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W/Associate Administrator  
for Manned Space Flight

MA/Apollo Program Director

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S-II-T Failure Corrective Action

- (a) Letter, Gen. Phillips to MSFC, subject: Actions resulting from S-II-T accident investigation, dtd. September 28, 1966
- (b) Letter, Gen. Phillips to MSC and NSC, subject: Safety in Test Operations, dtd. September 21, 1966
- (c) Letter, Gen. O'Connor to Gen. Phillips, subject: Actions resulting from S-II-T accident investigation, dtd. November 30,

To close out the program action on the S-II-T failure, I instructed MSFC in reference (a) to: (1) summarize for me, with copies to MSC and NSC, the actions they have taken to preclude the possibility of a similar accident; and (2) at the same time I sent letters to MSC and NSC in reference (b) asking them: (1) to review the MSFC action; and (2) to summarize for me the actions they take to avoid similar incidents.

Enclosure (c) is the MSFC response to my letter and contains comments from all the major launch vehicle contractors describing measures taken by them to avoid these failures.

Specific actions taken by S&ID and MSFC are covered in this package and include significant corrections in the areas of: (1) work control methods; (2) test and safety procedures; and (3) design changes.

Interest also in this MSFC package is the unique emphasis placed on test and flight operations by Chrysler which are under further study by this office for application by other contractors.

I believe the corrective actions implemented at MTF by S&ID and MSFC have identified the specific problems that led to the demise of the S-II-T stage. I, further, that the comprehensive action taken to preclude similar accidents has resulted in a much improved organization and test capability at MTF.

Samuel C. Phillips  
Major General, USAF

Closures: References  
(a), (b), & (c)

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## INTRODUCTION

This Engineering Capabilities Presentation lists the competence and capability that has been demonstrated by the Space Support Division of Sperry Rand Corporation while fulfilling contractual commitments in the aerospace industry. This is a preliminary presentation; the preparation of a complete capabilities history of the division is currently in the developmental stage.

The Capabilities Experience Summary is comprised of ten categories, e.g. Category 1 - Aeronautics, etc.

The capabilities reported herein were performed by the Space Support Division under Contract NAS8-20055 to the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Astrionics Laboratory, Huntsville, Alabama.

1967

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# CAPABILITIES EXPERIENCE SUMMARY

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## CATEGORY 1 - AERONAUTICS

- Engine-Out Study, Saturn IB Vehicle

A simulation study was performed to determine which engine and/or actuator failure would be most critical during the launch phase. A digital program, reflecting trajectories and response characteristics, was used to determine control system parameter variations.

- Wind Profiles Simulation

Synthetic wind profiles and a computer (digital) program were developed to determine wind disturbance effects on the response and stability of launch vehicles. The basic scalar profile was altered to provide a realistic model with shear build-up, superimposed gusts, and the reduction of wind speeds to zero.

## CATEGORY 2 - MANAGEMENT

- Administrative Data

Performed analyses and studies of existing organizations, functions, and R&D Operations management directives. Prepared criteria for management plan by lending continuous assistance in the implementation, coordination, and assignment of directives, planning, scheduling, control, and configuration data activities.

- Apollo Telescope Mount (ATM) Project Office Integration

Operated a communications, project status, data assimilation and retrieval center where reports and presentations were prepared by writers and analysts on request of George C. Marshall Space Flight Center (MSFC) ATM Project Office. Inputs for reports were obtained from research, interviews, and extractions from other documents.

- Instrumentation and Components Program List

An instrumentation and components program list for the ATM was prepared, maintained and distributed. This program list is a configuration control document listing all telemetry measurements, measurement ranges, type of signal conditioning, telemetry channel assignments, and total equipment requirements for an airborne RF telemetry and command system.

- Technical Assistance

Technical coordination has been provided to MSFC laboratories in the preparation and maintenance of instrumentation parts and components lists (IP & CL). This requires an evaluation of all measurement requests and the drafting of engineering change requests (ECR) for updating purposes. Levels II and III Configuration Control Board meetings are attended by division personnel to review proposed changes, and to provide technical evaluations of contractor-submitted engineering change proposals (ECP).

- Program Management

Responsible for providing direct engineering and technical support to MSFC Astrionics Laboratory in program assessment, evaluation of progress, and development and maintenance of a program baseline change control system. Currently performing project requirements coordination tasks related to schedules, changes, and interface control.

- ATM Configuration Management

Established a system for configuration control and documentation flow for the ATM program. The concept of a workable configuration management plan and documentation control plan was presented to and approved by the MSFC ATM Project Office; then documented and implemented.

- ATM Experiment Interface Control Documents

Reviewed and analyzed experimenter and ATM electrical circuits, and maintained electrical systems compatibility between experimenters, MSFC, and Manned Spacecraft Center by generating electrical interface control documents and electrical interface defining documents. Reviewed experimenter's proposed changes and recommended acceptance or refusal by the Configuration Control Board.

- Operations Analysis

This activity involves the performance of analyses and studies for the establishment of documentation plans and operational procedures, and for defining project support required of line organization elements. This effort involves the review of test procedures, test plans, logistic requirements, reliability plans, quality plans, and other documentation concerning assigned projects.

- Technological Information Summary, Saturn IB and V Flight Vehicles

Assemble all information required for publishing a Technical Information Summary on each flight vehicle. Prepare sketches of appropriate block diagrams of electrical, telemetry, measuring, RF, control guidance, tracking, emergency detection, and range safety systems; in order to provide a generalized portrayal of, and a description (narrative) for each system.

