission analysis, engineering assessments, and preliminary spacecraft concepts are discussed. In addition, critical spacecraft systems and required technology advancements are examined. The mission requirements and an engineering assessment of a precursor flight test of the instrument are discussed.

TM-4091 November 1988

Superconducting Gravity Gradiometer Mission – Volume II: Study Team Technical Report. Edited by S.H. Morgan and H.J. Paik. Program Development Office. N89-19749

This report is based upon the scientific and engineering studies and developments performed or directed by a study team composed of various Federal and university activities involved with the development of a three-axis superconducting gravity gradiometer integrated with a six-axis superconducting accelerometer. This instrument is being developed for a future orbital mission to make precise global gravity measurements. The scientific justification and requirements for such a mission are discussed. This includes geophysics, the primary mission objective, as well as secondary objectives, such as navigation and tests of fundamental laws of physics, i.e., a null test of the inverse square law of gravitation and tests of general relativity. The instrument design and status along with mission analysis, engineering assessments, and preliminary spacecraft concepts are discussed. In addition, critical spacecraft systems and required technology advancements are examined. The mission requirements and an engineering assessment of a precursor flight test of the instrument are discussed.

TM-4101 October 1988

Atmospheric Laboratory for Applications and Science Mission 1. Edited by P.D. Craven and M.R. Torr. Space Science Laboratory.

A brief description of each of the experiments selected for flight on the first atmospheric laboratory for applications and science (ATLAS) mission is given in this report. Each description has been prepared by the investigator responsible for the experiment. Most of the experimental equipment on ATLAS 1 has been flown before on one of the first three Spacelab missions.

TP-2872 November 1988

Effects of Variables Upon Pyrotechnically Induced Shock Response Spectra – Part II. J.L. Smith. Structures and Dynamics Laboratory. N89-13814

Throughout the aerospace industry, large variations of 50 percent (6 dB) or more in shock response spectra (SRS) derived from pyrotechnic separation events continue to be reported from actual spaceflight data and from laboratory tests. As a result of these variations, NASA funded a research program for 1984 through 1986. The purpose of the 1984–1986 project was to analyze variations in pyrotechnically induced SRS and to determine if and to what degree manufacturing and assembly variables and tolerances, distance from the shock source, data acquisition instrumentation, and shock energy propagation affect the SRS. Sixty-four free-free boundary plate tests were performed. NASA funded an additional study for 1987–1988. This study was a continuation of the previous study. This paper is a summary of the additional study. The purpose of this study was to evaluate shock dissipation through various spacecraft structural joint types, to evaluate shock variation for various manufacturing and assembly variables on clamped boundary test plates, and to verify data correction techniques. Five clamped boundary plate tests investigated manufacturing and assembly variables and mass loading effects. Six free-free boundary plate tests investigated shock dissipation across spacecraft joint structures.

TP-2881 December 1988

The Estimation Error Covariance Matrix for the Ideal State Reconstructor With Measurement Noise. M.E. Polites. Structures and Dynamics Laboratory. N89-13994

This paper derives a general expression for the state estimation error covariance matrix for the ideal state reconstructor when the input measurements are corrupted by measurement noise. An example is presented which shows that the more measurements used in estimating the state at a given time, the better the estimate.

TP-2882 January 1989

The Interaction of Hydrogen With Elemental Metals Contained in Alloys Used in the Space Shuttle Main Engine. M.D. Danford. Materials and Processes Laboratory. X89-10294

Hydrogen diffusion, trapping, and hydride stability have been investigated for several elements which form the alloys of the SSME. The hydrogen diffusion coefficient in Ni 270 at 25 °C has been found to be in acceptable agreement with results from other investigations. Hydrogen trapping in Ti and Hf was found to be extensive, while it is relatively small in Co, Ni, and very likely Mo. Stability of the elemental metal hydrides agrees rather well with theoretical predictions for hydrogen affinities of the elements, although stability and affinity are not necessarily the same. Structural studies of some of the elemental metals have been carried out by x-ray diffraction, and correlations of hydrogen absorption on charging at 25 °C with structure are discussed. Bonding in the elemental hydrides is postulated to be covalent.

TP-2884 December 1988

Cyclic Loads Tests of Carbon Involute Solid Rocket Motor Outer Boot Ring Segments. R. Ahmed. Structures and Dynamics Laboratory. N89-16192

This report documents the cyclic load tests performed on 30-in segments of the DM-9 configuration solid rocket outer boot ring. The tests found that the effect of the cyclic loadings on the structural integrity of the outer boot ring was negligible. The results are compared with a hand analysis of the strength of a 30-in outer boot ring segment.

Several phenomena of engineering interest are also described in this report.

