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GEORGE C. MARSHALL SPACE FLIGHT CENTER

FY 1973 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

Management Services Office

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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ABSTRACT

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY 73. It also includes papers of MSFC contractors.

After being announced in STAR or C STAR, all of the NASA series reports listed may be obtained from the Scientific and Technical Information Facility, P.O. Box 33, College Park, Maryland 20740.

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

FY 1973 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

Scientific and Technical Information Division
Management Services Office

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."

The N numbers shown for the reports listed are assigned by the NASA Scientific and Technical Information Facility, College Park, Maryland, indicating that the material is unclassified and unlimited and is available for public use. The N number should be cited when requesting a document.

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

FY 1973 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

TABLE OF CONTENTS

(Note: The following four reports were published but not listed in the FY 1972 edition of this publication.)

TM X-64649 June 9, 1972
Precise Linear Sun Sensor. Danny D. Johnston. Astrionics Laboratory.
N72-29468

An evaluation of the precise linear sun sensor relating to future mission applications was performed. The test procedures, data, and results of the dual-axis, solid-state system are included. Brief descriptions of the sensing head and of the system's operational characteristics are presented. A unique feature of the system is that multiple sensor heads with various fields of view may be used with the same electronics.

TM X-64664 May 24, 1972
Design of a Mach 8.0 Axisymmetric Nozzle for a Hypersonic Test Facility. Joseph L. Sims and Robert F. Elkin. Aero-Astrodynamics Laboratory.
N72-27273

An axisymmetric nozzle has been designed to produce test section flow at a Mach number of 8.0 for use in a hypersonic test facility at MSFC. Nominal design conditions used to calculate the viscous correction to the wall contour were selected from the results of a parametric boundary layer investigation so that the widest possible range of satisfactory operating conditions could be obtained. Coordinates for the nozzle are presented in a tabular form suitable for design and manufacturing. The basic analysis techniques have been used to generate results to compare with experimental data from a facility at Langley Research Center. The agreement was reasonably good.

TM X-64666 May 30, 1972
Research Achievements Review. Vol. IV, No. 5. Quality and Reliability Assurance Research at MSFC. J. B. Beal, M. C. McIlwain, T. F. Morris, M. J. Berkebile, and F. Villella. Science and Engineering.
N72-27516

TM X-64669 December 1, 1971
Vibration Manual. Claude Green, ed. Astronautics Laboratory. N72-28901

This document provides guidelines of the methods and applications used in vibration technology at MSFC. Its purpose is to provide a practical tool for coordination and understanding between industry and government groups concerned with vibration of systems and equipments. Topics covered include measuring, reducing, analyzing, and methods for obtaining simulated environments and formulating vibration specifications. Other sections cover methods for vibration and shock testing, theoretical aspects of data processing, vibration response analysis, and techniques of designing for vibration.

TM X-2635 November 1972
Chemical Processing Manual. F. J. Beyerle. Process Engineering Laboratory.
N73-14117

This manual presents all documents directly related to chemical processes that were prepared by the Product Engineering and Process Technology Laboratory and are pertinent to the continuing technology of spacecraft development. Chemical processes presented in this document include cleaning, pickling, surface finishes, chemical milling,

plating, dry film lubricants, and polishing. All types of chemical processes applicable to aluminum, for example, are to be found in the Aluminum Alloy Section. There is a separate section for each category of metallic alloy plus a section for non-metals, such as plastics. The refractories, super-alloys and titanium, are prime candidates for the Space Shuttle; therefore, the chemical processes applicable to these alloys are contained in individual sections of this manual.

TM X-64671 June 8, 1972
Probability of Satellite Collision. James W. McCarter. Aero-Astrodynamics Laboratory. N72-29833

A method is presented for computing the probability of a collision between a particular artificial earth satellite and any one of the total population of earth satellites. The collision hazard incurred by the proposed modular Space Station is assessed using the technique presented. The results of a parametric study to determine what type of satellite orbits produces the greatest contribution to the total collision probability are presented. Collision probability for the Space Station is given as a function of Space Station altitude and inclination. Collision probability was also parameterized over miss distance and mission duration.

TM X-64672 March 1972
Flat Conductor Cable Applications. W. Angele. Process Engineering Laboratory. N72-32222

This report contains brief descriptions, supplemented with artwork, of some of the numerous applications of flat conductor cable (FCC) systems. Both Government and commercial uses have been considered, with described applications designated as either aerospace, military, or commercial. The document is designed to illustrate the number and variety of ways in which FCC is being applied and considered for future designs.

TM X-64673 April 13, 1972
Pulse Performance Analysis for Small Hypergolic Propellant Rocket Engines. Gerald W. Smith and Richard H. Sforzini. Astronautics Laboratory. N72-24823

Small rocket engine tests were conducted for the purpose of obtaining pulse performance data to aid in preliminary design and evaluation of attitude control systems. Both monopropellant and hypergolic bipropellant engines of thrust levels from 1 to 100 lbs were tested. The performance data for the hypergolic propellant rockets are compared with theoretical performance calculated from idealized chamber filling and evacuation characteristics. Electromechanical delays in valve response and heat transfer characteristics were found to cause substantial deviation between theoretical and test performance. The theoretical analysis is modified to obtain a semi-empirical model for hypergolic propellant rockets which is demonstrated to be reasonably accurate for two different engine configurations over a considerable range of duty cycles.

TM X-64674 August 1972
A Catalogue of Normalized Intensity Functions and Polarization From a Cloud of Particles with a Size Distribution of α^{-4}. P. D. Craven and G. A. Gary. Space Sciences Laboratory. N72-28717

The Mie theory of light scattering by spheres is used to calculate the scattered intensity functions resulting from single scattering in a polydispersed collection of spheres. The distribution used behaves according to the inverse fourth power law; graphs and tables for the angular dependence of the intensity and polarization of this law are given. The effects of the particle size range and the integration increment are investigated.

TM X-64675 June 27, 1972
Space Shuttle Earth Orbital Rendezvous Targeting Techniques for Near Circular Target Satellite Orbits. A. W. Deaton. Aero-Astrodynamics Laboratory.
N72-28835

This report develops the targeting techniques required to achieve space shuttle rendezvous with a target satellite in a near circular orbit.

TM X-64676 May 26, 1972
Feasibility Study – Replacement of the Inoperative Decommutating Buffer Subsystem for the Instrumentation Checkout Complex in the Quality and Reliability Assurance Laboratory. James W. Hilliard. Computation Laboratory.
N72-28458

The intent of this document is to describe a general purpose computer system that is necessary for replacement of the present inoperative signal decommutator special purpose computer subsystem of the Instrumentation Checkout Complex in the Quality and Reliability Assurance Laboratory. The present decommutator subsystem has a very poor history of reliability and since April 1970, it has become inoperative because the core memory cannot be repaired. Functions of the present signal decommutator subsystem are to receive, demultiplex, record in real-time, playback in real-time, and output to the SDS-930 control computer for analysis of the telemetry data. Recommendations for replacement of the inoperative telemetry decommutator subsystem are for the purchase of a mini-computer that is described in this document. A review of the General Service Administration Automatic Data Processing Equipment (ADPE) Availability List disclosed no general purpose or special purpose equipment that could meet telemetry decommutator requirements.

TM X-64677 May 1972
Comets and Asteroids – A Strategy for Exploration. Comet and Asteroid Mission Study Panel. N72-33831

Many of the asteroids probably formed near the orbits where they are found today. They accreted from gases and particles that represented the primordial solar system cloud at that location. Comets, in contrast to asteroids, probably formed far out in the solar system, and at very low temperatures; since they have retained their volatile components they are probably the most primordial matter that presently can be found anywhere in the solar system. Exploration and detailed study of comets and asteroids, therefore, should be a significant part of NASA's efforts to understand the solar system. A comet and asteroid program should consist of six major types of projects: ground-based observations; Earth-orbital observations; flybys; rendezvous; landings; and sample returns. A preliminary listing of the primary objectives of each project

type is found in Table I. The Comet and Asteroid Mission Study Panel recommends that planning and implementation of these six types of projects be initiated as soon as practical. Missions of the flyby type could be accomplished with existing conventional propulsion systems. Missions of the other types, however, must be carried out with electric propulsion systems, such as solar-electric propulsion. Some of the scientific instruments for the recommended observations could be adopted from previous planetary and interplanetary projects; some would represent new developments.

TM X-64678 May 15, 1972
A Preliminary Investigation of the Environmental Control and Life Support Subsystems (EC/LSS) for Animal and Plant Experiment Payloads. Hubert B. Wells. Preliminary Design Office, Program Development. N72-29050

This report presents a preliminary study of the environmental control and life support subsystems (EC/LSS) necessary for an earth orbital spacecraft to conduct biological experiments. The primary spacecraft models available for conducting these biological experiments are the Space Shuttle and Modular Space Station. The experiments would be housed in a separate module that would be contained in either the Shuttle payload bay or attached to the Modular Space Station. This module would be manned only for experiment-related tasks, and would contain a separate EC/LSS for the crew and animals. Metabolic data have been tabulated on various animals that are considered useful for a typical experiment program. The minimum payload for the 30-day Space Shuttle module was found to require about the equivalent of a one-man EC/LSS; however, the selected two-man Shuttle assemblies will give a growth and contingency factor of about 50 percent. The maximum payloads for the Space Station mission will require at least a seven-man EC/LSS for the laboratory colony and a nine-man EC/LSS for the centrifuge colony. There is practically no room for growth or contingencies in these areas.

TM X-64679 March 29, 1972
Variational Differential Equations for Engineering Type Trajectories Close to a Planet With an Atmosphere. E. D. Dickmanns. Aero-Astrodynamics Laboratory. N72-27891

A model for trajectory computations for engineering-type application is described. The differential equations for the adjoint variables are derived and coded in FORTRAN. The program is written in a form to either take into account or neglect thrust, aerodynamic forces, planet rotation and oblateness, and altitude dependent winds.

TM X-64680 March 6, 1972
HEAO Star Tracker Search Program. William J. Weiler. Preliminary Design Office, Program Development. N72-28665

The High Energy Astronomy Observatory (HEAO) requires a highly accurate and flexible control system to accommodate its scientific payload. One of the critical elements of this system is the star tracker subsystem, which defines an accurate three-axis attitude reference. A digital computer program has been developed to evaluate the ability of a particular star tracker configuration to meet the

requirements for attitude reference at various vehicle orientations. Used in conjunction with an adequate star catalog, this program provides information availability of stars for each tracker and on the ability of the system to maintain three-axis attitude reference throughout a representative sequence of vehicle orientations. This program was developed to provide information necessary for the selection of baseline and possible alternate star tracker configurations for the HEAO-C mission. It could be adapted, however, to other missions which utilize star tracker systems.

TM X-64681 July 5, 1972
Apollo 15 Contamination Photography. R. J. Naumann. Space Sciences Laboratory. N72-29839

The problem of optical contamination in the form of particulates in the vicinity of a spacecraft has been a source of concern for any astronomical experiment that must be performed in sunlight. This concern prompted a photographic photometric experiment on Apollo 15 to measure the brightness of the residual contamination cloud as well as the cloud produced by dumping waste water overboard. An upper limit of $10^{-12.3}$ $B_{\odot}$ ($B_{\odot}$ designates the brightness of the solar disc) was placed on the residual cloud at a 90-deg sun angle, which is comparable to the zodiacal light. The brightness of the cloud produced by the waste dump was estimated to be $10^{-9.2}$ $B_{\odot}$. It was observed to decrease rapidly to $10^{-11.6}$ $B_{\odot}$ in minutes, then fluctuate in brightness for at least 25 minutes as additional material left the spacecraft. The cloud was observed to consist of individually resolved particle tracks estimated to be particles ranging from millimeters to centimeters in diameter in addition to a background of unresolved particles with an average diameter of 10.5 microns. Most of the tracks proceeded in straight-line paths from the dump nozzle. Several tracks violated this direction, apparently having been scattered by collisions. A few tracks appeared to have definite curvatures, which are believed to be caused by charged particle interactions.