- Artist's Concept of the ATM Electrical Support Equipment Console

A detailed water color drawing, an artist's concept of a typical ATM electrical support equipment console, was prepared for a presentation given by Dr. Wernher Von Braun to the National Aeronautics and Space Administration Headquarters.

- Evaluation and Summary of Discrete Components

Prepared Parts Analysis Summary Sheets (PASS) for discrete electronic components from summation of data from three or more Interagency Data Exchange Program (IDEP) reports. This task involved the study, evaluation, and analysis of IDEP reports for a specific component, and liaison with customer and vendor to insure that the device was within the current state-of-the-art and conformed to the indicated specifications.

- Electrical System Schematic Documentation

Prepared Class I electrical schematic documentation. The schematics were produced in accordance with MSFC format and document mission requirements.

- MSFC Preferred Parts Document

MSFC-PPD-600 was revised to maintain state-of-the-art quality of electrical parts suitable for space systems. Criteria was established for the selection of deletion of items listed and a new concept of document organization was effected.

### CATEGORY 3 - ELECTRONICS AND ELECTRICAL ENGINEERING

- Discrete Components Packaging

An electromechanical package, involving thick and thin masks and substrates, was designed utilizing the evaporation technique. Weldable discrete components were mounted on the finished substrate and the assembly was then encased in an electron-beam welded housing.

- Saturn Vehicle Parts Inventory Program

A system for performing an electrical parts inventory of all parts used in the Saturn S-IB vehicle was devised. The electrical parts inventory was prepared from an input of designer reports.

- Component Specification Control Drawings

Specification control drawings for various electromechanical components were revised to augment the requirements for their inclusion into the ATM program. The revision effort included the updating of component design and environmental qualification requirements.

- Solid State Distributors - Device Screening

Screened solid state devices with the capability of being configured as a relay. The screening activity consisted of reviewing the device characteristics from manufacturer specifications and by subjecting the devices to testing.

- Thin-Film Multilayer Registration System

Designed a thin-film magnetic memory array consisting of magnetic memory elements, word drive lines, digit sense lines, with associated insulative and hermetic sealing layers. The array was combined in one vacuum pumpdown.

- Digital Multiplexer

A multiplexer was designed and fabricated for use with the ATM X-ray telescope experiment. The multiplexer is packaged on eight double-sided cards containing 410 flatpack integrated circuit packages and miscellaneous discrete components.



- Video Selector Switch

A light weight, remote-controlled, solid state video scanning switch was designed, developed, and fabricated for use in the ATM video system. The switch has a power rating of 5 watts at 28 volts direct current.

- Semiconductor Reliability Screening Specifications

Prepared high reliability screening specifications for semiconductor devices. The George C. Marshall Space Flight Center (MSFC) specifications outline and establish the operational and mechanical characteristics of the devices, thereby establishing minimum requirements for their purchase.

- Stratoscope II Electrical Parts Review

An electrical parts review of Stratoscope II parts was conducted to confirm the merit of their applicability in the Stratoscope II; as related to the environmental and reliability requirements of the mission. Stratoscope II is a telescope-instrument system, pod-mounted to a balloon which is capable of lifting the telescope pod to an altitude of 80 to 100 miles, for the purpose of R&D astronomical surveillance.

- Bayonet Coupling Connectors - Design Guide Lines

Two MSFC Design Guide Lines (DGL's) are being prepared for two types of bayonet coupling connectors. One DGL describes connectors which conform to MIL-C-26482C (circular, miniature, quick disconnect); with solder or crimp type terminals, accessories and insert arrangements which are considered standard.

- Systems-Components Qualification Testing

Qualification tests were performed on various systems and components to qualify them for use in space applications. Parts and systems tested include, but are not limited to: satellite experiment packages, stable platforms, antennas, RF components, electronic subsystems, capacitors, potentiometers, semiconductors, and integrated circuits.

- Solar Cell Module Performance Data Analysis

A total of 858 solar cell modules are being analyzed for suitability of application as the ATM primary power source. The electrical characteristics under simulated flight illumination environment will be determined.

- Electrical Components Qualification Testing

Currently performing electrical and environmental testing of electrical parts (relays, connectors, fuses, circuit breakers, wire, etc.) in accordance with qualification test criteria established for the Saturn-Apollo programs. Developed the test procedures, conducted and monitored testing, and evaluated and published the test results.

- System Simulator Facility Development

A real time digital computer system, for simulation of the Saturn IB and Saturn V launch vehicles and their respective ground support equipment, is under development. A complete review has been made of all types of circuitry and systems used in the Saturn launch vehicles and ground support equipment.

- Computerized Filter Study

The purpose of this study is to investigate the possibility of using a computer for designing aerospace telemetry system filters. The study has, thus far, resulted in a program featuring a series of charts for the selection of a particular filter, based on designer's specifications.

- Saturn V Simulator Datum Base

Analyzed the circuitry of the Saturn V (SA-501) vehicle by converting circuitry to a mathematical model; reduced to its simplest form by use of Boolean algebra, and the further conversion of the reduced equations to machine language logic equations. Empirical analysis and substitution was required for the simulation of ramp functions such as tank pressurization and flight control computer adaptation.

