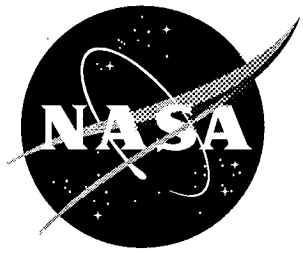

NASA Technical Memorandum 108528
Volume I

FY 1996 Scientific and Technical Reports, Articles, Papers, and Presentations

Compiled by
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National Aeronautics and Space Administration
Marshall Space Flight Center • MSFC, Alabama 35812

October 1996

FOREWORD

In accordance with the NASA Space Act of 1958, the MSFC has provided for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

Since July 1, 1960, when the George C. Marshall Space Flight Center was organized, the reporting of scientific and engineering information has been considered a prime responsibility of the Center. Our credo has been that "research and development work is valuable, but only if its results can be communicated and made understandable to others."

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

FY 1996 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

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TM–4737 April 1996

Second United States Microgravity Payload: One Year Report. P.A. Curreri and D.E. McCauley,* Editors. Space Sciences Laboratory. *University of Alabama in Huntsville.

19960038726N (96N–30996)

The second United States Microgravity Payload (USMP–2), flown in March 1994, carried four major microgravity experiments plus a sophisticated accelerometer system. The USMP program is designed to accommodate experiments requiring extensive resources short of a full *Spacelab* mission. The four USMP–2 experiments dealt with understanding fundamental aspects of materials behavior, three with the formation of crystals from melts, and one with the critical point of a noble gas. This successful, scientifically rich mission also demonstrated telescience operations.

TM–4759 September 1996

Statistical Technique for Intermediate and Long-Range Estimation of 13-Month Smoothed Solar Flux and Geomagnetic Index. K.O. Niehuss, H.C. Euler, Jr., and W.W. Vaughan.* Systems Analysis and Integration Laboratory. *University of Alabama in Huntsville.

19960048010N (96N–33521)

This report documents the Marshall Space Flight Center (MSFC) 13-month smoothed solar flux ($F_{10.7}$) and geomagnetic index (A_p) intermediate (months) and long-range (years) statistical estimation technique, referred to as the MSFC Lagrangian Linear Regression Technique (MLLRT). Estimates of future solar activity are needed as updated input to upper atmosphere density models used for satellite and spacecraft orbital lifetime predictions. An assessment of the MLLRT computer program's products is provided for 5-year periods from the date estimates were made. This was accomplished for a number of past solar cycles.

TM–108502 October 1995

FY 1995 Scientific and Technical Reports, Articles, Papers, and Presentations (Volume I). Compiled by Joyce E. Turner. Management Operations Office, Human Resources and Administrative Support Office.

19960020622N (96N–24159)

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY95. It also includes papers of MSFC contractors.

After being announced in STAR, all of the NASA series reports may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

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–108503 December 1995

Laboratory Electron Exposure of TSS–1 Thermal Control Coating. J.A. Vaughn, M. McCollum, and M.R. Carruth, Jr. Materials and Processes Laboratory.

19960012277N (96N–18514)

RM400, a conductive thermal control coating, was developed for use on the exterior shell of the tethered satellite. Testing was performed by the Engineering Physics Division to quantify effects of the space environment on this coating and its conductive and optical properties. Included in this testing was exposure of RM400 to electrons with energies ranging from 0.1 to 1 keV, to simulate electrons accelerated from the ambient space plasma when the tethered satellite is fully deployed. During this testing, the coating was found to luminesce, and a prolonged exposure of the coating to high-energy electrons caused the coating to darken. This report describes the tests done to quantify the degradation of the thermal control properties caused by electron exposure and to measure the luminescence as a function of electron energy and current density to the satellite.