TM X-64682 August 2, 1972
A Mechanical Property and Stress Corrosion Evaluation of Custom 455 Stainless Steel Alloy. J. W. Montano. Astronautics Laboratory. N73-11509

This report is a continuation of the work reported in NASA TM X-53665, dated October 20, 1967. Presented in this report are the mechanical and stress corrosion properties of vacuum melted Custom 455 stainless steel alloy bar [1.0-inch (2.54 cm) diameter] and sheet [0.083-inch (0.211 cm) thick] material aged at 950°F (510°C), 1000°F (538°C), and 1050°F (566°C). Low temperature mechanical properties were determined at temperatures of 80°F (26.7°C), 0°F (-17.8°C), -100°F (-73°C), and -200°F (-129°C). For all three aging treatments, the ultimate tensile and 0.2 percent offset yield strengths increased with decreasing test temperatures while the elongation held fairly constant down to -100°F (-73°C) and decreased at -200°F (-129°C). Reduction in area decreased moderately with decreasing temperature for the longitudinal round [0.250-inch (0.635 cm) diameter] specimens. Notched tensile strength and charpy V-notched impact strength decreased with decreasing test temperature. For all three aging treatments, no

failures were observed in the unstressed specimens or the specimens stressed to 50, 75, and 100 percent of their yield strengths for 180 days of alternate immersion testing in a 3.5 percent NaCl solution. As indicated by the results of tensile tests performed after alternate immersion testing, the mechanical properties of Custom 455 alloy were not affected by stress or exposure under the conditions of this evaluation.

TM X-64683 July 1972
Optical Depths in the Interstellar and Intergalactic Media. Klaus Schocken. Space Sciences Laboratory. N72-29836

Optical depths of the interstellar and intergalactic media for supernova remnants, stars, and galaxies are presented in tabular form.

TM X-64684 August 18, 1972
Fundamental Concepts of Structural Loading and Load Relief Techniques for the Space Shuttle. R. S. Ryan, D. K. Mowery, and S. W. Winder. Aero-Astrodynamics Laboratory. N72-31881

The prediction of flight loads and their potential reduction, using various control system logics for the Space Shuttle vehicles, is very complex. Some factors not found on previous launch vehicles that increase the complexity are large lifting surfaces, unsymmetrical structure, unsymmetrical aerodynamics, trajectory control system coupling, and large aeroelastic effects. This paper discusses these load-producing factors and load-reducing techniques. Identification of potential technology areas is included.

TM X-64685 September 1, 1972
Manufacture and Quality Control of Interconnecting Wire Harnesses. MSFC AD HOC Committee. Quality and Reliability Assurance Laboratory.

Vol. I N72-33206
Vol. II N72-33207
Vol. III N72-33208
Vol. IV N72-33209

This document has been prepared for use as a standard for manufacture, installation, and quality control of eight types of interconnecting wire harnesses. It is made up of four volumes under one reference number to simplify control and referral on contracts. Each volume can be independently employed should only harnesses within one volume be of interest. The processes, process controls, and inspection and test requirements reflected are based on (a) acknowledgment of harness design requirements defined in MSFC document 40M39582, "Harness, Electrical Design Standard," (b) acknowledgment of harness installation requirements defined in MSFC-SPEC-494, "General Specification for Installation of Harness Assembly (Electrical Wiring), Space Vehicle," (c) identification of the various parts, materials, etc, utilized in harness manufacture, and (d) formulation of a typical manufacturing flow diagram for identification of each manufacturing and quality control process, operation, inspection, and test. The document covers interconnecting wire harnesses defined in the design standard. Volume I covers type I, enclosed in fluorocarbon elastomer convolute tubing; type II, enclosed in TFE convolute tubing lined with fiberglass braid; type III, enclosed in TFE convolute tubing; type V, combination of

types III and IV: Volume II covers type IV, open bundle (not enclosed): Volume III covers type VI, enclosed in TFE heat shrink tubing; type VII, flexible armored: and Volume IV covers type VIII, flat conductor cable. Volume breadth covers installations of groups of harnesses in a major assembly and the associated post installation inspections and electrical tests. All volumes are TM X-64685. Knowledge gained through experience on the Saturn V Program coupled with recent advances in techniques, materials, and processes have been incorporated into this document.

TM X-64686 October 1972
Reliability of Hybrid of Microcircuit Discrete Components. Robert V. Allen and Salvadore V. Caruso. Astrionics Laboratory. N73-16208

Hybrid microcircuit technology has rapidly become a standard technique in development and fabrication of electronic hardware. The most obvious reasons for the rapid acceptance of hybrids are small size, reduced weight and higher reliability. The reliability of a hybrid microcircuit is determined by factors such as wire bonding, interconnection techniques, thick- and thin-film processing, discrete component mounting, and hermetic sealing. Most of these factors can be controlled during fabrication cycles with proper process controls. However, since the hybrid manufacturer has little or no control on the design and fabrication of discrete components, these devices have the most paramount effect on microcircuit reliability. Therefore, each hybrid manufacturer must establish criteria for selection, qualification, and screening of discrete devices. This report details the data accumulated during 4 years of research and evaluation of ceramic chip capacitors, ceramic carrier mounted active devices, beam-lead transistors, and chip resistors. Life and temperature coefficient test data, and optical and scanning electron microscope photographs of device failures are presented and the failure modes are described. Particular interest is given to discrete component qualification, power burn-in, and procedures for testing and screening discrete components. Burn-in requirements and test data will be given in support of 100 percent burn-in policy on all NASA flight programs.

TM X-64687 June 15, 1972
Monolithic Microcircuit Techniques. Bobby W. Kennedy. Astrionics Laboratory. N72-30232

Contained in this report are brief discussions of the techniques used at MSFC and in industry to make dielectric and metal thin-film depositions for monolithic circuits. Silicon nitride deposition and the properties of silicon nitride films are discussed. Deposition of dichlorosilane and thermally grown silicon dioxide are discussed. The deposition and thermal densification of borosilicate, alumino-silicate, and phosphosilicate glasses are discussed. Metallization for monolithic circuits and the characteristics of thin films are also included.

TM X-64688 August 1972
Mask and Pattern Characteristics. Donald E. Routh. Astrionics Laboratory. N72-31288

This document provides the individuals planning to use the mask and pattern facility

with detailed information on equipment accuracy, limitations, and pattern-making capabilities. It also provides insight into potential areas of pattern applications, the sequence of mask making, as well as the possible inputs and outputs available to the user.

TM X-64689 September 1972
Actuator Participation in a Bending Mode Identification System. Zack Thompson and Perry Davis. Astrionics Laboratory. N72-33380

A hydraulic actuator designed for a thrust vector control system used as a shaker for a vehicle to determine the bending mode frequencies is described. The actuator is used as the prime mover and the frequency sensor for the flexible vehicle in a test tower. Advantages in using the actuator piston position with respect to a commanded position to obtain the bending mode frequencies are shown.

TM X-64690 August 1972
Chemical Propulsion Research at MSFC. Research Achievements Review. Vol. IV, No. 6. Science and Engineering. N73-12840

TM X-64691 June 30, 1972
Fabrication and Testing of Scatter Plates for Interferometry. Joseph J. Pour, Sr., and John R. Pitts. Astrionics Laboratory. N72-32473

Scatter plate interferometry has become a reliable method of measuring surface configurations of telescope mirrors and other optical components. The scatter plate used in an instrument should be of optimum quality if the surface it is being used to measure is to be of high accuracy. Tests were performed and results show that, although many scatter plates would function, few were of the optimum quality necessary. These few were of the 180 grit group, using 35- and 30-s exposures, which are figures derived from calculations.

TM X-64692 January 31, 1972
Experiment Pointing Control During Space Shuttle Sortie Missions. P. D. Nicaise. Preliminary Design Office, Program Development. N73-12892

The pointing and stability problems of the Sortie mission are examined from the standpoint of basic Shuttle capability and the techniques that could be used for improving this capability to accommodate a maximum number of experiments. Augmentation of the basic Shuttle control system is proposed to provide an acceptable pointing environment. A stabilized reference base is recommended as a general pointing instrument for certain earth observation and astronomy experiments. Simulation results are presented which were obtained by modeling the Skylab Experiment Pointing Control (EPC) system on a thruster controlled Shuttle.

TM X-64693 August 2, 1972
Two Different Approaches for a Control Law of Single Gimbal Control Moment Gyros. Werner O. Schiehlen. Astrionics Laboratory. N72-31660

In the field of momentum exchange attitude control systems, single gimbal control moment gyros (SGCMG's) are of increasing

interest. This report presents a gimbal angle approach and a gimbal rate approach for the SGCMG control law including the singularity avoidance. Both approaches are compared and some illustrative examples are given.

TM X-64694 September 25, 1972
Closed-Form Solutions for Atmospheric Flight with Applications to Shuttle Guidance. Hugo L. Ingram. Aero-Astrodynamics Laboratory. N73-11677

Closed-form solutions for the motion of a rocket-powered vehicle during atmospheric ascent and closed-form solutions for unpowered atmospheric reentry are developed. These closed-form solutions are then used to develop a simplified guidance scheme and to develop a variation-of-parameters integration of more accurate equations of motion with the closed-form solutions as base solutions. The variation-of-parameters integration of the more accurate equations of motion also allows the transition partial derivative matrices associated with these equations to be easily developed. Then the partial derivative transition matrices are used to develop a guidance scheme based on the more accurate equations of motion instead of the less accurate closed-form solutions.

TM X-64695 August 1972
Flat Conductor Cable Connectors with Individually Sealed Contacts. W. Angele. Process Engineering Laboratory. N72-32231

The report contains information on the latest NASA/MSFC flat conductor cable connectors, a series with individually sealed contacts. Data and artwork are concerned with connector historical development, design requirements, design description, and test and cost data.

TM X-64696 August 15, 1972
User's Manual for MSFC Mask and Display Program. Donald Routh and Dae-Shik Woo. Astrionics Laboratory. N72-33193

This report is intended to serve as the User's Manual for the MSFC Mask and Display Program. All program options and a detailed definition of the format of each input card (with examples) are given. Output options and their applications are detailed. A listing of the main program is provided and all update points are explained. All information required for a designer/draftsman (for program use) is provided, and it will not be necessary to become intimately familiar with the internal operations to effectively use the extensive capability it has to offer.

