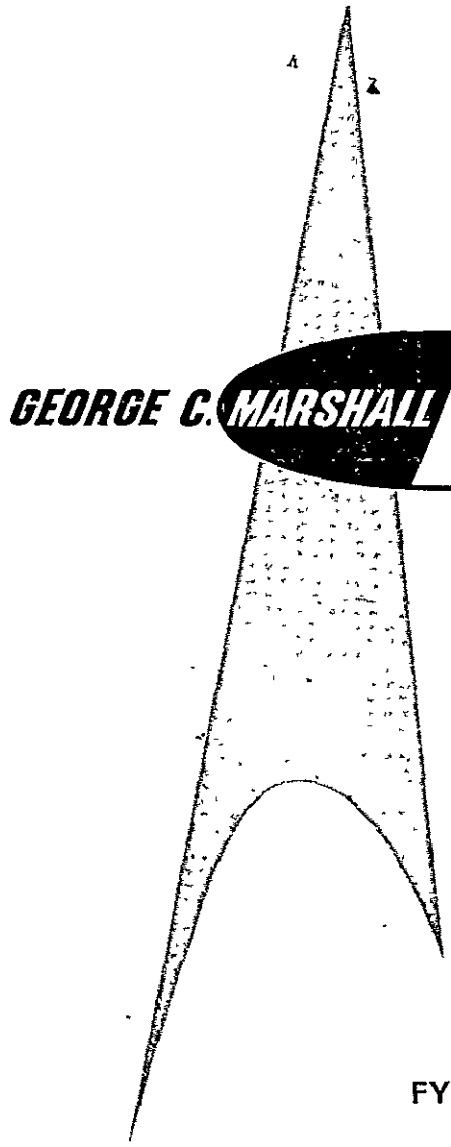
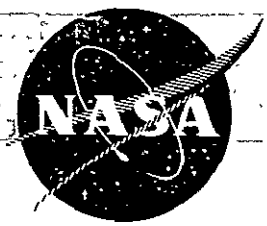


FY 1974 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

Management Services Office

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



Richard Grabowski

ABSTRACT

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY 74. It also includes papers of MSFC contractors.

After being announced in STAR or C STAR, all of the NASA series reports 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 1974 SCIENTIFIC AND TECHNICAL REPORTS, ARTICLES, PAPERS, AND PRESENTATIONS

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FOREWORD

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

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

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
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TM X2935 October 1973

An Analytical Analysis of the Dispersion Predictions for Effluents from the Saturn V and Scout-Algol III Rocket Exhausts. J. Briscoe Stephens, Michael Susko, John W. Kaufman, C. Kelly Hill. Aero-Astrodynamics Laboratory. N74-33327

Predictions of the spatial concentration mapping of the potentially toxic constituents of the exhaust effluents from a launch of a Saturn V and of a Scout-Algol III vehicle utilizing the NASA/MSFC Multilayer Diffusion Program are provided. In the case of the Saturn V, special attention was given to the concentration fields of carbon monoxide with a correlation of carbon dioxide concentrations. The Scout-Algol III provided an example of the centerline concentrations of hydrogen chloride, carbon monoxide, and alumina under typical meteorological conditions. While these results define the specific environmental impact of these two launches under the meteorological conditions existing during launches, they also provide a basis for the empirical monitoring of the constituents of the exhaust effluents of these vehicles.

TM X-2938 December 1973

Data for First NASA Atmospheric Variability Experiment (AVE I) Part I: Data Tabulation. James R. Scoggins and Orvel E. Smith. Aero-Astrodynamics Laboratory. N74-15350

This report presents a tabulation of rawinsonde data for NASA's first Atmospheric Variability Experiment (AVE I) conducted during the period February 19-22, 1964. Methods of data handling and processing, and estimates of error magnitudes are also given.

Data taken on the AVE I project in 1964 enabled an analysis of a large sector of the eastern United States on a fine resolution time scale. This experiment was run in February 1964, and data were collected as a wave developed in the East Gulf on a frontal system which extended through the eastern part of the United States. The primary objective of AVE I was to investigate the variability of parameters in space and over time intervals of three hours, and to integrate the results into NASA programs which require this type of information. The results presented in this report are those from one approach, and represent only a portion of the total research effort that can be accomplished.

This report consists of two parts: Part I – Data Tabulation and Part II – Graphical Presentation of Data.

TM X-2939 November 1973

Prediction of Engine Exhaust Concentrations Downwind from the Delta-Thor Telsat-A Launch of November 9, 1972. John W. Kaufman, Michael Susko, C. Kelly Hill. Aero-Astrodynamics Laboratory. N74-10583

Presented in this report are the results of the downwind concentrations of engine exhaust by-products from the Delta-Thor Telsat-A vehicle launched from Cape Kennedy, Florida, on November 9, 1972 (2014 EST). The meteorological conditions which existed are identified as well as the exhaust cloud rise and the results from the MSFC Multilayer Diffusion Model calculations. These predictions are herein compared to exhaust cloud sampled data acquired by the Langley Research Center personnel.

Values of the surface level concentrations show that very little hydrochloric acid (HCl), carbon monoxide (CO), or aluminum oxide (Al_2O_3) reached the ground.

TM X-2948 December 1973

Data for First NASA Atmospheric Variability Experiment (AVE I) Part II: Graphical Presentation of Data. James R. Scoggins and Orvel E. Smith. Aero-Astrodynamics Laboratory. N74-16321

This report presents a graphical representation of data for NASA's first Atmospheric Variability Experiment (AVE I) conducted during the period February 19-22, 1964. Graphical representation is in the form of synoptic charts and time cross section.

Data taken on the AVE I project in 1964 enabled an analysis of a large sector of the eastern United States on a fine resolution time scale. This experiment was run in February 1964, and data were collected as a wave developed in the East Gulf on a frontal system which extended through the eastern part of the United States. The primary objective of AVE I was to investigate the variability of parameters in space and over time intervals of three hours, and to integrate the results into NASA programs which require this type of information. The results presented in this report are those from one approach, and represent only a portion of the total research effort that can be accomplished.

This report consists of two parts: Part I – Data Tabulation and Part II – Graphical Presentation of Data.

TM X-64757 July 5, 1973

Terrestrial Environment (climatic) Criteria Guidelines for Use in Aerospace Vehicle Development, 1973 Revision. Glenn E. Daniels, Editor. Aero-Astrodynamics Laboratory. N74-16293

This document provides guidelines on probable climatic extremes and probabilities-of-occurrence of terrestrial environment data specifically applicable for NASA space vehicles and associated equipment development. The geographic areas encompassed are The Eastern Test Range (Cape Kennedy, Florida); Huntsville, Alabama; New Orleans, Louisiana; The Space and Missile Test Center (Vandenberg AFB California); Sacramento, California; Wallops Test Range (Wallops Island, Virginia); White Sands Missile Range, New Nexico; and intermediate transportation areas. In addition, sections have been included to provide information on the general distribution of natural environment extremes in the United States (excluding Alaska and Hawaii), cloud cover, and some worldwide climatic extremes. Although all these areas are covered, the major emphasis is given to the Kennedy Space Center launch area and Vandenburg Air Force Base due to importance in NASA's future large space vehicle programs.

This document presents the latest available information on probable climatic extremes, and supersedes information presented in TM X-64589. The information in this document is recommended for employment in the development of space vehicles and associated equipment design and operational criteria, unless otherwise stated in contract work specifications.

TM X-64758 July 9, 1973

Statistical Properties of Filtered Pseudorandom Digital Sequences Formed from the Sum of Maximum-Length Sequences. G. R. Wallace, Glenn D. Weathers, and Edward R. Graf. Astrionics Laboratory. N73-27516

The statistics of filtered pseudorandom digital sequences called hybrid-sum sequences, formed from the modulo-two sum of several maximum-length sequences, are analyzed. The results indicate that a relation exists between the statistics of the filtered sequence and the characteristic polynomials of the component maximum-length sequences. An analysis procedure is developed for identifying a large group of sequences with good statistical properties for applications requiring the generation of analog pseudorandom noise. By use of the analysis approach, the filtering process is approximated by the convolution of the sequence with a sum of unit-step functions. The first five moments of the resulting weight tuples are used to characterize the statistics of the filtered sequence. At this point, a parameter reflecting the overall statistical properties of filtered pseudorandom sequences is derived. This parameter is called the statistical quality factor. A computer algorithm to calculate the statistical quality factor for the filtered sequences is presented, and the results for two examples of sequence combinations are included. The analysis reveals that the statistics of the signals generated with the hybrid-sum generator are potentially superior to the statistics of signals generated with maximum-length generators. Furthermore, fewer calculations are required to evaluate the statistics of a large group of hybrid-sum generators than are required to evaluate the statistics of the same size group of approximately equivalent maximum-length sequences. Pseudorandom signals generated by filtering hybrid-sum sequences have a potential application in a multichannel communications system evaluation technique. There are also applications for these sequences in areas such as coding theory and modulation format design for pseudonoise transponders.

TM X-64759 April 20, 1973

Thermal Conductivity of Particulate Materials: A Summary of Measurements Taken at the Marshall Space Flight Center. James A. Fountain, Ronald W. Scott, and Edward A. West. Space Sciences Laboratory. N73-27801

Thermal conductivity measurements of particulate materials in vacuum are presented in summary. Particulate basalt and soda lime glass beads of various size ranges were used as samples. The differentiated line heat source method was used for the measurements. A comprehensive table is shown giving all pertinent experimental conditions. Least-squares curve fits to the data are presented for $K = A + BT^3$ and $K = A + BT + CT^3$. The latter equation is shown to give a slightly better fit to the data in most cases. In the relatively low vacuum data, the curves $K = A + BT$ and $K = A + BT + CT^2$ were fitted to the data.

TM X-64760 June 12, 1973

Development and Evaluation of Polyimide Laminates for Printed Wiring Board Applications. William J. Patterson. Astronautics Laboratory. N73-26581

This report describes a developmental and evaluation program on polyimide

laminates as printed wiring boards. The development of an experimental polyimide with low linear coefficient of thermal expansion normal to the plane of the board is discussed, and its properties are evaluated along with two commercial polyimide printed wiring boards for comparison with the type G-10 epoxy board. Thermal cycling data indicate an urgent need for effectively controlling the expansion normal to the plane of the board in order to minimize solder joint damage.

TM X-64761 July 24, 1973
Natural Environment Design Requirements for the Solar Electric Propulsion Stage (SEPS). Lewis E. Andrews. Aero-Astrodynamics. N73-27708

Given in this report are the natural environment design requirements for the Solar Electric Propulsion Stage. Environment criteria for the SEP Stage will cover earth orbital operations out to geosynchronous altitudes and also interplanetary missions including comet and asteroid missions.

TM X-64762 July 27, 1973
Notes for the Improvement of a Remote Sensing Multispectral Data Non-Supervised Classification and Mapping Technique. Charles C. Dalton. Aero-Astrodynamics. N73-27332

The report examines the "Sequential Clustering" technique for the unsupervised automatic classification and mapping of earth resources satellite data, makes theoretical analysis of the tests which were used, and derives an alternative set of tests and their necessary algorithm.

TM X-64763 August 1, 1973
LST Phase A Design Update Study. Program Development. N73-28494

This document is an update of the Phase A study (TM X-64726) of the Large Space Telescope (LST), based on changes in guidelines and new data developed subsequent to the Phase A study. 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 instruments (SI), and a support systems module (SSM). The report consists of one volume. 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.

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. Ground-return maintenance is the primary maintenance mode, with limited on-orbit EVA as an adjunct.

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 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-64764(Revised) June 1974
The Project Management Role in Safety. R. C. Callaway. Safety and Manned Flight Awareness Office. N73-28937

Techniques to be utilized by project management in the planning, implementation, and administration of a project safety program are presented.

Safety functional responsibilities are classified into two categories: safety management and safety engineering. The emphasis in this document is the safety management role, and how safety activities are to be integrated throughout the project and made visible in the work breakdown structure and cost accounting and reporting. Safety inputs into the RFP, contractor program plans. etc., constitute an effective method of safety achievement.

The project manager must provide for and have visibility into systematic identification and control of hazards.