TM–108504 January 1996

Development of an Open Architecture Flight Qualified Computer (CDDF Final Report, Project Number 92–R07). B. Beabout. Astrionics Laboratory. 19960017665N (96N–23199)

A space flight qualified controller for experiments that is modular and based on an open architecture commercially available standard can reduce system development time by leveraging off commercial hardware and software. While the unique requirements of flight may mandate custom hardware designs, a modular design approach in which a core set of modules is designed and built would provide a basis for future experiment controllers. Any unique requirements could then be met by adding modules as necessary. A central processing unit module, a MIL–STD–1553 interface module, and a *Spacelab* interface module were developed. These modules are linked using the IEEE standard 1296 Multibus II™ bus architecture. This report describes the work done to develop this core set of processing and interface modules that meet the IEEE 1296 Multibus II™ standards.

TM–108505 March 1996

Investigation Into Radiation-Induced Compaction of Zerodur™. D.L. Edwards, K. Herren, M. Hayden, K. McDonald, J.A. Sims, and C.L. Semmel. Materials and Processes Laboratory. 19960017568N (96N–23147)

Zerodur™ is a low coefficient of thermal expansion glass-ceramic material. This property makes Zerodur™ an excellent material for high precision optical substrates. Functioning as a high precision optical substrate, a material must be dimensionally stable in the system operating environment. Published data indicate that Zerodur™ is dimensionally unstable when exposed to large doses of ionizing radiation. The dimensional instability is discussed as an increase in Zerodur™ density. This increase in density is described as a compaction.

Experimental data showing proton-induced compaction of Zerodur™ is presented. The dependence of compaction on proton dose was determined to be a power law relationship. Previous publications determined a powder law relationship between Zerodur™ compaction and electron radiation. Correlation between the published data and the results of this investigation are currently being studied.

TM–108506 March 1996

Interpolation Errors in Spectrum Analyzers. J.L. Martin. Systems Analysis and Integration Laboratory. 19960017567N (96N–23146)

To obtain the proper measurement amplitude with a spectrum analyzer, the correct frequency-dependent transducer factor must be added to the voltage measured by the transducer. This report will examine how entering transducer factors into a spectrum analyzer can cause significant errors in field amplitude due to the misunderstanding of the analyzer's interpolation methods. It will also discuss how to reduce these errors to obtain a more accurate field amplitude reading.

TM–108507 April 1996

Sliding Mode Thermal Control System for Space Station Furnace Facility. M.E. Jackson. Structures and Dynamics Laboratory. 19960021179N (96N–24648)

The space station furnace facility (SSFF) provides the necessary core systems to operate various material processing furnaces. The thermal control system (TCS) is defined as one of the core systems, and its function is to collect excess heat from furnaces and to provide precise cold temperature control of components and of certain furnace zones. Physical interconnection of parallel thermal control subsystems through a common pump implies the description of the whole TCS by coupled nonlinear differential equations in flow and pressure. The report formulates the system equations and develops the sliding mode controllers that cause the interconnected subsystems to operate in the local sliding modes, resulting in control system invariance to interaction disturbances and plant uncertainties. The desired decoupled flow rate profile tracking is achieved by optimization of the local linear sliding mode equations. Extensive digital simulation results are presented to show the flow rate tracking robustness and invariance to plant nonlinearities, time-varying plant parameters, and variations of the system pressure supplied to the controlled subsystems. A comparison against the popular proportional-plus-derivative-plus-integral (PID) control algorithm is included to demonstrate improved performance over traditional control techniques.

TM–108508 May 1996

International Space Station ECLSS Technical Task Agreement Summary Report. Compiled by C.D. Ray and S. Minton-Summers. Structures and Dynamics Laboratory. 19960045292N (96N–32259)

This report is a summary of work accomplished under Technical Task Agreement by the Marshall Space Flight Center (MSFC) and documents activities regarding the Environmental Control and Life Support Systems (ECLSS) of the International Space Station (ISS) program. These MSFC activities were in-line to the designing, the development, the testing, and the flight of ECLSS equipment. MSFC's unique capabilities for performing integrated system testing and analyses, and its ability to perform some tasks cheaper and faster to support ISS program needs are the basis for the Technical Task Agreement activities. Tasks were completed in the water recovery systems, air revitalization systems, and microbiology areas. The results of each task are described in this summary report.