- Tape-to-Tape Translator Modification

Modified the GE 235/SEL 810 tape-to-tape translator by using an SEL 840A computing system to provide a conversion from floating point binary data on magnetic tape to fixed point binary data on punched paper tape. The punched paper tape format meets the input requirements of function generator programs for the PB 250 digital computer that is used to generate time varying analog signals.

- System Launch Control Computer - Change Control Program

Currently performing reviews of System Launch Control Computer (SLCC) programs, the supporting documentation, and software change information to ascertain that no undocumented or undesirable changes have been incorporated. The primary functions of the SLCC are to verify that key elements of the Saturn V system are working properly during the launch phase and to provide the test conductor with a continuous input of inertial platform and propellant information.

- Diagnostic Program for Hybrid Computers

A program was developed to provide a diagnostic routine for checking the transfer of digital information from the central processor to interface with an analog computer. The purpose of the program was to provide a flight simulation of the Saturn V vehicle to include vehicle dynamic, flight computer, and aerodynamic characteristics.

- Saturn V System Real-Time Simulation

Formulated the basic concept for a computer, real-time simulation of the Saturn V system. The simulation system was comprised of the SDS-930 computer, a set of SDS-930 programs, a datum base of equations, and a special hardware interface.

- Digital Data Storage System

A highly reliable, low power, digital data storage system was designed and fabricated. It shall be used with a portable reflectometer which shall be operated in a deep-space environment.

- Programming of Telemetry Tape Recordings

Developed a digital program for processing magnetic tape recordings of Saturn V telemetry data. The program utilizes process input/output codes that identify words associated with flight sequencing events, hardware malfunctions, and backup modes.

- Wire List Handling Improvement Program (WHIP)

A comprehensive study was made of current wire list and engineering change order requirements for Saturn V electrical support equipment. An analysis of the requirements problem was made and a unique matrix technique developed for the handling of large wire lists.

- Computer Systems Evaluation Study

Systems analysis and trade-off studies were performed on existing and proposed digital type computer systems. The digital events evaluators, DEE-6 and DEE-4 computer systems are used (or are proposed for use) in the automatic checkout of launch vehicles.

- Cable and Distribution System

A 700-cable distribution system is currently being designed to provide control, power distribution, and data transmission interconnections between a 52-rack, 260-panel electrical support equipment checkout system and the ATM. An analysis has been made of the entire cable and distribution checkout system to establish design goals and criteria.

- ATM Distributors

Preliminary studies of ATM power, measuring, and command signal distribution requirements established the need for especially designed distributors. The distributors route commands, measurements, and electrical power between the command capsule control panel, the ATM experiment packages, and the electrical support equipment, both prior and subsequent to launch of the ATM.

- Grounding Techniques Study for Noise Reduction

A detailed study of grounding techniques was conducted to establish methods which would be effective in eliminating or reducing vehicle noise that is detrimental to the operational mission of launch vehicle telemetry systems. The study was performed by locating the major sources of noise and by recommending methods for its suppression.

- Noise Simulation Study

A simulation study was performed to investigate the effects of noise on the frequency response of the servo actuator and the stability control system of the Saturn IB (AS-201) vehicle. During the preflight checkout of the AS-201, a noise signal was detected in the S-IVB stage thrust vector control system.

- ATM Clock

Designed the logic and packaging of the ATM clock to provide ultra-stable time references for various ATM experiments. The clock is capable of providing time references in milliseconds, seconds, minutes, hours, and days, with a stability of  $1 \times 10^8$  throughout the temperature range of  $-20^{\circ}$  to  $85^{\circ}$  Celsius.

- ATM Switch Selector Panel

Prepared Class I documentation of the ATM switch selector panel.

The panel is required for ATM selector switch test and check out.

- Automatic Checkout System For Pressure Transducers

An automatic test station, to be used in conjunction with an IBM 1130 computer, was designed for the purpose of automatically testing and analyzing pressure transducers. The system shall dynamically evaluate pressure transducers which have been designed for use in space flight applications.

- Pulse Width Analyzer

Designed a pulse width analyzer for checking digital tape recorders to determine if they meet pulse repetition specifications. The system accepts a programmed number of pulses from the tape recorder, measures each pulse width, stores the measured data, and provides a display of the number of pulses of equal width.

- Cable (Electrical) Stress Test Fixture

Designed and documented a twist, bend, impact, torque test fixture for use in testing prototype electrical cables. A prototype model of the fixture was built to prove the feasibility of the device.

- RF Communications Coding Techniques

Conducted a comprehensive study of various group and cyclic codes; each with error detection and correction capabilities. Pseudo-noise, Reed-Mueller, and Hamming-Chandhuri coding principles were analyzed in detail and the advantages and disadvantages of each code was listed.

- Low-Noise Preamplifier Study

Conducted a design study (analytical investigation) of existing low-noise preamplifiers to determine the type best suited for amplifying signals from a space-operated, low-light level television camera tube. Although preamplifiers containing electron tube components were investigated, mission requirements dictated the desirability of using a preamplifier that utilizes solid state devices.

- Command Decoders (Saturn and Apollo Missions)

Mission requirements for the design of command decoders were established and the design effected. The decoder units are designed to fulfill the requirements of the Saturn IB, Saturn V, and ATM Solar Observatory missions.

- Sync Generator

A multiple output, highly reliable, standard scan sync generator was designed, developed, and is presently in the final stages of mechanical layout. Requirements for the sync generator were outlined in MSFC-SPEC-50M12741.

