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Compiled by Joyce E. Turner
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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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# FY 1985 Scientific and Technical Reports, Articles, Papers, and Presentations

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**TM-86470** November 1984

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**TM-86471** October 1984

Using a 3-component sinusoidal fit of $R_{\text{MAX}}$ versus sunspot cycle number (where $R_{\text{MAX}}$ is the smoothed sunspot number at cycle maximum) for cycles 8 through 20, considered to be the most reliably known cycles, values of $R_{\text{MAX}}$ are projected for cycles 21 and 22.

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**TM-86472** October 1984

Signal-to-noise ratios for the Wide Field Camera and Planetary Camera of the Space Telescope have been calculated as a function of integration time. Models of the optical systems and CCD detector arrays were used with a 27th visual magnitude point source and a 25th visual magnitude per arc-second$^2$ extended source. A 23rd visual magnitude per arc-second$^2$ background was assumed. The models predicted signal-to-noise ratios of 10 within 4 hours for the point source centered on a single pixel. Signal-to-noise ratios approaching 10 are estimated for approximately 0.25 x 0.25 arc-second areas within the extended source after 10 hours integration.

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**TM-86473** October 1984

The final results of the Drop Tube Solidification of NiAl$_3$ are presented. Problems associated with the utilization of a “dripper” furnace in the drop tube are discussed and the modification of experimental procedures required to achieve results are described. Sample microstructures of drop tube samples are compared with other samples. The dendrite arm spacings of drop tube samples are correlated with the rapid cooling rates.

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**TM-86474** October 1984

A ray-trace modeling of the star-tracker telescope for Gravity Probe has been used to predict the character of the output signal and its sensitivity to fabrication errors. In particular, the impact of the optical subsystem on the requirement of 1 milliarc-second signal linearity over a ±50 milliarc-second range has been examined. Photomultiplier and solid state detector options were considered. Recommendations are made.

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**TM-86475** September 1984

A star-tracker telescope, constructed entirely of fused silica elements optically contacted together, has been proposed to provide submilli-arc-second pointing accuracy for Gravity Probe.
First this report provides a bibliography on optical contacting; the bonding of very flat, highly polished surfaces without the use of adhesives. Then results are presented from preliminary experiments on the strength of optical contacts including a tensile strength test in liquid helium. The report emphasizes the need for further study to verify an optical contacting method for the Gravity Probe star-tracker telescope.

TM-84676 November 1984

The Marshall Space Flight Center conducts research programs in space sciences, materials processing in space, and atmospheric sciences, as well as technology programs in such areas as propulsion, materials, processes, and space power. This Marshall Space Flight Center 1984 Annual Report on Research and Technology contains summaries of the more significant scientific and technical results obtained during FY-84.

TM-86477 August 1984

Trajectory and mission requirement data is presented for Earth-Mars opposition class and conjunction class round trip stopover mission opportunities available during the time period year 2000 to year 2045. The opposition class mission employs the gravitational field of Venus to accelerate the space vehicle on either the outbound or inbound leg. The gravitational field of Venus was used to reduce the propulsion requirement associated with the opposition class mission. Representative space vehicle systems are sized to compare the initial mass required in low Earth orbit of one mission opportunity with another mission opportunity. The interplanetary space vehicle is made up of the spacecraft and the space vehicle acceleration system. The space vehicle acceleration system consists of three propulsion stages. The first propulsion stage performs the Earth escape maneuver, the second stage brakes the spacecraft maneuver into the Mars elliptical orbit and effects the escape maneuver from the Mars elliptical orbit. The third propulsion stage brakes the mission module into an elliptical orbit at Earth return. The interplanetary space vehicle was assumed to be assembled in and depart from the Space Station circular orbit.

TM-86478 October 1984

Presented are selected thermospheric/exospheric global mean and extreme density values computed between 130 and 1100 km altitude. These values were generated from the MSFC/J70 reference orbital atmospheric model using different input conditions of solar flux and geomagnetic index, ranging from low to peak. Typical magnitudes of day-night density changes are presented, as an example, for use in space vehicle orbital analyses.

TM-86479 October 1984

Two electrochemical methods for the determination of hydrogen concentrations in metals are discussed and evaluated. The take-up of hydrogen at a pressure of 5,000 psi by Waspaloy metal was determined experimentally at 24°C. It was found that the metal becomes saturated with hydrogen after an exposure time of about 1 hr. For samples charged with hydrogen at high pressure, most of the hydrogen is contained in the interstitial solid solution of the metal. For electrolytically charged samples, most of the hydrogen is contained as surface and subsurface hydrides. Hydrogen elimination rates were
determined for these two cases, with the rate for electrolytically charged samples being greater by over a factor of two. Theoretical effects of high temperature and pressure on hydrogen take-up and elimination by bare and gold plated Waspaloy metal was considered. The breakthrough point for hydrogen at 5,000 psi, determined experimentally, lies between a gold thickness of 0.0127 mm (0.0005 in.) and 0.0254 mm (0.001 in.) at 24°C.

Electropolishing was found to greatly reduce the uptake of hydrogen at high pressure by Waspaloy metal at 24°C. Possible implications of the results obtained in this study, as they apply to the turbine disk of the Space Shuttle Main Engine, are discussed.