TM–108509 May 1996

Mars Global Reference Atmospheric Model (Mars-GRAM 3.34): Programmer's Guide. C.G. Justus,* B.F. James, and D.L. Johnson. Electromagnetics and Aerospace Environments Branch, System Analysis and Integration Laboratory. *Computer Sciences Corporation, Huntsville, AL. 19960036976N (96N–30652)

This is a programmer's guide for the Mars Global Reference Atmospheric Model (Mars-GRAM 3.34). Included are a brief history and review of the model since its origin in 1988 and a technical discussion of recent additions and modifications. Examples of how to run both the interactive and batch (subroutine) forms are presented. Instructions are provided on how to customize output of the

model for various parameters of the Mars atmosphere. Detailed descriptions are given of the main driver programs, subroutines, and associated computational methods. Lists and descriptions include input, output, and local variables in the programs. These descriptions give a summary of program steps and "map" of calling relationships among the subroutines. Definitions are provided for the variables passed between subroutines through "common" lists. Explanations are provided for all diagnostic and progress messages generated during execution of the program. A brief outline of future plans for Mars-GRAM is also presented.

TM–108510 June 1996

Semiconductor Crystal Growth in Crossed Electric and Magnetic Fields—Center Director's Discretionary Fund Final Report (Project No. 93–25). M.P. Volz and K. Mazuruk.* Space Science Laboratory. *Universities Space Research Association, Huntsville, AL.

19960027992N (96N–29111)

A unique growth cell was designed in which crossed electric and magnetic fields could be separately or simultaneously applied during semiconductor crystal growth. A thermocouple was inserted into an InSb melt inside the growth cell to examine the temperature response of the fluid to applied electromagnetic fields. A static magnetic field suppressed time-dependent convection when a destabilizing thermal field was applied. The simultaneous application of electric and magnetic fields resulted in forced convection in the melt. The InSb ingots grown in the cell were polycrystalline. An InGaSb crystal, 0.5 cm in diameter and 23-cm long, was grown without electromagnetic fields applied. The axial composition results indicated that complete mixing in the melt occurred for this large aspect ratio.

TM–108511 June 1996

Importance of the Natural Terrestrial Environment With Regard to Advanced Launch Vehicle Design and Development. S.D. Pearson, W.W. Vaughan,* G.W. Batts,** and G.L. Jasper. Systems Analysis and Integration Laboratory. *University of Alabama in Huntsville; **Computer Sciences Corporation.

19960047082N (96N–32864)

The terrestrial environment is an important forcing function in the design and development of the launch vehicle. The scope of the terrestrial environment includes the following phenomena: Winds; atmospheric thermodynamic models and properties; thermal radiation; U.S. and world surface environment extremes; humidity; precipitation, fog, and icing; cloud characteristics and cloud cover models; atmospheric electricity; atmospheric constituents; vehicle engine exhaust and toxic chemical release; occurrences of tornadoes and hurricanes; geological hazards, and sea states. One must remember that the flight profile of any launch vehicle is in the terrestrial environment. Terrestrial environment definitions are usually limited to information below 90 km. Thus, a launch vehicle's operations will always be influenced to some degree by the terrestrial environment with which it interacts. As a result, the definition of the terrestrial environment and its interpretation is one of the key launch vehicle design and development inputs. This definition is a significant role, for example, in the areas of structures, control systems, trajectory shaping (performance), aerodynamic heating, and take off/landing capabilities. The launch vehicle's capabilities which result from the design, in turn, determines the constraints and flight opportunities for tests and operations.

TM–108512 June 1996

Advanced Liquid Oxygen (LO_2) Propellant Conditioning Concept Testing II. G.L.E. Perry, G.K. Mehta,* and J.H. Hastings.* Propulsion Laboratory. *Lockheed Martin, Huntsville, AL.