TP-2893 January 1989

Practices in Adequate Structural Design. R.S. Ryan. Structures and Dynamics Laboratory. N89-18504

Structural design and verification of space vehicles and space systems is a very tricky and awe inspiring business, particularly for manned missions. Failures in the missions with loss of life is devastating personally and nationally. The scope of the problem is driven by high performance requirements which push state-of-the-art technologies, creating high sensitivities to small variations and uncertainties. Insurance of safe, reliable flight dictates the use of sound principles,

procedures, analysis, testing, etc. This paper deals with many of those principles which have been refocused by the Space Shuttle Challenger (51-L) accident on January 26, 1986, and the activities conducted to insure safe shuttle reflights. The emphasis will be focused on engineering, while recognizing that project and project managment are also key to success.

TP-2909 March 1989

Further Developments in Modeling Digital Control Systems With MA-Prefiltered Measurements. M.E. Polites. Structures and Dynamics Laboratory. X89-36049

This paper presents new state variable representations for a continuous-time plant driven by a zero-order-hold with multirate-sampled measurements prefiltered by multi-input/multi-output moving average (MA) processes. These representations have broad application, but are known to be useful in the aerospace field for modeling systems with startrackers and some state-of-the-art rate-gyroscopes and accelerometers.

TP-2934 July 1989

Stress Corrosion Study of PH13-8Mo Stainless Steel Using the Slow Strain Rate Technique. P.D. Torres. Materials and Processes Laboratory. N89-26976

The need for a fast and reliable method to study stress corrosion in metals has caused increased interest in the slow strain rate technique (SSRT) during the last few decades. In this work, PH13-8Mo H950 and H1000 round tensile specimens were studied by this method. Percent reduction-in-area, time-to-failure, elongation at fracture, and fracture energy were used to express the loss inductility, which has been used to indicate susceptibility to stress corrosion cracking (SCC). Results from a 3.5 percent salt solution (corrosive medium) were compared to those in air (inert medium). A tendency to early failure was found when testing in the vicinity of $1.0 \times 10^{-6}$ mm/mm/s in the 3.5-percent salt solution. PH13-8Mo H1000 was found to be less likely to suffer SCC than PH13-8Mo H950. This program showed that the SSRT is promising for the SCC characterization of metals and results can be obtained in much shorter times (18 hr for PH steels) than those required using conventional techniques.

TP-2935 August 1989

Weld Stresses Beyond Elastic Limit – Materials Discontinuity. V. Verderaime. Structures and Dynamics Laboratory. N89-27214

When welded structures depend on properties beyond the elastic limit to qualify their ultimate safety factor, and weld-parent materials abruptly change in the interface, then stress discontinuity is inevitable. The stress concentration is mildly sensitive to material relative strain hardening and acutely sensitive to applied stress fields. Peak stresses occur on the weld surface, at the interface, and dissipate within a 0.01-inch band. When the stress is intense, the weld will always fracture at the interface. The analysis incorporates a classical mechanics model to more sharply define stress spikes within the bandwidth, and suggests a relative material index and Poisson's ratio related to strain hardening. Implications are discussed which are applicable to industries of high performance structures.

TP-2936 August 1989

A New State Reconstructor for Digital Control Systems Using Weighted-Averaged Measurements. M.E. Polites. Structures and Dynamics Laboratory. N89-27039

This paper presents a new state reconstructor for a linear continuous-time plant driven by a zero-order-hold. It takes a continuous-time output vector from the plant and convolutes it with a weighting-function matrix whose elements are time dependent. This result is integrated over T second intervals to generate weighted-averaged measurements, every T seconds, that are used in the state reconstruction process. If the plant is noise-free and can be modeled precisely, the output of this state reconstructor exactly equals the true state of the plant and accomplishes this without knowledge of the plant's initial state. If noise or modeling errors are a problem, it can be catenated with a state observer or a Kalman filter for a synergistic effect.

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N89-15790

CP-3032 March 1989
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N89-23892

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CP- August 1989
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Analysis and Use of VAS Satellite Data. NAG8-033. Department of Meteorology, Florida State University. X89-36052

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Operational Implications of a Cloud Model Simulation of Space Shuttle Exhaust Clouds in Different Atmospheric Conditions. NAS8-36715. J.A. Zak. ST Systems Corp. (STX). N89-21425

CR-4223 March 1989
A Cloud Model Simulation of Space Shuttle Exhaust Clouds in Different Atmospheric Conditions.. NAS8-36715. C. Chen and J.A. Zak. ST Systems Corp. (STX). N89-21426

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Space Shuttle Main Engine Alternate Turbopump Development Program. For presentation at the 26th Space Congress, KSC, Florida, April 25–28, 1989.

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Compiled by Joyce E. Turner

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Director, Administrative Operations Office

☆U.S. GOVERNMENT PRINTING OFFICE 1989–731-061/20011