TM-86480 October 1984
An Evaluation of Grease Type Ball Bearing Lubricants Operating in Various Environments (Final Status Report No. 8). E. L. McMurtrey. Materials and Processes Laboratory. N85-11239

Because many future spacecraft or space stations will require mechanisms to operate for long periods of time in environments which are adverse to most bearing lubricants, a series of tests has been completed to evaluate 38 grease-type lubricants in R-4 size bearings in five different environments for a 1-year period. Four repetitions of each test were made to provide statistical samples. These tests were also used to select four lubricants for 5-year tests in selected environments with five repetitions of each test for statistical samples. In this completed program, 172 test sets have been completed. The three 5-year tests in (1) continuous operation and (2) stop operation, with both in vacuum at ambient temperatures, and (3) continuous vacuum operation at 93.3°C have been completed. In both the 1-year and 5-year tests, the best results in all environments have been obtained with a high viscosity index perfluoroalkylpolyether (PFPE) grease.

TM-86482 November 1984

A. C. Nunes, Jr., E. O. Bayless, Jr., and W. A. Wilson. Materials and Processes Laboratory. N85-14115

This report describes progress in the implementation of the Variable Polarity Plasma Arc Welding (VPPAW) process at the External Tank (ET) assembly facility. Design allowable data has been developed for thicknesses up to 1.00 in. More than 24,000 in. of welding on liquid oxygen and liquid hydrogen cylinders has been made without an internal defect.

TM-86483 December 1984
Improving the Spacelab Mass Memory Unit Tape Layout with a Simulation Model. Steven R. Noneman. Systems Analysis and Integration Laboratory. N85-14571

A tape drive called the Mass Memory Unit (MMU) stores software used by Spacelab computers. MMU tape motion must be minimized during typical flight operations to avoid a loss of scientific data. A projection of the tape motion is needed for evaluation of candidate tape layouts. A computer simulation of the scheduled and unscheduled MMU tape accesses is developed for this purpose. This simulation permits evaluations of candidate tape layouts by tracking and summarizing tape movements. The factors that affect tape travel are investigated and a heuristic is developed to find a “good” tape layout. An improved tape layout for Spacelab I is selected after the evaluation of fourteen candidates. The simulation model will provide the ability to determine MMU layouts that substantially decrease the tape travel on future Spacelab flights.

TM-86484 October 1984

This report presents a summary of selected atmospheric conditions observed near Space Shuttle STS-41D launch time on August 30, 1984, at Kennedy Space Center, Florida. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and
winds aloft are included. The sequence of pre-launch Jimsphere measured vertical wind profiles is given in this report. Also presented are wind and thermodynamic parameters representative of surface and aloft conditions in the SRB descent/impact ocean area. Final atmospheric tapes, which consist of wind and thermodynamic parameters versus altitude, for STS-41D vehicle ascent and SRB descent/impact have been constructed. The STS-41D ascent meteorological data tape has been constructed by Marshall Space Flight Center's Atmospheric Sciences Division to provide an internally consistent data set for use in post flight performance assessments.

TM-86486 November 1984

This report presents a summary of selected atmospheric conditions observed near Space Shuttle STS-41G launch time on October 5, 1984, at Kennedy Space Center Florida. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of pre-launch Jimsphere measured vertical wind profiles is given in this report. The final atmospheric tape, which consists of wind and thermodynamic parameters versus altitude, for STS-41G vehicle ascent has been constructed. The STS-41G ascent atmospheric data tape has been constructed by Marshall Space Flight Center's Atmospheric Sciences Division to provide an internally consistent data set for use in post flight performance assessments.

TM-86487 January 1985

The Monodisperse Latex Reactor experiment has flown five times on the space shuttle, with three more flights currently planned. The objective of this project is to manufacture, in the microgravity environment of space, large particle-size monodisperse polystyrene latexes in particle sizes larger and more uniform than can be manufactured on Earth. Historically it has been extremely difficult, if not impossible, to manufacture in quantity very high quality monodisperse latexes on Earth in particle sizes much above several micrometers in diameter due to buoyancy and sedimentation problems during the polymerization reaction. However the MLR project has succeeded in manufacturing in microgravity monodisperse latex particles as large as 30 micrometers in diameter with a standard deviation of 1.4 percent. It is expected that 100 micrometer particles will have been produced by the completion of the three remaining flights.

These tiny, highly uniform latex microspheres have become the “FIRST SPACE PRODUCT,” that is, the first material ever to be commercially marketed that was manufactured in space. The U.S. National Bureau of Standards has certified the first batch of “space latex,” which was transferred to NBS by NASA in July 1984, and they will begin marketing this material in mid-1985 as the U.S. national 10-micrometer Standard Reference Material.

TM-86488 December 1984

This study deals with the numerical implementation of a formulation for a class of interface problems in elastodynamics. This formulation combines the use of the finite element and boundary integral methods to represent the interior and the exterior regions, respectively. In particular, the response of a semicylindrical alluvial valley in a homogeneous halfspace to incident antiplane SH waves is considered to determine the accuracy and convergence of the numerical procedure. Numerical results are obtained for several combinations of the incidence angle, frequency of excitation and relative stiffness between the inclusion and the surrounding halfspace. The results tend to confirm the theoretical estimates, that the convergence is of the order $h^2$ for the piecewise linear elements used. It is also observed that the accuracy decreases as the frequency of excitation increases or as the relative stiffness of the inclusion decreases.
In recent years, a new body of control theory has been developed for the design of control systems for Large Space Structures (LSS). The problems of testing this theory on LSS hardware are aggravated by the expense and risk of actual "in orbit" tests. Ground tests on large space structures can provide a proving ground for candidate control systems, but such tests require a unique facility for their execution. The current development of such a facility at the NASA Marshall Space Flight Center (MSFC) is the subject of this report.

An overview of the Large Space Structure (LSS) control system design problem is presented. The LSS is defined as a class of system and LSS modeling techniques are discussed. Included are discussions concerning model truncation, control system objectives, current control law design techniques, and particular problem areas.

This report describes the Large Space Structure Ground Test Facility under development at the NASA Marshall Space Flight Center in Huntsville, Alabama. It presents the status of the tests being performed and the present and proposed utilization of that facility by DOD. The Ground Test Facility was established initially to test experimentally the control system to be used on the Solar Array Flight Experiment. Further, the structural dynamics of the selected test article were to be investigated, including the fidelity of the associated mathematical model. It became apparent that many of the LSS objectives of NASA were similar to those of DARPA and the US Air Force. In particular, all three agencies are interested in a Government test facility that can accommodate large structures emulating actual space systems. The facility must permit the investigation of structural dynamics phenomena and be able to evaluate candidate attitude control and vibration suppression techniques.

This report presents a test and evaluation of an improved 2.4-m photorefractor ocular screening system, jointly developed by Medical Sciences Corporation and the Marshall Space Flight Center.

The photorefractor system works on the principal of obtaining a colored photograph of both human eyes; and, by analysis of the retinal reflex images, certain ocular defects can be detected such as refractive error, strabismus, and lens obstructions.

The 2.4-m photorefractor system uses a 35-mm camera with a telephoto lens and an electronic flash attachment. Retinal reflex images obtained from the new 2.4-m system are significantly improved over earlier systems in image quality. Other features were also improved, notably portability and reduction in mass.

A total of 706 school age children were photorefracted, 211 learning disabled and 495 middle school students. The total students having abnormal reflexes were 156 or 22 percent, and 133 or 85 percent of the abnormal had refractive error indicated. Ophthalmological examination was performed on 60 of these students and refractive error was verified in 57 or 95 percent of those examined.

The new 2.4-m system has a NASA patent pending and is authorized by the FDA. It provides a reliable means of rapidly screening the eyes of children and young adults for vision


problems. It is especially useful for infants and other non-communicative children who cannot be screened by the more conventional methods such as the familiar "E" chart.

TM-86493 January 1985

This report presents an analysis of the Shuttle SRM thrust imbalance during the steady-state and tailoff portions of the boost phase of flight. The study includes results from flights STS-1 through STS-13. A statistical analysis of the observed thrust imbalance data is presented. A 3σ thrust imbalance history versus time has been generated from the observed data and is compared to the vehicle design requirements. The effect on Shuttle thrust imbalance from the use of replacement SRM segments is predicted. Comparisons of observed thrust imbalances with respect to predicted imbalances are presented for the two Space Shuttle flights which used replacement aft segments (STS-9 and STS-13).

TM-86494 February 1985

A series of copper-nickel alloys were fabricated, notched tensile specimens machined, for each alloy and the specimens tested in 34.5 MPa hydrogen and in air. A notched tensile ratio was determined for each alloy and the hydrogen environment embrittlement (HEE) determined for the alloys of 47.7 weight percent nickel to 73.5 weight percent nickel.

Stacking fault probability and stracking fault energies were determined for each alloy using the X-ray diffraction line shift and line profiles technique.

Hydrogen environment embrittlement was determined to be influenced by stacking fault energies; however, the correlation is believed to be indirect and only partially responsible for the HEE behavior of these alloys.

TM-86495 November 1984

An overview for the definition of a ground test for the verification of Large Space Structure (LSS) control is given. The definition contains information on the description of the LSS ground verification experiment, the project management scheme, the design, development, fabrication and checkout of the subsystems, the systems engineering and integration, the hardware subsystems, the software, and a summary which includes future LSS ground test plans. Upon completion of these items, NASA/MSFC will have an LSS ground test facility which will provide sufficient data on dynamics and control verification of LSS so that LSS flight system operations can be reasonably ensured.

TM-86496 December 1984

NASA Marshall Space Flight Center has developed a facility in which closed loop control of Large Space Structures (LSS) can be demonstrated and verified. The main objective of the facility is to verify LSS control system techniques so that on-orbit performance can be ensured. The facility consists of an LSS test article which is connected to a payload mounting system that provides control torque commands. It is attached to a base excitation system which will simulate disturbances most likely to occur for Orbiter and DOD payloads. A control computer will contain the calibration software, the reference system, the alignment procedures, the telemetry software, and the control algorithms. The total system will be suspended in such a fashion that the LSS test article has the characteristics common to all LSS.
This report presents a summary of selected atmospheric conditions observed near Space Shuttle STS-51A launch time on November 8, 1984, at Kennedy Space Center Florida. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of pre-launch Jimsphere measured vertical wind profiles is given in this report. The final atmospheric tape, which consists of wind and thermodynamic parameters versus altitude, for STS-51A vehicle ascent has been constructed. The STS-51A ascent atmospheric data tape has been constructed by Marshall Space Flight Center's Atmospheric Sciences Division to provide an internally consistent data set for use in post flight performance assessments.

This document provides the natural environment design criteria for the Space Station Program (SSP) definition and preliminary design. It addresses the atmospheric dynamic and thermodynamic environments, meteoroids, radiation, magnetic fields, physical constants, etc., and is intended to enable all groups involved in the definition and preliminary design studies to proceed with a common and consistent set of natural environment criteria requirements. The Space Station Program Elements (SSPE) shall be designed with no operational sensitivity to natural environment conditions during assembly, checkout, stowage, launch, and orbital operations to the maximum degree practical.

The Space Physics Analysis Network (SPAN) is a computer network connecting scientific institutions throughout the United States. This network provides an avenue for timely, correlative research between investigators, in a multidisciplinary approach to space physics studies. An objective in the development of SPAN is to make available direct and simplified procedures that scientists can use, without specialized training, to exchange information over the network. Information exchanges include raw and processes data, analysis programs, correspondence, documents, and graphic images. This handbook details procedures that can be used to exchange graphic images over SPAN.

The intent is to periodically update this handbook to reflect the constantly changing
facilities available on SPAN. The utilities described within reflect an earnest attempt to provide useful descriptions of working utilities that can be used to transfer graphic images across the network. Whether graphic images are representative of satellite observations or theoretical modeling and whether graphics images are of device dependent or independent type, the SPAN graphics display utilities handbook will be the users guide to graphic image exchange.


Initial results have been completed on a mathematical/statistical analysis of inphase gusts and wind velocity moment forces over the first 150 m at the Kennedy Space Center, Florida. The wind velocity profile data used in the analysis were acquired at the KSC 150 m Ground Wind Tower. The results show that planetary boundary layer (PBL) winds can sustain near-peak speeds for periods up to 60 sec and longer. This is proven from calculating the auto-correlation functions of moment forces for several 10-min cases of wind profile data. Although this analysis is preliminary, the results prove that lower atmospheric planetary boundary layer winds do have a periodic variation for long periods of time. This flow characteristic is valuable as aerospace vehicle engineering and design criteria where wind loading must be determined. Such information is also important to the aviation and surface transportation engineers.


This report describes the infrared array developed in the Space Science Laboratory at Marshall Space Flight Center with Center Director's Discretionary Funds. The array, referred to as Big Mac (for Marshall Array Camera), was designed for ground-based astronomical observations in the wavelength range 5 to 35 μm. It contains 20 discrete gallium-doped germanium bolometer detectors at a temperature of 1.4K. Each bolometer is irradiated by a square field mirror constituting a single pixel of the array. The mirrors are arranged contiguously in four columns and five rows, thus defining the array configuration. Big Mac utilizes cold re-imaging optics and an up-looking dewar. The total Big Mac system also contains a telescope interface tube for mounting the dewar and a computer for data acquisition and processing. Initial astronomical observations at a major infrared observatory indicate that Big Mac performance is excellent, having achieved the design specifications and making this instrument an outstanding tool for astrophysics.


The physics governing the applicability and limitations of gas tungsten arc (GTA), electron beam (EB), and laser beam (LB) welding are compared. An appendix on the selection of laser welding systems is included.

Preparation of Silicon Carbide-Silicon Nitride Fibers by the Pyrolysis of Polycarbosilazane Precursors (Center Director's Discretionary Fund Final Report. B. G. Penn, J. G. Daniels, F. E. Ledbetter, III and J. M. Clemons. Space Science Laboratory.

The development of silicon carbide-silicon nitride fibers (SiC-Si3N4) by the pyrolysis of polycarbosilazane precursors that was carried out in this laboratory is reviewed. Precursor resin, which was prepared by heating tris(N-methylamino)-methylsilane or tris(N-methylamino)phenylsilane to about 520°C, was drawn into fibers from the melt and then made unmeltable by humidity conditioning at 100°C and 95 percent relative humidity. The humidity treated
precursor fibers were pyrolyzed to ceramic fibers with good mechanical properties and electrical resistivity. For example, SiC-Si₃N₄ fibers derived from tris(n-methylamino)methylsilane had a tensile rupture modulus of 29 x 10⁶ psi and electrical resistivity of 6.9 x 10⁸ Ω-cm which is 10¹² times greater than that obtained for graphite fibers.

This research was sponsored by the MSFC Center Director's Discretionary Fund Project [No. 82-13, "Preparation of New Continuous Silicon Carbide-Silicon Nitride (SiC-Si₃N₄) Fibers by the Controlled Pyrolysis of Organosilane Polymeric Precursors"].

TM-86506 April 1985
Systems Dynamics Laboratory. N85-27935

This is a closed form solution for the longitudinal oscillation of the Solar Array Flight Experiment (SAFE) blanket for all phases of deployment. The frequency response shows that the blanket frequency increases shortly before full deployment. That fact causes a coupling between the mast and the blanket frequency but, because of the relatively high speed of deployment, a buildup of resonance is unlikely.

TM-86507 March 1985

An Extended Range X-Ray Telescope (ERXRT) of high sensitivity and spatial resolution capable of functioning over a broad region of the X-ray/XUV portion of the spectrum has been designed and analyzed. This system has been configured around the glancing-incidence Wolter Type I X-ray mirror system which was flown on the Skylab Apollo Telescope Mount as ATM Experiment S-056. Enhanced sensitivity over a vastly broader spectral range can be realized by the utilization of a thinned, back-illuminated, buried-channel Charge Coupled Device (CCD) as the X-ray/XUV detector rather than photographic film. However, to maintain the high spatial resolution inherent in the X-ray optics when a CCD of 30 micron pixel size is used, it is necessary to increase the telescope plate scale. This can be accomplished by use of a glancing-incidence X-ray microscope to enlarge and re-focus the primary image onto the focal surface of the CCD.

In the ERXRT program, several glancing-incidence hyperboloid/ellipsoid X-ray microscope optical elements were designed and analyzed. An 8X microscope of 2-m focal length was selected as the optimum configuration to couple the S-056 X-ray mirrors to a 30-micron pixel RCA CCD X-ray/XUV detector. Detailed ray trace analysis studies have shown that this system has theoretical performance which should permit sub-arc second images to be achieved over the entire field of view of the detector. This research has shown that the ERXRT concept is theoretically feasible and that this system may be of great value for future high-resolution X-ray telescope/X-ray spectroscopy instruments. It has also provided valuable insights into other hybrid X-ray optical systems, such as are now being developed in the Wolter/LSM X-ray telescope program, which is also a Center Director's Discretionary Fund program.

TM-86508 April 1985

This report presents a summary of selected atmospheric conditions observed near Space Shuttle STS-51C launch time on January 24, 1985, at Kennedy Space Center, Florida. Values of ambient pressure, temperature, moisture, ground winds, visual observations (cloud), and winds aloft are included. The sequence of pre-launch Jimsphere measured vertical wind profiles is given in this report. The final atmospheric tape, which consists of wind and thermodynamic parameters versus altitude, for STS-51C vehicle ascent has been constructed. The STS-51C ascent atmospheric data tape has been constructed.
TM-86509
June 1985

The wake environment of the space shuttle is analyzed to determine whether it is feasible to perform ultra-high vacuum experiments in or near the payload bay with the shuttle oriented such that the payload bay faces the anti-velocity direction. Several mechanisms were considered by which molecules could approach the payload bay from this direction and their relative contributions to the wake environment are estimated. These mechanisms include ambient atmospheric molecules that have velocities in excess of the orbital velocity which can overtake the shuttle, ambient atmospheric molecules that are back-scattered by collisions with the shuttle-induced atmosphere, and self-scattering from the induced atmosphere.

These estimates are compared with the measurements made with the collimated mass spectrometer which was part of the Induced Environment Contamination Monitor flown on several of the early shuttle flights. Although the collimated mass spectrometer was not designed for this purpose and the instrument background for the species for which the collimator is effective is above the expected levels, upper limits can be established for these species in the wake environment which are consistent with the analysis. There was considerably more helium and argon observed in the wake direction that was predicted, however. Possible origins of these gases are discussed.

TM-86511
June 1985

The purpose of this report is to examine the Hubble Space Telescope pointing error produced by optical benches mounted on free ball joints. Spacecraft cable connections are assumed to produce translational and rotational damping and restoring forces which act through the optical bench center of mass. The nonlinear dynamics are modeled and then implemented using an existing computer program for simulating the vehicle dynamics and pointing control system algorithm. Results are presented for the test case which indicate acceptable performance.
Structures and Propulsion Laboratory.

This report describes the design, analysis, fabrication, and test of a complex “bathtub fitting.” Graphite fibers (P75) in an epoxy matrix were utilized in manufacturing of 11 components representing four different design and layup concepts. Design allowables were developed for use in the final stress analysis. Strain gage measurements were taken throughout the static load test and correlation of test and analysis data were performed, yielding good understanding of the material behavior and instrumentation requirements for future applications.

TM-86513 August 1985

On April 5, 1983, an Inertial Upper Stage (IUS) spacecraft experienced loss of control during the burn of the second of two solid rocket motors. The anomaly investigation showed the cause to be a malfunction of the solid rocket motor. This paper presents a description of the IUS system, a failure analysis summary, an account of the thermal testing and computer modeling done at Marshall Space Flight Center, a comparison of analysis results with thermal data obtained from motor static tests, and describes some of the design enhancements incorporated to prevent recurrence of the anomaly.

TM-86514 July 1985
Improved Turbopump Dynamics, Center Director's Discretionary Fund Final Report. Larry Kiefling. Systems Dynamics Laboratory. N85-31509

A study was initiated to investigate the practicality of increasing rotor critical speeds by changes in manufacturing method. The technique would be to build a pump with an all-laser-welded shaft and case; such unit to be opened by laser cutting and rebuilt by rewelding the same surface. Use of a split casing, common in industry, would permit assembly of the rotor outside the case. A team was formed to perform the study; however, the work of the team was severely restricted by conflict with higher priority tasks. No manpower was available to evaluate alternate configurations. Thus, much of the synergetic effects of cohesive design modification was lost. Although very limited results were achieved, nothing was found to indicate that the method is not worth further investigation.

TM-86515 July 30, 1985
Weibull Distribution Based on Maximum Likelihood with Interval Inspection Data. Mario H. Rheinfurth. Systems Dynamics Laboratory. N85-32847

This technical note determines the two Weibull parameters based upon the method of maximum likelihood as presented in memorandum, “Oxidizer Turbine (HPOTP) First Stage Blade Reliability Analysis,” dated July 10, 1985, by the author. The test data used were failures observed at inspection intervals. The application was the reliability analysis of the SSME oxidizer turbine blades.

TM-86516 July 1985
Surface Voltage Gradient Role in High Voltage Solar Array/Plasma Interactions – Center Director's Discretionary Fund Final Report. M. R. Carruth, Jr. Space Science Laboratory.

A large amount of experimental and analytical effort has been directed toward understanding the plasma sheath growth and discharge phenomena which lead to high voltage solar array-space plasma interactions. An important question which has not been addressed is how the surface voltage gradient on such an array may affect these interactions. The results of this study indicate that under certain conditions, the voltage gradient should be taken into account when evaluating the effect on a solar array operating in a plasma environment.

TM-86517 July 1985
Hardware Math for the 6502 Microprocessor. Ralph Kissel and James Currie. Information and Electronic Systems Laboratory.
A floating-point arithmetic unit is described which is being used in the Ground Facility for Large Space Structures Control Verification (GF/LSSCV). The experiment uses two complete inertial measurement units and a set of three gimbal torquers in a closed loop to control the structural vibrations in a flexible test article (beam). A 6502 (8-bit) microprocessor controls four AMD 9511A floating-point arithmetic units to do all the computation in 20 milliseconds.

TM-86519 October 1985
The Role of Tethers on Space Station.
Georg von Tiesenhausen, Editor. Program Development.

This report describes the results of research and development that addressed the usefulness of tether applications in space, particularly for space station. A well organized and structured effort of considerable magnitude involving NASA, industry and academia have defined the engineering and technological requirements of space tethers and their broad range of economic and operational benefits. This report consolidates the work directed by seven NASA Field Centers and is structured to cover the general and specific roles of tethers in space as they apply to NASA's planned space station. This is followed by a description of tether systems and operation. The report closes with a summary of NASA's plans for tether applications in space for years to come.
An algorithm was developed to simulate the expected signal-to-noise ratio as a function of observation time in the charge coupled device detector plane of an optical telescope located outside the Earth’s atmosphere for an extended, uniform astronomical source embedded in a uniform cosmic background. By choosing the appropriate input values, the expected extended source signal-to-noise ratios can be computed for the Hubble Space Telescope using the Wide Field/Planetary Camera science instrument.

An algorithm was developed to simulate the expected signal-to-noise ratios as a function of observation time in the charge coupled device detector plane of an optical telescope located outside the Earth’s atmosphere for a signal star, and an optional secondary star, embedded in a uniform cosmic background. By choosing the appropriate input values, the expected point source signal-to-noise ratio can be computed for the Hubble Space Telescope using the Wide Field/Planetary Camera science instrument.

A statistical evaluation is used to compare vertical profiles of temperature and moisture derived from VAS with three different algorithms to that of corresponding rawinsonde measurements for a clear-cold environment. To account for time and space discrepancies between the data sets, rawinsonde data were adjusted to be representative of the satellite sounding times. Both rawinsonde and satellite sounding data were objectively analyzed onto a mesoscale grid. These grid point values were compared at 50 mb pressure increments from the surface up to 100 mb. The data were analyzed for horizontal and vertical structure, representativeness of derived parameters, and significant departure (improvement) from the a priori (first guess) information.

Results indicate some rather strong temperature and moisture biases exist in the satellite soundings. Temperature biases of 1°C to 4°C and dewpoint biases of 2°C to 6°C generally occur in layers where strong inversions are present and vary with time as these atmospheric features evolve. The biases also change as a function retrieval scheme suggesting limitations and restrictions on the applications of the various techniques. Standard temperature deviations range from 1°C to 2°C for each retrieval scheme with maximum values around 800 to 400 mb. Derived parameters (precipitable water and thickness) suffer from similar biases, though to a somewhat lesser extent. Gradients of basic and derived parameters are generally weaker but have good horizontal structure where magnitudes of the parameters are relatively strong. Integrated thermal (temperature) and moisture (precipitable water) parameters show mixed results. Although biases are small in the precipitable water values from the regression scheme, horizontal structure is poor.

An analysis of a priori and first guess information show similar biases when compared to the ground truth measurements. This information, however, seems to provide the majority of the vertical structural information present in the VAS retrievals.
by 3 or 6 hr intervals and in space by approximately 50 n.mi. Cloud cover amount is recorded for each grid point (of a square grid) by a single alphanumeric character representing each 5 percent increment of sky cover.

The data are arranged in both quarterly and monthly formats. A quarterly format computer tape usually contains 3 months of data for one hemisphere while each monthly format tape contains up to 5 years of 1 month for one hemisphere.

Although there are gaps in the data, notably all of 1976 for the Northern Hemisphere, the data base currently provides daily, 3-hr observed total sky cover for the Northern Hemisphere (NH) from 1972 through 1977 less 1976. For the Southern Hemisphere (SH), there are data at 6-hr intervals for 1976 through 1978 and at 3-hr intervals for 1979 and 1980. More years of data are being added in both hemispheres.

To validate the data base, the percent frequency of $<0.3$ and $>0.8$ cloud cover was compared with ground observed cloud amounts at several locations with generally good agreement.

Mean or other desired cloud amounts can be calculated for any time period and any size area from a single grid point to a hemisphere.

The data base is especially useful in evaluating the consequence of cloud cover on Earth viewing space missions. The temporal and spatial frequency of the data allow simulations that closely approximate any projected viewing mission. The greatest attribute is that no adjustments are required to account for cloud continuity.

**NASA TECHNICAL PAPERS**

TP-2450

**January 1985**

Three-Dimensional Baroclinic Instability of a Hadley Cell for Small Richardson Number.


A three-dimensional, linear stability analysis of a baroclinic flow for Richardson number, $\alpha$, is subjected to horizontal and vertical temperature gradients. The basic state is a Hadley cell which is a solution of the complete set of governing, nonlinear equations and contains both Ekman and thermal boundary layers adjacent to the rigid boundaries; it is given in a closed form. The stability analysis is also based on the complete set of equations; and perturbations possessing zonal, meridional, and vertical structures were considered. Numerical methods were developed for the stability problem which results in a stiff, eighth-order, ordinary differential eigenvalue problem. The objectives of this work were to extend the previous work on three-dimensional baroclinic instability for small $\alpha$ to a more realistic model involving the Prandtl number, $\alpha$, and the Ekman number, $E$, and to finite growth rates and a wider range of the zonal wavenumber. The study covers ranges of $0 < \alpha \leq 1.1$, $0.2 \leq \alpha \leq 5.0$, and $E = 10^{-3}$. For the cases computed, it was found for $\alpha < 1$ that conventional baroclinic instability dominates for $\alpha > 0.8$ and symmetric baroclinic instability dominates for $\alpha < 0.8$. However, for $\alpha = 1$ in the range $0.3 \leq \alpha < 0.8$, conventional baroclinic instability always dominates. Further, it was found for $\alpha < 1$ that when symmetric instability dominates, the mode of maximum growth rate is not purely symmetric but has weak zonal structure. This means that the wave fronts are inclined at a small angle to the basic state flow. For these weak zonal modes it was also found that the critical Richardson number is increased by a small amount above its value for pure symmetric instability. Because these modes differ so slightly from the pure symmetric modes, it is unlikely that they represent a new mode of instability.

TP-2456

**December 1984**


The limit series for the Euler-Mascheroni constants is represented as an integral. Using this new representation, we compute the first 200 values and assorted others up to 2000. The first 13 roots of $\gamma_n$, where $n$ is a positive continuous variable, are also given.
NASA TECHNICAL PAPERS

TP-2459 January 1985

The corrosion behavior for 2219-T87 aluminum coated with various primers, including those used for the External Tank and Solid Rocket Boosters of the Space Shuttle Transportation System, has been investigated using electrochemical techniques. Corrosion potential-time, polarization resistance-time, electrical resistance-time, and corrosion rate-time measurements were all investigated. It was found that electrical resistance-time and corrosion rate-time measurement were most useful for studying the corrosion behavior of painted aluminum. Electrical resistance-time determinations give useful information concerning the porosity of paint films, while corrosion rate-time curves give important information concerning overall corrosion rates and corrosion mechanisms. In general, the corrosion rate-time curves all exhibited at least one peak during the 30 day test period, which was attributed, according to the proposed mechanisms, to the onset of the hydrogen evolution reaction and the beginning of destruction of the protective properties of the paint film.

TP-2469 March 1985
Adding Computationally Efficient Realism to Monte Carlo Turbulence Simulation. C. Warren Campbell. Systems Dynamics Laboratory. N85-28708

Frequently in aerospace vehicle flight simulation, random turbulence is generated using the assumption that the craft is small compared to the length scales of turbulence. The turbulence is presumed to vary only along the flight path of the vehicle but not across the vehicle span. The addition of the realism of three-dimensionality is a worthy goal, but any such attempt will not gain acceptance in the simulator community unless it is computationally efficient. A concept for adding three-dimensional realism with a minimum of computational complexity is presented. The concept involves the use of close rational approximations to irrational spectra and cross-spectra so that systems of stable, explicit difference equations can be used to generate the turbulence.

TP-2474 January 1985

The report presents a brief account of various turbulent models employed in the computation of turbulent flows, and evaluates the application of these models to internal flows by examining the predictions of various turbulence models in selected important flow configurations. The main conclusions of this analysis are: (a) The k-epsilon model is used in a majority of all the two-dimensional flow calculations reported in the literature. (b) Modified forms of the k-epsilon model improve the performance for flows with streamline curvature and heat transfer. (c) For flows with swirl, the k-epsilon model performs rather poorly; the algebraic stress model performs better in this case. (d) For flows with regions of secondary flow (noncircular duct flows), the algebraic stress model performs fairly well for fully developed flow. For developing flow, the algebraic stress model performance is not good; a Reynolds stress model should be used.

Two important factors in the numerical solution of the model equations, namely false diffusion and inlet boundary conditions, are discussed. The existence of countergradient transport and its implications in turbulence modeling are mentioned. Two examples of recirculating flow predictions obtained using PHOENICS code are discussed. Other approaches to turbulent flow computations, such as the vortex method, large eddy simulation (modeling of subgrid scale Reynolds stresses), and direct simulation, are briefly discussed. Finally, some recommendations for improving the model performance are made. The need for detailed experimental data in flows with strong curvature is emphasized.

TP-2476 March 1985
Formulation/Cure Technology for Ultra-High Molecular Weight Silphenylene-Siloxane Polymers. N. H. Hundley and W. J.
Molecular weights above one million were achieved for methylvinylsilphenylene-siloxane terpolymers using a two-stage polymerization technique which was successfully scaled up to 200 grams. The resulting polymer was vulcanized by two different formulations and compared to an identically formulated commercial methylvinyl silicone on the basis of ultimate strength, Young's modulus, percent elongation at failure, and tear strength.

Relative thermal/oxidative stabilities of the elastomers were assessed by gradient and isothermal thermogravimetric analyses performed in both air and nitrogen. The experimental elastomer exhibited enhanced thermal/oxidative stability and possessed equivalent or superior mechanical properties.

The effects of variations in prepolymer molecular weight on mechanical properties was also investigated.

Measurements of rotating equilibrium bubble shapes in the low-gravity environment of a free-falling aircraft are presented. Emphasis is placed on bubbles which intersect the container boundaries. These data are compared with theoretical profiles derived from Laplace's formula and are in good agreement with the measurements. Two types of instability are explored. The first occurs when the baffle spacing is too large for the bubble to intersect both the top and bottom boundaries. The second occurs when the hydrostatic pressure beneath a displaced free surface does not compensate for pressure change due to capillary forces. The interface shape depends on the contact angle, the radius of intersection with container, and the parameter F, which is a measure of the relative importance of centrifugal force to surface tension. For isolated bubbles, F has a maximum value of 1/2. A further increase in F causes the bubble to break contact with the axis of rotation. For large values of F, the bubble becomes more cylindrical and the capillary rise occurs over a thinner layer so that the small radius of curvature can generate enough pressure drop to balance the increased hydrostatic contribution.

Newton's method for finding the zeroes of a single real function is investigated in some detail. Convergence is generally checked using the Contraction Mapping Theorem which yields sufficient, but not necessary, conditions for convergence of the general single point iteration method. The resulting convergence intervals are frequently considerably smaller than actual convergence zones. For a specific single point iteration method, such as Newton's method, better estimates of regions of convergence should be possible. A technique is described which, under certain conditions (frequently satisfied by well behaved functions), gives much larger zones where convergence is guaranteed.

In the past, distorted pyrotechnic shock time history data has been discarded completely or "cleaned up" by questionable means. Too often the "clean up" procedures introduced as much error into the data as previously existed. The purpose of this paper is to outline techniques for data recovery so that true signals are obtained and so that these recovery procedures will be completely reproducible by any scientist in any lab. Most ordnance shock data is distorted by baseline shifts or accelerometer resonances. The methodology of recovering true signals from these two types of distortion is discussed.
This report presents a procedure for estimating the potential orbital debris risk to the world's populace from payloads or spent stages left in orbit on future missions. This approach provides a consistent, but simple, procedure to assess the risk due to random reentry with an adequate accuracy level for making programmatic decisions on planned low Earth orbit missions.

TP-2508  May 1985

The use of high performance systems, which is the trend of future space systems, naturally leads to lower margins and a higher sensitivity to parameter variations and, therefore, more problems of dynamical physical systems. To circumvent dynamic problems of these systems, appropriate design, verification analysis, and tests must be planned and conducted. The basic design goal is to define the problem before it occurs. The primary approach for meeting this goal is a good understanding and reviewing of the problems experienced in the past in terms of the system under design.

This paper reviews many of the dynamic problems experienced in space systems design and operation, categorizes them as to causes, and envisions future program implications, developing recommendations for analysis and test approaches.

TP-2510  May 1985

Alternate remote sensing techniques that could utilize the slight losses of energy from the microwave beam which powers the NASA/MSFC Carbon Dioxide Observational Platform System (CO-OPS) to achieve the objectives of the U.S. Department of Energy (DOE) Carbon Dioxide Research Program’s regional observational data requirements, ODRs, are addressed heuristically.

The opportunity for regional remote sensing of the carbon dioxide and water vapor constituents in the atmosphere are discussed as a potential spin-off of the CO-OPS. The CO-OPS is envisioned as a high altitude (~25 km) observational platform system powered by microwave energy for regional observational use by the DOE in their Carbon Dioxide Research Program.

TP-2511  May 1985
Space Station Rotational Equations of Motion. Mario H. Rheinfurth and Stanley N. Carroll. Systems Dynamics Laboratory.

Dynamic equations of motion are developed which describe the rotational motion for a large space structure having rotating appendages. The presence of the appendages produce torque coupling terms which are dependent on the inertia properties of the appendages and the rotational rates for both the space structure and the appendages. These equations were formulated to incorporate into the Space Station Attitude Control and Stabilization Test Bed to accurately describe the influence rotating solar arrays and thermal radiators have on the dynamic behavior of the Space Station.
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The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

C. D. BEAN
Director, Administrative Operations Office