19960027985N (96N–29104)

More extensive testing was performed through a NASA research announcement (NRA) between Marshall Space Flight Center (MSFC) and Lockheed Martin Astronautics on the promising LO_2 propellant conditioning concept of passive recirculation (no-bleed). Data from the project are being used to further anchor models in LO_2 conditioning behavior and broaden the data base of no-bleed and low-bleed conditioning. Data base expansion includes results from testing the limits of no-bleed and low-bleed conditioning with various configuration changes to the test facility and designed test article. Configuration changes include low velocity effects in the recirculation loop above the test article, test article internal constriction impacts, test article out-of-plane effects, impact from an actual Titan LO_2 pump attachment, feed duct slope effects, and up-leg booster effects. LN_2 was used as the test fluid. The testing was conducted between July 1994 and January 1995 at the west test area of MSFC. Data have shown that in most cases passive recirculation was demonstrated when the aforementioned limits were applied.

TM–108513 July 1996

A Revised Thermosphere for the Mars Global Reference Atmospheric Model (Mars-GRAM Version 3.4). C.G. Justus,* D.L. Johnson, and B.F. James. Systems Analysis and Integration Laboratory. *Computer Sciences Corporation.

19960042695N (96N–31648)

This report describes the newly revised model thermosphere for the Mars Global Reference Atmospheric Model (Mars-GRAM, Version 3.4). It also provides descriptions of other changes made to the program since publication of the programmer's guide (Justus et al., 1996) for Mars-GRAM Version 3.34. The original Mars-GRAM model thermosphere was based on the global-mean model of Stewart (1987). The revised thermosphere is based largely on parameterizations derived from output data from the three-dimensional Mars Thermospheric Global Circulation Model (MTGCM) of Bougher et al. (1990). The new thermospheric model includes revised dependence on the 10.7-cm solar flux for the global means of exospheric temperature, temperature of the base of the thermosphere, and scale height for the thermospheric temperature variations, as well as revised dependence on orbital position for global mean height of the base of the thermosphere. Other features of the new thermospheric model are (1) realistic variations of temperature and density with latitude and time of day; (2) more realistic wind magnitudes, based on improved estimates of horizontal pressure gradients; and (3) allowance for user-input adjustments to the model values for mean exospheric temperature and for height and temperature at the base of the thermosphere. Other new features of Mars-GRAM 3.4 include (1) allowance for user-input values of climatic adjustment factors for temperature profiles from the surface to 75 km, and (2) a revised method for computing the sub-solar longitude position in the "ORBIT" subroutine.

TM–108514 June 1996

Computer-Aided System Engineering and Analysis (CASE/A) User's Manual—Version 5.0. Edited by J.C. Knox. Structures and Dynamics Laboratory.

19960044383N (96N–31927)

The Computer-Aided System Engineering and Analysis (CASE/A) Version 5.0 User's Manual provides the user with information needed to execute and learn the CASE/A 5.0 modeling package. CASE/A 5.0 is a trade study tool that provides modeling/simulation capabilities for analyzing environmental control and life support systems and active thermal control systems. CASE/A has been successfully used in studies such as the evaluation of carbon dioxide removal in the Space Station *Freedom*.

CASE/A modeling provides a graphical and command-driven interface for the user. This interface allows the user to construct a model by placing equipment components in a graphical layout of the system hardware, then connect the components via flow streams and define their operating parameters. Once the equipment is placed, the simulation time and other control parameters can be set to run the simulation based on the model constructed. After completion of the simulation, graphical plots or text files can be obtained for evaluation of the simulation results over time. Additionally, users have the capability to control the simulation and extract information at various times in the simulation (e.g., control equipment operating parameters over the simulation time or extract plot data) by using "User Operations (OPS) Code." This OPS code is written in FORTRAN with a canned set of utility subroutines for performing common tasks.

CASE/A version 5.0 software runs under the VAX VMS™ environment. It utilizes the Tektronics 4014™ graphics display system and the VT100™ text manipulation/display system.