TM X-64697 September 1, 1972
DDP-116 General Digital Filtering. Jack A. Jones and Ronald J. Graham. Computation Laboratory. N72-33189

This report describes the methods for calibrating, selecting filter weights, filtering, and computing filter response functions. These methods are computed on a Statistical Analyzer (STAN) system with a Honeywell DDP-116 Central Processor. The following filter types are computed:

1. All Pass
2. Low Pass
3. High Pass

4. Band Pass
5. Band Rejection
6. Derivative.

TM X-64698 July 1972
The Pseudonoise Test Set: Communication System's Performance Evaluation Based Upon rms Error Testing. G. R. Wallace, S. S. Gussow, W. E. Salter, and G. D. Weathers. Astrionics Laboratory. N73-12146

A pseudonoise (PN) test set has been built to provide a relatively easy means of accurately determining the end-to-end rms error introduced by a communication system when subjected to wideband data. It utilizes a filtered pseudorandom sequence generator as a wideband data source, providing a convenient means for digitally delaying the input reference signal for comparison with the distorted test communication system output. In addition to providing a means to measure the end-to-end rms error and the average delay of a communication system, the PN test set also provides a means to determine the tested system's impulse response and correlation function. The theory of PN testing is discussed in detail along with the most difficult aspects of implementation, the building of matched filter pairs. Both analytical and empirical results are reported which support the contentions that this is an accurate and practical way to acquire figures of merit for complete communication systems.

TM X-64699 October 4, 1972
Development of a Container for Handling, Testing, and Storing Discrete Microelectronic Components. George L. Filip and Salvadore V. Caruso. Astrionics Laboratory. N72-33485

A container has been developed for handling, testing, burning-in, and storing discrete microelectronic components without removal from the protective package. The package was designed to accommodate the Leadless Inverted Device (LID) and other carrier-mounted active devices and chip-type discrete resistors and capacitors. Before the indicated development, components were handled and tested in various ways, some of which resulted in damage or contamination. The basic design of the container utilizes precision-machined printed circuit boards and chemically milled (photoetched) contact springs. Included in this design for protection is an O-ring-sealed cover. Methods of fabrication and limitations of the current hardware are presented. Current applications of and possible extensions to the technology are discussed.

TM X-64700 March 14, 1972
Experimental Evaluation of the Skylab Orbital Workshop Ventilation System Concept. Steve L. Allums, Leon J. Hastings, and James T. Ralston. Astronautics Laboratory. N73-16875

Extensive testing was conducted to evaluate the Orbital Workship ventilation concept. Component tests were utilized to determine the relationship between operating characteristics at 1 and 0.34 atm. System tests were conducted at 1 atm within the Orbital Workshop full-scale mockup to assess delivered volumetric flow rate and compartment air velocities. Component tests with the Anemostat circular diffusers (plenum- and duct-mounted) demonstrated that the diffuser produced essentially equivalent airflow patterns and velocities in 1- and 0.34-atm environments. The tests also showed that the pressure drop across the diffuser could be

scaled from 1 to 0.34 atm using the atmosphere pressure ratio. Fan tests indicated that the performance of a multiple, parallel-mounted fan cluster could be predicted by summing the single-fan flow rates at a given ΔP. The fan volumetric flow rate and the Orbital Workshop system flow rate at 28 V, 1 atm are equivalent to the flow rates at 26 V, 0.34 atm. The shutdown of one fan in a four-fan cluster resulted in a flow decrease of approximately 40 percent because of the backflow through the inoperative fan. For normal operation at 28 V, the average air velocity in the crew quarters was 6.1 to 15.2 m/min (20 to 50 ft/min) depending upon diffuser flow-pattern. The average air velocity in the forward plenum could be varied from 4.6 to 9.1 m/min (15 to 30 ft/min) with the crew quarters diffusers or from 9.1 to 12.2 m/min (30 to 40 ft/min) with the use of three portable fans. The portable fans could supply $\geqslant$30.5 m/min (100 ft/min) to localized areas.

TM X-64701 October 19, 1972
The Effect of Hot Salt on the Mechanical Properties of Several Superalloys. E. E. Nelson. Astronautics Laboratory. N73-11510

The effect of sodium chloride on unstressed, transverse, tensile, metal specimens at elevated temperatures has been determined. Results indicate, under the conditions of this test, that the mechanical properties of Inconel 718, René 41, Titanium base alloy 13V-11Cr-3Al, Hastelloy X, HS25 (L605), HS188, and TDNiCr suffer degradation in tensile strength and ductility due to hot-salt exposure.

TM X-64702 October 15, 1972
Ultrasonic Scanning System for Inspection of Brazed Tube Joints. J. L. Haynes and N. A. Maurer. Quality and Reliability Assurance Laboratory. N73-11445

Described herein is the Ultrasonic Scanning System used to inspect and evaluate in-place brazed tube joints. Because of the expanding use of brazed fittings in the aerospace field the Ultrasonic Scanning System was designed, developed, and built especially for nondestructive testing. It was selected because of its known response to brazing defects not associated with material density changes. The developed scan system is capable of scanning brazed joints in union, tee, elbow, and cross configuration of 3/16-inch through 5/8-inch diameters. The system is capable of detecting brazed defects as small as 0.008 by 0.010 inch which exceeds the 0.015-inch diameter defect resolution required by specification. The ultrasonic brazed tube scanner is recommended for the evaluation of all brazed tube joints that are within its dimensional capabilities and for which an inspection is desired. This recommendation is based upon the in-place scanning and the rapid inspection time capabilities of the system and the innate ability of ultrasonic test methods to detect defects which are not related to material density changes.

TM X-64703 November 6, 1972
Maskmaking Facilities at the Marshall Space Flight Center. Donald E. Routh. Astrionics Laboratory. N73-10284

This report describes the research and development maskmaking facilities at the Astrionics Laboratory of the Marshall Space Flight Center. Information is provided on the level of cleanliness and the environmental control within the various work areas. The available equipment and its function in the maskmaking process are detailed. Sufficient information is provided so that a competent clean-room builder could duplicate the facility capabilities.

TM X-64704 October 13, 1972
Systems Simulation for an Airport Trailing Vortex Warning System. Harold B. Jeffreys. Aero-Astrodynamics Laboratory. N73-12267

This report documents the approach, development, and limited system studies associated with a system simulation for an Airport Trailing Vortex Warning System (ATVWS). It attempts to show the usefulness of a systems engineering approach to the problem of developing a system, as dictated by aircraft vortices, which will increase air-traffic flow in the takeoff/landing corridors of busy airports while maintaining the required safety factor for each operation. It is felt that the development and integration of a total system simulation computer program are essential to provide the system designers a way to develop proper and realistic ATVWS requirements to meet the objectives of decreasing aircraft spacings on takeoff and landing while maintaining an adequate safety margin. This report documents the capabilities (assumptions and limitations) provided by the Total System Simulation Model. The simulation provides the capability of investigating potential problem areas at a fraction of the cost that would be involved in hardware tests only. The simulation program has been developed in a modular form which permits new, more sophisticated component models, when they become available and are required, to be incorporated into the program with a minimum of program modifications. This report documents a limited system study that has been performed using this Total System Simulation Model. The resulting preliminary system requirements, conclusions, and recommendations are given in Section V.

TM X-64705 April 1972
A Cosmic X-Ray Astronomy Bibliography: The Astrophysical Journal, 1962 to 1972. Robert M. Wilson. Space Sciences Laboratory. N73-11869

This report presents the results of a survey of the Astrophysical Journal for the time period January 1962 through March 1972 (volumes 135-172). Some 395 references are contained within this document related to cosmic X-ray astronomy.

TM X-64706 September 30, 1972
Assessment of and Standardization for Quantitative Nondestructive Testing. Robert W. Neuschaefer and James B. Beal. Quality and Reliability Assurance Laboratory. N73-14483

This document assesses present capabilities and limitations of Nondestructive Testing (NDT) as applied to aerospace structures during design, development, production, and operational phases. It will help determine what useful structural quantitative and qualitative data may be provided

from raw materials to vehicle refurbishment. This assessment considers metal alloy systems and bonded composites presently applied in active NASA programs or strong contenders for future use. Quantitative and qualitative data has been summarized from recent literature, and in-house information, and presented herein along with a description of those structures or standards where the information was obtained. Examples, in tabular form, of NDT technique capabilities and limitations have been provided. NDT techniques discussed and assessed were radiography, ultrasonics, penetrants, thermal, acoustic, and electromagnetic. Quantitative data is sparse; therefore, obtaining statistically reliable flaw detection data must be strongly emphasized. The new requirements for reusable space vehicles have resulted in highly efficient design concepts operating in severe environments. This increases the need for quantitative NDT evaluation of selected structural components, the end item structure, and during refurbishment operations.

TM X-64707 October 27, 1972
Fast Digital Noise Filter Capable of Locating Spectral Peaks and Shoulders. T. R. Edwards and R. D. Knight. Space Sciences Laboratory. N73-12212

Experimental data frequently have a poor signal-to-noise ratio which one would like to enhance before analysis. With the data in digital form, this may be accomplished by means of a digital filter. A fast digital filter based upon the principle of least squares and using the techniques of convoluting integers is described. In addition to smoothing, this filter also is capable of accurately and simultaneously locating spectral peaks and shoulders. This technique has been adapted into a computer subroutine, and results of several test cases are shown, including mass spectral data and data from a proportional counter for the High Energy Astronomy Observatory.

TM X-64708 September 1972
An Automatic Data Acquisition System for the 150-Meter Ground Winds Tower Facility, Kennedy Space Center. Wilson B. Traver, Jr., Thomas E. Owen, and Dennis W. Camp. Aero-Astrodynamics Laboratory.

This report summarizes the design concepts and operational functions of an automatic meteorological data acquisition system for use with the NASA 150-meter ground winds tower at Kennedy Space Center. The technical approach and system specifications are presented in a generalized manner to give a clear overall view of the automatic system and to suggest methods and guidelines for using similar digital systems in other applications. Samples of the output meteorological data are illustrated together with brief discussions of their applications. References are given for additional details on the 150-meter tower structure as well as the engineering development and computer software programs associated with the automatic system.

TM X-64709 June 26, 1972
Analyses of Solar Viewing Time, Beta Angle, and Doppler Shift for Solar Observations from the Space Shuttle. Judith P. Brandon. Mission and Payload Planning Office, Program Development. N73-14840

Studies of solar physics phenomena are aided by the ability to observe the Sun from Earth orbit without periodic occultation. This report presents charts for the selection of suitable orbits about the Earth at which a spacecraft is continuously illuminated through a period of a few days. Selection of the orbits considers the reduction of Doppler shift and wavefront attenuation due to relative orbital velocity and residual Earth atmosphere.

TM X-64710 June 1972
Photogrammetry and Photo-Interpretation Applied to Analyses of Cloud Cover, Cloud Type, and Cloud Motion. Paul A. Larsen. Aero-Astrodynamics Laboratory. N73-21385

A determination was made of the areal extent of terrain obscured by clouds and cloud shadows on a portion of an Apollo 9 photograph at the instant of exposure. This photogrammetrically determined area was then compared to the cloud coverage reported by surface weather observers at approximately the same time and location, as a check on result quality. Stereograms prepared from Apollo 9 vertical photographs, illustrating various percentages of cloud coverage, are presented to help provide a quantitative appreciation of the degradation of terrain photography by clouds and their attendant shadows. A scheme, developed for the U.S. Navy, utilizing pattern recognition techniques for determining cloud motions from sequences of satellite photographs, is summarized. Clouds, turbulence, haze, and solar altitude, four elements of our natural environment which affect aerial photographic missions, are each discussed in terms of their effects on imagery obtained by aerial photography. Data of a type useful to aerial and orbital photographic mission planners, expressing photographic ground coverage in terms of flying height above terrain and camera focal length, for a standard aerial photograph format, are provided. Two oblique orbital photographs taken during the Apollo 9 flight are shown, and photo interpretations, discussing the cloud types imaged and certain visible geographical features, are provided.