TM X-64765 August 9, 1973
Biodetection Grinder. F. J. Beyerle. Process Engineering Laboratory. N73-29059

One method of sampling materials for detection of embedded organisms utilizes the crushing action of a Mill Blender. Destruction of microorganisms is high and decreases accuracy of the biotests.

To improve upon this method and device, a Biodetection Grinder was developed. It is a device that employs a shearing action to generate controllable, sized particles with a minimum of energy input.

TM X-64766 June 1973
Stripping Flat Conductor Cable. W. Angele. Process Engineering Laboratory.

Techniques and equipment are described for stripping flat conductor cable (FCC) prior to cable termination to connectors. Major areas covered are the standard FCC insulation systems, methods for stripping unshielded cables, and methods for stripping shielded cables.

TM X-64767 August 1973
The Load-Carrying and Thermal Characteristics of Flat Conductor Cable. George D. Adams. Process Engineering Laboratory. N73-29125

The load-carrying and thermal characteristics of flat conductor cable and round wire cables have been investigated with all conductors in each cable under varying loads in air and vacuum environments. The test procedure is described and results are presented in graphic form. Derating factors for both round wire and flat conductor cable are established for operation in a vacuum environment. Rating factors are established for flat

conductor cable for use with round wire loading tables. The results of these tests show that single layer flat conductor cable can carry over 150 percent of the load of a conventional round cable of the same conductor size, or that the voltage drop across flat conductor cable will be lower than that of round cable under the same load.

TM X-64768 May 16, 1973

Space Shuttle Rendezvous, Radiation and Reentry Analysis Code. Dave M. McGlathery. Aero-Astrodynamics Laboratory. N73-30795

Documented in this report is the development of a preliminary Space Shuttle Mission Design and Analysis Tool emphasizing versatility, flexibility, and user interaction through the use of a relatively small computer (IBM-7044). The Space Shuttle Rendezvous, Radiation and Reentry Analysis Code is used to perform mission and space radiation environmental analyses for four typical Space Shuttle missions. Included also is a version of the proposed Apollo/Soyuz Rendezvous and Docking Test Mission. Tangential steering circle to circle low-thrust tug orbit raising and the effects of the trapped radiation environment on trajectory shaping due to solar electric power losses are also features of this mission analysis code.

The computational results include a parametric study on single impulse versus double impulse deorbiting for relatively low Space Shuttle orbits as well as some definitive data on the magnetically trapped protons and electrons encountered on a particular mission.

TM X-64769 July 27, 1973

Sensitivity and Comparison Evaluation of Saturn V Liquid Penetrants. G. H. Jones. Quality and Reliability Assurance Laboratory. N73-31529

This report describes a sensitivity and comparison evaluation performed on six liquid penetrants that were used on the Saturn V vehicle and other space hardware to detect surface discontinuities.

The relationship between penetrant materials and crack definition capabilities, the optimum penetrant materials evaluation method, and the optimum measurement methods for crack dimensions were investigated. A unique method of precise developer thickness control was envolved, utilizing clear radiographic film and a densitometer.

The method of evaluation included five aluminum alloy, 2219-T87, specimens that were heated and then quenched in cold water to produce cracks. The six penetrants were then applied, one at a time, and the crack indications were counted and recorded for each penetrant for comparison purposes. Measurements were made by determining the visual crack indications per linear inch and then sectioning the specimens for a metallographic count of the cracks present. This method provided a numerical approach for assigning a sensitivity index number to the penetrants.

Of the six penetrants evaluated, two were not satisfactory (one was not sufficiently sensitive and the other was too

sensitive, giving false indications). The other four were satisfactory with approximately the same sensitivity in the range of 78 to 80.5 percent of total cracks detected.

TM X-64770 July 1973
CVT/PCS Phase I Integrated Testing. Robert O. McBrayer and Jackie D. Steadman. Astronautics Laboratory. N73-31207

Five breadboard experiments representing three Sortie Lab Experiment disciplines were installed in a Payload Carrier Simulator. The experimenters were asked to provide approximately 1½ pages engineering data, to provide an outline of the experiment protocol, and to simultaneously perform their experiments to their protocol for 8 hours per day, during the 4½ days of integrated testing. A description of the experiments and the Payload Carrier Simulator is provided. An assessment of the experiment interface with the Simulator and an assessment of the Simulator experiment support systems is presented. The results indicate that a hardware integrator for each experiment is essential; a crew chief, or mission specialist, for systems management and experimenter liaison is a vital function; a payload specialist is a practical concept for experiment integration and operation; an integration fixture for a complex experiment is required to efficiently integrate the experiment and carrier, simultaneous experiment utilization of simulator systems caused unexpected problems in meeting individual experiment requirements; experimenter traffic inside the dual-floor simulator did not hamper experiment operations; and the requirement for zero-g operation will provide a significant design challenge for some experiments.

TM X-64771 April 16, 1973
Normal Probabilities for Cape Kennedy Wind Components – Monthly Reference Periods for All Flight Azimuths – Altitudes 0 to 70 Kilometers. L. W. Falls. Aero-Astrodynamics Laboratory. N73-30625

This document replaces Cape Kennedy empirical wind component statistics which are presently being used for aerospace engineering applications that require component wind probabilities for various flight azimuths and selected altitudes. The normal (Gaussian) distribution is presented as an adequate statistical model to represent component winds at Cape Kennedy.

Head-, tail-, and crosswind components are tabulated for all flight azimuths for altitudes from 0 to 70 km by monthly reference periods. Wind components are given for 11 selected percentiles ranging from 0.135 percent to 99.865 percent for each month.

Results of statistical goodness-of-fit tests are presented to verify the use of the Gaussian distribution as an adequate model to represent component winds at Cape Kennedy, Florida.

TM X-64772 July 26, 1973
Apollo 17 Heat Flow and Convection Experiments Final Data Analyses Results. T. C. Bannister, P. G. Grodzka, L. W. Spradley, S. V. Bourgeois, R. O. Hedden, and B. R. Facemire. Space Sciences Laboratory. N73-31840

A group of experiments called the Apollo 17 Heat Flow and Convection (HFC) Experiments was conducted by Astronaut

Ron Evans on December 8, 1972, aboard the Apollo 17 spacecraft while in translunar coast on the way to the moon. These experiments together with the HFC experiments flown on Apollo 14 demonstrated and provided data on two types of low-g natural convection: cellular, surface tension-driven convection and convection in confined fluids caused by spacecraft and astronaut movements. Observed convection onset times show that surface tension-driven convection occurs at lower temperature gradients in low-g than in one-g environments. Data on heat flow in confined fluids show that spacecraft and astronaut movements can cause significant degrees of convection.

TM X-64773 August 10, 1973

Effects of Ascent Trajectory Mode and Tank Disposal Method on Shuttle Payload Accommodation. James C. Blair, William W. Heuser, Jerome R. Redus. Aero-Astrodynamics Laboratory. N73-30831

The capability of the Space Shuttle to deliver payloads of a given weight and length to the desired orbital altitude can be significantly affected by the trajectories and operational modes used for the Shuttle mission. This report documents an investigation of how Shuttle payload accommodation capability is affected by (1) external tank disposal by retro-rocket versus passive tank drop and (2) targeting the main engine burn for high apogee (direct insertion) versus the baseline parking-orbit ascent method. Missions launched from Eastern Test Range were investigated over a range of orbit altitudes to determine tank disposal requirements including footprint dispersions and alternate impact locations, performance, and Orbital Maneuvering System requirements. Passive tank drop, which is known to be superior to retro disposal from a Shuttle system standpoint, somewhat surprisingly proved to be advantageous from a payload accommodation standpoint also. Direct insertion is shown to be a means of accommodating long payloads at higher altitudes than permitted by the baseline ascent method; however, direct insertion required disposal of the tank in the Pacific rather than the Indian Ocean. It is recommended that direct insertion be considered a viable Shuttle ascent mode, but because of the preferability of Indian Ocean disposal and the desire for standardization of mission profiles, its use should be restricted to those payloads which cannot be accommodated by the baseline ascent mode.

TM X-64774 August 1973

Measurement Capabilities of a One-Dimensional LDV System. William C. Cliff and Charles E. Fuller, III. Aero-Astrodynamics Laboratory. N73-30427

The capability of a single component laser Doppler velocimeter (LDV) system for the measurement of three dimensional mean and turbulent flow statistics is investigated. Sets of general equations defining the parameters measured by a single component LDV system are derived. Solutions to the equations for different configurations of a single forward scatter LDV system show that three dimensional mean velocity measurements can be made with a minimum restriction on the precision for detecting the Doppler frequency. Measurements of the three dimensional RMS, cross products and correlation parameters are shown to require a significantly higher precision in the Doppler frequency detection.

TM X-64775 August 1973

A Modified Quadrupole Mass Spectrometer with Custom RF Link Rods Driver for Remote Operation. Philip W. Tashbar, Daniel B. Nisen, and W. Walding Moore, Jr., Space Sciences Laboratory. N73-30435

A commercial quadrupole residual gas analyzer (RGA) system has been upgraded for operation at extended cable lengths. Operation inside a vacuum chamber for the standard quadrupole nude head is limited to approximately 2 m from its externally located rf/dc generator because of the detuning of the rf oscillator circuits by the coaxial cable reactance. The advance of long distance remote operation inside a vacuum chamber for distances of 45 and 60 m was made possible without altering the quadrupole's rf/dc generator circuit by employing an rf link to drive the quadrupole rods. Applications of the system have been accomplished for in situ space simulation thermal/vacuum testing of sophisticated payloads.

TM X-64776 March 30, 1973

The V-3 Contamination Test of the Chamber A Facility and A Subsequent Cryogenic/Vacuum Study of the V-3 Test Quartz Crystal Microbalance. W. Walding Moore, Jr., and Philip W. Tashbar. Space Sciences Laboratory. N73-30220

The areas of orbital and ground contamination of flight experiment hardware have been well established. This report relates directly to results of vacuum chamber testing for the ground evaluation of flight experiment hardware performance. First, the data obtained during the V-3 contamination testing in the Johnson Space Center's Chamber A space simulation test facility are presented. Second, during the V-3 contamination test, the MSFC Space Sciences Laboratory's quartz crystal microbalance exhibited two periods of anomalous readings. Therefore, a subsequent small chamber test was conducted in a controlled cryogenic/vacuum environment. The objective was to reproduce with known parameters the anomalous behavior patterns of the V-3 test data. Analyses of the anomalous readings are made on the basis of these tests. Additionally, as a by-product of the small chamber tests, calibration curves then existing for the quartz crystal microbalance were empirically extended, and certain data-formatting aids were documented.

TM X-64777 August 1, 1973

Proposed Reliability Cost-Model. Dr. Leon M. Delionback. Systems/Products Office. N73-32372

The research investigations which were involved in this study include: cost analysis/allocation, reliability and product assurance, forecasting methodology, systems analysis, and model-building. This is a classic example of an interdisciplinary problem, since the model-building requirements include the need for understanding and communication between technical disciplines on one hand and the financial/accounting skill categories on the other.

The systems approach is utilized within this context to establish a clearer and more objective relationship between Reliability Assurance and the subcategories (or subelements) that provide, or reenforce, the

reliability assurance for a system. Subcategories are further subdivided as illustrated by a tree diagram. The reliability assurance elements can be seen to be potential alternative strategies, or approaches, depending on the specific goals/objectives of the trade studies. The scope was limited to the establishment of a proposed reliability cost-model format.

The model format/approach is dependent upon the use of a series of subsystem-oriented CER's, and sometimes possible CTR's, in devising a suitable cost-effective policy.

TM X-64778 June 8, 1973

Quartz Crystal Microbalance Contamination Monitors on Skylab — A Quick-Look Analysis. R. Naumann, W. Moore, D. Nisen, W. Russell and P. Tashbar. Space Sciences Laboratory. N73-31412

Six quartz crystal microbalance contamination monitors were flown on Skylab to monitor the deposition of material from spacecraft outgassing and from the rendezvous and docking maneuvers of the Command/Service Module. This report contains a quick-look analysis of the data from these units during the unmanned and manned portions of SL2.