TM–108515 June 1996

Enhancement of High-Speed Infrared Array Electronics (Center Director's Discretionary Fund Final Report, Project 93–03). W.T. Sutherland. Astrionics Laboratory.

A state-of-the-art infrared detector was to be used as the sensor in a new spectrometer-camera for astronomical observations. The sensitivity of the detector required the use of low-noise, high-speed electronics in the system design. The key component in the electronic system was the pre-amplifier that amplified the low voltage signal coming from the detector. The system was designed based on the selection of the amplifier and that was driven by the maximum noise level, which would yield the desired sensitivity for the telescope system.

TM–108516 September 1996

Vacuum Chamber for Shearography Non-destructive Evaluation. C.M. Horton and S.S. Russell. Materials and Processes Laboratory.

A vacuum chamber designed for use in shearography nondestructive evaluation of aerospace components is presented. The inspection of an aerospace insulation is used as an example of vacuum excitation shearography for evaluation of debonds. Design drawings of subcomponents and the assembly are included in an appendix.

TM–108517 September 1996

Computer-Aided System Engineering and Analysis (CASE/A) Programmer's Manual, Version 5.0. Edited by J.C. Knox. Structures and Dynamics Laboratory (96N–36544)

The Computer Aided System Engineering and Analysis (CASE/A) Version 5.0 Programmer's Manual provides the programmer and user with information regarding the internal structure of the CASE/A 5.0 software system. CASE/A 5.0 is a trade study tool that provides modeling/simulation

capabilities for analyzing environmental control and life support systems and active thermal control systems. CASE/A has been successfully used in studies such as the evaluation of carbon dioxide removal in the space station.

CASE/A modeling provides a graphical and command-driven interface for the user. This interface allows the user to construct a model by placing equipment components in a graphical layout of the system hardware, then connect the components via flow streams and define their operating parameters. Once the equipment is placed, the simulation time and other control parameters can be set to run the simulation based on the model constructed. After completion of the simulation, graphical plots or text files can be obtained for evaluation of the simulation results over time. Additionally, users have the capability to control the simulation and extract information at various times in the simulation (e.g., control equipment operating parameters over the simulation time or extract plot data) by using "User Operations (OPS) Code." This OPS code is written in FORTRAN with a canned set of utility subroutines for performing common tasks.

CASE/A version 5.0 software runs under the VAX VMS™ environment. It utilizes the Tektronics 4014™ graphics display system and the VT100™ text manipulation/display system.

TP–3588 November 1995

Studies of Localized Corrosion in Welded Aluminum Alloys by the Scanning Reference Electrode Technique. M.D. Danford and A.C. Nunes. Materials and Processes Laboratory.
19960016630N (96N–22263)

Localized corrosion in welded samples of 2219–T87 Al alloy (2319 filler), 2090 Al-Li alloy (4043 and 2319 fillers), and 2195 Al-Li alloy (4043 and 2319 fillers) has been investigated using the relatively new scanning reference electrode technique. The weld beads are cathodic in all cases, leading to reduced anode/cathode ratios. A reduction in anode/cathode ratio leaders to an increase in the corrosion rates of the welded metals, in agreement with results obtained in previous electrochemical and stress corrosion studies involving the overall corrosion rates of welded samples. The cathodic weld beads are bordered on both sides by strong anodic regions, with high propensity for corrosion.

TP–3589 November 1995

High Pressure Oxidizer Turbopump (HPOTP) Inducer Dynamic Design Environment. D.A. Herda and R.S. Gross.* Structures and Dynamics Laboratory. *Auburn University.
19960014632N (96N–19293)

The dynamic environment must be known to evaluate high pressure oxidizer turbopump inducer fatigue life. This report sets the dynamic design loads for the alternate turbopump inducer as determined by water-flow rig testing. Also, guidelines are given for estimating the dynamic environment or other inducer and impeller applications.