TM X-64711 October 1, 1972
Compatibility of Materials with Liquid Oxygen – Vol. I. C. F. Key. Astronautics Laboratory, X73-10133

The test instrument and procedure developed by Lucas and Riehl (Ref. 1) was used to determine the compatibility of a wide variety of materials with liquid oxygen (LOX). This method is based upon the tendency of materials to react with LOX on impact and is commonly known as the "ABMA Tester." Within the past 15 years' use, over 240,000 individual test drops have been made on approximately 2,000 different materials. Pertinent data from these tests have been compiled, and the findings are presented in this report. Recommendations are made for the guidance of designers and others in the selection of safe materials for use in oxygen systems. Materials are discussed according to the following classifications: (1) lubricants, (2) sealants and threading compounds, (3) thermal and electrical insulation, (4) elastomers, plastics and adhesives, (5) gaskets and packing, (6) metals, alloys and solders, (7) solvents, cleaning solutions, and miscellaneous, and (8) dye penetrants.

TM X-64712 January 4, 1973
Monthly and Annual Percentage Levels of Wind Speed Differences Computed by Using FPS-16 Radar/Jimsphere Wind Profile Data from Cape Kennedy, Florida. Michael Susko and John W. Kaufman. Aero-Astrodynamics Laboratory. N73-14650

This report presents the percentage levels of wind speed differences computed from sequential FPS-16 radar/Jimsphere wind profiles. The results are based on monthly profiles obtained from December 1964 to July 1970 at Cape Kennedy, Florida. The profile sequences contain a series of three to ten Jimspheres released at approximately 1.5-hour intervals. The results given are the persistence analysis of wind speed difference at 1.5-hour intervals to a maximum time interval of 12 hours. Tables 1a through 12e are the monthly percentage levels of wind speed differences and Tables 13a through 13e are the annual percentage of wind speed differences. The percentage levels are based on the scalar wind speed changes calculated over an altitude interval of approximately 50 meters and printed out every 25 meters as a function of initial wind speed within each 5-km layer from near sea level to 20 km. In addition, analyses were made of the wind speed differences for the 0.2- to 1-km layer as an aid for studies associated with take-off and landing of the Space Shuttle. The results may be used as an aid to (1) predict statistical wind speed change limits of lower and upper level winds, (2) provide an understanding of the statistical probabilities of wind speed changes as a function of time, and (3) apply the data in the study of winds aloft for such projects as the Space Shuttle, HEAO, Skylab, and aeronautical vehicles. Information such as this is also important to many aerospace vehicle structural and control system designers in studying the effects of wind speed variations on the prelaunch monitorship and wind biasing schemes. The availability of this type of information is also important in mission planning and operational analyses plus general meteorological forecasting studies.

TM X-64713 January 5, 1973
Natural Environment Design Requirements for the Space Tug. George S. West, Jr. Aero-Astrodynamics Laboratory. N73-14881

Given in this report are the natural environment design requirements for the Space Tug. Since the Space Tug is carried as "cargo" to orbital altitudes in the Space Shuttle bay, orbital environmental impacts and short-period atmospheric density variations are the main concerns of this report.

TM X-64714 January 10, 1973
The Beta Distribution: A Statistical Model for World Cloud Cover. Lee W. Falls. Aero-Astrodynamics Laboratory. N73-14653

Much work has been performed in developing empirical global cloud-cover models. The investigation in this report was made to determine an underlying theoretical statistical distribution to represent worldwide cloud cover. The beta distribution with probability density function,

$$f(x) = \frac{\Gamma(\gamma + \eta)}{\Gamma(\gamma)\Gamma(\eta)} x^{\gamma-1} (1 - x)^{\eta-1}$$

$$0 \leqslant x \leqslant 1 \quad , \quad \gamma > 0 \quad , \quad \eta > 0 \quad ,$$

is given to represent the variability of this random variable. It is shown that the beta distribution possesses the versatile statistical characteristics necessary to assume the wide

variety of shapes exhibited by cloud cover. A total of 160 representative empirical cloud-cover distributions were investigated and the conclusion was reached that this study provides sufficient statistical evidence to accept the beta probability distribution as the underlying model for world cloud cover.

TM X-64715 January 10, 1973
Development and Applications of an Orbital Insertion Surface for the Space Shuttle Orbiter/Tug. A. W. Deaton and P. D. Brandon. Aero-Astrodynamics Laboratory. N73-15862

This report develops the concept of a space shuttle orbiter/tug orbital insertion surface and identifies practical applications in the area of ascent targeting, on-orbit rendezvous targeting, payload/OMS propellant off-loading, and mission analysis.

TM X-64716 December 8, 1972
Flat Conductor Cable Symposium, October 10-12, 1972. James D. Hankins (Coordinator). Process Engineering Laboratory. N73-23294

This report documents the proceedings of a Flat Conductor Cable (FCC) Symposium and Hardware Exhibit which was held at Marshall Space Flight Center during October 10, 11, and 12, 1972. A total of 24 (out of 26) papers and presentation outlines are included covering cables, connectors, termination techniques, electrical characteristics, aerospace applications, and non-aerospace applications. Questions and answers during a panel discussion are included plus a listing of vendors that displayed FCC hardware.

TM X-64717 January 1973
Traffic Model for the Space Shuttle. Shuttle Utilization Planning Office, Program Development. X73-71658

The traffic model for the Space Shuttle is presented along with some supporting and summary data. This document and subsequent editions will provide the Shuttle Program and potential Shuttle users with traffic model information.

TM X-64718 January 18, 1973
High Resolution Power Spectra of Daily Zurich Sunspot Numbers. Harold C. Euler, Jr. Aero-Astrodynamics Laboratory. N73-15840

High resolution power spectra of 77 years of Zurich daily sunspot numbers were computed using various lags and data point intervals. Major harmonic peaks of the approximately 124-month period showed up strongly as well as the 27-day solar rotational period.

TM X-64719 January 1973
Recommendations Relative to the Scientific Missions of a Mars Automated Roving Vehicle (MARV). Robert L. Spencer, ed. Mission and Payload Planning Office, Program Development. N73-16219

This document establishes logical scientific objectives, defines specific science systems requirements, and recommends scientific experiment payloads which will effectively accomplish the established

objectives through the utilization of an automated roving vehicle systematically exploring the surface of Mars. No concepts of the roving vehicle itself have been presented or recommended. It is intended that this document be used in the formulation of any such vehicle design concepts.

TM X-64720 November 1972
Ascent Control Studies of the 049 and ATP Parallel Burn Solid Rocket Motor Shuttle. Robert S. Ryan, David K. Mowery, Morris Hammer, and A. C. Weisler. Aero-Astrodynamics Laboratory. N73-17854

The control authority approach is a major problem of the parallel burn solid Shuttle configuration due to the many resulting system impacts regardless of the approach. This report discusses the major trade studies and their results, which led to the recommendation of an SRB TVC control authority approach.

TM X-64721 January 22, 1973
Transient Permeation of Organic Vapors Through Elastomeric Membranes. James E. Curry. Astronautics Laboratory. N73-16112

The permeation of benzene and acetone vapors through sulfur-cured natural rubber was studied by the time-lag method. The experimental results were analyzed by a method suggested by Meares. D_o, the zero concentration diffusion coefficient, was obtained by the early-time method. The Frisch time-lag equation was utilized to estimate both the solubility coefficient (a) and the additional parameter (b) required to define the concentration-dependence of the diffusion coefficient, $D(c) = D_o \exp(bc)$. This form of concentration dependence was manifested by the corresponding permeability coefficient values. At low entering penetrant pressure where the transport coefficients are constant, indirect evidence was obtained that D_o is the mechanistically correct diffusion coefficient. The solubility coefficient values calculated for benzene vapor in natural rubber are in reasonable agreement with published equilibrium sorption data for a similar rubber compound. At higher entering penetrant pressures, average diffusion coefficients obtained at steady state tended to be larger than the corresponding average diffusion coefficients derived from the time-lags. This has been attributed to slow relaxation effects in the swollen membrane which inject an element of time dependence into the transport process.

TM X-64722 March 1973
The Attenuation of X Rays Emitted by Supernovae. Klaus Schocken. Space Sciences Laboratory. N73-21701

The attenuation of X rays in Arnett's C^{12} detonation supernova model is computed. The attenuation of X rays in the filaments of the Crab Nebula is computed using a model for the filaments by Woltjer and a model by Davidson and Tucker. An empirical expression by Gorenstein, Kellogg, and Gursky for the optical thickness of the interstellar medium for three supernova remnants is analyzed.

TM X-64723 February 1973
Research Achievements Review. Vol. IV, No. 7. Process Engineering Research at MSFC. Science and Engineering. N73-22915

TM X-64724 November 1972
Electrophoresis Demonstration on Apollo 16. R. S. Snyder. Astronautics Laboratory. N73-18157

Free fluid electrophoresis, a process used to separate particulate species according to surface charge, size, or shape was suggested as a promising technique to utilize the near-zero-gravity condition of space. Fluid electrophoresis on earth is disturbed by gravity-induced thermal convection and sedimentation. An apparatus was developed to demonstrate the principle and possible problems of electrophoresis on Apollo 14 and the separation boundary between red and blue dye was photographed in space. The basic operating elements of the Apollo 14 unit were used for a second flight demonstration on Apollo 16. Polystyrene latex particles of two different sizes were used to simulate the electrophoresis of large biological particles. The particle bands in space were extremely stable compared to ground operation because convection in the fluid was negligible. Electrophoresis of the polystyrene latex particle groups according to size was accomplished although electro-osmosis in the flight apparatus prevented the clear separation of two particle bands.

TM X-64725 February 28, 1973
Scientific Involvement in Skylab by the Space Sciences Laboratory of the Marshall Space Flight Center. Carl E. Winkler, ed. Space Sciences Laboratory. N73-20886

This report briefly describes the involvement of the Marshall Space Flight Center's Space Sciences Laboratory in the Skylab program from the early feasibility studies through the analysis and publication of flight scientific and technical results. This includes Mission Operations Support, the Apollo Telescope Mount, Materials Science/Manufacturing in Space, Optical Contamination, Environmental and Thermal Design Criteria, and several corollary measurements and experiments.

TM X-64726 December 15, 1972
Large Space Telescope, Phase A Final Report. Vols. I through V. Program Development.

Vol. I N73-18449
Vol. II N73-18450
Vol. III N73-18451
Vol. IV N73-18452
Vol. V N73-18453

This document is a report of the Phase A study of the Large Space Telescope (LST). The study defines an LST concept based on the broad mission guidelines provided by the Office of Space Science (OSS), the scientific requirements developed by OSS with the scientific community, and an understanding of long range NASA planning current at the time the study was performed. The LST is an unmanned astronomical observatory facility, consisting of an optical telescope assembly (OTA), scientific instrument package (SIP), and a support systems module (SSM). The report consists of five volumes: Volume I is an executive summary, Volume II is a summary of the entire report, and Volumes III, IV, and V contain the analyses and conceptual designs of the OTA, SIP, and SSM, respectively. The report describes the constraints and trade off analyses that were performed to arrive at a reference design for

each system and for the overall LST configuration. The LST will be launched into low earth orbit by the Space Shuttle and operated for 10 to 15 years. The Shuttle will also be used to maintain the LST and to update the scientific instrument complement. Several maintenance modes have been investigated, including on-orbit pressurization of the SSM to provide a shirtsleeve environment for maintenance, and earth return of the LST. The LST will provide the scientific community with several fundamentally unique capabilities which will permit the acquisition of new and important observational data. Its location in space permits observations over the entire spectrum from about 100 nm to the far infrared. A low cost design approach was followed in the Phase A study. This resulted in the use of standard spacecraft hardware, the provision for maintenance at the black box level, growth potential in systems designs, and the sharing of Shuttle maintenance flights with other payloads.