TM X-64779 September 1973

Simulation of an Experiment Pointing System for the Space Shuttle. P. D. Nicaise. Program Development. N73-32760

The pointing and Control of experiments during sortie missions are examined from the standpoint of accuracy and performance. The effect of gimbal characteristics, pallet stiffness, and variation in the servo control loop are described. Simulation results are shown for a number of pointing options under the disturbing influences of man motion, thruster firings, and experiment operations. One option of particular interest is the suspended pallet which offers the possibility of high accuracy pointing of very large payloads without using conventional gimbals. The pallet is suspended within the payload bay by non-rigid attachments such as springs, thereby isolating experiments from most Shuttle disturbances. Control moment gyros apply torques directly to the pallet to maintain pointing accuracy within the arc second range. Spring torques constrain Shuttle attitude so thruster operation is not required. The suspended pallet approach will meet the base stability requirements of any sortie experiment and offers the possibility of a standardized low weight, low cost alternative to gimbaled mounts. However, the practical aspects, including possible implementation problems, have not been fully explored.

TM X-64780 August 1973

Optimum Inclination for Shuttle Retrieval of Inclination Non-Sensitive Satellites. Douglas L. Blackwell. Aero-Astrodynamics Laboratory. N73-31730

This report presents the results of a study to identify the optimum inclination for a satellite when the satellite is inclination non-sensitive and is to be retrieved. This inclination is such that it provides an opportunity for a retrieval flight at least once each day with minimal on-orbit phasing requirements and minimal ascent performance losses.

TM X-64781 July 1, 1973

A Comparison of Digital Computer Programs for the Numerical Solution of Ordinary Differential Equations. Hugo L. Ingram. Aero-Astrodynamics Laboratory. N73-32487

Recently the determination of the best technique for numerically solving systems of ordinary differential equations on a digital computer has received much attention. Phyllis Fox in A Comparative Study of Computer Programs for Integrating Differential Equations; and Hull, Enright, Fellen, and Sedgewick in Comparing Numerical Methods for Ordinary Differential Equations made studies on the computational efficiency of several different numerical integration techniques, but their studies did not include the Runge-Kutta formulas developed by Fehlberg (NASA TR R-287 and R-315). The use of these formulas in conjunction with a stepsize control developed in this report is explained, and one of the formulas is chosen for comparison with other integration techniques. This comparison of one of the best of Fehlberg's formulas with the different numerical techniques described in the aforementioned studies on a variety of test problems clearly shows the superiority of Fehlberg's formula. That is, on each of the test problems, the chosen Fehlberg formula is able to achieve a given accuracy in less computer time than any of the other techniques tested. Also, the computer program for the chosen Fehlberg formula is less complex and easier to use than the computer programs for most of the other techniques. To illustrate the use of the chosen Fehlberg formula, a computer listing of its application to several example problems is included along with a sample of the computer output from these applications.

TM X-64782 June 1974

Recording and Cataloging Hazards Information. Revision A. Richard J. Stein. Safety and Manned Flight Awareness Office. N73-31918

Investigating and reporting of accidents is basically a data collection process whose purpose is to discern causation factors of accidents. These factors, once known, lead, in turn, to either the establishment of boundaries or controls aimed at mitigating accident effects or eliminating accidents altogether. A procedure is herein proposed that suggests a discipline approach to hazard identification based on energy interrelationships together with an integrated control technique which takes the form of checklists.

TM X-64783 September 1973

Flammability of Materials in Gaseous Oxygen Enviornments. C. F. Key, J. G. Austin, J. W. Bransford. Astronautics Laboratory. N73-33081

The results of evaluation of a wide variety of materials and configurations to determine their flammability characteristics in gaseous oxygen environments are reported. The data in this report are compiled to enable the designer to select materials applications that will meet the flammability requirements of MSFC SPEC 101B.

TM X-64784 September 19, 1973

Natural Environment Criteria for the NASA High Energy Astronomy Observatory (HEAO). Lewis E. Andrews. Aero-Astrodynamics Laboratory. N73-33807

This document provides environment criteria for the NASA High Energy

Astronomy Observatory (HEAO) Program. Information in selected disciplinary areas is given for the region of space that is within 1000 km from the earth's surface. This report supersedes NASA TM X-64576, "Natural Environment Criteria Guidelines for the HEAO," dated March 25, 1971.

TM X-64785 September 18, 1973

Binary Selectable Detector Holdoff Circuit: Design, Testing, and Application. K. A. Kadrmas. Aero-Astrodynamics Laboratory. N74-10501

A very high speed switching circuit, part of a laser radar data acquisition system, has been designed and tested. The primary function of this circuit was to provide computer controlled switching of photodiode detector preamplifier power supply voltages, typically less than ±20 volts, in approximately 10 nanoseconds. Thus, in actual use, detector and/or detector preamplifier damage can be avoided as a result of sudden extremely large values of backscattered radiation being detected, such as might be due to short range, very thin atmospheric dust layers. Switching of the power supply voltages was chosen over direct switching of the photodoide detector input to the preamplifier, based on system noise considerations. Also, the circuit provides a synchronized trigger pulse output for triggering devices such as the Biomation Model 8100 100 MHz analog to digital converter.

A point by point description of the circuit operation is presented, with actual signal waveforms shown. In addition, printed circuit board layouts and a parts listing are given to assist implementation of the circuit by interested individuals.

Finally, further applications of this device are discussed and summarized.

TM X-64786 May 23, 1973

The Development of a Two-Component Force Dynamometer and Tool Control System for Dynamic Machine Tool Research. Ian Alexander Sutherland. Process Engineering Laboratory. N73-33371

The increasing demands for higher production rates necessitate a deeper knowledge of the metal cutting process under dynamic machining conditions.

This work describes the successful development of a tooling system that makes a controlled sinusoidal oscillation, simulating a dynamic chip removal condition, and measures the machining forces in two mutually perpendicular directions without any cross sensitivity.

TM X-64787 September 1973

A Survey of Integrated Optics with Bibliography. Robert B. Owen. Astrionics Laboratory. N73-33641

A brief survey of the field of integrated optics is made. Light coupling into films, modulation of light propagating in films, and current integrated optics developments and devices are discussed. It is concluded that one can expect integrated optics technology to revolutionize the electronics industry as completely as did microcircuit technology. An extensive bibliography for the field of integrated optics is included in this report.

TM X-64788 October 1973

ATM C&D Panel/EREP Cooling System Contamination Problem. James G. Williamson. Astronautics Laboratory. N74-10792

This report presents the history of a preflight contamination problem that occurred in the ATM C&D Panel/EREP Cooling System on the Skylab, the studies that were made by the Materials Division to determine the cause of the problem, and corrective actions that were made prior to lift-off.

The results of all the observations, analyses and laboratory testing indicated that the contamination came from one or more of the EREP Tape Recorder coldplates and was caused by some abnormal electrolytic action, either during bench testing or in the spacecraft. Studies indicate that no such electrolytic action is likely to occur under normal operating conditions.

TM X-64789 July 1973

Design Guidelines for Use of Adhesives in Hybrid Microcircuits. Salvadore V. Caruso, K. L. Perkins, and J. J. Licari. Astrionics Laboratory. N74-10226

Although it is generally accepted that the use of adhesives in the assembly of hybrid microcircuits offers advantages over other bonding methods, there currently does not exist a set of guidelines for the selection of adhesives which will insure that hybrid microcircuits assembled with them will meet the long use-life, high-reliability requirements of electronic equipment for space applications. This study was directed to the identification of the properties of electrically insulative adhesives that potentially could cause problems in such an application, and to the development of evaluation tests to quantify these properties and thus form the basis for establishing suitable guidelines and, ultimately, specifications. Bond strength, outgassing after cure, and corrosivity were selected for detailed attention since they are considered to be especially critical.

Introductory discussion includes enumeration and brief comments on the properties of adhesives considered to be important for the proposed application, a general review of polymeric types of adhesives, and identification of the major types of adhesives commercially available and specifically designed for microelectronic use. The specific tests developed to evaluate bond strength, outgassing after cure, and corrosivity are discussed in detail, and comparative results obtained for selected adhesives representative of the major types are given.

TM X-64790 August 24, 1973

A Reactive Torque Control Law for Gyroscopically Controlled Space Vehicles. John E. Farmer. Astrionics Laboratory. N74-10419

This report develops a method of control based on the reactive torques as seen by the individual CMG gimbals. The application of a torque to the gimbal of a CMG rotates the momentum vector and applies a torque to the spacecraft according to well-known laws. The response (rotation) of the vehicle produces a reverse or reaction torque opposing the torque producing the gimbal movement. The reactive torque and the pseudoinverse control schemes are contrasted in order to point out the simplicity of the first method. Simulation was performed only to the extent necessary to prove that reactive torque stabilization and control is feasible.

TM X-64791 November 1973

Low Temperature Mechanical Properties, Fractographic & Metallographic Evaluation of Several Alloy Steels. J. W. Montano. Astronautics Laboratory. N74-10530

This report presents the mechanical properties of alloy steels, 4130, 4140, 4340, 6150, and 8740. Test specimens were manufactured from approximately 1.00 inch (2.54 cm) diameter bar stock which had been heat treated to two different hardness levels, (Rockwell C-30 and Rockwell C-40).

The following mechanical tests were performed at temperatures of 80°F (+26.7°C), 0°F (-17.8°C), -100°F (-73°C), and -200°F (-129°C):

1. Tensile test (Ultimate yield, modulus, elongation, and reduction of area)
2. Notched Tensile Test
3. Charpy V-Notched Impact Test (Impact Energy)
4. Double Shear Strength Test (Ultimate and Yield).

The test data indicate excellent tensile strength, notched/unnotched tensile ratios, ductility, impact, and shear properties at all test temperatures, except at -200°F (-129°C) where the impact strength of the higher strength group of alloy steels, 4130 (Rc-37) and 4140 (Rc-44) decreased to approximately 9 ft-lb (12 joules) and 6 ft-lb (8 joules), respectively.

Chemical, metallographic, and fractographic analyses were also performed to evaluate microstructure, microhardness and the effect of decrease in temperature on the ductile to brittle failure transition.

TM X-64792 November 1973

A Survey of Mass Analyzers. W. Walding Moore, Jr., and Philip W. Tashbar. Space Sciences Laboratory. N74-11289

With the increasing applications of mass spectrometry technology to diverse services areas, a need has developed for a consolidated survey of the essential characteristics and features of the various instruments and techniques. This report is one approach to satisfying this need. Information has been collected and consolidated into a format which includes for each approach: (1) a general technique description, (2) instrument features information, and (3) a summary of pertinent advantages and disadvantages. With this information, the potential mass spectrometer user should be able to more efficiently select the most appropriate instrument.

TM X-64793 December 6, 1973

A Brief Description of an Earth Resources Technology Satellite (ERTS) Computer Data Analysis and Management Program. Robert R. Jayroe, Jr. Aero-Astrodynamics Laboratory. N74-12165

This report describes a data analysis and management procedure currently being used at Marshall Space Flight Center to analyze ERTS digital data. The objective of the report is to acquaint potential users with the various computer programs that are available for analysis of multispectral digital imagery and to show how these programs are used in the overall data management plan. The report contains a brief description of each computer routine, and references are provided for obtaining more detailed information.

TM X-64794 October 15, 1973
Column Densities Resulting From Shuttle Sublimator/Evaporator Operation. Robert J. Naumann. Space Sciences Laboratory. N74-11848

The proposed disposal of H_2O from the Shuttle fuel cell operation by ejecting it in vapor form through a supersonic nozzle at the rate of 100 lb/day has been investigated from the point of view of the possible interference to astronomical experiments. If the nozzle is located at the tail and directed along the Shuttle longitudinal axis, the resulting column density will be less than 10^{12} molecules/cm^2 at viewing angles larger than 48 deg above the longitudinal axis. The molecules in the trail will diffuse rapidly. The column density contribution from molecules expelled on the previous orbit is 1.3×10^8 molecules/cm^2. This contribution diminishes by the inverse square root of the number of orbits since the molecules were expelled. Summing the contributions from each orbit over a 30-day mission results in a maximum column density of 5×10^9 molecules/cm^2 along a perpendicular to the flight path. The maximum return flux from water molecule buildup along the flight path is 2.2×10^9 molecules/cm^2/sec at the stagnation point.

The molecular backscatter from atmospheric molecules is also calculated. If the plume is directed into the flight path, the column density along a perpendicular is found to be 1.5×10^{11} molecules/cm^2. The return flux is estimated to be of the order of 10^{12} molecules/cm^2/sec at the stagnation point. With reasonable care in design of experiments to protect them from the backscatter flux of water molecules, the expulsion of 100 lb/day does not appear to create an insurmountable difficulty for the Shuttle experiments.

TM X-64795 November 19, 1973
Distributions of Eight Meteorological Variables at Cape Kennedy, Florida and Vandenberg Air Force Base, California. M. E. Graves, R. L. King and S. Clark Brown. Aero-Astrodynamics Laboratory. N74-13325

Extreme values, median values, and nine percentile values are tabulated for eight meteorological variables at Cape Kennedy, Florida and at Vandenberg Air Force Base, California. The variables are temperature, dew point temperature, relative humidity, station pressure, water vapor pressure, water vapor mixing ratio, density, and enthalpy. For each month eight hours are tabulated, namely, 0100, 0400, 0700, 1000, 1300, 1600, 1900, and 2200 local time. These statistics are intended for general use for the Space Shuttle design trade-off analysis and are not to be used for specific design values. Appropriate documents, e.g., Appendix 10.10, Volume X, Space Shuttle Design Requirements, JSC Doc. No. 07700 and NASA TM X-64757 shall be used for specific natural design requirements data for the Space Shuttle.

TM X-64796 December 5, 1973
Summary of Atmospheric Data Observations for 155 Flights of MSFC/ABMA Related Aerospace Vehicles. D. L. Johnson. Aero-Astrodynamics Laboratory. N74-13312

A summary of selected atmospheric conditions observed near launch time for 155 NASA-Marshall Space Flight Center and Army Ballistic Missile Agency related vehicles, launched primarily from Cape Kennedy, Florida, between August 20, 1953, and November 16, 1973, is presented. Values of ambient pressure, temperature, relative

humidity, ground winds, visual observations, density aloft, and wind/wind shear aloft are included. The extremes of these parameters are listed for each type of launch vehicle.

This summary of atmospheric conditions at launch for the various vehicles is not meant to imply that this is the range of atmospheric conditions which may occur at the launch site. These were basically R and D type vehicles and an "operational" deployed vehicle might encounter a larger range (variation) of atmospheric conditions. It should be noted that the atmospheric conditions at launch for these vehicles were closely monitored during the prelaunch period. Adverse weather conditions were deliberately avoided based on trend indications, prediction of probably T-0 conditions and real time measurements.

This report supersedes "Selected Atmospheric Observations for 101 Consecutive Flight Tests of the Redstone, Jupiter and Pershing Missiles," NASA MTP-AERO-60-14, December 19, 1960.

TM X-64797 December 26, 1973
Metabolic Analyzer. Cortes L. Perry. Astronautics Laboratory. N74-13819

This is a description of an apparatus for the measurement of metabolic rate and breathing dynamics in which inhaled and exhaled breath are sensed by sealed, piston-displacement type spirometers. These spirometers electrically measure the volume of inhaled and exhaled breath. A mass spectrometer analyzes simultaneously for oxygen, carbon dioxide, nitrogen and water vapor. Computation circuits responsive to the outputs of the spirometers, mass spectrometer, temperature, pressure and timing signals compute oxygen consumption, carbon dioxide production, minute volume and respiratory exchange ratio. A selective indicator provides for read-out of these data at predetermined cyclic intervals. The metabolic analyzer, as herein described, is being patented with the author and Dr. John A. Rummel, Environmental Physiology Laboratory, Johnson Space Center as co-inventors. The system has had successful operation during the Skylab missions both on the ground and in flight as part of Skylab Biomedical Experiment M-171, Mr. Edward Michel, of Johnson Space Center, principal investigator.

TM X-64798 January 1974
The October 1973 NASA Mission Model Analysis and Economic Assessment. Program Development. N74-15507

This document presents the results of the 1973 NASA Mission Model Analysis performed by Program Development, Marshall Space Flight Center, under the direction of the Mission and Payload Integration Office of NASA Headquarters. The purpose of this analysis was to obtain an economic assessment of using the Shuttle to accommodate the payloads and requirements as identified by the NASA Program Offices and the DoD.

The 1973 Payload Model represents a baseline candidate set of future payloads which can be used as a reference base for planning purposes. The cost of implementing these payload programs utilizing the capabilities of the Shuttle system is analyzed and compared with the cost of conducting the same payload effort using expendable launch vehicles.

There is a net benefit of 14.1 billion dollars as a result of using the Shuttle during the 12-year period as compared to using an expendable launch vehicle fleet.

TM X-64799 January 18, 1974
A Guide for Performing System Safety Analysis. J. M. Brush, R. W. Douglass III, and F. R. Williamson. Martin C. Dorman, ed. Systems/Products Office. N74-14689

This document is a general guide for performing system safety analyses of hardware, software, operations and human elements of an aerospace program. The guide describes a progression of activities that can be effectively applied to identify hazards to personnel and equipment during all periods of system development.

This document describes the general process of performing safety analyses; setting forth in a logical order the information and data requirements, the analytical steps and the results. These analyses are the technical basis of a system safety program. Although the guidance established by this document cannot replace human experience and judgement, it does provide a methodical approach to the identification of hazards and evaluation of risks to the system.

TM X-64800 December 12, 1973
Double Scattering Corrections for the Theory of the Sun's Aureole. Adarsh Deepak. Aero-Astrodynamics Laboratory. N74-14497

Double scattering corrections for aureole radiances are calculated by adding the effects of two successive single scatterings. Atmospheric absorption, polarization, and variation of refractive index with altitude are ignored. Corrections due to spherical atmosphere have been taken into account by the use of a generalized Chapman function. Realistic scattering phase functions based upon the Lorenz-Mie theory and model altitude-size distribution are used. The model distribution is assumed to be representable in terms of two separable particulate components. We find that for a moderately clear day, $\tau(0) \cong 0.5$, and for forward scattering angles, the Radiance, B_2, due to double scattering is less than 6 percent of that due to single scattering.

TM X-64801 January 23, 1974
Notes for the Improvement of the Spatial and Spectral Data Classification Method. Charles C. Dalton. Aero-Astrodynamics Laboratory. N74-15058

This report examines the "Spatial and Spectral Clustering" technique for the unsupervised automatic classification and mapping of earth resources satellite data, and makes theoretical analysis of the decision rules and tests in order to suggest how the method might best be applied to other flight data such as Skylab and Spacelab.

TM X-64802 January 1974
The October 1973 NASA Mission Model Cost and Economic Analysis. Program Development. X74-71302

This document presents the cost and economic results of The October 1973 NASA Mission Model Cost and Economic Analysis performed by the Program Development Directorate, Marshall Space Flight Center, under the direction of the mission and Payload Integration Office of NASA

Headquarters. The purpose of this analysis was to obtain an economic assessment of using the Shuttle to accommodate the payloads and requirements as identified by the NASA Program Offices and the DoD.

The 1973 Payload Model represents a baseline candidate set of future payloads which can be used as a reference base for planning purposes. The cost of implementing these payload programs utilizing the capabilities of the Shuttle system is analyzed and compared with the cost of conducting the same payload effort using Expendable Launch Vehicles.

There is a net benefit of $14.1 billion as a result of using Shuttle during the 12-year period as compared to using an Expendable Launch Vehicle fleet.

TM,X-64803 February 12, 1974
Remote Sensing in Agriculture. Sanford W. Downs, Jr. Astrionics Laboratory.
N74-18040

The purpose of this report is to show some examples of the use of remote sensing in cultivated crops, forestry, and range management. It is not the intent to show all the uses of remote sensing, but rather to illustrate what can be done and is being done in a few selected areas. These are the determination of crop areas and types, prediction of yield, and detection of disease; the determination of forest areas and types, timber volume estimation, detection of insect and disease attack, and forest fires; and the determination of range conditions and inventory, and livestock inventory. This is done by summarizing articles in the literature and giving specific examples of work being performed at the Marshall Space Flight Center. No attempt has been made to provide an extensive bibliography. Although remote sensing includes photography, radar, infrared scanners, television, and passive microwave receivers, this report is confined primarily to aerial photographs and photo-like ERTS images.

TM X-64804 November 16, 1973
Diffusion from a Line Source. Rowland E. Burns. Aero-Astrodynamics Laboratory. N74-17333

The problem with predicting pollutant diffusion from a line source of arbitrary geometry is treated. The concentration at the line source may be arbitrarily varied with time. Special attention is given to the meteorological inputs which act as boundary conditions for the problem, and a mixing layer of arbitrary depth is assumed. Numerical application of the derived theory indicates the combinations of meteorological parameters that may be expected to result in high pollution concentrations.

TM X-64805 February 13, 1974
Conceptual Design of the Scientific Instrument Arrangement for the Large Space Telescope. J. Zurasky and D. Korsch. Astrionics Laboratory.
N74-16112

This report documents the work of the Astrionics Laboratory, Technology and Electromechanical Engineering Divisions (S&E-ASTR-R and M), at the Marshall Space Flight Center in support of the Large Space Telescope Working Group (LSTWG). A

description of the Scientific Instrument arrangement for the Large Space Telescope (LST) is given, with some of the rationale for selecting this concept. The first section of this report, entitled Initial Design, describes the basic configuration and was designed for an f/20 telescope focal plane. The subsequent LSTWG meeting held in November gave some redirection to the scientific requirements, and these changes are described in the section, Configuration Update.

TM X-64806 February 14, 1974
Large Space Telescope (LST) Pointing Control System (PCS) Analytical Advanced Technical Development (ATD) Program. Sherman M. Seltzer. Astrionics Laboratory. N74-17165

The purpose of this memorandum is to describe the Large Space Telescope (LST) Pointing Control System (PCS) Advanced Technical Development (ATD) program. The approach used is to describe the overall PCS development effort, showing how the analytical ATD program elements fit into it. Then the analytical ATD program elements are summarized (although alluded to summarily in the introduction and several times in the body of this memorandum, the hardware development portion of the ATD program is omitted). If only the list of ATD program elements were presented and described, the program would appear disjointed. However, by showing how these program elements fit into the overall PCS development effort, their connection to the program and their purpose is then evident.

TM X-64807 February 14, 1974
Development of Coatings to Control Electroosmosis in Zero Gravity Electrophoresis. A. C. Krupnick. Astronautics Laboratory. N74-18196

A major problem confronting the operation of free fluid electrophoresis in zero gravity is the control of electrokinetic phenomena and, in particular, electroosmosis. Due to the severity of counter flow, as a result of electroosmosis, the electrical potential (ζ potential) developed at the surface of shear must be maintained at near, or close to, zero millivolts as possible. Based upon this investigation, it has been found that the amount of bound water or the degree of hydroxylation plays a major role in the control of this phenomena. Of necessity, factors, e.g. adhesion, biocompatibility, protein adsorption, and insolubility were considered in this investigation because of the long buffer-coating exposure times required by present space operations. Based upon tests employing microcapillary electrophoresis, it has been found that γ amino propyl trihydroxysilane produced a coating which provides the lowest ζ potential (-3.86 mv) at the surface of shear between the stationary and mobile layers. This coating has been soaked in both borate and saline buffers, up to three months, in a pH range of 6.5 to 10 without deleterious effects or a change in its ability to control electrokinetic effects.

TM X-64810 April 1974
MSFC Skylab Airlock Module. Skylab Program Office.
Vol. I N74-26321
Vol. II N74-26338

This report presents the history and development of the Skylab Airlock Module and the Payload Shroud, NASA Contract No. NAS9-6555, from initial concept through final design, related test programs, mission performance and lessons learned.

Although some problems were encountered, the Airlock Module performed

successfully throughout the three manned Skylab missions.

TM X-64812 April 1974
MSFC Skylab Multiple Docking Adapter. Skylab Program Office.
Vol. I N74-26328
Vol. II N74-26329

This report presents the history of the development of the Skylab Multiple Docking Adapter (MDA), NASA Contract No. NAS8-24000, from initial concept through its final design, related test programs, mission performance, and lessons learned.

The MDA performed with no significant problems throughout the three manned Skylab missions.

TM X-64813 May 1974
MSFC Skylab Orbital Workshop. Skylab Program Office.
Vol. I N74-28328
Vol. II N74-28329
Vol. III N74-28330
Vol. IV N74-28331
Vol. V N74-28332

This report documents and summarizes the results of the Orbital Workshop technical contract including development, verification, mission performance, and conclusions based on program results and experience. The report is published in five (5) volumes.

TM X-64815 June 28, 1974
MSFC Skylab Apollo Telescope Mount Summary Mission Report. A. R. Morse. Skylab Program Office. N74-28311

This report presents a summary of the Apollo Telescope Mount (ATM) performance during the 8.5-month Skylab mission. The report contains a brief description of each ATM system, system performance summaries, discussion of all significant ATM anomalies which occurred during the Skylab mission, and, in an appendix, a summary of the Skylab ATM Calibration Rocket Project (CALROC). The text is supplemented and amplified by photographs, drawings, curves, and tables.

The report shows that the ATM not only met, but exceeded premission performance criteria, and that participation of Man in space for this scientific investigation greatly enhanced the quality and quantity of the data attained.

TM X-64816 March 1974
MSFC Skylab Mission Sequence Evaluation. J. D. Hoverkamp. Skylab Program Office. N74-28317

Planned and actual major Skylab sequences are presented. Off-nominal events are highlighted. Differences between planned and actual events are discussed.

TM X-64817 July 1974
MSFC Skylab APCS Mission Evaluation. W. B. Chubb. Skylab Program Office.

This report offers the results of detailed performance analyses for all Attitude and Pointing Control System in-orbit hardware and software. Performance is compared with requirements, test results, and prelaunch predictions.

A brief history of the Attitude and Pointing Control System evolution leading to the launch configuration is presented. This historical information, as well as a brief physical description of the launch configuration, is included as an aid to a clear understanding of mission performance.

In conclusion, the report asserts that the Attitude Pointing and Control System satisfied all imposed requirements. Conclusions based upon flight data analysis offer insights which may be beneficial during early concept and design requirement stages of future spacecraft systems.

TM X-64818 June 1974

MSFC Skylab Electrical Power Systems Mission Evaluation. A. P. Woosley. Skylab Program Office.

Planned and actual major Electrical and Caution and Warning Performance is presented. Off-nominal events are highlighted. Differences between planned and actual events are discussed.

TM X-64819 June 1974

MSFC Skylab Instrumentation and Communication System Mission Evaluation. B. M. Adair. Skylab Program Office.

This report presents an evaluation of the in-orbit performance of the Instrumentation and Communications Systems. Performance is compared with functional requirements and the fidelity of communications.

In-orbit performance includes processing engineering, scientific, experiment, and biomedical data, implementing ground-generated commands, audio and video communication, generating rendezvous ranging information and radio frequency transmission and reception.

A brief history of the system evolution based on the functional requirements along with a physical description of the launch configuration is included as an aid to a clear understanding of the System performance.

In conclusion, the report affirms that the Instrumentation and Communication Systems satisfied all imposed requirements. Recommendations are offered which may be beneficial to future space programs.

TM X-64821 June 2974

MSFC Skylab Apollo Telescope Mount Experiment Systems Mission Evaluation. A. F. White, Jr. ATM Experiments Branch. N74-28318

This report presents a detailed evaluation of the Skylab Apollo Telescope Mount (ATM) experiments performance throughout the eight and one-half month Skylab Mission. Descriptions and the objectives of each instrument are included. Also included is a discussion of the anomalies experienced, the causes, and corrective actions taken. Conclusions, based on evaluation of the performance of each instrument, are presented. Examples of the scientific data obtained, as well as a discussion of the quality and quantity of the data, are presented. This report shows that the ATM instruments, individually larger and more complex than any previous instruments flown on satellites, surpassed all performance expectations. In many cases the instruments greatly exceeded their design operating life. The spatial resolution of each instrument was an order of

magnitude better than any similar instrument flown on previous satellites. This report also shows that, as never before, it was possible to simultaneously collect multispectral data of specific solar phenomena. This report clearly demonstrates the major advantage of Man to point the instruments precisely at small targets and immediately react to unpredictable events. As a result of the data obtained by the ATM instruments, many theories of solar physics will undergo significant revisions.

TM X-64826 May 1974
MSFC Skylab Contamination Control Systems Mission Evaluation. Skylab Program Office. N74-26335

Cluster external contamination control evaluation was made throughout the Skylab Mission. This evaluation indicated that contamination control measures instigated during the design, development, and operational phases of this program were adequate to reduce the general contamination environment external to the Cluster below the threshold sensitivity levels for experiments and affected subsystems specified by Principal Investigators (PIs) and Technical Discipline Managers (TDMs) except for anomalous conditions.

Launch and orbit contamination control features included eliminating certain vents, rerouting vents for minimum contamination impact, establishing filters, incorporating materials with minimum outgassing characteristics and developing operational constraints and mission rules to minimize contamination effects.

Prior to the launch of Skylab, contamination control math models were developed which were used to predict Cluster surface deposition and background brightness levels throughout the mission.

The report summarizes the Skylab system and experiment contamination control evaluation. The Cluster systems and experiments evaluated include Induced Atmosphere, Corollary and ATM Experiments, Thermal Control Surfaces, Solar Array Systems, Windows, and Star Tracker.

TM X-64827 March 1974
Spacelab Phase B Study Environmental Control System Component Handbook. R. A. Burns and A. J. Ignatonis. Astronautics Laboratory. N74-18512

This document contains descriptions of candidate components for the Phase B Study of the Spacelab Environmental Control System. Most of the hardware was defined for the baseline ECS design concept. A low cost design approach was followed, with most of the components being selected from the Apollo and Skylab Programs.

TM X-64828 February 14, 1974
Spacelab Soft Mockup Comparative Evaluation. Harry Watters. Astronautics Laboratory. N74-20537

An assessment of two proposed Spacelab configurations with diameters of 14 and 12 feet was conducted by using two inexpensive wooden mockups containing cardboard fixtures. Also examined was an alternate mounting arrangement for the 12-foot diameter configuration, taking advantage of conforming equipment racks to the cylinder walls. A volume comparison of the three configurations was made using a life sciences payload which is considered to be one of the more voluminous payloads. As a result of the

study, it was found that crew volume in the 12-foot baseline configuration appeared marginal for the life sciences payload, especially where crewmen were engaged in activities with competing demands. It was also found that the 12-foot configurations of life sciences payloads offered little margin for stowage or equipment growth. Increased demands would necessitate longer module lengths. Similar results could be expected with other large volume payloads.

TM X-64829 March 1974

A Solution to the Problem of Optimizing the Fuel Bias for a Liquid Propellant Rocket by an Application of the Central Limit Theorem. William Viera, Jr. Astronautics Laboratory. N74-18393

This paper presents an accurate and efficient method of determining the fuel bias for a bipropellant liquid rocket that minimizes outage associated penalties on payload potential. A fuel bias so derived is normally called "the optimum fuel bias."

TM X-64830 January 1974

An Investigation of Chatter and Tool Wear When Machining Titanium. Ian A. Sutherland. Process Engineering Laboratory. N74-18130

The low thermal conductivity of titanium, together with the low contact area between chip and tool and the unusually high chip velocities, gives rise to high tool tip temperatures and accelerated tool wear. Machining speeds have to be considerably reduced to avoid these high temperatures with a consequential loss of productivity. Restoring this lost productivity involves increasing other machining variables, such as feed and depth-of-cut, and can lead to another machining problem – namely, machine tool instability – more commonly known as chatter.

The object of this work is to acquaint the reader with these problems, to examine the variables that may be encountered when machining a material like titanium, and to advise the machine tool user on how to maximize the output from the machines and tooling available to him.

Recommendations are made on ways of improving machining tolerances, reducing machine tool instability or chatter, and improving productivity. New tool materials, tool coatings, and coolants are reviewed and their relevance examined when machining titanium.

Finally this report can be used as a guide to the reader who is interested in setting up a program of machine tool research.

TM X-64831 December 1973

The George C. Marshall Space Flight Center High Reynolds Number Wind Tunnel Technical Handbook. H. S. Gwin. Aero-Astrodynamics Laboratory. N74-19890

This report is a description of the High Reynolds Number Wind Tunnel at the George C. Marshall Space Flight Center and is a handbook for the potential user who may not be familiar with its operation. The following items are presented to illustrate the operation and capabilities of the facility: facility description and specifications, operational and performance characteristics, model design

criteria, instrumentation and data recording equipment, data processing and presentation, and preliminary test information required.

TM X-64832 March 1974
MSFC Sortie Lab Environmental Control System (ECS) Phase B Design Study Results. A. J. Ignatonis and K. L. Mitchell. Astronautics Laboratory.
N74-20545

Phase B effort of the Sortie Lab program has been concluded. Included herein are the results of that effort which pertains to the definitions of the environmental control system (ECS). Numerous design studies were performed in Phase B to investigate system feasibility, complexity, weight, and cost. The results and methods employed for these design studies are included.

The study has resulted in an autonomous Sortie Lab ECS, utilizing a deployed space radiator. Total system weight was projected to be 1814.4 kg (4000 lbs) including the radiator and fluids. ECS power requirements were estimated at 950 watts.

TM X-64833 February 21,1974
CMG-Induced LST Dynamics. Sherman M. Seltzer. Astrionics Laboratory.
N74-22110

The nature of the control moment gyroscope (CMG) output gimbal bearing friction has been the subject of many discussions and presentations by various investigators. It is important to know the precise nature of the torque caused by the bearing friction so that its effect on the dynamic behavior of the Large Space Telescope (LST) and its pointing and control system (PCS) can be predicted. The objective of the analysis and supporting computer simulations reported herein is to study the effect of the assumed CMG nonlinearity upon the system dynamics in order to develop an understanding of the nature and effect of variations of numerical values of parameters upon the system. The weakness of the mathematical analysis used results from the need to restrict the complexity of the model studied; however, the design insight obtained is valuable. The importance of mathematical analysis as a supplement to computer simulations is stressed. Reference is made to several current examples where sole reliance on computer simulation has led to erroneous conclusions. For one particular LST model, several digital simulation efforts reported led to the erroneous conclusion that vehicle dynamics were resulting in limit cycle behavior.

TM X-64834 February 1974
Auger Measurements on T-027 Samples Exposed During the Skylab 2 Mission. Palmer N. Peters. Space Sciences Laboratory.
N74-21362

Auger electron spectroscopy measurements performed on samples flown on Skylab 2 indicate a low rate of deposition of permanent, continuous-film contamination on nickel and gold surfaces positioned on the antisolar side of the spacecraft. These measurements and supportive evidence indicate that for the particular locations and orientations of these samples permanent films of less than 3 nm (30 Å) thickness were deposited during an exposure of 40 hours at a temperature of approximately -32°C.

TM X-64835 March 1974

Skylab III and IV Science Demonstrations Preliminary Report. Tommy C. Bannister. Space Sciences Laboratory. N74-22488

Twelve Marshall Space Flight science demonstrations were accomplished on the Skylab III and IV missions. These were defined in response to crew requests for time-gap fillers and were designed to be accomplished using onboard equipment. Nine of these demonstrations were in the area of materials science and space processing. The following 12 are described and the preliminary results are given:

Skylab III: Diffusion in Liquids (No number), Ice Melting (No number).

Skylab IV: Liquid Floating Zone (TV 101), Immiscible Liquids (TV 102), Liquid Films (TV 103), Gyroscope (TV 104), Rochelle Salt Growth (TV 105), Deposition of Silver Crystals (TV 106), Fluid Mechanics Series (TV 107), Neutron Environment (TV 108), Orbital Mechanics (TV 110), Charged Particle Mobility (TV 117).

TM X-64836 November 1973

Asymptotic Solution to the Tangential Low Thrust Energy Increase Trajectory. Klaus J. Schwenzfeger. Aero-Astrodynamics Laboratory. N74-21433

An approximate analytic solution to the low-thrust constant acceleration energy increase trajectory using a tangential steering program is presented. The solution is based on a two-variable asymptotic expansion of the equations of motion formulated in regularized variables. The high accuracy of the second order solution derived is demonstrated by comparing it with numerically integrated trajectories.

TM X-64837 April 1974

Stress Corrosion Cracking Susceptibility of 18 Ni Maraging Steel. T. S. Humphries and Eli E. Nelson. Astronautics Laboratory. N74-21136

The stress corrosion cracking (SCC) resistance of 18 Ni maraging steel (grades 200, 250, 300, and 350) has been determined in 3.5 percent salt (NaCl) solution, synthetic sea water, high humidity, and outside MSFC atmosphere. All grades of the maraging steel were found to be susceptible to SCC in varying degrees according to their strengths, with the lowest strength steel (grade 200) being the least susceptible and the highest strength steel (grade 350), the most susceptible to SCC.

The SCC resistance of 250 grade maraging steel was also evaluated in salt and salt-chromate solutions using fracture mechanics techniques. The threshold value, K_{ISCC}, was found to be approximately 44 $MN/m^2\sqrt{m}$ (40 $ksi\sqrt{in.}$) or 40 percent of the K_Q value.

TM X-64838 February 21, 1974

A Stokes' Velocity Photographic Method for Measuring the Size Distribution of Aerosols. Adarsh Deepak. Aero-Astrodynamics Laboratory. N74-22344

Aerosol particles are allowed to settle in a vertical glass-walled vessel, and their settling velocity is determined by photographing them

while the light entering the camera is being chopped at a known rate. The settling velocity (V_s) of each particle can be determined from the photographs, and by applying the Stokes' law, one can calculate the radius (r) of each particle. The Stokes' law for a sphere (specific gravity ρ_p) settling freely in a quiet medium (specific gravity ρ_m and viscosity η_m) is given by the relation, $v_s = 2(\rho_p - \rho_m)\ g\ r^2/9\ \eta_m$, where g is the acceleration due to gravity. If the volume of the photographed region of the illumination is known, one can obtain the aerosol number density and size distribution. Experiments with alumina particles of given size distributions indicate that the method works accurately for aerosols with diameters $\gtrsim 2.0\ \mu m$ [or $> 2\ (4/\rho_p)^{1/2}$ for particles with specific gravity ρ_p]. One set of a typical experiment with 3.0-μm Al_2O_3 particles is presented, which shows that the measured size distribution peaks at approximately 3.0 μm. The precise error limits have not been established thus far.

TM X-64839 May 1, 1974

Retention and Application of Skylab Experiment Experiences To Future Programs. Nancy Milly and Victor G. Gillespie. Quality and Reliability Assurance Laboratory. N74-22474

This document has been prepared to consolidate into one listing certain outstanding problems encountered on Skylab Experiments in order that these experiences and associated recommendations might help to prevent similar problems on future programs. The criteria for selection of the data to be utilized in this document was to identify the problem areas within the Skylab Program which it was felt would be of major significance with respect to future programs. Also, the problem had to be unique in that it would help identify to a designer/manufacturer an unforeseen or unanticipated occurrence which could cause failures, delays, or additional cost. This would not include the multitude of run-of-the mill anomalies which are normally encountered in the design, manufacture and test of an aerospace experiment system. This document addresses only those unexpected problems that may occur due to the nature of aerospace experiment environmental and operational requirements.

TM X-64840 January 1974

Vehicle Misalignment Prediction and Vehicle/Experiment Pointing Compatibility Assessment. J. D. Hoverkamp. Astronautics Laboratory. N74-23199

A technique for predicting vehicle misalignment, the relationship of vehicle misalignment to the total vehicle/experiment integration effort, and the methodology used in performing a vehicle/experiment pointing compatibility assessment, are presented. The technique is demonstrated in detail by describing how it was used on the Skylab Program.

TM X-64841 February 18, 1974

SSME/Side Loads Analysis for Flight Configuration. Wayne Holland and John Harbison. Astronautics Laboratory. N74-22509

This document describes the statistical loads analysis for the Space Shuttle Main Engine (SSME) due to transient flow separation during ignition. The salient features of the analysis and the dynamic responses (loads and accelerations) of the engine are summarized. The results are based upon a

preliminary structural model of the engine and its support structure. This analysis will be updated to include an active thrust vector control system and the most current representation of the engine and support structure backup models.

TM X-64842 February 1, 1974
Spectral Irradiance Curve Calculations for Any Type of Solar Eclipse. Adarsh Deepak and J. E. Merrill. Aero-Astrodynamics Laboratory. N74-26266

This paper describes a simple procedure for calculating the eclipse function (EF),α, and hence the spectral irradiance curve (SIC), $(1-\alpha)$, for any type of solar eclipse: namely, the occultation (partial/total) eclipse and the transit (partial/annular) eclipse. The SIC (or the EF) gives the variation of the amount (or the loss) of solar radiation of a given wavelength reaching a distant observer for various positions of the moon across the sun. The problem of computing the SIC is complicated by the presence of the solar limb-darkening. Our scheme is based on the theory of light curves of eclipsing binaries, the results of which are tabulated in Merrill's Tables, and is valid for all wavelengths for which the solar limb-darkening obeys the cosine law: $J = J_c (1 - x + x \cos \gamma)$. As an example of computing the SIC for an occultation eclipse which may be total, the calculations for the March 7, 1970, eclipse are described in detail. The calculations for the transit eclipses can be carried out in a similar manner.

TM X-64843 April 2, 1973
A Procedure for Calculation of Boundary Layer Trip Protuberances In Over-expanded Rocket Nozzles. Robert H. Schmucker. Astronautics Laboratory. N74-25804

A procedure is described for sizing, scaling, positioning and performance loss calculation of a boundary layer trip protuberance. The theoretical results are compared with some experimental data.

TM X-64845 June 1974
MSFC Skylab Operations Support Summary. James R. Martin. Skylab Programs Office.

The Skylab mission began May 14, 1973, with the launch of SL-1 and ended February 8, 1974, with SL-4 splashdown. During this time, the Huntsville Operations Support Center (HOSC) was the actionee of 1,882 actions in addition to performing daily routine mission support activities. Almost 200 significant problems were identified during the mission that required thorough investigation and in cases hardware modification to be provided for the next manned mission phase.

Approximately 1,400 civil service and contractor personnel had permanent access to the 10,000 square foot HOSC in Building 4663 and three adjacent trailers. All other support was from remote permanent work stations. Around 300 personnel per shift, 3 shifts per day, were in the HOSC during the entire mission.

This operations report is a summary of the actions and problems MSFC encountered, together with procedures and staffing required to provide the mission support role. This report has been prepared as a reference for future operations planning as well as an evaluation report for the Skylab mission.

TM X-64846 May 1974
MSFC Skylab ATM Calibration Rocket Project. Skylab Programs Office. N74-26319

This report provides the National Aeronautics and Space Administration (NASA) Headquarters, Office of Space Science (OSS), Marshall Space Flight Center (MSFC), and other interested agencies, with results of the Apollo Telescope Mount (ATM) Calibration Rocket (CALROC) performances and anomalies encountered. The performance period included six CALROC flights during the Skylab 2, 3 and 4 missions as well as those rocket flights prior to the Skylab mission which carried CALROC hardware for test purposes. Background material such as project purpose, management, launch facilities, booster and payload configuration is included for better understanding of the CALROC payload and its mission objectives.

Three successful calibration flights with the NRL CALROC Scientific Instrument and two successful calibration flights with the HCO CALROC Scientific Instrument were obtained. Both the NRL and HCO data are being processed and the curves and/or data will be available at NRL, HCO or MSFC in late 1974 or early 1975.

Initial calibration data analyses indicate that the data are adequate to excellent and that calibration of the Skylab ATM solar astronomy data will be successfully achieved.

TM X-64847 May 1974

Orbital Operation for Large Automated Satellites. J. L. Lusk and V. Biro. Mission Operations Office. N74-26320

This preliminary study presents orbital operations concepts for the shuttle launcher Large Automated Satellites (LAS). It includes the orbital operations elements and the major options for accomplishing each element.

This study is based on the preliminary payload information available in Level I and II documents and on orbital operations methods used on past programs, both manned and unmanned. It includes a definition of detailed trade studies which need to be performed as satellite design details and organization responsibilities are defined.

The major objectives of this study were to define operational methods and requirements for the long duration LAS missions which are effective and primarily economical to implement.

TM X-64848 April 1974

Spacelab Data Management Subsystem Phase B. Study. Astrionics Laboratory. N74-26334

The data management subsystem (DMS) integrates the avionics equipment into an operational system by providing the computations, logic, signal flow, and interfaces needed to effectively command, control, monitor, and check out the experiment and subsystem hardware. Also, the DMS collects/retrieves experiment data and other information by recording and by command of the data relay link to ground.

The major elements of the DMS are the computer subsystem, data acquisition and distribution subsystem, controls and display subsystem, onboard checkout subsystem, and software.

This report documents the results of the DMS portion of the Spacelab Phase B Concept Definition Study and defines MSFC's DMS design reference model. The following sections provide a detailed description of the

DMS and its major subsystems. Related studies and trade-offs are presented in the appendices.

TM X-64849 January 1974

An Assessment of Separable Fluid Connector System Parameters to Perform a Connector System Design Optimization Study. Willibald Peter Prasthofer. Astronautics Laboratory. N74-27911

The engineer today is more than ever concerned with the optimum solution to highly complex problems involving numerous, and often conflicting or unspecific demands made by stringent requirements in the areas of environment, cost, materials, performance, date of delivery, reliability, safety, and numerous other constraints imposed upon the designer. In this paper the key to optimization of design where there are a large number of variables, all of which may not be known precisely, lies in the mathematical tool of dynamic programming developed by Bellman. This methodology can lead to optimized solutions to the design of critical systems and in a minimum amount of time even when there are a great number of acceptable configurations to be considered.

To demonstrate the usefulness of dynamic programming, an analytical method is developed for evaluating the relationship among existing numerous connector designs to find that configuration which is best (optimum). The data utilized in the study were generated from the some 900 flanges designed for six subsystems of the S-IB stage of the Saturn IB space carrier vehicle. The algorithm is general enough to be useful in optimizing design and systematizing decision-making in a variety of related technical fields such as aeronuatics, construction, electronics, etc.

TM X-64850 May 30, 1974

System Safety Checklist Skylab Program Report. Skylab Program Office. N74-28344

This document contains over 500 design criteria statements applicable to a wide variety of flight systems, experiments and other payloads, associated ground support equipment and facility support systems. The document reflects a composite of experience gained throughout the aerospace industry prior to Skylab and additional experience gained during the Skylab Program. It has been prepared to provide current and future program organizations with a broad source of safety-related design criteria and to suggest methods for systematic and progressive application of the criteria beginning with preliminary development of design requirements and specifications. Recognizing the users obligation to shape the checklist to his particular needs, a summary of the historical background, rationale, objectives, development and implementation approach, and benefits based on Skylab experience has been included.

TM X-64851 April 1974

Design of a Digital Controller for Spinning Flexible Spacecraft. B. C. Kuo, S. M. Seltzer, G. Singh, and R. A. Yackel. Astrionics Laboratory. N74-26322

A new approach to digital control system design is applied to the analysis and design of a practical onboard digital attitude control system for a class of spinning vehicles characterized by a rigid body and two connected flexible appendages. The approach used is to design a continuous-data control system that will provide a satisfactory system response. Then, using the digital redesign method, a digital controller with onboard

digital computer is designed to provide a digital control system whose states are similar to those of the continuous system at sampling instants. The simplicity of application of this approach is indicated by example. The example, using spinning Skylab parameters, is used to substantiate the conclusions.

TM X-64852 July 1974

Skylab Thruster Attitude Control System. G. E. Wilmer, Jr. Skylab Program Office.

This report documents the preflight activities and the Skylab mission support effort for the Thruster Attitude Control System (TACS). The preflight activities include a description of problems and their solutions encountered in the development, qualification, and flight checkout test programs. The mission support effort is presented as it relates to system performance assessment, real-time problem solving, flight anomalies, and the daily system evaluation. Finally, the detailed flight evaluation is presented for each phase of the mission using system telemetry data.

The report asserts that the TACS met or exceeded design requirements and fulfilled its assigned mission objectives.

TM X-64856 March 1974

Report of the Plasma Physics and Environmental Perturbation Laboratory (PPEPL) Working Groups Volume III – Magnetospheric Experiments Working Group. Program Development.

Vol. I N74-28169
Vol. II N74-28170
Vol. III N74-28171

A number of general studies that have been proposed for the PPEPL-Shuttle program are considered in qualitative detail from both the theoretical and practical points of view. The selection of experimental programs was restricted to those which may be considered active as opposed to refinements of the passive observational programs done previously. It is concluded that, while these new studies were scientifically worthwhile and could be performed in principle, in most cases insufficient attention had been paid to the practical details of the experiments. Several specific areas of study, stressing in particular the practical feasibility of the proposed experiments, are recommended. In addition, recommendations are made for further theoretical study, where appropriate.

TM X-64857 June 1974

A Standard Particle Sizer – Velocimeter. A. Deepak, R. Ozarski, and J. A. L. Thomson. Systems Dynamics Laboratory.

This report describes a standard particle sizer-cum-velocimeter designed and build for the purpose of providing a standard source of aerosols of known size-distribution, moving with a known velocity, for the purpose of calibrating the continuous wave (CW) CO_2 – Laser Doppler Velocimeters at Marshall Space Flight Center. The instrument is designed with the capabilities of: (1) monitoring the size-distribution of particles of diameters larger than 1.0 μm; (2) measuring flow velocities in the range 0.05 - 100.0 cm/sec; (3) photographing particles of diameters above 0.2 μm moving at slow speeds ($\sim$ 0.1 cm/sec); (4) measuring the size-distribution of particles settling in quiet air (or convection velocities

of less than 0.15 cm/sec); (5) use in the laboratory or in the field.

The instrument is made up of the laser scattering counter (LSC) and the photographic system, each of which can function independently or in conjunction for simultaneous monitoring of the same sample of particles. The LSC can be easily modified to operate in two modes: (1) as a forward-scattering particle sizer-counter or (2) as a forward dual-beam velocimeter. The two modes of operation of the LSC are described in detail, though the experimental results of its use as a velocimeter are not reported here.

TM X-64858 May 1974

Charged Particle Radiation Environment for the LST. John W. Watts, Jr., M. O. Burrell, and J. J. Wright. Space Sciences Laboratory. N74-28156

Preliminary charged particle dose rates are presented for the LST orbit. The trapped proton component appears to dominate the total dose for the expected shielding available. Typical dose rates should range from 400 to 800 millirads/day.

TM X-64859 July 1974

Similitude Requirements for Hypersonic, Rarefied, Nonequilibrium Flow. William L. Hendricks. Systems Dynamics Laboratory. N74-27758

Similitude requirements for hypersonic, rarefied flow with nonequilibrium chemistry and vibration are presented. The full Navier-Stokes equations with catalytic or non-catalytic walls and with or without slip conditions are nondimensionalized. The heat transfer coefficient is written in terms of fourteen dimensionless parameters and reduced to four by making the binary scaling assumption. The duplication of blunt and sharp nose heat transfer requires the use of air over a geometrically similar model with the same free stream velocity, wall temperature and product of free stream density and characteristic length. Estimates of this heat transfer coefficient are also presented.

TN D-7211 October 1973

The Effect of Finite Thrust and Heating Constraints on the Synergetic Plane Change Maneuver for a Space Shuttle Orbiter-Class Vehicle. E. D. Dickmanns. Aero-Astrodynamics Laboratory. N73-32759

Numerical solutions to the optimal three-dimensional glide/thrust atmosphere skip maneuver are obtained using the multiple shooting iteration scheme. A singular thrust arc, induced by the heating constraints, is encountered. The synergetic plane change maneuver is shown to be superior to an extra-atmospheric one for 556-km (300-nm) circular orbit plane changes of more than 5 degrees.

TN D-7386 August 1973

Approximations for Neutron Emission Spectra from Proton Collisions between 20 and 500 MeV on Nuclei of $A \geqslant 12$. M. O. Burrell. Space Sciences Laboratory. N73-29825

When high-energy protons from solar proton events or trapped radiation belts impinge on spacecraft structures, secondary particles are emitted. The most pernicious secondaries, from either a biological or physical standpoint, are the cascade and evaporation neutrons because of their reaction with matter leading to radioactive materials in the spacecraft structures. This report presents an empirically determined cascade and evaporation neutron emission spectra for protons of energy between 20 and 500 MeV incident on all meterials at or above carbon in mass number.

TN D-7416 October 1973

Measurements and a Model for Convective Velocities in the Turbulent Boundary Layer. William C. Cliff and Virgil A. Sandborn. Aero-Astrodynamics Laboratory. N74-10319

A physical model is presented which describes convective velocities within a flat plate turbulent boundary layer. A production zone concept similar to that which Kline has reported with his visualization techniques is used as a basis for the physical model. The production zone concept employs the idea that packets of turbulent fluid are generated near the viscous sublayer. These packets are found to be discernible from the mean motion and may move either outward from the production zone or inward depending on their circulation relative to the fluid surrounding the packet. The packets are predicted to travel with a convective velocity different from the local mean velocity throughout most of the boundary layer. The model also predicts that the convective velocities will be functions of wave number outside the production zone.

The model predicts that the convective velocity profile approaches the mean velocity profile after a finite length or time period. After the finite length, the convective velocities are predicted to become independent of wave number. The model predicts that the asymptotic growth of the boundary layer will be a linear function of distance. Experimental results are presented which agree with the predictions of the model.

Correlation concepts are used to measure the convective velocity. Convective velocity as a function of frequency indicates Taylor's hypothesis to be invalid for the turbulent boundary layer.

TN D-7422 December 1973

Multiple Regression Technique for Pth Degree Polynomials With and Without Linear Cross Products. John William Davis. Aero-Astrodynamics Laboratory. N74-14254

A multiple regression technique has been developed by which the nonlinear behavior of specified independent variables can be related to a given dependent variable. The polynomial expression can be of Pth degree and can incorporate N independent variables. Two cases are treated such that mathematical models can be studied both with and without linear cross products. The resulting surface fits can be used to summarize trends for a given phenomenon and provide a mathematical relationship for subsequent analysis.

To implement this technique, separate computer programs have been developed for the case without linear cross products and for the case incorporating such cross products which evaluate the various constants in the model regression equation. In addition, the significance of the estimated regression equation is considered and the standard deviation, the F statistic, the Maximum absolute percent error, and the average of the absolute values of the percent of error evaluated.

The computer programs and their manner of utilization are described. Sample problems are included to illustrate the use and capability of the technique which show the output formats and typical plots comparing computer results to each set of input data.

TN D-7432 November 1973

Optimization of Wave Cancellation in Variable Porosity Transonic Wind Tunnel Flows. John William Davis. Aero-Astrodynamics Laboratory. N74-11097

A technique has been developed which is capable of determining the optimum wall configuration for a variable porosity perforated wall transonic wind tunnel. The technique is based on a mathematical model arrived at by considering the results of theory and past experimental investigations. A performance index was determined as a function of the significant wind tunnel parameters by comparing a formulation of this mathematical model, using MSFC 14 inch Trisonic Wind Tunnel Experimental results, to interference free results. The resulting relationship was then used to determine the combination of wind tunnel parameters which should yield minimum reflected wave interference.

A theoretical development of wall porosity requirements for thick wall inclined hole test sections is included which follows the trends and generally the magnitude of available experimental data. This theory is useful in studying the present variable porosity case, but also should be of value in studies concerning the wave cancellation process for fixed porosity walls.

To implement this optimization procedure a multiple regression technique for Pth degree polynomials is developed to evaluate the mathematical models. This powerful general purpose tool can be used in any scientific endeavor where the process can be measured or for which experimental data exist. Using this regression technique many phenomena can be correlated or suspected laws or relationsips investigated and optimizations determined other than those developed in the course of this study.

TN D-7433 October 1973

Contamination Assessment and Control in Scientific Satellites. Robert J. Naumann. Space Sciences Laboratory. N73-32738

Techniques for assessment and control of the contamination environment for both particulates and condensible vapors in the vicinity of spacecraft are developed. An analysis of the deposition rate on critical surfaces is made considering sources within the line of sight of the surface in question as well as those obscured from the line of sight. The amount of contamination returned by collision with the surrounding atmosphere is estimated. Scattering and absorption from the induced atmosphere of gases and particulates around the spacecraft are estimated. Finally, design techniques developed for Skylab to reduce the contamination environment to an acceptable level are discussed.

TN D-7451 October 1973

An Experimental Investigation of Two-Phase Liquid Oxygen Pumping. Loren A. Gross. Astronautics Laboratory. N73-33747

The results of an experimental program to explore the feasibility of pumping two-phase oxygen (liquid and gas) at the pump inlet are reported. Twenty-one cavitation tests were run on a standard J-2 oxygen pump at the MSFC Components Test Laboratory. All tests were run with liquid oxygen 5 to 10°K above the normal boiling point temperature. During ten tests run at approximately 50 percent of the nominal operating speed, two phase conditions were achieved. Vapor volumes of 40 to 50 percent at the pump inlet were noted before complete pump performance loss. The results are compared to predictions based upon the work of J. A. King. Nine cavitation tests run at the nominal pump speed over a 5°K temperature range showed progressively lower net positive suction head (NPSH) requirements as temperature was increased. Two-phase operation was not achieved. The temperature varying NPSH data were used to calculate thermodynamic effects on NPSH, and the results were compared to existing data.

TN D-7457 October 1973

Round-Off Errors in Cutting Plane Algorithms Based on the Revised Simplex Procedure. John Edd Moore. Aero-Astrodynamics Laboratory. N73-33517

This report statistically analyzes computational round-off errors associated with the cutting plane approach to solving linear integer programming problems. Cutting plane methods require that the inverse of a sequence of matrices be computed. The problem basically reduces to one of minimizing round-off errors in the sequence of inverses. Two procedures for minimizing this problem are presented, and their influence on error accumulation is statistically analyzed. One procedure employs a very small tolerance factor to round computed values to zero. The other procedure is a numerical analysis technique for "reinverting" or improving the approximate inverse of a matrix. The results indicate that round-off accumulation can be effectively minimized by employing a tolerance factor which reflects the number of significant digits carried for each calculation and by applying the reinversion procedure once to each computed inverse. If 18 significant digits plus an exponent are carried for each variable during computations, than a tolerance value of 0.1×10^{-12} is reasonable.

The prerequisite for reading this report is a working knowledge of the simplex method and the revised simplex algorithm in particular.

TN D-7469 November 1973

Lunar Roving Vehicle Navigation System Performance Review. Earnest C. Smith and William C. Mastin. Astrionics Laboratory. N74-11434

The design and operation of the Lunar Roving Vehicle (LRV) navigation system are briefly described. The basis for the premission LRV navigation error analysis is explained and an example included. The real-time mission support operations philosophy is presented. The LRV navigation system operation and accuracy during the lunar missions are evaluated.

TN D-7472 November 1973

Analysis of Axisymmetrical Vibration of a Partially Liquid-Filled Elastic Sphere by the Method of Green's Function. Rudolf F. Glaser. Astronautics Laboratory. N74-12546

The longitudinal dynamic behavior of launch vehicles is largely determined by their huge liquid propellant masses which are spring supported by the elastic tank walls. Throughout much of the powered flight time, these masses constitute a high percentage of the entire vehicle mass and, therefore, may dominate the fundamental modes of the vehicle.

In this report, a spherical container is considered. The analysis is based on a Galerkin approach, in the course of which a second-order differential equation must be solved. The solution has been obtained by the method of Green's function. This method is favorable because it displays the manner in which the analysis can be extended to partially liquid-filled general shells of revolution.

The computer programs currently available for partially liquid-filled propellant tanks are based on the finite element methods and result in analytical models having as many as several hundred degrees of freedom. The method applied in this report results in a model having less than 10 degrees of freedom as can be shown by numerical evaluation. Therefore, it will be possible to analyze propellant tanks using much less computer time with comparable accuracy.

TN D-7500 December 1973

A Fine Pointing System for the Large Space Telescope. Werner O. Schiehlen. Astrionics Laboratory. N74-14507

The large Space Telescope (LST) developed by NASA required ultra-high pointing stability within 0.005 arc sec rms. A fine guidance system is proposed to body-point the entire spacecraft within this limit. The spacecraft is modeled as a rigid body having reaction wheel actuators and subject to gravitational and magnetic disturbance torques. The fine guidance sensor is cluttered with electronic noise. The Disturbance Accommodation Standard deviation Optimal Controller (DASOC) is designed to be optimal with respect to the transient and the steady-state response to noise, whereas the steady-state response to deterministic external torques is exactly zero. Compared with

conventional controllers, the fine guidance system with the DASOC offers as much as a factor of 30 improvement in pointing stability, resulting in an optimal performance of nearly 0.0001 arc sec rms. Thus, the required pointing stability can easily be obtained, and a large margin remains for the compensation of possible deteriorations.

TN D-7508 December 1973

A New Technique for Calculating Reentry Base Heating. James C. S. Meng. Aero-Astrodynamics Laboratory.

N74-13507

The laminar base flow field of a two-dimensional reentry body has been studied by Telenin's method. The flow domain was divided into strips along the x-axis, and the flow variations were represented by Lagrange interpolation polynomials in the transformed vertical coordinate. The complete Navier-Stokes equations were used in the near wake region, and the boundary layer equations were applied elsewhere. The boundary conditions consisted of the flat plate thermal boundary layer in the forebody region and the near wake profile in the downstream region. The resulting two-point boundary value problem of 33 ordinary differential equations was then solved by the multiple shooting method. The reentry body was assumed at zero angle of attack in a Mach 11 free stream with Reynolds number $Re_{\infty,H}$ ranging from 0.8×10^5 to 1.2×10^5. The detailed flow field and thermal environment in the base region are presented in the form of temperature contours, Mach number contours, velocity vectors, pressure distributions, and heat transfer coefficients on the base surface. The maximum heating rate was found on the centerline, and the two-dimensional stagnation point flow solution was adequate to estimate the maximum heating rate so long as the local Reynolds number could be obtained.

TN D-7515 December 1973

A Method of Billing Third Generation Computer Users. Philip N. Anderson and Delano R. Hyter. Computation Laboratory.

Presented in this report is a method for charging users for the processing of their applications on third generation digital computer systems. For background purposes, problems and goals in billing on third generation systems are discussed. Detailed formulas are derived based on expected utilization and computer component cost. These formulas are then applied to a specific computer system (UNIVAC 1108).

The method, although possessing some weaknesses noted herein, is presented as a definite improvement over use of second generation billing methods.

TN D-7590 February 1974

Dynamics and Column Densities of Small Particles Ejected from Spacecraft. Robert J. Naumann. Space Sciences Laboratory.

N74-17539

Trajectories and relative motions of small particles ejected from a spacecraft have been analyzed, and modifications to the clearing times and column densities because of orbital

dynamics have been assessed. It was found that despite the fact that such particles are confined by orbital dynamics to move along similar trajectories with the spacecraft rather than to continue their free expansion, the effect is negligible for viewing angles away from the orbital path. Small particles are rapidly swept away by drag and will not contribute significantly to the column density when viewing along the velocity vector in a 420-km earth orbit. However, substantial increases in column density can result when viewing in a direction opposite to the velocity vector because of drag effects. In the absence of drag, significant column densities can build up both in front of and behind the spacecraft in earth orbit for particles released at a few meters per second. This effect is much less pronounced in lunar orbit because the same release velocity produces a larger orbital perturbation for the particle.

TN D-7591 February 1974

Secondary Electron Background Produced by Heavy Nuclei in a Multiwire Proportional Counter Hodoscope. S. H. Morgan, Jr., J. W. Watts, Jr., H. Schwille, and U. Pollvogt. Space Sciences Laboratory. N74-17526

The secondary electron background produced by heavy nuclei in a multiwire proportional counter hodoscope is calculated using both a simplified and a more complete Monte Carlo model. These results are compared with experimental data from a small multiwire proportional counter hodoscope operated in a 530 MeV/nucleon accelerator beam of nitrogen nuclei. Estimates of the secondary electron background produced by heavy relativistic nuclei are presented along with the detailed results from calculations of energy deposition in the hodoscope counter cells.

TN D-7592 February 1974

Inclusion of Known Integrals in the Optimal Trajectory Problem. Rowland E. Burns. Aero-Astrodynamics Laboratory. N74-16537

The classical problem of determination of the rocket trajectory which minimizes mass expenditure during motion between two points in the field of a single gravitating body is analyzed.

The known integrals of the system are incorporated into the adjoint equations, resulting in a reduction from a seventh-order adjoint system to a third-order adjoint system. The first case which is treated is that of planar motion under specific end conditions. In this case a regularization of the recently derived equations is achieved.

The general three-dimensional case is also reduced from a seventh-order adjoint system to a third-order adjoint system. In this case a regularization has not been found.

TN D-7607 March 1974

Digital Image Registration Method Based Upon Binary Boundary Maps. R. R. Jayroe, J. F. Andrus, and C. W. Campbell. Aero-Astrodynamics Laboratory. N74-19035

A relatively fast method is presented for matching or registering the digital data of imagery from the same ground scene acquired at different times, or from different multispectral images, sensors, or both. In using this method, it is assumed that the digital images can be registered by using translations and rotations only, that the images are of the same scale, and that little or no distortion exists between images. It is further assumed that by working with several local areas of

the image, the rotational effects in the local areas can be neglected. Thus, by treating the misalignments of local areas as translations, it is possible to determine rotational and translational misalignments for a larger portion of the image containing the local areas. This procedure of determining the misalignment and then registering the data according to the misalignment can be repeated until the desired degree of registration is achieved. The method to be presented is based upon the use of binary boundary maps produced from the raw digital imagery rather than the raw digital data.

TN D-7646 June 1974

Reliability-Based Econometrics of Aerospace Structural Systems: Design Criteria and Test Options. Jerrell M. Thomas and S. Hanagud. Astronautics Laboratory.

Several new areas in aerospace structural reliability were investigated. The more significant original contributions were:

1. Development of a decision methodology for selecting a combination of structural tests and structural design factors for aerospace systems on the basis of optimized expected cost. The decision method involves the use of Bayesian statistics and statistical decision theory as exemplified by the work of Pratt, Raiffa, and Schlaifer of the Harvard School of Business Administration.

2. Development of Procedures for obtaining and updating data-based probabilistic strength distributions for aerospace structures when test information is available and for obtaining subjective distributions when data are not available. Techniques used in developing these distributions included:

a. The use of subjective expert opinion obtained through mail questionnaires. Such subjective data were required because observed data were not available for one particular type of testing considered in the optimization procedure. Probabilistic models were derived for analyzing the subjective opinions.

b. Incorporation of new information with prior data through the use of Bayesian statistics. Laboratory test results were used to determine a prior distribution, and flight data were used as new information for revising the prior distribution.

The methodology developed was applied to several typical aerospace structures to illustrate the effect of system characteristics such as value of weight, cost of failure, and cost of testing on the optimum decision.

TN D-7681 May 1974

Test Tesults from a Breadboard Cryogenic Propellant Conditioning Assembly. Henry P. Stinson, Jr. Astronautics Laboratory. N74-23333

Cryogenic auxiliary propulsion systems consist of five major subsystems: propellant tanks, propellant conditioning assemblies, accumulators, propellant distribution systems, and thrustors. The propellant conditioning assembly (PCA) converts low pressure liquid to high pressure gas for use by the thrustors, and is one of the most complex subsystems of the cryogenic propulsion system. The ability to achieve rapid starts and at the same time maintain system control are two critical areas of PCA operation. To investigate these critical areas of operation, a PCA of the general type required was designed, fabricated, and tested using existing hardware. Realistic start times were achieved and system control was maintained at all operating conditions.

TR R-409 September 1973

The Application of Holography as a Real-Time Three-Dimensional Motion Picture Camera. Robert L. Kurtz. Space Sciences Laboratory. N73-31413

A historical introduction to holography is presented, as well as a basic description of sideband holography for stationary objects. A brief theoretical development of both time-dependent and time-independent holography is also provided, along with an analytical and intuitive discussion of a unique holographic arrangement which allows the resolution of front surface detail from an object moving at high speeds. As an application of such a system, a real-time three-dimensional motion picture camera system is discussed and the results of a recent demonstration of the world's first true three-dimensional motion picture are given.

TR R-415 September 1973

Thermotransport in Liquid Aluminum-Copper Alloys. B. N. Bhat. Process Engineering Laboratory. N73-31030

A thermotransport study was made on a series of liquid aluminum-copper alloys which contained from trace amounts to 33 weight percent copper. The samples in the form of narrow capillaries were held in known temperature gradient of thermotransport apparatus until the stationary state was reached. The samples were analyzed for the concentration of copper along the length. Copper was observed to migrate to colder regions in all the samples. The heat of transport, Q*, was determined for each composition from a plot of concentration of copper versus reciprocal absolute temperature. The value of Q* is the highest at trace amounts of copper (4850 cal/gm-atom), but decreases with increasing concentration of copper and levels off to 2550 cal/gm-atom at about 25 weight percent copper. The results are explained on the basis of electron-solute interaction and a gas model of diffusion.

TR R-417 October 1973

Solute Diffusion in Liquid Metals. B. N. Bhat. Process Engineering Laboratory. N73-32032

A gas model of diffusion in liquid metals is presented. In this model, ions of liquid metals are assumed to behave like the molecules in a dense gas. Diffusion coefficient of solute is discussed with reference to its mass, ionic size, and pair potential. The model is applied to the case of solute diffusion in liquid silver. An attempt has been made to predict diffusion coefficients of solutes with reasonable accuracy.

TR R-424 May 1974

Optical Holography Applications for the Zero-g Atmospheric Cloud Physics Laboratory. Robert L. Kurtz. Space Sciences Laboratory. N74-25876

A complete description of holography is provided, both for the time-dependent case of moving scene holography and for the time-independent case of stationary holography. Further, a specific holographic arrangement is proposed for application to the detection of particle size distribution in an atmospheric simulation cloud chamber. In this chamber particle growth rate is investigated; therefore, the proposed holographic system must capture continuous particle motion in real time. Such a system is described.

TR R-426 April 1974

Low Thrust Space Vehicle Trajectory Optimization Using Regularized Variables. K. J. Schwenzfeger. Aero-Astrodynamics Laboratory. N74-20520

Optimizing the trajectory of a low thrust space vehicle usually means solving a nonlinear two point boundary value problem. In general, accuracy requirements necessitate extensive computation times. In celestial mechanics, regularizing transformations of the equations of motion are used to eliminate computational and analytical problems that occur during close approaches to gravitational force centers. It was shown in previous investigations that regularization in the formulation of the trajectory optimization problem may reduce the computation time. In this study, a set of regularized equations describing the optimal trajectory of a continuously thrusting space vehicle is derived. The computational characteristics of the set are investigated and compared to the classical Newtonian unregularized set of equations. The comparison is made for low thrust, minimum time, escape trajectories and numerical calculations of Keplerian orbits. The comparison indicates that in the cases investigated for bad initial guesses of the known boundary values a remarkable reduction in the computation time was achieved. Furthermore, the investigated set of regularized equations shows high numerical stability even for long duration flights and is less sensitive to errors in the guesses of the unknown boundary values.

TR R-430 June 1974

Holographic Nondestructive Tests Performed on Composite Samples of Ceramic-Epoxy-Fiberglass Sandwich Structure. Robert L. Kurtz and H. K. Liu. Space Sciences Laboratory. N74-26367

When a hologram storing more than one wave is illuminated with coherent light, the reconstructed wave fronts interfere with each other or with any other phase-related wave front derived from the illuminating source. This multiple wave front comparison is called holographic interferometry, and its application is called holographic nondestructive testing (HNDT).

The theoretical aspects of HNDT techniques and the sensitivity of the holographic system to the geometrical placement of the optical components are briefly discussed. A unique HNDT system which is mobile and possesses variable sensitivity to stress amplitude is described, and experimental evidence of the application of this system to the testing of the hidden debonds in a ceramic-epoxy-fiberglass structure used for sample testing of the radome of the Pershing missile system is presented.

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Tables for Supersonic Flow of Helium Around Right Circular Cones at Zero Angle of Attack. Joseph L. Sims. Aero-Astrodynamics Laboratory. N73-27807

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