TP–3595 December 1995

Evaluation of Thermal Control Coatings and Polymeric Materials Exposed to Ground Simulated Atomic Oxygen and Vacuum Ultraviolet Radiation. R.R. Kamenetzky, J.A. Vaughn, M.M. Finckenor, and R.C. Linton. Materials and Processes Laboratory.
19960029068N (96N–29631)

Numerous thermal control and polymeric samples with potential *International Space Station* applications were evaluated for atomic oxygen and vacuum ultraviolet radiation effects in the Princeton Plasma Physics Laboratory 5-eV Neutral Atomic Oxygen Facility and in the MSFC Atomic Oxygen Drift Tube System. Included in this study were samples of various anodized aluminum samples, ceramic paints, polymeric materials, and beta cloth, a Teflon™-impregnated fiberglass cloth. Aluminum anodizations tested were black duranodic, chromic acid anodize, and sulfuric acid anodize. Paint samples consisted of an inorganic glossy black paint and Z–93 white paint made with the original PS7 binder and the new K2130 binder. Polymeric samples evaluated included bulk Halar™, bulk PEEK, and silverized FEP Teflon™. Aluminized and nonaluminized Chemfab 250™ beta cloth were also exposed. Samples were evaluated for changes in mass, thickness, solar absorptance, and infrared emittance. In addition to material effects, an investigation was made comparing diffuse reflectance/solar absorptance measurements made using a Beckman DK2 spectroreflectometer and like measurements made using an AZ Technology-developed laboratory portable spectroreflectometer.

TP–3615 April 1996

Review of Our National Heritage of Launch Vehicles Using Aerodynamic Surfaces and Current Use of These by Other Nations (Center Director's Discretionary Fund Project 93–05 Part II). C. Barret. Structures and Dynamics Laboratory. (96N–26811)

Marshall Space Flight Center has a rich heritage of launch vehicles that have used aerodynamic surfaces for flight stability and for flight control. Recently, due to the aft center-of-gravity (cg) locations on launch vehicles currently being studied, the need has arisen for the vehicle control augmentation that can be provided by these flight controls. Aerodynamic flight control can also reduce engine gimbaling requirements, provide actuator failure protection, enhance crew safety, and increase vehicle reliability and payload capability.

As a starting point for the novel design of aerodynamic flight control augmentors for a Saturn class, aft cg launch vehicle, this report undertakes a review of our national heritage of launch vehicles using aerodynamic surfaces, along with a survey of current use of aerodynamic surfaces on large launch vehicles of other nations. This report presents one facet of Center Director's Discretionary Fund Project 93–05 and has a previous and subsequent companion publication.

TP–3642 July 1996

Working on the Boundaries: Philosophies and Practices of the Design Process. R. Ryan, J. Blair, J. Townsend, and V. Verderaime. Structures and Dynamics Laboratory.
19960049664N (96N–33957)

While the systems engineering process is a program formal management technique and contractually binding, the design process is the informal practice of achieving the design project requirements throughout all design phases of the systems engineering process. The design process and organization are systems- and component-dependent. Informal reviews include technical information meetings and concurrent engineering sessions, and formal technical discipline reviews are conducted

through the systems engineering process. This paper discusses and references major philosophical principles in the design process, identifies its role in interacting systems and disciplines analyses and integrations, and illustrates the process application in experienced aerostructural designs.

TP–3648 August 1996

On the Importance of Cycle Minimum in Sunspot Cycle Prediction. Robert M. Wilson, David H. Hathaway, and Edwin J. Reichman. Space Sciences Laboratory.