TM X-64727 July 17, 1972

A Comparison of CMG Steering Laws for High Energy Astronomy Observatories (HEAOs). Billy G. Davis. Preliminary Design Office, Program Development. N73-20718

This report contains a comparison of six selected control moment gyro (CMG) steering laws for use on the HEAO spacecraft. Basic equations are developed to project the momentum and torque of four skewed, single gimbal CMGs into vehicle coordinates. In response to the spacecraft attitude error signal, six algorithms (steering laws) are derived for controlling the CMG gimbal movements. HEAO performance data were obtained using each steering law and compared on the basis of such factors as accuracy, complexity, singularities, gyro hang-up and failure adaption. Moreover, each law was simulated with and without a magnetic momentum management system. With magnetics, momentum is continuously dumped against the earth's magnetic field and the gimbal angles stay small, thus permitting linear operation of the steering law. The performance of any steering law was enhanced by the magnetic system and all performed equally well. Without magnetics, the gimbal angles get large and there are significant differences in steering law performances due to cross coupling and nonlinearities. The performance of the pseudo inverse law was consistently better than the other laws and is recommended for HEAO.

TM X-64728 October 1972

Termination of Flat Conductor Cable to NASA/MSFC Plugs. W. Angele. Process Engineering Laboratory. N73-20239

The report contains data, supplemented with artwork, on the major steps involved in terminating flat conductor cable (FCC) to MSFC's FCC plugs. Cable and shield preparation steps include material cutting, insulation stripping, and plating of exposed conductors. Methods and equipment required to terminate FCC to each of four MSFC plugs are described.

TM X-64729 March 7, 1973

A Mechanical Property and Stress Corrosion Evaluation of 431 Stainless Steel Alloy. J. W. Montano. Astronautics Laboratory. N73-21441

This report presents the mechanical properties of type 431 stainless steel in two conditions: annealed bar and hardened and tempered bar. Test specimens, manufactured from approximately 1.0 inch (2.54 cm) diameter bar stock, were tested at temperatures of 80°F (+26.7°C), 0°F (-17.8°C), -100°F (-73°C), and -200°F (-129°C). The test data indicated excellent tensile strength, notched/unnotched tensile ratio, ductility, shear, and impact properties at all testing temperatures. Results of the alternate immersion stress corrosion tests on stressed and unstressed longitudinal tensile specimens 0.1250 inch (0.3175 cm) diameter and transverse "C"-ring specimens, machined from 1.0 inch (2.54 cm) diameter bar stock, indicated that the material is not susceptible to stress corrosion cracking when tested in a 3.5-percent NaCl solution for 180 days.

TM X-64730 January 12, 1973
Evaluation of Flexible Ring Baffles for Damping Liquid Oscillations. Frank Bugg. Aero-Astrodynamics Laboratory. N73-21273

An experimental study was undertaken of damping produced by single flexible-ring baffles in a 396-cm diameter tank of liquid nitrogen. Two 24.8-cm wide baffles were tested. One baffle was 0.00635-cm thick type 301 stainless steel and the other 0.0254-cm thick Teflon FEP. Each baffle produced damping of liquid oscillations equal to or greater than that expected from rigid baffles of the same size. The equations used to determine the baffle thickness required were found to be adequate baffle design equations.

TM X-64731 March 1973
Space Shuttle Traffic Model Developed from 1971 Mission Model. Shuttle Utilization Planning Office, Program Development. N73-26878

Traffic model data for the Space Shuttle using the 1971 NASA, DoD, and commercial mission models are presented along with descriptions and schedules for the NASA and commercial payloads used to develop the data.

TM X-64732 January 15, 1973
Structural Control Interaction. Robert S. Ryan, D. K. Mowery, S. W. Winder, and Halsey E. Worley. Aero-Astrodynamics Laboratory. N73-21834

The basic guidance and control concepts that lead to structural control interaction and structural dynamic loads are identified. Space vehicle ascent flight load sources and the load relieving mechanism are discussed, along with the characteristics and special problems of both present and future space vehicles including launch vehicles, orbiting vehicles, and the Space Shuttle flyback vehicle. The special dynamics and control analyses and test problems apparent at this time are summarized. This report is in essence a presentation that was prepared for "NASA Structures and Materials Advisory Committee" as a means of providing information for research planning.

TM X-64733 March 21, 1973
Synthetic Sea Water – An Improved Stress Corrosion Test Medium for

Aluminum Alloys. T. S. Humphries and E. E. Nelson. Astronautics Laboratory.
N73-22062

A major problem in evaluating the stress corrosion cracking resistance of aluminum alloys by alternate immersion in 3.5-percent salt (NaCl) water is excessive pitting corrosion. Several methods were examined to eliminate this problem and to find an improved accelerated test medium. These included the addition of chromate inhibitors, surface treatment of specimens, and immersion in synthetic sea water. The results indicate that alternate immersion in synthetic sea water is a very promising stress corrosion test medium. Neither chromate inhibitors nor surface treatment (anodize and alodine) of the aluminum specimens improved the performance of alternate immersion in 3.5-percent salt water sufficiently to be classified as an effective stress corrosion test method.

TM X-64734 February 23, 1973
Microbiological Surveillance of Food Handling at NASA-MSFC. F. J. Beyerle. Process Engineering Laboratory.
N73-20127

A microbiological surveillance program of cafeterias and snack bars at MSFC was conducted to supplement the inspections by NASA Medical Center personnel and to gather information for cafeteria management to pinpoint areas of possible contamination. This report summarizes the work conducted under the program from its inception in January, 1972, to its termination on September 15, 1972. Ten food handling facilities were included in the surveillance at NASA-MSFC.

TM X-64735 March 29, 1973
Heat Flow and Convection Demonstration (Apollo 14). Tommy C. Bannister. Space Sciences Laboratory.

Apollo 14 Astronaut Stuart A. Roosa conducted a group of experiments during the lunar flyback on February 7, 1971, to obtain information on heat-flow and convection in gases and liquids in an environment of less than 10^{-6} g. Flow observations and thermal data have shown that (1) as expected, there are convective motions caused by surface tension gradients in a plane liquid layer with a free upper surface; (2) heat flow in enclosed liquids and gases occurs mainly by diffusive heat conductions; and (3) some convective processes, whose characteristics are not fully known, add to the heat transfer. The raw data are presented in this report, and the analysis approach is given.

TM X-64736 February 16, 1973
Microbiological Assay of the MSFC Neutral Buoyancy Simulator. F. J. Beyerle. Process Engineering Laboratory.
N73-21127

Personnel safety for divers and astronauts, from the microbiological and medical viewpoint, is the primary reason for monitoring the Neutral Buoyancy Simulator water. Of secondary importance is the detection of microorganisms which may degrade the mockups in the water and the carpeted area around the simulator. A Neutral Buoyancy Program was initiated in 1965 in the Process Engineering Laboratory, MSFC, to perform microbiological studies of the water in the 1.4-million gallon tank. A broad

spectrum of water sampling procedures was performed, and personal communications with mycology experts were conducted to familiarize laboratory personnel with fungal problems in water. With the addition of control procedures and remedial actions taken, the water was considered sanitary and in a safe condition for the divers and astronauts to perform their underwater neutral-buoyancy work.

TM X-64737 April 1973
Preliminary Flight Trajectories for the Apollo Soyuz Test Project. Joe D. Brooks. Aero-Astrodynamics Laboratory.

This report documents preliminary data for a typical launch window opening, a typical in-plane case, and a typical launch window closing trajectory, not necessarily in the same daily launch window, for the Apollo Soyuz Test Project Mission. The Soyuz will be launched first and the Apollo will be launched on the first opportunity, 7 hours 21 minutes later. If the Apollo is unable to be launched on the first opportunity, four additional opportunities are available at 30 hours 56 minutes, 54 hours 31 minutes, 78 hours 05 minutes, and 101 hours 40 minutes. If the Apollo cannot be launched in this time frame, no further attempt will be made to launch and rendezvous with the first Soyuz. Soyuz will then be deorbited; however, a second Soyuz has been made available for the same purposes.

TM X-64738 April 5, 1973
Structural Load Reduction of the Space Shuttle Booster/Orbiter Configuration Using a Load Relief Guidance Technique. A. W. Deaton and P. B. Kelley. Aero-Astrodynamics Laboratory.
N73-21812

A space shuttle booster/orbiter atmospheric ascent guidance algorithm is developed that will reduce the aerodynamically induced structural loads as compared to an open loop guidance algorithm.

TM X-64739 April 1973
1973 NASA Mission Model. Shuttle Utilization Planning Office, Program Development.

The April 1973 NASA Mission Model and the NASA estimate of the April 1973 Non-NASA/Non-DoD Mission Model for calendar years 1973 through 1991 are presented along with summary Mission Model totals for NASA, Non-NASA/Non-DoD, and DoD for calendar years 1980 through 1991.

TM X-64740 December 1972
Phase A Reaction Control System Design for the Large Space Telescope (LST). William B. Price. Preliminary Design Office, Program Development.
N73-21394

In response to a request from the Office of Space Science, a Phase A study of the Large Space Telescope was undertaken by the George C. Marshall Space Flight Center. The design of a Reaction Control System (RCS) for the LST was a part of this study, the results of which are reported in this document. The primary requirement for an RCS on the LST is to serve as an emergency backup control system to the LST primary attitude control system. A regulated gaseous nitrogen RCS was selected, and a description of the operation of the system and its individual components is presented. An on-orbit maintenance procedure for the system is also described. The alternate RCS concepts considered during the study are

summarized. Principal design goals of the RCS for the LST were to minimize contamination effects, make use of existing components, and modularize the system to provide ease in manned orbital maintenance. The RCS described herein will provide a point of departure for a more in-depth Phase B system design study. A summary of this report is presented in NASA TM X-64726, entitled "Large Space Telescope Phase A Report," and reference is made to that report for a description of all aspects of the LST.

TM X-64741 April 13, 1973
Scintillator Handbook with Emphasis on Cesium Iodide. John L. Tidd, Joseph R. Dabbs, and Norman Levine. Program Development and HEAO Project Office. N73-22398

The objective of this report is to provide a background of reasonable depth and reference material on scintillators in general. Particular attention is paid to the cesium iodide scintillators as used in the High Energy Astronomy Observatory (HEAO) experiments. It is intended especially for use by persons such as laboratory test personnel who need to obtain a working knowledge of these materials and their characteristics in a short time.

TM X-64742 March 16, 1973
The Gaertner L119 Ellipsometer and Its Use in the Measurement of Thin Films. Michael Linkous. Space Sciences Laboratory. N73-21392

An introduction to the study of ellipsometry is presented, with special attention given to the Gaertner model L119 ellipsometer and the techniques of measuring thin films with this instrument. Values obtained from the ellipsometer are analyzed by a computer program for a determination of optical constants and thickness of the film.

TM X-64743 February 23, 1973
Hypervelocity Impact Testing of L-Band Truss Cable Meteoroid Shielding on Skylab. David W. Jex. Space Sciences Laboratory. N73-24867

The purpose of this series of tests was to determine if the L-band truss cable meteoroid shielding as currently designed and supplied for Skylab provides adequate protection when it is at the expected space environment temperature of -118°C (-180°F).

TM X-64744 January 1, 1973
Computer User's Manual for a Generalized Curve Fit and Plotting Program. Ronald A. Schlagheck, B. D. Beadle II, B. D. Dolerhie, Jr., and J. W. Owen. Astronautics Laboratory. N73-24213

A Fortran-coded program has been developed for generating plotted output graphs on 8-½ by 11-inch paper. The program is designed to be used by engineers, scientists, and non-programming personnel on any IBM 1130 system that includes a 1627 plotter. The program has been written to provide a fast and efficient method of displaying plotted data without having to generate any additional Fortran instructions. Various output options are available to the program user for displaying data in four different types of formatted plots. These options include discrete, linear, continuous, and histogram graphical outputs. The manual

contains information about the use and operation of this program. Example cases illustrate the sample input and output for five selected plots. A mathematical description of the least-squares "goodness of fit" test is presented. A program listing is also included.

TM X-64745 May 9, 1973
Offgassing of Non-Metallic Materials in 5 psia Oxygen. F. T. Wells and D. R. Hamilton. Astronautics Laboratory.
N73-23631

Offgas analyses results of non-metallic materials to determine their conformance with MSFC-SPEC-101B, "Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments Which Support Combustion," are reported. This report contains results obtained since early 1969 to the present time. Only results of Test No. 7 of MSFC-SPEC-101B are shown in this report. A brief test and analysis description including procedure development is also presented.

TM X-64746 January 12, 1973
Skylab Attitude Control and Angular Momentum Desaturation with One Double-Gimbaled Control Moment Gyro. Hans F. Kennel. Astrionics Laboratory.
N73-23851

In case two control moment gyros fail, attitude control of Skylab can be maintained with the thruster attitude control system. This results, however, in a severely increased fuel consumption, depleting the fuel in a few days. A reduction in fuel consumption can be achieved by allowing the attitude reference to yield with the gravity-gradient torques at twice orbital frequency. For an ideal case, fuel consumption can be drastically reduced, but any unanticipated disturbance torques and principal moment-of-inertia axes misalignments will again increase the fuel consumption sizeably. Therefore, an alternate concept was developed, which does not have large fuel consumption under any circumstances. In this concept the attitude reference is commanded to oscillate in the orbital plane with twice the orbital frequency and the remaining control moment gyro controls about orbital north and about the minimum moment-of-inertia axis, while the thruster attitude control system controls rate only about the remaining axis. This rate control in conjunction with the restoring torque due to the gravity gradient will keep bounded the excursion of the minimum moment-of-inertia axis out of the orbital plane. This alternate concept has the additional advantage that it needs no information on the principal moment-of-inertia axes misalignment and is completely insensitive to star tracker failure. Proper phasing of the attitude reference oscillation even allows angular momentum desaturation, which is responsible for the insensitivity of the thruster fuel consumption to unknown disturbances, like vent torques, magnetic torques, etc.

TM X-64747 May 10, 1973
X-Ray Reflection Efficiency of Nickel-Coated Quartz Optical Flats. John M. Reynolds, Stanley A. Fields, and Robert M. Wilson. Space Sciences Laboratory.
N73-24694

Results of tests to determine the reflection efficiency of quartz optical flats vacuum coated with 1000-Å nickel are

presented. Of the three vacuum-coated samples tested, two had been contaminated during the firing of the Lunar Module Reaction Control System in the JSC vacuum chamber (Chamber A). Measurements were made for 1.54-, 1.79-, and 2.29-Å incident radiation. The reflection efficiency of the contaminated samples was reduced by as much as 50 percent for some angles of incidence.

TM X-64748 August 1972
A Model for Estimating the Cost Impact of Schedule Perturbations on Aerospace Research and Development Programs. Donald F. Bishop. Engineering Cost Group, Program Development.
N73-24948

The problem of determining the cost impact attributable to perturbations in an aerospace R&D program schedule is becoming increasingly important as the availability of R&D funds diminishes. This memorandum develops the methodology from which a model is presented for updating aerospace R&D cost estimates as a function of perturbations in program time.

TM X-64749 February 16, 1973
A Simple Performance Calculation Method for LH_2/LOX Engines with Different Power Cycles. Robert H. Schmucker. Astronautics Laboratory.
N73-24786

A simple method for the calculation of the specific impulse of an engine with a gas generator cycle is presented. The solution is obtained by a power balance between turbine and pump. Approximate equations for the performance of the combustion products of LH_2/LOX are derived. Performance results are compared with solutions of different engine types.

TM X-64750 April 16, 1973
Flat Conductor Cable Design, Manufacture, and Installation. W. Angele and James D. Hankins. Process Engineering Laboratory.

This report presents pertinent information for hardware selection, design, manufacture, and quality control necessary for flat-conductor cable interconnecting harness application. Detailed information is provided on cable, connectors, and support hardware that has been developed on various programs conducted and funded by the National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Alabama. The relation of this hardware to the new MIL-C-55543 and MIL-C-55544 specifications for flat-conductor cable and flat-conductor cable connectors is defined. Comparisons are made between round-wire cable and flat-conductor cable. The flat conductor cable interconnecting harness systems show major cost, weight, and space savings, plus increased system performance and reliability. The design application section includes electrical characteristics, harness design and development, and a full treatise on EMC considerations. Manufacturing and quality control sections pertain primarily to the NASA/MSFC developed conductor-contact connector system and special flat-conductor cable to round-wire cable transitions. This report presents flat-conductor cable technology as of June 1968, and predicts the role of flat-conductor cables in interconnecting harness applications for future programs.

TM X-64751 July 1973
The 1973 Space Shuttle Traffic Model. Shuttle Utilization Planning Office, Program Development. N73-26845

Traffic model data for the Space Shuttle for calendar years 1980 through 1991 are presented along with some supporting and summary data. This model was developed from the 1973 NASA Payload Model and the NASA estimate of the 1973 Non-NASA/ Non-DoD Payload Model. The estimates for the DoD flights included in this document are based on the 1971 DoD Mission Model.

TM X-64752 July 1973
The 1973 Expendable Launch Vehicle Traffic Model. Shuttle Utilization Planning Office, Program Development.

Traffic model data for current expendable launch vehicles (assuming no Space Shuttle) for calendar years 1980 through 1991 are presented along with some supporting and summary data. This model was based on a payload program equivalent in scientific return to the 1973 NASA Payload Model, the NASA estimated non NASA/non DoD Payload Model, and the 1971 DoD Mission Model.

TM X-64753 June 8, 1973
Phased-Array Laser Radar: Concept and Application. Kenneth A. Kadrmas. Aero-Astrodynamics Laboratory. N73-25561

Basic principles of laser radar, LIDAR, have been documented by numerous authors. In spite of this intensity of effort, present day system concepts have not been sufficiently concentrated on improving the "optical compatibility" of the LIDAR transmitter-receiver combination. A unique new approach has been undertaken in the design and construction of a coaxial transmitter-receiver combination. Major emphasis has been placed on simple permanent optical alignment, transmitter-receiver field of view matching, use of a pulsed gas laser as a transmitter, maximum optical efficiency, complete digital control of data acquisition, and optical mount pointing and tracking. Also, a means of expanding the coaxial transmitter-receiver concept to allow phased-array LIDAR, par-LIDAR, is described.

TM X-64754 May 1, 1973
Vamistor Resistor Investigation. Quality and Reliability Assurance Laboratory.

This report presents the results of the failure investigation conducted by MSFC on resistors produced by the Vamistor Division, Wagner Electric Corporation. This failure investigation included: failure analyses, chemical and metallurgical analyses, failure mechanism studies, seal leak analyses, and nondestructive stress tests. The data, information, conclusions, and recommendation presented herein can be helpful in assessing current usage of these resistors.

TM X-64755 February 1, 1973
Guidelines for Selection and Application of Tantalum Electrolytic Capacitors at MSFC. A. M. Holladay, Leon C. Hamiter, Jr., and Benton A. Vizzier, Sr. Quality and Reliability Assurance Laboratory. N73-26200

This document presents guidelines for selection and application of three types of

tantalum electrolytic capacitors in current use at MSFC in the design of electrical and electronic circuits for manned space flight missions. In addition, the guidelines supplement requirements of existing Military Specifications used in procurement of capacitors. A need exists for these guidelines, to assist designers in preventing some of the recurring, serious problems experienced with tantalum electrolytic capacitors in the recent past. The three types of capacitors covered by these guidelines are: solid (CSR), wet foil (CLR 25, 27, 35, and 37), and wet slug (CLR 65).

TM X-64756 June 26, 1973

Hot and Cold Atmospheres for Vandenberg AFB, California (1973 Version). D. L. Johnson. Aero-Astrodynamics Laboratory.

Extreme atmospheres, pertaining to summer (hot) and winter (cold) conditions for Vandenberg Air Force Base, California, are presented from 0- to 90-km altitudes. Computed values of pressure, e, kinetic temperature, virtual temperature, density, and relative differences [percentages from Vandenberg Reference Atmosphere, 1971 (VRA 71)] of the atmospheric parameters versus altitude are tabulated in increments of 250 m. Hydrostatic and gas law equations were used in conjunction with radiosonde and rocketsonde thermodynamic data in determining the vertical structure of the two atmospheric models. The summer-type density profile deviated from -9.0 percent (of the VRA-71) at the ground to 28.4 percent at 74.5-km altitude. The winter density profile went from 5.2 percent at the surface to -31.4 percent at 72 km.

TN D-6824 August 1972

Experimental Findings From Zero-Tank Net Positive Suction Head Operation of the J-2 Hydrogen Pump. Henry P. Stinson and Raymond J. Strickland. Astronautics Laboratory. N72-29807

The results of a series of liquid hydrogen turbopump tests to demonstrate the feasibility of zero-tank net positive suction head are presented. A J-2 engine hydrogen pump and S-IVB stage fuel feed system were used for this investigation. The pump was operated at flows and speeds equivalent to normal J-2 engine operating conditions and at hydrogen bulk temperatures between 39 and 45°R. These tests show zero-tank net positive suction head to be a realistic operating mode that should be considered for future applications.

TN D-6825 July 1972

Wall Temperature Distribution Calculation for a Rocket Nozzle Contour. Satoaki Omori, Klaus W. Gross, and Alfred Krebsbach. Astronautics Laboratory. N72-30773

The JANNAF Turbulent Boundary Layer (TBL) computer program, applicable to rocket nozzles, requires a wall temperature distribution among other input parameters to determine boundary layer behavior, heat transfer, and performance degradation. The inclusion of a complete regenerative cooling cycle model with associate geometry, material and fluid property data provides a capability to internally calculate wall temperature profiles on the hot gas and coolant flow-side, as well as the coolant flow bulk temperature variation. Besides the regular heat transfer and performance degradation calculations, the new concept can be used to optimize the cooling cycle, coolant flow requirements, and cooling jacket geometry.

TN D-6829 July 1972

Spherical Balloon Response to Three-Dimensional Time-Dependent Flows. George H. Fichtl. Aero-Astrodynamics Laboratory. N72-27001

The dynamic response of a balloon to atmospheric flow is a function of the aerodynamic drag and lift forces, virtual mass effects, the Archimedean buoyancy forces, and dynamic buoyancy forces. The equations of motion for a spherical balloon which include these effects are derived by examining the various forces that can act on a spherical balloon in relation to the atmospheric equations of motion. It is assumed that the atmosphere affects the balloon but the balloon does not affect the atmosphere. An analysis shows that Coriolis effects in the balloon equations of motion can be neglected for most rising or falling balloons. The concept of the Lagrangian displacement of a balloon is introduced. It is shown that the general balloon response problem is extremely complicated because the wind-forcing functions in the balloon equations of motion are functions of the wind velocity vector and its Eulerian first derivatives evaluated at the location of the balloon. The balloon location is the dependent variable of the problem. The linear perturbation equations for a spherical balloon are derived by perturbing the components of velocity of the balloon about a terminal velocity state which is in equilibrium with a space-time invariant mean horizontal flow. The atmospheric flow is also

perturbed such that the resulting equations can be used to analyze the responses of spherical balloons to three-dimensional time-dependent flows. The wind field is represented in terms of a four-fold Fourier integral that involves three orthogonal wave numbers and a frequency, while the balloon components of velocity are represented as Fourier integrals involving a frequency which, in turn, is a function of the wind field wave numbers and frequency and the unperturbed flow components of velocity. The general nonstationary spectra of the balloon components of velocity are obtained in terms of integrals of the nonhomogeneous and nonstationary spectra of the wind field. The flow associated with a statistically stationary and homogeneous atmospheric velocity field is treated as a special case. The introduction of Taylor's frozen eddy hypothesis reduces the response integrals to algebraic equations which are relatively simple forms for the balloon transfer functions.

TN D-6868 July 1972
Mass Influx Obtained from LLLTV Observations of Faint Meteors. Robert J. Naumann and K. Stuart Clifton. Space Sciences Laboratory. N72-28830

Since the advent of low light level television (LLLTV) systems, it has been recognized that such devices offer the ability to observe meteors as faint as 10th magnitude which allows the extension of optical meteor data to masses as small as 10^{-4} gram. The Space Sciences Lab at Marshall Space Flight Center has been actively engaged in such observations using image orthicons and intensified SEC vidicons. The results of these observations are presented along with an interpretation in terms of mass-flux. This interpretation includes the development of a relationship between peak luminosity of a meteor and mass, velocity, and zenith angle that was derived from single body meteor theory and compares favorably with results obtained from the Artificial Meteor Program. Also included in the mass flux interpretation is an analysis of the observation response of a LLLTV system to fixed and moving point sources.

TN D-6873 October 1972
A Workload Model and Measures for Computer Performance Evaluation. H. Kerner and K. Kuemmerle. Computation Laboratory. N72-33195

A generalized workload definition is presented which constructs measurable workloads of unit size from workload elements, called Elementary Processes. An Elementary Process makes almost exclusive use of one of the processors, CPU, I/O processor, etc., and is measured by the cost of its execution. Various kinds of user programs can be simulated by quantitative composition of Elementary Processes into a Type. The character of the Type is defined by the weights of its Elementary Processes and its structure by the amount and sequence of transitions between its Elementary Processes. A set of Types is batched to a Mix. Mixes of identical cost are considered as equivalent amounts of workload. These formalized descriptions of workloads allow investigators to compare the results of different studies quantitatively. Since workloads of different composition are assigned a unit of cost, these descriptions enable determination of cost effectiveness of different workloads on a

machine. Subsequently performance parameters such as Throughput Rate, Gain Factor, Internal and External Delay Factors are defined and used to demonstrate the effects of various workload attributes on the performance of a selected large scale computer system.

TN D-6901 September 1972
Atmospheric Electricity Criteria Guidelines for Use in Aerospace Vehicle Development. Glenn E. Daniels. Aero-Astrodynamics Laboratory. N72-31617

Lightning has always been of concern for aerospace vehicle ground activities. The unexpected triggering of lightning discharges by the Apollo 12 space vehicle shortly after launch and the more recent repeated lightning strikes to the launch umbilical tower while the Apollo 15 space vehicle was being readied for launch have renewed interest in studies of atmospheric electricity as it relates to space vehicle missions. This report reflects some of the results of these studies with regard to updating the current criteria guidelines.

TN D-6930 September 1972
Optimum Runway Orientation Relative to Crosswinds. L. W. Falls and S. C. Brown. Aero-Astrodynamics Laboratory. N72-30250

Specific magnitudes of crosswinds may exist that could be constraints to the success of an aircraft mission such as the landing of the proposed space shuttle. A method is required to determine the orientation or azimuth of the proposed runway which will minimize the probability of certain critical crosswinds. Two procedures for obtaining the optimum runway orientation relative to minimizing a specified crosswind speed are described and illustrated with examples. The empirical procedure requires only hand calculations on an ordinary wind rose. The theoretical method utilizes wind statistics computed after the bivariate normal elliptical distribution is applied to a data sample of component winds. This method requires only the assumption that the wind components are bivariate normally distributed. This assumption seems to be reasonable. Studies are currently in progress for testing wind components for bivariate normality for various stations. The close agreement between the theoretical and empirical results for the example chosen substantiates the bivariate normal assumption.

TN D-7061 October 1972
The Optical Properties of Platinum and Gold in the Vacuum Ultraviolet. Roger C. Linton. Space Sciences Laboratory. N72-33662

The optical constants of platinum and gold thin films have been determined in the spectral region of 40 to 200 nm by reflection measurements. The highly polarized continuum of synchrotron radiation emitted by the 240-MeV electron storage ring at the Physical Sciences Laboratory of the University of Wisconsin was used as a light source for the spectrum below 120 nm, while a windowless discharge lamp coupled to a normal incidence monochromator provided a source for the longer wavelengths. Optical constants were determined by a computer program based on iterative solutions to the Fresnel equations for reflection as a function of the angle of incidence.

TN D-7091 January 1973
Longitudinal Oscillation of Launch Vehicles. Rudolf F. Glaser. Astronautics Laboratory. N73-15924

During powered flight a vehicle may develop longitudinal self-excited oscillations, so-called "POGO" oscillations, of its structure. The energy supplying the vibration is tapped from the thrust by the activity of the system itself; that is, oscillation of the structure causes oscillation of the propellant system, especially of the pumps. In this way an oscillating thrust can be created that, by a feedback loop, may sustain the structural oscillation under certain circumstances. Two special features of the system prove to be essential for creation of instability. One is the effect of the inherent time interval that the thrust oscillation is lagging behind the structural oscillation. The other is the decrease of system mass caused by the exhausting of gas. The latter feature may cause an initially stable system to become unstable. To examine the stability of the system, a single mass-spring model, which is the result of a one-term Galerkin approach to the equation of motion, has been considered. The Nyquist stability criterion leads to a stability graph that shows the stability conditions in terms of the system parameter and also demonstrates the significance of time lag, feedback magnitude, and loss of mass. An important conclusion can be drawn from the analysis: large relative displacements of the pump-engine masses favor instability. This is also confirmed by flight measurements. During some of the Apollo flights, severe POGO oscillations of the S-II stage occurred. The relative soft support of the center engines by a pin-ended crossbeam led to this situation. Data obtained at the time the oscillation occurred show extremely large displacements of the crossbeam at the attachment point.

TN D-7115 December 1972
Minimum Weight Design of Structures Via Optimality Criteria. J. Kiusalaas. Astronautics Laboratory. N73-14901

This report reviews the state of the art of automated structural design through the use of optimality criteria, with emphasis on aerospace applications. The contents include constraints on stresses, displacements, and buckling strengths under static loading, as well as lower bound limits on natural frequencies and flutter speeds. It is presumed that the reader is experienced in finite element methods of analysis, but is not familiar with optimal design techniques.

TN D-7159 February 1973
Development and Application of Vibro-acoustic Structural Data Banks in Predicting Vibration Design and Test Criteria for Rocket Vehicle Structures. H. J. Bandgren and W. C. Smith. Astronautics Laboratory. N73-20914

This report presents a method of predicting broadband random vibration criteria for components on space vehicles. Large amounts of vibration and acoustic data obtained from flights and static firing tests of space vehicles were formulated into vibro-acoustic data banks for structural categories of ring frame, skin stringer, and honeycomb. The vibration spectra with their associated acoustic spectra are normalized to a reference acoustic spectrum. The individual normalized

spectra are grouped according to definite structural characteristics and statistically analyzed to form the vibroacoustic data banks in this report. These data banks represent the reference vibration criteria available for determining the new vehicle vibration criteria.

TN D-7178 February 1973
Hypervelocity Impact Testing of Cables. David W. Jex, Albert B. Adkinson, James E. English, and Carl E. Linebaugh. Space Sciences Laboratory. N73-16186

This report presents the physics and electrical results obtained from simulated micrometeoroid testing of certain Skylab cables. The test procedure, electrical circuits, test equipment, and cable types utilized are also explained.

TN D-7195 March 1973
Calculation of Energy Deposition Distributions for Simple Geometries. John W. Watts, Jr. Space Sciences Laboratory. N73-17832

When high-energy charged particles pass through a thin detector, the ionization energy loss in that detector is subject to fluctuations or "straggling" which must be considered in interpreting the data. This problem has been treated by Landau, Symon, Vavilov, and others. Under many conditions, which depend upon the charge and energy of the incident particle and the detector geometry, the ionization energy lost by the particle is significantly different from the energy deposited in the detector. Since most detectors respond according to the ionization energy deposited, the difference between energy lost in the detector and energy deposited there must be considered. This difference is caused by high-energy secondary electrons produced in the ionization process that travel far from their point of production, often leaving the detector. This problem divides naturally into a calculation of the energy loss that results in excitation and low-energy secondary electrons which do not travel far from their production points, and a calculation of energy loss that results in high-energy secondary electrons which can escape from the detector. The first calculation is performed using a modification of the Vavilov energy loss distribution. A cutoff energy is introduced above which all electrons are ignored and energy transferred to low energy particles is assumed to be equivalent to the energy deposited by them. For the second calculation, the trajectory of the primary particle is considered as a source of secondary high-energy electrons. The electrons from this source are transported using Monte Carlo techniques and multiple scattering theory, and the energy deposited by them in the detector is calculated. The results of the two calculations are then combined to predict the energy deposition distribution. The results of these calculations are used to predict the charge resolution of parallel-plate pulse ionization chambers that are being designed to measure the charge spectrum of heavy nuclei in the galactic cosmic-ray flux.

TN D-7200 March 1973
Proposal for Hierarchical Description of Software Systems. H. Trauboth. Computation Laboratory. N73-21200

The programming of digital computers has developed into a new dimension full of difficulties, because the hardware of

computers has become so powerful that more complex applications are entrusted to computers. The costs of software development, verification, and maintenance are outpacing those of the hardware and the trend is toward further increase of sophistication of application of computers and consequently of sophistication of software. To obtain better visibility into software systems and to improve the structure of software systems for better tests, verification, and maintenance, a clear, but rigorous description and documentation of software is needed. The purpose of this report is to extend the present methods in order to obtain a documentation that better reflects the interplay between the various components and functions of a software system at different levels of detail without losing the precision in expression. This is done by the use of block diagrams, sequence diagrams, and cross-reference charts. In the appendices, examples from an actual large software system, i.e., the Marshall System for Aerospace Systems Simulation (MARSYAS), are presented. The proposed documentation structure is apt to automation of updating significant portions of the documentation for better software change control. This report should also stimulate research into new practical methods and principles for the development, verification, and maintenance of complex software systems.

TN D-7240 May 1973

Retrieval of Dispersive and Convective Transport Phenomena in Fluids Using Stationary and Nonstationary Time Domain Analysis. J. Briscoe Stephens and Robert M. St. John. Aero-Astrodynamics Laboratory. N73-25284

Simultaneously occurring dispersive and convective components of fluid kinematics are obtained by a time domain analysis of optically retrieved temporal histories of the transport phenomena. Utilizing triangulation of collimated optical fields of view from two radiometers to obtain the temporal histories of the intensity fluctuations associated with the transport phenomena has enabled investigators to retrieve the local convective transport by employing correlation statistics. The location of the peak in the covariance curve determines the transit time from which the convection velocity is calculated; whereas, the change in shape of the peak in the covariance curve determines the change in average frequency of the wave packet from which the dispersion velocity is calculated. Thus, our two-component analysis requires the maximum possible enhancement of the delineation for the transport. The convection velocity is the result of a fixed reference frame calculation; whereas, the dispersion velocity is the result of a moving reference frame calculation. This moving reference frame is constrained to move along the common streamline at the convection velocity. The transport probability has been developed as an estimate of whether the transport phenomena have been measured along the common stream, and also provides an indication of whether the period of stationarity is sufficient to provide adequate information enhancement. The time information is suppressed by the utilization of a fourth-order autocovariance curve. This moving frame delineation is analyzed in the time domain with the wave packet algorithm for the dispersion parameters. The effectiveness of these models is demonstrated on empirical data sets obtained in glow discharge

investigations, cold jet experiments, and air quality investigations.

TN D-7263 June 1973

A Study of Zodiacal Light Models. G. A. Gary and P. D. Craven. Space Sciences Laboratory. N73-26843

This report presents a review of the basic equations used in the analysis of photometric observations of zodiacal light. A survey of the methods used to model the zodiacal light in and out of the ecliptic is given. Results and comparison of various models are presented, as well as recent results by the authors.

TN D-7312 May 1973

Unsupervised Spatial Clustering with Spectral Discrimination. Robert R. Jayroe, Jr. Aero-Astrodynamics Laboratory. N73-24410

The recent development of manned and unmanned space vehicles has brought about an almost unprecedented advance in studies of remotely sensed earth observations. These observations require a multidisciplinary study which includes such fields as agriculture, forestry, geography, demography, cartography, geology, meteorology, hydrology, oceanography, environmental quality, ecology, sensor technology, and interpretation techniques development. With this unprecedented advance comes an unprecedented amount of data. The problem arises of how to analyze and extract information from such large volumes of data in an efficient manner. The main emphasis of this work is the development of a computer program for extracting features from remotely sensed data presented in digital image form. This computer program requires no human supervision or prejudgment and operates unassisted on the raw digital data. The presentation of this work also includes a condensed general background on remote sensing of earth features and a short synopsis on some of the most commonly used types of feature extraction techniques. This discussion is followed by a presentation of results obtained from the unsupervised feature extraction computer program along with a description and listing of the computer program.

TN D-7317 June 1973

Measurements of the Performance of Multiwire Proportional Chambers. R. W. Austin, A. Aglitis, J. C. Gregory, S. A. Metzger, T. A. Parnell, H. F. Rutledge, W. Selig, and N. P. Cumings. Space Sciences Laboratory. N73-24816

This report presents data that may be useful in formulating engineering specifications and test procedures for the proportional counter hodoscope to be flown as part of the High Energy Cosmic Ray Experiment on the High Energy Astronomy Observatory (HEAO), Mission A. A collection of preliminary data taken in laboratory tests of multiwire counters with an anode wire spacing of 5 mm and cathode gap spacing of 1 cm is presented. The data are from laboratory development models or counters for balloon flights and were selected to illustrate several aspects of proper and improper counter performance. Most of the data were taken from a large area proportional counter hodoscope which has an active area of 0.5 by 0.5 m and 104 wires per plane.

TN D-7318 June 1973

Axisymmetric Oscillation of a Partially Liquid-Filled Cylindrical Shell Container Having Hemispherical Bulkheads. Rudolf F. Glaser. Astronautics Laboratory.

N73-25925

The longitudinal oscillations of launch vehicles represent an area of concern. During ignition liftoff or cutoff, longitudinal vibrations occur as transients and may cause considerable dynamic loads. However, longitudinal oscillation can also be excited during powered flight. From experience it is well known that under certain circumstances energy can be tapped by the activity of the system itself and can produce very undesirable self-excited oscillation, the so-called "pogo" oscillation of the vehicle structure. Thus, it is understandable that the longitudinal dynamics of vehicles have received continued attention over the last years. A simplified vehicle model must be used to analyze the longitudinal dynamic behavior of vehicles or, in other words, to determine the longitudinal frequencies and mode shapes. Usually only a few of the fundamental modes are of interest; thus, only significant dynamic properties must be considered. The liquid propellants constitute a high percentage of the overall vehicle masses throughout much of the powered flight time and, coupled with the solid vehicle masses and springs, may generate the fundamental modes of the entire vehicle. Thus, the correct comprehension of the liquid oscillation inside the elastic container is extremely important. In this report a spring-supported, cylindrical container of the length l having hemispherical bulkheads is considered. The analysis, however, is also valid for $l = 0$, which represents the cases of sphere and hemisphere. A computer program and numerical evaluation of the analysis contained in this report can be found in the contractor report, Axisymmetric Oscillation of a Partially Liquid-Filled Cylindrical Shell Container Having Hemispherical Bulkheads: Computer Program and Numerical Evaluation, by Dwight Caughfield of the Department of Mathematics, Abilene Christian College, Abilene, Texas.

TR R-387 August 1972

Maximum Range Three-Dimensional Lifting Planetary Entry. E. D. Dickmanns. Aero-Astrodynamics Laboratory. N72-29845

Variational equations for maximum range three-dimensional quasisteady glide are given. Nonlinear oscillatory maximum range trajectories obtained with a refined gradient program are approximated by a superposition of quasisteady glide and linearized perturbation equation results. A "basic" control law is found which is closely followed for maximum cross-range trajectories. The effect of a reradiative heating constraint involving velocity, altitude and angle of attack on a maximum cross-range trajectory for a Space Shuttle orbiter-type vehicle reentering the earth's atmosphere is investigated numerically.

TR R-393 December 1972

A Study of the Microstructure and Optical Properties of Thin Lead-Dielectric Cermet Films. Robert B. Owen. Astrionics Laboratory. N73-12811

A transmission electron microscopy study involving direct and replicating techniques is directed to a definition of the microstructure of radio frequency-sputtered, thin lead-dielectric cermet films. Once defined, this microstructure is used to obtain theoretical film refractive indices. The Maxwell Garnett theory provides a basis for the theoretical results. Measurements of film transmission and reflectivity are used to obtain rough experimental values for film refractive indices by the Tekucheva method. More exact values are obtained via ellipsometry. The rough Tekucheva values are used to determine the range over which computer calculations interpreting the ellipsometric results must be made. This technique yields accurate values for the film refractive indices. The films are radio frequency-sputtered from lead glass targets with varying amounts of lead attached to their faces. Three different targets are used, resulting in three sets of films, each containing a different percentage of lead. The lead content of the films is measured by microprobe analysis as well as visual inspection of micrographs. The lower content lead films are seen to consist of tiny balls of lead embedded in the dielectric, as are the intermediate lead content films, but the higher lead content films form metallic networks throughout the dielectric. The lower and intermediate lead content films have indices which agree with the predictions of the Maxwell Garnett theory, but the higher lead content films, whose structure fails to conform to the Maxwell Garnett configuration, have indices whose values diverge from the Maxwell Garnett predictions. It is thus shown that the theory of Maxwell Garnett is valid for thin cermet films whose structure consists of tiny metal balls embedded in a dielectric medium.

TR R-401 December 1972

Mobility Performance of the Lunar Roving Vehicle: Terrestrial Studies – Apollo 15 Results. Nicholas C. Costes, John E. Farmer, and Edwin B. George. Space Sciences Laboratory and Astrionics Laboratory. N73-16817

The constraints of the Apollo 15 mission dictated that the average and limiting performance capabilities of the first manned

Lunar Roving Vehicle, when operated on the lunar surface, be known or estimated within narrow margins. For this reason, extensive studies were conducted during the year preceding the Apollo 15 launch and are described herein. The results of these studies are compared with the actual performance of the Lunar Roving Vehicle during the Apollo 15 mission. From this comparison, conclusions are drawn relating to the capabilities and limitations of current terrestrial methodology in predicting the mobility performance of lunar roving vehicles under in-situ environmental conditions, and recommendations are offered concerning the performance of surface vehicles on future missions related to lunar or planetary exploration.

TR R-404 March 1973

The Techniques of Holographic Particle Sizing. Robert L. Kurtz. Space Sciences Laboratory. N73-18448

Depending on the mechanism of particle production, the resultant particle size and velocity distribution may range over several orders of magnitude. In general, if particle size information is desired from a given type generator, one must resort to some form of experimental determination of the distribution. If the source of particle production is a dynamic one involving a reasonable volume, holography provides a tailor-made particle size and velocity distribution detector. This is evidenced by the fact that holography allows the entire volume to be recorded on one exposure without any interference with the volume of interest. Herein lies a very important characteristic of the holographic particle detection technique: It provides a holographic nondestructive testing technique in the fullest sense of the definition of nondestructive testing. This report provides a description of three different systems useful in this technique and includes the experimental results from one of the holographic systems which was used to detect particle size and velocity distribution from the Skylab waste tank.

TR R-410 June 1973

Classical Eighth- and Lower-Order Runge-Kutta-Nyström Formulas with a New Stepsize Control Procedure for Special Second-Order Differential Equations. Erwin Fehlberg. Computation Laboratory. N73-24614

New Runge-Kutta-Nyström formulas of the eighth, seventh, sixth, and fifth order are derived for the special second-order (vector) differential equation $\ddot{x} = f(t,x)$. In contrast to Runge-Kutta-Nyström formulas of an earlier NASA report by this author, these formulas provide a stepsize control procedure based on the leading term of the local truncation error in $\dot{x}$. This new procedure is more accurate than the earlier Runge-Kutta-Nyström procedure of this author (with stepsize control based on the leading term of the local truncation error in x) when integrating close to singularities. Two central orbits are presented as examples. For these orbits, the accuracy and speed of the formulas of this report are compared with those of Runge-Kutta-Nyström and Runge-Kutta formulas of earlier NASA reports by this author.

TR R-414 June 1973

Digital Simulation of the Serpentuator Using MARSYAS. Sudarshan P. Singh. Computation Laboratory. N73-25210

Serpentuator is a serpentine teleoperator device for intravehicular and extravehicular activities in space. The serpentuator is simulated using the digital simulation software system MARSYAS and using the Component-Connection Simulation model and the Direct Simulation model. A comparison of the results for the two cases shows that under identical conditions, simulation execution time in the Component-Connection model case is reduced by a factor of the order of 100. A visual display of the serpentuator positions is obtained using the AMTRAN system on the Datacraft DC 6024 computer.

SP-299 1973
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SP-313 1972
Space for Mankind's Benefit. Proceedings of a space congress held November 15-19, 1971, at Huntsville, Alabama, sponsored by the National Aeronautics and Space Administration and the Huntsville Association of Technical Societies. Jesco von Puttkamer and Thomas J. McCullough, eds. Center Plans and Resources Control Office.
N73-13829

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(Abstracts for these reports may be obtained from STAR.)

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CR-2160 January 1973
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CR-2213 April 1973
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CR-2248 May 1973
An Innovative Approach to Compensator Design. Final Report. NAS8-21377. Mississippi State University. N73-25651

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