- ATM Electrical System Networks

The electrical circuitry to interconnect all ATM subsystems and to perform switching, control, power distribution, and signal conditioning functions is currently being designed. The system consists of three power distributors, five control distributors, three measuring distributors, a transfer assembly, a controls and display logic distributor, and approximately 500 interconnecting cables.

- Electrical Design of Control Panels and System Networks

Currently performing the electrical design of control panels and system networks for the ground support equipment checkout and launch systems of the ATM. A comprehensive analysis of the flight systems design and

function is being made to aid in preliminary design of the panels, unit electrical schematics, and system networks.

- Silicon Microelectronics Research Studies

Advanced research studies in silicon microelectronics technology are currently being performed. Theoretical and experimental studies are continuing to determine possible applications of complimentary bipolar integrated circuits and metal oxide semiconductor devices such as, complimentary field effect transistor (FET) arrays, and combined FET and bipolar arrays.

- Miniature Power Supply Modules

The miniaturized power supply modules are used in the assembly of various dc-to-dc converters used in the Apollo telemetry subsystems. Cordwood construction is used to provide maximum electronic components density in the minimum amount of space.

- Encoder/Decoder Panel Assembly

Designed the front panel and panel components layout of the ATM electrical support equipment 24-inch encoder/decoder panel assembly. Prepared the documentation to fabricate the panel.

- High Voltage, Super High Frequency (SHF) Power Supply

Designed a prototype 1600 volt, SHF power supply for use in supplementing telemetry signals during a specific portion of the Saturn vehicle flight trajectory. Fabrication of the power supply was effected utilizing preliminary drawings.



- Ground Support Electrical Power System

A power system is currently being designed to furnish power to the ATM solar bus and/or load bus and to the electrical support equipment when performing ground checkout of the ATM. The design effort includes an overall system analysis to establish design criteria, an evaluation of existing systems to determine their adaptability to the ATM requirements, and a comprehensive study of each subsystem to provide details needed for preparation of the preliminary design drawings.

- AC/DC Power Supply

A ac/dc electronic power supply was designed and fabricated to furnish dc power to the ATM platform modules and ac power to the ATM gyro spin motor. The dc portion of the power supply is equipped with a step-up switching pre-regulator, a dc-to-dc converter and a pulse regulator.

- Television Test Transmitter

An FM television test transmitter was developed to simulate the television signal received from the Saturn IB (SA-203) vehicle during flight. The test transmitter is used to check out receiving ground stations for the SA-203 mission.

- Control Dynamics Analysis

An analysis was performed to study the effects of nonlinear disturbances on the frequency response of the hydraulic servo-actuator of the Saturn S-IVB stage. The comparison of the responses, actual and simulated, revealed that the simulation was accurate.

- Helical Antenna for Television Test Transmitter

A helical antenna with right-hand circular polarization and six decibel gain was developed for use on the Saturn IB, SA-203 television test transmitter. The test transmitter is used to check out receiving ground stations for the SA-203 mission.

- C-Band Radar Antennas

C-band transmit-receive radar antennas, for use on the Saturn IB and Saturn V Instrument Units, were redesigned and modified to meet specific frequency and polarization requirements. The cavity-backed, crossed-slot aperture antennas are operated at a frequency range of from 5690 MHz to 5765 MHz, with a VSWR of less than 1.5:1.

- Turnstile Dipole Antennas

Two orthogonal VHF dipole antennas, fed 90 degrees out of phase for right-hand circular polarization, were designed to feed a nineteen-foot parabolic dish antenna. Drawings were prepared and the antennas were fabricated and tested.

- Command Receiving Antenna

Modified the original design of the command receiving antenna for use on the Instrument Unit of the Saturn IB, SA-200 vehicle. The antenna consists of two orthogonal square loops mounted on a base plate, with the open circuited portion of the loop facing away from the ground plane.

- ATM Command and Telemetry Antennas

Originated the design concept and fabricated scale models and prototypes of ATM antennas. The antennas are mounted on the solar wings.

- Antenna Couplers and Shields

Five antenna couplers for transmit antennas and two antenna shields for receiving antennas, to be used to prevent RF interference during vehicle checkout, were designed, fabricated, and tested. The laboratory prototypes were developed to confirm the initial design confirm the initial design concepts.

- S-Band Helical Array Antenna

Designed a S-band helical array. The array consists of a single helix, with a gain of 8 db, mounted upon a common base plate, adjacent to an array of four helices.

- Altimeter Antenna

A high power, transmit-receive altimeter radar antenna was designed to operate with a peak power output rating of 10 kilowatts. The antenna is configured for an operating bandwidth of 45 MHz, centered at 1610 MHz, and a fan-shaped beam with a gain of 18 db.

- Antenna System Transmission Line Components

Antenna system transmission line components were designed, tested and assembled (or tested and evaluated) for use in the Saturn IB and Saturn V instrument units and the ATM. S-band hybrid rings, stripline directional couplers, stripline power supplies, and VSWR measuring assemblies are currently being designed, fabricated and tested.

- Inflatable Transmission Line

An inflatable transmission line was designed for installation on the Ryan deployable boom. The transmission line that was developed has the characteristic of low RF loss with an attenuation of 0.06 db per meter.

- Antenna Pattern Measurements

Analyzed three methods of measuring antenna patterns in relation to the antenna attitude in a 200 nautical mile orbit. The study was made to evaluate a contractor's proposal to NASA for measuring the characteristics of a large space erectable parabolic antenna.

- Antennas Directivity Measurement Technique Study

A study was initiated to mathematically explain a method for the simultaneous integration of great circle antenna patterns while they are being measured. A new integration equation was derived for the purpose of integrating great circle patterns.

- Antenna Patterns Duplication

Constructed and tested scale model antennas to verify pattern duplication of the full size antenna. These antenna patterns are used for antenna coverage studies and signal strength predictions.

- S-Band Telemetry Power Amplifier

An S-band power amplifier, capable of delivering 20 watts of RF power in a space environment, was developed for use on the Saturn IB, SA-203 vehicle. The amplifier transmits the television signal used for the investigation of the behavior of cryogenic fluids under zero gravity conditions.

- Time-Division Multiplexer

A time-division multiplexer was designed to accept up to 270 data inputs of 0 to 5 volts in amplitude, and to provide two parallel output wave trains. The multiplexer has 30 primary channels with a sampling rate of 120 samples per second.

- Pulse Code Modulated Digital Data Acquisition Subsystem

Designed the oscillator, analog switches, power supply, and logic of a pulse code modulated (PCM) digital data acquisition subsystem (DDAS) to provide a state-of-the-art prototype telemetry package. The PCM/DDAS is an integrated system capable of sampling the outputs from six analog multiplexers, converting the inputs to ten-bit code groups, establishing and supplying a word format containing all data from the multipliers.

- Frequency Translator

A frequency translator, for use in any constant bandwidth telemetry system, was designed, fabricated, and tested. The translator is basically comprised of a modulator and a precision constant phase bandpass filter, having a bandwidth equal to the translated spectrum.

- Analog Telemetry Calibrator

Designed a microelectronic analog calibrator to produce accurate voltage levels for calibration of FM/FM telemeters. Voltage levels of 0, 1.25, 2.50, 3.75, and 5.00 Vdc are produced from an external precision power supply.

- 270 Channel Multiplexer

The 270 multiplexer was designed to accrue data and channel the data via 270 lines to the data acquisition system. The multiplexer utilizes the latest circuit configurations, including integrated circuits.

#### CATEGORY 4 - ENERGY CONVERSION, NON-PROPULSIVE

- Charger-battery Regulator Module Documentation

This effort involves preparation of the specification, and the acceptance preliminary and qualification test procedures for the Apollo Telescope Mount (ATM)

charger-battery regulator module. A review of the ATM power requirements and prototype circuitry provided detail requirements for the three documents.

- Charger-battery Regulator Module - Prototype Test Model

An engineering analysis was performed to establish design requirements for the thermal mechanical and vibration prototype of the ATM charger-battery regulator module. The packaging design required compliance with MSFC Document 50M02408, Environmental Design and Qualification Test Criteria for ATM Components.

- Fuel Cell Test Console Modification

Analyzed problem areas in fuel cell testing and checkout, and designed the required modifications to the fuel cell test console for more efficient fuel cell operation and checkout. Performed checkout of a fuel cell utilizing the test console, and amended applicable test procedures for more efficient testing and checkout of both single and parallel cell operation.

- Traction Drive Systems

Traction drive systems, for a inverter and ac induction motor, a electronically controlled dc motor, and a dc torquer motor were designed, fabricated and tested to determine which of the systems provided optimum characteristics. Reviewed and analyzed MSFC specifications and guidelines established for the design of traction drive systems.

- Packaging Design for the Charger/Battery/Regulator Module (CBRM)

Performed the packaging design and documentation of the ATM CBRM, which included engineering design, drafting, and checking. The packaging design required compliance with the Environmental Design and Qualification Test Criteria for ATM Components specification.

CATEGORY 5 - MATHEMATICAL SCIENCES

- Reliability Apportionment Techniques

A comparative study of existing reliability techniques was performed to derive a theoretically valid, and efficient technique for optimum allocation of reliability goals for astrionic systems and ground support equipment. Various reliability apportionment techniques were analyzed and the results documented.

- Multiple Correlation in Circuit Design Analysis

Performed a study of multiple correlation applications in circuit design analysis for use in a seminar presentation. The study considered multivariate distribution, the estimated coefficient of correlation, and the assumption of normal distribution.

- Analysis and Criticality Determination of Components

Procedures, guidelines, and example analyses were prepared, utilizing the failure mode, effects, and criticality analysis technique (FMEA) developed by Saturn stage and equipment contractors. The FMEA technique was used to assure that the analysis and criticality determination of components was adequate for inclusion in the Level II math modeling program, Reliability Analysis Model Summary.

- Saturn Contractors Reliability Methods Study

Saturn prime contractors reliability methods (equations and techniques) were reviewed to verify them for technical accuracy. The mathematical models and reliability problems, furnished by the contractors, were subjected to a mathematical verification.

- Methods for Determining Unreliability of Electrical Components

A study was performed to determine the effects of the environmental adjustment factor on the predicted unreliability of electrical components. Part failure information was compiled on relays, resistors, transistors, diodes, and capacitors for both the open and short circuit failure modes.

#### CATEGORY 6 - METHODS AND EQUIPMENT

- Test Control System for Radioisotope Thermoelectric Generator

Designed the control system necessary to operate the Radioisotope Thermoelectric Generator (SNAP-19) during the life testing activity. The requirements for the system were determined and components were screened in accordance with the operational requirements for the life test (Test Duration: 13 months, Environment: thermal-vacuum).

- Fuel Cell Hoist

Prepared the design for a fuel cell hoist. The hoist is to be used when relocating or moving the fuel cells during testing and checkout activities.

- Optical Experiments Chamber

Performed the preliminary cryogenic calculations, chamber configuration, and environmental mechanism controls design of an Optical Experiments Chamber to be used to test the telescope of the Apollo Telescope Mount (ATM) and other optical components. The chamber is a three-section vacuum chamber with each section 5 feet in diameter by 10 feet long.

- Redundant Pointing Control System

Performed a study to determine the optimum design for a redundant pointing control system. The purpose of this study was to aid designers and management in determining the optimum design approach to use for the ATM pointing control system.



- Single Failure Point List

A single failure point list for the Saturn IB and Saturn V programs was prepared for component level items in accordance with Saturn V Program Directive #26. Schematics were researched to locate all single failure points on a GO or NO-GO basis for determination, depending on the failure effect of a particular component on overall system operation.

- Reliability Apportionment

Electrical support equipment (ESE) for the Saturn V vehicle was analyzed and a reliability apportionment of the ESE black boxes and astrionics systems was prepared. The apportionment was made in accordance with reliability predictions using the technique of allocations in terms of criticality ranking in Sperry Rand Corporation, report SSD-K-2-66-2, Reliability Apportionment Techniques and Applications.

- Reliability Prediction

Engineering manpower was provided to analyze electronic equipment and prepare a reliability prediction based on generic failure rates of electronic components operating under various environmental stresses. The analysis was based on MSFC Drawing No. 10M30111A, Failure Rates from Components Failure Physics Analysis, and the knowledge of electronic circuits.

- Failure Mode and Effect Analysis

A study of the potential failures that might occur in any part of the ATM systems was made to determine the severity of the effect of each failure in terms of safety hazard, degradation of performance, or loss of mission.

The task was accomplished through the study of potential failures and their effect on all other parts of the system, and determination of probable locations and mechanisms where failures will occur.

- Failure Effect Analyses

Failure effect analyses, prepared by several contractors, were reviewed for technical accuracy, content, and compliance with MSFC procedures and guidelines. These analyses contained reliability determinations at system, sub-system, and component levels.

- Reliability Analyses

Guidelines were prepared for making reliability analyses on electrical cable assemblies used in the Saturn vehicles. Methods were researched, a plan was established for the guidelines, and the results were documented.

- Failure Rate Derivations Study

Performed a study to determine a statistically valid procedure for deriving failure rates from all pertinent components test data. The study utilized several different approaches, e.g. Bayesian, Classical, Finite Markoff Chain, and Non-Parametric statistics.

- Power Distribution Systems Reliability Analysis

An analysis was performed on three separate power distribution systems (Saturn Program) to determine which of the three designs had the highest predicted reliability. The systems were analyzed by utilizing component level determinations.

- Redundant Configurations Comparison Study

Reliability comparisons of redundant configurations (Saturn systems) were conducted to determine which configurations possessed highest reliability

characteristics as a function of operating time. Equations were prepared for each redundant configuration and the calculated reliability level for each was performed using various operational time limits.

- Reliability Comparison

A reliability comparison was made between the T and TS series modules used in the Saturn IB and V Digital Data Acquisition System (DDAS) electrical support equipment (ESE). The comparison was made between plug-in transistorized circuit modules and modules using standard parts.

#### CATEGORY 7 - ROCKET AND MISSILE TECHNOLOGY

- Low-Level Signal Simulator

A low-level signal simulator was designed, assembled and packaged to provide dc signals for testing the Saturn telemetry analog submultiplexer subsystem. Precise outputs are obtained within the 2.5 to 100 millivolt range.

- Apollo Telescope Mount (ATM) Control System

Designed the ATM control system to provide adequate stability against extraneous motions produced by the crew operating in the Orbital workshop. Developed an analog simulation of the control system to include control moment gyro, rate gyro, and sun-sensor characteristics to establish design parameters.

- Design of an Optimal Control System for Saturn IB AS-208 Vehicle

Designed an optimal control system to compensate for deflection caused by wind disturbance occurring during vehicle flight. Performed analysis and digital simulation study to determine which control gains would result in minimum engine deflection and to determine allowable trade-off between engine deflection and stability margins.

- Traction Drive System (Lunar Vehicle) Motor Controller

An electronic control for a variable speed, variable torque, ac induction motor was developed for use on the lunar vehicle traction drive system. The controller provides parametric variations in load torque, motor speed, and applied voltage with a negative feedback signal that is proportional to shaft speed.

- Experiment Pointing Control System

Derived a two-body math model for the vehicle and experiment package equations utilizing both Lagrange and Euler techniques. Hybrid simulation of the model is used to investigate the effects of component nonlinearities, parallel motor action, and sensor action upon the control system.

- Battery Case Assembly Documentation

Prepared Class I documentation of a battery case assembly from field and vendor drawings. The drawing was detailed and evaluated by possible suppliers.

- Range Safety System Controller

The design of the range safety system controller was modified to provide for new packaging techniques of printed-circuit boards, radio frequency interference (RFI) filter circuits, and relocation of connectors. The range safety system controller is a relay logic device located in the Saturn vehicle to form a part of the destruct operation.

- Saturn Breadboard Maintenance Documentation

Provided documentation maintenance of the Saturn vehicle Instrument Unit for the SA-504 breadboard facility. Performed analysis of the flight vehicle Engineering Orders (EO's) to determine the applicability of the breadboard facility to maintain a system consistent with the flight vehicle.

- Logic Card Tester

A logic card tester was designed and developed to troubleshoot the logic cards used in the Saturn telemetry system. The tester simulates the loads and signals that are supplied to various logic cards by their respective systems.

- Test Program Design-Oriented Criteria Booklets

Performed engineering analysis of equipment, types of tests performed, and the time required for testing, during checkout and launch of Saturn vehicle. Designed a booklet for optimizing the telemeter checkout test, and for illustrating the overall system test areas.

- Saturn V Vehicle Systems Logic Diagrams

Generated Saturn V vehicle systems logic diagrams for use in mission program analysis and verification. Performed an engineering analysis of the Saturn V and associated electrical support equipment systems circuitry, and engineering sketches to effect logic verification.

#### CATEGORY 8 - NAVIGATION, COMMUNICATIONS, AND DETECTION

- Bit Sync Indicator

Designed logic and packaging of a bit sync indicator for detecting errors in the nonreturn-to-zero data output of Pulse-code-modulation (PCM) telemetry systems. The bit sync indicator automatically locks on the master frame or frame sync code group.

- Overmodulation Detector

Designed the circuitry and housing of an overmodulation detector. The detector accurately measures the percentage of time that the modulation

exceeds a preset level in the ranges of 0 percent, 0.1 percent, and 1.0 percent and over a frequency range of dc to 250 kHz.

- Control Circuitry for Data Acquisition System

Designed the amplifier and switch assembly to be used on the ATM to amplify and select the proper output of redundant PCM digital data acquisition subsystems. Switching between the two PCM subsystems is accomplished by commands to internal control circuitry.

- Advanced Optical Communications Systems Research and Development

Research in this area involves state-of-the-art theoretical and experimental studies of visible and infrared laser systems, with an aim to the eventual development of a deep-space laser communications link. Included in this program are projects that involve laboratory photomixing experiments, beam steering and alignment technique studies, the design and testing of signal processing and information retrieval electronics, laser stability and control studies, and the development of transmitting optical systems.

- Low-Light Level Television Camera

Performed a requirements analysis for the design of a low-light level television camera system. The ultrasensitive requirements of the camera dictated the design and manufacture of a special camera tube.

- High-Resolution Television Monitor

A high-resolution, seven-inch television monitor, for use in the ATM mission, is currently being designed and developed. The monitors (two) shall be used by astronauts to view the outputs of six TV cameras, which are monitoring the sun telescope outputs.

- Television System Video Programmer

Performed the packaging design (electronic-mechanical) of a prototype video programmer. The programmer module, though not destined for immediate application, is being developed for the purpose of incorporating into one module the functions that are currently being performed by a number of separate modules.

- Vidicon Television Camera

A standard-scan, high-resolution (700 lines) Vidicon Television Camera system is currently being developed for the ATM mission. The camera system circuits were designed to the requirements established in MSFC-SPEC-50M12740.

- Inertial Platform Control Electronics (Closed Loop System)

Electronic circuitry was designed for the closed-loop operation and control of a rate gyroscope, and for conditioning of the output signal of a control accelerometer. The gyro loop electronics included a dc switching preregulator, a frequency-controlled power inverter for the gyro wheel and dc regulators, a crystal oscillator, torque amplifier for the gyro, and a closely controlled temperature regulator for the gyro assembly.

- Platform Error Analysis Capability

A platform error analysis capability for the Saturn IB and V vehicles was developed. Digital simulations were developed to introduce platform error source into the guidance system of the vehicle.

- Sun Sensor and Star Tracker Computer Simulator

A computer simulator is currently being developed for ground checkout of the sun sensor and star tracker. The simulator performs a function similar

to that of the on-board digital computer during flight: it generates an interrogate pulse, together with clock pulses, that are used in the internal electronics of the fine sun sensor and star tracker for timing purposes, gating, and shifting of the data; and also accepts serial binary data of the direction and magnitude of the resolver rotation and the resolver zero, and presents them to the display panel.

- Iterative Guidance Scheme Sensitivity Study

Developed the equations and digital program for computing the iterative guidance scheme from launch to injection into an earth parking orbit for Saturn V vehicles. The guidance scheme includes the computing of partial derivatives of 20 parameters with respect to 14 variables.

- Thrust Vector Control System Study

A control dynamics study was conducted to determine the response of the thrust vector control system to low thrust levels encountered during passivation (deactivation) of the Saturn S-IVB stage. The plots resulting from this study detailed the dynamic response characteristics for the S-IVB stage attitude, attitude rate, and the J-2 engine deflection angle.

- Navigation and Guidance Schemes Verification Studies

Developed six degree-of-freedom digital simulations of Saturn IB and V trajectories to be used in the verification of the navigation and guidance schemes and associated software for the Saturn vehicles. The studies included the evaluation of error analysis and studying the performance of iterative guidance mode (IGM) under various vehicle perturbations.

- Saturn S-IVB Orbital Flight Simulator

A six degree-of-freedom digital simulation of the Saturn S-IVB orbital flight was developed. This mathematical simulation includes guidance, navigation, and control of the S-IVB stage.



- Saturn Vehicle Trajectory Simulation

Developed a six degree-of-freedom digital simulation of Saturn vehicle trajectories from guidance reference release through lunar injection including guidance, navigation and control systems. The simulation required the development of equations of motion, navigation scheme, iterative guidance scheme, control system equations, failure modes, failure backup schemes, environment equations and perturbation simulations.

- Strapdown Inertial Measuring Unit Noise Filter Simulation Study

An alignment procedure for a digital filter, used to filter noise (vehicle vibration, sway, etc.) from the velocity output of the coordinate transformation computer, was developed. Activities provide for the development of a digital simulation of the strapdown vehicle on the launch pad, with wind-induced sway and vibration.

- Advanced Optical Tracking Systems Research and Development

Under this program, research and development is being conducted on a precision optical tracker that utilizes a visible laser transmitter for monitoring the elevation and azimuth angles, angular rates, range, and range rate of a spacecraft during the critical launch phase which occurs immediately after liftoff. Current activity in this program involves the prototype development of laser amplitude modulations, modulator drivers, and diverse detection and demodulation electronics.

#### CATEGORY 9 - PHYSICS

- Gas Laser Research

This research and development program is directed at optimizing the

parameters of gas laser photomixing systems for potential use in tracking and communication applications. Current program activities include projects involved in the measurement of laser mode stability, the prototype development of scanning interferometers for monitoring laser mode patterns, and the experimental and theoretical research on the dependence of photomixing on optical path length difference.

- Laser Atmospheric Propagation Studies

These studies involve the experimental and theoretical research on the random phase variations in laser radiation during long-distance atmospheric propagation.

- Optical Component Development

This R&D effort is organized to provide optical systems-components integration and correlation technology. The program consists of an optical systems design study that is being conducted in conjunction with an optical components design and development activity (mirrors, lenses); which in turn results in the integration of the individual components into complex optical systems.

- Advanced Semiconductor Memory Devices Research

Theoretical and experimental research studies into the use of a metal-insulator-semiconductor (MIS) device, as a bistable active memory element, were performed. The device utilizes the tunneling effect between the semiconductor and the insulator to store trapped charges.

- Advanced Semiconductor Materials Research

Research studies involve state-of-the-art epitaxial and diffusion techniques. Current research includes development of deep diffusion for power transistors, deposition of silicon nitrides and oxides, and epitaxial growth of semiconductor materials.

- Nonlinear Magnetics Memory Research and Development

This research effort is involved with state-of-the-art studies of magnetic thin-film memory materials and device techniques. Areas researched include magnetic material properties, techniques of deposition, and the development of advanced memory systems.

CATEGORY 10 - SPACE TECHNOLOGY

- Power Control and Monitor Panel

A control panel, for monitoring and controlling the generation and distribution of ATM electrical support equipment power, is currently in the preliminary stage of development. The subsystem will simulate the ATM solar sources and control the Charger-Battery-Regulator Modules (CBRM) during ground checkout.

- Solar Simulator

A solar simulator, for testing solar cell performance, has been engineered and designed for use in the ATM quality assurance program. The simulator tube, capable of illuminating a 24- by 26-inch area, has a 100 mw/cm<sup>2</sup> intensity capability at any temperature setting between 10° and 90° Celsius.

- Statistical Analysis of S-IB/S-IVB Stage Separation

A Monte Carlo simulation of the vehicle rigid body equations was performed to determine attitude and altitude rate errors. Because data is entered and extracted in terms of frequency distributions, this technique provides more realistic results that have the capacity to be analyzed by statistical methods.

- Portable Solar Reflectometer

A portable solar reflectometer for measuring reflective property of materials in space is currently under development. The instrument will make measurements over a wave-length range of 2500 Å to 2.5 microns in eleven bands.

- X-Ray Telescope and Camera System

An X-ray telescope and camera system was designed and developed. The total requirements for the system were established in liaison with MSFC.

- Electronics Design Support

The breadboard, prototype, and flight systems of the ATM X-ray telescope system electronics were designed and developed. The electronics system consists of the X-ray Event Analyzer for detecting the X-ray Activity and camera control electronics.

- Optimization Study of AS-206 Saturn Vehicle Control System

Analog simulations of the AS-206 Saturn vehicle control system were run to establish the design values necessary to assure reliable control system flight operation. Vehicle control system dynamic response curves were obtained, from which gain and phase control margin values were extrapolated.

- Effects of Disturbance on Spacecraft

A study was made to determine the effects of various disturbances on the vehicle body rates. The disturbances included: continuous propulsive venting, lunar excursion module extraction, docking of command service module and deactivation of the stage by dumping propellant through the J-2 engine.

- Encoder/Decoder Modification - Switch Selector Panel

Designed the panel-components configuration of the ATM test and checkout Switch Selector Encoder/Decoder Panel. The modification to the 19 inch wide Switch Selector Panel was designed, and detailed documentation for the printed circuit nests and connectors was furnished to MSFC requirements.

- ATM Electronic Component Checkout System

A two-rack, ten-panel portable experiment checkout equipment system was designed and developed to meet the need for the complete diagnostic testing of the Goddard X-ray telescope experiment electronic components.

- Life Test System for Charger-Battery-Regulator Modules (ATM)

This effort involved the component integration, packaging design, and documentation of the Life Test System for the ATM Charger-Battery-Regulator Modules. The system is capable of testing as many as six modules simultaneously and sustaining the test environment for a two-year period.