19960045438N (96N–32360)

The characteristics of the minima between sunspot cycles are found to provide important information for predicting the amplitude and timing of the following cycle. For example, the time of the occurrence of sunspot minimum sets the length of the previous cycle, which is correlated by the amplitude-period effect to the amplitude of the next cycle, with cycles of shorter (longer) than average length usually being followed by cycles of larger (smaller) than average size (true for 16 of 21 sunspot cycles). Likewise, the size of the minimum at cycle onset is correlated with the size of the cycle's maximum amplitude, with cycles of larger (smaller) than average size minima usually being associated with larger (smaller) than average size maxima (true for 16 of 22 sunspot cycles). Also, it was found that the size of the previous cycle's minimum and maximum relates to the size of the following cycle's minimum and maximum with an even-odd cycle number dependency. The latter effect suggests that cycle 23 will have a minimum and maximum amplitude probably larger than average in size (in particular, minimum smoothed sunspot number Rm = 12.3±7.5 and maximum smoothed sunspot number Rm = 198.8±36.5, at the 95-percent level of confidence), further suggesting (by the Waldmeier effect) that it will have a faster than average rise to maximum (fast-rising cycles have ascent durations of about 41±7 months). Thus, if, as expected, onset for cycle 23 will be December 1996 ±3 months, based on smoothed sunspot number, then the length of cycle 22 will be about 123±3 months, inferring that it is a short-period cycle and that cycle 23 maximum amplitude probably will be larger than average in size (from the amplitude-period effect), having an Rm of about 133±39 (based on the usual ±30-percent spread that has been seen between observed and predicted values), with maximum amplitude occurrence likely sometime between July 1999 and October 2000.

TP–3652 September 1996

On Determining the Rise, Size, and Duration Classes of a Sunspot Cycle. Robert M. Wilson, David H. Hathaway, and Edwin J. Reichmann. Space Sciences Laboratory.

19960050464N (96N–34504)

The behavior of ascent duration, maximum amplitude, and period for cycles 1 to 21 suggests that they are not mutually independent. Analysis of the resultant three-dimensional contingency table for cycles divided according to rise time (ascent duration), size (maximum amplitude), and duration (period) yields a chi-square statistic (= 18.59) that is larger than the test statistic (= 9.49 for 4 degrees-of-freedom at the 5-percent level of significance), thereby, inferring that the null hypothesis (mutual independence) can be rejected. Analysis of individual 2 by 2 contingency tables (based on Fisher's exact test) for these parameters shows that, while ascent duration is strongly related to maximum amplitude in the negative sense (inverse correlation)—the Waldmeier effect, it also is related (marginally) to period, but in the positive sense (direct correlation). No significant (or marginally significant) correlation is found between period and maximum amplitude. Using cycle 22 as a test case, we show that by the 12th month following conventional onset, cycle 22 appeared highly likely to be fast-rising, larger-than-average-size cycle. Because of the inferred correlation between ascent duration and period, it also seems likely that it will have a period shorter than average length.

TP–3653 September 1996

A History of Aerospace Problems, Their Solutions, Their Lessons. R.S. Ryan. Structures and Dynamics Laboratory.

The positive aspect of problem occurrences is the opportunity for learning and a challenge for innovation. The learning aspect is not restricted to the solution period of the problem occurrence, but can become the beacon for problem prevention on future programs. Problems/failures serve as a point of departure for scaling to new designs. To ensure that problems/failures and their solutions guide the future programs, a concerted effort has been expended to study these problems, their solutions, their derived lessons learned, and projections for future programs. This includes identification of technology thrusts, process changes, codes development, etc. However, they must not become an excuse for adding layers upon layers of standards, criteria, and requirements, but must serve as guidelines that assist instead of stifling engineers. This report is an extension of prior efforts to accomplish this task. Although these efforts only scratch the surface, it is a beginning that others must complete.

CP–3332 March 1996
Thirteenth Workshop for Computational Fluid Dynamic Applications in Rocket Propulsion and Launch Vehicle Technology (Volume I). Compiled by R.W. Williams. Structures and Dynamics Laboratory.
19960029140N (96N–29670)

CP–3332 March 1996
Thirteenth Workshop for Computational Fluid Dynamic Applications in Rocket Propulsion and Launch Vehicle Technology (Volume II). Compiled by R.W. Williams. Structures and Dynamics Laboratory.
19960029254N (96N–29750)

CP–3325 February 1996
The 1995 NASA Aerospace Battery Workshop. Compiled by Jeffrey C. Brewer. Astrionics Laboratory. 19960020567N (96N–24116)

RP–1390 August 1996

Spacecraft System Failures and Anomalies Attributed to the Natural Space Environment. Keith L. Bedingfield,* Richard D. Leach,** and Margaret B. Alexander, Editor, Systems Analysis and Integration Laboratory. *Universities Space Research Association. **Computer Sciences Corporation.

19960050463N (96N–34503)

NASA CONTRACTOR REPORTS
(Abstracts for these reports may be obtained from STAR)

CR–4705 February 1996
User's Manual for Space Debris Surfaces (SD_SURF). NAS8–38856. Lockheed Martin Marietta Manned Space Systems.
19960016404N (96N–22207)

CR–4706 February 1996
Structural Damage Prediction and Analysis for Hypervelocity Impacts—Handbook. NAS8–38856. Lockheed Martin Marietta Manned Space Systems. 19960016651N (96N–22275)

CR–4707 February 1996
Formation and Description of Debris Clouds Produced by Hypervelocity Impact. NAS8–38856. University of Dayton Research Institute.
19960015933N (96N–22124)

CR–4716 February 1996
Vulnerability of Space Station *Freedom* Modules: A Study of the Effects of Module Perforation on Crew and Equipment. NCC8–28. University of Alabama in Huntsville.
19960048094N (96N–33587)

CR–4720 February 1996
Catastrophic Failure Modes Assessment of the *International Space Station Alpha*. NAS8–37383. Meyer Analytics. Inc.
19960017822N (96N–23346)

CR–4740 May 1996
Contamination Control Engineering Design Guidelines for the Aerospace Community. NAS5–32876. Rockwell International Corporation. 19960044619N (96N–32082)

CR–4744 May 1996
New Instrumentation Technologies for Testing the Bonding of Sensors to Solid Materials. NAS8–40165. Analysis and Measurement Services Corporation.
19960027988N (96N–29107)

CR–199197 July 7, 1995
Radar Investigations of Barium Releases Over Arecibo Observatory, Puerto Rico, Final Report, (August 21, 1991 to June 30, 1994). NAS8–39075. Geospace Research, Inc.
19960002142N (96N–12150)

CR–199198 October 1995
Zero Side Force Volute Development, Final Report. NAS8–39286. SECA, Inc.
19960009112N (96N–16278)

CR–199201 September 1995
Special Environmental Control and Life Support Equipment Test Analyses and Hardware, Final Report. NAS8–38250. ION Electronics.
19960004068N (96N–14078)

CR–199817 September 1995
Methods of Video and Shearography Inspection, Final Report (September 22, 1994 to September 21, 1995). NAS8–38609, D.O. No. 119. University of Alabama in Huntsville.
19960009111N (96N–16277)

CR–199818 September 25, 1995
Characterization of Coating for Replication, Final Report, March 27, 1995 to September 25, 1995. NAS8–38609, D.O. No. 139, University of Alabama in Huntsville.
19960010955N (96N–70388)

CR–199819 September 18, 1995
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APPROVAL

FY 1996 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

Compiled by Joyce E. Turner Waits

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Director
Human Resources and Administrative Support Office

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operation and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1996	Technical Memorandum

4. TITLE AND SUBTITLE
FY 1996 Scientific and Technical Reports, Articles, Papers, and Presentations

5. FUNDING NUMBERS

6. AUTHORS
Joyce E. Turner-Waits, Compiler

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA TM–108528
Volume I

11. SUPPLEMENTARY NOTES
Prepared by Management Operations Office, Human Resources and Administrative Support Office

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified–Unlimited
Availability: NASA CASI (301) 621-0390

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY96. 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.

14. SUBJECT TERMS

15. NUMBER OF PAGES
68

16. PRICE CODE
NTIS

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited