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GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

January 1, 1967

SATURN IB LAUNCH VEHICLE PROJECT DEVELOPMENT PLAN

National Aeronautics and Space Administration

NASA

NASA and NASA Contractors Only

APPROVAL

SATURN IB LAUNCH VEHICLE PROJECT DEVELOPMENT PLAN

This document is an official release of Manned Space Flight and its requirements shall be implemented by all cognizant elements of Manned Space Flight Program.

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INTRODUCTION

PURPOSE

The Saturn IB Project Development Plan is prepared in accordance with the requirements of paragraph 1.4.1, Apollo Program Development Plan. The Saturn IB Project Development Plan, herein called the PDP, is established and will be maintained by the Saturn IB Program Manager to clearly identify the program requirements, responsibilities, tasks, resources, and time phasing of the major actions required to accomplish the Saturn IB Program. This PDP will be the single, integrated MSFC summary document which will:

1. Delineate the manner in which the objective of the Saturn IB Program, as established by NASA, shall be achieved;
2. Be the primary decision/approval documentation of the Saturn IB Program Office for the evaluation of program performance and proposed program changes;
3. Be the basic guidance/directive instrument to participating organizations for implementation of approved program changes.

Program planning and implementation by organizations participating in the Saturn IB Program will be responsive to and consistent with this PDP.

This PDP is not intended to provide an exhaustive treatment of each program element. Rather, the approach has been to provide sufficient information on each subject to satisfy the needs of most readers, while at the same time making reference to appropriate supporting documents where greater detail may be found. Also, in order to avoid unnecessarily frequent updating of this PDP, reliance by reference has been placed on the current approved edition of basic and authoritative NASA, OMSF, Apollo Program, and Saturn IB documents. Prime examples of these are:

1. The NASA Management Instructions for agency wide policies, regulations, and procedures;
2. The MSF Program Operating Plan (POP) for budgetary and funding data;

3. The Schedule and Review Procedure (SARP) Charts for Program Schedules and Assessments;

4. The Apollo Flight Mission Assignments Documents for individual mission objectives and configurations;

5. The MSFC Administrative Regulations and Procedures;

6. The Saturn IB Project Specification for vehicle design requirements and vehicle configuration;

7. Saturn IB Program Directives;

8. Individual Saturn IB Mission Directives, published for each launch vehicle.

UPDATING

Revisions to this PDP will be published semiannually (January and July) in the form of replacement pages. Significant program changes or decisions which occur between scheduled revisions to the PDP will be disseminated in the form of Program Directives.

BACKGROUND

In 1958 Congress created the National Aeronautics and Space Administration to direct those aeronautical and space activities sponsored by the United States which are devoted to peaceful purposes for the benefit of mankind. Congress stated that aeronautical and space activities shall be conducted so as to contribute to one or more of the following objectives:

1. The development of aeronautical and space vehicles,

2. The scientific investigation of space environment,

3. The manned exploration of space and the solar system,

4. The application of space science and technology for peaceful uses,

5. The application of space science and technology in support of the National Defense.

In September 1959 the Booster Evaluation Committee of the Office of the Secretary of Defense, following a series of presentations on Saturn, Nova, and Titan C launch vehicles. chose the Saturn system, then being developed by the Army Ballistic Missile Agency under ARPA Order 14-59, as the launch vehicle family that would most feasibly promote NASA objectives of space exploration. Based on recommendations of the Booster Vehicle Evaluation Committee, the NASA Administrator, on December 31, 1959, established a ten-vehicle Saturn I R&D program. On July 1, 1960, the Saturn Program was formally transferred to the George C. Marshall Space Flight Center (MSFC). In January 1962 NASA authorized MSFC to design and develop a large, three-stage launch vehicle, Saturn V, to launch the three-man Apollo spacecraft, under development by MSC Field Center, on circumlunar flights and manned lunar landing missions.

On July 11, 1962, NASA announced that an advanced Saturn I vehicle, the Saturn IB, would be developed for manned earth-orbital missions with full-scale Apollo spacecraft. This member of the Saturn family combines the third stage and instrument unit of the Saturn V with an improved version of the first stage of the Saturn I.

THE SATURN IB PROGRAM

The Saturn IB Program objectives will be achieved as the culmination of a logical and carefully planned and managed development program.

This program will result in an operational two-stage launch vehicle capable of placing a payload of approximately 40,000 pounds into a low earth orbit. The Saturn IB will have sufficient payload capability to launch a manned Apollo spacecraft into low earth orbit for extensive mission exercises and for operational tests. As defined in the Apollo Flight Mission Assignments Document, M-D MA500-11, the Saturn IB launch vehicle will make these Apollo spacecraft tests possible far in advance of the development of the Saturn V launch vehicle.

The overall Saturn IB Program consists of five major mission types.

1. Unmanned Suborbital Flights. This phase is a developmental phase for the launch vehicle and the Apollo spacecraft, and will verify the compatibility and structural integrity of CSM-Saturn IB. Furthermore, it will test the launch concept pertaining to checkout and launch facilities and equipment.

2. Unmanned Earth-Orbital LH_2 Experiment. This mission will qualify the continuous venting system, demonstrate the Saturn V S-IVB orbital engine chilldown and recirculation system, and determine orbital tank fluid dynamics and thermodynamics of the S-IVB stage. In addition, it will check out the S-IVB and Instrument Unit in an orbital environment and will demonstrate mission support facilities required for launch and mission orbital operations.

3. Manned Earth-Orbital CSM Long Duration Operations. This phase will follow the unmanned launch vehicle and spacecraft qualification and will verify the man/system interfaces and demonstrate the crew/CSM/Ground Systems performance for extended missions.

4. Unmanned Earth-Orbital LM Development. This mission will provide verification of LM systems operation, demonstrate LM fire-in-the-hole abort, and provide an evaluation of the LM staging characteristics.

5. Manned Earth-Orbital Dual Launch CSM-LM Operations. This phase will provide verification of Block II CSM systems, further verification of LM systems, and rendezvous, docking, and crew transfer experience. In addition, rendezvous missions to simulate the lunar orbit rendezvous phase of the lunar mission will extend the experience gained in the Gemini Program and will flight-qualify Apollo systems for the lunar mission.

The Saturn IB schedule of major milestones in support of the Manned Lunar Landing program is as follows:

First Saturn IB flight	1966
First Saturn IB orbital flight	1966
First Saturn IB manned flight	1967
First Saturn IB LM flight	1967

THE MANAGEMENT TASK

Within the Office of Manned Space Flight, by delegation from the Associate Administrator, Manned Space Flight (AA/MSF), the Director of Marshall Space Flight Center, under the cognizance of the Apollo Program Director, is responsible for the development of the Saturn family of launch vehicles. By delegation from the Director, MSFC, the Saturn IB Program Manager is immediately responsible, under the cognizance of the Apollo Program Director, for directing, controlling, and integrating the management of several developmental activities which constitute the total Saturn IB Program.

SECTION 1

PROGRAM MANAGEMENT

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SECTION 1

PROGRAM MANAGEMENT

1.1 SCOPE

This section is a summary description of the management philosophy, organizational relationships, responsibility assignments, and communication/coordination modes required to effectively manage the Saturn IB Program.

1.2 MANAGEMENT PHILOSOPHY

The Apollo Program Office in Washington, under the direction of the Apollo Program Director, is responsible for overall Apollo program management, acting within the policy guidelines and broad plans established by the Program Management Council.

The George C. Marshall Space Flight Center at Huntsville, under the direction of the MSFC Director, is responsible for the research, development, manufacture, test, transportation, and logistics support of the Saturn family of launch vehicles and engines. MSFC has basically two line organizations: Research and Development Operations (R&DO) and Industrial Operations (IO). The Director of R&DO is responsible for maintaining competence in depth in all technical disciplines related to launch vehicles and has responsibility for all efforts, including active projects, future project studies, and supporting research work, within the scope of these disciplines. The Director of Industrial Operations is responsible for management of industrial contractors and MSFC in-house elements in the Saturn program in the areas of concurrent development, concurrent manufacturing and testing, and the integration of interfaces. IO's principal functions are contract management and technical direction to the contractors using the capabilities of the MSFC R&DO disciplines. Other functions are fiscal management, logistic management, and facilities acquisition and management. Within Industrial Operations, the Saturn IB Program Office, under the direction of the MSFC Director and the cognizance of the Apollo Program Director, is responsible for overall Saturn IB Program management. The Saturn IB Program Manager reports to the Director of Industrial Operations, but is responsive to program direction from the Apollo Program Director.

Saturn IB Program Management is predicated upon the principle of maximum delegation of responsibility and authority. The Saturn IB Program Manager has appointed Stage Managers who are responsible for directing Saturn IB project activities assigned to Saturn IB Program.

The Program Management Council, consisting of the Associate Administrator for Manned Space Flight and the Directors of the three MSF Field Centers, establishes Apollo Program policy and plans, reviews progress, and evaluates performance of Apollo Program elements. The Program Management Council is responsible for ensuring that adequate resources are available for the successful conduct of the program and that policy, progress goals, and performance goals are being met. The Apollo Program Director operates within the policy guidelines and broad plans established by the Program Management Council, and is responsible for advising the Program Management Council of program plans and status, potential problem areas, cost status, and requirements for additional resources. The Saturn IB Program Manager is responsible for advising the Apollo Program Director of program plans and status, potential and real problem areas, cost status, and requirements for additional resources.

The Saturn IB Program Manager receives from the Apollo Program Director the allocation of resources needed to carry out the Saturn IB Program and, in gross terms, the schedules, mission objectives, program specifications, reliability and quality standards, and development and test plans. Within this broad framework, the Saturn IB Program Manager, subject to the approval of the MSFC Industrial Operations Director, establishes the detailed schedules, financial operating plans, project and system specifications, reliability and quality procedures, and detailed development and test plans for the Saturn IB Program.

1.3 ORGANIZATIONAL RELATIONSHIPS

1.3.1 GENERAL. The primary organizations responsible for the implementation of the Saturn IB Program are: the Office of Manned Space Flight (OMSF) within NASA Headquarters, the Apollo Program Office within OMSF, Marshall Space Flight Center (MSFC) within OMSF, Industrial Operation within MSFC, the Saturn IB Program Manager within IO, and supporting industrial contractors. These organizational elements and their responsibilities are described in the paragraphs that follow.

1.3.2 NASA HEADQUARTERS. The National Aeronautics and Space Administration (NASA), established on October 1, 1958, is responsible for directing aeronautical and space activities of the United States which are devoted to peaceful purposes for the benefit of mankind. The organization of NASA Headquarters is shown in Figure 1-1. The main functions of Headquarters are to: establish

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

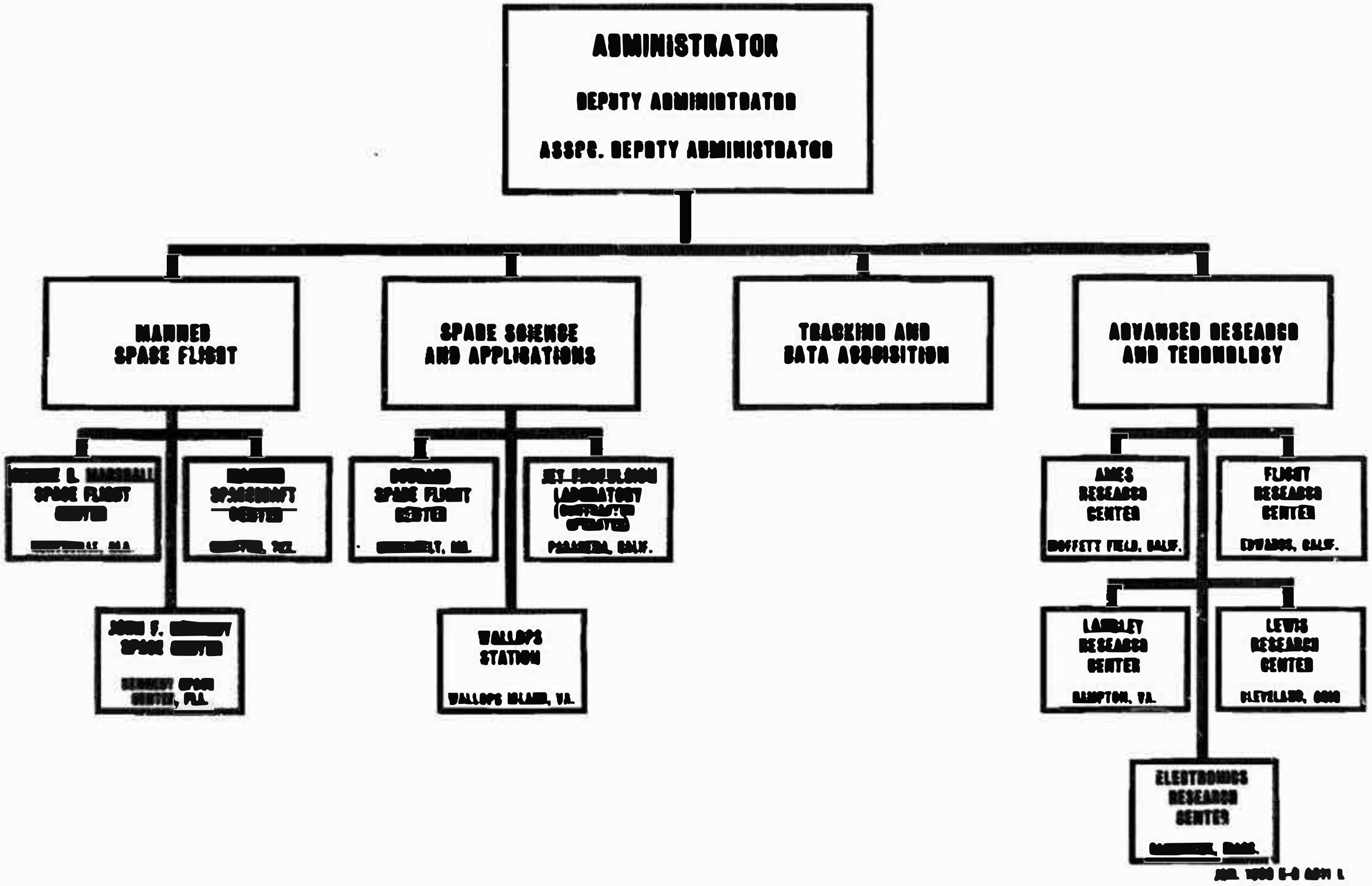


FIGURE 1-1. NASA ORGANIZATION

policy, define goals and objectives, approve plans, provide resources, review utilization of resources, and review progress toward established goals and objectives. Within Headquarters, the Associate Administrator for Manned Space Flight (AA/MSF), is responsible for directing and executing the Manned Space Flight Programs.

1.3.3 MANNED SPACE FLIGHT ORGANIZATION. The overall structure of the Manned Space Flight organization is shown in Figure 1-2. It consists of three major functional elements reporting to the AA/MSF. These are:

a. A staff in Washington which provides institutional administrative direction and support to the Field Center organizations as well as facilities management and other required support to the Program Offices in Washington;

b. The four Program Offices in Washington which provide overall program management direction for the Apollo, Gemini, Advanced Missions, and Mission Operations Programs;

c. The three Field Centers, MSFC, MSC, and KSC which perform their respective Research and Development programs and implement directives issued by the AA/MSF and the Program Director.

1.3.4 APOLLO PROGRAM MANAGEMENT. The Apollo Program Director, under the overall direction of the Program Management Council, is vested with the sole authority for Apollo Program Direction and is the official source within NASA for issuing policy directives and imposing requirements on Field Centers. The Director and his staff are responsible for establishment of overall technical requirements, program standards, and management policies and procedures to accomplish program goals and objectives. He provides the program direction and program coordination necessary for the Field Centers to accomplish their assigned program tasks.

The Apollo Program Office consists of staff and directorate functions. The directorate functions are: Program Control, Test, Reliability and Quality, Flight Operations, and Systems Engineering. Figure 1-3 illustrates this organization.

1.3.5 MARSHALL SPACE FLIGHT CENTER MANAGEMENT. Within the Office of Manned Space Flight, by delegation from the Associate Administrator for Manned Space Flight, the Director of the Marshall Space Flight Center is directly responsible for development of the Saturn I, Saturn IB, and Saturn V launch vehicles and engines, associated ground support equipment, and flight operations

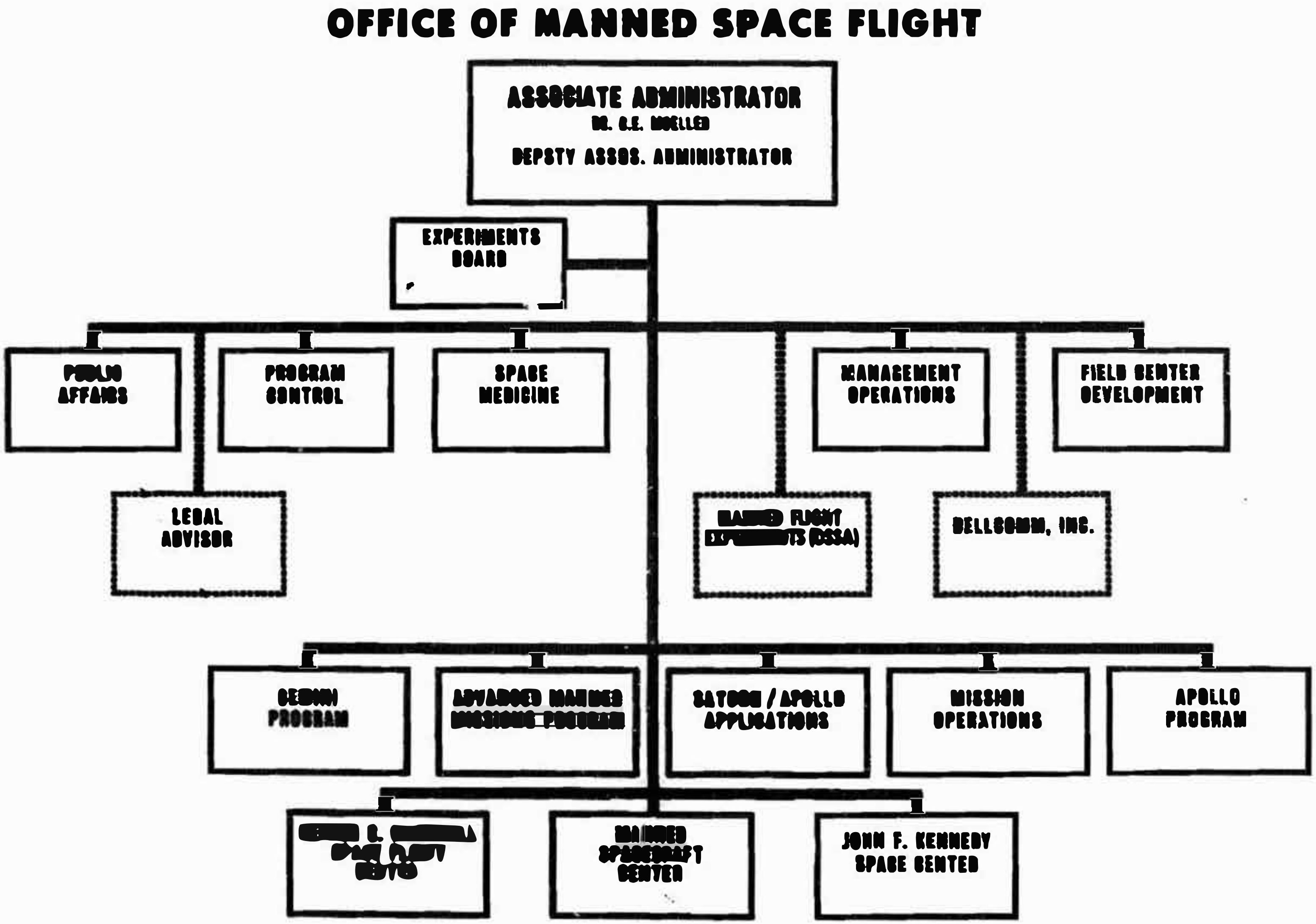
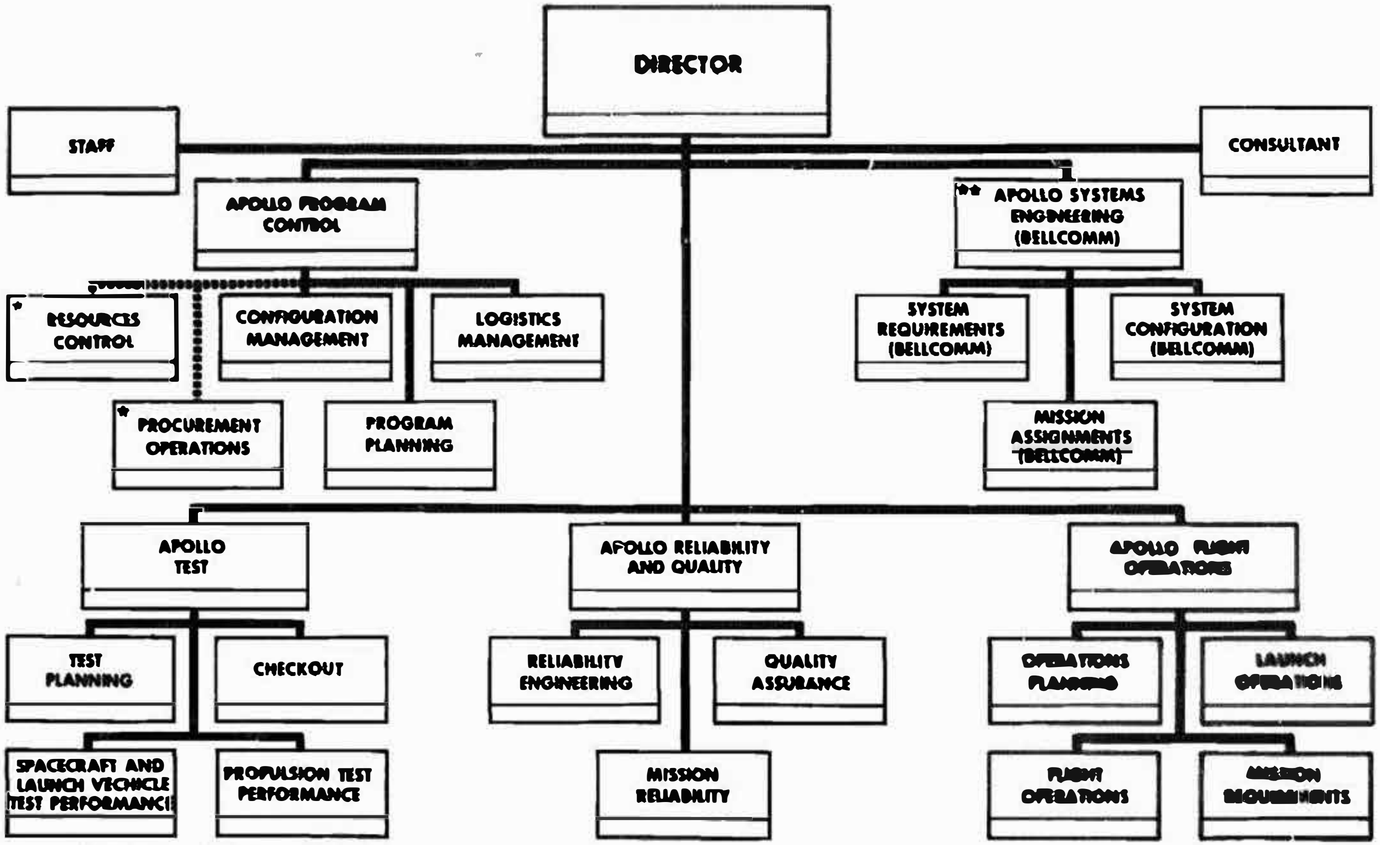


FIGURE 1-2. MANNED SPACE FLIGHT ORGANIZATION



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OFFICE OF MANNED SPACE FLIGHT
APOLLO PROGRAM

* PERSONNEL ARE ON LOAN FROM MSF PROGRAM CONTROL
** ALL PERSONNEL ARE UNDER CONTRACT WITH BELLCOMM

FIGURE 1-3. APOLLO PROGRAM ORGANIZATION

support. This development includes both research and development responsibility and responsibility for the production of flight-ready vehicles. To make the in-depth technical competence in all launch vehicle disciplines available to each Program Office within MSFC as required and at maximum efficiency, Research and Development Operations (R&DO) has been established. Industrial Operations (IO) has been established to execute the responsibilities of managing the industrial contractors and MSFC in-house production elements. Figure 1-4 illustrates this organization. The major management relationships existing among the MSFC elements is illustrated in Figure 1-5.

1.3.6 MSFC INDUSTRIAL OPERATIONS MANAGEMENT. The Director, Industrial Operations, MSFC, by delegation from the Director of the Marshall Space Flight Center, is assigned the overall responsibility for the conduct and management of the Saturn Launch Vehicle Systems Programs. In discharging these responsibilities, IO performs the following functions:

a. Management of the Saturn Launch Vehicle Systems Programs, including related GSE and MSFC-assigned Saturn payloads. IO takes all actions necessary to ensure that the entire series of Saturn launch vehicle systems is successfully developed, produced, tested, delivered, and launched to carry out the specified missions on the officially scheduled dates and at the most reasonable cost to the government within allotted funds. The term, "Saturn Launch Vehicle Systems" includes the complete launch vehicles (Saturn I, IB, and V), MSFC-assigned payloads, related GSE and software, and all support, handling, and logistics requirements.

b. Assure the technical adequacy of the overall launch vehicle system and the successful integration of vehicle stages, engines, GSE, associated equipment, and MSFC-assigned payloads. Wherever possible, courses of action and final decisions will be reached by mutual agreement between program and project managers and responsible R&DO senior personnel involved.

c. Be the final authority on all program matters assigned by the foregoing paragraphs, as well as the launch vehicle and GSE configuration, related software, test programs, and quality and reliability programs. IO will ensure that all program participants conform to established systems specifications and program requirements.

d. Direct all government contracting activities for launch vehicle stages, program-related facilities, program logistics, and MSFC-assigned Saturn payloads, except for those sub-systems and other Saturn-related elements which are assigned to R&DO.

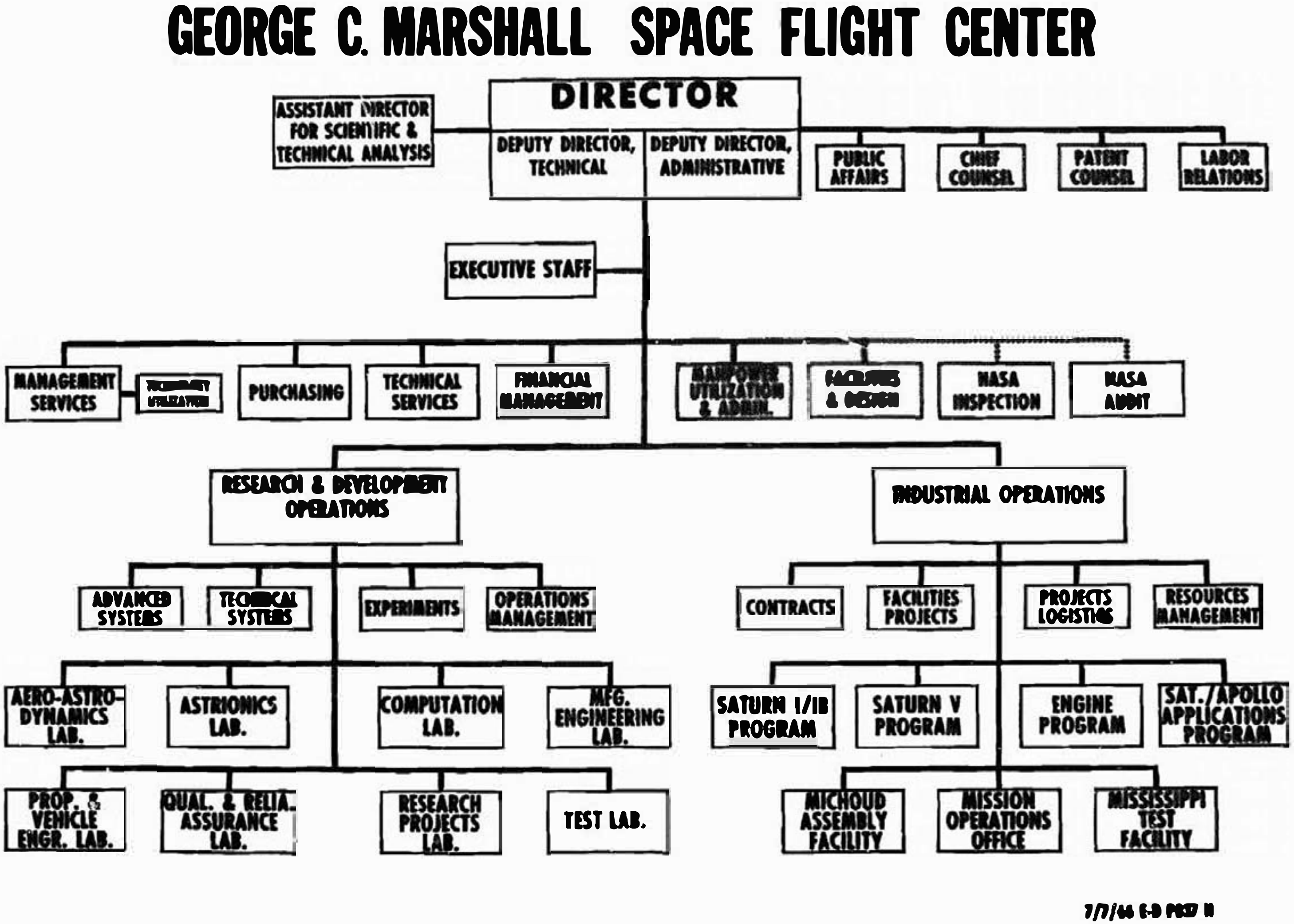
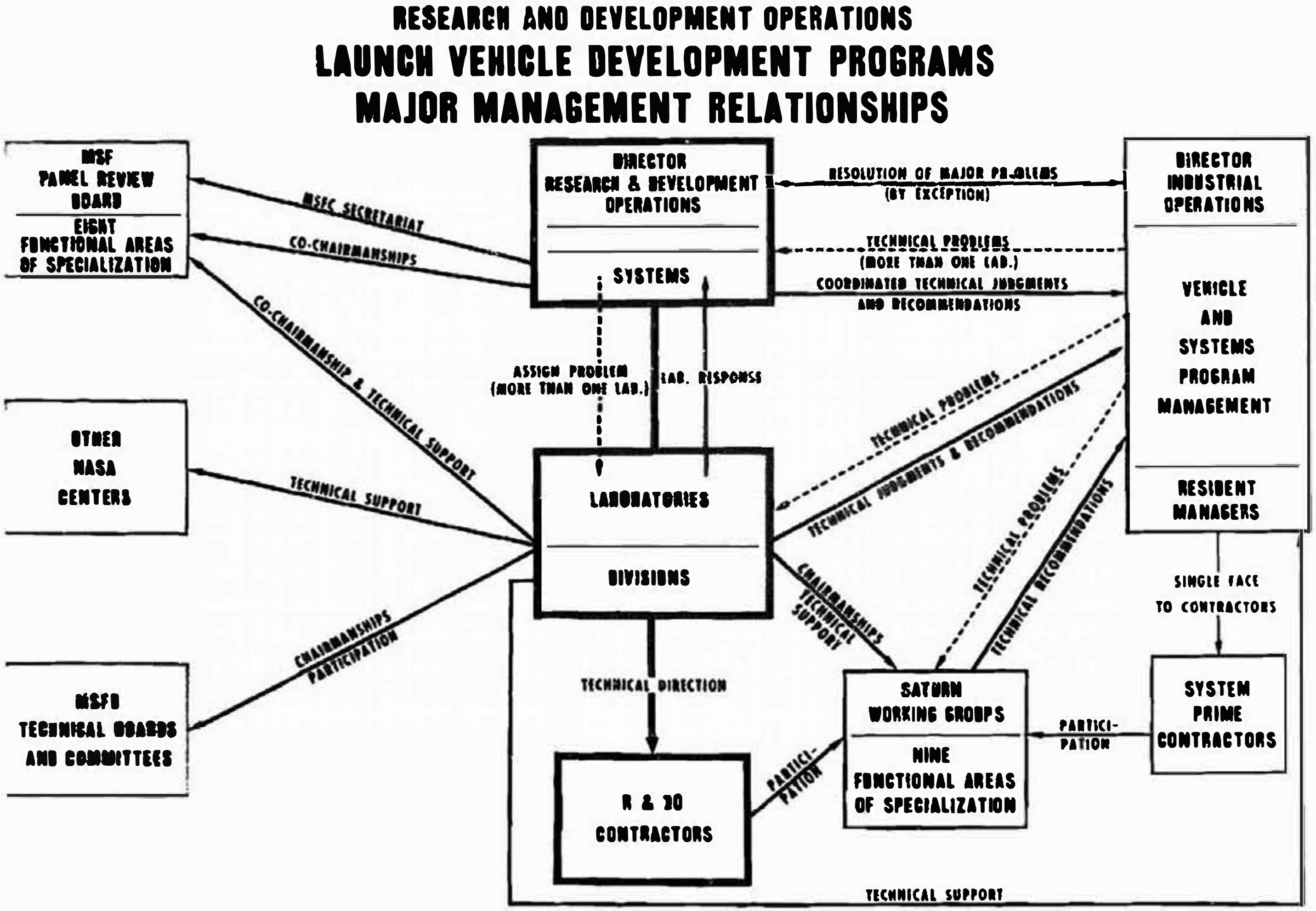


FIGURE 1-4. INDUSTRIAL OPERATIONS ORGANIZATION



RESEARCH AND DEVELOPMENT OPERATIONS
LAUNCH VEHICLE DEVELOPMENT PROGRAMS
MAJOR MANAGEMENT RELATIONSHIPS

FIGURE 1-5. MAJOR MANAGEMENT RELATIONSHIPS

e. Manage the off-site field operations of MSFC, including the Mississippi Test Facility, Michoud Assembly Plant, and Resident Management Offices and attached elements.

f. Manage MSFC program logistics activities, including spare parts, propellants and pressurants, transportation, equipment and facilities, and field operations.

g. Direct a facilities program to provide and maintain facilities and equipment required for the Saturn program.

The organization of Industrial Operations is illustrated in Figure 1-6.

1.3.7 SATURN IB PROGRAM MANAGEMENT

1.3.7.1 GENERAL. The Saturn IB Program Manager, under the direction of the MSFC Industrial Operations Director and the Apollo Program Director, is vested with the sole authority for Saturn IB Program direction. Management relationships with contractors is illustrated by Figure 1-7.

1.3.7.2 SATURN IB PROGRAM OFFICE FUNCTION. The functions of the Saturn IB Program Office are:

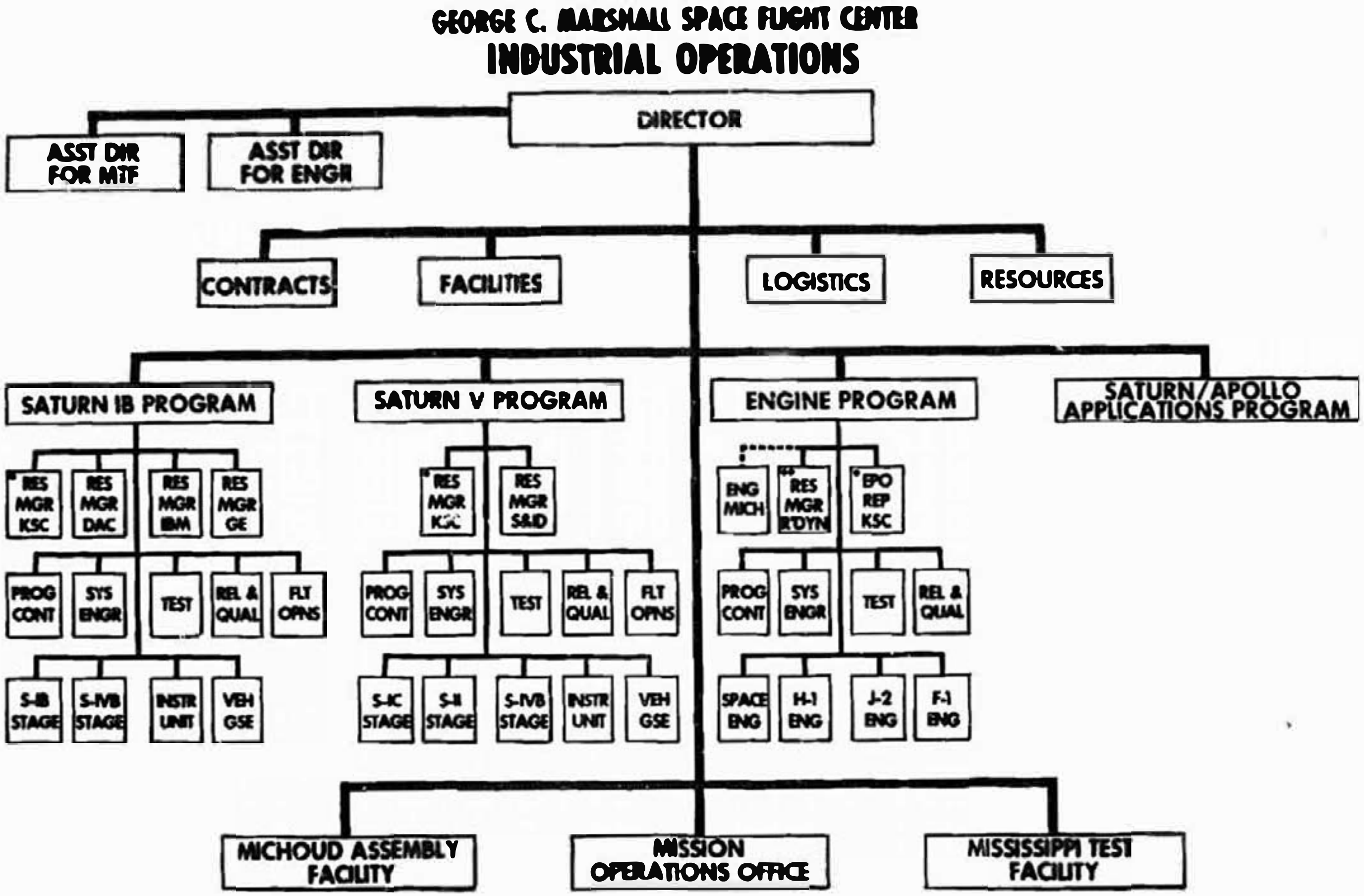
a. To plan and direct the execution of the Saturn IB Program within established technical, schedule, and resources limitations.

b. To manage the composite MSFC/industry performance through the phases of program planning, coordination, and contractor managerial and technical direction in the design, engineering, integration, development, control, production, testing, delivery, and pre-launch checkout of the Saturn IB vehicle and associated equipment.

c. To assure the technical adequacy of the overall vehicle system and the successful integration of vehicle stages and associated equipment within the assigned mission objectives of the Saturn IB Programs.

1.3.7.3 SATURN IB PROGRAM OFFICE AUTHORITY. Subject to established Apollo and MSFC policy and the limitations prescribed by the Director, MSFC Industrial Operations, the Saturn IB Program Manager:

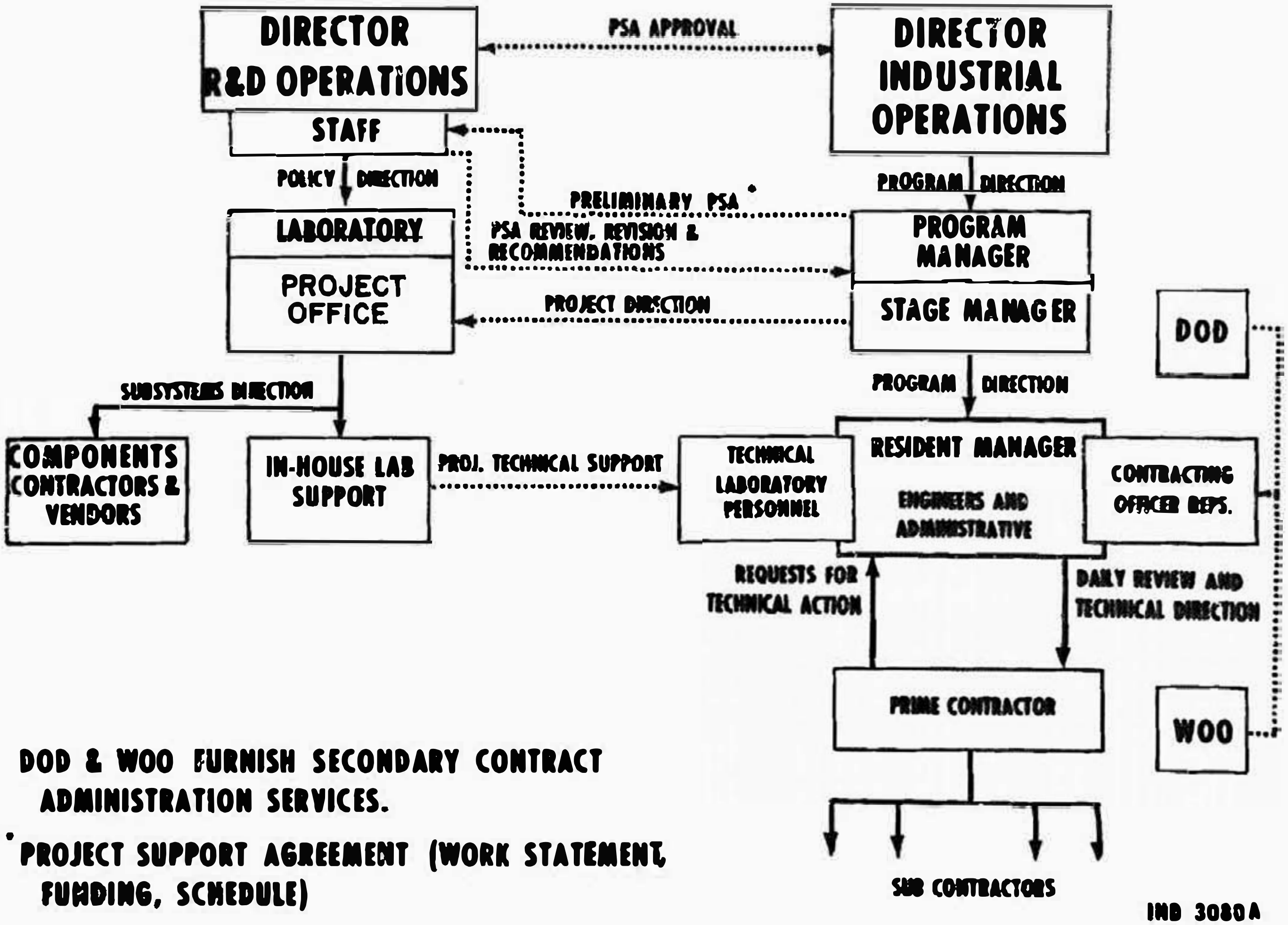
a. Is the official and accountable source for overall program management and control of the Saturn IB vehicle systems.



*ONE RESIDENT OFFICE; REPRESENTATION FROM SAT IB, SAT V AND ENGINE
**RESIDENT MANAGER OFFICES LOCATED AT CANOGA, NEOSHO AND EAFB

FIGURE 1-6. INDUSTRIAL OPERATIONS ORGANIZATION

MSFC INTERNAL MANAGEMENT AND TECHNICAL RELATIONSHIPS



DOD & WOO FURNISH SECONDARY CONTRACT ADMINISTRATION SERVICES.

*PROJECT SUPPORT AGREEMENT (WORK STATEMENT, FUNDING, SCHEDULE)

IND 3080A

FIGURE 1-7. INTERNAL MANAGEMENT AND TECHNICAL RELATIONSHIPS

b. Is the official source of managerial and technical direction, within the scope of Project Approval Documents and applicable contracts, for Industrial Operations contractors engaged in projects administered by his office.

c. Is the official source of assurance for technical adequacy of the overall Saturn IB vehicle systems, including systems engineering, fabrication, quality, reliability, test, and flight operations.

d. Determines and assigns responsibility for Saturn IB vehicle stages, associated hardware, and facilities within MSFC and to contractors or other NASA Centers.

1.3.7.4 SATURN IB PROGRAM OFFICE MANAGEMENT RELATIONSHIPS. The Saturn IB Program Manager and Deputy Managers will:

a. Serve as advisors and consultants to the Director, Industrial Operations, on matters pertaining to the Saturn IB Program;

b. Serve as points of contact with NASA Headquarters, NASA Field Centers, other MSFC organizational elements, and private industry on Saturn IB Program matters and activities;

c. Serve as points of contact with, and provide program direction and review of Saturn IB activities performed by the R&D Operations and associated working groups, panels, and technical committees;

d. Serve as the central point of determination and dissemination of program status in all areas of the Saturn IB Program.

1.3.7.5 SATURN IB PROGRAM OFFICE ORGANIZATION. The Saturn IB Program Office consists of three major functional elements reporting to the Saturn IB Program Manager. Figure 1-8 illustrates this organization. These elements are:

a. A staff to provide functional support to the Program Manager and the Stage Managers,

b. Stage and System Offices which manage their respective projects,

c. Resident Management Offices which provide on-site supervision and management of the Contractors.

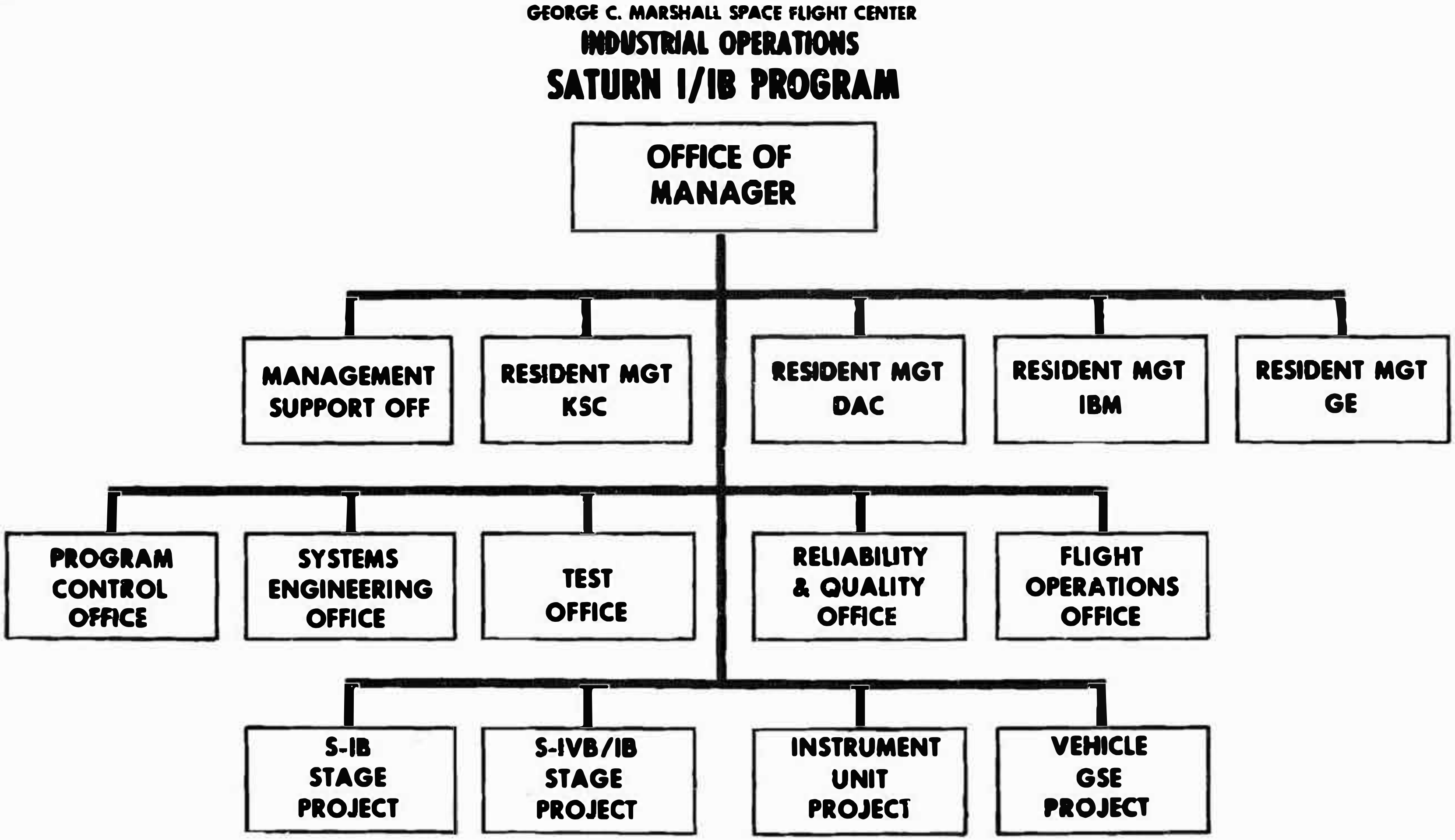


FIGURE 1-8. SATURN IB PROGRAM OFFICE ORGANIZATION

The staff structure is modeled after that of the Apollo Program Office directorate structure, with similar areas of responsibility in the corresponding offices. These staff offices are: Program Control, Test, Reliability and Quality, Flight Operations, and Systems Engineering. This parallel structure facilitates the day-to-day communication and free flow of information between the functional elements in the Saturn IB Program Office in Washington. In addition, there is a Management Support Office to provide support in internal administrative actions. These staff offices provide program-oriented functions related to planning, scheduling, budgeting, and assessment of program accomplishments, and assist and advise the line managers on matters related to their particular areas of assignment.

There are four project offices within the Saturn IB Program Office: The S-IB Stage Office, the S-IVB Stage Office, the Instrument Unit Office, and the Vehicle GSE Office. The function of these offices is to define, direct, review, and evaluate composite MSFC/industry performance throughout the phases of planning, coordination, and contractor direction in the design, development, integration, production, testing, delivery, and pre-launch checkout of the stages, vehicle ground support equipment, Instrument Unit, and associated equipment.

The Stage, Vehicle Ground Support Equipment, and Instrument Unit Project Managers are authorized to take the actions necessary to accomplish these assigned functions and responsibilities within the policy delineated by MSF/MSFC and the Director, Industrial Operations, for the Saturn I/IB Program Manager. These Project Managers serve as the project managers for the Saturn IB Program Manager in relationships with the prime contractors, NASA Headquarters Program Offices, and MSFC Research and Development Operations Laboratories on matters pertaining to the stages, instrument unit or vehicle ground support equipment, as assigned.

The Project Managers also serve as the control within the Saturn IB Program Office for activities of the MSFC working groups with respect to resolution of stage, instrument unit, or vehicle ground support equipment technical problems.

There are four Resident Management Offices which have elements to provide on-site Saturn IB representation and direction at KSC and certain key contractor locations. These are the KSC Resident Office at KSC; the DAC Resident Office at Douglas Aircraft Company's operations at Huntington Beach, with a division at Santa Monica; the IBM Resident Office at International Business Machines' Operations at Huntsville, Alabama; and the GE Resident Office at General Electric's Operations at Huntsville, Alabama.

1.3.7.6 RESPONSIBILITIES OF SATURN IB STAFF AND LINE OFFICES

1.3.7.6.1 OFFICE OF THE MANAGER. This office directs and manages the Saturn IB Program by establishing program policies and requirements, determining program priorities, and effecting a system of program scheduling and status analysis; reviews and approves design, production, qualification, and test schedules; ensures that supporting contractors meet requirements of established schedules; approves technical baselines and exercises control over the technical progress of MSFC elements in attaining vehicle system objectives; highlights major technical problems requiring attention of Center top management or higher authority and recommends solutions; ensures effective implementation of Center management control systems.

1.3.7.6.2 MANAGEMENT SUPPORT OFFICE. This office performs the following functions;

a. Establishes and ensures implementation of internal administrative management policy;

b. Conducts studies involving organization, functional alignment, communication and management systems, manpower, physical space, and administrative operations;

c. Establishes management support policies, systems, methods, and procedures required to accomplish management services and staff functions;

d. Develops, prepares, justifies, and modifies the internal operating budget for the Saturn IB Program Office, and develops, administers, and analyzes policies, procedures, and practices required in the management of the approved internal operating funds;

e. Provides administrative management services and support to all organizational elements of the Saturn IB Program, including Resident Management and Resident Stage Offices.

1.3.7.6.3 KSC RESIDENT MANAGEMENT OFFICE, SATURN IB ELEMENT. This office:

a. Serves as the Senior Representative for all matters pertaining or related to execution of Saturn IB Program Office responsibilities at Kennedy Space Center;

b. Detects, analyzes, and provides quick-response solutions to problems, real or incipient, at KSC which may affect Saturn IB program management;

c. Assures compatibility and continuity of effort by timely planning, coordination, and implementation to assure mission success;

d. Implements designated configuration management responsibilities for the launch vehicle and active GSE hardware involved in checkout and launch, and related instrumentation;

e. Assures prompt, timely, and effective technical support in accordance with KSC requirements;

f. Monitors KSC performance on the Saturn IB vehicles as related to requirements developed under the provisions of approved MSFC-KSC agreements;

g. Actively participates in working groups, panels, technical committees, and ad hoc group activities, meetings, conferences, etc., conducted at KSC which concern the Saturn IB Program;

h. Recognizes the authority and responsibility of other agencies and centers and fully coordinates actions taken or instructions issued with any official authoritative, joint, or supporting interests compatible with Saturn IB Program responsibilities.

1.3.7.6.4 CONTRACTOR RESIDENT MANAGEMENT OFFICES (DAC, IBM, AND GE). These offices perform the following functions:

a. In accordance with MSFC policy statements and the master charter for Resident Management Offices, provide on-site supervision and management of MSFC operations at DAC, IBM, and GE sites and act as the single overall channel of communications between MSFC and the Contractor regarding assigned contracts;

b. Recognize the authority and responsibilities of other agencies (such as Army, Navy, Air Force, MSFC and NASA Headquarters) and fully coordinate all actions or instructions with any other officials having authoritative, joint, or supporting interests;

c. Provide on-site supervision and control over MSFC personnel assigned, attached to, or otherwise present at the contractor plant in relation to assigned programs, recommending changes or additions as required for effective local program management;

d. Assign duties to resident representatives which are pertinent to the disciplines and specialities represented;

e. Establish and maintain appropriate communication channels between the Program Manager, Resident Stage Managers, MSFC personnel and the Contractors;

f. Implement designated configuration management responsibilities and execute established plans, schedules, budgets, systems, and other resources plans and requirements.

1.3.7.6.5 PROGRAM CONTROL OFFICE. The Program Control Office performs the following functions:

a. Establishes program plans and resources requirements which are reflected in Program Development Plans, schedules, budgets, PERT, technical operating plans, and program operating plans;

b. Establishes and maintains information channels with counterparts in the Apollo Program Office, Office of Manned Space Flight, NASA Headquarters;

c. Provides program guidance and advice to the Saturn IB Program Manager and his staff and stage managers, and integrates plans and resources requirements within the Saturn IB Program;

d. Coordinates interrelated program schedules; plans and issues program guidelines and instructions; and maintains control over program schedules, resource allocations and reallocation of funds within assigned limitation;

e. Analyzes program cost, developing a means of projecting cost through runout of the program and assuring that program objectives are achieved at minimum costs;

f. Maintains cognizance over the Stage PERT Reports and prepares the Systems PERT Report;

g. Coordinates, or prepares and revises, Project Development Plans for the Saturn IB Program Office; ensures preparation and submission of reports reflecting program plans and resources status; makes timely identification and assessment of problem areas and program balance; and recommends solutions to minimize impacts; provides a briefing capability on program status;

h. Serves as senior member of the Saturn IB Configuration Control Board on program changes affecting overall program schedules and resources;

i. Evaluates procurement plans and contracts to ensure compliance with program objectives and funding plans;

j. Integrates Saturn IB Program elements to ensure total program configuration management;

k. Directs management effort in conduct of identification, control, and accounting for Saturn IB system configuration;

l. Coordinates and consolidates managerial data for presentation to the MSF Management Council and as input to the IO Program Control Center.

The Program Control Office consists of the Plans and the Requirements Branch, Resources Management Branch, and the Configuration and Data Management Branch.

1.3.7.6.6 SYSTEMS ENGINEERING OFFICE. This office performs the following functions:

a. Performs, coordinates, or directs the performance of the technical reviews, analyses, and evaluations required to assure the technical adequacy of the vehicle system and interfaces;

b. Coordinates detailed functional and performance requirements related to program and system specifications, system descriptions and model specifications;

c. Performs or directs the performance of technical analysis, systems evaluation, and integration in the areas of mission requirements, weight and performance, automation and network, mechanics and propulsion, instrumentation and communications, flight mechanics, dynamics and control, guidance and navigation, flight evaluation, and logistics;

d. Conducts the program technical reviews;

e. Coordinates and integrates systems engineering aspects within the program and with the counterpart elements at the NASA Apollo Program Office and other space flight centers.

The Systems Engineering Office is composed of the functional areas of Systems Evaluation and Integration. Mission and Payload Requirements, Weight and Performance, Automation, Networks and Instrumentation, Mechanics and Propulsion, Flight Mechanics, Dynamics, Guidance and Control, and Systems Engineering Contracts.

1.3.7.6.7 <u>TEST OFFICE.</u> The Test Office:

a. Plans, establishes, coordinates, analyzes, evaluates and consolidates test and checkout requirements;

b. Establishes and maintains Saturn IB Master Test Plans in accordance with program requirements;

c. Reviews contracts or scopes of work to assure implementation of established test and checkout requirements, and determines status of implementation of approved programs;

d. Evaluates and coordinates impacts of test requirements on programs;

e. Assesses program test accomplishments;

f. Establishes and/or coordinates test reporting systems and techniques;

g. Coordinates and integrates test and checkout plans within the program and with the counterpart elements at the NASA Apollo Program Office and other space flight centers.

h. Plan, establish and coordinate the MSFC preparations for Saturn IB Vehicle Preflight Reviews and the MSF Flight Readiness Reviews, including the required written assessments.

The Test Office consists of the Test Plans and Evaluation Branch and the Checkout Branch.

1.3.7.6.8 <u>RELIABILITY AND QUALITY ASSURANCE OFFICE.</u> The R&QA office:

a. Plans, establishes, coordinates, analyzes, evaluates, and consolidates reliability and quality requirements;

b. Establishes and maintains cognizance of reliability and quality requirements in accordance with program requirements;

c. Assures implementation of established reliability and quality requirements and determines the status of implementation of approved programs;

d. Evaluates and coordinates impacts of quality and reliability requirements on programs;

e. Assesses reliability and quality program accomplishments;

f. Establishes and/or coordinates reporting systems and techniques;

g. Coordinates and integrates reliability and quality assurance actions within the program and with the counterpart elements at the NASA Apollo Program Office and other space flight centers.

1.3.7.6.9 FLIGHT OPERATIONS OFFICE. This office performs functions as follows:

a. Plans, establishes, coordinates, analyzes, evaluates, and consolidates flight operations requirements;

b. Establishes and maintains cognizance of flight operations requirements in accordance with program requirements, and participates in the MSF Mission Operations Program;

c. Assures implementation of requirements and determines the status of approved flight operations programs;

d. Coordinates and integrates flight and support operations plans within the counterpart elements at the NASA Apollo Program Office and other space flight centers.

1.3.7.6.10 PROJECT OFFICES (S-IB, S-IVB/IB, IU, AND VEHICLE GSE). Each of the Project Offices:

a. Determines stage, instrument unit or vehicle ground support equipment tasks to be assigned to MSFC organizations, NASA Field Centers, and contractors;

b. Determines and develops consolidated operating plans, approves the allocation and commitment of funds within established operating plans, determines the necessity for reprogramming of funds; and initiates necessary actions within assigned limitations;

c. Analyzes costs, imposing restrictions as necessary to control costs;

d. Formulates the technical work requirements to be performed under the prime contracts, assists MSFC procurement elements in preparation of necessary contractual instruments, participates in major contract negotiations as the principal MSFC negotiator for technical and project aspects;

e. Evaluates contractor performance and recommends or takes action to ensure that objectives are attained;

f. Establishes the requirements for and reviews the prime stage contractor's PERT network structures for accuracy and adequacy, evaluates the prime stage contractor's PERT reports, such as design, production, and other areas of related effort;

g. Establishes and controls development plans and milestones in areas of responsibility;

h. Provides MSFC and NASA top management with periodic overall status, including applicable MSF schedules;

i. Establishes and directs the implementation of overall requirements, coordinating technical requirements with cognizant R&DO laboratories;

j. Directs the detail design integration of stage contained and ground support equipment performed by R&DO laboratories and contractors;

k. Determines logistics requirements for support of operations that are peculiar to stage and ground support equipment;

l. Determines requirements for and ensures timely availability of stage, instrument unit, and ground support equipment oriented tooling, equipment and facilities;

m. Participates in working groups and similar activities established to resolve project technical problems and assures that necessary action is taken;

n. Maintains cognizance of overall program status reports required by the program manager and higher authority.

1.3.8 INDUSTRY PARTICIPATION

1.3.8.1 GENERAL. To accomplish the Saturn IB Program within established funding, schedules, and technical performance constraints, NASA must utilize the management, technical, and scientific resources of industry. All contracts with industry for support of the Saturn IB Program are solicited, negotiated, and managed by one of the organizational elements within the MSFC organization. The major contractors and their areas of contribution are summarized below:

1.3.8.2 BENDIX CORPORATION. Bendix performs engineering, design, and fabrication services in support of the ST-124M Stabilized Platform systems used in the Saturn IB launch vehicle.

1.3.8.3 CHRYSLER CORPORATION. Chrysler Corporation Space Division is the prime contractor for the first stage of the launch vehicle. CCSD provides design, development, and fabrication services for these S-IB stages. In conjunction with this work, CCSD is providing engineering services for KSC's Launch Complex 34 and Launch Complex 37B, qualification and reliability testing of related group support equipment and stage components, and facilities support at the Michoud Assembly Facility.

1.3.8.4 DOUGLAS AIRCRAFT CORPORATION. Douglas Aircraft Corporation, Missiles and Space Division, is the prime contractor for the second stage of the Saturn IB vehicle, the S-IVB, which is also the third stage of the Saturn V vehicle. Douglas is responsible for the engineering, research, development, and fabrication services for the S-IVB, and also for the design and manufacture of GSE in support of stage assembly and checkout operations.

1.3.8.5 GENERAL ELECTRIC COMPANY. The General Electric Company, Apollo Support Department, provides engineering design effort and manufacturing effort for Saturn IB Electrical Support Equipment (ESE) used in automatic checkout of the instrument unit at Huntsville and the launch vehicle at KSC.

1.3.8.6 INTERNATIONAL BUSINESS MACHINES. International Business Machines (IBM) is responsible for the design, development, and fabrication of the Saturn guidance computer signal processor, launch vehicle digital computer, and launch vehicle data adapter for the Saturn IB instrument unit, as well as the design, development, integration, and checkout of the instrument unit for the Saturn IB, the basic design of which is common with the Saturn V.

1.3.8.7 **MASON-RUST.** Mason-Rust is responsible for furnishing personnel, management, supplies, and equipment (not otherwise furnished by the Government) necessary to provide support services of transportation, security, fire protection, photographs, medical services, food services, supply communication, custodial, plant maintenance, engineering, mail and messenger services, and reporduction services at the Michoud Assembly Facility.

1.3.8.8 **NORTH AMERICAN AVIATION.** North American Aviation, Rocketdyne Division, is the contractor for development and manufacture of the H-1 and J-2 Engines. Eight H-1 engines are used in the first stage of the Saturn IB, and one J-2 engine is used in the second stage.

1.3.8.9 **RADIO CORPORATION OF AMERICA.** Radio Corporation of America (RCA) is the contractor for design, development, fabrication, installation, checkout, and demonstration of the Saturn IB RCA-110A ground computer system.

1.4 COMMUNICATION/COORDINATION MODES

1.4.1 **GENERAL.** Continual flows of information exist among various levels of Apollo-Saturn IB elements. The Saturn IB Program Office must have effective upward, lateral, and downward channels of communication available to accomplish its assigned responsibilities. In general, in addition to communications among the staff and project offices at MSFC within the Saturn IB Program Office, the Saturn IB Program Office elements must communicate with elements of the Apollo Program Office in Washington, both I O and R&DO at MSFC, other Apollo Centers (KSC and MSC), Saturn IB Resident Offices, and contractors.

The following sections discuss the means used in communicating with these elements.

1.4.2 **SATURN IB PROJECT DEVELOPMENT PLAN.** Effective communications among elements of the Apollo Program with regard to the Saturn IB Program can be achieved only if these elements have a common basis for the understanding of the Saturn IB Program. To provide this basis for understanding the objectives, responsibilities, resources, schedules, and interrelationships, the Saturn IB Program Director has prepared and will maintain this Saturn IB Project Development Plan in accordance with the requirements of paragraph 1.4.1 of the Apollo Program Development Plan. This Saturn IB PDP will be the single integrated summary document which will:

a. Delineate the manner in which the objectives of the Saturn IB Program will be achieved;

b. Be the primary decision/approval documentation of the Saturn IB Program Office for the evaluation of program performance and proposed program changes;

c. In the case of approved or directed changes to the Saturn IB Program, be the basic guidance/directive instrument to participating organizations for implementation of the approved program.

1.4.3 PROGRAM DIRECTIVES. The Saturn IB Program Office receives official program guidance and direction from two sources, the Apollo Program Office, through Apollo Program Directive, and the Director of MSFC Industrial Operations, through MSFC and IO Directives. Apollo Program Directives are prepared and disseminated by the Apollo Program Office in Washington in accordance with the provisions of the NASA Management Manual, Part V, Technical Management Instrument 4-1-1, dated July 3, 1962, and OMSF Instruction M-1 M905.004, subject OMSF Directive Documentation (M-D), dated July 1, 1962. Saturn IB Program Directives are prepared and disseminated in accordance with Saturn IB Program Directive number M-1-1, dated June 21, 1965. Contractors are given project direction by Project Managers through recognized contractual channels.

1.4.4 SATURN IB PROGRAM SCHEDULES. The Saturn IB Program Schedules are maintained to reflect currently approved plans and the status of effort against the plans through the Manned Space Flight Schedule and Reporting System. These schedules are contained in Volume III, Book 2, of the OMSF Schedules Document, which is maintained and published on a monthly basis. The requirements for Manned Space Flight Program Scheduling and Review Handbook, NHB2330.1, is dated October 1965. This schedule and review procedure (SARP) provides a single system procedure, uniform in format, presentation, structure, and content that permits the establishment and maintenance of an integrated schedule base for which the authority and accountability for program status and schedule changes are clearly defined and documented.

Just as the Apollo Program Control Director serves as the focal point in all matters pertaining to Apollo Program Schedules, the Chief of the Saturn IB Program Control Office serves as the focal point in all Saturn IB scheduling actions.

1.4.5 PROGRESS REVIEWS AND WEEKLY REPORTS. In accordance with requirements of the Apollo Program Development Plan, the Saturn IB Program Manager participates in or has established the following regular progress reviews:

a. Apollo Program Monthly Management Council Meetings, at which the Saturn IB Program Manager, on alternating months, presents major Saturn IB Program progress and problems to the Apollo Program Management Council;

b. Saturn IB Monthly Program Reviews, at which Saturn IB Staff Chiefs and Project Managers present monthly status reports, including progress achieved and potential problem areas, to the Saturn IB Program Manager;

c. Contractor Quarterly Reviews of each major contractor, at which the Saturn IB Program Manager, the responsible Project Manager, and other cognizant NASA personnel review the progress of the past quarter. These reviews will be used as a basis for periodic updating of the Saturn IB Project Development Plan.

d. Weekly Saturn IB Staff Meetings, which the Saturn IB Program Manager holds with his Staff Chiefs and Project Managers;

e. A system of Flash Reports concerning progress and problems requiring the immediate attention or action of general management. Flash Reports will be used to report situations which jeopardize program objectives or launch schedules.

Saturn IB Staff Offices and Project Offices keep the Saturn IB Program Manager informed of current status and potential problems within their specific areas of responsibility, and prepare for his action the general directives, specifications, requirements, procedures, and controls necessary to manage the program. In reviews with his staff, actual and projected performance will be related in terms of schedule, manning, costs, facilities utilization, and program objectives. These reviews, to be conducted in the Saturn IB Program Control Center, when it becomes operational, provide management with the ability to discriminate in exercising judgement and serve as a tool to initiate decision-making at the proper management level. The Saturn IB Program Control Center will be operated to:

a. Present data so as to inform and motivate management action in a timely manner;

b. Admit and show pacing items;

c. Reflect the Program's strengths and weaknesses;

d. Present history to establish perspective;

e. Assign to a single individual the responsibility for corrective action;

f. Follow up action assignments and ensure timely results;

g. Standardize symbols and nomenclature. Visual communication techniques are employed to retain simplicity while showing a necessary minimum amount of information.

h. Require authentication of Saturn IB Program Control Center Records;

i. Ensure Saturn IB Program Control Center records are updated in a timely manner and that they reflect the true situation.

The Saturn IB Program Control Center will contain funding requirements and expenditure curves, manpower charts, facilities requirements and utilization charts, PERT networks, program phasing charts, master operating schedules, detail milestone schedules, problem area reports and analyses, action assignments, and follow-up records. This data will be updated on a periodic cycle and will be available to Saturn IB Program Management personnel at all times.

Saturn IB Weekly Notes are published formally each week. These reports summarize progress for the week, as well as problems existing at the time of the report, with associated probable impact and corrective action taken.

1. 4. 6 WORKING RELATIONSHIPS. To ensure that all significant working relationships are identified, the Apollo Program Control Director, with the support of other Apollo technical and management personnel, will delineate all foreseeable working relationships in a family of documents. These documents, approved by the Program Director, will reflect the means of implementing these working relationships. Headquarters/Field Center interactions in the following areas will be documented: coordination and communication methods, functional analyses and design reviews, technical direction and support, specification and documentation approval, configuration control and engineering change processing, equipment acceptance and allocation, reliability and discrepancy reporting,

interaction with other Government agencies and facilities, personnel reassignment, training requirements and procedures.

1.4.7 COORDINATION MODES. In addition to previously discussed communication channels, the Saturn IB Program Director maintains the following coordination modes:

a. Telecon - Coordination by telephone is utilized as a method of communication to suit the urgency of the immediate question. "Hot" lines exist for this purpose between the various Saturn IB Staff Offices and KSC. Telephone communications will be used for Flash Reports. In all instances, telecon requests are verified in writing by the requesting party, and telecon commitments and decisions are to be verified in writing by the committed party.

b. TWX-Type Messages - TWX-type messages are employed for coordination as necessitated by expediency requirements. TWX messages are to be answered or acknowledged within two working days of receipt. Acknowledgement must specify the date for final answer.

c. Letters - Letters are used when program expediency allows or when dictated by security requirements. Requested action completion and/or reply date are specified.

d. Datafax Facsimile Transmissions - Datafax circuits exist between the Saturn IB Program Office and elements in OMSF, KSC, MSC, Douglas Aircraft Corporation, and the Michoud Assembly Facility for transmission of unclassified written communications of a high priority nature.

Whenever possible, matters of mutual concern are resolved by direct communication between participating organizations. Mutual agreements which affect other Field Centers are relayed to those Centers for information and/or consideration.

1.4.8 PANELS, BOARDS, WORKING GROUPS, AND COMMITTEES.

1.4.8.1 GENERAL. To provide the necessary communications channels with regard to Inter-Center interfaces and to provide the Saturn IB Program elements with the necessary in-depth technical competence available in MSFC R&DO, certain groups have been established. The following paragraphs will briefly describe their purpose and activities. The latest edition of the Directory of MSFC Boards, Working Groups and Committees, published by the Management Analysis Office of the MSFC Executive Staff, should be referred to for a complete listing of active MSFC Boards, Councils, Working Groups, Committees, Panels, Task Groups, and Teams, with their mission, organizational relationship, authority for establishment, and membership.

1.4.8.2 APOLLO-SATURN COORDINATION PANELS. As authorized by the Charter of the Panel Review Board, dated November 7, 1963, eight Apollo-Saturn Coordination Panels have been established to recommend the solution of technical interface problems between the launch vehicle, spacecraft, facilities, and associated equipment. Basically, these panels are composed of engineering personnel who are responsible through the panel chairman to the Panel Review Board. The PRB Organization (Fig. 1-9) consists of the Board, an Executive Secretariat, eight panels, and twenty-four sub-panels. Saturn IB Program personnel are included in the membership of each panel in addition to qualified personnel from appropriate MSFC R&DO Laboratories. Figure 1-10 illustrates MSFC participation in these coordination panels.

The panels are formed to make available the technical competence of the Office of Manned Space Flight, MSFC, MSC, KSC, and their contractors for the solution of interface problems. The panels are responsible, within their specified areas, to resolve interface problems and initiate actions regarding design, analysis, study, test, and operations by employing the organizations of the Office of Manned Space Flight, the Field Centers or the various contractors; establish sub-panels as required; recommend solutions to problems outside their assigned responsibility to the PRB for action by the proper panel and organization. For a more detailed treatment of the organization and functions of the Inter-Center Coordination Panels see the Manned Space Flight Panel Review Board Directory.

1.4.8.3 WORKING GROUPS. To make the vast technical experience and knowledge of MSFC's Research and Development Operations organization available to the Saturn IB Program for the solution of technical problems arising within stage systems and technical interface problems existing between stages, working groups have been established. Standing working groups have provided a continuity of effort within R&DO in solving problems of a related nature as they arise. Members of each group are senior representatives of applicable R&DO Laboratories, who are chosen by the heads of their organizations because of their experience in disciplines required for arriving at a coordinated solution to the problem presented, and are authorized to act as the "point of technical commitment" for their organization. The working group chairmen are responsible

PANEL REVIEW BOARD ORGANIZATION

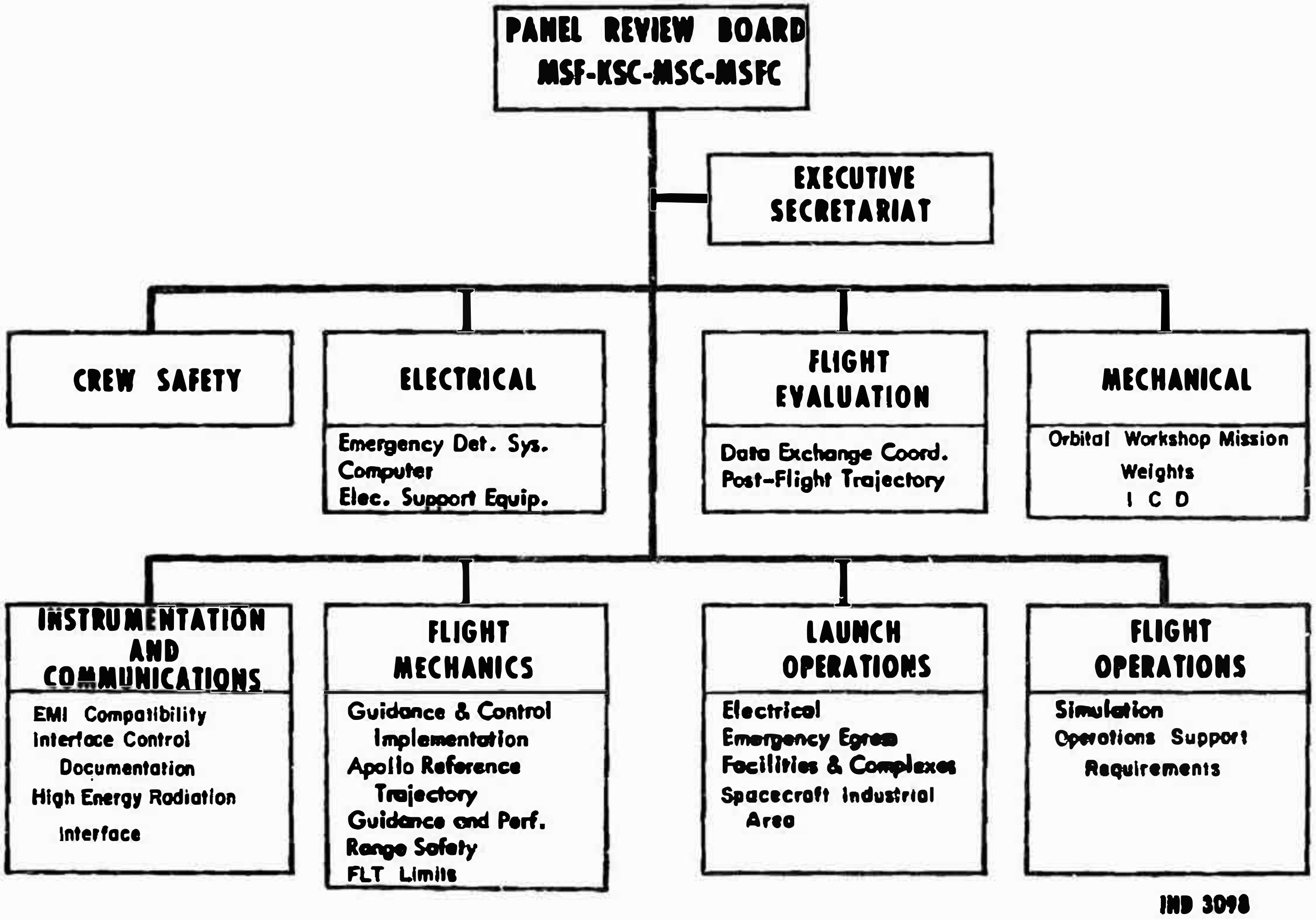
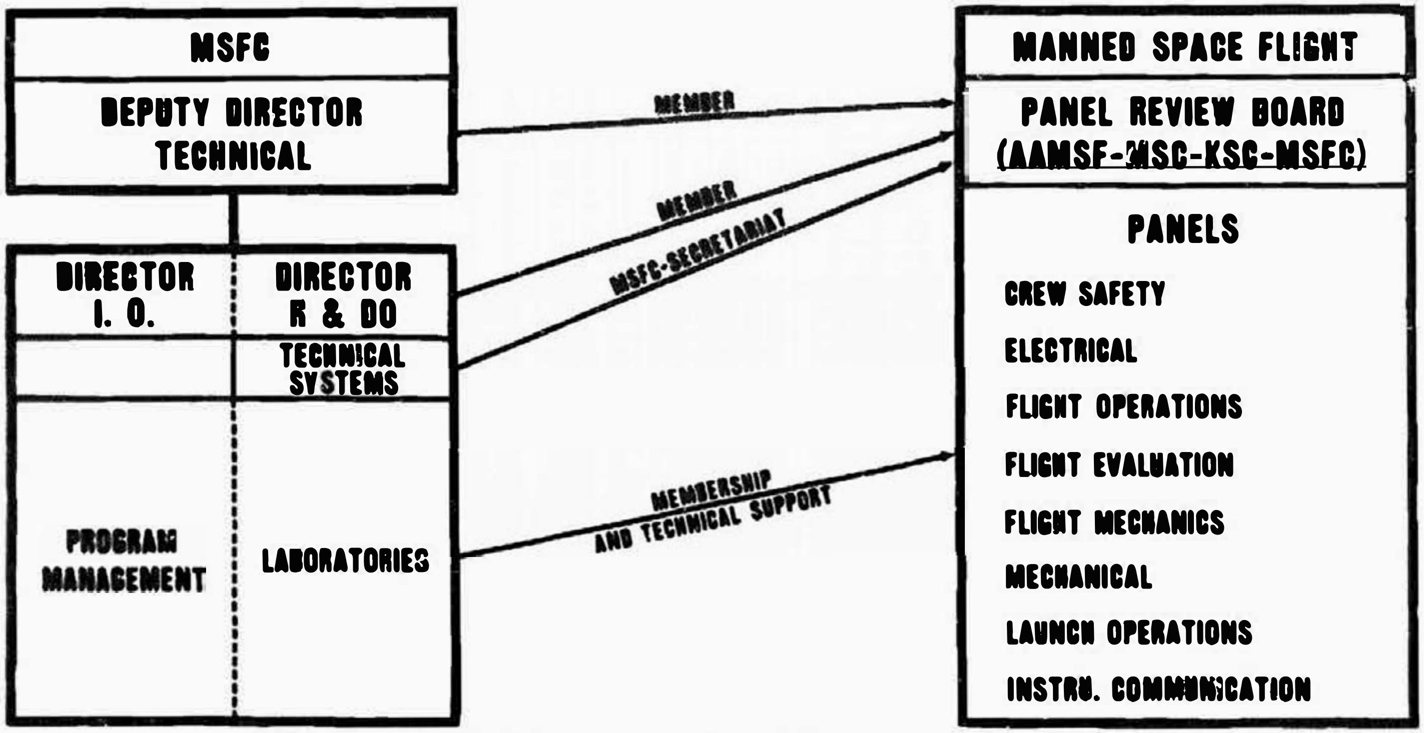


FIGURE 1-9. PANEL REVIEW BOARD ORGANIZATION

MSFC PARTICIPATION IN MSF PANEL STRUCTURE

PANEL REVIEW BOARD: SUPERVISES THE ACTIVITIES OF THE INTER-CENTER PANELS.

INTER-CENTER PANELS: RECOMMEND TO PROGRAM MANAGEMENT SOLUTION OF TECHNICAL INTERFACE PROBLEMS INVOLVING THE LAUNCH VEHICLE, SPACECRAFT, FACILITIES AND ASSOCIATED EQUIPMENT.



MSFC

DEPUTY DIRECTOR TECHNICAL

DIRECTOR I. O.

DIRECTOR R & DO

TECHNICAL SYSTEMS

PROGRAM MANAGEMENT

LABORATORIES

MEMBER

MEMBER

MSFC-SECRETARIAT

MEMBERSHIP AND TECHNICAL SUPPORT

MANNED SPACE FLIGHT

PANEL REVIEW BOARD (AAMSF-MSC-KSC-MSFC)

PANELS

- CREW SAFETY
- ELECTRICAL
- FLIGHT OPERATIONS
- FLIGHT EVALUATION
- FLIGHT MECHANICS
- MECHANICAL
- LAUNCH OPERATIONS
- INSTRU. COMMUNICATION

MSFC PROVIDES CO-CHAIRMEN FOR ALL PANELS EXCEPT LAUNCH OPERATIONS.

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FIGURE 1-10. MSFC PANEL STRUCTURE

ensuring that technical activities and resulting technical recommendations to the Saturn IB Program Office present a coordinated R&D Operations technical position. All recommendations from these working groups are forwarded to appropriate Saturn IB Program Office elements for execution. When the need for a particular working group no longer exists that group will be discontinued.

There are currently seven Working Groups which operate with the following prime mission assignments:

The Vehicle Dynamics and Control Working Group is responsible for defining and solving flight mechanics, dynamics, and control problems with particular emphasis on interface aspects.

The Flight Evaluation Working Group is responsible for planning, coordinating, and monitoring the integrated engineering flight evaluation effort on Saturn launch vehicles by internal MSFC and stage, engine, and systems contractor evaluation groups. This effort includes the publication of an integrated engineering vehicle evaluation report.

The Electrical Systems Integration Working Group is responsible for defining, analyzing, and ensuring implementation of the requirements for system checkout during stage mating, final checkout, and firing, streamlining the design of the checkout system, and resolving the interface problem areas.

The Vehicle Instrumentation and Communications Working Group is responsible for defining and resolving all instrumentation system and interface problems concerning the complete Saturn vehicle system and for ensuring mutual exchange of instrumentation information for the various stages.

The Systems Checkout Working Group is responsible for coordinating the efforts of MSFC and contractors on interrelated system problems in the area of stage checkout in manufacturing and pre- and post-static operations.

The Vehicle Mechanical Design Integration Working Group defines and solves problems connected with the operational concepts applied to structures and mechanical, pneumatic, hydraulic, and propulsion systems, and defines and solves mechanical interface problem areas between stages and GSE, and launch facilities.

The Static Firing Working Group is responsible for ensuring implementation of MSFC standards and concepts in both developmental and flight-stage static tests.

1.4.8.4 COMMITTEES, SUB-COMMITTEES, AND AD HOC COMMITTEES. As the need arises, special committees are established by cognizant authorities to study specific problems and return with recommendations for solution. Many of these problems directly or indirectly affect the Saturn IB Program, and representation from the Saturn IB Program is furnished as appropriate.

SECTION 2

SCHEDULES

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SECTION 2

SCHEDULES

2.1 SCOPE

This section provides a summary description of the Saturn IB Program scheduling policies, responsibilities, and procedures. The guidance provided herein conforms to the overall NASA, OMSF, and Apollo Program schedule and review policies and procedures. Detailed scheduling procedures may be found in the current edition of the OMSF Program Scheduling and Review Handbook, NHB 2330.1.

2.2 POLICY

To achieve established missions and objectives of the Saturn IB Program and to ensure that these missions and objectives will be accomplished in the timely manner required to support the Apollo Program, it is essential that all program effort be undertaken on the basis of approved schedules. In addition, it is important that there be a continuing review process by which potential problems can be identified, assessed, and channeled to the proper management level. To this end, the Saturn IB portion of the OMSF Program Schedule Document (SARP), will be maintained to reflect the currently approved schedules and the monthly status of effort against these schedules. The Saturn IB Program Schedules are contained in Volume III, Book 2, of the OMSF Schedules Document. Furthermore, monthly Saturn IB Program Reviews will be held to evaluate progress and to determine corrective actions as required.

2.3 RESPONSIBILITIES AND PROCEDURES

The Saturn IB Program Manager is responsible for implementation of the scheduling and review procedure. Under his direction, and the direction of the Saturn IB Program Control Office, Project Managers within the Saturn IB Program Office are responsible for implementing the scheduling and review procedure for their projects. Schedules for the Saturn IB Program will be maintained under levels as defined in the Scheduling Manual.

Hardware delivery requirements and delivery schedules require approval by the Apollo Program Director and the Saturn IB Program Manager before any proposed schedule change can be effected. Approval for changes may be obtained from the Apollo Program Director as follows:

a. A request for change may be submitted through the normal cycle as defined in the OMSF Program Scheduling Manual; that is, request a change in the monthly Saturn IB Schedule Document (OMSF Schedules, Book III, Volume 3) submittal and receive the Apollo Program Director's decision through the monthly Schedule Exception and Operations Directive. This directive is transmitted to the Saturn IB Program two weeks following receipt of the schedule document.

b. If the timing of the normal cycle is inappropriate, the Saturn IB Program Manager may request a change by telegram or letter to the Apollo Program Director with a copy to the Apollo Program Control Director. All proposed changes received in this manner will be acted on and the decision will normally be returned to the Saturn IB Program Manager within two working days. These change actions will also be compiled by the Apollo Program Office and included in the monthly Schedule Exceptions and Operations Directive as required by the OMSF Program Scheduling Manual.

Approval will authorize immediate implementation unless otherwise noted. In either of the above cases, sufficient information will be submitted for evaluation by the Apollo Program Director. The requested change will indicate the current schedule, the proposed schedule, the reason for the proposed change, and the estimated program impact.

2.4 SCHEDULES

Included in this section are the following schedules:

the Saturn IB Summary Development and Delivery Plan (Fig. 2-1),

the S- IB Stage Summary Development and Delivery Plan (Fig. 2-2),

the S-IVB/IB Stage Summary Development and Delivery Plan (Fig. 2-3),

and the S-IU Summary Development and Delivery Plan (Fig. 2-4).

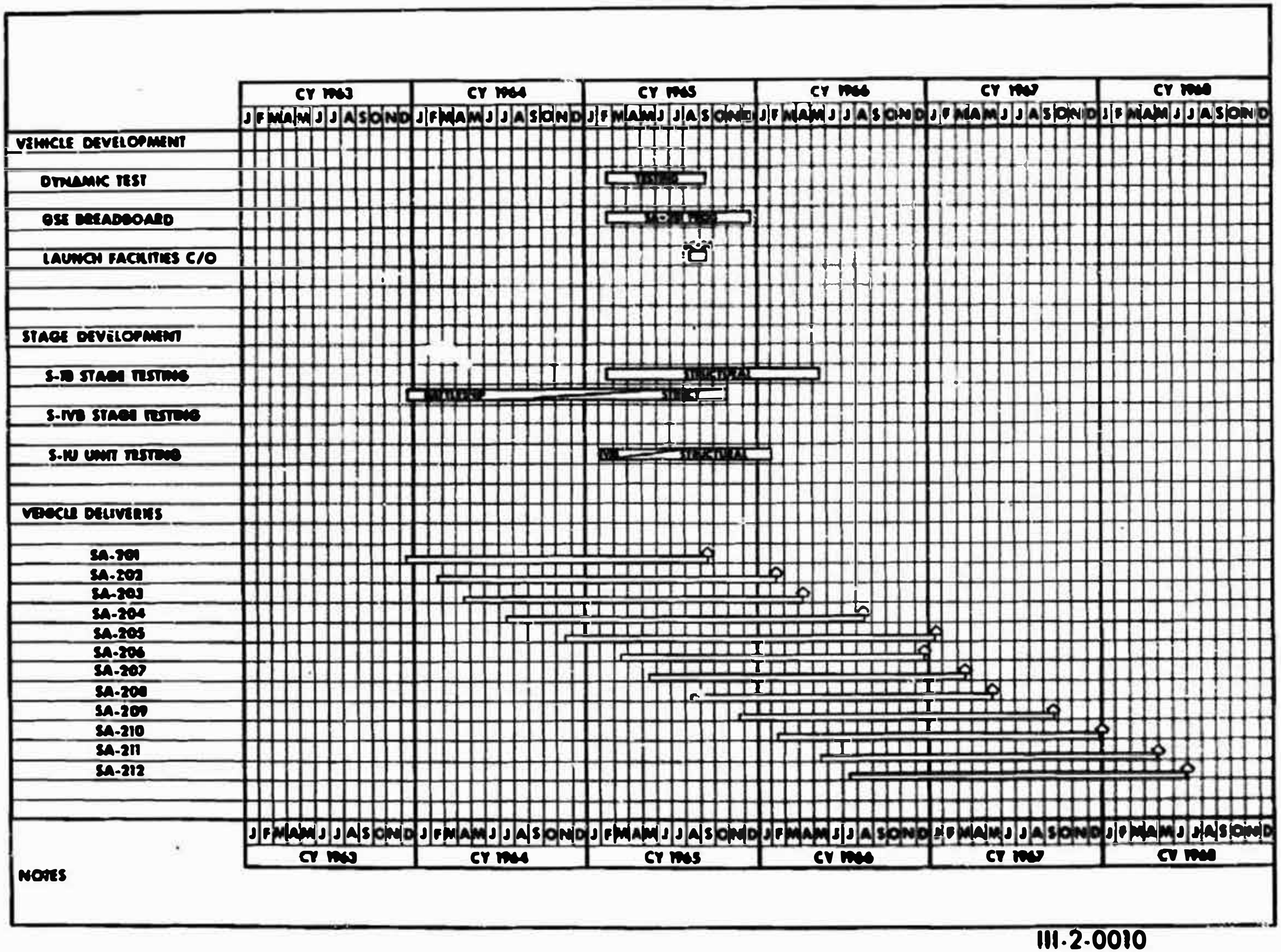

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FIGURE 2-1. SATURN IB LAUNCH VEHICLE DEVELOPMENT AND DELIVERY PLAN

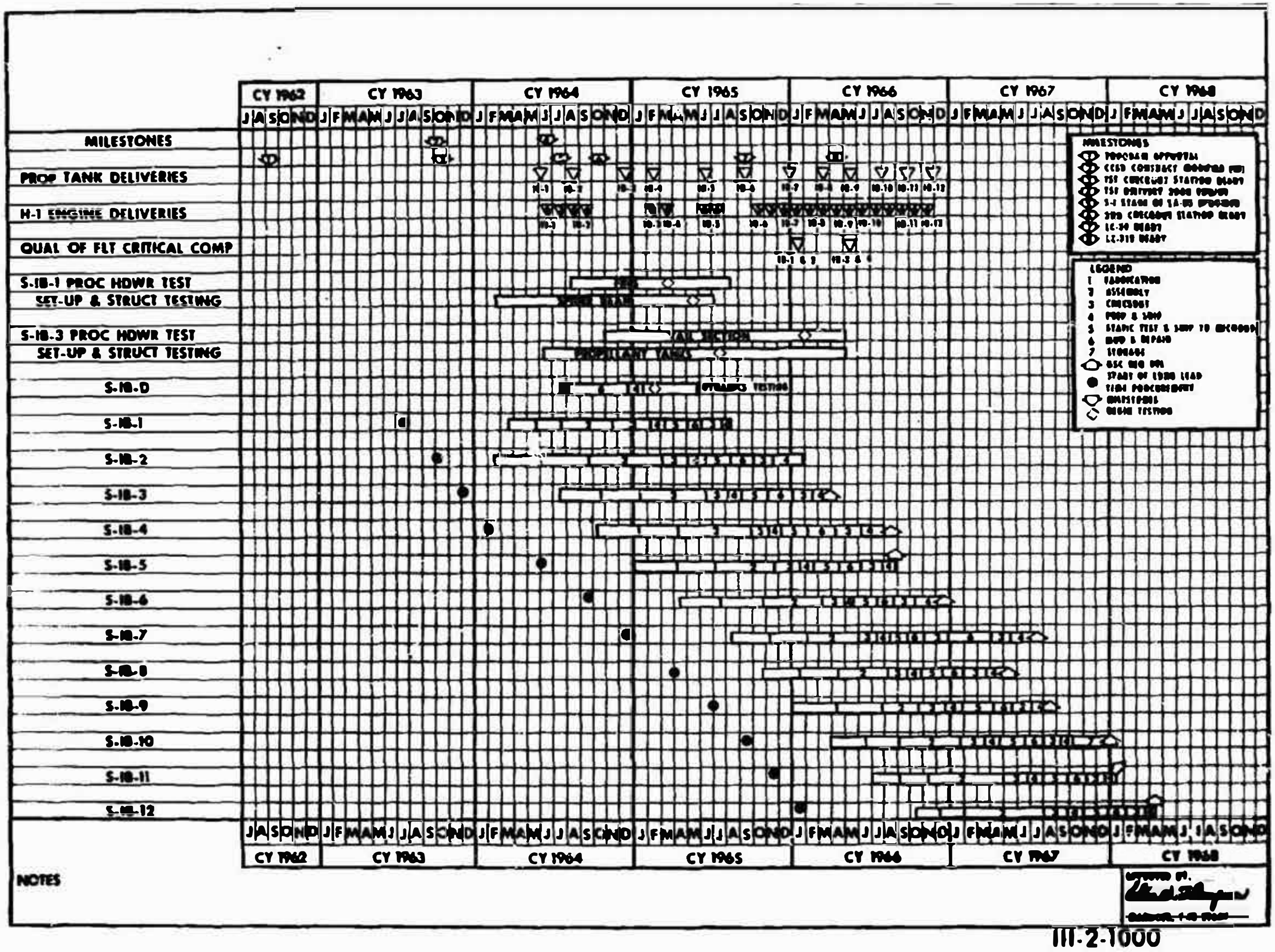

FIGURE 2-2. S-IB STAGE DEVELOPMENT AND DELIVERY PLAN

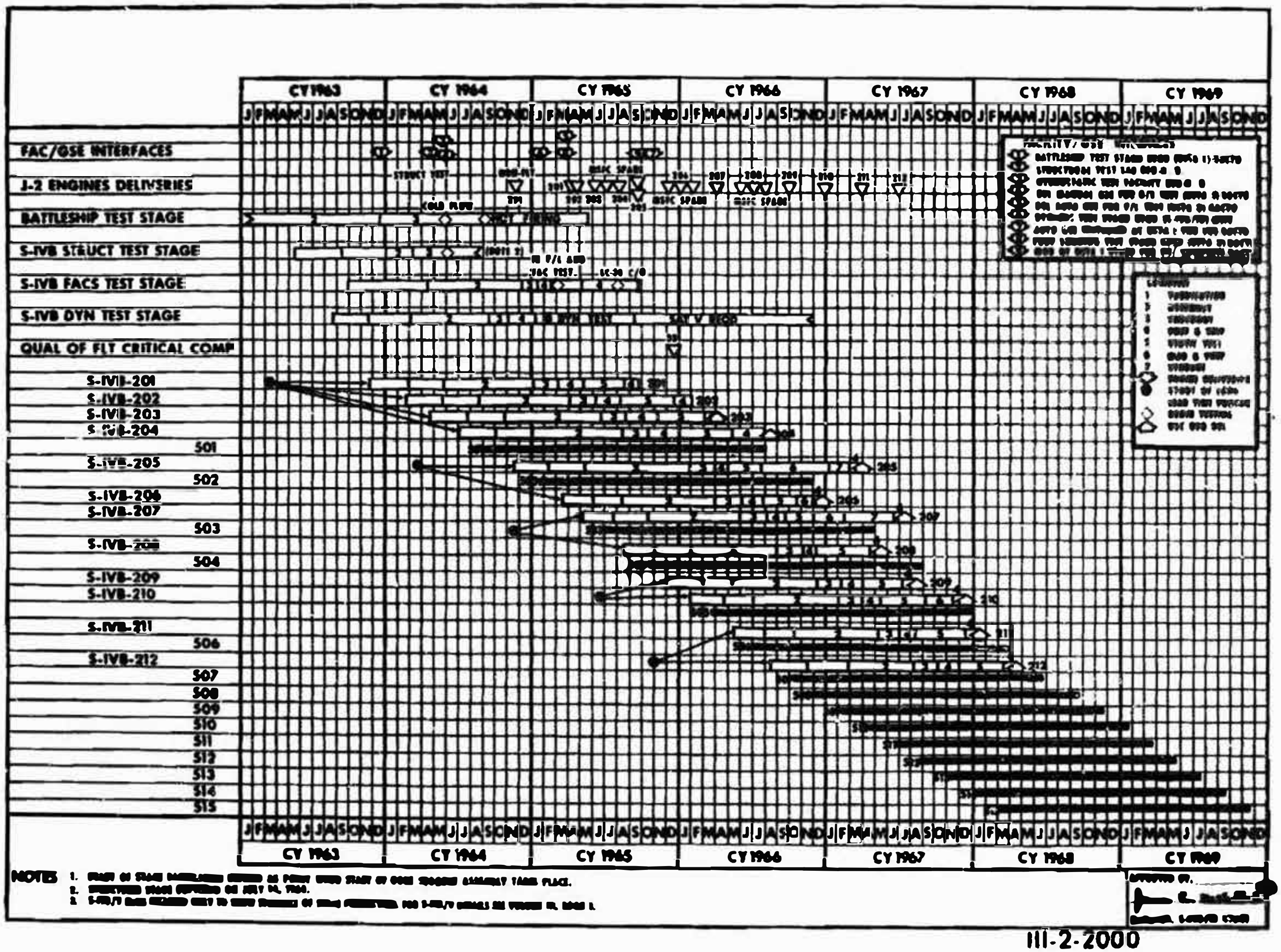

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FIGURE 2-3. S-IVB/1B STAGE DEVELOPMENT AND DELIVERY PLAN

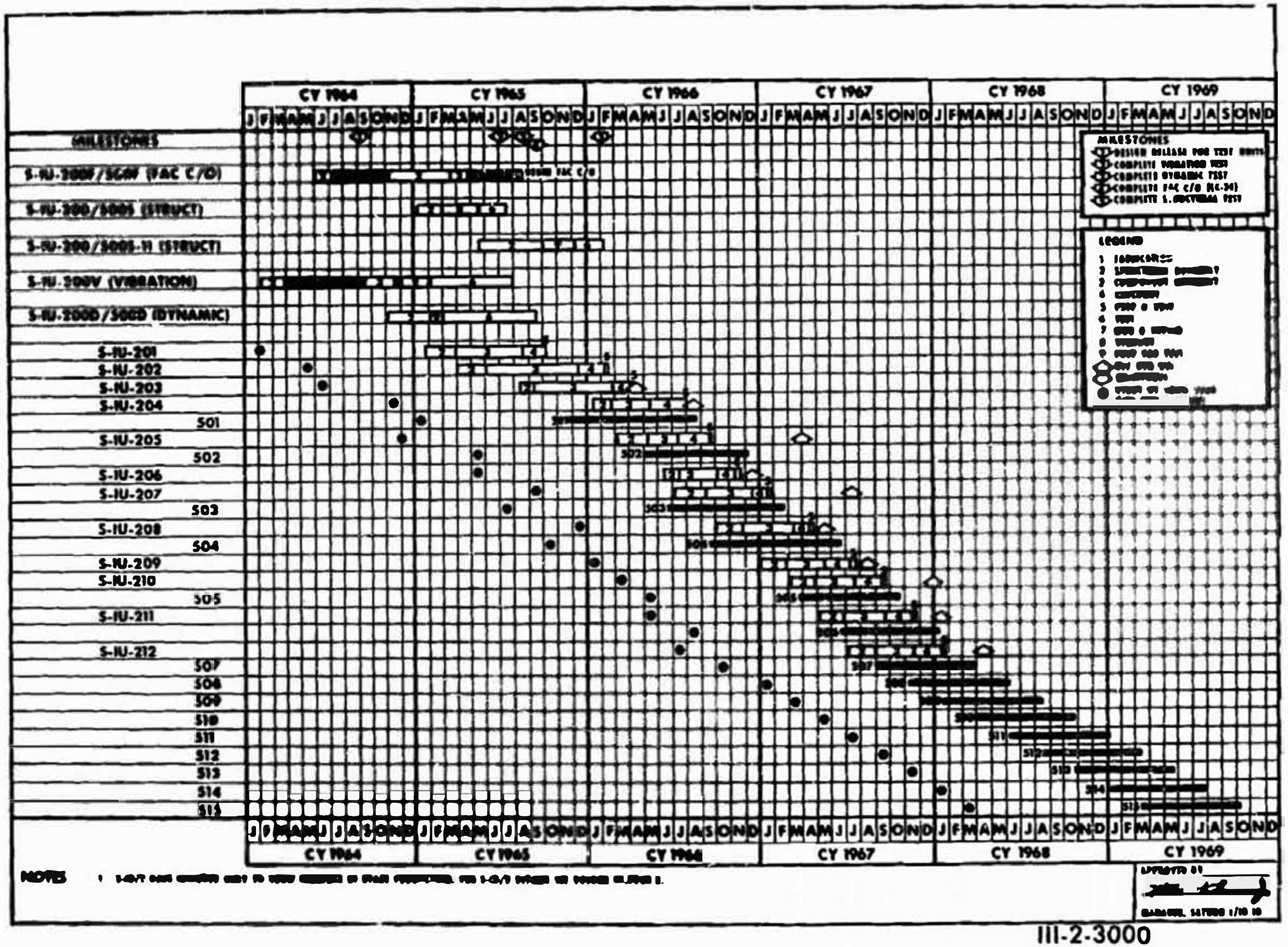

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FIGURE 2-4. SATURN 1B INSTRUMENT UNIT STAGE DEVELOPMENT AND DELIVERY PLAN

SECTION 3

PROCUREMENT MANAGEMENT

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SECTION 3

PROCUREMENT MANAGEMENT

3.1 SCOPE

This section provides a summary description of the procurement practices and procedures implemented to attain the Saturn IB Program goals. Contract administration is achieved in accordance with NASA Procurement Regulation NPC-400 and associated directives. In fulfilling the assigned responsibilities of providing the Saturn IB Launch System, MSFC has contracted with private industry for a large part of the engineering design, research, development, fabrication, assembly, and testing of all elements which comprise the launch vehicle.

Included in this section is an outline of MSFC procurement procedures and responsibilities, a listing of major contracts, and the assignment of contract administration and technical monitoring duties related to the Saturn IB Program.

3.2 PROCUREMENT ADMINISTRATION

3.2.1 GENERAL. Procurement administration for industrial participation in the Saturn IB Program is assigned to Industrial Operations. Within this division, the Saturn IB Program Office directs, coordinates, programs, and budgets for all effort specifically related to the program. Responsibilities for implementing these functions are assigned to four stage managers as outlined under the program elements specified below.

The stage managers determine and place their contractual requirements, by means of procurement requests, upon the Contracts Office, a staff office of Industrial Operations, which is responsible for negotiation, execution, modification, and administration of contracts. The Contracts Office functions include development of procurement plans, preparation and review of RFP's, source evaluation, pre-negotiation review, and award of contracts and modifications, contract deviations and waivers, and associated functions.

3.2.2 SATURN IB PROGRAM ELEMENTS

3.2.2.1 S-IB STAGE. The Chrysler Corporation, Space Division, is the prime contractor for the first stage of the Saturn IB vehicle. Chrysler responsibilities include development, fabrication, assembly, checkout, stage testing, and engineering of the S-IB stage produced at the government-owned Michoud Plant near New Orleans. The H-1 engines used in the S-IB stage are government-furnished equipment procured by the MSFC Engine Program Office, and supplied under contract by Rocketdyne.

3.2.2.2 S-IVB STAGE. Douglas Aircraft Company, Inc., is the prime contractor for design, development, and testing of a 260-inch diameter S-IVB stage. The J-2 engines used in this stage are government-furnished equipment procured by the MSFC Engine Program Office under contract from Rocketdyne.

3.2.2.3 INSTRUMENT UNIT. The prime contract for manufacture and assembly of the Instrument Unit was awarded to International Business Machines Corporation. The design, testing, and procurement responsibility is divided between MSFC and IBM. Bendix is the major contractor for provision of ST-124M stabilizing platforms.

3.2.2.4 GROUND SUPPORT EQUIPMENT. Acquisition of Electrical Ground Support Equipment for the Saturn IB launch vehicle was contracted for delivery by General Electric Company. RCA is the prime contractor for RCA 110A computers and test equipment. Mechanical Ground Support Equipment was procured from Chrysler Corporation under mission contract.

3.2.2.5 VEHICLE SUPPORT. Transportation, communications, DOD Inspection, performance studies, and other special support projects associated with the overall Saturn IB vehicle, other than stage-affiliated functions, are contracted for as required.

Vehicle Support also includes tooling and special test equipment procured in the design and development of hardware related to the overall vehicle.

Systems Engineering projects such as Design Integration Computer Program, RF Evaluation Reports, Propulsion System Analysis, and Ordnance System Documentation are under contract with Chrysler.

Research and development functions, including engineering and fabrication services, are performed by civil service and support contractors at Marshall Space Flight Center.

3.2.3 RESIDENT MANAGEMENT OFFICES

The stage managers of the above program elements are represented at the respective contractor's facility (Fig. 3-1) by a Resident Manager who provides on-site supervision and management of MSFC operations at the contractor sites and establishes the proper MSFC/contractor relationships, insuring a coordinated approach to effective program management.

The Resident Manager's staff includes a Resident Contracting Officer who has authority to execute contract change orders when the estimated value does not exceed $250,000, to approve sub-contracts and overtime used by the contractor, and to take other action as specifically delegated.

Resident Contract Offices are responsive to the requirements of the Resident Managers and are functionally responsible to the Chief, Contracts Office.

Department of Defense and other government agencies are utilized to maximum to support NASA contracting officers in areas of quality and reliability control, audit, contract administration, industrial property administration, production monitoring, and other related services in accordance with Procurement Regulation Directive 65-9.

3.2.4 PROGRAM SUPPORT ELEMENTS

The following staff offices assist the stage managers in analyzing, evaluating and coordinating pertinent technical requirements in their specific areas prior to initial procurement and after award of contract.

3.2.4.1 SYSTEMS ENGINEERING OFFICE. System engineering aspects are integrated within the program and counterpart elements by the Systems Engineering Office. Functional responsibilities to assure technical adequacy of the vehicle system and interfaces include such areas as (a) Mission and Payload Requirements, (b) Weight and Performance, (c) Automation, (d) Networks and Instrumentation, (e) Mechanics and Propulsion, (f) Dynamics, and (g) Guidance and Control.

3.2.4.2 TEST OFFICE. The Test Office establishes the Saturn IB Master Test Plan in accordance with program requirements and assesses the impact of test requirements and accomplishments.

3.2.4.3 RELIABILITY AND QUALITY OFFICE. Reliability and quality requirements are established in accordance with program requirements by the Reliability and Quality Office. This office also integrates actions within the program and assesses accomplishments.

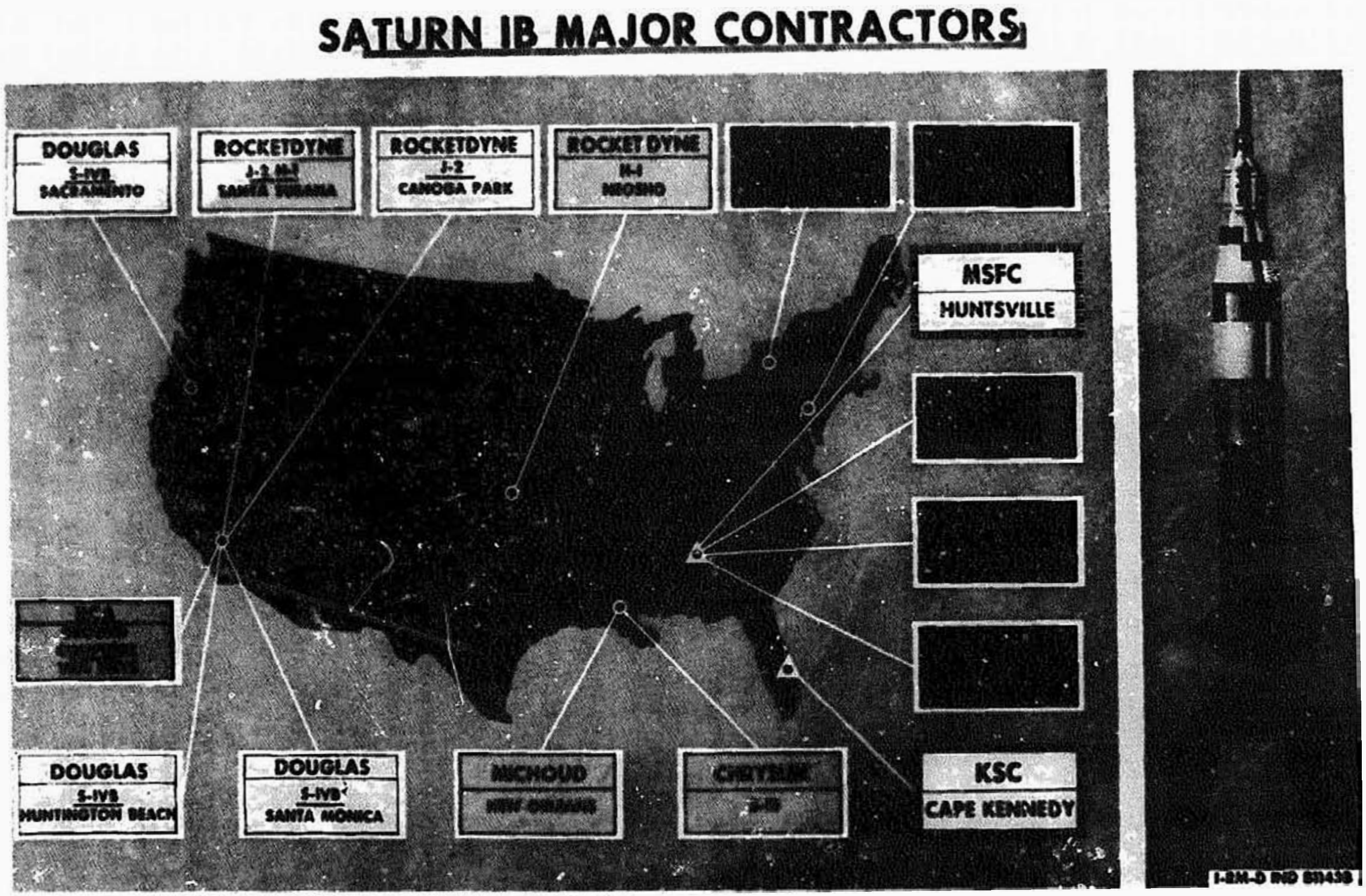

FIGURE 3-1. SATURN IB MAJOR CONTRACTORS

3.2.4.4 FLIGHT OPERATIONS OFFICE. The Flight Operations Office establishes and maintains flight and support operations plans in accordance with program requirements, assuring implementation and integration of requirements.

3.2.4.5 RESEARCH AND DEVELOPMENT OPERATIONS. All necessary in-house engineering, testing, and technical management services to support the stage managers are provided by MSFC Research and Development Operations.

The Project Support Agreement is an MSFC management tool directed by the MSFC Center Director, and is presently being developed by I.O. and R&DO. The Project Support Agreement will clearly define technical support to be supplied the Saturn IB program by MSFC R&DO, and will be implemented for FY 67 effort.

3.3 PROCUREMENT FUNCTIONS

3.3.1 GENERAL. Procurement functions, initiated after approval of the Project Development Plan, are briefly defined below with approximate time for accomplishment. Guidelines for implementing these functions are contained in NASA Procurement Manual NPC-400. Responsibilities relative to major phases in completing the administrative procurement cycle are shown on Figure 3-2. Phase I covers MSFC procedures for the start of procurement action after development of requirements. Phase II establishes the method for solicitation of bid to contract award. Phase III constitutes the contract management and performance to be attained.

3.3.2 PROJECT DEVELOPMENT PLAN. The PDP is a detailed plan, approved by the Office of Manned Space Flight, which delineates objectives, technical and management plans, program requirements, responsibilities, resources, and time phasing of actions for accomplishment of the Saturn IB Program. Preparation time is 4 to 12 weeks.

3.3.3 PROCUREMENT REQUEST. In defining and documenting the requirement, a clear and complete itemization of materials, description of services, and estimated costs provides the negotiator with adequate data to obtain satisfactory bids and carry out the contractual processes until award of contract. Preparation and coordination time is 2 to 4 weeks.

3.3.4 SHORT-FORM PROCUREMENT REQUEST. This coordinating document defines the proposed task, is prepared for all procurements exceeding $100,000, and precedes processing of the Procurement Request, NASA Form 404. Preparation and coordination time is 1 to 2 weeks.

3.3.5 DETERMINATION AND FINDINGS (D&F). The D&F documents facts and circumstances which clearly indicate why a certain type of contract will be less costly and property or services can be provided most economically; consistent with meeting program schedules. Preparation time is 1 to 2 weeks.

COGNIZANT OFFICE	APPLICABLE DIRECTIVE	ACTION	WORK STAFF (INDIVIDUAL) (OR TEAM)
PHASE I			
Project Office	NMM 4-1	Project Development Plan	Project Manager (or REP) Technical Personnel (I.O. or R&DO)
Technical Office	NPC 400	Procurement Request (MSFC Form 404) Short Form Procurement Request (Over $100,000) Determination & Findings	Contracting Officer Program Control Office REP. Financial Mgmt Rep. Negotiator (Procurement)
Program Control/Financial Mgmt	NMM 3-3	Authorization of Availability of Funds	
Contracting Officer	NPC 400 NASA PR 3.802	Procurement Plan/Approved by: $0-1,000,000,000 MSFC Proc. Div./1,000,000-5,000,000 MSFC Director/ Over $5,000,000 NASA HQ Proc. Div.	
PHASE II			
Procurement Office	NPC 400 NASA PR 3.802.3	Solicitation for Proposal (RFP)	Contracting Officer Negotiator (COR) Project Manager (or Rep)
Contractor	NPC 400	Submittal of Proposal/$0 to $100,000 30 days/ 100,000 to 1,000,000 60 days/ Over $1,000,000 90 da.	Technical Personnel Small Business Specialist Legal Counsel
Contracting Officer	GMI 2-4-3 NPS 402	Evaluation of Proposal; Source Eval. Board (Over $1,000,000)	Price Analyst Auditor
Contracting Officer	NPC 400 NASA PR 50.1	Pre-Negotiation; Negotiation; Legal Review/ Changes; HQ Approval/Award	
Financial Management	NMM 3-5	Obligation of Funds	
PHASE III			
Resident Contracting Officer		Contractor Performance (Contract Admin.)	Contracting Officer C. O. Adm. Rep C. O. Tech. Rep Project Manager & Tech Rep Legal Counsel
Contracting Officer	NPC 500 PR 51-27	Mods. to Contact; Reporting; Contract Closing; Termination	Auditor Inspection Agency

FIGURE 3-2. BASIC ADMINISTRATIVE PROCUREMENT CYCLE, SATURN IB LAUNCH VEHICLE (IB, IVB, IU STAGES) (H-1, J-2 Engines)

3.3.6 **AUTHORIZATION OF FUNDS.** Saturn IB Program Control establishes authorization of program- and financial-management-certified availability of funds, within program limitations, following approval of procurement documents as shown below:

	OVER $1,000,000		$100,000 to $1,000,000		Under $100,000	
	Approv.	Concur	Approv.	Concur	Approv.	Concur
MSFC Director	X					
I. O. Director		X				
Proj. Manager		X	X			
Stage Manager (Respective)		X	X			
R&DO Director		X		X		
Cognizant Lab					X	

Coordination Time is 1 to 1 ½ weeks

3.3.7 **PROCUREMENT PLAN.** The procurement plan, required on all negotiated procurements estimated to exceed $100,000, is a detailed description of services to be performed, associated materials and support to be furnished, and method for accomplishment to award of contract. Preparation time is 2 to 4 weeks.

3.3.8 **SOLICITATION FOR PROPOSAL.** The Request for Proposal provides a complete item description or statement of work, delivery or performance schedules, method for cost or price breakdown, and other factors needed by a contractor for preparation of a proposal by which complete appraisal may be conducted by procurement and technical personnel. Preparation time is 1 to 3 weeks.

3.3.9 **CONTRACTOR PROPOSALS.** Research and Development proposals are prepared by prospective contractors in two parts; (1) a technical proposal, and (2) a cost proposal cross-referenced to the technical proposal. Preparation time is 4 to 12 weeks.

3.3.10 **EVALUATION OF PROPOSALS.** The technical proposal is submitted to the using activity for technical evaluation and recommendation. The cost and pricing analyses supply the negotiator with a detailed cost analysis report and recommendations. A source evaluation board is activated for competitive procurements in accordance with NPC 402. Evaluation time is 4 to 6 weeks.

3.3.11 **NEGOTIATION.** Pre-negotiations are conducted (a) to resolve questionable areas discovered in the evaluation and (b) to establish an agenda for contract agreements to be reached in the final negotiations. Areas of negotiation include the technical "statement of work," contract schedule, and cost provisions. Following Legal Counsel action and incorporation of changes, contractor signature is obtained subject to Headquarters' approval and final award. Negotiation time is 13 to 20 weeks.

3.4 CONTRACT MANAGEMENT

All major Saturn IB hardware items have been placed under contract. Engineering changes resulting in modifications to the Saturn IB vehicle are resolved at local and higher headquarters levels by Configuration Control Board action in accordance with the intent of NPC 500-1.

Current contracts under Saturn IB Program management are contained in Figure 3-3. These contracts are illustrative of the major contracts of greatest value which are primarily awarded on a competitive basis. The total contract structure provides support by industrial, scientific, and in-house support contractors as well as educational institutions.

A plan for action for converting cost-plus-fixed-fee contracts to incentive type contracts for major Saturn IB contractors is shown below. This schedule is up-dated and submitted monthly to NASA Headquarters. The request for proposal was issued to the contractors specifying performance and schedule requirements. A two-segment proposal from the contractor will contain (1) technical and incentive aspects with budgeting cost/target fee position and (2) firm target cost/target fee position.

	Date for Compliance	
Activity	CCSD, 8-4016 (M.G.S.E. Mission)	CCSD, 8-4016 (Systems Engr.)
Proposal due from Contractor	10/6/66	8/12/66
Pre-negotiation with OMSF	11/14/66	9/22/66
Negotiation with Contractor	12/1/66	10/14/66
Negotiations Completed	1/6/67	11/15/66
Final Headquarters Approval	2/6/67	12/15/66

CONTRACTOR	CONTRACT #	TYPE (& QTY) PROCUREMENT	TYPE CONTRACT	ORIGINAL EFFECTIVE DATE	PRESENT CONTR. VALUE ($ IN THOUS)
Chrysler	NAS 8-4016	S-IB Stage (12)	CPFF/ CPIF	8/23/63	191,355
Chrysler	NAS 8-4016	S-IB Stage-KSC Pre-Launch checkout support	CPAF	2/1/65	6,320
Chrysler	NAS 8-4016	Mechanical Ground Support Equipment	CPFF	9/4/65	9,064
Chrysler	NAS 8-4016	Systems Engineering	CPFF	12/30/65	18,909
Chrysler	NAS 8-5602(F)	S-IB Stage Facilities and Tooling	CPFF	7/27/62	3,280
Douglas	NAS 7-101	S-IVB Stage (12)	CPFF/ CPIF	4/2/62	222,434
IBM	NAS8-11561	Digital Computers (7) and Data Adapters (6)	CPIF	8/17/64	2,626
IBM	NAS 8-11562	Digital Computers (13) and Data Adapters (13)	CPIF	9/18/64	17,601
IBM	NAS 8-14000	Instruments Units (12)	CPIF	3/31/65	64,679
IBM	NAS 8-14020	Instrument Unit Facilities	COST REIM.	3/31/65	.408
Bendix	NAS 8-5399	ST-124 M Stabilizing Platforms (15)	CPFF	8/23/63	9,436
Bendix	NAS 8-13005	ST-124 M Stabilizing Platform System (flight) (12)	CPIF	10/2/64	18,044
Rocketdyne	NAS 7-162 NAS 7-190	H-1 Engines (114)	CPIF	Prod 7/60	32,272
Rocketdyne	NAS 8-19B	J-2 Engines (19) IB	CPIF	Prod 6/27/62	36,554
G.E.	NAS W-410	ESE Mission	CPFF	—	35,700
RCA	NAS 8-5423	RCA 110A Computer and Test Equip.	CPFF/ FFP	8/21/63	10,997
RCA	NAS 8-5433	Displays	CPFF	10/25/63	1,455
RCA	NAS 8-13007	RCA 110A Computers	FPIF	8/21/64	7,088
RCA	NAS 8-15496	Logistics	FFP	12/1/65	2,726
Mason-Rust	NAS 8-5618	S-IB Facility Support			
Mason-Rust	NAS 8-4019	(Michoud Facility)	CPFF	7/1/63	4,030
Mason-Rust	NAS8-14017	S-IB Facility Support (Michoud Facility)	CPAF	4/7/65	10,917

SUPPORT CONTRACTORS

Sperry-Rand	NAS8-20055	Astrionics -- Design, Eval & Qual Test Guide/Control; elec/ instr Sys.	CPAF	3/1/65	7,728
Brown Eng.	NAS 8-20073	P&VE -- Struct, Propul; Mech Sys. Research; conceptual & Prelim Design Studies	CPAF	4/1/65	7,227
Spaco	NAS 8-20081	Qual & Reliab. Assurance -- Qual, Engr Anal & Eval; Reliab. Docum; vehicle checkout data Acquisition	CPAF	4/1/65	3,749
Vitro	NAS 8-20070	Test -- Component & sub-sys Test; Design and oper serv; power control & communications	CPAF	3/16/65	948
Northrup System	NAS 8-20082	Aero-Astrodynamics -- Dynamics & Aero-Astrophysics Concepts Plan; flight mechanics	CPAF	3/16/65	1,295

FIGURE 3-3. SATURN IB MAJOR CONTRACTORS (PRIME PRODUCTION)

3.5 PROCUREMENT MANAGEMENT PROCEDURES

3.5.1 GENERAL. Procurement Management, as performed within MSFC, will conform to MSFC Procurment management policies and regulations and established OMSF policies contained in NPC 107, NPC 400 and other NASA Procurement Regulations.

3.5.2 DOCUMENTATION. A current documentation validation study, which itemizes reporting requirements placed upon MSFC contractors, is nearing completion. This study defines each contractor's present reporting requirements on Document Requirements List (DRL's) and Document Requirements Description (DRD's) as prescribed by Apollo Documentation Administration procedures. Future validated data requirements will be approved by the respective stage manager prior to finalizing DRL's into the contract.

In addition to administrative correspondence pertinent to procurement activities, each contract file contains a comprehensive resume of actions which include (a) procurement request, (b) scope of work, (c) determination and findings, (d) Legal Counsel and Security briefs, (e) procurement plan, (f) RFP, (g) source selection board results, (h) technical and price evaluations; (i) schedule of negotiations, (j) synopsis of final negotiations and (k) change orders, supplemental agreements, and related documentation generated subsequent to contract award.

3.5.3 REPORTING REQUIREMENTS. NASA Procurement Regulations require that NASA Headquarters receive certain reports from MSFC which provide records and statistics necessary for procurement management purposes and serve as a basis for recurring and special reports to President, Congress, General Accounting Office, and other Federal agencies. These reports include the following:

a. Individual Procurement Action Report, NASA Form 507, NASA Management Manual, Chapter 18, 50-404.1 (b).

b. MSF Procurement Milestone Status Report, NASA Form 1213, NMI 5150.1, Dated June 15, 1965.

c. MSF Contract Change Order Status Report, NASA Form 1214, MSF Instruction M-1 MS 9110.064, Dated May 14, 1965.

d. Monthly Contract Termination Status Report, MSFC Form 1804, NASA Management Manual, Chapter 18, 8.5001.

e. Notice of Award of Contract, Standard Form 99, NASA Management Manual, Chapter 18, 12.602-2.

f. Summary Contract Report, NASA Forms 1042, 1042B, and 1043, Teletype from Mr. Vecchietti, Director of Procurement, NASA Headquarters, dated April 11, 1963.

g. Report on Allotments and Authorized Controlled Material Orders, Form No. DD-492.

h. Estimated Controlled Materials Quarterly Report, Form No. DD-614 and 614-1.

i. Report on Status of Incentive Contracts, Reference NPC 400, Paragraph 16.903.

Special reports are also submitted to NASA Headquarters to meet unique situations as they occur.

In addition to utilization of procurement reports prepared for NASA Headquarters, MSFC develops internal reports as required to effect adequate surveillance and management of the production and technological research programs developed in-house and under contract.

Certain contractor-generated reports as required to permit evaluation of performance. MSFC Management Instruction 9501.1 requires contractor submittal of a monthly Contractor Financial Management Report, NASA Form 533, for each contract with value exceeding $25,000. This report provides basic financial management data for evaluation of actual cost-type contract performance and assurance that contractor performance is efficiently planned and supported by dollar and man-power resources. NASA Management Manual 6-2 provides instructions for preparation and use of NASA Form 533.

Technical reporting requirements are tailored to the specific technical contract effort and are designed to place minimum impact upon the contractor consistent with sound technical surveillance of his performance. NASA PR 7.204 and 7.302 outline general guidance for technical reporting requirements.

The Contractor also submits a separate monthly progress report of all work accomplished during each month of contract performance. Reports are in narrative form, brief and informal in content, and include:

a. quantitative description of overall progress;

b. indications of any current problems which may impede performance and proposed corrective action, and

c. a discussion of the work to be performed during the next monthly reporting period.

The quarterly and final reports contain factual data with analytical interpretation of results of the entire contract with recommendations based on experience and results achieved.

SECTION 4

DATA MANAGEMENT

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SECTION 4

DATA MANAGEMENT

4.1 SCOPE

This section establishes a data management system for the Saturn IB Program and includes policy requirements and administrative responsibilities.

4.2 POLICY

In the development, acquisition, and support of Saturn IB Program equipment, data is a complex product. Consequently, data has become a separate and distinct area of management concern. Effective Data Management requires identification, justification, selection, acquisition, auditing, and control of all data necessary for the acquisition and follow-on support of each system and development program.

The Saturn IB Data Management Program has the following objectives:

a. Assure that the Saturn IB Program acquires, in the most timely and economical manner, only the data absolutely essential for program use;

b. Review continuously all existing data requirements in order to eliminate from the program all non-essential or duplicated data;

c. Evaluate carefully the cost-versus-effective value of each data item;

d. Provide controls for efficient and effective distribution and accounting of Saturn IB and contractor-generated data.

To effectively implement the management of data on the Saturn IB Program, orientation and training in data management must be accomplished on a timely basis with all affected Saturn IB and contractor personnel.

The timely implementation of data management depends largely on the interest, cooperation, and support provided by all MSFC personnel but especially by Saturn IB personnel, including personnel within the stage offices.

As stipulated by the Program Manager in October 1965, the Saturn IB Program Documentation Tree was established to define the relationships of the

OMSF and MSFC major program control documents and define changes required to consistently update the documents. It is intended that in the future each document will specify its precedence, its subsidiary documents, or its supporting documents.

4.3 DATA REQUIREMENTS AND PROGRAM DATA DIRECTIVES

The Saturn IB Data Management System will implement the aforementioned policies through the use of Data Requirements and Program Data Directives. Data Requirements are those requirements which stipulate the identification and issuance of documents that identify, define, direct, control, and measure the Saturn IB Program.

Program Data Directives are those directives which prescribe and control the policies and procedures to implement the Saturn IB Program Requirements.

Interrelationships among data management representatives, program and project managers, contractors, and data support elements are reflected in organizational chart (Fig. 4-1).

4.3.1 DOCUMENT STRUCTURE. Based upon the NASA Management Manual and other Headquarters requirements, a documentation tree of the key Saturn I/IB Requirements documents required at each management level has been developed, using the Program Development Plan as a guide (Fig. 4-2).

4.3.2 DATA IDENTIFICATION. Each Project Office will ensure that all data are properly identified relative to need, source, authorization, functional area, and application using the following references:

Center Apollo Document Index (CADI), DM 204.001-2H

Data Requirement Description (DRD), NASA Form 1107

Data Requirement List (DRL), NASA Form 1106(11-65)

4.3.3 PROGRAM DATA DIRECTIVES. These directives will serve to standardize documentation within the Saturn IB Program and provide uniformity of data among the various Project offices. The directives will be implementations of such documents as the Center Apollo Document Description Standards (CADDS), Engineering Documentation Standards, and the Apollo Documentation Administration Instruction.

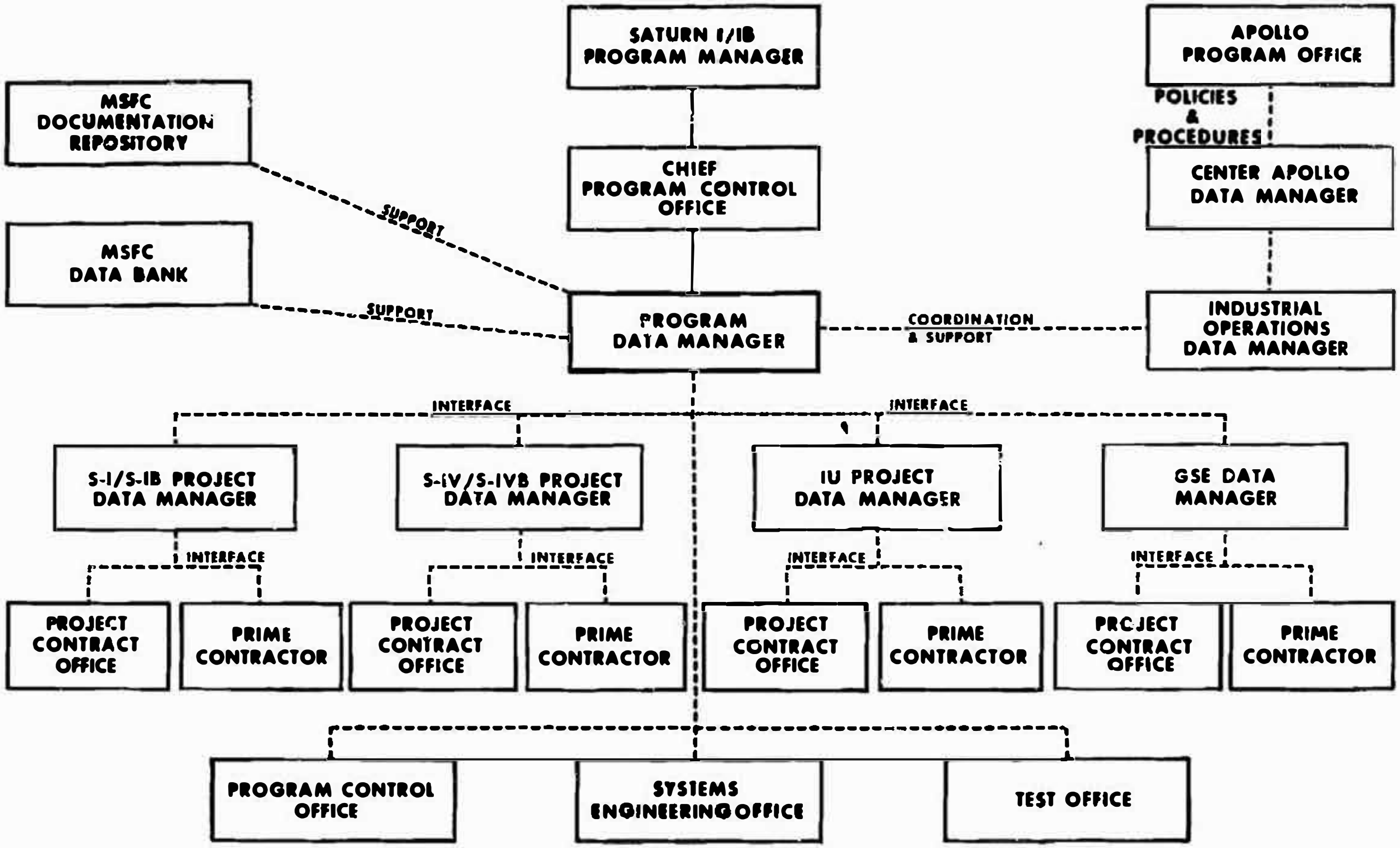

FIGURE 4-1. SATURN I/IB DATA MANAGEMENT INTERRELATIONSHIPS

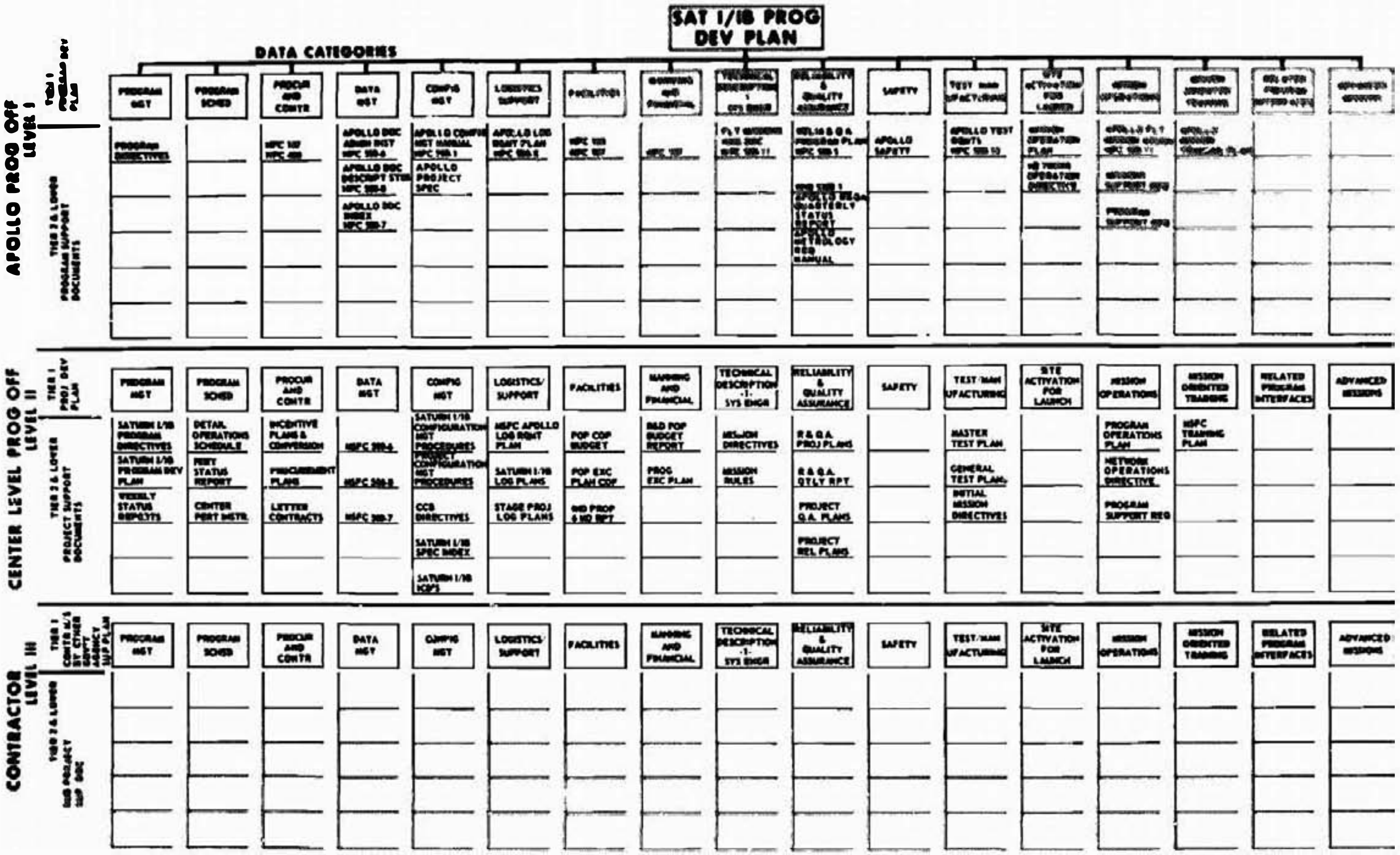

FIGURE 4-2. SATURN I/IB PROGRAM DATA STRUCTURE

4.4 DEFINITION AND DESCRIPTION

4.4.1 GENERAL. The Documentation Management Program can be defined as a functional activity operating within the Saturn IB Program with primary responsibilities for developing, coordinating, administrating, and operating an internal Documentation Management System.

Documentation Management is concerned with the methods by which Saturn IB Program documents and documentation activities are identified, acquired, and controlled. Basically, it is formalized routine by which the documentation requirements of the Saturn IB organizational elements are determined, justified, reviewed, and implemented.

The basic guidelines for the Apollo Documentation Management Program are established by Section 4 of the Apollo PDP. Implementation is directed by the Documentation Administration Instruction NPC 500-6 as modified by the MSFC Documentation Administration Plan. In applying Documentation Management to the Saturn IB Program, these instructions have been extended to fit the Program task elements defined in the following paragraphs.

4.4.2 ADMINISTRATIVE PROCEDURES AND INSTRUCTIONS. The procedures and instructions required to establish administrative and operating controls within the Saturn IB Program will be identified, developed, coordinated, implemented, and maintained.

4.4.3 ORIENTATION AND TRAINING. The program for Data Management will include orientation and training of both Saturn IB Program and prime contractor personnel on a planned basis. This is a responsibility of the Industrial Operations Data Manager.

4.4.4 DATA REQUIREMENTS IDENTIFICATION. During an Identification Phase, data requirements will be identified on existing Saturn IB contracts. This will be accomplished by each Project or Staff Office through a review of all contractual documents. Contractual documents and guidance in contractual interpretation shall be provided by the Contracting Office. The following additional steps will be taken:

a. Evaluate and provide definition for those data requirements which lack valid definition. Definitions will be provided by preparation of Document Requirement Descriptions, NASA Form 1107.

b. Prepare an initial Data Requirements List (DRL) listing all data requirements. All data requirements listed shall define exactly the contractual data requirement for the purpose of adding or deleting definition. DRL's will be prepared calling for only that data which is authorized by approved DRD's.

c. Data Requirement Justifications (DRJ's) shall be furnished by data requiring organizations as determined by the Project Manager.

Upon completion of the total data package, it will be submitted to the Center Ad Hoc Data Review Team (CAHDRT) for review.

This effort will be supported by the Center Apollo Data Manager (CADM) through the I.O. mission support contract. The second phase will be a Preliminary Review and Approval Phase, during which the CAHDRT shall review the total data package and make appropriate recommendations to the Project Manager or Staff Office Chief. The CADM shall perform a secretarial function for the CAHDRT. During this phase, the Project Manager shall:

a. Evaluate the CAHDRT recommendations and determine need for revisions to the DRL and DRD's. Such revisions shall be made by the CADM in accordance with established revision procedures.

b. Approve the DRL and DRD's for contractual pre-negotiation review.

c. Retain copies of the DRJ's for use during subsequent negotiations.

During the third phase, Pre-negotiation, the Project Manager or Staff Office Chief, via the Contracting Officer, shall transmit the DRL and DRD's to the Contractor for pre-negotiation review. The Contractor shall:

a. Review the DRL and DRD's and make recommendations.

b. Prepare cost data.

c. Submit recommendations and cost data to the CAHDRT, via the Contracting Office.

In the Final Review and Approval Phase, the CAHDRT shall review and evaluate the contractor's recommendations, cost data, and make recommendations to the Project Manager or Staff Office Chief. DRJ's maintained by the Project Manager or Staff Office Chief may be used for evaluation of contractor cost data. This effort shall be supported by the CADM, who will perform a secretarial function. The Project Manager or Staff Office Chief shall:

a. Evaluate the CAHDRT recommendations and determine need for revisions to the DRL and DRD's. Such revisions shall be made by the CADM.

b. Give final approval to the DRL and DRD's and submit to the Contracting Office for final contractual negotiation.

During the Final Negotiation Phase, the Contracting Officer shall negotiate the DRL into the contract in the normal manner (Contract Change Notice). The next phase is the Recording Phase, during which the Contractor shall prepare Document Information Records (DIR's) for the purpose of gathering information pertinent to each response document. The DIR's shall be submitted to the CADM. In this phase the CADM shall:

a. Prepare DIR's for all new applicable DRL line item response documents.

b. Prepare keypunch inputs for each DRL line item.

c. Submit keypunch data to the Data Bank.

d. Data bank inputs will be used to provide management with a tool for review and analysis of the data management effort.

In the Survey Phase, the CADM shall perform a Data Management Assistance Survey and notify the Program Manager of all cases of non-compliance with contractual requirements.

The Program Manager and/or Project Manager shall evaluate all cases of contractual non-compliance and, via the Contracting Office, direct appropriate corrective action.

4.4.5 <u>DATA REQUIREMENTS DEFINITION.</u> Descriptions will be prepared either by the particular stage office or prime contractor and ultimately be approved and finalized by the stage office. Should staff offices have occasion to prepare Data Requirement Descriptions, or prevail upon contractors to prepare them, the same general procedure will obtain.

4.4.6 <u>DATA REQUIREMENTS AUDITING.</u> Contractor and stage office document submittals will be analyzed to insure compliance with contractual and program requirements. Contract data requirements will be reviewed periodically to assure that they are current. Similar action will be taken should staff offices, or selected contractors, prepare document submittals

4.4.7 DOCUMENTATION DISTRIBUTION CONTROL. An automated document distribution control system, developed under the cognizance of the Center Apollo Data Manager, will be provided to reflect current distribution requirements.

4.4.8 REPOSITORY. Repository procedures developed by R&DO, in conjunction with the Center Apollo Data Manager, will be reviewed for the purpose of assuring adherence to the procedures by all Saturn IB elements.

4.5 RESPONSIBILITIES AND WORKING RELATIONSHIPS

The general responsibilities for implementation of the Apollo Documentation Management Program are outlined in NPC 500-6. Additional clarification is required to relate these responsibilities to the Saturn IB Program. The Configuration Management Branch, Program Control Office, is an administrative element in support of the Saturn IB Program. Designated personnel within the Saturn IB stage offices and staff offices will coordinate data requirements identification and definition emanating from Center Staff elements and R&D Operations Laboratories. The Center Apollo Data Manager, within the Resources Management Office of Industrial Operations, provides overall data program integration support and administers the procedural and accounting functions of data management.

The Saturn IB Program Control Office is responsible for implementation of data management requirements within its area. Within the Saturn IB Program, each stage office and staff office is individually responsible for contractually implementing these requirements in its respective stage, ground support equipment, or support contracts.

4.6 DATA MANAGEMENT SUPPORT

Support to the Saturn IB Data Management Program, through the Center Apollo Data Manager's Office, is being provided by the General Electric Company under a mission contract. This contract encompasses support in developing individual stage office and staff office Data Requirement Descriptions from both the management and technical standpoint.

SECTION 5

CONFIGURATION MANAGEMENT

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SECTION 5

CONFIGURATION MANAGEMENT

5.1 SCOPE

This section outlines configuration management procedures that define the configuration of Saturn IB Program Equipment at any point in time.

5.2 CONFIGURATION MANAGEMENT SYSTEM REQUIREMENTS

The hardware requirements of the Apollo Program Specification and the Saturn IB Program Specification will be accomplished by the deliverable end items.

Every deliverable end item in the Saturn IB Program will:

1. Have a specification for accurately describing the configuration of each deliverable end item.

2. Provides, for every change in end item configuration, a corresponding change to all related documentation affected by the change to assure that a one-to-one relationship is maintained between the item and its supporting documentation.

Baseline concepts and sequential phasing of configuration management from design through launch are shown in Figure 5-1.

The Configuration Management Branch, Program Control Office, Saturn I/IB Program Office, will provide necessary direction required to conduct configuration management throughout the Saturn I/IB Program. The Saturn I/IB Program Office will establish a Level II Configuration Control Board (CCB) to operate within the administrative framework of the Configuration Management Charter. In addition, each project (stage) office and prime contractors will establish a configuration management element. Each project (stage) office will establish a Level III Configuration Control Board, and each prime contractor will establish a Level V Configuration Control Board. Class II Engineering Changes will be submitted to the Resident Manager's Office for approval of the classification. Class I Engineering Changes will be submitted by the contractors to the Level III CCB for review and processing.

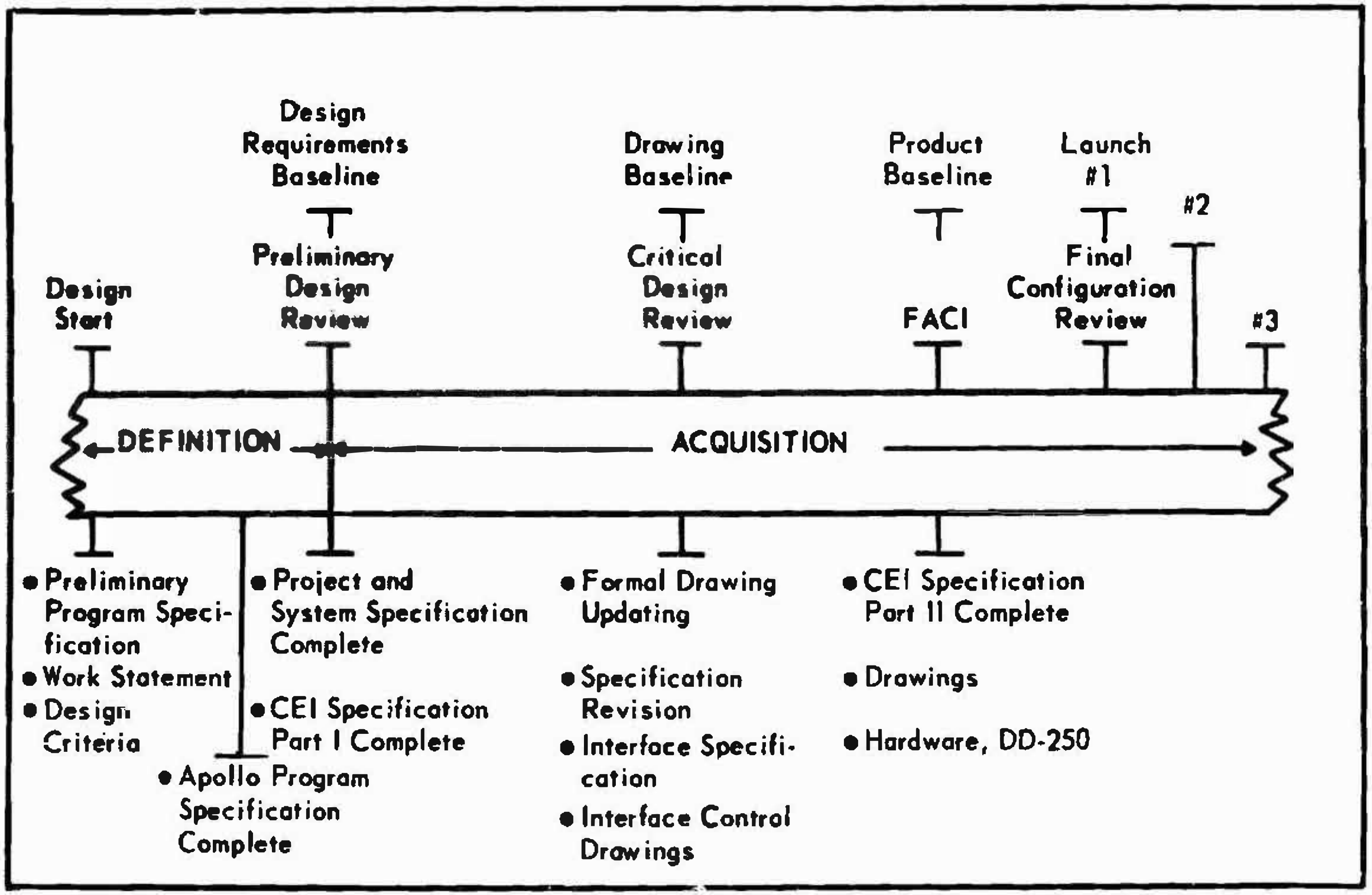

FIGURE 5-1. CONFIGURATION MANAGEMENT CONCEPTS AND PHASING

5.3 CONFIGURATION CONTROL

Configuration control is the systematic evaluation, coordination and approval or disapproval of proposed changes to any baseline. The Level II Configuration Control Board will make decisions on changes affecting the Saturn IB Program Specification, interfacing engineering changes of two or more different stage contractors which are not agreed to by the stage managers, and will process all proposed Level I Changes.

The Level III Configuration Control Board will make decisions on all Class I Changes submitted by the contractor. Level I and Level II Changes will be referred to the appropriate board for consideration.

All Class I changes submitted by the contractor will be reviewed by the Level III CCB for effect on program specification, interfaces, costs, and schedule impact. Changes which will result in substantial cost savings without compromising safety, performance, or schedule should receive maximum consideration. All CCB decisions will be recorded on a Configuration Control Board Directive (CCBD) and will be forwarded to the appropriate contracting officer for implementation.

5.4 CONFIGURATION IDENTIFICATION

Configuration identification is the technical documentation definition of the approved configuration of the system or equipment during the acquisition phase. All deliverable contract end items will be identified by specifications. All changes to the approved specifications will be documented through Specification Change Notices (SCNs) and by approved Engineering Change Proposals (ECPs). The engineering drawing system of each prime contractor will be reviewed by fully qualified configuration management specialists. Procedures will be established by each project (stage) office to identify Class I and Class II changes, and to assure that all changes are processed for approval prior to being implemented.

5.5 CONFIGURATION ACCOUNTING

Configuration accounting is the reporting and documenting of changes made to systems and equipment subsequent to the establishment of a baseline configuration. Configuration accounting will be accomplished in accordance with procedures published by the Configuration Management Group, Resources Management Office, Industrial Operations.

5.6 CONFIGURATION IDENTIFICATION AND ACCOUNT INDEX.

The configuration identification and accounting index is used for reporting configuration identification and configuration status accounting. This document shall be arranged in tabular form and shall permit incorporation of changes resulting from contractor or project (stage) office action. A format similar to that contained in NPC 500-1 will be used for this purpose.

SECTION 6

LOGISTICS

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SECTION 6

LOGISTICS

6.1 SCOPE

Logistics is the integral element of the Saturn IB Program that assures operational continuity by support of all program phases following factory functional checkout and proceeding through launch (launch vehicle assembly, checkout, test refurbishment, and transportation). This plan identifies the activities and coordination required of all Saturn IB elements to ensure the implementation of a timely and economical logistics support program. The provisions of this plan apply to all MSFC organizations engaged in the execution of the Saturn IB Program and to the MSFC contractors required to provide logistics support by Saturn IB Program Management.

The Saturn IB logistics program consists of identifying, acquiring, providing, maintaining, managing, and subsequently disposing of the material and human resources required to provide the logistics engineering, maintenance, repair, transportation, training, technical support documentation, propellant pressurants, and supply services required to adequately but economically support the Saturn IB Program in a planned, systematic manner. The functions included in this program are: logistics planning, maintenance and maintainability, material support, training, transportation, propellants and pressurants, and management techniques to assure efficient application of these resources. The Saturn IB Program Manager is responsible for the development of the Saturn IB logistics program, management system, and distribution of logistics functions to the various MSFC elements.

6.2 OBJECTIVE

The objectives of the Saturn IB Logistics Program are:

a. The establishment of a management system to provide direction and control of the Saturn IB Logistics Program.

b. To identify and evaluate available logistics resources and make maximum use where applicable.

c. Systematically develop logistics requirements based on program needs.

d. Provide effective, economical, uniform and timely logistics support.

e. Ensure complete interface between other Saturn IB functions and the Saturn IB Logistics Program.

To meet these objectives the following must be accomplished:

a. Identification of all end items (airborne and ground) which require logistics support.

b. Systematic analysis of all end items from initial concept through operation from the logistics viewpoint with respect to the timely availability of material, propellants and support personnel, and logistics documentation such as descriptions and maintenance procedures.

c. Physical accomplishment on space vehicles, ground support equipments, spares and repair parts, and facilities (after delivery to NASA) of changes approved by the configuration management organization. Maintenance of the necessary configuration control system documentation for space vehicle equipments and spares in the custody of NASA.

d. Establishment and control of stock levels and stocking point for Saturn IB hardware.

e. Assignment of responsibilities for maintenance of all Saturn IB space vehicles, ground support equipment and facilities.

f. Establishment, coordination, and adoption of compatible logistics plans and procedures for all Saturn IB program elements and the means by which it can be ascertained that the requirements in these documents are being met.

6.3 LOGISTIC PLANNING

The fundamental management concept upon which the Saturn IB Program logistics support is to be created is that of contractor support at both Program and Project levels. Under this concept NASA organizations will provide management direction and overall control of contractor performed logistics functions. Logistic Plans detailing the methods and responsibilities of providing logistic support will be developed at the Program and Project level. Project level plans will be based on the Saturn IB Vehicle Logistic Program Plan which will be based on the MSFC Center Logistics Plan.

The management responsibilities will be established in these plans and the reporting systems required to establish management visibility will be defined.

Logistics plans will be developed covering the period from the completion of manufacturing until the item is withdrawn from service or until it is expended.

6.4 MAINTENANCE AND MAINTAINABILITY

Maintenance consists of those activities necessary to restore an item to serviceable condition or to prevent degradation in performance by a planned action. As such it also includes the analysis necessary to determine the methods by which maintenance is to be accomplished. Maintainability consists of those studies and actions taken to enhance the probability of successfully performing maintenance within the allowable time and cost to meet program objectives.

6.4.1 MAINTENANCE CONCEPTS. The basic corrective maintenance concept for the Saturn IB Vehicle and GSE is the removal and replacement of failed components at the level which:

a. The replacement item can be functionally tested to system specification as an entity.

b. A minimum amount of verification testing and rechecking is required.

Normally failed items will be returned to a depot level for failure analysis, repair and recertification or disposal. Certain items which are relatively simple to fabricate, not normally subject to failure and subject to configuration changes will be fabricated at field sites when the capability for quality assurance exists at the sites. Examples of these items are cables and tube assemblies.

The basic preventive maintenance concept which applies only to GSE is the performance of periodic checks and required servicing on a scheduled basis in accordance with requirements established by maintenance analysis.

Maintenance concepts used in the Saturn IB Vehicle Program will be in consonance with the MSFC/KSC Working Relationship-Logistics.

6.4.2 MAINTENANCE ANALYSIS. A maintenance analysis will be prepared by the activity responsible for support on all end items of equipment to develop the requirements for spares, maintenance GSE, tools and test equipment, maintenance requirements, technical data, maintenance personnel and skill levels, failure rates, time to repair or maintain, test requirements, age control, retest, rebuild, calibration, cleaning, environmental control and logistic criticality.

The maintenance analysis will be based on an operations analysis which defines the operations to be conducted and the sequence and time required to conduct the operations.

The maintenance analysis will provide the types of maintenance, the levels and locations for maintenance and maintenance flow describing the maintenance loop.

In addition to maintenance analysis on each end item, an overall analysis will be performed on the integrated vehicle to provide data for forecasting total quantities of maintenance resources required.

6.4.3 MAINTAINABILITY. An analysis of the operational requirements will be conducted to establish the maintainability requirements and goals for the Saturn IB Vehicle. The requirements and goals will be in agreement with those established in the Apollo Program Development Plan.

These requirements will be stated in numerical terms and apportioned to the various stages and pieces of ground equipment as design requirements in the Part I CEI Specifications.

A continuous survey of maintenance operations will be maintained to assure that the end items and integrated system meet the maintainability requirements.

6.4.4 MAINTENANCE SERVICES. Saturn IB Vehicle will utilize three levels of maintenance.

a. First level maintenance is that maintenance performed on the system installed equipment at the test or launch site by operational personnel. It includes fault isolation, remove and replace, servicing, replenishing, inspecting and repair in place.

b. Second level maintenance is all other maintenance performed at the test or launch sites. Normally it consists of repair in shops at the sites.

c. Third level maintenance is depot maintenance and consists of all maintenance performed at an established depot, the manufacturing facility or vendor facility.

First level maintenance will normally be performed by contractor operating personnel at static testing and launch sites. The responsibility for the performance of maintenance of equipment will be specified in each contract. There will be a minimum of second level maintenance.

The repair of failed items or major refurbishment requiring depot facilities will normally be performed by the contractor or government agency responsible for equipment design. For certain items of GSE which are supplied on a single order basis plans will be developed to assure capability for depot support at a facility other than the original manufacturer.

6.5 MATERIAL SUPPORT

Material Support includes the actions of funding, spares selection, acquisition, inventory management, repair, refurbishment and modification of spares, tools and test equipment and repair parts.

MSFC is responsible to provide spares, repair parts and special tools and test equipment to support the Saturn IB Vehicle. Normally these items will be procured from the contractor responsible for fabrication of the end items.

The cost of the logistic material support program will be an identifiable item in each contract and the responsibility for providing spares, including schedules and period of performance, will be established in each contract.

6.5.1 SPARES SELECTION ACQUISITION. Each contractor with spares support responsibility will determine spares requirements. Spares selection will be based on the Maintenance Analysis, usage data (when available), failure rates and program schedules.

A listing of spares will be prepared for each end item and will indicate as a minimum the Part Number, Next Assembly, Quantity of the part on the end item requiring support, Stock levels and location of stocks, Repair Code and Effectivity for which the part is authorized.

These lists will be maintained current with design definition during the period that the equipment is in use. The spares lists will be reviewed by the appropriate project office and the using activity and comments and recommendations will be forwarded to the contractor for consideration. Contractors will procure spares in adequate quantities to assure that stock levels established in the spares list are maintained. Contractors will prepare procurement lists at least quarterly indicating the planned procurement for the quarter.

All spares procured under a Saturn IB Vehicle contract will be inspected and processed in the same manner as production material and will be packaged and preserved in such a manner that they are ready to be installed without adjustment, servicing or testing.

Failed items will be repaired and recertified if the cost of repair does not exceed 65 percent of replacement cost and the item replacement cost exceeds $200.00, if there is a requirement for further use in the spares program.

All spares in stock will be tagged to indicate requirements for age control or periodic recertification due to drift, lubricant deterioration or other causes. No spare will be issued after the date of age control or recertification has passed.

Each contractor with spares support responsibility will establish a planned program to refurbish or retest such items without withdrawing all stock from a test or launch site.

6.5.2 INVENTORY MANAGEMENT. The contractor responsible for spares supply will establish an inventory management system to insure that sufficient serviceable logistic material of the proper configuration is available to meet specified stock levels:

a. Property Control. A property account for logistic material will be maintained by the supplier of the spares at the factory. Property account records to be maintained at the warehouse will be held to a minimum. The property accounts will be maintained current with daily usage data and all property accounts will be continuously purged of material no longer required. All property accounting will be in accordance with NPC 105A.

b. Shipping. The inventory manager will be authorized to ship material at his discretion..

c. Storage. Warehouses will be provided by MSFC and KSC to meet requirements. Each contractor will provide an estimate of his requirements for storage space and environmentally controlled areas. These estimates will be revised periodically as required.

d. Modification. Requirements for modification of spares will be processed in accordance with ANA Bulletin/445 and the contractor will take appropriate action in accordance with his proposal when it is approved.

6.5.3 GFP. Spares to support items which are established as GFP on the contractors make or buy list will be GFP and maintained by NASA unless otherwise specified. Items furnished by the government in lieu of contractor purchase will be supported by the contractor.

6.6 TRAINING

Training will be an integral part of the logistics program for the Saturn IB Vehicle. Training under the Logistics Program will be limited to training of operation and maintenance personnel for static test and launch sites.

An analysis of the training requirements will be conducted and plans established to develop and obtain justified training.

Training plans will be developed documenting the required courses, schedules, training equipment and training aids and facilities. Training plans will also indicate the methods to be used to maintain the training and training resources up to date with program changes.

Due to the prior experience gained on the Saturn I program, it is anticipated that the majority of training required will be fulfilled by on-the-job training of newly acquired personnel.

6.7 TECHNICAL SUPPORT DOCUMENTATION

Technical Support Documentation is an integral part of the logistics program. By established practice the operational type of technical data is prepared by the operating element. For example, KSC is responsible for preparation of launch site test and operating procedures. The maintenance technical data will be prepared by the contractor.

Requirements for maintenance technical data will be established in each contract. A method will be specified to assure that technical data is maintained to the requirements of NPC 200-2 and NPC 500-1.

Maintenance documentation will be prepared to meet the requirements of site personnel and will be based on an analysis of the skill and proficiency level of the using activity.

Technical documentation will be verified by selecting sample procedures and actual performance of each procedure selected.

6.8 TRANSPORTATION

Transportation consists of delivery of end items and supporting material, either hardware or software, in a timely, safe and economical manner. To insure that transportation is adequately considered and effected each contractor responsible for the movement of material will prepare a detailed transportation plan. This plan will define the modes of transportation, the special transportation equipment required, transportation routes and contigency methods of transportation to meet emergency requirements.

6.9 PROPELLANTS AND PRESSURANTS

Propellants and Pressurants Management is the responsibility of the MSFC Program Logistics Office Saturn IB Vehicle Program participants will provide forecasts of propellant and pressurant requirements as required and each contractor requiring propellants and pressurants will obtain these through the channels established by the MSFC Program Logistics Office.

6.10 SATURN IB VEHICLE LOGISTICS MANAGEMENT

The Saturn IB Program Manager has established a Saturn IB Logistics Manager who is responsible for the development and implementation of an integrated Saturn IB Logistics Program. Recognizing that there is a commonality between Saturn IB and Saturn V, the Saturn IB Logistics Manager will assure that IB and V requirements for logistics support are coordinated and that single MSFC direction is provided to the contractors who have common items. Each Project Manager has established a Logistics Manager who is responsible to effect a project logistics plan and program to meet the requirements of the project and the integrated vehicle.

SECTION 7

FACILITIES

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SECTION 7

FACILITIES

7.1 SCOPE

• This section sets forth the overall facilities plan for the Saturn IB Program, including:

1. Facilities acquisition policies, responsibility, and procedures;

2. Descriptions of facilities supporting the Saturn IB Program, including NASA, DOD, and industry-owned facilities;

3. Overall NASA Saturn IB facilities development planning.

7.2 FACILITIES ACQUISITION AND PROCEDURES

Guidelines provided by NASA Basic Administrative Processes Document, dated February 1964, cover the policies and procedures, definitions, and summary of authorities for the facilities planning and approval process. In addition Section II of NPC 107 covers the budget execution process, including the procedure for reprogramming and delegation of authority and instructions relating to construction. Such details include the format for projects incrementally and non-incrementally funded.

Under current NASA practice, projects included in the MSFC Construction of Facilities Program contained all of the equipment elements required to create a useable facility. In the facilities planning and approval process, the following basic policies and principles are applicable.

1. Conceptual studies of facilities design are conducted as a basis for advance design and the programming of facilities construction.

2. Advance design for proposed new facility projects is accomplished by MSFC to serve as the basis for preliminary facility cost estimates. Advance design funds are then approved and authorized by the Associate Administrator through the project approval process.

3. Design and construction efforts which cover repair, alteration, modification, extension or remodeling projects estimated to cost in excess of

$250,000 each are submitted to NASA Headquarters for approval and authorization by the Associate Administrator through the Project Approval Document process.

4. The criteria for all directly-supporting facilities are subjected to configuration control procedures and documentation requirements. Figure 7-1 delineates participation in facilities acquisition.

7.3 PROGRAM ANALYSIS

Facilities supporting the Saturn IB Program are many and diverse. Some of the facilities are: assigned to MSFC programs and projects which directly or indirectly support Saturn IB; others are assigned to programs belonging to other governmental agencies.

7.4 MAJOR MSFC, DOD, AND INDUSTRIAL FACILITIES AND DESCRIPTIONS

7.4.1 GENERAL. The Saturn IB facilities program encompasses projects at MSFC, Department of Defense installations, and contractor sites.

Facilities supporting the Saturn IB Program are identified in Figure 7-2. The locations of the facilities required to meet the needs of the Saturn IB Program are:

George C. Marshall Space Flight Center, Huntsville, Alabama
Michoud Assembly Facility, New Orleans, Louisiana
Sacramento Test Operations (SACTO) Sacramento, California
Canoga Park, California
Santa Monica, California
Santa Susana, California
Huntington Beach, California
Huntsville, Alabama - IU, IBM
Slidell, Louisiana
Neosho, Missouri

Following are descriptions of some of the major locations.

7.4.2 MARSHALL SPACE FLIGHT CENTER. The George C. Marshall Space Flight Center, Huntsville, Alabama, is well established in the field of launch vehicle development. The Center occupies 1,796 acres of land. As the site plan indicates, MSFC has facilities for manufacture, development, and ground test of launch vehicles and propulsion systems. The manufacturing facilities

- a. User develops functional requirements for a new facility
- b. Facilities Projects Office prepares & submits Preliminary C of F Budget
- c. Facilities Projects Office obtains authority & FP&D funds for preparation of a Preliminary Engineering Report (PER)
- d. Site Manager & Facilities Project Manager authorize the using contractor or C of E to sub-contract for preparation of a PER
- e. Stage or support contractor or C of E awards sub-contract for PER
- f. Design sub-contractor prepares PER

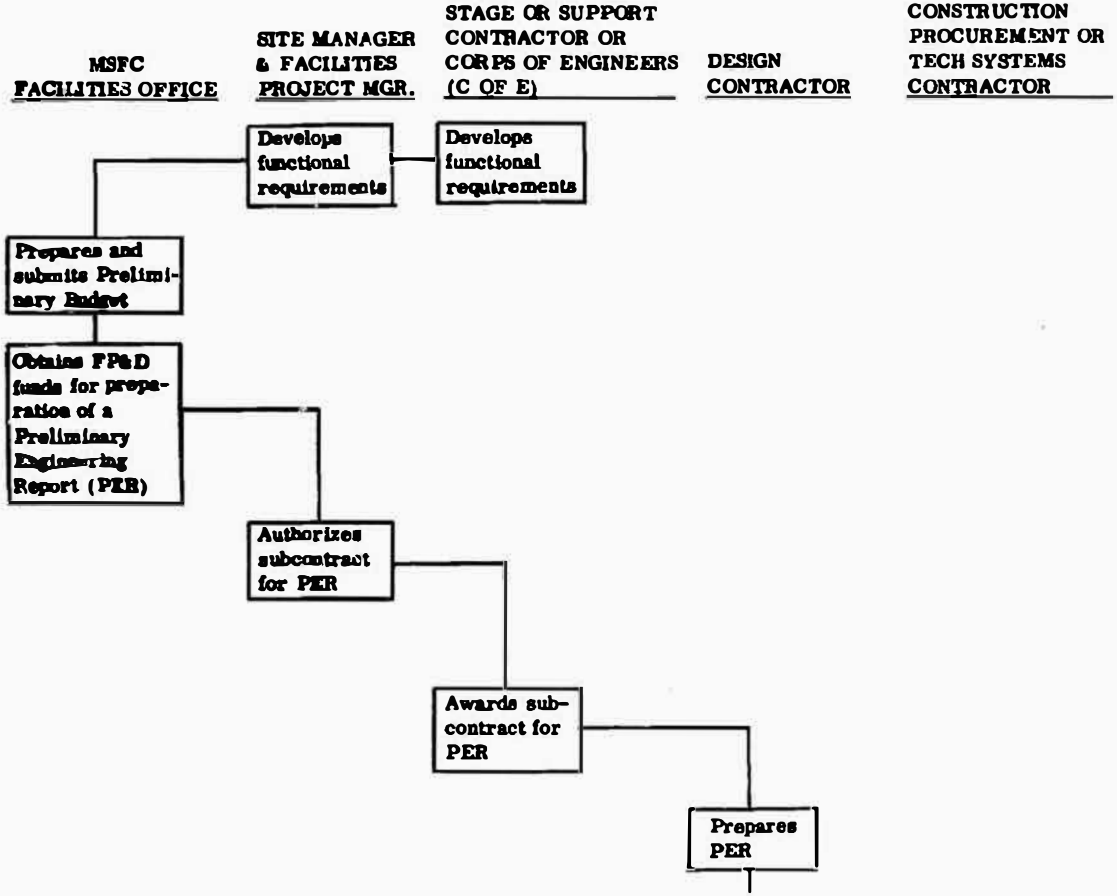

FIGURE 7-1. FACILITIES BUDGETING AND ACQUISITION CYCLE

g. Site Manager & Facilities Project Manager review & evaluate PER; using contractor participates

h. Facilities Projects Office prepares final C of F Budget & submits with PER

i. Facilities Projects Office obtains authority for design using FP&D funds

j. Site Manager & Facilities Project Manager allocate funds for design

k. Stage or support contractor or C of E awards A-E contract & supervises design

l. Architect-Engineer prepares final design & construction cost estimate

m. Stage or support contractor or C of E conducts design reviews; using contractor participates; Site Manager approves final design

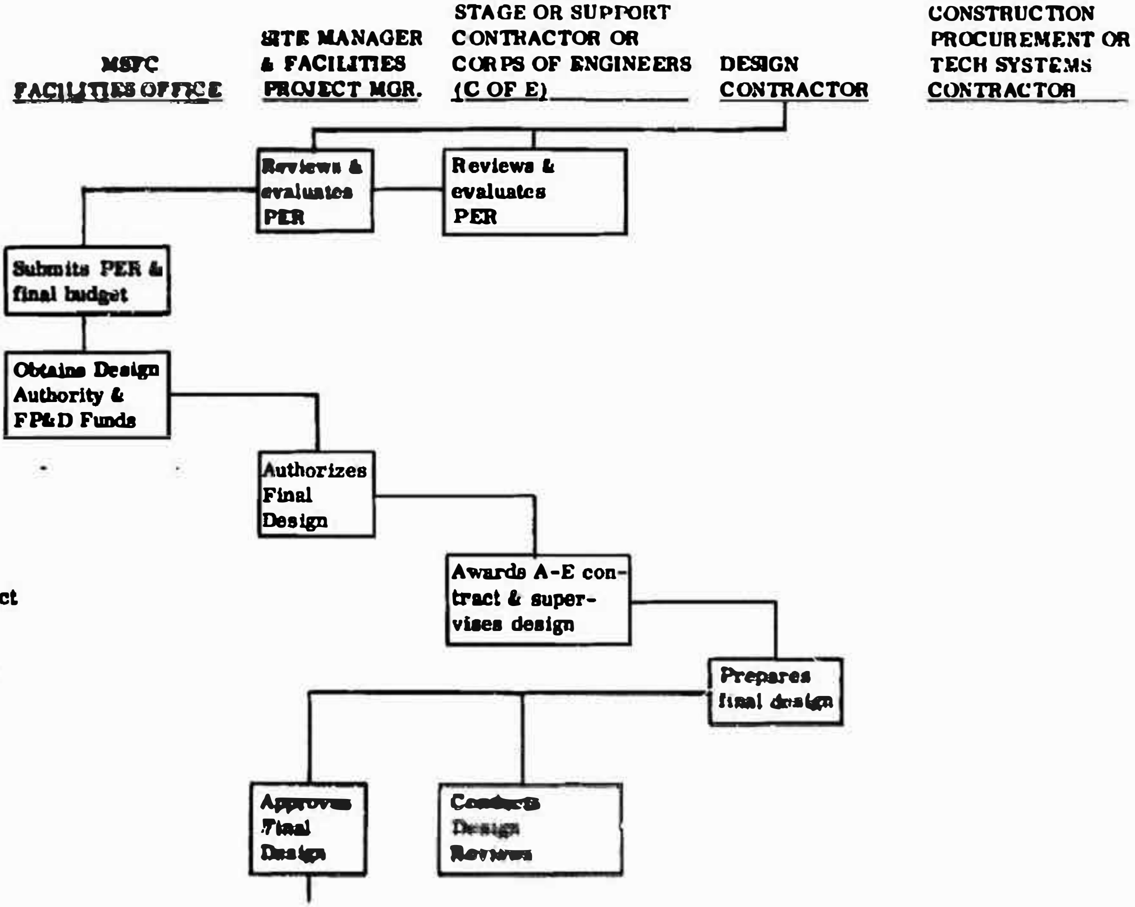

FIGURE 7-1. FACILITIES BUDGETING AND ACQUISITION CYCLE (Continued)

n. Facilities Projects Office obtains construction authority & allocates C of F funds for construction

o. Site Manager authorizes stage or support contractor or C of E to initiate construction, procurement, or tech systems actions according to the approved design & allocates the C of F funds

p. Stage or support contractor or C of E awards construction, procurement, or Tech Systems contracts; supervises & inspects the work of the construction procurement, of Tech Systems contractor. Obtains approval for design changes from Site Manager & Facilities Project Manager

q. Construction, procurement, or Tech Systems contractor performs construction, procurement or Tech Systems

r. Stage or support contractor or C of E conducts acceptance inspections; using contractor participates; Site Manager accepts completed work

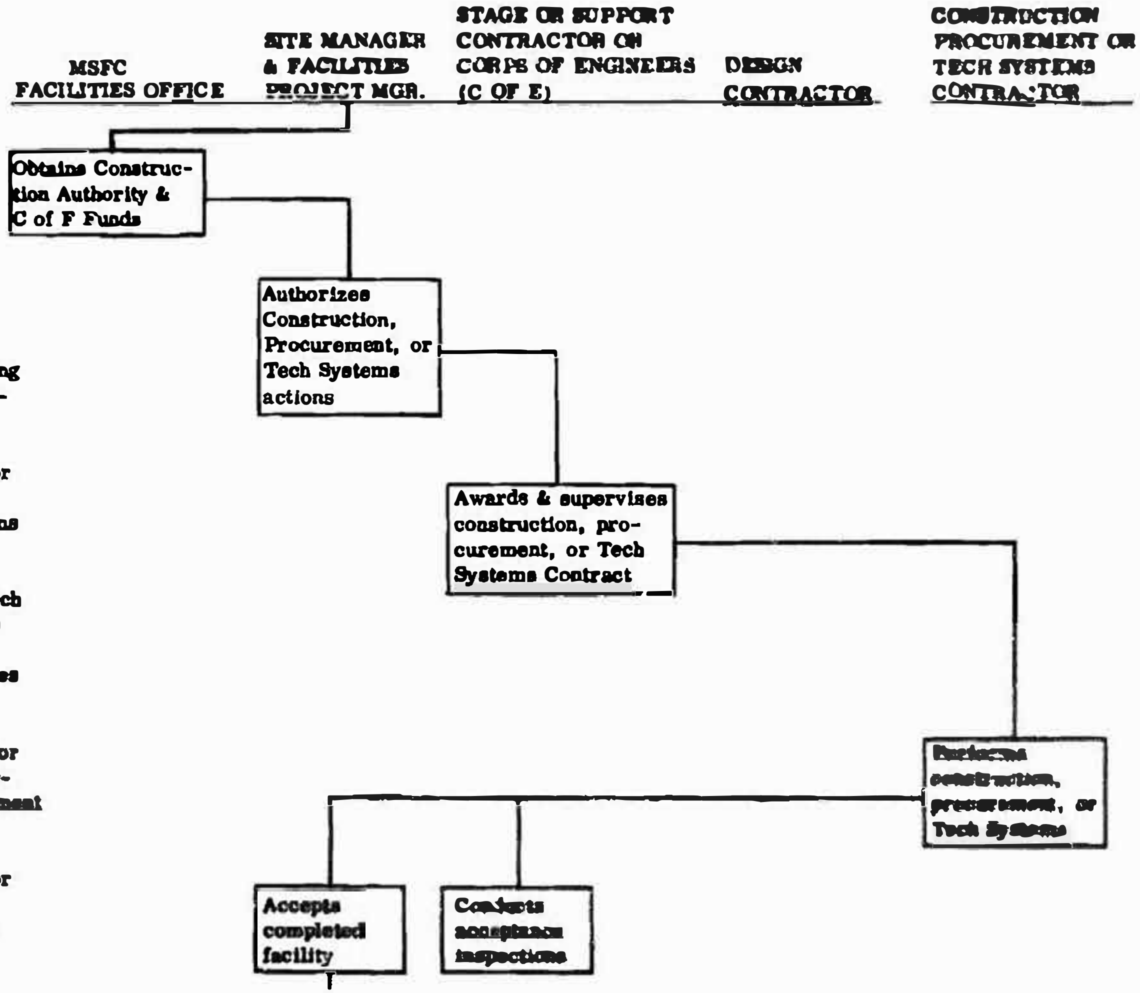

FIGURE 7-1. FACILITIES BUDGETING AND ACQUISITION CYCLE (Continued)

s. Site Manager assigns responsibility for operation & maintenance to appropriate using contractor

t. Using contractor operates & maintains the facility under the provisions of his facilities use contract

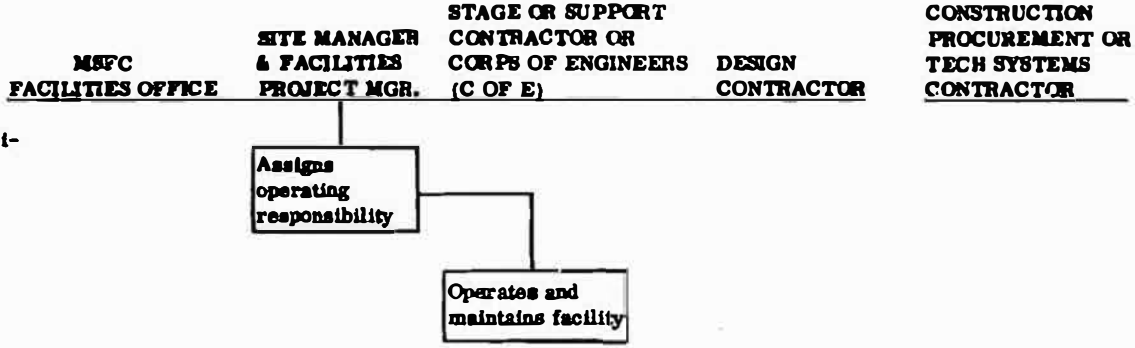

FIGURE 7-1. FACILITIES BUDGETING AND ACQUISITION CYCLE (Concluded)

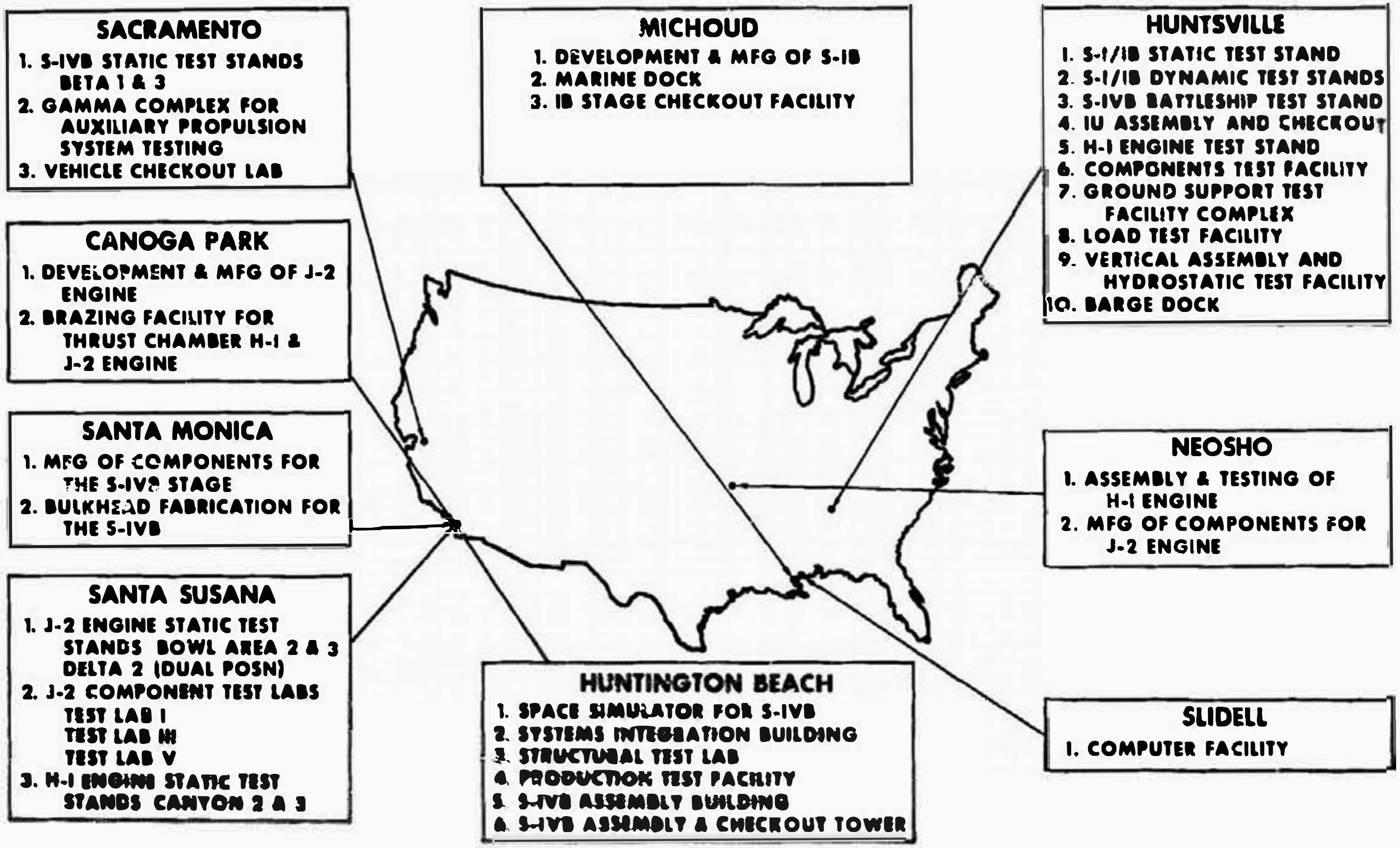

FIGURE 7-2. MSFC SATURN 1B FACILITIES

are concentrated at the northern end of the Center; the development facilities are clustered nearby; the test area is situated in the southern portion.

7.4.3 MICHOUD ASSEMBLY FACILITY. The MSFC mission at the NASA Michoud Assembly Facility (MAF), New Orleans, Louisiana, is the manufacture of the S-IB stages for the Saturn IB vehicles and the S-IC stage for the Saturn V vehicle. The MAF complex covers an area of 824 acres including approximately 210,000 square feet of engineering and office space; 1,959,000 square feet of manufacturing space; and 415,000 square feet of space for storage, handling, and maintenance activities. The Michoud plant and facilities are owned by NASA. Two major contractors occupy portions of the plant; the Chrysler Corporation is responsible for production of the S-IB stages, and the Boeing Company is manufacturing the S-IC stage. All support services for operation of the plant and facilities are furnished by the Mason-Rust Company under contract. Construction of facilities at Michoud is accomplished directly by MSFC.

7.4.4 SACTO. The MSFC mission at the Sacramento, California, facility is the development and testing of the S-IVB stage for the Saturn IB and Saturn V vehicles. The administrative area of this location contains approximately 182,600 square feet of covered space. Of this, approximately 54,700 square feet are used for engineering and office space, 17,200 for laboratories, 50,500 for storage and miscellaneous use, and 60,600 for post-static-test checkout of the S-IVB stages. The test area consists of two complexes: the Beta complex which contains two static test stands for the S-IVB stages, and the Gamma complex which is an auxiliary propulsion system test facility. The Sacramento site area is owned by the Douglas Aircraft Company. The Beta and Gamma complexes, however, are located on 341 acres of land leased by NASA from Douglas under a long term agreement. Construction of facilities at the Sacramento location is accomplished through the U. S. Army Corps of Engineers.

7.4.5 CANOGA PARK. The MSFC mission at Canoga Park, California, is the development, manufacture, and components testing of the F-1 and J-2 engines for use in the Saturn IB and Saturn V vehicles. The Canoga Park facility is a plant complex containing 588,000 square feet of engineering and office space, and 1,178,000 square feet for manufacturing and related activities. The complex is composed of buildings either owned or leased from private business by North American Aviation, Inc., plus Air Force Plant 56, which is owned by the U. S. Air Force. The entire complex, including Air Force Plant 56, is operated by the Rocketdyne Division of North American Aviation, Inc. Construction of facilities at Canoga Park is performed by Rocketdyne.

7.4.5 SANTA MONICA. The MSFC mission at Santa Monica, California, is the manufacture of components for the S-IVB stage for the Saturn IB and Saturn V vehicles. The Santa Monica plant is owned and operated by the Douglas Aircraft Company and covers an area of 2,962,000 square feet. Of this, approximately 1,925,000 square feet is devoted to NASA production. This includes 442,000 square feet used for engineering and office space, 853,000 square feet for manufacturing, 143,000 square feet used for laboratories, and 487,000 square feet used for storage and miscellaneous use.

7.4.7 SANTA SUSANA. The MSFC mission at Santa Susana, California, is the developmental testing of the S-II stage of the Saturn V vehicle, development and testing of the H-1 and J-2 engines, and components testing of the F-1 and J-2 engines. This facility covers approximately 411 acres of mountainous land near Los Angeles. Part of the facility is owned by the U. S. Air Force (Air Force Plant 57) and part by North American Aviation, Inc. Approximately 25,000 square feet of building area is available for engineering and office space. Other facilities consist of control centers, fuel storage and transmission systems, and an extensive test area. The test facilities include two S-II stage test positions, two F-1 components test laboratories, two H-1 components test laboratories, three H-1 engine test stands, three J-2 components test laboratories, and five J-2 engine test stands. The components test laboratories are common facilities in some instances. Test operations at this location for the S-II stages are carried out by the Space and Information Division, North American Aviation, Inc. All testing and related activities pertaining to engines and engine components are performed by North American's Rocketdyne Division.

7.4.8 HUNTINGTON BEACH. The MSFC mission at Huntington Beach, California, is the development, manufacture, assembly, and final checkout of the S-IVB stage for the Saturn IB and Saturn V vehicles. This facility is owned and operated by the Douglas Aircraft Company and covers an area of 675,000 square feet. Of this, 261,800 square feet are used for engineering and office space, 107,100 square feet for manufacturing, 54,300 square feet for laboratories, and 251,800 square feet for storage and miscellaneous use. The facilities include a space simulator building, a systems integration building, a structural test laboratory, a production test facility, an assembly building, and an assembly and checkout tower complex.

7.4.9 SLIDELL. The MSFC mission for the Central Computer Facility at Slidell, Louisiana, is to provide housing and facilities for the digital and analog computers and other data reduction equipment necessary for the operation of a computer center. This Slidell facility, originally constructed by the Federal Aviation Agency, is now owned by NASA and is a part of NASA Michoud Plant Operations at New Orleans, Louisiana. The computer center is contractor-operated by Telecomputer Services, Incorporated. The facility's location at Slidell is approximately 20 miles from the Michoud Assembly Facility and 15 miles from the Mississippi Test Facility. This allows convenient computer service to both installations without duplication of facilities. Modification of existing facilities and construction of new facilities is accomplished at this location directly by MSFC.

7.4.10 NEOSHO. The MSFC mission at Neosho, Missouri, is the manufacture and acceptance testing of the H-1 engine for use in the Saturn IB vehicle and manufacture of certain J-2 engine components. This facility covers 3644 acres and contains 245,000 square feet of manufacturing space, 59,000 square feet of test area, and 40,000 square feet of engineering and office space. The test area consists of two H-1 engine test stands with dual positions. The Neosho facility is owned by the U. S. Air Force (Air Force Plant 65) and is operated by the Rocketdyne Division of North American Aviation, Inc.

7.5 NASA FACILITIES DEVELOPMENT PLAN

Figure 7-3 identifies existing and planned MSFC facilities supporting the Saturn IB launch vehicle, indicating program by fiscal year, location, and title of project, funding and schedule for completion.

7.6 LAUNCH FACILITIES

Launch Facilities for the Saturn IB space vehicle are located at the Eastern Test Range, Cape Kennedy, Florida. These facilities are comprised of Complex 34 and Complex 37B at the Kennedy Space Center which are designed to provide all the services necessary to launch the Saturn IB space vehicle.

Kennedy Space Center has the responsibility for design, construction and modification of the complexes to assure operational interrelation with the Saturn IB space vehicle. KSC will also provide and install Ground Support Equipment designed to conform to the Saturn IB vehicle concept of operation. This GSE provides for functions preparatory to launch of the vehicle. Equipment peculiar to a particular stage of the vehicle will be provided by the stage contractor (MSFC). Specially-designed and developed vehicle-oriented checkout equipment will be provided jointly by MSFC and KSC.

PROGRAM	FY	PROJECT NUMBER	PROJECT TITLE	PROG. PLAN	FUNDING RELEASED TO MSFC	COMPLETION
	62		Marshall Space Flight Center			
I-IB-V		6213	Ext. of Primary Utilities	.39	.39	Completed
J-2		9131	J-2 Engine Facilities	6.30	6.30	Completed
V		9130	Fac. for S-IVB Stage Program*	.18	.18	Completed
	63		MSFC			
I-IB-V		6235	Utility Installations	3.57	3.57	Completed
			Michoud Plant			
I-IB-V		6308	Engineering Building	8.5	8.5	Completed
			Various Locations			
J-2		9131	Facil. for J-2 Engine Prog.	4.95	4.95	Completed
V		9130	Facil. for S-IVB Stage Program*	.19	.19	Completed
V		9130	Facil. for S-IVB Stage Program**	20.24	20.24	Completed
	64		MSFC			
I-IB-V		6238	Acoustic Model Test Fac.	2.06	2.06	Completed
I-IB-V		6239	Add to Comp. Test Fac.	3.67	3.67	Completed
I-IB-V		6240	Add to Test Support Shop	1.29	1.31	Completed
I-IB-V		6241	Barge Dock U Loading Fac.	.29	.29	Completed
I-IB-V		6242	Expansion & Mod. High Press Gas Prop. Syst.	1.90	1.9	Completed
I-IB-V		6247	Hazard Ops Lab	.70	.63	Completed
I-IB-V		6248	Mods Inst. & Control Sys. East Area	3.70	3.7	Completed
I-IB-V		6250	Project Engineer Office	2.59	2.59	Completed
I-IB-V		6252	Utilities Installations	3.40	3.5	Completed
			Michoud Plant			
IB		6309	Add to Production Facility	4.08	4.08	3/67
IB		6310	Parking & Security Improve	.56	.56	Completed
I-IB-V		6311	Road & Airstrip Rehabil.	.49	.49	Completed
IB		6312	Vehicle Comp Supply Bldg.	2.46	2.46	Completed
			Various Locations			
J-2		9131	Facil. for J-2 Eng. Prog.	6.48	6.48	12/66
H-1		9133	Facil. for H-1 Eng. Prog.	1.8	1.8	2/67
V		9130	Facil. for S-IVB Stage Prog.*	5.0	5.0	11/66
	65		Marshall Space Flight Center			
I-IB-V		6252	Ext. Utility System	3.0	3.0	1/67
			Michoud Plant			
I-IB-V		6314	Mod Util. & Rehab. Stat. Sup. Fac.	1.48	1.48	3/67
			Various Locations			
J-2		9131	Facs. for J-2 Eng. Prog.	2.90	2.90	Completed
V		9130	Facs. for S-IVB Stage Prog.*	5.23	5.23	2/67

* This project is funded through the Saturn V Program under the Agency wide coding structures; however, it also supports the Saturn IB Program.

** This project is funded through the Saturn V R&D program under the Agency wide coding structures; however, it also supports the Saturn IB Program.

FIGURE 7-3. SATURN IB FACILITIES LINE ITEM DATA

The facilities of a single launch complex consist of: launch pad; umbilical tower; launch pedestal; mobile service structure; launch control center (blockhouse); automatic ground control station; operations support building; storage, pumping and transfer facilities for RP-1, LOX, and LH_2 propellants; and storage, pumping, liquid-to-gas conversion, pressurizing and transfer facilities for liquid nitrogen and liquid helium.

SECTION 8

FUND AND MANPOWER REQUIREMENTS

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SECTION 8

FUND AND MANPOWER REQUIREMENTS

8.1 SCOPE

This section prescribes MSFC policies and procedures for planning, budgeting, reporting, and managing Saturn IB Program manpower and funds. The Administrative Operations appropriation provides for civil service manpower; travel and transportation of persons and material; rents, communications and utilities; printing and reproduction; other service or contract administration services and operational supplies and equipment. Requirements for administrative operations are submitted and updated quarterly consistent with MSFC submission of the Research and Development Program.

Procedures involving funds for construction of facilities are described in Section 7. The basic assumptions, and budgeting and Program Operating Plan procedures outlined in this section apply mainly to the Research and Development appropriation.

8.2 DEFINITIONS

8.2.1 PROJECT APPROVAL DOCUMENT (PAD). A Project Proposal, brief summarization of the proposed project, is prepared by MSFC with a draft Project Approval Document which presents a concise description of the project objectives, technical plans, Reliability and Quality Assurance provisions, management plans, management reporting, procurement arrangements, schedules, and resource requirements. General Management Manual 4-1-1 outlines the method for reporting resources by fiscal year through completion of the project and insuring that data is consistent with applicable budget estimates. These are the basic documents utilized to secure approval of the Project by the NASA Associate Administrator.

8.2.2 PROGRAM OPERATING PLAN (POP). The Program Operating Plan is the official quarterly submission of the MSFC financial plan which provides NASA Headquarters with a basis for formulating the Agency budget estimates. This document presents a comprehensive detailed study of resources, and fund and manpower requirements essential to operational development and completion of mission assignments.

8.2.3 APPROVED PROGRAM AUTHORITY. After approval of the PAD, Manned Space Flight Authorization of program, NASA Form 643, provides MSFC with specific amounts of Program Authority for the conduct of the Saturn IB Program.

8.2.4 ALLOTMENT. A grant of funds approved by NASA Headquarters, Resources Authorization, NASA Form 506, is issued to MSFC for the purpose of incurring commitments and obligations and making program disbursements.

8.2.5 INITIATIONS. This is the process of establishing a requirement for obtaining goods or services. The Procurement Request, MSFC Form 404, is the official document utilized by MSFC to define requirements and approximate value.

8.2.6 COMMITMENTS. Commitments are firm administrative reservations of funds by the MSFC Financial Management Office based on procurement requests or other acceptable written evidence which authorizes the creation of obligations within specified amounts.

8.2.7 OBLIGATIONS. Obligations are binding agreements in writing between the Government and one or more parties for a purpose authorized by law for orders placed, specific goods to be delivered, or work or services to be performed, which will result in the disbursement of money.

8.2.8 COSTS. Cost is defined as the value of material delivered or services performed for which payment is due or has been made. Costs should always exceed or be equal to disbursements.

For the purpose of contractor reporting on NASA Form 533, unfilled orders are defined as an incurrence of a firm obligation by the contractor. These obligations include contracts, purchase orders, and similar items which have not become costs.

8.2.9 DISBURSEMENTS. Disbursements are the dollar amount of checks issued and cash payments made.

8.3 BUDGET CYCLE

Figure 8-1 establishes a typical timetable for the recurring budget and financial planning actions required of the MSFC activities preliminary to submission of the Saturn IB Program Operating Plan to NASA Headquarters. This

MSFC SATURN IB
BUDGET CYCLE
(TIME INTERVALS IN DAYS)

1. Exec. Staff Guidelines for preliminary Budget
2. R&DO Formulation of PEP
3. R&DO Review of PEP
4. I. O. Formulation of POP with R&DO Coordination
5. Program Office Preliminary Guidelines for POP
6. Program Office Guidelines for POP
7. I. O. Guidelines for POP
8. Exec. Staff Guidelines for POP
9. Receipt of MSF Guidelines for POP
10. Program Office Review of POP
11. I. O. Review of POP
12. Center Review of POP
13. MSF Review at Center

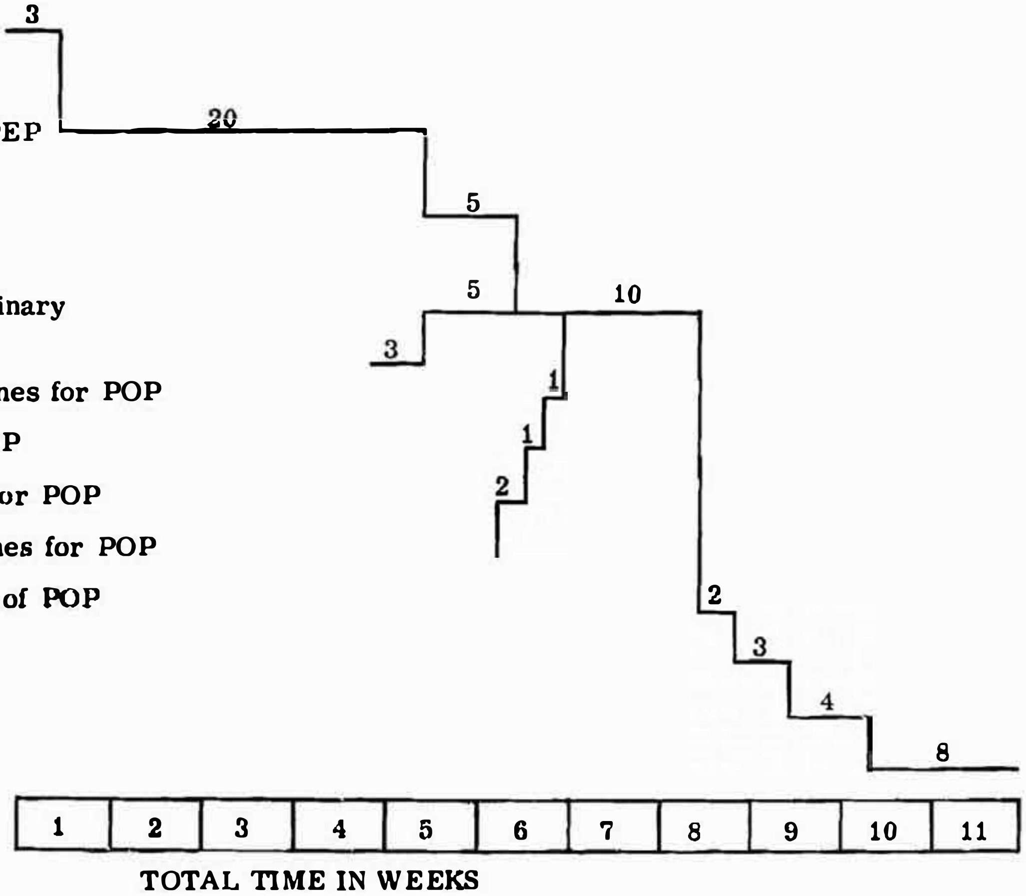


FIGURE 8-1. MSFC SATURN IB BUDGET CYCLE
(TIME INTERVALS IN DAYS)

report is submitted on a quarterly basis in accordance with the MSF schedule, generally February, May, August, and November.

8.4 PROGRAM OPERATING PLAN

8.4.1 GENERAL. The basic MSFC policies, principles and procedures for formulating the Saturn IB Program Resources requirements are contained in NPC-107. The current plan contains obligation and cost summarizations by project and system account (major contractor and other) for the initial MSFC budget and subsequent assessment of requirements by NASA Headquarters.

8.4.2 GUIDELINES AND INSTRUCTIONS. Program Operating Plans are based on currently approved programs and projects as extended and/or modified by budget guidelines issued by Headquarters, Manned Space Flight. The POP is used as the source document for preliminary budget estimates for the MSF program development to the Bureau of the Budget and subsequently to Congress. This document presents a comprehensive study of resources essential to development and completion of approved mission assignment and provides data to (1) measure financial status, (2) determine need for adjustment of current resource and program authorizations for the current year, and (3) indicate levels and phasing of activity for subsequent years.

The Saturn IB Program Control Office participates in the preparation of MSFC Industrial Operations POP guidelines and instructions to insure that adequate data to validate and justify funds and manpower requirements is included in the submission of the final POP to MSF. Saturn IB direct manyears for R&D civil service, in-house, and major contractor support are shown on Figure 8-2.

8.4.3 FORMULATION AND SUBMISSION OF PROGRAM OPERATING PLAN. The Saturn IB Program Office is responsible for developing and preparing fund requirements for the Saturn IB Project. Requirements are documented at the lowest practical level within the stage account with various factors such as contractor estimates, anticipated contractual changes, engineering proposals, etc., used as a basis for the estimates. Backup material to facilitate justification of the estimates includes technical narrative and detailed program information such as hardware to be procured, major prime and support contracts, current value through run-out, summary of accomplishments to date, explanations of significant differences between requirements in the various fiscal years, and concise itemization of other support requirements.

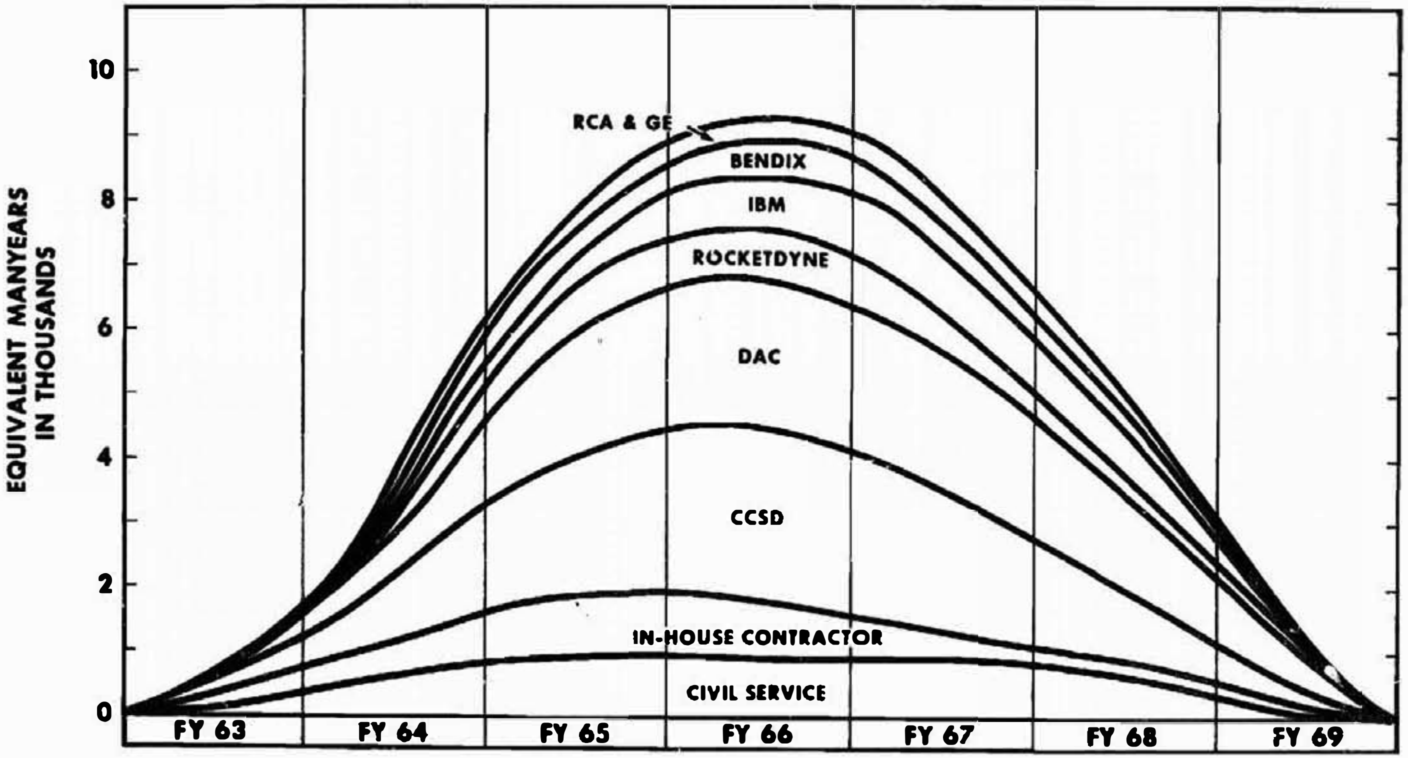


FIGURE 8-2. SATURN 1B DIRECT MAN-YEARS-R& D (Major Contractors and In-House)

8.4.4 REVIEW AND APPROVAL. Review and evaluation of the POP is a joint function of all organizational elements of the Saturn IB Program Office. The purpose of the review is to (1) validate the program requirements and the assumptions used in establishing the budgetary requirements, (2) insure proper balance between the various elements of the program, and (3) ascertain that the assumptions, programming, and justification of the POP are consistent with the latest NASA policies.

Saturn IB Program organizational elements are responsible, within their areas of technical and program cognizance, for the validity of the POP as well as providing assistance in the review and evaluation of fund requirements.

The Saturn IB Program Control Office has responsibility for coordination of the review and evaluation efforts of the Saturn IB Program within MSFC. This entails preparation, revision, and editing of the necessary formats for justification and backup material required for the review and coordination with the Industrial Operations Resources Management Office on any changes required for the POP presentation to MSF.

The Saturn IB Program Office provides representatives to meet with Apollo Program Office personnel to review and evaluate the project details contained in the POP.

8.5 RESOURCES AUTHORIZATIONS AND FUNDS

8.5.1 GENERAL. MSFC availability of funds is subject to (1) Resources Authorization, which is a NASA administrative limitation on initiations undertaken for specific projects, or (2) Allotment of Funds, which is a legal limitation on commitments, obligations and expenditures. Any official who incurs obligations or expenditures in excess of the amount authorized in the Allotment of Funds is in violation of Section 3679 of the Revised Statutes (31 USC 665).

8.5.2 RESOURCES AUTHORIZATIONS - DOLLARS. The Saturn IB Project Resources Authorization, based on an approved POP, is issued to the MSFC Financial Management Office by the Apollo Program Director on NASA Form 643 (MA's) for the current year. This document is received in increments and establishes a limitation on initiations. The first increment covers fiscal year program requirements through February, including any amount authorized earlier to cover program requirements in the period of "continuing resolution." The second increment is based on the revised POP and covers program requirements through May while the third increment covers the remainder of the fiscal year.

The Financial Management Office distributes MAs to the applicable Program Office. Sub-authorizations to other centers are requested by the respective Program Office for issuance by MSFC Financial Management. For example, in accordance with the MSFC/KSC Agreement and based on an approved POP, the Saturn IB Program Office issues sub-authorization to KSC on an incremental basis for prelaunch checkout operations. The current Saturn IB Program Operating Plan contains obligation and cost summarizations by system account major contractors.

Any reprogramming between projects or increased in limitations is subject to change only by MSF amendment unless authority is specifically delegated on the MA. Based upon approved justification, within MSFC, Saturn IB reprogramming is requested by the Saturn IB Program Office through the Industrial Operations Division.

8.5.3 RESOURCES AUTHORIZATIONS-PERSONNEL. Resources Authorizations on civil service personnel ceilings are issued to MSFC by MSF on NASA Form 506 (White) without specific reference to programs, projects, or systems. Manpower authorizations are aligned in accordance with approved POPs with internal allocation by MSFC top management made semi-annually based on manpower reassessments. These reassessments result from endeavors to equalize manpower assignments with changing workloads, such as phase-out of the Saturn I Program, staffing of newly created offices such as IB/Centaur, Mission Operations Office, etc.

Within MSFC, the staff Program Planning and Resources Office controls ceilings for staff and service offices, Research and Development Operations and Industrial Operations.

Within Industrial Operations, which is still a growing organization, manpower ceilings are allocated by the Director, Industrial Operations, through the Resources Management Office to the Saturn IB, Saturn V, Engine Program Office, Facilities, Logistics, and other offices.

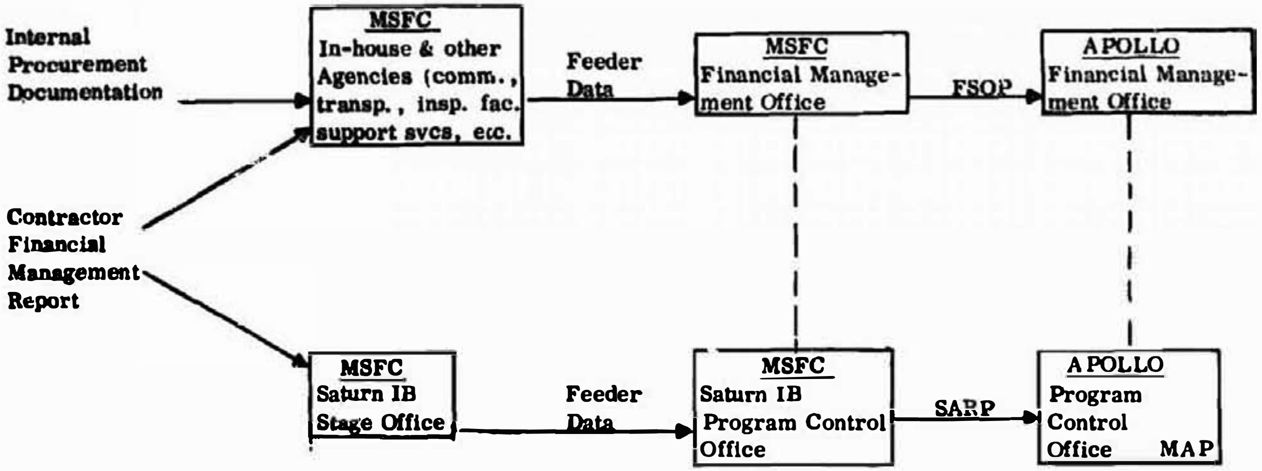
An MSFC Position Management Report submitted monthly to MSF contains the status of civil service positions and compilation by skills, grades, average salary and grade under regular, permanent, termporary and other classifications.

8.6 STATUS REPORTING

Basic financial status reports prepared by MSFC for submission to MSF, including Saturn IB Program data, consist of:

1. "Manned Space Flight Schedules" are prepared by the cognizant stage office and include data on funding, contractor accrued costs, and manpower. Detailed data is also available from the Contractor Financial Management Report, NASA Form 533, which is furnished to MSF on all Saturn IB major cost-type contracts.

2. Reports on 'Financial Status of Programs" are prepared by the MSFC Financial Management Office and provide the monthly status of financial data for all programs. The MSFC flow chart is shown on Figure 8-3.



F. S. O. P. - Financial Status of Programs

Prepared by MSFC Financial Management Office from internal operations and contractor feeder data for three programs, (1) Administrative Operations; (2) Construction of Facilities and (3) Research and Development Detailing by Fiscal Year (Since 1959) and Project Code Number; (a) Program Authorization, (b) Initiations, (c) Commitments, (d) Obligations, (e) Costs and (f) Disbursements.

SARP - Manned Space Flight Schedules; Obligations, Costs and Manpower Reports

Prepared by Program Office for reporting project hardware development and delivery milestones with major contractor current POP financial status through run-out by fiscal year which includes (a) Obligations, (b) Accrued Costs, (c) Unfilled Orders, (d) Advanced Funding and (e) Equivalent Manpower requirements. A separate chart is also submitted which includes this basic information by month for the current year. These major Saturn IB cost-type contracts are funded on an incremental basis.

FIGURE 8-3. FLOW OF BASIC MSFC FINANCIAL STATUS REPORTS TO MSF

SECTION 9

TECHNICAL DESCRIPTION AND SYSTEMS ENGINEERING

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SECTION 9

TECHNICAL DESCRIPTION AND SYSTEMS ENGINEERING

9.1 SCOPE

This section contains a statement of the objectives and missions of the Saturn IB program, a technical description of the vehicle design requirements and configuration, and a description of the launch facilities.

9.2 PROGRAM OBJECTIVES

A launch vehicle capable of placing a version of the Apollo spacecraft into earth orbit for flight testing is needed at the earliest date possible. The payload capability of the Saturn I launch vehicle was insufficient for such a mission and the Saturn V will not be available until approximately one year after the Apollo spacecraft is ready for operational testing. The Saturn IB launch vehicle is therefore being developed as an intermediate step between the Saturn I and Saturn V launch vehicles to provide the capability required for early testing of the Apollo spacecraft in earth orbit.

The objective of the Saturn IB Program is to provide launch capability for the development of the Apollo spacecraft and to provide for development of spacecraft orbital maneuvering techniques. Specific Saturn IB mission assignments and specific flight objectives to accomplish the above program objectives are defined by the Apollo Flight Mission Assignments Document, NPC-C500-11. The MSFC Mission Directive for each particular Saturn IB launch vehicle will implement the requirements and objectives of the Flight Mission Assignments Document. The Mission Directive is the single instrument for authoritative identification and control of the requirements, objectives, assignment of responsibilities, and specific details of implementation for individual flights consistent with Center responsibilities.

The Saturn IB launch vehicle will combine a modified version of the first stage of the Saturn I launch vehicle with a modified version of the third stage of the Saturn V launch vehicle. The resulting Saturn IB launch vehicle will provide an earth orbital payload capability of approximately 20 tons. This capacity is about nine tons greater than that of the Saturn I launch vehicle.

The experience, skills, and technical knowledge gained in conducting the Saturn IB Launch Vehicle Program will be directly related to the mission assigned and to the functional requirements and reliability goals of the vehicle and payload. Technological advances made during the Saturn IB Launch Vehicle Development Program will be used to expedite and improve the Saturn V launch vehicle. Advances will occur in practically every phase of launch vehicle development, including propulsion, liquid hydrogen technology, vehicle structures, guidance and instrumentation, propellant tank manufacturing methods, and ground-test and flight-test philosophies.

The Saturn IB launch vehicle has many potential uses in addition to those specified for the Saturn IB/Apollo Program. Possible missions other than Apollo will be described in Section 17, Advanced Missions, as the information becomes available.

9.3 MISSION ASSIGNMENTS

9.3.1 MISSION DESCRIPTION. The primary mission of the Saturn IB Launch Vehicle is to place a manned Apollo spacecraft into a low earth orbit using a flight azimuth of 72 degrees east of north. The Apollo spacecraft used for these missions will consist of a Command Module (CM), Service Module (SM), Lunar Module (LM), Spacecraft LM Adapter (SLA), and a Launch Escape System (LES). Each mission will be unique in that the Command Module, the Service Module, and the Lunar Module will be incorporated in various combinations and in various conditions of final-configuration loading. The final configuration of the S-IVB/IB stage and the Instrument Unit will be capable of supporting the operation of the Apollo spacecraft during a 4-1/2 hour earth orbital coast period. Effective with the eighth Saturn IB vehicle, this capability will be extended to 7-1/2 hours.

The secondary mission of the Saturn IB launch vehicle will be to provide flight tests of operational systems which will be incorporated into both the third stage (S-IVB/V) and the Instrument Unit (IU/V) of the Saturn V space vehicle for use in manned missions to the moon.

Twelve Saturn IB/Apollo flights are planned, utilizing launch vehicles SA-201 through SA-212. The primary objective of the first two Saturn IB/Apollo vehicles (SA-201 and SA-202) was the flight testing of the launch vehicle and unmanned Apollo spacecraft, and verification of heat shield performance under maximum reentry heat rate and heat load, respectively. The primary objective of a third vehicle (SA-203) was to study the dynamics of liquid hydrogen containment in a near zero-g environment by injecting the S-IVB/IU into a low-earth orbit with a maximum of residual liquid hydrogen remaining aboard. The next flight will evaluate and verify man/system interface configuration, demonstrate system performance, and accomplish S-IVB/IU orbital checkout. The sixth space vehicle mission will consist of the LM alone being placed into earth orbit to verify

LM systems operation, staging characteristics, and fire-in-the-hole abort demonstration. The primary objective of the following two flights will be a dual launch to place an Apollo CSM and LM, respectively, into earth orbit. While in earth orbit, the Apollo spacecraft will undergo operational tests in order to prove the capability of its design. Essential capability will be that necessary to perform the maneuvers required for the eventual voyage to the moon as part of the Saturn V Launch Vehicle Program. Such a voyage will be undertaken only after the Apollo spacecraft design capability has been proven in earth orbital maneuvers. Assignments for the Saturn IB space vehicles are shown in the Apollo Flight Mission Assignments Document, NPC-C500-11.

9.3.2 TYPICAL MISSION SEQUENCE. A typical Saturn IB launch vehicle manned mission will consist of a series of events which will begin with vehicle launch, include earth orbital maneuvers, and end with separation of the Apollo spacecraft from the S-IVB/IU. This series of events is described in the paragraphs which follow.

Figure 9-1, Saturn IB Space Vehicle at Launch, illustrates the launching of the space vehicle from Complex 34 or from Complex 37 at Cape Kennedy, Florida. The vehicle is shown just after liftoff from the launch pad. In the background is the Umbilical Tower, approximately 268 feet high, through which all propellants, gases, and electrical, electronic, and pneumatic services have been extended to the vehicle up until liftoff. The eight H-1 rocket engines, operating in unison, develop a thrust level as shown in Table 9-I.

The Saturn IB space vehicle will be approximately 224 feet long and 22 feet in diameter, consist of the launch vehicle and the Apollo spacecraft, and at liftoff will weigh approximately 650 tons. The Apollo spacecraft will be approximately 53 feet in length and 13 feet in diameter with the Launch Escape Tower extending above approximately 33 feet. Launch operations are being controlled from the Launch Control Center (Blockhouse) some 1,000 feet away.

Figure 9-2, First Stage Separation, illustrates discard of the lower stage of the Saturn IB after completion of first stage powered flight. First stage separation will take place at an altitude of approximately 35 nautical miles. Prior to the instant protrayed in this view, the inboard engines of the S-IB stage were cut off by fuel level sensors located in two of the fuel tanks. Three seconds later the outboard engines were cut off by either fuel level sensors in the same two fuel tanks or a programmed signal from the Instrument Unit guidance computer

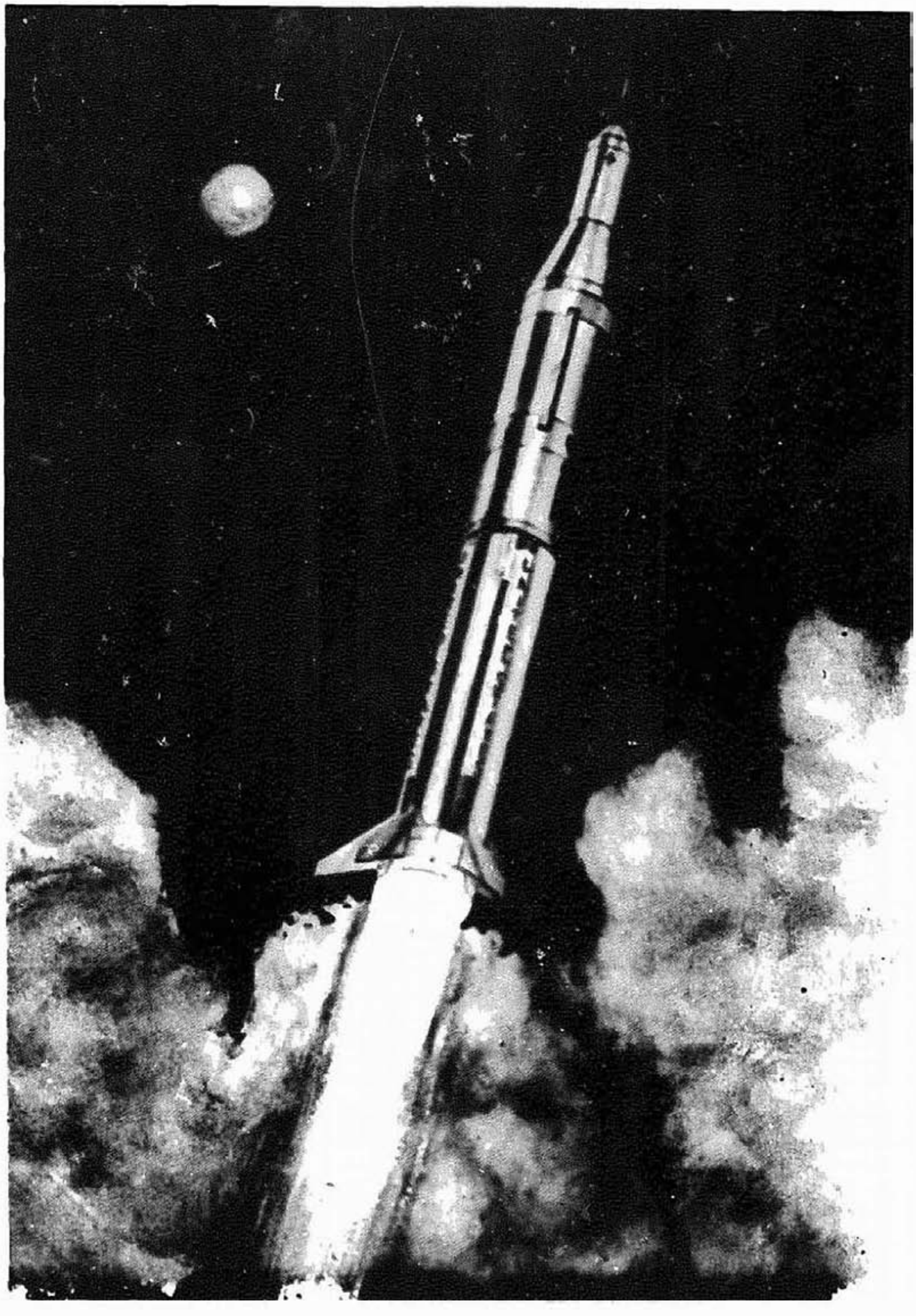

FIGURE 9-1. SATURN 1B LAUNCH

TABLE 9-I. SATURN IB NOMINAL POWER PLANT PERFORMANCE

ITEM	S-IB STAGE	S-IVB/IB STAGE
Number of Engines	8	1
Total Nominal Thrust (lbs)	1,600,000 (201-205) 1,640,000 (206 & Subs) (Sea Level)	200,000 (201-207) 205,000 (208 & Subs) (Vacuum)
Propellants	LOX & RP-1	LOX & LH_2
Nominal Propellant Weight (lbs)	884,000	230,000
Nominal Mixture Ratio (oxidizer to fuel)	2.23:1	5:1
Specific Impulse (Sec, nominal)	262.6 (201-205) 263.4 (206 & Subs) (Sea Level)	422 (201-203) 426 (204 & Subs) (Vacuum)
Nominal Burning Time (sec)	145	450
Mixture Ratio Range	Fixed	4.7:1 to 5.5:1
LOX Pump NPSH (minimum)	35 ft.	26 ft.
Fuel Pump NPSH (minimum)	35 ft.	150 ft.

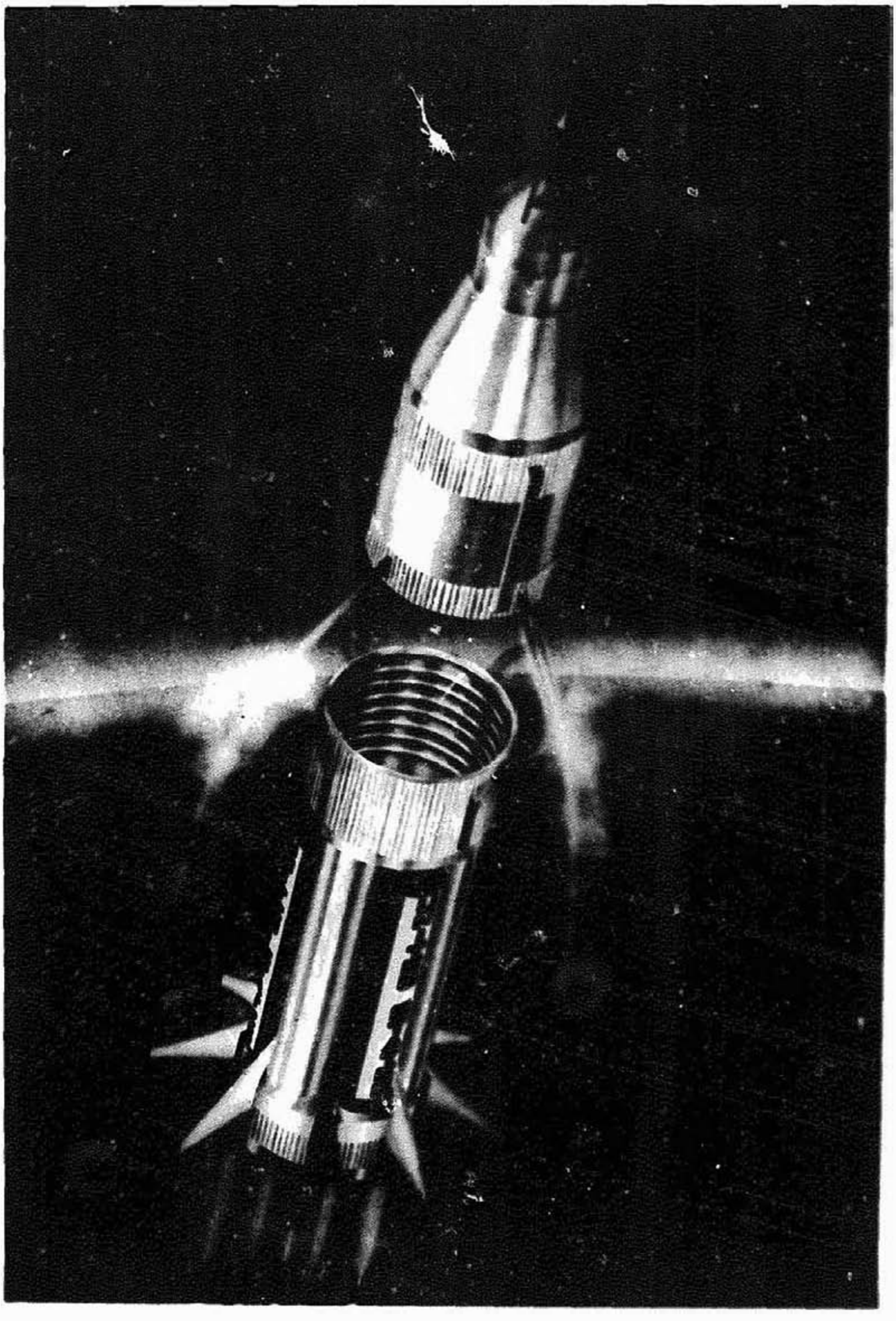

FIGURE 9-2. LOWER STAGE DISCARD

through the S-IB stage switch selector to the engines. This cutoff mode for the outboard engines is determined by the amount of residual fuel remaining. Within about one second after outboard engine cutoff the S-IVB stage ullage rockets were ignited, the separation structure was severed, and the four retrorockets on the S-IVB/IB aft interstage were ignited. Mechanical separation of the stages has been accomplished by an explosive "skin cutting" and tension plate system which has parted the stages near the forward end of the S-IVB/IB aft interstage. The four retrorockets mounted on the S-IVB/IB aft interstage apply a retarding force to facilitate separation of the stages. The three ullage rocket motors mounted on the S-IVB/IB stage aft skirt are shown in operation, applying an accelerating force to the upper stage. This acceleration will be used to settle the liquid hydrogen and liquid oxygen propellants in their tanks to assure the presence of liquid propellant at the inlet of the turbopumps. This is essential for proper starting of the S-IVB/IB stage J-2 rocket engine. The instant portrayed in this view is that just prior to ignition of the second stage J-2 engine and the beginning of the second phase of powered flight.

After the ullage rockets have burned out, the empty rocket cases will be jettisoned as a weight-saving measure about 10 seconds after J-2 engine ignition. The J-2 engine will deliver a thrust level as specified in Table 9-I and thereby propel the second flight configuration along its flight trajectory. Proper sequencing of each of the actions which take place during vehicle flight will be initiated automatically from the Instrument Unit through the S-IVB stage flight sequencer. The S-IB stage and S-IVB/IB aft interstage will lose velocity after being discarded at the time of first stage separation, will fall back to the earth's surface, and impact about 270 nautical miles downrange.

Figure 9-3, Jettison of Launch Escape System, illustrates the ejection of the LES tower from the forward end of the Apollo Spacecraft Command Module thirty seconds after J-2 engine ignition, and approximately 47 nautical miles above the surface of the earth. At this altitude and in this phase of flight the LES is no longer required for successful abort of the Command Module and is therefore ejected to save weight during the rest of the mission. The LES is ejected by igniting its "jettison" rockets in the tower. These rockets will propel the LES tower forward and upward, respectively, and will thus project the tower out of the way of the launch vehicle. A brief description of the various abort procedures and operations can be found in Section 9.5.2, Emergency Detection System (EDS).

The S-IVB stage, the Instrument Unit, and the Apollo Spacecraft of the Saturn IB space vehicle will be inserted into a low earth orbit as determined by

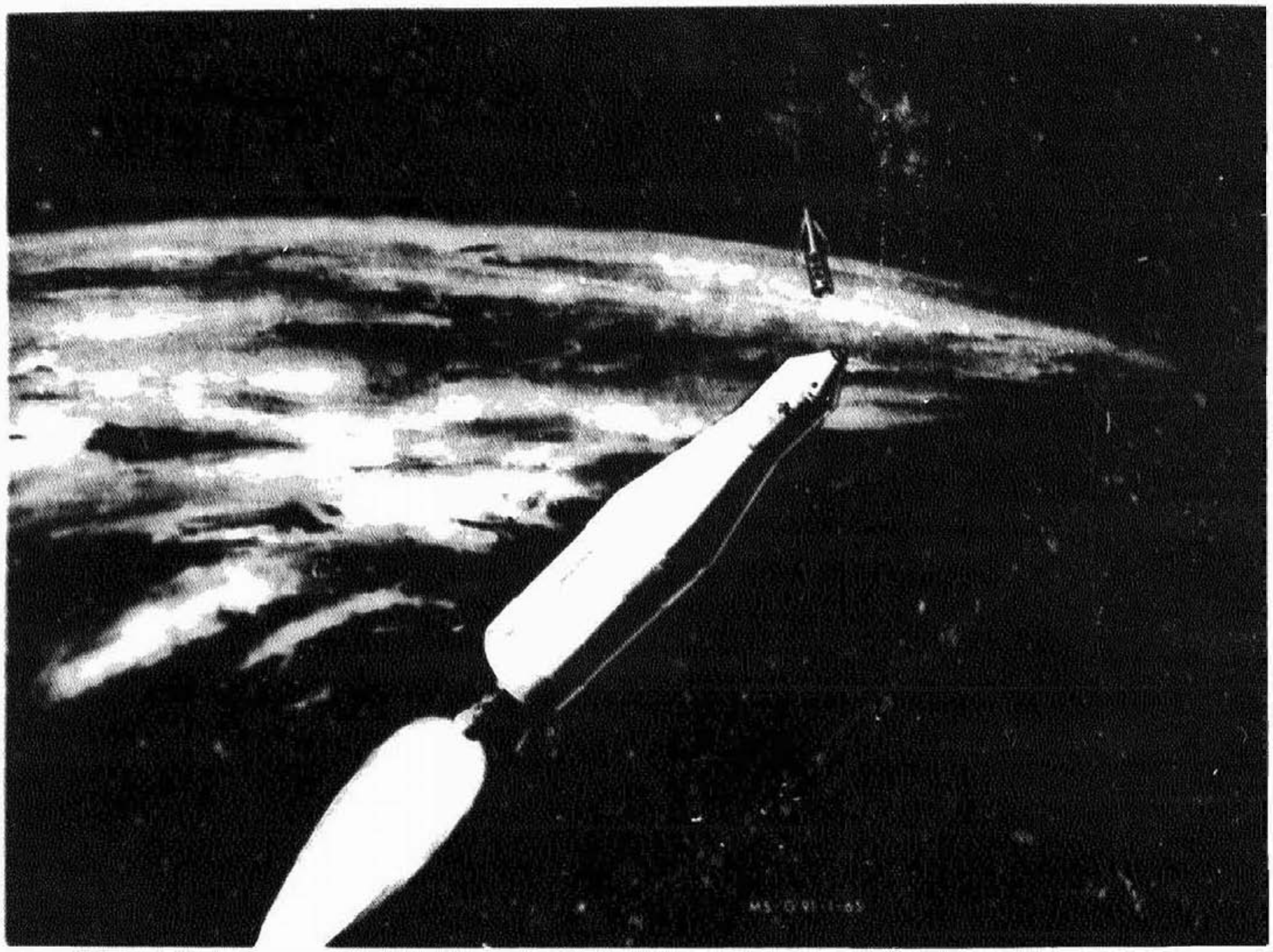

FIGURE 9-3. LAUNCH ESCAPE SYSTEM JETTISON

the Instrument Unit guidance system. Upon entry into earth orbit, the J-2 engine will remain in operation until proper orbital velocity has been attained. At that time the J-2 engine will be cutoff, and the second flight configuration will coast in earth orbit for a duration of up to 7-1/2 hours. During this period of orbital coast the astronauts will conduct tests of equipment and will perform maneuvers of the spacecraft comparable to those to be conducted during the earth-orbital portion of the Saturn V lunar mission program. The primary purpose of these maneuvers is to provide rigorous testing of the Apollo spacecraft under realistic environmental conditions. The secondary purpose is to provide astronaut training in the utilization of spacecraft controls under actual orbital conditions. These conditions will include weightlessness, artificial atmosphere, isolation, and other environmental and psychological conditions which will affect space travel. A more definitive description of these missions and objectives can be found in the Apollo Flight Mission Assignments Document, NPC-C500-11, or the Flight Mission Directive for a given flight.

Figure 9-4, Apollo Spacecraft, is shown here only to provide a perspective as to the various module locations. The combined Command Module & Service Module (CSM), Lunar Module (LM), and Spacecraft LM Adapter (SLA) make up the major components of the Apollo spacecraft. Recent mission planning has altered the spacecraft configuration such that the CSM and LM will be launched on separate vehicles to comprise a dual launch mission. The basic external configuration will remain for the CSM launch, however, for the LM launch a nose cap will replace the CSM atop the SLA. This protective shroud will be carried to orbit and jettisoned prior to CSM/LM rendezvous and docking.

Figure 9-5, Spacecraft/LM Rendezvous, illustrates the deployed SLA panels, the S-IVB/IU/LM combination, and the CSM undergoing the final maneuvers of the rendezvous just prior to docking. The nose cap located atop the SLA was jettisoned by a spring assembly similar to that used on the Saturn I/pegasus missions. After jettison of the nose cap, the SLA panels are separated and deployed.

The LM will remain attached to the combined S-IVB/IU for stability until after the subsequent docking maneuver has been completed. The Auxiliary Propulsion System (APS) Modules, which are located on the aft skirt of the S-IVB/IB stage, provide stabilization to the S-IVB/IU and LM. The APS will be pulsed in accordance with inputs from the control system located in the IU to maintain a fixed orientation in space since stability is extremely important during the docking maneuvers. Attitude changes would severely complicate the docking process and could result in collision of the CSM with the LM. The Reaction Control System jets on the SM apply the necessary force to execute the docking maneuvers.

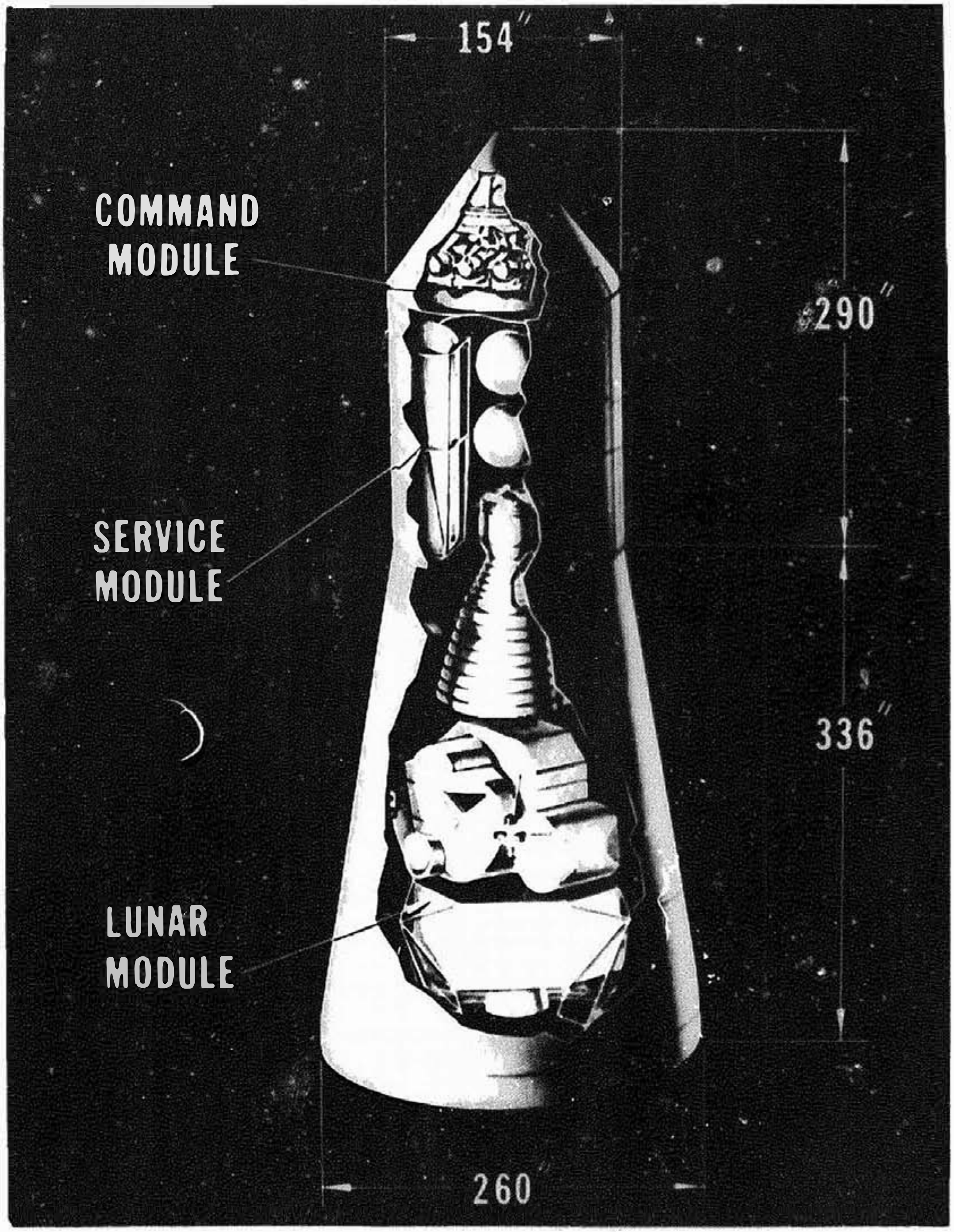

FIGURE 9-4. APOLLO SPACECRAFT

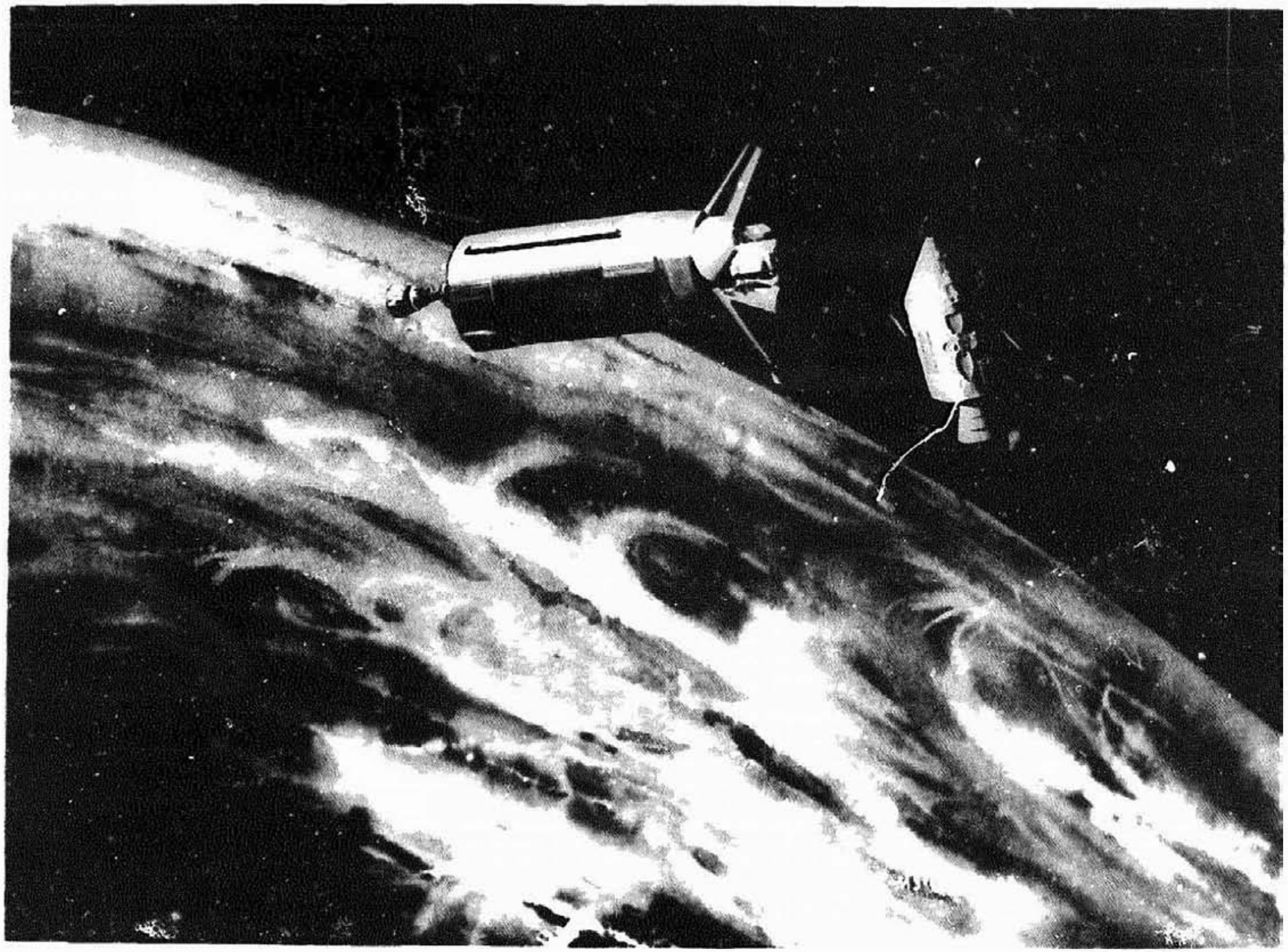

FIGURE 9-5. SPACECRAFT/LM RENDEZVOUS

Figure 9-6, Spacecraft Docking Maneuver, illustrates the docking maneuver of the CSM into the LM. Docking will be conducted by the CSM at the upper docking tunnel of the LM, as illustrated. Contact between the CM and the LM will be made by a probe and drogue arrangement wherein a conical probe extended from the CM docking tunnel will engage a funnel-shaped alignment drogue mechanism on the LM tunnel. Locking will be automatic when the CM and the LM docking tunnels are placed in proper alignment and when they make complete contact with each other. The APS of the S-IVB stage will continue to provide stabilization after docking up through the time at which the CSM/LM withdraws from the remainder of the launch vehicle.

Figure 9-7, Spacecraft Disengagement after Docking, illustrates the separation and withdrawal of the CSM/LM from the S-IVB/IU after completion of the docking procedure. This withdrawal will mark the end of the contribution of the launch vehicle to the Saturn IB/Apollo mission. The S-IVB/IB stage and Instrument Unit combination will be discarded and remain behind in orbit until orbital decay forces cause reentry into the earth's atmosphere and subsequent burnup by reentry heat.

9.4 VEHICLE SYSTEMS DESIGN REQUIREMENTS

9.4.1 APPROACH. During the development period of the Saturn IB launch vehicle system, maximum utilization will be made of known engineering methods, technical principles, and existing facilities, tools, and equipment. To achieve the highest system reliability prior to the first flight, particular emphasis will be placed upon the use of components and subsystems developed for or provided by the Saturn I Launch Vehicle Program. A test plan has been formulated to emphasize the extensive ground and flight tests required for establishing confidence in the use of the Saturn IB space vehicle system for manned application. A failure-effect analysis will be performed to identify and establish critical areas in the design and checkout of all systems and subsystems. Such an approach is necessary for analyzing systems of the magnitude of complexity present in this vehicle.

The development phase of each stage and of the entire vehicle includes both laboratory and manufacturing research. Each component, subsystem, system, and stage will be tested sufficiently to assure maximum reliability before it is assembled into a complete vehicle.

Operational components will be tested and tried to their maximum expected limits in numerous trials before being declared suitable for incorporation into the design. This type of testing will insure maximum reliability with a minimum of either operational testing, flight testing, or both.

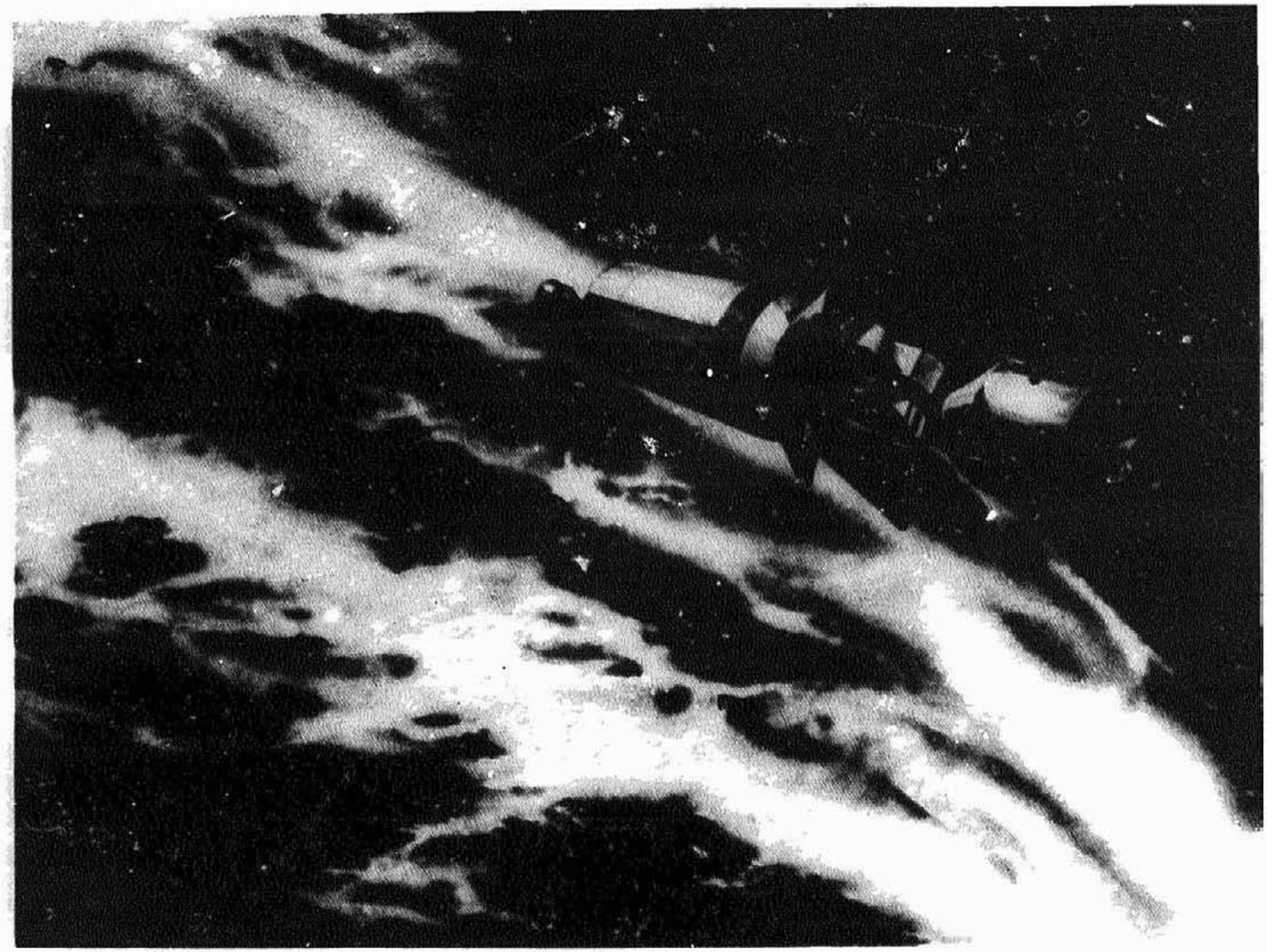

FIGURE 9-6. DOCKING MANEUVER

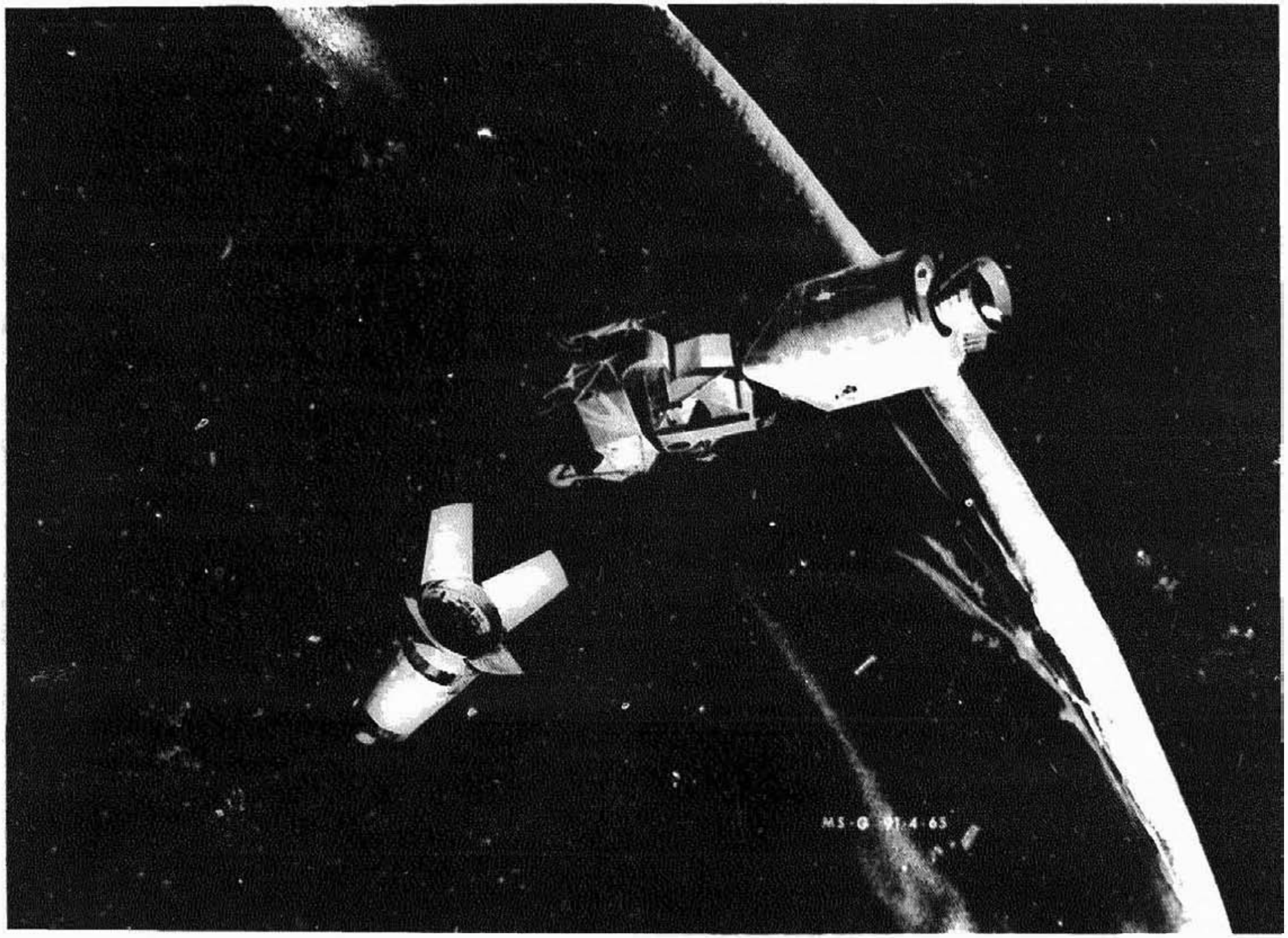

FIGURE 9-7. SEPARATION AND WITHDRAWAL

Static firings of prototype or test engines will allow verification of engine design and components. All flight engines will be static fired to assure reliable operation.

The development flight program will consist of a series of three, or perhaps four, flights which will serve the objective of evaluating the flight performance of the Saturn IB launch vehicle system to establish operational reliability.

9.4.2 DESIGN GROUND RULES AND GUIDELINES. The Saturn IB launch vehicle design will incorporate requirements necessary to assure mission success and flight crew safety. To attain this goal, special considerations will be incorporated into the design.

Special manrating reliability requirements will be developed and applied throughout launch vehicle development to achieve maximum safety and reliability.

The Saturn IB launch vehicle will be designed so that the operational manned vehicles will not exceed the physiological limits of the flight crew. Human engineering parameters for crew safety and effective performance have been determined through extensive research and testing programs. These parameters will be applied to the launch vehicle design.

The Saturn IB launch vehicle will be designed to minimize the probability of vehicle loss resulting from malfunction of any component, subsystem, or system. Specially-developed malfunction-control schemes will be utilized to achieve design goals. An Emergency Detection System (EDS) will be designed into the Saturn IB launch vehicle to insure escape of the astronaut crew in the event of a catastrophic failure of the launch vehicle. The EDS will be designed to detect malfunctions and to indicate such malfunctions to the astronauts on an instrument display located in the CM of the Apollo spacecraft, or to automatically initiate abort. The selection of parameters and the identification of sensor locations for the EDS will be determined by a cause-and-effect analysis and by a criticality priority establishment with respect to component failures.

The failure-effect analysis provides logical guidelines for design review, improvements, and system studies, and for identification of critical components to be monitored. In determining the effect of a component failure on subsystem performance, four modes of failure will be considered:

a. Premature operation of a component,

b. Failure of a component to operate at a prescribed time,

c. Failure of a component to cease operation at a prescribed time,

d. Failure of a component during operation.

Each component will be evaluated in this manner for the failure modes which are applicable. Component evaluation will include an estimate of time from component failure to vehicle loss. In evaluating systems which will be used on manned space vehicles, first priority will be given to critical items which can cause catastrophic loss of the system and of the vehicle itself.

The test points at which systems will be monitored will be determined from a detailed study of schematics and flow diagrams and will incorporate those points necessary for a complete on-the-pad checkout.

Automatic Checkout is a term applied to the use of mechanical, electrical, hydraulic and pneumatic automatic equipment for checkout and test of launch vehicles. Use of automatic checkout equipment will optimize the probability of mission success for operational vehicles due to increased reliability brought about by more comprehensive checkout capability. Equipment which has automatic capability will be operated in such a manner that it will perform continuous monitoring of vehicle components and systems during checkout and test. The automatic checkout system will provide its own stimuli and will contain provisions for self-monitoring. S-IB stage automatic checkout is limited to the level of automation of the S-IB stage.

Human abilities, such as the capacity for reliable performance and the exercise of judgement under varying conditions, will be employed in the overall man-machine system to increase the probability of mission success.

The vehicle subsystems will be described in Section 9.5 and are classified as follows:

a. Structures

b. Propulsion

c. Flight Control

d. Instrumentation

e. Electrical

f. Environmental Control

g. Ordnance

h. Guidance

The design requirements for these subsystems of the launch vehicle can be found in the Saturn IB Project Specification.

9.5 SATURN IB LAUNCH VEHICLE DESCRIPTION

9.5.1 VEHICLE

9.5.1.1 GENERAL. The Saturn IB space vehicle consists of the Saturn IB launch vehicle and the Apollo spacecraft, as shown in Figure 9-8. The space vehicle will have an overall length of approximately 224 feet.

The space vehicle will have an approximate liftoff weight as shown in Table 9-II and will be capable of placing its Apollo spacecraft payload into a low earth orbit. Vehicle and stage numbering will be in accordance with Figure 9-9.

The Saturn IB launch vehicle will be composed of an S-IB first stage, an S-IVB/IB second stage and an Instrument Unit. The S-IB stage will be propelled by eight H-1 rocket engines which will lift the launch vehicle and payload (first flight configuration) to a height of approximately 35 nautical miles. The S-IVB/IB stage will be propelled by one J-2 rocket engine which will boost the second flight configuration (S-IVB/IB stage, IU and Apollo spacecraft) into a

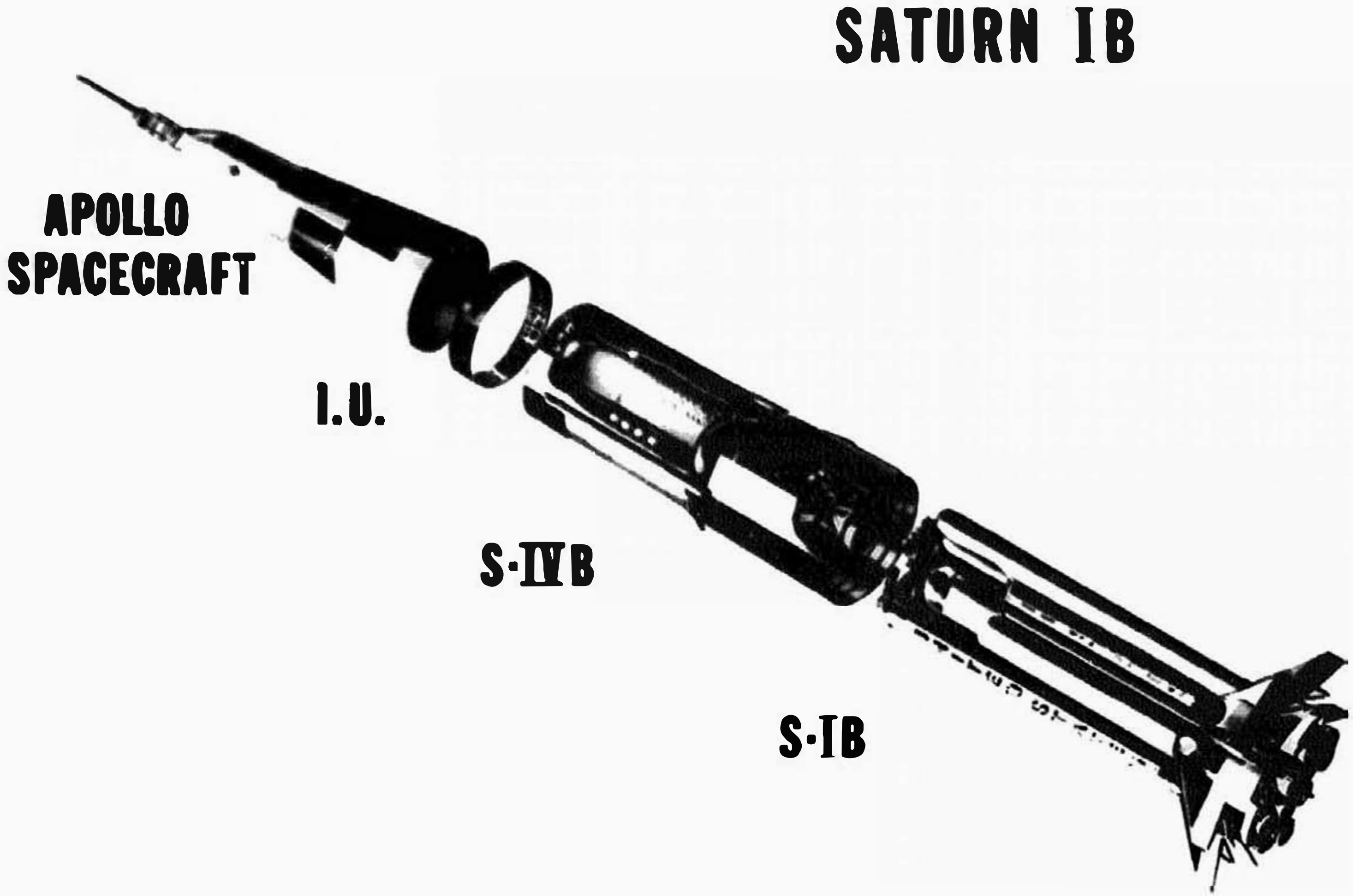

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FIGURE 9-8. SATURN 1B SPACE VEHICLE

TABLE 9-II. SATURN IB SPACE VEHICLE CHARACTERISTICS

Component	Approx. Length (ft)	Approx. Diameter (ft)	Nominal Liftoff Weight	Nominal Mainstage Propel-lant
S-IB Stage	80.28	21.4	985,400	884,000
S-IB/S-IVB Interstage	(18.71)*	21.7	6,600	---
S-IVB/IB Stage	58.38**	21.7	254,750	230,000
Instrument Unit	3.00	21.7	4,150	---
Apollo Spacecraft (including LES)	82.93	12.8	46,300	
Flight Performance Reserves	----	---	1,500	(Included in S-IVB/IB) Stage Weight
Space Vehicle	224.60	21.7***	1,297,200	

* Interstage length (18.71) is included in S-IVB/IB Stage length (58.38).

** The liquid hydrogen tank protrudes 8" (0.67 feet) forward of S-IVB/IB Stage Forward Skirt and into the Instrument Unit void. Thus, only 58.38 feet of the total 59.1 feet overall length of the S-IVB/IB Stage is reflected in the length of the space vehicle.

*** Maximum diameter including fins is 40.7 feet.

SPACE VEHICLE	SPACE-CRAFT	LAUNCH VEHICLE	S-IB STAGE	S-IVB STAGE	INSTRU. UNIT
AS-201	CSM-009	SA-201	S-IB-1	S-IVB-201	S-IU-201
AS-202	CSM-011	SA-202	S-IB-2	S-IVB-202	S-IU-202
AS-203	NOSE CONE	SA-203	S-IB-3	S-IVB-203	S-IU-203
AS-204	CSM-012	SA-204	S-IB-4	S-IVB-204	S-IU-204
AS-205	CSM-014	SA-205	S-IB-5	S-IVB-205	S-IU-205
AS-206	LM-1	SA-206	S-IB-6	S-IVB-206	S-IU-206
AS-207	CSM-101	SA-207	S-IB-7	S-IVB-207	S-IU-207
AS-208	LM-2	SA-208	S-IB-8	S-IVB-208	S-IU-208
AS-209	CSM-105	SA-209	S-IB-9	S-IVB-209	S-IU-209
AS-210	LM-6	SA-210	S-IB-10	S-IVB-210	S-IU-210
AS-211	CSM-108	SA-211	S-IB-11	S-IVB-211	S-IU-211
AS-212	LM-9	SA-212	S-IB-12	S-IVB-212	S-IU-212

FIGURE 9-9. SATURN IB LAUNCH VEHICLE IDENTIFICATION

low earth orbit. The IU will provide guidance, control and sequence signals for successful operation of the total Saturn IB launch vehicle. The launch vehicle will be aligned to the proper trajectory and orbital insertion conditions by the inertial guidance system, which uses the iterative guidance mode, currently being developed for the Saturn IB and the Saturn V launch vehicles.

Design characteristics of a typical Saturn IB space vehicle are given in Table 9-II. Payload weight limitations will not be stringent during early Saturn IB space vehicle flights and will provide for extensive instrumentation for the vehicle. Later, when vehicle performance parameters have been established by actual flight tests, much of the instrumentation will be removed. Subsequently, emphasis will be placed upon Apollo spacecraft monitoring, and the weight saved by removal of vehicle instrumentation will be converted into payload component and instrumentation reinforcement. The nominal power plant performance for the Saturn IB launch vehicle can be found in Table 9-I.

9.5.1.2 MASS CHARACTERISTICS. Typical mass characteristics of the Saturn IB space vehicle (i.e., combined launch vehicle and Apollo spacecraft) are given in the Saturn IB Program Specification.

9.5.1.3 FLIGHT MECHANICS. A stability analysis, assuming baffles which provide 3 percent of critical slosh damping, indicates that propellant sloshing presents no stability problem.

During separation of the S-IB stage from the remainder of the space vehicle after H-1 engine cutoff (first stage separation), the second flight configuration, which consists of the S-IVB stage, IU and Apollo spacecraft, is controllable within the maximum expected initial conditions of attitude and of roll, pitch, and yaw rates.

9.5.1.4 AERODYNAMIC DATA. At liftoff, base suction produces a drag force of approximately 10,000 lb. This force reduces to a value of about 3300 lb by the time the vehicle reaches a height of 100 feet. Thereafter, the drag has been computed by use of one empirical equation for the power-on condition and another for the power-off condition.

Normal-force-coefficient-gradient and center-of-pressure data have been obtained from experimental tests on the Saturn IB space vehicle configuration. Local normal force distributions have been obtained from linearized theory. The normal forces of the fins and of the Apollo CM are considered as concentrated loads acting at specific points.

Local axial force distributions have been calculated along the vehicle airframe at zero angle of attack. The drag of the Apollo CM and of the engine shrouds, and the base drag of the S-IVB/S-IB interstage and of the S-IB stage under power-on and power-off conditions have been calculated as concentrated loads.

Local pressure coefficients have been calculated along the vehicle airframe for zero angle of attack. The distributions have been determined experimentally from wind tunnel tests.

Non-linear viscous cross flow data have been calculated along the vehicle airframe. Non-linear viscous cross flow information is required to supplement linear normal force data to determine the total normal forces at angles of attack greater than 6 degrees.

9.5.1.5 STRUCTURAL LOADS. Structural loads for the Saturn IB launch vehicle for the Apollo spacecraft payloads are available in tabular and graphical form. Basic data used in computation of the structural loads are included in the Saturn IB Program Specification. The structural loads are based on inertia and aerodynamic loading only, and do not include temperature and internal pressure effects. The design-structural-loads calculations will be made on a continuing basis by MSFC.

Structural design of the Saturn IB launch vehicle will assure free standing (fueled or unfueled), launch, and in-flight capabilities in conformance with all probable wind forces.

MSFC and KSC design groups will provide technical direction for structural development of the Saturn IB launch vehicle and for its associated ground support equipment and launch facilities. This will include responsibility for determining and approving all structural loads and safety factors in accordance with recommended MSFC procedures. The structure will be designed to withstand all loads experienced during prelaunch, launch, and flight of the Saturn IB launch vehicle and the Apollo spacecraft. Typical of such are those imposed by ground wind forces, engine start and cutoff transients, holddown, release, vibration, acoustics, flight wind forces, and loads imposed by the action of flight control systems.

9.5.1.6 RANGE SAFETY SYSTEM. Each stage of the Saturn IB launch vehicle contains a Range Safety System. The purpose of the Range Safety System is to terminate the flight of the launch vehicle and to disperse the propellants upon command from the range safety ground station. The system in each stage consists of two separate command receivers, each of which has a separate battery power supply, antenna, destruct system controllers, exploding bridge wire (EBW) firing units and detonators, destruct explosives and a safe-arm device. This system will function upon receipt of a coded command signal. The Range Safety System is capable of thrust termination and of firing explosives to rupture the fuel and oxidizer tanks. If in-flight destruction of the Saturn IB launch vehicle is required, commands will be transmitted to the launch vehicle by dual command FM transmitters. The command signal will be converted at the vehicle to signals which initiate engine cutoff and after a predetermined time, fire the propellant-dispersion explosive charges.

9.5.2 EMERGENCY DETECTION SYSTEM (EDS)

9.5.2.1 GENERAL. The Emergency Detection System (EDS) is for crew protection on all manned Saturn IB launch vehicles to provide continuous information to astronauts concerning selected vehicle parameters. The system is designed to accomplish the following functions:

a. Detect the adverse effects of equipment malfunctions and failures, and therefore the impending emergencies;

b. Issue warning signals to the astronauts and to the personnel at ground monitoring stations; and

c. Under certain circumstances, automatically initiate abort to protect the astronauts by accelerating the CM away from the launch vehicle with the LES.

Abort is defined as the sequence of separating the CM of the Apollo spacecraft from the remainder of the space vehicle and propelling the CM away from the vehicle a distance sufficient to protect it from the effects of fire or explosion. Abort will be necessary in the event a malfunction causes the vehicle to burn or explode on the launch pad during late checkout or during an early phase of flight. The abort process includes safe return of the astronauts to earth inside the CM. The selection of parameters and the identification of sensor locations for the EDS will be determined by a cause-and-effect analysis and by a criticality priority establishment with respect to launch vehicle failures.

The abort sequence consists of the following steps:

a. Abort initiation,

b. Shutdown of vehicle propulsion (from liftoff +40 seconds),

c. Separation of CM from service module/LEM adapter,

d. Ignition of the LES launch escape and pitch control motors,

e. Flight of LES and CM into safety zone distant from launch vehicle,

f. Launch vehicle propellant dispersion,

g. Deployment of drogue parachutes,

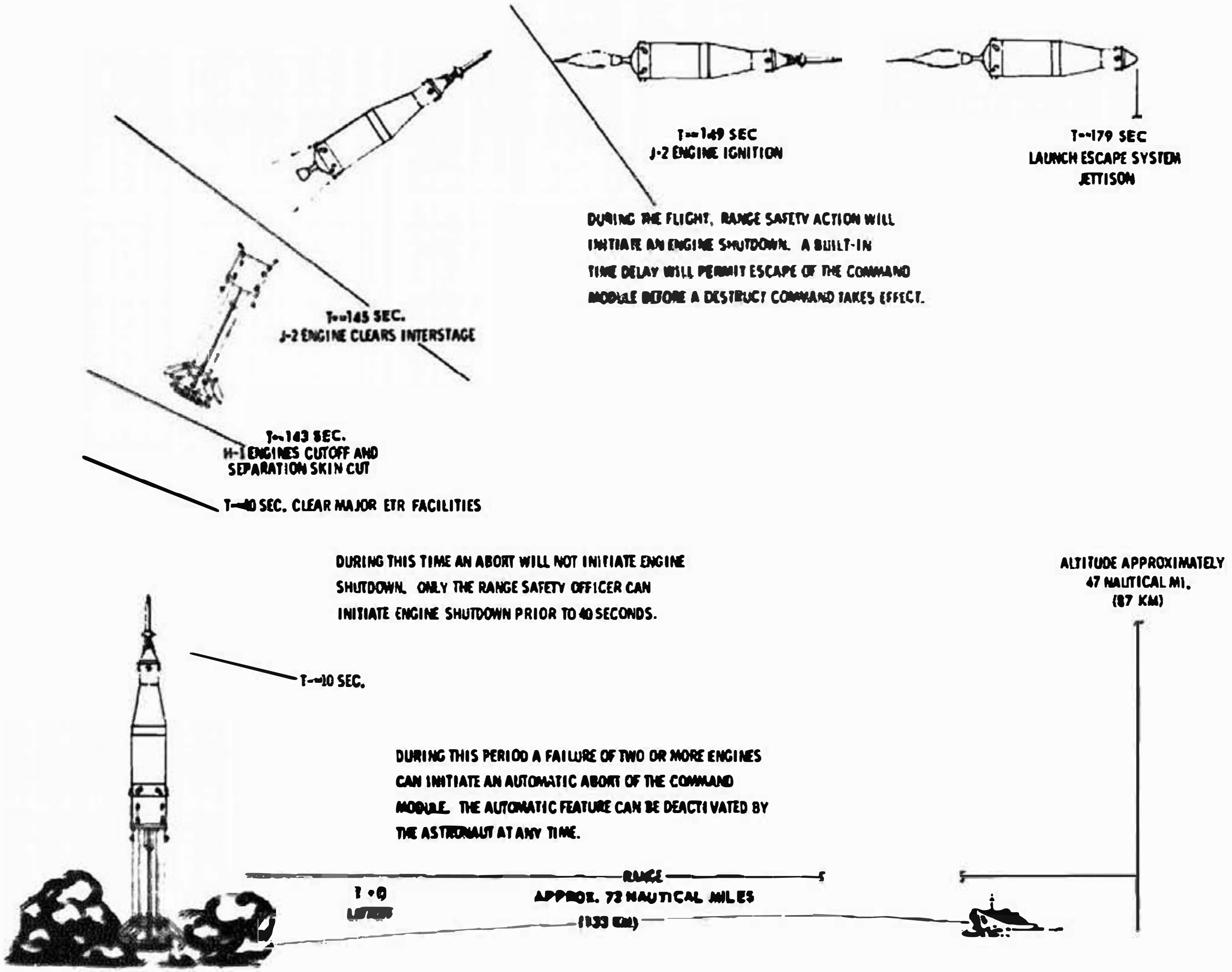
h. Descent of CM to impact,

i. Soft landing of CM.

The various zones within which effective abort control may be exercised are described in Figure 9-10.

The evaluation of onboard vehicle irregularities is divided into two basic categories for the purpose of classifying Emergency Detection System reaction: those which consist of, or will precipitate, "critical failures," and those which consist of, or will precipitate, "catastrophic failures." "Critical failures" are those which will cause serious limitations to the capability of the vehicle to accomplish its mission. "Catastrophic failures" are those which are almost certain to result in destruction of the vehicle and for which the danger is imminent. "Critical failures" may, depending upon the circumstances, create conditions which later may degenerate into more serious conditions and culminate in the eventual loss of the vehicle. Because of a certain inherent time asset, "critical failures" are susceptible to human evaluation as to the extent of their effects and as to the urgency of their demands.

The EDS will provide for manually-initiated abort action when time permits, and automatically-initiated abort for "catastrophic failures." The EDS will thereby take advantage of the superior assets of onboard human reasoning and reaction by the astronauts in a highly capable man-machine system. Utilization of astronaut talent is possible when time is available for human response. The EDS will likewise protect the astronauts by instantaneous automatic abort



DURING THE FLIGHT, RANGE SAFETY ACTION WILL INITIATE AN ENGINE SHUTDOWN. A BUILT-IN TIME DELAY WILL PERMIT ESCAPE OF THE COMMAND MODULE BEFORE A DESTRUCT COMMAND TAKES EFFECT.

DURING THIS TIME AN ABORT WILL NOT INITIATE ENGINE SHUTDOWN. ONLY THE RANGE SAFETY OFFICER CAN INITIATE ENGINE SHUTDOWN PRIOR TO 40 SECONDS.

DURING THIS PERIOD A FAILURE OF TWO OR MORE ENGINES CAN INITIATE AN AUTOMATIC ABORT OF THE COMMAND MODULE. THE AUTOMATIC FEATURE CAN BE DEACTIVATED BY THE ASTRONAUT AT ANY TIME.

FIGURE 9-10. ZONES OF EFFECTIVE ABORT CONTROL initiation when time is not available for human decision and action. Automatic abort conditions will result if vehicle angular overrate occurs or loss of thrust of two or more first stage engines is indicated. The astronauts will be provided with the means of bypassing either or both automatic abort features. Back-up capability for deactivation of either or both automatic abort capabilities will be provided in the Saturn IB launch vehicle sequencer. During both automatic and manual abort conditions, an emergency signal will be transmitted to the EDS display panel in view of the astronauts in the Apollo spacecraft CM. The signal display is advisory-only to the astronauts during automatic abort conditions. Under manual abort conditions, however, the astronauts will be given the option to continue the mission or to initiate the abort sequence and thus terminate the mission in accordance with their own judgement. Information generated by the EDS, plus other "early warning" vehicle performance indications, will be telemetered to ground monitoring stations. The ground operating personnel may thus assist in evaluating the factors involved in "critical failure" conditions wherein manual abort may be required.

Manual abort will be initiated based on at least two separate and distinct indications. A manual abort request can be given based on telemetered data but the onboard information shall always take precedence.

About thirty seconds after S-IVB engine ignition, the Saturn IB space vehicle will have reached an altitude of approximately 47 nautical miles and the Launch Escape System will be jettisoned. An abort can be effected at this altitude without the use of the LES even though the probability of an abort requirement at this phase of flight is considered minimal. Also, from this altitude the astronauts will have adequate time in which to escape in the event the vehicle should malfunction. Should an abort occur, the stage engine would be shut down prior to the remainder of the abort sequence. The danger of fire or explosion will still be present, but this danger will be greatly minimized after successful completion of the first stage separation procedure. The exact time at which the automatic abort feature may be deactivated will be determined by the requirements of the individual mission for each vehicle. If the range safety officer initiates a command destruct signal, the vehicle onboard command destruct receivers will arm the destruct system and simultaneously give engine cutoff of the launch vehicle engines. If the two-engine-out automatic abort capability of the EDS has not been deactivated (either manually or by sequencer), the engine cutoff will automatically initiate the abort sequence. If the two-engine-out automatic abort capability has been deactivated, the astronauts will be warned of the impending range safety destruct by the abort request light, engine status lights, voice communication, and physiological indications; and must manually initiate the abort sequence.

The Range Safety Command System will provide a delay in detonation of the ordnance elements to permit escape of the CM prior to initiation of propellant dispersion by the Ordnance Destruct System.

The reliability goals of the EDS are such that the probability of detecting a failure will be 0.9973 and the probability of not detecting a false failure will be 0.9997. These goals are applied to each separate sensed parameter by the EDS. This EDS is designed so that multiple failures in the EDS are required to prevent a false launch vehicle failure indication. All failures that could jeopardize crew safety will be designed out if at all possible.

9.5.3 S-IB STAGE

9.5.3.1 GENERAL. The S-IB Stage (Fig. 9-11) has a nominal length of 80.3 feet and diameter of 21.4 feet. It is powered by eight Rocketdyne H-1 rocket engines which burn liquid oxygen (LOX) and kerosene (RP-1) fuel to provide a total nominal sea level thrust as shown in Table 9-I. The dry weight of the stages and mainstage propellant loading capacity is shown in Table 9-II. The propellants are contained in four 70-inch diameter fuel, and four 70-inch diameter LOX, containers clustered around a central 105-inch diameter LOX container. The S-IB stage contains its own instrumentation and range safety systems, but will receive guidance and control commands from the IU. The first two stages to be produced will differ somewhat from subsequent stages. The S-IB stages S-IB-1 and S-IB-2 are modifications of stages originally planned for the Saturn I program. Significant differences in the designs include a structural modification for S-IB-3 and subsequent stages, addition of partial aspirator turbine exhaust ducts and modifications to the propellant sensing system. A more definitive description of these modifications can be found in the respective subsystems descriptions.

9.5.3.2 STRUCTURAL SYSTEM

9.5.3.2.1 GENERAL DESCRIPTION. When the Saturn IB space vehicle is assembled on the launch pad, the S-IB stage structural system will support the weight of the S-IVB/IB stage, Instrument Unit and Apollo spacecraft as illustrated in Figure 9-8. The S-IB stage structure consists of the propellant container assembly, the tail unit assembly fins, and the second stage adapter assembly. Most of the structure is fabricated of aluminum alloy, designed to give maximum support with minimum weight. Figure 9-12, S-IB, Stage Structural Components, illustrates construction of the S-IB stage. Thrust loads produced by the engines are transmitted through the engine mounting pads and thence through the thrust outriggers to the LOX containers. Approximately 10 percent of the total engine

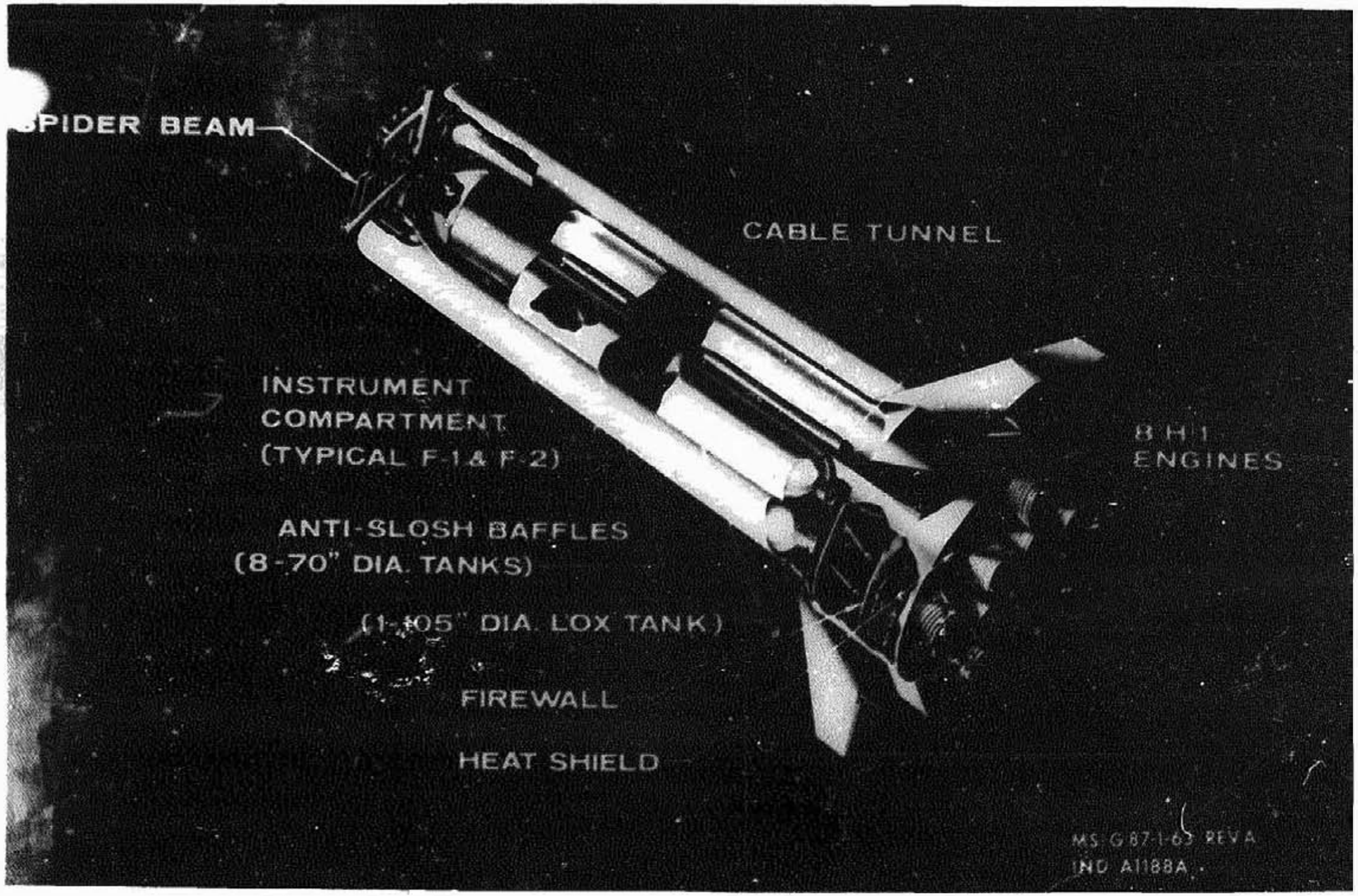


FIGURE 9-11. S-1B STAGE

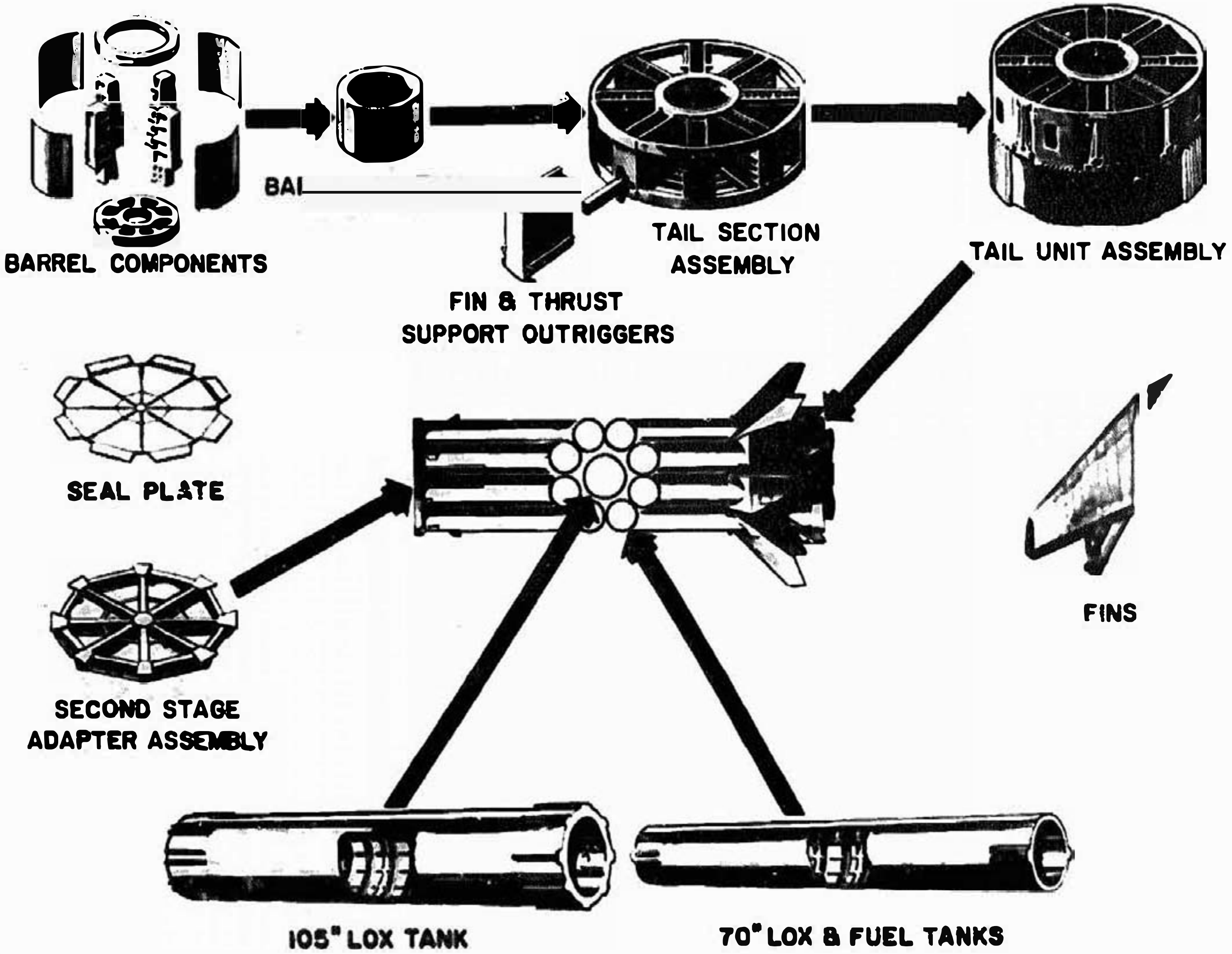


FIGURE 9-12. S-1B STAGE STRUCTURAL COMPONENTS

thrust load is transmitted through the center 105-inch LOX container. From the 70-inch diameter LOX containers, the thrust load is transmitted through eight compression and shear fittings into the spider beam. The thrust load from the center container is transmitted to the spider beam by a rigid connection. From the spider beam, the thrust load is transmitted to the upper stage connection points.

The structural redesign between the first two S-IB stages and subsequent stages will result in significant weight decrease. The weight reduction amounts to about 5300 pounds and is broken down as follows:

Structure forward of tanks	800 pounds
Structure aft of tanks	700 pounds
Thrust structure	1200 pounds
Fairings	800 pounds
Fuel tanks	80 pounds
LOX tanks	250 pounds
Base heat protection	800 pounds
Instrumentation	700 pounds

9.5.3.2.2 TAIL UNIT ASSEMBLY. The most complex structural assembly of the S-IB stage is the tail unit assembly. The tail unit assembly consists of a corrugated central barrel, eight outriggers (attached radially to the barrel), firewall, heat shield, flame shield, shrouding, and accessories (see Fig. 9-11 and 9-12). The outboard engines are mounted to alternate outriggers, while the inboard engines are attached to the lower end of the center barrel assembly in the same plane as the outboard engines. The heat shield is located at the plane of the thrust chamber throat, serving as the lateral support for the lower shroud and also as a thermal barrier. Each quadrant of the heat shield is composed of nine removable panels constructed of stainless steel to which is brazed an open-face stainless steel honeycomb which serves as a mechanical attachment for the thermal insulation. In order to accommodate engine gimbaling, a flexible curtain constructed of glass fiber cloth and insulation is installed between the outboard engine thrust chambers and the brazed stainless steel honeycomb heat shield. The lower shroud is cylindrical and is designed for minimization of aerodynamic loads. Aluminum alloy sheet is used for the upper panels of the lower shroud. Stainless steel is utilized for the lower panels because of the higher temperatures which they will encounter. A firewall is located above the engine compartment at about the turbopump level to protect the propellant tank area from engine compartment fires. Eight sweepback type fins, each having a surface area of approximately 53.5 square feet, are mounted on the tail section to increase aerodynamic stability of the space vehicle during flight.

9.5.3.2.3 PROPELLANT CONTAINER ASSEMBLY. The propellant container assembly consists of four 70-inch diameter LOX containers and four 70-inch diameter fuel (RP-1) containers all of which are clustered alternately around a 105-inch diameter central LOX container. The 105-inch diameter LOX container is mounted on the central barrel and the 70-inch diameter fuel containers are attached to the outriggers. Figure 9-11 S-IB Stage, and Figure 9-12, S-IB Stage Structural Components, illustrate the arrangement of these tanks.

Each of the propellant containers is an aluminum alloy cylinder with hemispherical bulkheads welded into each end. Mounted in each container are perforated aluminum, accordion-type anti-slosh baffles. These baffles are designed to minimize propellant sloshing in flight and thus assist in maintaining space vehicle stability.

The LOX containers are load-bearing components which support the weight of the upper stages and payload in the launch position and which transmit engine thrust during flight. Because of the significant shrinkage of the LOX tanks at cryogenic temperatures, the fuel tanks, which do not experience such contraction, cannot be rigidly attached to the stage structure at both ends and therefore cannot contribute to the structural strength of the vehicle. The fuel tanks are attached to sliding fittings at their forward ends.

The 105-inch diameter LOX container is nominally 749 inches long and is constructed of aluminum alloy skin segments and ring frames. The forward and aft skin sections contain hemispherical bulkheads, longerons, and GOX and LOX manifold lines.

The four 70-inch diameter LOX containers are nominally 749 inches long and are constructed of aluminum alloy skin segments and ring frames. The forward skin section contains a hemispherical bulkhead with an 18.0 inch diameter manhole. The aft skin section contains the lower hemispherical bulkhead, longerons, and the LOX manifold lines.

The four 70-inch diameter fuel containers are nominally 743 inches long and are constructed of aluminum alloy skin segments and ring frames. Basically, all four containers are similar except for the forward skin sections. Two forward skin sections contain instruments in a compartment formed by a double hemispherical bulkhead. The other two forward skin sections contain a 20-cubic-foot, high-pressure sphere. An access door is incorporated to provide personnel entry into the instrument compartment for use as required for maintenance or repair. The center skin sections are milled for weight reduction. The aft skin section contains the lower hemispherical bulkhead, the longerons, and the fuel manifold.

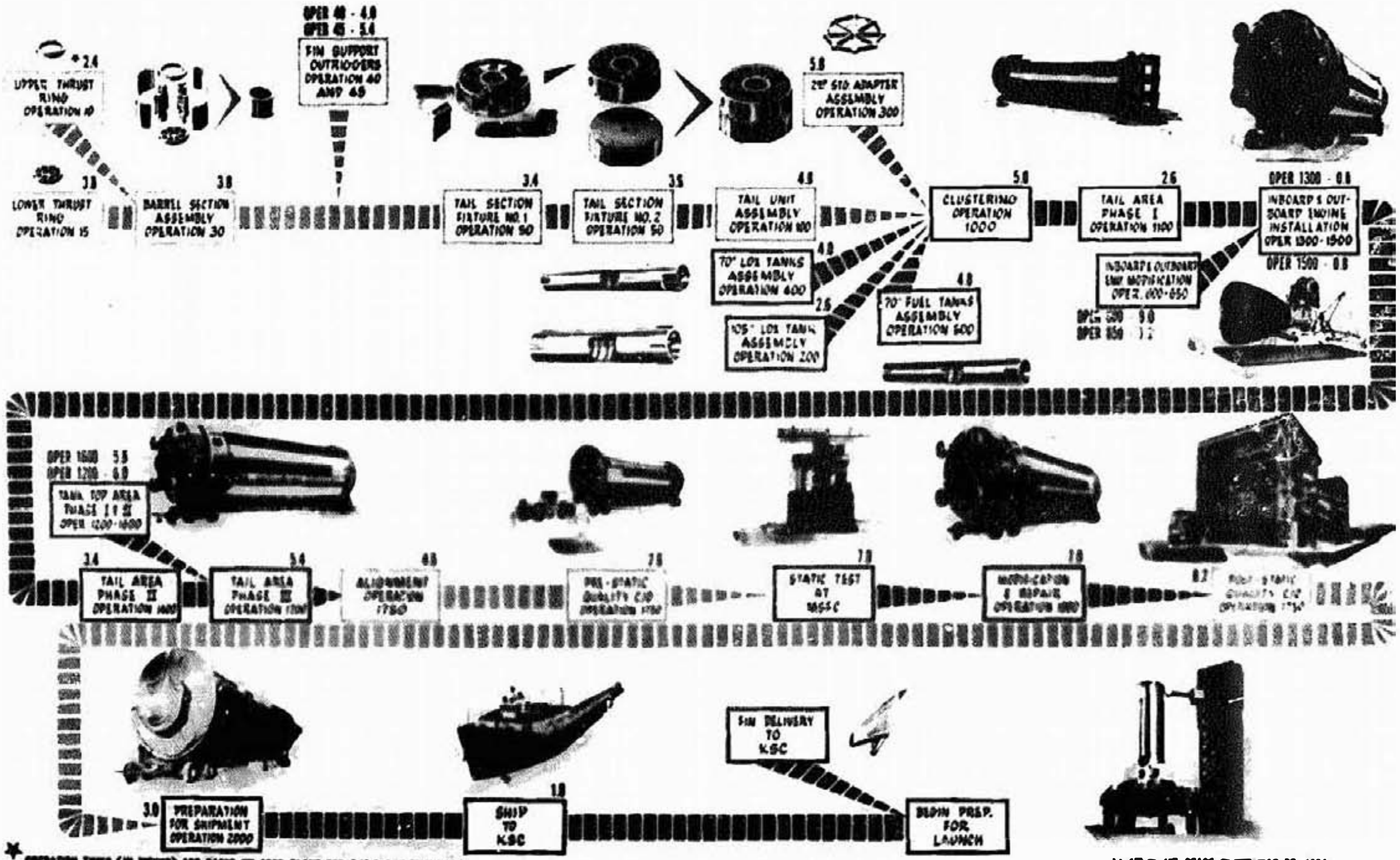
9.5.3.2.4 SECOND STAGE ADAPTER ASSEMBLY. The second stage adapter assembly consists of the spider beam assembly and the seal plate assemblies.

The spider beam assembly provides an attachment for the propellant containers, supports the weight of the S-IVB/IB stage, Instrument Unit, and Apollo spacecraft and transmits engine thrust loads to the upper stages. The spider beam assembly is comprised of a center hub with eight I-beams spaced radially around the hub. Figure 9-12 illustrates this structure. Lateral stability is provided by crossbeams that are secured to the radial beams by splice plates.

The seal plate assemblies consist of eight aluminum honeycomb panels which are fastened to the spider beam to provide a firewall between the S-IB stage propellant containers and the S-IVB/IB stage engine compartment. Access openings are provided just below the spider beam for maintenance and inspection requirements. Two fittings will be used to connect each of the 70-inch diameter outer LOX containers rigidly to the spider beam. The 105-inch diameter central LOX container will be attached rigidly to the spider beam. Two sliding fittings will be used to fasten each of the fuel containers to the spider beam. The fittings will provide for longitudinal movement of the fuel containers resulting from contraction of the LOX containers. Figure 9-13 depicts the S-IB Production Sequence.

9.5.3.3 PROPULSION SYSTEM.

9.5.3.3.1 GENERAL. The propulsion system for the S-IB stage consists of eight H-1 engines, a fuel system, a LOX system and the necessary accessories. The major items of the propulsion system are described in the paragraphs that follow.



★ OPERATION TIMES (IN WEEKS) ARE BASED ON CCSD PLANS FOR S-IB-3 AND MAY VARY.

I-I/IB-SI/IB STAGE OFFICE MAR 30, 1964

FIGURE 9-12. S-1B STAGE PRODUCTION SEQUENCE

9.5.3.3.2 H-1 ENGINE. The H-1 rocket engine is a bipropellant engine which develops a sea level thrust as shown in Table 9-I, using RP-1 (kerosene) as fuel and LOX as oxidizer. An H-1 rocket engine is illustrated in Figure 9-14. Eight H-1 engines will be mounted on the aft end of the S-IB stage in two groups of four inboard and four outboard. The four inboard engines will be equally spaced on a 64-inch diameter and fixed so that their exhaust nozzles are at a 3-degree cant outward from the centerline of the stage. The four outboard engines will be equally spaced on a 190-inch diameter and oriented at 45-degree angles with respect to the inboard engines. The outboard engine exhaust nozzles will be canted outward 6-degrees from the centerline of the stage when they are in the "zero" (null) position. This 6-degree outward cant of the outboard engines will minimize pitch and yaw disturbances which may result from variation of engine thrust or total loss of performance of an engine during S-IB stage powered flight. Each outboard engine will be mounted in gimbals to permit a ±8-degree range of engine gimbaling in a square pattern with reference to the zero (null) position. Gimbal control of each engine will be effected by two hydraulic actuators mounted 90-degrees apart on the circumference of the engine. Gimbaling of the four outboard engines will direct their thrust vectors such that roll, pitch, and yaw control of the Saturn IB space vehicle can be exercised by these four engines during S-IB stage powered flight.

A study has been made of the dynamic loads experienced by the vehicle during engine start, thrust build-up, holddown release, and cutoff conditions. During launch countdown the inboard engines will be started first, two diametrically-opposite engines at a time, with a short time interval between each pair. The starting sequence is described as 2, 2-2, 2. During actual flight the eight H-1 engines will be cut off in a 4-4 sequence at the completion of first stage powered flight. The four inboard engines will be cut off simultaneously and then after a short time interval (varying from 100 milliseconds minimum to 6 seconds maximum) the four outboard engines will also cut off simultaneously. If a malfunction should occur during launch operations after the engines have been ignited but before liftoff, an emergency cutoff procedure is available. This emergency cutoff sequence is 4-4, wherein the four inboard engines are cut off simultaneously. Approximately 10 milliseconds later the four outboard engines are cut off.

The H-1 engine thrust chamber is the unit in which LOX and RP-1 propellants are burned to generate thrust. The propellants are forced into the thrust chamber under pressure by the engine turbopump. The propellants are mixed in a specific ratio as dictated by orificing of the engine to a predetermined value. The nominal mixture ratio and thrust chamber propellant flow rate of LOX and RP-1 for the H-1 engine is shown in Table 9-I, Saturn IB Nominal Power

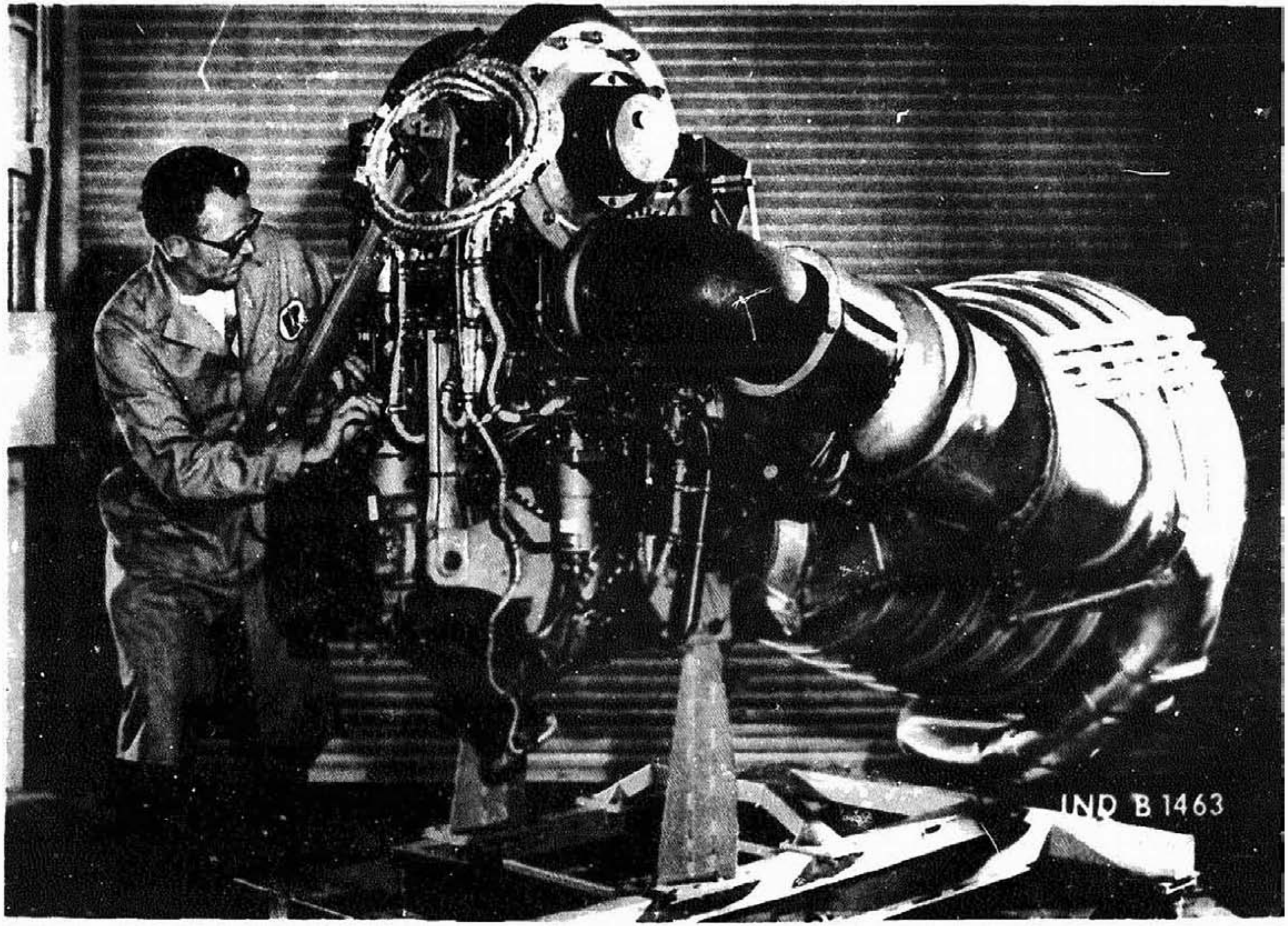


FIGURE 9-14. H-1 200 K ENGINE

Plant Performance. The thrust chamber consists of a chamber body, LOX dome gimbal, and propellant injector. The thrust chamber of each engine is equipped with an aspirator for control of turbine exhaust gases. These aspirators are fed hot gases by turbopumps via turbine exhaust ducts which emanate from each of the eight turbopumps associated with the engines. Each turbopump provides both LOX and RP-1 to only one H-1 engine. The hot gases originate in the Gas Generator of each engine where LOX and RP-1 are burned to create an energizing force to drive the turbine. These hot gases pass through the turbine, providing impulse, and then are exhausted from the stage via the aspirators.

On the first two S-IB stages the turbine exhaust ducts for the inboard engines are located inside fairings, which resemble small stub fins, and are located on the aft skirt of the present S-IB stage. A modification will be incorporated on S-IB-3 and subsequent stages to provide an aerodynamically "cleaner" design and to utilize the thrust which will be generated by expelling hot gases through ducts in a direction opposite to that of flight. The modification will include equipping the four inboard engines with turbine exhaust ducts mounted on the external surface of the H-1 engine thrust chamber and extending into the area surrounded by the four inboard engines. The turbine exhaust gases will flow through these ducts under the impetus of a low pressure created by the normal exhaust flow from the inboard H-1 engines. The overall effect of the modification will be an increase in propulsive thrust for the stage and "cleaner" aerodynamic design by elimination of protuberances into the airstream surrounding the vehicle during flight.

The H-1 engine turbopump assembly supplies both LOX and RP-1 fuel to the engine thrust chamber. The turbopump assembly provides the line pressure and fluid flow rates necessary for assurance of engine operation at rated thrust. The turbopump assembly also supplies the gas generator with propellants. The turbopump assembly consists of a turbine, a gearbox, a LOX pump, a fuel pump, and a lube system.

A normally-closed main fuel valve is installed in the high-pressure fuel line of each engine between the fuel pump and the engine thrust chamber. The main fuel valve has an unbalanced butterfly gate and is spring loaded in the closed position. The valve is opened initially by turbopump fuel discharge pressure acting through the igniter fuel valve and the ignition monitor valve. Three drain lines, one from the main fuel valve body and two from the valve actuator, transfer leakage fuel to a manifold from which it drains overboard.

A normally-open fuel prevalve is located in the fuel line of each engine adjacent to the fuel tank outlet fitting. Each fuel prevalve provides emergency cutoff of fuel to its associated engine in the event the main fuel valve fails to close upon signal to do so. The fuel prevalve is designed in accordance with the "fail-safe" concept applicable to manned space vehicles. That is, the valve is normally open and requires electric power to close. A power failure in flight would not affect the open position of the prevalves and hence would not disrupt the flow of fuel to the engines since it is imperative that engine operation after liftoff be maintained for as long as possible even in the case of critical or catastrophic failure.

A normally-closed main LOX valve is installed in the high-pressure LOX line of each engine between the LOX pump and LOX dome. The main LOX valve is opened initially by turbopump fuel discharge pressure acting through a control line to the valve actuator. The actuator cylinder on the main LOX valve is equipped with a heater blanket to prevent seals from freezing due to extremely low temperature. Two LOX-leakage drain lines, one from the main LOX valve body and one from the valve actuator, vent LOX overboard. A fuel overboard drain line is provided from the closing port of the main LOX valve actuator cylinder.

A normally-open LOX prevalve is located in the LOX line of each engine adjacent to the LOX tank outlet fitting. Each LOX prevalve provides emergency cutoff of LOX to its associated engine in the event of a failure of the main LOX valve to close upon receipt of a closure signal. The LOX prevalves are "fail-safe" in that loss of electric power will not affect their open position and consequently will not interfere with the flow of LOX to the engines. The LOX prevalves function as counterparts of the fuel prevalves in maintaining engine operation for a successful mission even if a malfunction should occur which results in a temporary or permanent loss of electric power. The LOX prevalves will act in conjunction with the fuel prevalves to maintain engine operation in the event of a critical or catastrophic failure after liftoff.

9.5.3.3.3 LOX SYSTEM. The LOX system will consist of one central 105-inch diameter LOX container surrounded by four outer 70-inch diameter LOX containers, together with various valves, piping, and control devices. All LOX tanks are interconnected by an interchange system. Each 70-inch diameter tank provides LOX to one inboard and one outboard engine through suction lines. Should an engine fail, the interchange system will permit the functioning engines to use the LOX which would have been consumed by the engine which failed. Suction lines to each engine will contain shutoff valves for emergency engine cutoff. Cutoff of inboard engines will be initiated by outputs from engine cutoff sensors while thrust OK pressure switches will cutoff the outboard engines. A signal from the onboard computer will be used as a backup system for cutoff of the outboard engines. A fuel-rich cutoff of engines will be accomplished since a LOX-rich cutoff could result in engine damage or failure.

The LOX tanks will be filled by pumping LOX at a rate of approximately 3100 gallons per minute into the interconnect system at the aft end of LOX tank (L-3) where it flows through interconnecting lines into the other four LOX tanks. After initial filling, LOX will be replenished through the replenishing lines to maintain a predetermined LOX load. The LOX containers can be drained through the opened LOX replenishing valve into the ground LOX system. The four LOX vent valves and LOX relief valve are closed during pre-flight pressurization.

A LOX container pressurization system will be provided to maintain sufficient total head pressure for satisfactory LOX pump performance. The system will consist of solenoid valves, ducting, heat exchangers, orifices, and tubing. The LOX containers will be interconnected at the top of each container. Provisions will be made to pressurize the LOX tanks to a value of approximately 50 psig before launch with gaseous helium supplied by a ground source at the launch facility. During flight the S-IB stage LOX tank pressurization will be provided by gaseous oxygen. This pressure will be obtained by passing LOX through the heat exchanger on each engine. Inflight pressure relief is provided by either the emergency LOX vent switch which controls a LOX relief valve or by the mechanical relief capability of the LOX relief valve.

9.5.3.3.4 FUEL SYSTEM. The fuel system will consist of four 70-inch diameter RP-1 containers and various piping systems, valves, and control devices. The four fuel containers will be filled from a single fill nozzle on the launch pad from a pressurized ground source at a fill rate of approximately 2000 gallons per minute. All of the fuel tanks will be interconnected at the top and at the bottom by piping manifolds to maintain a uniform fuel level and pressure in all containers. Should an engine fail, the manifold will permit the functioning engines to use the fuel which would have been consumed by the engine which failed. Each of the containers will have a fuel prevalve in the outlet line for emergency cutoff of fuel to the engines. Cutoff sensors located in the two fuel containers designated F-2 and F-4 will provide a signal to the IU which will generate a signal to the switch selector to initiate cutoff of the inboard engines. Two fuel depletion sensors are located in the sumps of the same two fuel tanks and detect the fuel level just prior to depletion. These sensors are activated by the switch selector after inboard engine cutoff (IECO). Since outboard engine cutoff (OECO) is programmed approximately three seconds after IECO, a period exists during which the outboard engines may be cut off by either sensor should the fuel be depleted.

A fuel container pressurization system will be provided to maintain sufficient total head pressure for satisfactory fuel pump performance. The system will consist of high pressure spheres, solenoid valves, a pressure switch, ducting lines, orifices and tubing. Pressurization will be provided by helium stored at a pressure of 3000 psi in two 20-cubic-foot spheres mounted on the forward skirt of fuel tanks F-3 and F-4. During flight, two fuel-container pressurization control valves remain open and helium flows from the spheres to the fuel tanks. Tank pressure varies from 17 psig at liftoff to not less than 11.5 psig during flight. Fuel tank overpressurization will not occur since a sonic nozzle in the pressurizing line limits the helium flow rate to the tanks.

9.5.3.3.5 FUEL AND LOX BUBBLING SYSTEM. A bubbling system will be provided for each of the LOX and fuel tanks. These bubbling systems will minimize thermal gradients inside their respective propellant tanks by evaporative cooling. Evaporative cooling will be accomplished by injecting helium bubbles at a point adjacent to the LOX pump inlets of each engine. These bubbles rise through the suction lines to the bottom of the tanks. As the bubbles rise to the top of the tanks, evaporation will take place between the LOX and helium bubble interface which results in subcooled LOX, thus minimizing temperature differentials within the individual tanks.

Each bubbling system will consist of couplings, ring-manifolds, and branch lines which contain orifices. Gaseous helium for the LOX bubbling system will be provided through the ground supply system at a nominal value of 300 psig and 560 SCFM into the manifold ring. After bubbling up and through the LOX inside the tanks, the gaseous helium will be vented into the atmosphere through the open LOX vent valves and LOX relief valve. Gaseous nitrogen for the fuel bubbling system will be provided by a system similar to the LOX bubbling system at a nominal value of 120 psig and 5 SCFM. Fuel bubbling will be initiated prior to LOX tanking and will continue until the beginning of fuel tank pressurization. After bubbling up through the fuel in the tanks, the gaseous helium will be vented into the atmosphere through the open fuel vent valves.

9.5.3.3.6 CONTROL PRESSURE SYSTEM. A Control Pressure System will be provided to supply gaseous nitrogen for actuating various valves in the fuel and LOX systems, for purging calorimeters for pressurizing the engine turbopump gearbox, and for purging the LOX turbopump seal. The system will consist of two high-pressure spheres, a pressure switch, a regulator, and related couplings and valves. Gaseous nitrogen will be supplied from the control pressure manifold at a nominal value of 750 psig for actuation of the fuel and LOX system valves. The Control Pressure System will provide gaseous nitrogen for the above purposes as required during the period of launch operations and during space vehicle flight. In the event of an aborted launch, continuous purging of the turbopumps will be effected until the pumps return to ambient temperature.

9.5.3.4 FLIGHT CONTROL SYSTEM

9.5.3.4.1 PURPOSE. The S-IB Stage Flight Control System will be capable of maintaining the Saturn IB Space Vehicle at attitudes that will allow the flight path of the vehicle to coincide with a predetermined reference trajectory. Guidance and stability augmentation commands will be transmitted through electrical ducts emanating from the electronic equipment located in the IU. The S-IB Stage Flight Control System will consist of eight electro-hydraulic actuators, a switch selector, and associated wiring and distribution boxes.

9.5.3.4.2 HYDRAULIC SYSTEM. Each of the four outboard engines will be equipped with a hydraulic system which will provide power for engine gimbaling. Each hydraulic system will be an independent, closed-loop system designed to eliminate the need for an external hydraulic pressurizing source. Each hydraulic system will consist of two hydraulic actuators, a main pump, an auxiliary pump and electric drive motor, and an accumulator-reservoir and manifold assembly. The actuators will be mounted at 90-degrees to each other and will be so arranged that they move the outboard engines with respect to the S-IB stage structure. The combined movement of each pair of actuators will gimbal the associated engine in a ±8-degree square pattern from its null position. In the null position, each outboard engine exhaust nozzle is canted 6-degrees outward from the stage centerline. In flight, the hydraulic system will be pressurized by the main hydraulic pump. During ground operation of the system it will be pressurized by the auxiliary hydraulic pump which will be driven by an electric motor. Engine gimbaling will be accomplished by supplying hydraulic pressure to the two actuators on each outboard engine. Hydraulic fluid at 3200 psi, controlled by the electro-hydraulic servovlave on each actuator, will be applied to one side of the actuator piston while the other side of the piston is exposed to a low pressure. Under these circumstances the actuator piston will move in the direction of the low pressure and thus extend (or retract) the actuator arm. Movement of the actuator arm will provide gimbaling action to the engine. The four outboard engines will move in unison to effect thrust vector changes for vehicle control. The Flight Control Computer, located in the IU, will provide inputs to control the actuators.

The main hydraulic pump, which furnishes pressure for each of the four independent hydraulic systems, is driven by its respective outboard engine turbopump. This pump will be operated only during vehicle flight since its associated engine must be operating to provide the necessary motive power. During operation of the main hydraulic pump, a check valve will prevent the flow of high pressure fluid through the nonoperating auxiliary pump. Similarly, another check valve will prevent the flow of high pressure fluid through the unused main pump during ground operations in which the auxiliary pump provides system pressure.

Two relief valves will protect the hydraulic system against excessive pressure buildup. A high-pressure relief valve will protect the accumulator-reservoir and the high-pressure side of the hydraulic system by venting high-pressure fluid into the low pressure side of the accumulator-reservoir. A low-pressure relief valve will protect the reservoir and low-pressure side of the system by venting fluid to the atmosphere. Various filters are provided in the system to minimize the clogging of orifices by system contamination. A number of monitoring and protective devices are installed to provide system status information on accumulator pressures, filter pressure drops, thermal sensing devices and switches to safeguard motors and fluid temperatures, and reservoir fluid levels.

9.5.3.4.3 CONTROL COMPONENTS. Pitch and yaw movements are sensed by control accelerometers in the IU and resulting signals are transmitted to the flight control computer of the IU. The rate gyro package is also located in the IU, and senses the rate of deviation from the predesignated vehicle trajectory in three axes. Signals resulting from attitude-rate and lateral acceleration deviations are transmitted to the flight control computer of the IU for evaluation and error correction as required.

Selector switches located in the stage provide sequential timing for the various stage functions. The selector is normally operated through the digital guidance computer in the IU; however, ground systems can be connected for preflight purposes. Components of the selector switch are control relays, register relays, diode decoder matrix, and transistor relay drivers. The digital guidance computer selects the desired stage through the use of control relays and a coded address signal. Eight-bit binary words are fed to the selector switch, stored on a register, and read out on command to the stage control circuits.

9.5.3.5 ELECTRICAL SYSTEM

9.5.3.5.1 GENERAL DESCRIPTION. The Electrical System will generate and distribute electrical power for all S-IB Stage electrical loads and control the operation and sequencing of various functions throughout checkout, countdown, and flight. The electrical system will be compatible with automatic, digital, computer-controlled, checkout equipment. The S-IB Stage Electrical System consists of an Electrical Power System and an Electrical Control System.

9.5.3.5.2 ELECTRICAL POWER SYSTEM. The Electrical Power System will generate and distribute electrical power for all of the S-IB stage electrical loads. It will include all the equipment necessary for the generation, conversion, control, and distribution systems in the stage. The primary source of electrical power will be an arrangement of two 28-volt silver-zinc batteries located in the instrument compartment of one of the fuel tanks. Each battery is composed of 21 cells sealed in a cast magnesium case. Each cell has a nominal voltage of 1.4 volts. The electrolyte is a 30 percent solution of potassium hydroxide in water and each battery is rated at 2650 amp-min at a 10 minute discharge rate.

Three master measuring voltage supplies on the stage furnish precisely regulated voltages to the instrumentation system. The master measuring voltage supplies convert the 28 Vdc input to a regulated 5-Vdc reference voltage. The power supplies perform identical voltage functions but keep the voltage within a precisely regulated ±15 millivolts.

9.5.3.5.3 ELECTRICAL DISTRIBUTION SYSTEM. The Electrical Distribution System will be provided to distribute and control the operations involved in the pressurization, propellant loading, propellant utilization, and H-1 engine systems.

The S-IB stage contains seven distributors, four of which are measuring distributors which provide power to instrumentation and connect measurement signals to telemetry channels. The power distributor contains the relays, busses, and circuitry for control and distribution of electrical power throughout the stage. The main distributor contains the relays, busses, and circuitry for control of the stage subsystems. The propulsion system distributor contains the relays, busses, and circuitry to control the engine functions. Thirteen plug J-boxes are located throughout the stage. The plug J-box is basically a standard connector modified to provide a junction point, a buss, or a mounting for a small component to save space in distributors.

9.5.3.6 INSTRUMENTATION AND RANGE SAFETY SYSTEM

9.5.3.6.1 GENERAL DESCRIPTION. The S-IB Stage Instrumentation and Range Safety System will consist of a Measuring System, a Telemetry System, an RF System, a Range Safety and Tracking System, and an Optical System. In performing its functions, the Measuring System will detect quantities representative of stage status and performance parameters during checkout and flight, will convert them into dc voltage signals, and will supply these signals as inputs to the Telemetry System. The Telemetry System will convert the dc voltage input signals into radio frequency energy for transmission to the ground monitoring station radio receivers. During the performance of vehicle prelaunch checkout procedures, the Telemetry, Measuring, and Radio Frequency (RF) Systems will function as they are designed to operate in flight except that the output of the Telemetry System will be sent to the Automatic Checkout Equipment on the Launch Complex via hardwire interconnections instead of by means of the RF System radio link. The Range Safety System will be used to destroy the stage in flight in the event of an emergency wherein the vehicle experiences a failure which would make it a hazard to life or property. A single tracking system will be employed on the S-IB stage. The Optical System will consist of film cameras to be used in studying the S-IB/S-IVB separation during R&D flights only.

The Instrumentation System for each of the first four S-IB flight stages will be designed to obtain comprehensive information pertinent to the Research and Development aspects of the Saturn IB vehicle and will be utilized to further the objectives of the overall Apollo Program. The Instrumentation System of each of these early vehicles will, of necessity, be complex in order to fulfill its purposes of maximal data sampling. On later S-IB flight stages the R&D instrumentation will be reduced to a minimum. The weight reduction from R&D to operational instrumentation will amount to about 2600 pounds.

9.5.3.6.2 TELEMETRY AND MEASURING SYSTEM. The Measuring System will consist of the electronic, electrical, and mechanical devices necessary for sensing the S-IB stage status and performance data, converting this data into analogous dc voltage signals, and applying these signals to the Telemetry System equipment. The devices comprising the Measuring System will be transducers, signal conditioners, and measuring distributors. Typical of the parameters which will be sensed by the Measuring System are temperatures, pressures, vibrations, strain, acoustics, accelerations, electrical power supply frequencies, voltages and currents, and switch and valve positions.

Since many of the source signals are unsuitable for use by the Telemetry System, signal conditioners will be used to transform the outputs of the transducers into signals compatible with the input signal requirements of the Telemetry System. The measuring distributors will distribute the signals from the transducers and from the signal conditioners to various units of the Telemetry System. The measuring distributors will also distribute reference voltage signals from the master measuring voltage supply to the transducers. About 500 measurements will be made on the S-IB stage during R&D flights. This number will be reduced to about 250 measurements for operational flights.

The S-IB Stage Telemetry System will provide for the transmission of both continuous and sampled data in a form compatible with the NASA/KSC-provided ground telemetry and data handling equipment at the Eastern Test Range. The developmental system will consist of three types of telemetry links, two separate telemetry antenna systems, a tape recorder, and a telemetry calibrator.

The basic types of telemetry links will be: two PAM/FM/FM, one SS/FM, and one PCM/FM. Each of these systems has characteristics suitable for the transmission of specific categories of data. Use of these three systems in combination will provide an efficient, reliable, and flexible telemetry system with sufficient channel capacity. For operational missions only the PCM/FM link and one PAM/FM/FM link will be used.

The PAM/FM/FM equipment has a capacity of 300 time-multiplexed and 14 continuous data channels. The SS/FM equipment has a capacity of 15 continuous channels which will be used for the transmission of wideband data such as vibration measurements. The PCM/FM telemetry equipment will be used to transmit in-flight data and also data gathered during ground checkout procedures.

The PCM/FM equipment consists of two separate units, the PCM/DDAS assembly and the PCM/RF assembly. These units will provide digital-coded pulse train outputs to the ground DDAS equipment. The Digital Data Acquisition System (DDAS) will serve as an intermediate link between the S-IB Stage Telemetry System and the ground computer used for automatic checkout and monitoring of the entire Saturn IB Space Vehicle at the Launch Facility. The DDAS will permit utilization of the stage telemetry equipment as a means of providing feedback information regarding stage equipment performance during prelaunch monitoring and checkout by the ground computer. Outputs from the stage telemetry equipment, given in response to ground computer checkout interrogation, will be returned to the ground computer for monitoring. These outputs will be transmitted by a hardwire (coaxial cable) interconnection routed through an umbilical from the S-IB stage telemetry equipment to the ground computer via the DDAS. A parallel RF channel may be used also for relay of the same information. Use of such an RF carrier link with the DDAS will permit real time vehicle monitoring after liftoff. Thus, an RF link, if used, will provide a degree of redundancy in the in-flight telemetry transmission as well as a means of calibrating the instrumentation system in flight.

The S-IB Stage Radio Frequency (RF) System comprises the RF transmission aspects of the Range Safety and Tracking System, Destruct System, Telemetry System and any special RF systems. The RF System will include the antennas for each of these systems. Antennas will be designed to provide omnidirectional coverage over their specific frequency bands. This coverage will assure effective radio linkage with the S-IB stage during its entire flight as part of the Saturn IB space vehicle. Antenna designs for the Range Safety and Tracking System will meet the requirements established by the Air Force Missile Test Center regulations which govern range safety requirements for the Eastern Test Range.

9.5.3.6.3 RANGE SAFETY AND TRACKING SYSTEM. The stage Range Safety System will be part of the overall Saturn IB Space Vehicle Range Safety System and will be interconnected with the S-IVB stage system to form an integral network which will affect both stages simultaneously. This system will incorporate units of both the RF and Destruct Systems and will consist of two separate radio receivers, each of which has an independent battery power supply and antenna. The system will also incorporate electrical devices for initiating H-1 engine cutoff and for triggering the destruct system.

The Range Safety System will provide the means of terminating powered operation of the S-IB Stage H-1 engines, dumping the remaining fuel and oxidizer into space, and destroying the stage in flight. It will be activated by coded radio pulses from UHF radio transmitters and the ground range safety stations. The Range Safety Officer will initiate such action to terminate the flight and destroy the space vehicle in the event a malfunction occurs that causes the vehicle to head off course or become erratic in its performance to the extent that the vehicle will create a safety hazard.

Upon receipt of a command signal from the ground Range Safety System the following sequence will take place. The S-IB Stage Range Safety System will introduce a time delay in the signals which it will send the H-1 engine cutoff mechanism and to the destruct system. Within this time delay the stage Range Safety System will issue a signal of impending catastrophic failure to the EDS which will, in turn, introduce an automatic abort signal to the CM of the Apollo spacecraft. The abort signal will ignite the Launch Escape System escape rockets and pull the command module free of the remainder of the spacecraft and launch vehicle. The EDS and the Apollo Command Module abort procedures are described in greater detail in Section 9.5.2, Emergency Detection System.

After abort of the CM has been initiated, the S-IB Stage Range Safety System will issue the delay signals to the engines and to the destruct system. The resulting actions will terminate the vehicle flight and rupture the fuel and oxidizer tanks on both the S-IB and the S-IVB stages with linear explosive charges. The combined action of the loss of engine thrust, tank rupture, and propellant spillage will cause the S-IB and S-IVB stages to break apart and fall back into the atmosphere where they will be destroyed by the heat of friction during reentry. Or, they will fall into the ocean along the Eastern Test Range if they have not transcended the earth's atmosphere at the time the Range Safety System is utilized.

An Offset Doppler (ODOP) System will be installed in the forward compartment of a propellant tank on the S-IB stage to perform tracking functions. Two antennas are provided for the ODOP System and are mounted on a command antenna panel located just below the spider beam assembly. One antenna will be for the receiver and the other for the transmitter.

9.5.3.6.4 OPTICAL SYSTEM. Two recoverable 16 mm motion picture cameras will be used on the first three flights to provide a permanent visual record with color film of the S-IB/S-IVB separation sequence. The cameras also record operation of the S-IVB stage ullage rockets and J-2 engine ignition. Each camera is contained in a capsule (Fig. 9-15) and photographs through an optically clear quartz window. The camera capsules consist of a waterproof aluminum shell incorporating a stainless steel nose section, a quartz window, a camera, reentry equipment, and recovery aids.

The cameras are started approximately 5 seconds before stage separation, and stopped 25 seconds after separation. Each camera film magazine has a capacity of 100 feet of film and a built-in precision regulator to maintain camera speed at 128 frames per second. The cameras are operated simultaneously by 28 Vdc from the S-IB stage electrical system.

Both camera capsules are ejected simultaneously at an altitude of approximately 400,000 feet. An 8-second time delay after stage separation is used to prevent ejection of the capsules during the time that the capsules could collide with the S-IVB stage. Each camera capsule is held in a separate ejection tube attached to a radial member of the spider beam in line with fins 2 and 6, at an approximate radius of 68 inches from the stage centerline. The ejection tubes protrude approximately 8 inches through the spider beam seal plate at an angle of 17 degrees from the stage centerline. This angularity provides collision-free ejection paths for the capsules.

The camera capsules are ejected from the forward end of the S-IB stage through the S-IB/S-IVB interstage area. Ejection is electrically initiated by energizing two solenoid valves which supply gaseous nitrogen under 3000 psig pressure to a piston on each ejection tube. A 3000 psig sphere, mounted on the spider beam, provides the gaseous nitrogen to operate the ejection system.

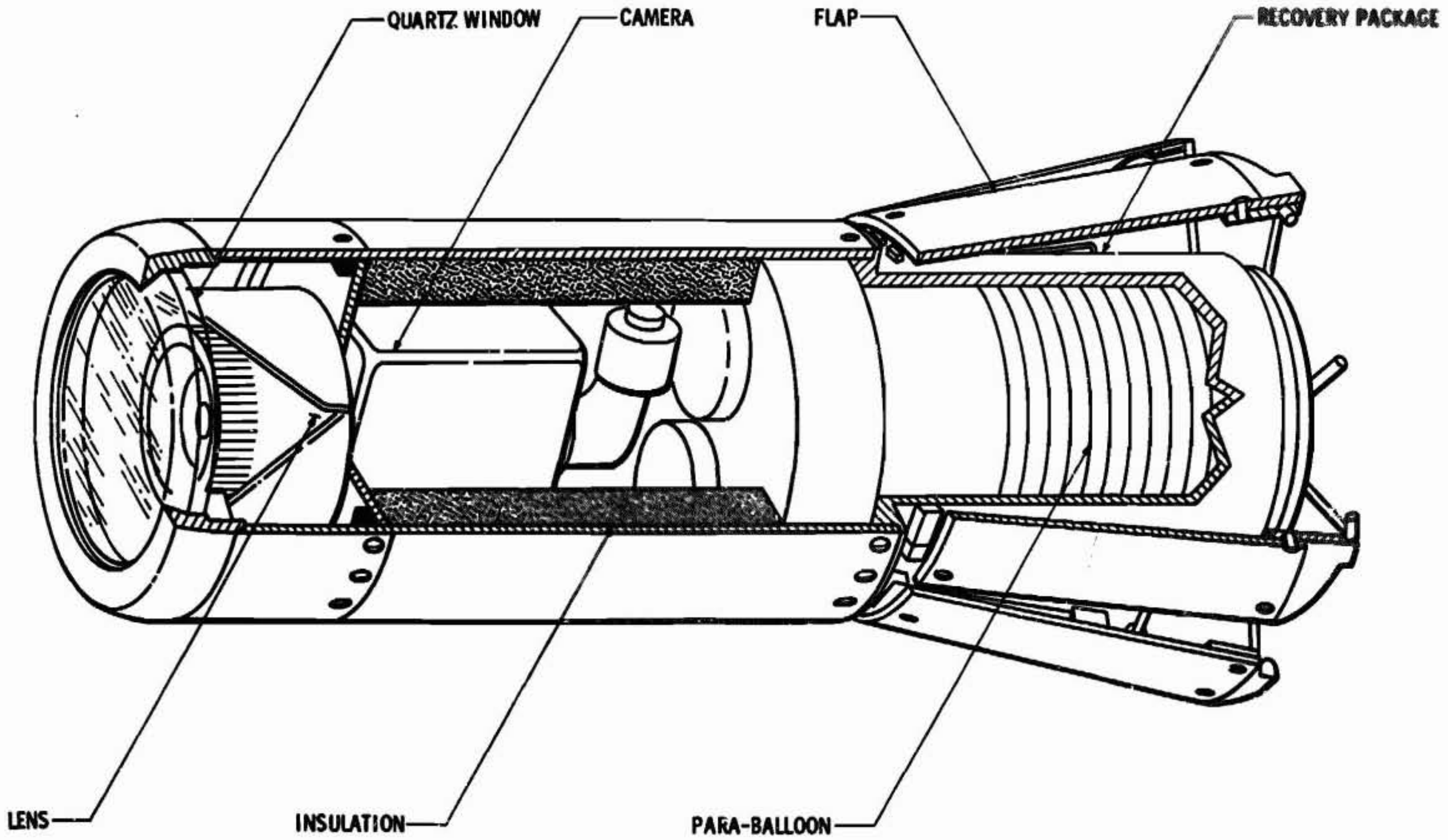


FIGURE 9-15. OPTICAL SYSTEM

Eight stainless steel flaps provide dynamic braking for deceleration during and after reentry. The capsules enter the atmosphere at approximately Mach 10 or 7900 mph.

At about 14,000 feet, an 18 inch para-balloon in the recovery package is inflated with gas. The capsule is then stabilized and decelerated by para-balloon drag to approximately 90 feet per second before impact.

The camera recovery aids in each camera capsule consist of a dye marker, special balloon color treatment to improve visibility, a high-intensity flashing light, and a radio-beacon transmitter. Shark repellant is also dissolved in the water to ward off marine life that might damage either the capsule or the para-balloon which keeps the capsule afloat.

9.5.3.7 ORDNANCE SYSTEM

9.5.3.7.1 GENERAL DESCRIPTION. The S-IB Stage Ordnance System will consist of a Flight Separation System and a Destruct System. The Flight Separation System will provide in-flight separation of the combined S-IB stage and S-IVB interstage from the remainder of the Saturn IB space vehicle at the conclusion of first stage powered operation. The destruct system will provide flight termination for the Saturn IB space vehicle and dispersion of its propellants should a catastrophic failure occur.

9.5.3.7.2 FLIGHT SEPARATION SYSTEM. The S-IB Flight Separation System will accomplish stage separation, as illustrated in Figure 9-16, First Stage Separation. This will be a normal flight function and will consist of discard of the S-IB stage and S-IVB interstage as a unit from the Saturn IB space vehicle.

The four retrorocket motors on the S-IVB interstage will apply a retarding force to the combined S-IB stage and S-IVB/IB interstage which will reduce the forward velocity and thus facilitate stage separation. The three ullage rocket motors on the S-IVB stage apply an accelerating force in the direction of flight to the Second Flight Configuration with an acceleration on the order of 0.01g magnitude. It will serve the primary purpose of settling the LOX and liquid hydrogen propellants in the S-IVB stage tanks and a secondary purpose of assisting in the stage separation process. The additional acceleration provided by the ullage rockets will effectively force the liquid propellants to the rear of their tanks to assure the presence of liquid propellant at the inlet of both fuel (LH_2) and LOX turbopumps. Adequate pressure is supplied by the stage propellant tank pressurizing system and is required to provide proper starting of the S-IVB stage J-2 engine.

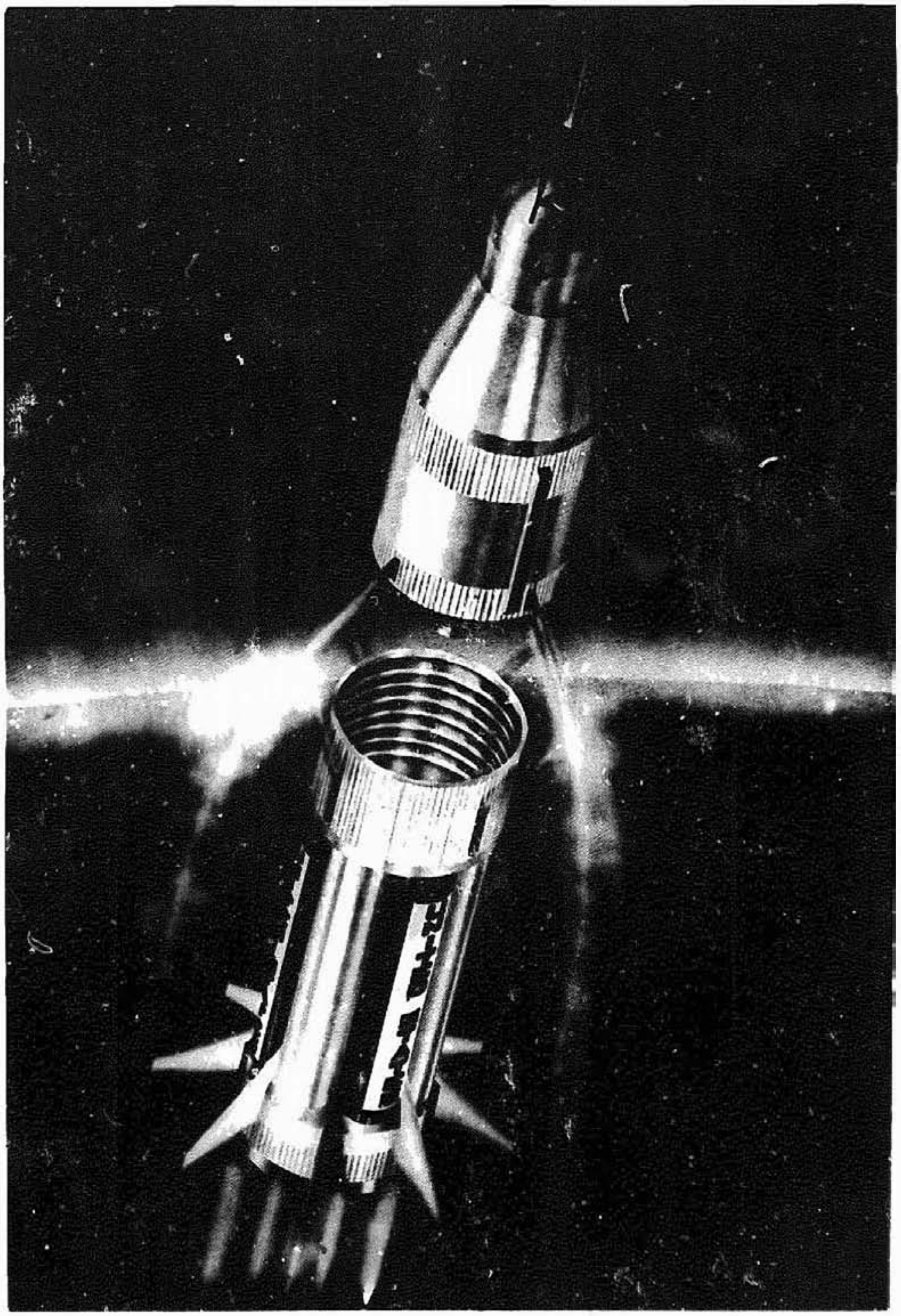


FIGURE 9-16. FLIGHT SEPARATION

Separation will be accomplished by a skin-cutting technique using a mild detonating fuse and a tension plate separation joint. The separation joint will be located between the S-IVB interstage and the S-IVB stage. Both the skin-cutting explosives and the retro-motor system will be initiated by an exploding bridge wire system. Two EBW detonators will be used to initiate the separation system. Mild detonating fuse and two EBW initiators will be used for initiating each retro and ullage motor.

9.5.3.7.3 DESTRUCT SYSTEM. The Destruct System will be used to destroy the Saturn IB space vehicle during flight in the event a malfunction should occur which would cause the vehicle to veer off course and thereby become a potential hazard to life or property. The Range Safety Officer will have the responsibility of determining whether vehicle performance will create such a safety hazard and will issue the signal to initiate the Destruct System. Command destruct signals will be transmitted by UHF radio as part of the Range Safety System. The Destruct Systems of the S-IB stage and the S-IVB stage are explosively interconnected so that initiation of the system in one stage will automatically initiate the system in the other stage as well. Thus, flight termination and propellant dispersion will occur in both stages simultaneously and will result in destruction of the entire launch vehicle.

After first stage separation, the S-IB stage (containing empty propellant tanks) will be discarded in flight. The processes of flight termination and propellant dispersion will be applicable to only the S-IVB stage after this point. The S-IB Stage Destruct System will provide flight termination by initiation of H-1 engine cutoff and propellant dispersion by rupturing both fuel and oxidizer tanks. Rupture of the propellant tanks will allow their contents to spill out into space as the vehicle coasts in the direction of flight with its propulsion terminated. The LOX and RP-1 tanks will be ruptured on opposite sides of the S-IB stage to minimize the explosion by reducing the amount of propellant mixing. The destruct system equipment in the S-IB stage will be initiated by command destruct signals received via two independent UHF command radio receivers. These radio receivers will have separate power supplies and antennas in order to provide redundancy and the high degree of reliability required for a safety system. Command destruct signals received by these radios will be used to actuate electrical equipment which will cut off the H-1 engines and then after a predetermined time detonate linear shaped charges which will, in turn, rupture the LOX and RP-1 propellant containers if required. Other equipment utilized in the destruct system will include two range safety controllers, two explosive bridge wire (EBW), firing units and detonators, a safe-arm device, and ordnance quick-disconnect fittings.

9.5.3.8 ENVIRONMENTAL CONTROL SYSTEM. All interstage areas will be purged with conditioned nitrogen gas during a period from 30 minutes prior to loading LH_2 into the S-IVB stage until the time of liftoff. The nitrogen gas will be provided by the Launch Facility and will minimize the danger of fire and explosion by excluding air from the purged areas. The nitrogen purge will reduce the oxygen level in the purged areas to 4 percent (or less) by volume and will maintain this status until liftoff. Environmental control will not be provided in the interstage areas during flight. The vacuum environment of space will permit any gases leaking into (or trapped within) the interstage areas to greatly expand and thus disappear from the confines of the space vehicle.

The S-IB stage instrument compartment located in the forward tank area will be cooled and ventilated during preflight operations to reduce the air temperature increase caused by electrical equipment operation. Cool air will be routed from a ground cooling supply system through an umbilical tower duct and admitted into the instrument compartment through an inlet coupling. A fixed orifice will be used to vent the instrument compartment during flight.

9.5.4 S-IVB STAGE

9.5.4.1 GENERAL. The S-IVB stage, Figure 9-17, is cylindrical in shape, nominally 59.1 feet long and 260 inches in diameter. The dry stage (i.e., without propellants) has a nominal weight as shown in Table 9-II and is powered by a single J-2 engine, providing a thrust as shown in Table 9-I.

The total propellant capacity is also shown in Table 9-II and consists of liquid oxygen and liquid hydrogen. The stage contains its own propulsion, electrical, flight control, environmental control, instrumentation, ordnance, and emergency detection systems.

9.5.4.2 STRUCTURAL SYSTEM

9.5.4.2.1 GENERAL DESCRIPTION. The S-IVB stage is a self-supporting aluminum alloy structure incorporating the following major structural components: forward skirt, propellant containers, thrust structure, aft skirt, aft interstage, and aft interstage fairing. The stage is structurally capable of supporting a load forward of approximately 42,500 pounds and is designed to allow launch preparation with or without payloads and with propellant containers full or empty, either pressurized or unpressurized. The structure will be able to withstand all loads imposed during the boost phase when the containers are fully loaded and pressurized. The empty stage can be ground-handled with the propellant containers unpressurized. Propellant loading can be accomplished only when the stage is in the upright position.

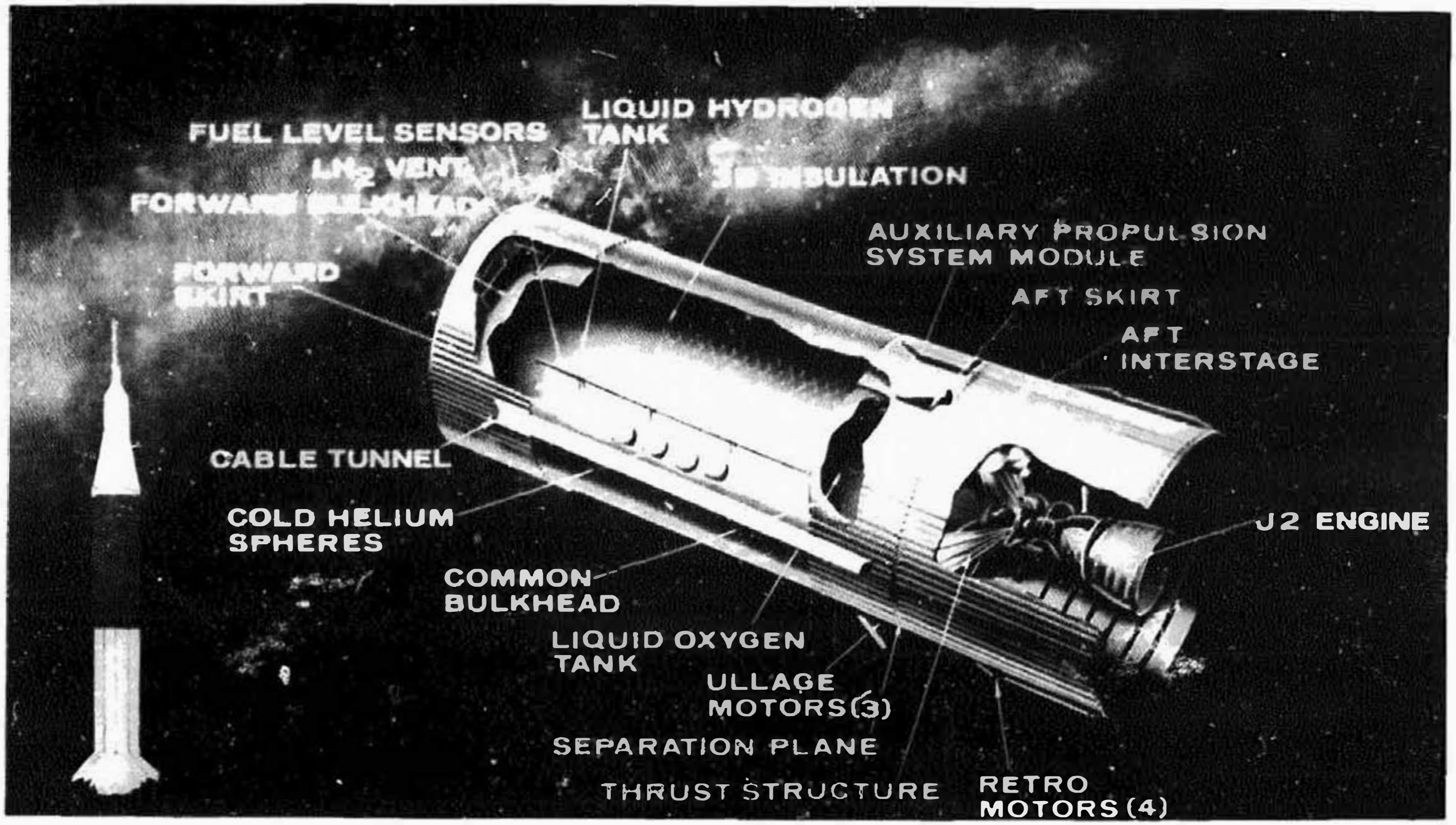


FIGURE 9-17. S-IVB STAGE

9.5.4.2.2 FORWARD SKIRT. The forward skirt is cylindrical, nominally 122 inches long and 260 inches in diameter. The forward skirt is of typical skin-and-external-stringer construction fabricated from 7075-T6 aluminum and incorporates provisions for mounting to the IU. Instrumentation and various types of equipment are mounted on cold plates inside the forward end of the skirt. Environmental conditioning for this electronic equipment is furnished by the IU Environmental Control System through an appropriate piping system containing liquid coolant. The forward skirt contains the forward electrical umbilical, LH_2 non-propulsive vent, primary batteries, telemetry and range safety antennas, and, in addition, mountings for a removable service platform. The non-flight platform function is to facilitate mounting and servicing equipment in the forward skirt and in the IU. This service platform will be removed before launch preparations are begun. Access to equipment in the forward skirt will be made through a door in the IU. The liquid hydrogen vent, telemetry antennas, and forward electrical umbilical are mounted on the forward skirt.

9.5.4.2.3 PROPELLANT CONTAINER ASSEMBLY. The propellant container assembly is constructed of 2014-T6 aluminum alloy and consists of two propellant containers which form an integral part of the stage structure and are separated by an insulated common bulkhead. The container assembly is nominally 528 inches long and 260 inches in diameter and consists of a cylinder having two hemispherical end bulkheads and a spherical-radius common bulkhead. The concave side of the common bulkhead faces aft and, together with the aft bulkhead, comprises the liquid oxygen container. The forward container is for storage of liquid hydrogen. The entire inner surface of this container, except for the common bulkhead, is insulated with three-dimensional polyurethane foam used to aid in maintaining the proper sub-zero temperatures to minimize LH_2 boil-off. The common bulkhead is of a sandwich construction, formed by bonding aluminum faces over a 1-3/4 inch thick temperature resistant fiber glass honeycomb core. The inner surface of the 3/4-inch thick cylindrical portion is milled in a 9-inch square waffle pattern to a thickness of 0.134 inch to reduce weight while maintaining strength and rigidity. A manhole in the forward bulkhead provides access to the liquid hydrogen container, and a removable liquid oxygen sump in the aft bulkhead provides access to the liquid oxygen container. The LOX tank contains a slosh baffle made up of four rings located in the upper portion of the tank.

9.5.4.2.4 AFT SKIRT. The aft skirt is a cylinder which has nominal dimensions of 260 inches in diameter and 85.5 inches in length. It is constructed of 7075-T6 aluminum with a skin-and-external-stringer design. The aft umbilical plate, the three ullage motors, and hydrogen feed line fairing and two auxiliary propulsion system modules are mounted on the aft skirt. The aft skirt structure is unpressurized and is attached to the S-IVB stage near the juncture of the aft bulkhead and cylinder of the propellant container assembly. The aft end of the aft skirt is mated with the S-IB/S-IVB interstage to form the in-flight separation plane.

9.5.4.2.5 THRUST STRUCTURE. The thrust structure supports the J-2 engine, transfers engine thrust to the S-IVB stage primary structure, and incorporates support points for the engine gimbaling actuators. The thrust structure is an inverted, truncated cone made of 7075-T6 aluminum using skin-and-stringer type construction. The structure has a base diameter of approximately 168 inches, a top diameter of 34 inches, and a height of 62 inches. The forward end of the thrust structure is attached to the hemispherical aft bulkhead of the LOX tank on a tangential intercept as illustrated in Figure 9-17. The aft end of the thrust structure is attached to the engine support fitting. Two doors provide access to the thrust structure through a trapezoidal opening.

9.5.4.2.6 AFT INTERSTAGE. The aft interstage (S-IB/S-IVB interstage) is a unit located between the aft skirt field splice plane of the S-IVB stage and the interface of the S-IB stage and serves to transmit structural loads between these stages. The interstage is of skin-and-external-stringer construction, fabricated from 7075-T6 aluminum, cylindrical in shape, nominally 224.5 inches long, and 260 inches in diameter. The interstage specification weight is shown in Table 9-II. There are provisions for eight equally-spaced mounting points on a 220 inch diameter circle at the interface of the S-IB and the S-IVB stages. Four retrorockets are mounted on the after interstage in locations aft of the separation plane at 90-degree intervals around the periphery. The retrorockets and support brackets are enclosed in aerodynamic fairings. A door, located in the forward portion of the interstage, will provide personnel access for maintenance or repair purposes. A removable service platform inside the aft interstage will facilitate access to the internal components. It will be removed from the aft interstage after launch preparations and prior to launch.

9.5.4.2.7 AFT INTERSTAGE FAIRING. The aft interstage fairing is a cylindrical section nominally 260 inches inside diameter and 27 inches long. It is attached to the rear of the aft interstage and provides a protective sheath over the S-IB spider beam and the uppermost portion of the S-IB stage propellant containers when the S-IB and S-IVB stages are assembled into the Saturn IB launch vehicle.

9.5.4.3 PROPULSION SYSTEM

9.5.4.3.1 GENERAL DESCRIPTION. The S-IVB stage propulsion system consists of the J-2 engine, fuel system, LOX system, propellant utilization system, and engine chilldown system.

9.5.4.3.2 J-2 ENGINE. The J-2 engine is a bipropellant engine utilizing LH_2 as a fuel and LOX as an oxidizer. It develops a vacuum thrust as shown in Table 9-I. The J-2 engine is illustrated in Figure 9-18. This engine will provide prime thrust for the S-IVB stage propulsion and also attitude vector control (pitch and yaw) through engine gimbaling during its period of operation. During this time the auxiliary propulsion system will provide roll control. The engine can be gimbaled over a range of ±7 degrees in a square pattern. Restart of the J-2 engine will not be required for any Saturn IB space vehicle flight. The nominal oxygen-hydrogen mixture ratio for the J-2 main engine is shown in Table 9-I, as well as the range of variable mixture ratios attainable. The accuracy with which the mixture ratio can be maintained is also shown in the same table, expressed as a percentage of the ratio value. The mixture ratio will be altered by the propellant utilization (PU) system during J-2 engine operation as required to maintain a proper balance of propellants remaining in the tanks to effect maximum utilization of propellant energy for S-IVB stage propulsion.

Each propellant system has the necessary pressurization to provide fluid flow and to operate valves to obtain engine ignition and operation, as required. Each system has a main propellant valve, prevalve, and associated valves, piping, and controls, as well as a separate turbopump on the engine which consists of a turbine, pump housing, and impellers. The functions of this equipment are similar to those of the counterparts of the H-1 engine used on the S-IB stage, as described in section 9.5.3.3.2.

9.5.4.3.3 FUEL SYSTEM. The liquid hydrogen container volume is approximately 10,426 cubic feet, which allows a useable fuel supply of 38,333 pounds. This volume will provide Saturn IB mission fuel capacity plus approximately 2 percent ullage. The tank will be pressurized from a ground source of cold helium gas to a value sufficient to fill the net positive suction head (NPSH) requirements of the engine fuel pump. After main engine ignition, the fuel tank pressurization will be provided by hydrogen gas instead of helium. This hydrogen gas will be obtained from a bleed system on the engine and will be supplied to maintain a pressure of 28 ± 1.5 psia in the tank. Adequate pressure will be assured by increasing the ullage pressure by a nominal value of 8 psia minimum in the late phases of flight to compensate for the loss of static head due to fuel consumption.

The increased ullage pressure will eliminate any pump net positive suction head problem that might be generated by a stratified fuel layer. Should the ullage pressure become excessive, hydrogen gas will be vented from the liquid hydrogen tank through two non-propulsive vents located 180 degrees apart on the forward skirt. A tee assembly with a pneumatically-operated combination consisting of a vent-relief valve and a back-up relief valve will be provided on the

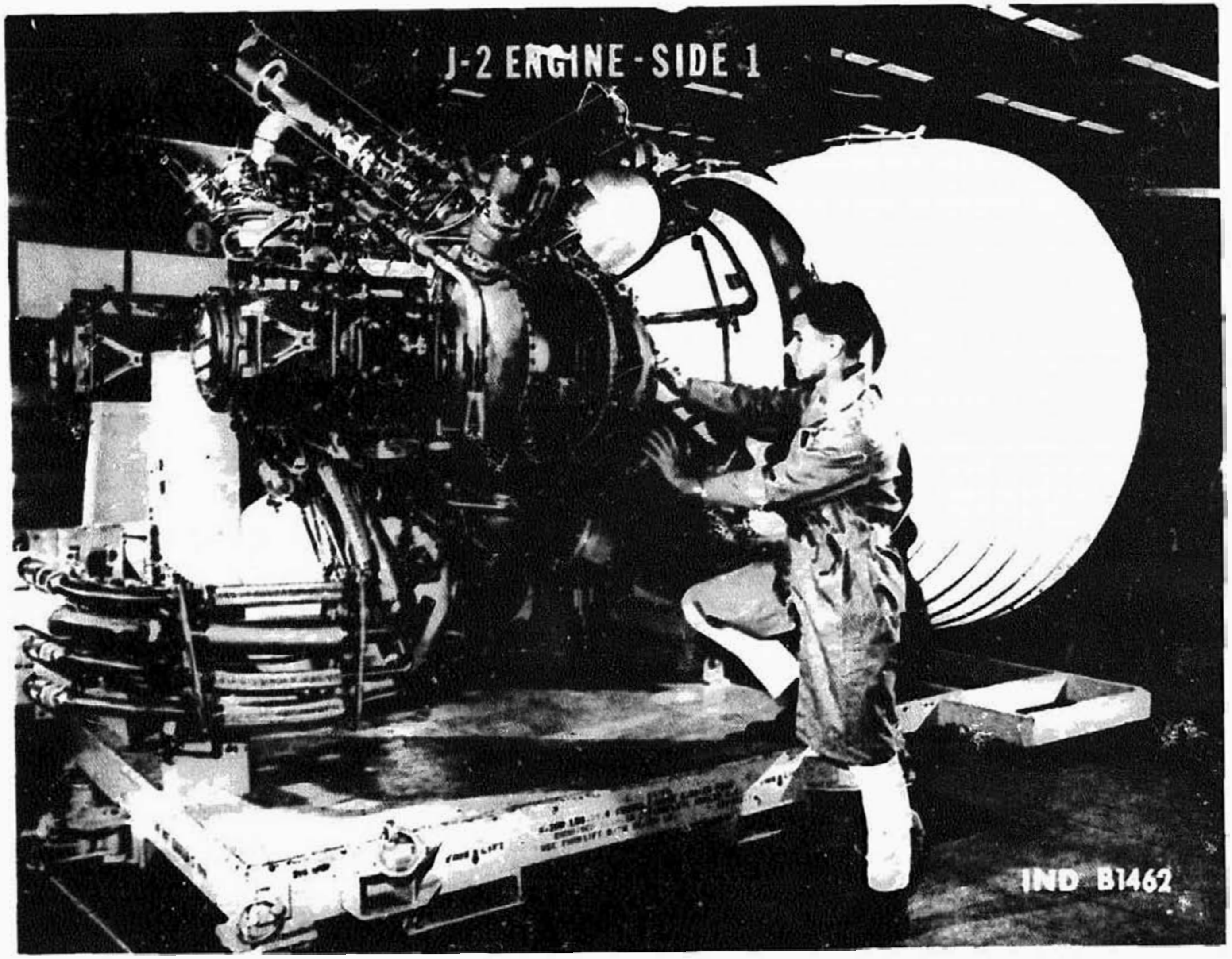


FIGURE 9-18. J-2 ENGINE - SIDE 1

liquid hydrogen tank. The valves will be set to actuate and reach the fully-opened position when the tank ullage pressure reaches a value of approximately 39 psia. Each relief valve will provide enough vent area to maintain safe pressure limits within the tank even if the other relief valve fails to operate. A screen at the liquid hydrogen tank outlet will provide vortex suppression and fuel filtering. The fuel line piping, which conducts the liquid hydrogen to the fuel pump and engine will be insulated with a vacuum jacket to minimize heat leakage. The piping will include a flexible bellows that will allow mechanical movement of the piping to correspond to structure deflections in the stage and engine. The flow rate of the fuel line system is about 80 pounds/second of LH_2 at nominal tank pressures and is designed to withstand surge pressures experienced during tests and in flight.

9.5.4.3.4 LOX SYSTEM. The liquid oxygen container volume is approximately 2828 cubic feet, which allows for a useable LOX supply of 191,667 pounds. This volume will provide Saturn IB mission oxidizer capacity plus approximately 2 percent ullage. The tank will be pressurized to 38.5 ± 1.5 psia from a ground source of low temperature helium gas. This pressure will be maintained in flight by cold helium gas stored in 3000 psi high-pressure spheres located inside the adjacent liquid hydrogen tank. The helium gas will be reduced to a low pressure by expanding it and passing it through a heat exchanger mounted on the J-2 engine. An orifice between the regulator and heat exchanger will provide a constant pressurant flow-rate to the LOX container.

A constant container pressure will be maintained without venting under varying conditions of heat transfer and mass transfer inside the LOX container. This constant pressure will be maintained by diverting the helium gas pressurant to by-pass the heat exchanger, thus varying the temperature of the pressurant at the LOX container inlet. The oxidizer tank vent system will consist of a tee assembly with a pneumatically-operated combination of a vent-relief valve and a backup relief valve. Each relief valve will provide enough vent area to maintain safe pressure limits within the tank even if the other valve fails to operate. The relief valves will be set to reach the fully opened position at a nominal tank pressure of 44 psia. A screen located at the tank outlet will provide vortex suppression and liquid oxygen filtering. No problem is anticipated in maintaining proper inlet pressure for the LOX pump or in meeting the requirement for orbital-coast (zero-gravity) venting of excess ullage pressure. The fact that the heat leak into the LOX container is nearly equal to the heat loss from the LOX container to the hydrogen container simplifies the problems of maintaining proper pump net positive suction head and zero-gravity venting capability. The liquid oxygen line from the tank to the LOX pump and to the engine will be insulated to minimize heat transfer and will include a flexible bellows to provide for structural deflections of the piping. The system is designed to withstand the surge pressures which will be experienced during tests and in flight.

9.5.4.3.5 PROPELLANT UTILIZATION SYSTEM. The propellant utilization system is designed to effect maximum utilization of propellants by maintaining the proper ratio of LOX to fuel remaining in the stage tanks at any time during J-2 engine operation.

The propellant utilization system will also insure proper loading and replenishing of the LOX and the liquid hydrogen propellants into the stage tanks during pre-launch operations. The propellant sensors provide continuous readout of the status of propellant loading in each of the two tanks. The information is fed back to the ground loading computer. This will enable the computer to control the loading procedure so that the proper useable propellant masses in the stage tanks will be maintained. These functions will be performed automatically and will thus maintain an optimum flight readiness condition until a minimum time before liftoff.

Final propellant topping will be accomplished during the individual propellant container pressurization cycle. Propellant loading, replenishing, and topping will be accomplished in each tank through a single individual fill line for that tank. The capability exists to fill both the oxidizer and the fuel containers within a period of 55 minutes.

The propellant mass sensors and PU electronics assembly will provide continuous signals representative of the propellant mass in each tank to the ground loading computer during propellant loading and replenishing operations and to the onboard telemetry system during S-IVB flight. The sensors will insure a propellant mass loading error for each tank of not more than 1.0 percent. The propellant mass quantity signals will also be sent to the telemetry system for transmission to the ground monitoring stations on an optional basis. Propellant mass sensors will be located in each propellant container and extend the length of the container. These sensors are devices which will detect and indicate propellant mass. They are shaped to compensate for flight ullage temperature and pressure, and tank shape.

The primary purpose of the propellant utilization system is the maintenance of a balanced depletion of propellants. Without this system, oxidizer and fuel could be consumed in such a ratio that one would be exhausted while some of the other would remain.

Such a condition would be detrimental to stage performance for several reasons. The remaining propellant would represent a loss in propulsive energy, a weight burden, and an offset in center of gravity of the stage. Also, the J-2 engine could be damaged by overheating if the liquid hydrogen propellant were depleted and the engine permitted to operate in a LOX rich condition. Engine damage could extend to stage damage or possibly to stage destruction.

The propellant utilization system will employ the propellant mass sensors to measure the propellant quantity in each tank, the propellant utilization valve mounted on the J-2 engine to vary the consumption of these propellants, and the propellant utilization electronics assembly to control the system. The electronics assembly receives the tank mass signals and compares them to a pre-programmed mass reference ratio. If the sensed propellant masses differ from this reference ratio, an error signal will be generated and sent to the propellant utilization valve. The signal will position the valve so that the engine will operate at an engine mixture ratio which will consume the excess propellant and therefore drive the actual propellant mass ratio back to the reference ratio. Control of the actual propellants continues throughout the flight until the stage cutoff is commanded by either attainment of the required velocity or propellant depletion. The error signal from the electronics assembly is also furnished to the stage telemetry system where it is transmitted for flight evaluation. The propellant utilization system will provide simultaneous depletion of propellants to within 0.25 percent by mass of propellant capacity (i.e., 575 pounds).

The J-2 engine will be cut off prior to complete exhaustion of propellants to assure a fuel-rich mixture for engine cutoff to prevent damage to the engine. Damage would result if the fuel should be exhausted before the oxidizer and consequently a LOX-rich combustion should occur. Destruction of the J-2 engine could result in damage, fire, or explosion involving the S-IVB stage and hence disintegration of the entire second flight configuration of the Saturn IB space vehicle.

The flow of liquid oxygen and liquid hydrogen to the engine will be stopped following receipt of inputs from liquid level propellant depletion sensors. Actual cutoff of propellants will be made by closing the main propellant valves. The prevalves will be closed after the main propellant valves are closed. This provides a redundant means of terminating propellant flow.

9.5.4.3.6 ENGINE CHILLDOWN SYSTEM. Chilldown pumps, one located in each propellant container, circulate LOX and LH_2 through the propellant feed ducts and the J-2 engine turbopumps. Engine chilldown will begin about 10 minutes prior to launch and continue until just after separation.

9.5.4.4 FLIGHT CONTROL SYSTEM

9.5.4.4.1 PURPOSE. The S-IVB stage flight control system directs and regulates the performance of the vehicle during the period just after first stage separation until the spacecraft is detached and withdrawn from the launch vehicle. This will take place at the conclusion of the turnaround and docking maneuver which is conducted in earth orbit. The system is composed of four retro rockets, three ullage rockets, the hydraulic system, and an auxiliary propulsion system.

The stage flight control system will receive inputs from within the S-IVB stage as well as from the guidance computer located in the IU. In response to these inputs the system will exercise control over the propulsion system, the separation sequence, and the auxiliary propulsion system to accomplish its objectives.

The S-IVB stage flight control system provides control of the vehicle during powered operation of the stage main propulsion system. The system will exercise control in the pitch and yaw planes by gimbaling the operating J-2 engine to produce changes in thrust vector and hence changes in direction of the vehicle flight path. The flight control system will provide control in the roll plane by energizing appropriate attitude control engines in the auxiliary propulsion system.

The flight control system will provide control of the vehicle during the period in which the configuration is coasting in earth orbit. The J-2 engine will be inoperative during this period and hence incapable of providing any vehicle control functions. The system will exercise control in the roll, pitch and yaw planes during the orbital coast period by energizing the auxiliary propulsion system attitude control engines.

9.5.4.4.2 HYDRAULIC SYSTEM. The S-IVB stage hydraulic system will provide position control of the main propulsion engine upon command from the

IU. Position control by means of the hydraulic system will produce gimbaling action of the J-2 engine over a ± 7 degree range from the null position in a square pattern. Engine gimbaling will be utilized to vary the direction of engine thrust and thereby provide resultant pitch and yaw control of the vehicle during J-2 engine operation.

The S-IVB stage hydraulic system will comprise a main hydraulic pump, an auxiliary hydraulic pump, an accumulator, a reservoir, piping, two electro-hydraulic servovalves, two hydraulic actuators, relief valves, check valves, filters, and instrumentation (position-indicating) transducers. The auxiliary hydraulic pump, driven by an electric motor, will be used to furnish pressure for checkout of the hydraulic system on the ground. It will be used also in flight for pressurizing the system prior to first stage separation to hydraulically hold the engine in a centered null position to prevent gimbal-like pendulum responses from forces encountered during S-IB stage burn.

The main hydraulic pump will furnish pressure for the hydraulic system during powered operation of the J-2 engine and the accumulator will provide a limited-pressure source which will compensate for line pressure drops. The accumulator will thus minimize pressure surges in the system which would otherwise result in erratic actuator control. The reservoir will provide an additional supply of hydraulic oil and a surplus system volume. These reserves will compensate for losses due to hydraulic oil leakage and for volumetric changes due to fluid expansion or contraction under thermal variations.

Engine position control will be effected through two hydraulic actuators each of which is fixed to the S-IVB stage structure at one end and to the J-2 engine at the other. The actuators will be mounted 90 degrees apart on the circumference of the engine. Thus, movement of one actuator will alter the engine thrust vector in the pitch plane, and movement of the other actuator will alter the engine thrust vector in the yaw plane.

The hydraulic system will be an independent, closed-loop system. The main hydraulic pump will pressurize the system to approximately 3650 psi to provide motive force to the actuators through the electro-hydraulic servovalves. A servovalve on each hydraulic actuator will apply high-pressure hydraulic fluid to one side of the actuator piston and low-pressure fluid to the other side of the piston,thus extending (or retracting) the actuator arm, which will effect gimbaling action of the J-2 engine. The hydraulic system control equipment will provide a minimum engine position rate of 8 degrees per second in each plane of motion (pitch or yaw) under any calculated flight load. The hydraulic control equipment will insure that minimum angular acceleration will be consistent with flight control requirements and that the average angular acceleration will be 100 degrees per second, per second.

9.5.4.4.3 AUXILIARY PROPULSION SYSTEM. The S-IVB, having only one main engine, requires the auxiliary propulsion system (APS) to provide roll control during powered flight. Because the stage is required to coast during its mission, it also requires three-axis control during these coast periods. This is accomplished through two bolt-on APS modules positioned on the S-IVB aft skirt 180 degrees apart just forward of the separation plane. Each module will contain three ablative-type control engines which develop 150 pounds of thrust at a chamber pressure of 100 psi and utilize a molybdenum hard throat. These non-gimbaling engines are pulse-type engines designed to be fired in very short duration bursts for conservation of propellants. They can be fired for a minimem pulse duration of 70 milliseconds. The engines burn storable hypergolic propellants. The oxidizer is nitrogen tetroxide (N_2O_4) and the fuel is monomethyl hydrazine (MMH). For the Saturn IB mission each module requires about 60 pounds of propellant. These propellants are contained in 775 cubic inch cylindrical tanks of the positive-expulsion metallic bellows type. Integrated into each propellant tank is a 3,000 psi helium sphere which is used to collapse the bellows to provide the positive expulsion which pressure-feeds the propellants to the thrust chambers of the APS engines. Since the propellants are hypergolic they will ignite upon admixture and will not require any separate ignition device.

The APS will provide control of the vehicle in the roll plane during powered flight of the S-IVB stage. During this time, control in the pitch and yaw planes will be maintained by gimbaling the operating J-2 engine and thereby utilizing thrust vector changes for correction of pitch and yaw errors. The APS will provide complete control of the vehicle in attitude (roll, pitch, and yaw) upon injection into earth orbit and during the orbital coast period. The J-2 engine will be cut off after entering earth orbit and hence will not contribute to attitude control thereafter. The APS will apply these controls either independently in the roll, pitch, or yaw planes or simultaneously in any combination of these three planes by means of appropriately directed thrust vectors in response to attitude control commands from the IU.

In addition, the APS will provide attitude control of the vehicle during some of the earth orbital checkout tests of the Apollo spacecraft. These tests, sometimes referred to as "Saturn V type maneuver exercises," will be conducted by the astronaut crew during the seven hour period of orbital coast. The purpose of the tests will be the evaluation of the Apollo spacecraft capability to perform the maneuvers which will be required to land astronauts on the moon and return them to the earth. Thus, the earth orbital tests of the Apollo spacecraft conducted during the Saturn IB Program will qualify the spacecraft design for actual lunar landing at a future date during the Saturn V Program.

The APS will be active throughout the rendezvous and docking maneuver of the spacecraft and throughout the subsequent procedure wherein the craft will disengage and withdraw from the S-IVB stage and instrument unit combination. Thereafter, the APS will no longer be able to contribute to the Apollo spacecraft mission, since it will be discarded along with the last remaining elements of the Saturn IB launch vehicle.

9.5.4.4.4 RETRO ROCKETS. Four modified Thiokol Recruit TE-29-IB solid fuel rockets are installed 90 degrees apart on the circumference of the S-IVB interstage. These rockets are enclosed in aerodynamic fairings and mounted such that their 1-1/2 second duration thrust of 34,860 pounds will decelerate the combined S-IB stage and S-IVB interstage after inflight separation. Two exploding bridge wire (EBW) initiators will be used to fire each of the four retrorockets. Either of the two initiators is capable of independently firing the motors.

9.5.4.4.5 ULLAGE ROCKETS. Three Th[illegible] mounted in jettisonable fairing 120 degrees apart on the S-[illegible] rocket has a nominal thrust of 3,460 pounds and burns for about 3. [illegible] upon activation by programmed signals from the IU via the stage sequencer. These rockets will fire in unison just prior to S-IB and S-IVB stage separation to provide 0.01g acceleration to seat the S-IVB propellants properly during J-2 engine start and thrust buildup and will also aid in effecting complete separation between the S-IB and S-IVB stages. Upon completion of J-2 engine thrust buildup and approximately 10 seconds after separation, the ullage rockets and their aerodynamic fairings will be jettisoned from the S-IVB stage. The ullage rockets and the ullage fairing jettison system will be ignited by an EBW ordnance system.

9.5.4.5 ELECTRICAL SYSTEM

9.5.4.5.1 GENERAL DESCRIPTION. The S-IVB stage electrical system will be composed of the components and networks required to generate and distribute electrical power throughout the stage. It will also include those elements necessary for control of the stage systems used for powered flight control, orbital coast control, sequencing, propellant utilization, explosive bridge wire initiation, stage separation, emergency malfunction detection, and stage status and performance instrumentation. The stage electrical system will be compatible with the automatic checkout equipment located at the Launch Facility at Cape Kennedy, Florida. The electrical system will consist of two major subdivisions, the electrical power system and the electrical control system.

9.5.4.5.2 ELECTRICAL POWER SYSTEM. The S-IVB stage will have an independent electrical power system to provide power for the S-IVB stage during the period of powered flight and 7 hour earth orbital coast. The electrical power system will generate and distribute both alternating and direct current electrical power for all of the stage loads and will consist of equipment necessary for the generation, conversion, control, and distribution systems in the stage. The electrical power system will consist of batteries, a static inverter/converter, a distribution network, a bonding and grounding network, and two chilldown inverters. Silver-zinc batteries will supply dc power for steady-state flight loads, high-power, short duration loads required during transient conditions, hydraulic system power unit loads and S-IVB stage propulsion loads required during engine operation, and emergency power for the emergency detection system and the destruct system, as required. The static inverter/converter will operate upon a +28 Vdc input and provide the following ac and dc output voltages for use in the APS.

115 ± 3 percent Vac, 400 cycles ± 1 percent single phase

2 ± 3 percent Vac, 400 cycles ± 1 percent single phase

117 ± 2 percent Vdc

22 ± 2 percent Vdc

5 ± 2 percent Vdc

Each of the two chilldown inverters will produce 56 Vac, 400 cycle, three-phase power for operation of two chilldown motors.

The electrical distributing network will consist of power busses, cabling, power distribution boxes, switches, protective devices, and test connections. The main power bus will provide electrical power distribution during flight. Network switching will provide for peak power requirements and for power management. The dc power will be regulated and maintained at a value of + 28 Vdc (+2, -4) at the equipment input terminals. The hydraulic pump motor starting current is of such magnitude that regulation to within the above limits will be possible during operation of the pump but not during starting transient conditions.

The electrical bonding and grounding network will minimize radio frequency interference (RFI) in accordance with the requirements of Military Specifications MIL-B-5087A, MIL-I-6181D and MIL-E-6051C. The S-IVB stage structure will be used for the negative return on dc circuits. Neutral return wires will be provided for ac circuits. The ac circuits will not use the stage structure for a neutral return. All signal circuits will be twisted-pair wires properly terminated at each end and grounded as may be required by circuit design, using a single-point ground. The electrical bonding and grounding network will minimize electromagnetic radiation and interference.

The interconnection cabling assemblies will consist of several wiring harnesses which will provide interconnection among the S-IVB stage electrical and electronic systems. Assemblies will provide wiring continuity from the stage equipment to the trunklines which extend the length of the stage and from the trunklines to the umbilical connections.

The S-IVB stage electrical umbilical connectors are the mechanical connections through which electrical interchange will be made between the Launch Facility and the stage. These connectors will be "dead faced," upon command, to isolate the stage electrical power sources from the stage electrical umbilical connector pins. This isolation will be accomplished during checkout and again prior to withdrawal of the umbilical tower arm from the stage at liftoff.

"Dead facing" will be provided during stage checkout as a means of separating the stage equipment from ground power and thus assuring that the stage electrical power system will function properly as an independent unit. During actual launch procedures "dead facing" will be required to isolate the stage power from the ground power for final checks before launch. The stage power system must display its capability to assume power responsibilities during final ground checkout or the vehicle will not be sent the signals which will commit it to launch. "Dead facing" of the stage umbilical connector pins will be mandatory througout flight to prevent arcing across the pins either at high altitude or in the vacuum of space where voltage breakdown resistance across the gap between the pins will be minimum. Arcing across these connector pins could cause an explosion in flight if it coincided with a flow of flammable gases past the umbilical plate during propellant tank venting.

"Dead facing" will be accomplished by "bus logic," a switching arrangement which will remove power from the connector pins approximately 300 to 400 milliseconds before the vehicle is committed to launch. Positive disconnection of the Launch Facility umbilical arm multiple-connector assembly from the stage connectors will be accomplished by an electropneumatic device on the umbilical arm carrier plate. Upon receipt of an electrical signal, a solenoid actuating valve will supply pneumatic pressure to the umbilical arm "push-offs." These "push-offs" will extend actuators and force the umbilical arm connectors free from the stage just prior to withdrawal of the umbilical arm at liftoff. The Launch Facility electrical umbilical cables which connect to the S-IVB stage electrical umbilical connectors will be supported by the umbilical tower swing arm. These cables will be moved clear of the Saturn IB vehicle at launch by retraction of the swing arm and its carrier plate.

9.5.4.5.3 ELECTRICAL CONTROL SYSTEM. The S-IVB stage electrical control system will exercise regulation over various aspects of the propulsion system and the flight control system. The electrical control system consists of a switch selector which will decode discrete commands from the IU, a sequencer which will provide time-phased commands within the S-IVB stage, and a control network which will distribute the signals. The system will operate on either ground electrical power or stage internal electrical power as required and will provide input signals to the propulsion and flight control systems either directly from the sequencer located in the stage or indirectly from the vehicle flight computer, a component of the guidance and control system located in the IU, via the switch selector and/or sequencer.

The S-IVB stage sequencer will provide in-flight control of an established sequence of events which will occur during a normal flight mission. The sequencer will perform this control by a process termed "relay logic." The sequencer will receive input signals from within the IU through the stage switch selectors as well as the systems within the S-IVB stage. The sequencer will respond to these inputs by providing or removing power from appropriate circuits and thereby initiating various flights functions. The sequencer is designed to perform logical gating of inputs necessary for sequencing control with as few timed inputs as possible from the guidance and control system. The sequencer will control only those functions which are established sequenced events. The solid state switch selector will convert discrete digital inputs from the IU guidance computer to output signals to the sequencer or to the applicable hardware actuation circuits. The attitude error signals to the engine hydraulic actuators will be routed from the IU analog flight control computer.

9.5.4.6 INSTRUMENTATION AND RANGE SAFETY SYSTEM

9.5.4.6.1 GENERAL DESCRIPTION. The instrumentation and range safety system of the S-IVB stage consists of a measuring system, telemetry system, radio frequency (RF) system, and range safety system. The measuring system will detect parameters indicative of stage status and performance during checkout and flight, and relay this information to the telemetry system. The telemetry system will transmit the information gained to the ground monitoring stations via the radio frequency (RF) system where it will be recorded and analyzed. The instrumentation system is designed to provide the channel capacity, frequency response, and accuracy necessary for the instrumentation of the S-IVB stage during its development flights and for the Saturn IB operational missions.

The first four S-IVB flight stages will contain a greater amount of instrumentation equipment and data sampling capacity than will the following operational flight stages. The operational missions will have reduced instrumentation capability in order to provide less complex stage and greater payload capability for launch vehicle due to the reduced weight. The reduction in instrumentation from the developmental flights to the operation of missions will amount to about 1600 pounds.

9.5.4.6.2 TELEMETRY AND MEASURING SYSTEM. The measuring system will consist of the electronic, electrical, and mechanical devices necessary for sensing the stage status and performance data, connecting these data into analogous dc voltage signals, and applying them to the telemetry system equipment. The measuring system will consist of transducers, signal conditioners, and measuring racks. Typical parameters to be sampled are temperature, pressure, vibration, strain, acoustics, accelerations, electrical power supply frequencies, voltages and currents, and switch and valve position.

Since many of the source signals are unsuitable for use by the telemetry system, signal conditioners will be used to transform the outputs of the transducers into signals compatible with the input signal requirements of the telemetry system. The measuring racks will distribute the transducer signals from the signal conditioners to the telemetry system. The developmental flights will require about 500 measurements while the operational flight requirement will be reduced to about 250 measurements.

The telemetry system consists of five subsystems utilizing four basic modulation schemes, Pulse Code Modulation/Frequency Modulation (PCM/FM), Pulse Amplitude Modulation/FM (PAM/FM), FM/FM, and Single Sideband/FM (SS/FM). For developmental flights the telemetry system will consist of three PAM/FM telemeters, one PCM/FM telemeter, one SS/FM telemeter, and one tape recorder. For operational flights this will be reduced to one PCM/FM system with provisions for rapidly mounting a PAM/FM telemeter if necessary.

The basic PCM/FM system accepts 7200 words per minute and digitizes these to a 10-bit accuracy. The primary use of the PCM system will be for the implementation of prelaunch automatic checkout of the vehicle. As a secondary role, the PCM system will serve as an accurate redundant data link for the sampled PAM information. The PCM system will accept inputs from two 30 x 210 PAM high-level multiplexers together with a remote digital and remote analog low-level submultiplexer operating into a PCM/Digital Data Acquisition System (PCM/DDAS). Each time-division multiplexer has 27 primary data channels with each channel sampled 120 times per second. The first 23 of these channels may each be submultiplexed internally by 10 subchannels to produce a sampling rate of 12 samples per second. This provides a total capability of 81 (3 x 27) prime channels at 120 samples per second, or 690 (3 x 10 x 23) submultiplexed channels plus 12 prime channels, or any combination of the above. All mission control data will be redundantly transmitted by the PCM/RF links in the S-IVB and IU.

Automatic checkout of the operational S-IVB stage is accomplished by utilizing a remote automatic calibration system (RACS) in conjunction with the PCM/DDAS link. The RACS contains equipment which will insert calibration resistances in to the input circuits of the signal conditioning modules to simulate transducer outputs. Checkout information carried through, or originating in, the modules is sent to the PAM multiplexers. These multiplexers transform the input into a wane train of equally spaced pulses of constant pulse width and varying amplitude, which are then transferred to the PCM/DDAS assembly to be digitized. The digitized pulse-trains modulate a 600 kc voltage-controlled oscillator and are carried on coaxial cable to the GSE reduction equipment.

The three PAM/FM links will provide data at a sample rate of 3600 samples per second through modulation of 70 kc voltage-controlled oscillators (VCO's) in the FM/FM sets. Because of the inherently high reliability and high data capacity of the PAM/FM/FM links, they are considered the primary data acquisition source. The three FM/FM sets accommodating the PAM channels will contain VCO's for 2 through 15 with plug-in provisions made for the standard inter-range instrumentation group (IRIG) Channels. Each set will be capable of accommodating the 3,600 pulse-per-second output of the one PAM multiplexer on the 70 kc channel.

Because of the developmental information required on early Saturn IB flights, retrieval of acoustics and vibration data is considered of prime importance. The function of the SS/FM telemetry unit is handled such wideband information. This link has 15 channels with a response of 3000 cycles per second.

An airborne tape recorder will be used on the PCM/FM system on developmental flights to recover information normally lost during "over-the-horizon" periods of orbital missions and during stage separation when ullage and retro rockets activation tends to cause telemetry signal interference. The recorder will store a portion of the sampled data for a maximum of 56 minutes and playback in 7 minutes upon command from one of the several selected ground stations.

This RF system is similar to S-IB stage RF system (Section 9.5.3.6.4). The five 25 Watt RF transmitters (3 FM/FM, 1 SS/FM, 1 PCM/FM) will operate in the 225 to 260 Mc band and be capable of sufficient power output to meet mission requirements. The telemetry antennas are designed to provide pattern flexibility, directivity, gain, coverage, array, and electrical switching capability consistent with the various mission applications.

The PCM/RF system will consist of the PCM transmitter, bidirectional coupler, coaxial switch, power divider, and antenna. Omnidirectional antenna pattern coverage is provided by two antennas. Automatic checkout is achieved by using the bidirectional coupler and two RF detectors to measure forward and reflected power. Closed-loop checkout will be achieved by using the coaxial switch.

9.5.4.6.3 RANGE SAFETY SYSTEM. The S-IVB stage range safety system is an emergency system designed to prevent the stage and its associated components from becoming a safety hazard in the event of erratic flight of the vehicle. The system will be initiated by the Range Safety Officer of the Eastern Test Range (ETR) only as an emergency situation may require and will be triggered by means of a radio link from ground range safety stations located along ETR. The range safety system will act through the stage radio frequency (RF) system, the destruct system, and the emergency detection system. By means of these other systems the stage range safety system will provide the following sequenced events: abort of the CM, cutoff of the J-2 engine (if first stage separation has already taken place and the engine is therefore operating), and rupture of the stage propellants tanks with resultant dispersion of propellants. Prior to first stage separation, the range safety system of the S-IVB stage and of the S-IB stage will be interconnected so that initiation of one system will automatically energize the other with simultaneous dispersion of the propellants from both stages.

The stage range safety system will be designed in accordance with the requirements of the Air Force Missile Test Center. Two range safety receivers and two range safety controllers will supervise the operation of the destruct system. System closed-loop checkout capability is provided by a directional power divider which consists of a single assembly containing two bidirectional couplers. The divider will be connected to the two range safety command receivers and the forward umbilical by three coaxial cables.

A more definitive description of the Destruct System itself can be found in section 9.5.4.7.

9.5.4.7 ORDNANCE SYSTEM

9.5.4.7.1 GENERAL DESCRIPTION. The S-IVB stage ordnance system consists of a flight separation system and a destruct system. Installation of all ordnance system devices will be accomplished at the launch site. Launch safety will be provided by remote-controlled safety and arming mechanisms to interrupt the dual explosive trains.

9.5.4.7.2 FLIGHT SEPARATION SYSTEM. Separation of the combined S-IB stage and S-IVB aft interstage from the S-IVB stage will be accomplished by a skin-cutting technique consisting of a mild detonating fuse and a tension plate separation joint. This separation will be facilitated by a retro rocket system comprising four retrorockets mounted at 90 degrees intervals around the S-IVB aft interstage circumference. Separation will take place at the forward end of the S-IVB aft interstage; the aft interstage will remain attached to the S-IB stage.

Separation of the stages will be aided by the three ullage rockets located in the S-IVB stage aft skirt. The ullage rockets will assist in stage separation by imparting an acceleration in the direction of flight to the S-IVB stage. The primary function of the ullage rockets, however, will be to provide propellant settling in order to attain proper NPSH for the propellant turbopumps. The stage separation sequence will take place upon command from the flight control system of the IU. The separation sequence is defined in section 9.3.2 and section 9.5.3.7.2.

Separation of the combined S-IVB stage and IU from the Apollo spacecraft will not require the use of retrorockets on either the forward part of the S-IVB stage or on the IU; however, the S-IVB stage forward skirt is designed to provide capability for installation of two retrorockets in the event they should be required for future missions. For example, the addition of a third stage, such as the Centaur stage, will necessitate use of retrorockets to facilitate separation.

Separation of the Apollo spacecraft from the S-IVB stage and IU combination will be achieved by the use of reaction control motors on the spacecraft. A skin-cutting explosive will forcibly divide the spacecraft/LEM adapter (SLA) at a separation plane forward of the interface with the IU. The spacecraft adapter will be divided into four segments and folded back 45 degrees from the vehicle centerline. The CSM will then execute the rendezvous and docking maneuver with the LEM. The LEM will remain fixed to the IU and S-IVB stage combination during this maneuver to assure stability of the LEM. Alignment will be attained and physical contact made between the CM and the LEM docking tunnel. The LEM will then be disengaged from the forward part of the IU, and the spacecraft and LEM will be withdrawn from the S-IVB stage and IU combination.

9.5.4.7.3 DESTRUCT SYSTEM. The S-IVB stage destruct system is an emergency system which will be used to terminate propulsion and to rupture the propellant tanks upon command of the range safety system ground stations. The destruct system will be activated only in the event a malfunction should occur during flight that would cause the vehicle to become a hazard to personnel or material. The system will initiate cutoff of the J-2 engine and upon command detonate linear shaped charges to rupture the propellant containers. The fuel and the oxidizer will be dispersed to minimize the possibility of fire or explosion. The systems of both stages are functionally identical. The system of the first stage is described in section 9.5.3.7.3.

The destruct system equipment will consist of a dual system of two EBW firing units, two EBW detonators, a safety and arming device, and a cable harness assembly. The destruct system will consist of a dual, linear shaped charge train for the LH_2 tank, and a single linear shaped change for the LOX tank. The charge trains will be connected by detonating cord leads which will be initiated by two EBW detonators receiving energy from two EBW firing units.

9.5.4.8 ENVIRONMENTAL CONTROL SYSTEM. Certain equipment and instrumentation located in the S-IVB stage forward skirt and aft interstage areas will require stable environmental conditions, maintained within prescribed limits, for proper operation. Control of environmental temperature and of the content of combustible gases will be necessary to prevent equipment malfunctions and to minimize the possibility of fire or explosion. The S-IVB stage thermal control system will provide component temperature control in flight and in earth orbit. The Launch Facility will insure that no combustible gases are present within the interstage while the Saturn IB vehicle is still on the launch pad.

Preflight environmental control will be provided by a low-pressure air source (1.5 psig maximum) external to the launch vehicle until approximately 30 minutes before the beginning of the liquid hydrogen load operations. Thereafter, both the S-IVB stage forward skirt and the aft interstage will be purged with gaseous nitrogen for safety purposes. This nitrogen purge will be maintained until liftoff to reduce the oxygen content of both the forward skirt and the aft interstage to a level insufficient to support combustion. The nitrogen purge will also provide thermal environmental conditioning for these same zones. The conditioned air and the gaseous nitrogen supplied by the Launch Facility will be directed through an umbilical connection in the skin of the S-IVB stage to distribution manifolds located inside the aft skirt. The conditioned air initial purge and the gaseous nitrogen final purge will also be supplied by the Launch Facility through an umbilical connection in the skin of the IU. From this inlet the purge gases will flow into the IU central void and thence into the S-IVB stage forward skirt internal area.

Temperature-sensitive electronic components in the forward skirt area will be actively heat-conditioned by mechanically attaching the components to cold plates through which a fluid of proper temperature is circulated. The components will dissipate heat by conduction through the attach points to the fluid. The cold plates are attached to the inside circumference of the forward skirt 1/4 inch below the S-IVB/IU interface. The inlet and outlet connections of each cold plate are attached to a supply and return manifold attached to the inner forward skirt structure about 6 inches below the bottom of the plates. This manifold is in turn connected to a similar manifold from the IU. The pumping and heat removal equipment for circulating coolant through the manifold is located in the IU. A description of this equipment can be found in section 9.5.5.6. The operating pressure is about 42 psia with a flow rate of about 3500 pounds per hour of a 60/40 percent (by weights) solution of methyl alcohol and distilled water. The temperature of the fluid will be maintained at 59 ± 1°F.

9.5.5 INSTRUMENT UNIT

9.5.5.1 GENERAL. The Instrument Unit (IU) is a major structural and functional segment of the Saturn IB space vehicle. The Instrument Unit contains the principal guidance, control, and monitoring mechanisms which will govern performance of the Saturn IB throughout a major portion of its mission. Instrument Unit control will begin at the time of liftoff, will include injection of the combined S-IVB stage, Instrument Unit, and Apollo spacecraft into earth orbit, and will extend through participation in initial orbital maneuvers thereafter. This period of active participation by elements within the IU will include the various early phases of the mission. Among these phases will be first stage powered flight, first stage separation, second stage powered flight, injection into earth orbit, earth orbital coast stabilization, and spacecraft turn-around and docking maneuvers. IU contribution will continue up through the spacecraft withdrawal from the remainder of the launch vehicle in earth orbit.

The Instrument Unit has a nominal flight weight as shown in Table 9-II and consists of the structural system, guidance and control system, electrical system, instrumentation system and environmental control system. The location of this equipment within the IU is shown in Figure 9-19.

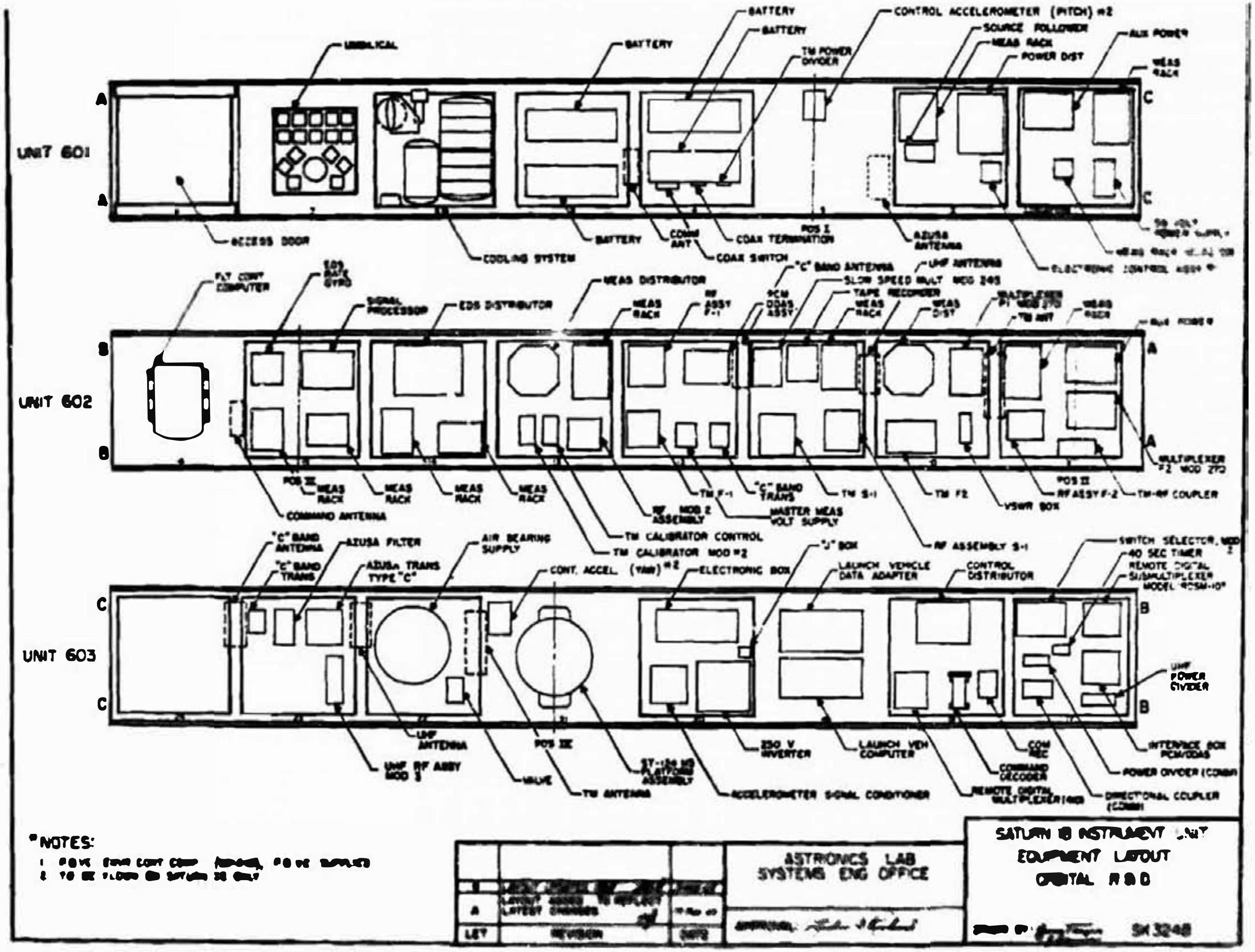


FIGURE 9-19. SATURN IB INSTRUMENT UNIT EQUIPMENT LAYOUT

9.5.5.2 STRUCTURAL SYSTEM. The Instrument Unit (Fig. 9-20) is a cylindrical structure 260 inches in diameter and 36 inches long. The cylindrical structure is divided into three sector segments which may be disassembled to facilitate packaging, handling, and shipment. The IU will be an unpressurized, load-supporting structure of a bonded construction design. It will consist of three 120-degree sector segments which, when fastened together, will comprise the overall cylindrical configuration. Each segment will be of a sandwich-type bonded panel design and will be composed of inner and outer skins, a honeycomb core, and forward and aft interstage connecting rings. These three arc-shaped segments will be assembled by splice plates. Welded brackets will be provided for installation of instrument mounting panels. An umbilical plate and an access door of bonded sandwich-type construction will be provided in one of the 120-degree segment assemblies.

9.5.5.3 GUIDANCE AND CONTROL SYSTEM. The guidance and control system has five major functions:

a. Generation and evaluation of information relative to the instantaneous state of the Saturn IB space vehicle,

b. Performance of inflight calculations concerning times for various inflight sequences,

c. Provision of vehicle function commands associated with engine ignition and cutoff,

d. Stabilization of the vehicle in accordance with information relative to vehicle instantaneous state, and

e. Generation of steering signals to control the vehicle along the predetermined path or along an optimized trajectory, as dictated by the guidance mode.

The guidance and control system which is being developed for the Saturn IB launch vehicle will be utilized also for the Saturn V launch vehicle. The guidance and control system design must be sufficiently versatile to accommodate a wide variety of space vehicle configurations and mission objectives. These requisites will consequently involve such variables as engine thrust parameters and vehicle flight path selections. The guidance and control system of the Saturn IB vehicle will, together with the S-IB switch selector and S-IVB sequencer and switch selector, direct the powered flight of both the S-IB stage and the S-IVB stage. In addition, the guidance and control system will regulate stabilization of the combined S-IVB stage, Instrument Unit, and Apollo spacecraft during the earth orbital coast period.

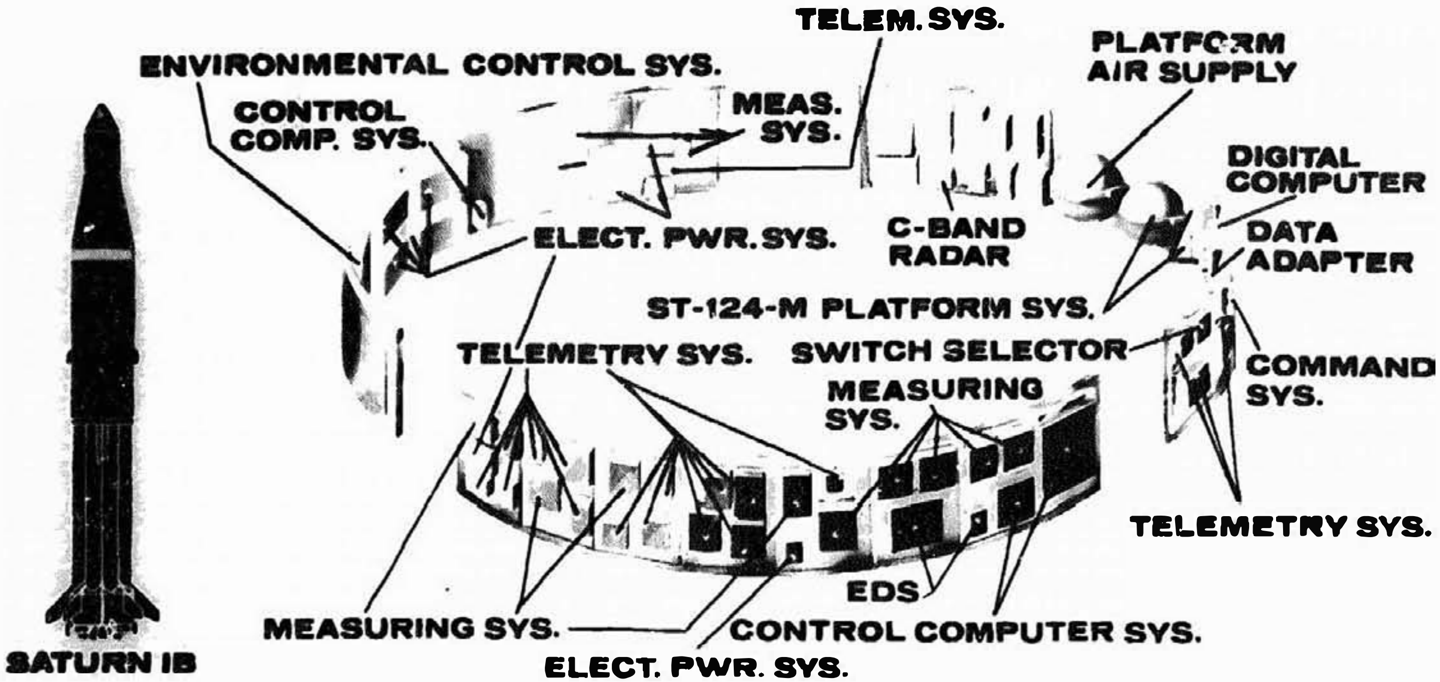


FIGURE 9-20. INSTRUMENT UNIT

During S-IB stage powered flight, the Launch Vehicle Data Adapter (LVDA), the control accelerometers and the control rate gyros (all located in the Instrument Unit) supply the flight control computer with the input signals required for it to generate the engine gimbaling commands as dictated by the drift-minimum control principle (DMP). The DMP may be defined as that case where, by the control mode, an attitude and engine throw-angle combination is enforced that leads to the cancellation of the sum of all force components perpendicular to the nominal flight plane.

During S-IVB stage powered flight, the vehicle will be steered and stabilized in both the pitch and yaw planes by gimbaling the J-2 engine while control in the roll plane will be attained by pulsing the appropriate engines of the auxiliary propulsion system. During the period of earth orbital coast the guidance and control system will maintain proper attitude of the combined S-IVB stage, Instrument Unit and Apollo spacecraft by pulsing the auxiliary propulsion system roll, pitch and yaw attitude control engines. During S-IVB stage powered flight, the vehicle will be steered and stabilized along an optimized trajectory by the guidance and control system utilizing a path-adaptive guidance mode. The path-adaptive guidance mode will provide inflight solutions to guidance equations by means of a digital computer in the vehicle which continuously evaluates the instantaneous vehicle coordinates and flight status. From the evaluation the computer will compute an optimum flight path for the vehicle. This computer will also provide the cutoff command signal through the S-IVB switch selector to the J-2 engine when the orbital injection conditions of position and velocity are fulfilled. A delta-minimum guidance mode will be utilized to provide direction in the cross-range plane. The iterative guidance mode will be utilized in both the pitch and yaw planes.

The guidance and control system will have functional interfaces with the Apollo spacecraft, with a number of the major systems of the Launch Vehicle and with the electrical support equipment (ESE) located at the Launch Facility. The system will incorporate provisions for alignment and checkout during the prelaunch tests of the vehicle conducted at the Launch Facility. The guidance and control system will also determine the instant at which the Saturn IB vehicle has attained the velocity and altitude required for injection into earth orbit and will issue the cutoff command signal to the S-IVB stage J-2 engine.

The integrated guidance and control system (Fig. 9-21) is made up of Launch Vehicle Data Computer (LVDC), LVDA, ST-124M inertial platform system, control computer, rate gyro package, control signal processor, control accelerometers. Two actuators per engine receive retract-or-extend

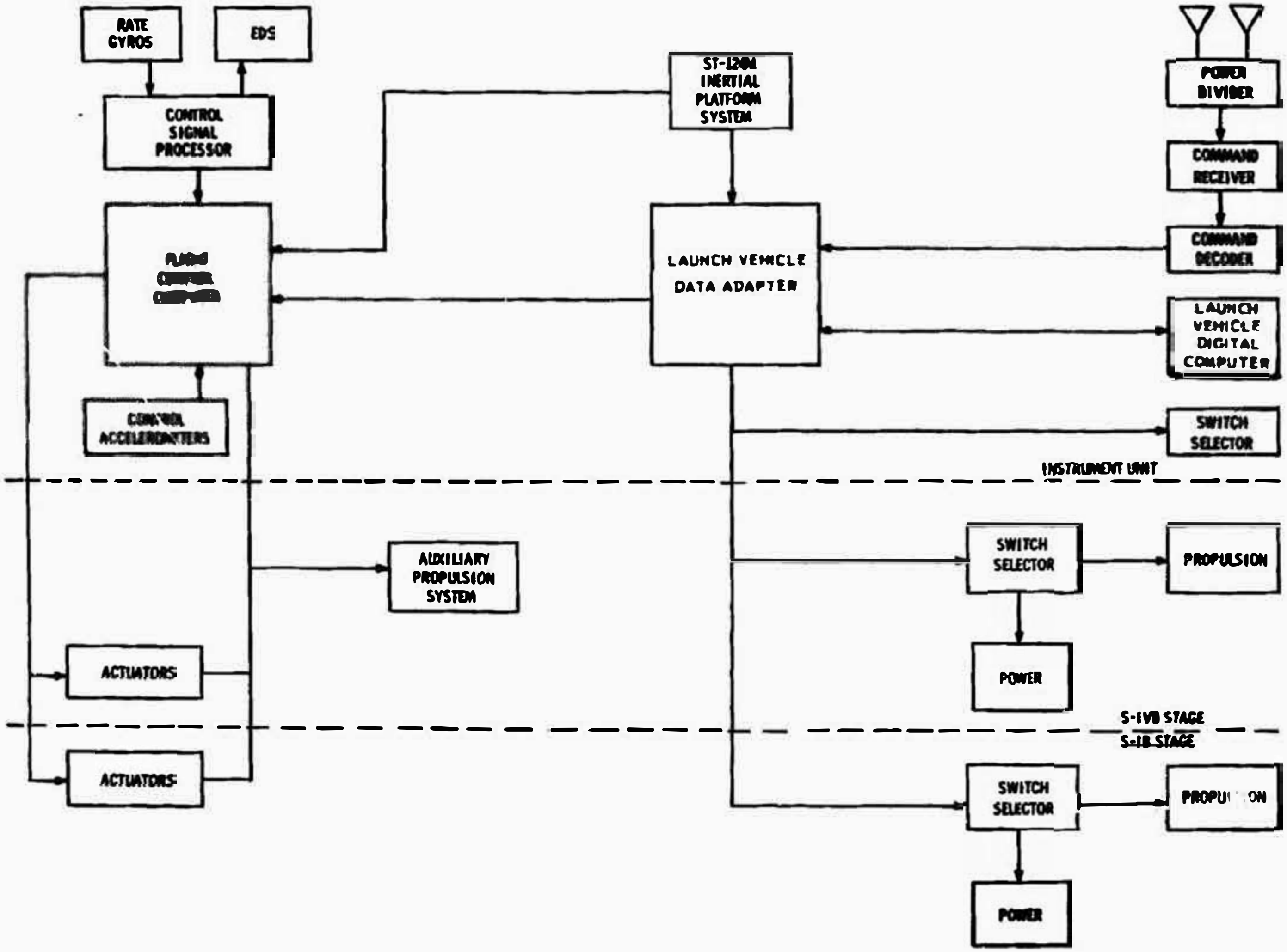


FIGURE 9-21. INTEGRATED GUIDANCE AND CONTROL

signals from the control computer. Control computer signals to the actuators come from the LVDA, control rate gyros and control accelerometer outputs. Sequenced commands for time-dependent operation of various S-IB, S-IVB, and IU systems come from the LVDC, through the data adapter, to the switch selectors on the IU, S-IVB, and S-IB stages.

The ST-124M stabilized platform system provides the inertial reference plane for the guidance system.

An air bearing GN_2 supply system supplies regulated GN_2 to the ST-124M stabilized platform air bearings for preflight and flight operation. The system consists of a storage sphere, a heat exchanger, a pressure regulator, one pressure switch, two filters, two coupling valves, a solenoid valve, and associated plumbing. During preflight operations, GN_2 at 3000 psig flows from a ground source to the two-cubic-foot storage sphere. Should the GN_2 storage sphere pressure drop below 925 psig during prelaunch system operation, the low pressure switch would deactuate, shutting off the ST-124M. During inflight operation, GN_2 at 3000 psig flows from the storage sphere through a pressure regulator, where the pressure drops to an acceptable value for air bearing operation. Next, the GN_2 flows through a heat exchanger, located on the environmental control system, to the air bearings in the ST-124M. The heat exchanger warms the GN_2 for proper air bearing operation.

The LVDA functions as the input-output signal conditioning device for the LVDC by controlling data flow to and from the computer, providing temporary data storage, transforming data into a form compatible with receiving equipment characteristics and performing simple computational and logical operations on the data. The data adapter consists of a digital section that buffers signal quantities and an analog section that converts analog to digital and vice versa.

The liquid-cooled, serial type, digital computer employs a random access magnetic core memory, microminiature packaging techniques, triple modular redundancy in the control logic, and multiple duplex memory modules for high reliability. The computer functions during prelaunch checkout, launch, S-IB powered flight, S-IVB powered flight, and orbital phases. The guidance computer monitors each sequence of events that it initiates to ensure receipt of and action upon its outputs.

The analog flight control computer receives attitude command signals from the LVDA and dynamic measurements from the rate gyros and accelerometers. From these signals the control computer establishes the allowable rate of attitude correction (based on predetermined limits of vehicle dynamics) and signals the engine actuators to correct vehicle direction to the predetermined trajectory.

Three switch selectors (one each for the S-IB, S-IVB, and IU) link the data adapter to the control distributor on each stage. Each selector consists of two sections: the input or register section composed of latch-type relays powered by the data adapter, and the output relay driver section powered by individual stage power supplies. Parallel wiring of all the switch selectors necessitates a coded input to the proper selector when an LVDA output must go to a particular stage. Once the stage-select signal has been received by the selector, the computer initiates the "read command," allowing the selector or selectors that have been given the stage-select command to drive the additional output.

Single-degree-of-freedom, redundant rate gyros which sense vehicle angular velocity about the pitch, yaw, and roll axes provide attitude rate feedback signals to the control signal processor during all phases of powered flight. The processor in turn feeds its output to the control computer pitch and yaw attitude rate channels. Should velocity rates exceed a specified limit, the rate gyro signals would energize relays in the EDS system to complete the EDS circuit.

Body-fixed control accelerometers provide vehicle angle-of-attack control from approximately liftoff +30 seconds to liftoff +120 seconds. Angle-of-attack control reduces steady state drift and minimizes bending moments on the vehicle structure by reducing the angle of attack and lateral component of thrust through dominant angle-of-attack feedback.

The IU command system updates guidance information stored in the onboard guidance computer and initiates command functions. The system consists of two antennas, a command receiver, and a command decoder.

9.5.5.4 ELECTRICAL SYSTEM. The electrical system will generate 28 ± 2 Vdc power utilizing four silver-zinc batteries and will distribute all of the power required for operation of its components during flight. A ground source will deliver the same power requirements during prelaunch operations.

The inflight system consists of the four 28 Vdc batteries, a power distributor, two auxiliary power distributors, an EDS distributor, two measuring distributors, and a control distributor. The power distributor supplies battery power via two buses to the two auxiliary power distributors, electrical assemblies within one IU segment, and the 56 Vdc power supply. The auxiliary power distributors supply power to the other two IU segments. The EDS distributor interconnects the EDS systems on each stage and performs EDS switching functions for EDS information to and from the Apollo spacecraft. The two measuring distributors provide measurement signals to the telemetry panels and supply 5 Vdc power to the measuring sensors. The control distributor provides a junction and power distribution point for the vehicle control circuits. The internal relay logic of the control distributor allows it to control equipment sequencing and distribution of power through its control of the contactors within the power distributor. The IU switch selector, which links the data adapter to the control distributor, accepts the proper power sequencing commands from the data adapter to energize the control distributor. The 56 Vdc power supply converts unregulated power required to operate the ST-124M platform circuits. The dc-to-dc type power supply uses a magnetic amplifier as its control unit.

The electrical system of the instrument unit will be compatible with the automatic checkout equipment located at the Launch Facility and with the Saturn IB vehicle electrical system.

9.5.5.5 INSTRUMENTATION SYSTEM

9.5.5.5.1 GENERAL DESCRIPTION. The instrumentation system is designed to obtain data regarding the Saturn IB vehicle performance parameters and will relay this data to ground stations via radio links. The instrumentation system will consist of two subsystems: a measuring and telemetry system, and tracking system. The measuring and telemetry system will detect performance data and will transmit these data to ground tracking stations via the RF telemetering networks. The tracking system will enable improved mission control and post-flight evaluation, and provide range safety trajectory information. The instrumentation system for operational missions will be reduced from the developmental flight design. This reduction will result in a weight decrease of about 500 pounds.

9.5.5.5.2 <u>TELEMETRY AND MEASURING SYSTEM.</u> The measuring system is a network for detecting conditions present in the Saturn IB vehicle. Inputs to the measuring system will be made by sensing devices located throughout the vehicle. Outputs from the measuring system will be the inputs to the telemetry system through which they will be transferred to ground stations by the RF system transmission. The measuring system is designed primarily for inflight operation but is also active during automatic checkout at the Launch Facility. The measuring system will consist primarily of transducer-type sensing devices for use in detecting quantities which are representative of vehicle performance parameters. In addition, the measuring system will contain signal conditioning equipment for modifying the outputs of some of the sensing devices in accordance with the input signal requirements of the telemetry system. The transducers and sensors convert physical quantities (pressure, temperature, vibration, etc.) into electrical signals that the signal-conditioning modules accept and convert to some voltage value between 0 to 5 Vdc. The signal conditioning modules consist of ac and dc amplifier modules, servo-accelerometer units, and frequency-to-dc converters. A measuring-rack selector determines which vehicle measuring-rack outputs go to the measuring distributors at given times, and provides power distribution for the flight remote automatic calibration system (RACS) equipment. The measuring distributors route the conditioned signals to the proper telemetry channel, which is dependent upon the measurement characteristics. The RACS is used during prelaunch automatic checkout to calibrate the transducers.

The measuring system for developmental instrument units will consist of about 300 measurements but will be reduced to about 140 measurements on operation missions.

The telemetry system is an array of equipment which will function to transmit data detected by the measuring system back to earth for receipt by ground monitoring stations. Rapid sampling techniques will permit transmission of a very large number of individual measurements in rapid succession over only a few radio frequency channels. The telemetry system will have adequate transmission power, channel capacity, and system accuracy to accommodate the stringent requirements of launch vehicle mission monitoring plans. The telemetry system for developmental flights will consist of two FM/FM telemeters, one PCM/FM telemeter, one SS/FM telemeter, and a tape recorder. For operational missions this instrumentation will be reduced to the one PCM/FM set and only one FM/FM telemeter. This telemetry equipment operates identically to similar equipment on the S-IB and S-IVB stages and descriptions of this equipment can be found under the telemetry descriptions of those sections.

The telemetry calibrator assembly provides both control and calibration signals for the subcarrier oscillators of the FM/FM and SS/FM sets during ground test and flight. The calibrator provides only the control signal for the multiplexers, since the multiplexers have built-in calibration capabilities.

The tape recorder records analog data (for periods up to 3 minutes) from the IU telemetry links during separation blackout caused by retrorocket and ullage rocket firing.

The radio frequency (RF) system located in the instrument unit is composed of equipment arrays which transmit, receive, or function as transponders for electromagnetic energy within the radio and radar frequency bands. This system accepts flight measurement data from the telemetry system and transmits this information to the ground monitoring stations via its radio transmission capabilities.

9.5.5.5.3 TRACKING SYSTEM. Tracking of the vehicle by various ground stations enables improved mission control, allows postflight trajectory evaluation, and provides range safety. The combination of several different tracking systems provides the best possible trajectory information for analysis.

The C-band radar system consists of a transponder and an antenna. The antenna accepts single- or double-pulse interrogation signals from a ground station, routes them to the transponder, and retransmits the single pulse output of the transponder over the same antenna to the ground station. The radar ground station determines the vehicle transponder position by measuring range, azimuth angle, and elevation angle. Pulse travel time determines range, while amplitude comparison monopulse techniques provide the angle determination. Propulsion and guidance evaluation and range safety impact predictions come from the Azusa system during powered flight. The Azusa system consists of a transponder, a radio interference filter, and an antenna. The transponder receives a C-band carrier frequency modulated by range signals from a ground tracking station. The transponder simultaneously retransmits the range signals to the tracking station. Range measurement and measurement of two angles at the ground station determines vehicle position.

9.5.5.6 ENVIRONMENTAL CONTROL SYSTEM. The Instrument Unit for the Saturn IB launch vehicle will contain an environmental control system. This is a closed-loop, pressurized, continuous-flow system which will provide environmental control for the equipment located within the Instrument Unit and within the forward skirt zone of the S-IVB stage. Stable optimum environmental conditions are essential to assure proper operation of the electrical and electronic equipment located within these areas. This system will absorb the heat created during operation of the electrical and electronic equipment. The environmental control system equipment in the IU consists of a methanol/water accumulator, a coolant pump, a thermistor, 16 cold plates, two heat exchangers, a flow control valve, two storage spheres, a GN_2/water accumulator, and a sublimator.

The environmental control system will perform its functions by circulating a cooling fluid through "cold plates" upon which the equipment to be cooled will be mounted. The cold plates will consist of a honeycomb type structural material into which tapped bolt holes are drilled for equipment mounting purposes. These holes will be drilled in a 2-inch square pattern over the entire surface of the panel, thus creating a pegboard appearance. The cooling fluid will be composed of 60 percent methanol and 40 percent water by weight.

Pressure for the coolant system will be provided by an electric pump. Upon completion of its passage through the system, where it absorbs heat from the operating equipment, the coolant fluid will be chilled in a sublimator wherein thermal energy stored in the coolant liquid will be dissipated to ice which will evaporate under low pressure and be exhausted through an overboard discharge from the Instrument Unit into space. The coolant will be circulated within several of the Instrument Unit components for additional cooling of those particular units. These components consist of the flight control computer, the ST-124M inertial platform, the data adapter, and the LVDC.

The environmental control system will contain a separate heat exchanger for use during preflight checkout of the Saturn IB vehicle. This preflight heat exchanger will substitute during ground operations for the water-evaporative components of the flight system. The preflight heat exchanger will receive cooling fluid input and circulation pressure from the ground support equipment at the Launch Facility. Circulation of this cooling fluid from the Launch Facility through the preflight heat exchanger will chill the methanol-water solution in the Instrument Unit system during the period of operation on the ground. The methanol-water solution will, in turn, be circulated throughout the regular cold plates to provide environmental control for equipment in the Instrument Unit and in the forward skirt of the S-IVB stage. Once the IU umbilical housing disconnects, no cooling of the onboard coolant occurs until the ambient pressure drops low enough for the sublimator to function. At this time, water will flow through the sublimator where it vaporizes, carrying away heat from the methanol-water mixture, thus cooling the coolant. The water vapor will then vent into the IU/S-IVB interstage area.

The two 3000 psig 50-cubic-inch GN_2 storage spheres pressurize the GN_2/methanol-water accumulator and the GN_2/water accumulator. Both accumulators contain GN_2 and fluid which is separated by a diaphram. A pressure is applied by the GN_2 spheres and the fluid is forced through the coolant lines. The GN_2/methanol-water accumulator provides adequate operating pressure to the coolant circulation pump inlet, dampens temperature fluctuations, and absorbs any fluid thermal expansion. The GN_2/water accumulator provides water flow to the sublimator for inflight cooling of the methanol-water coolant.

A modulation flow control valve located at the sublimator inlet controls the coolant temperature by allowing varying amounts of coolant to either flow through or bypass the sublimator. The thermistor varies the position of the flow control valve.

SECTION 10

RELIABILITY AND QUALITY ASSURANCE

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RELIABILITY AND QUALITY ASSURANCE

10.1 SCOPE

This section sets forth the policies, requirements, disciplines, and procedures for the Saturn IB Reliability and Quality Assurance Program. Included in this section are organizational responsibilities for identifying and interpreting NASA documents affecting the Saturn IB Reliability and Quality Assurance Program, and for assuring their implementation. The requirements established herein are applicable to all NASA organizations and contractors participating in the Saturn IB Program.

10.2 ORGANIZATION AND RESPONSIBILITIES

10.2.1 GENERAL. The various MSFC organizational elements having reliability and quality assurance responsibilities for the Saturn IB Program are described in the following paragraphs.

10.2.2 RELATIONSHIP OF IO WITH R&DO. Industrial Operations, through the Saturn IB Program Office, has the overall responsibility for the conduct and management of the Saturn IB Program. The Saturn IB Reliability and Quality Office, I-I/IB-Q, and other staff offices, provide program management and have overall responsibility for establishing, administering, conducting, and evaluating their respective portions of the Saturn IB Program. Research and Development Operations, through the Quality and Reliability Assurance Laboratory and other Laboratories, provides development and technical capabilities in reliability assurance and other areas to support Industrial Operations by providing the technical input with which the Saturn IB Program Office gives technical direction to its contractors. Industrial Operations utilizes the capabilities of Research and Development Operations in the performance of the functions necessary to accomplish Saturn IB Program objectives.

10.2.3 SATURN IB RELIABILITY AND QUALITY ASSURANCE, I-I/IB-Q. I-I/IB-Q has overall responsibility for administering, coordinating, and evaluating that portion of the Q&RA Program over which the Saturn IB Program Office has cognizance. This responsibility encompasses the Saturn IB Program from initial concept through design, development, manufacture, inspection, ground test, checkout and completion of flight operations. I-I/IB-Q will ensure that MSFC Industrial Operations and R&D Operations elements and MSFC Resident

Offices establish and implement procedures to support the Saturn IB Program and that these elements monitor, evaluate, and provide technical guidance to concerned contractors, subcontractors, suppliers, and government agencies within established requirements and the constraints of this plan.

10.2.4 SATURN IB STAGE PROJECTS. The Saturn IB Stage Projects are responsible for managing the MSFC/Industry performance for their respective areas for all phases of planning, coordination, and contractor technical directions. Stage Projects will:

a. Ensure that R&DO elements and MSFC Resident Offices establish and implement procedures to support individual Saturn IB Stage Offices and that these elements monitor, evaluate, and provide technical guidance to concerned contractors, subcontractors, suppliers, and government agencies within established requirements and the constraints of this plan;

b. Provide the sole point of official direction to contractors and serve as the focal point for all formal contact between contractors and MSFC relating to Saturn IB reliability and quality assurance matters.

10.2.5 MICHOUD ASSEMBLY FACILITIES, INDUSTRIAL OPERATIONS. The Office of Assistant for Quality Assurance and Reliability at Michoud is responsible for assuring that Michoud contractors conduct their portion of the Saturn IB Reliability and Quality Assurance programs in accordance with requirements and within the constraints established by this plan.

10.2.6 QUALITY AND RELIABILITY ASSURANCE LABORATORY (R-QUAL). R-QUAL maintains a composite Reliability and Quality Assurance technical capability in depth which will be used to ensure the technical adequacy and performance of all contractors. R-QUAL will:

a. Serve as the Center central point of authority for developing and establishing MSFC-wide reliability and quality policies, procedures, and capabilities;

b. Support the Saturn IB Program in the establishment, implementation, and evaluation of the reliability and quality assurance programs;

c. Establish, implement, administer, coordinate, and evaluate the Reliability and Quality Assurance programs for the hardware that R&D Operations designs, procures, assembles, tests, etc., for the Saturn IB Program;

d. Perform Reliability and Quality Assurance functions on hardware manufactured and/or assembled at MSFC.

10.2.7 OTHER R&DO LABORATORIES. Other R&DO Laboratories participate in the implementation of reliability and test programs in their design or cognizant areas by mutual agreements with the Q&RA Laboratory.

10.2.8 OPERATIONS AT PRIME CONTRACTORS' PLANTS

10.2.8.1 GENERAL. The following paragraphs define the operational responsibilities and relationships for performance of Reliability and Quality Assurance activities at prime contractors' plants.

10.2.8.2 RESIDENT PROJECT MANAGERS. Each Resident Project Manager:

a. Provides on-site supervision and management of MSFC operations at stage contractor sites and acts as the single overall channel of communications between MSFC and the contractor;

b. Monitors, evaluates, and assesses, through the resident Q&RA Laboratory representative, the Reliability and Quality Assurance Program performance to ensure that Stage Project requirements are met;

c. Is responsive to the policies and requirements established by Center Components as directed by Stage Projects.

10.2.8.3 Q&RA LABORATORY RESIDENT REPRESENTATIVES. The Senior Q&RA Laboratory Representative at the contractor's facility is the focal point for all Q&RA matters at the contractor's plant site. He is responsive to program and technical direction from and utilizes the capabilities of the Q&RA Laboratory in the performance of assigned duties. Q&RA Laboratory Representatives will support the Resident Project Manager in ensuring the overall adequacy of contractor's Reliability and Quality Assurance activities and furnish the technical inputs necessary to direct contractor Reliability and Quality Assurance activities.

10.3 SATURN IB RELIABILITY AND QUALITY ASSURANCE REQUIREMENTS

10.3.1 GENERAL. The objective of the reliability program is the assurance that the Saturn IB launch vehicle will have an inherent reliability acceptance for manned space flight. The inherent design reliability goals are as follows:

a. Flight Vehicle (Total) 0.95 (including engines)

(1) S-IB stage and engines 0.986

(2) S-IVB stage and engine 0.974

(3) Instrument Unit 0.990

(4) Emergency Detection System*

Probability of not inducing a false abort 0.9997.

Probability of detecting a failure 0.9973

(5) H-1 engines 0.99 at 50% confidence

(6) J-2 engine 0.99 at 50% confidence

b. Flight-critical ground support equipment 0.99

The assurance that the Saturn IB reliability is acceptable shall be determined by:

a. Reliability analysis using MSFC approved data and MSFC document 10M30111A, Procedure for Performing System Design Analysis, dated February 10, 1965, as a guideline. Redesign of high criticality items shall be considered along with other methods of failure elimination when the analysis fails to meet the apportioned goals.

b. Test information obtained from acceptance qualification and specific reliability demonstration tests. Test requirements shall be based on NPC 500-10, Apollo Test Requirements, May 20, 1964, as implemented by contractual actions. The test procedures will include an analysis of all failures observed in the test programs and the elimination of the causes of such failures. Engineering appraisal of all available data shall be made to determine the confidence in each article to meet the reliability apportionment.

10.3.2 <u>NPC 250-1, NPC 200-2, AND NPC 200-3.</u> The Provisions of NPC 250-1, Reliability Program Provisions for Space System Contractors, and NPC 200-2,

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*Goals apply to each sensing parameter.

Quality Program Provisions for Space System Contractors, constitute basic requirements for the Saturn IB Program systems. The provisions of NPC 200-3, Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services, constitute basic requirements for Saturn IB Program materials, parts, components, and services. The Saturn IB Program Office is responsible for incorporating the requirements into NASA contracts. NPC 250-1, NPC 200-2 and NPC 200-3, or elements thereof, serve as imposed requirements, and are tailored to meet the needs of the specific contracted tasks. Factors affecting the contractor's reliability and quality assurance plan include equipment complexity, criticality of the system and use, and maturity. When contractor reliability and quality assurances plans are approved by the cognizant Field Center Program Office, they shall serve as the basis for implementation of reliability and quality assurance requirements through the contractor's activities.

Additional provisions to cover the Apollo R&QA will be established in NPC 500-5, Apollo Reliability and Quality Assurance Program Plan.

10.3.3 NPC 200-1A. The provisions of NPC 200-1A, Quality Assurance Provisions for Government Agencies, constitute basic requirements for Government Agencies, either NASA or DOD, at contractors' plants performing inspection and quality assurance functions for NASA.

10.4 PRINCIPAL ELEMENTS OF R&QA PROGRAM

10.4.1 ANALYSIS OF MISSION PROFILE. Analysis of demands on equipment and astronauts during each phase of the mission enables capabilities to be incorporated in the design which permit the crew to abort safely when a dangerous condition is suspected, or to continue the normal mission in an alternate mode if safety is not involved but equipment is not operating properly.

10.4.2 PERFORMANCE OF FAILURE MODE AND EFFECTS ANALYSIS. This procedure requires (1) every mode of failure for every component of each element of the system to be identified, (2) the consequences of each failure mode on the operation of each assembly, subsystem, and system to be detailed, and (3) those components contributing most to unreliability to be identified and ranked according to criticality.

The failure effects analyses assist the designer in making four kinds of decisions: (1) redesign to eliminate the failure mode, (2) redesign to eliminate the consequences of the failure mode if it cannot be eliminated, (3) concentration of development and qualification effort on these areas shown by the analyses to have the most serious consequences, and (4) provision for alternate or redundant modes of operation.

10.4.3 QUALITY ASSURANCE. Controls, covering design activities, appropriate management policies, purchased or fabricated articles, government furnished property, inspection-measuring and test equipment, packaging-handling and shipping of articles, will be established and maintained to ensure performance to contractual requirements. Action will be taken to ensure non-conforming material will not become a part of Saturn IB flight hardware.

10.4.4 PERIODIC DESIGN REVIEW. A systematic design review of each flight critical item is performed using comprehensive check lists, the failure mode and effects analyses, criticality ratings, and reliability predictions. These tools enable the designer to review the design approach for problems not uncovered in previous analyses. Actions will be taken as appropriate to overcome deficiencies noted.

10.4.5 SELECTION OF RELIABLE PARTS, MATERIALS, AND COMPONENTS. Parts and materials previously proved reliable in other missile and space programs will be selected from preferred parts lists and tested to make certain they are satisfactory for the Saturn IB Program. NASA-wide failure reports will be used by the Centers and their contractors to ensure that types of failure already encountered will not be repeated.

10.4.6 TESTING OF EQUIPMENT AND SUBSYSTEMS. It is Saturn IB Program policy to achieve maximum reliability for a given amount of funding by broadening and extending engineering, development, and qualification tests so that reliability, as well as performance, criteria are met.

Ground test programs are planned to determine points of potential failures, establish strength margins, and determine functional capabilities in the space environments to which equipment will be subjected. Drop, vibration, and shock tests, and combined temperature and vacuum tests are examples of the kinds of environments in which Saturn IB equipment must perform successfully. General requirements for Apollo testing are contained in the Apollo Test Requirements Directive, NPC 500-10. Test plans for demonstrating compliance with these requirements are reviewed by Reliability and Quality Assurance personnel at appropriate levels to ensure integration of reliability objectives. Test results will be made available to Reliability and Quality Assurance personnel at appropriate levels for evaluation. Every failure encountered in testing will be studied by the designer and compared with previous failure analyses. Action will be taken to eliminate the cause of failure.

10.4.7 ACCEPTANCE CRITERIA. The formulation of acceptance criteria by which the various hardware items can be evaluated as suitable for flight and/or manrating is required. These criteria are prepared in advance of acceptance and are incorporated as milestones in the Flight Schedules. These criteria must be met, or specifically waived, prior to signing the DD 250 at the point of acceptance. Responsibility for preparation of these criteria and the waiving thereof, if necessary, is placed at the project or stage level except in those cases where direction of the subsystem is not under the Saturn IB Program Office. These criteria, together with waivers, if granted, shall become a part of the Certificate of Flight Worthiness (COFW) in accordance with the Apollo Test Requirements Directive, NPC 500-10.

10.4.8 MISSION SUCCESS AND CREW SAFETY. The primary criterion governing the design of the system is that of achieving mission success without necessitating unacceptable risk of life or permanent serious physical disablement on the part of the crew. Reliability goals and minimum standards of mission success are established in accordance with guidelines of the Apollo Reliability and Quality Assurance Program Plan. Trade-offs in design and performance will be made to establish required use of redundancy, including alternate or backup equipment, to meet the mission goals within the program constraints of time, cost, and weight. Redundancy shall be considered in eliminating single-point failures which might result in the loss of mission or crew.

10.4.9 QUANTITATIVE ASSESSMENT. Probabilistic models for reliability prediction, apportionment, and assessment of the Saturn IB Program reliability during all phases of design and development will be developed and utilized. In addition, reliability data associated with hardware testing and operational use shall be assimilated and correlated with previous predictions to evaluate progress in goal achievement. Specific uses of the models by engineering personnel shall include:

a. Guide to feasibility determination,

b. Basis for system design modification or reallocation of requirements and/or resources.

c. Means of comparing alternative configurations or missions,

d. Aid in the establishment or maintenance of logistic concepts,

e. Indicator in evaluation of equipment design,

f. Warning of the existence of data limitations,

g. Aid in establishing acceptance criteria.

10.4.10 QUALITATIVE ASSESSMENTS. Quantitative assessments are indicative of the inherent design reliability and do not consider the effects of factors such as human induced failures, poor workmanship, or short cuts taken to meet schedule. Test data used for quantitative assessments is limited. For these reasons, qualitative methods must also be employed for engineering evaluation. The effectiveness of the total reliability and quality assurance program is evaluated by means of continuous surveillance and periodic audits.

10.4.11 FAILURE MALFUNCTION REPORTING ANALYSIS AND CORRECTIVE ACTION. A data system will be used by the Centers and contractors to record all discrepancies and failures with appropriate analysis and corrective action taken. This information will be made available to cognizant organizations participating in the Apollo Program together with appropriate follow-up on actions pending.

10.4.12 STATUS REPORTING AND AUDITING. Periodic Reliability and Quality Assurance Status Reports from the various Saturn IB organizational levels (i.e., subcontractors to contractors, contractors to Centers, Centers to Headquarters) are required. The amount of detail in each report shall be compatible with the decision-making authority of the next higher level.

Periodic summary reports of reliability and quality actions are prepared for NASA management to provide progress information and problem area recommendations. Auditing will be performed at intervals to determine how well the next lower level is carrying out its responsibilities.

10.4.13 TRAINING. Adequate training in Reliability and Quality Assurance requirements and applications will be provided to all organizations requiring it. The fabrication, sub-assembly, final assembly, checkout, and test of hardware for research and development programs necessitates care and precision in each operation. Poor workmanship is intolerable. A comprehensive training and certification program for equipment operators is an essential part of the efforts of the Centers and their contractors.

10.5 PROCEDURES FOR IMPLEMENTATION AND CONTROL

The policies, requirements, and disciplines stated in the above paragraphs shall be implemented by the cognizant Saturn IB organizations. Contractors' Reliability and Quality Assurance Plans shall contain milestone schedules for implementation of major activities under Reliability and Quality Assurance cognizance. Certain Reliability and Quality Assurance key events established in the Apollo Reliability and Quality Assurance Program Plan, shall be reflected in the Manned Space Flight Schedules. The schedules will be set so that Reliability and Quality Assurance milestone events are phased in consonance with hardware events.

10.6 RELIABILITY AND QUALITY ASSURANCE CONTROLS

Reliability and quality assurance controls shall be exercised through:

a. Establishment of requirements in, and review of, control documents such as program plans and procurement actions;

b. Assessment of mission success and crew safety against assigned goals for selected hardware systems and mission phases of the Apollo Program through mission model analysis;

c. Establishment of status reporting (including key events and trend indicators) of progress in achieving Reliability and Quality Assurance requirements at intervals from contractor to Center, GA to Center, and Center to MAR;

d. Performance of periodic surveillance and monitoring of Reliability and Quality Assurance activities performed by the various participants of the Saturn IB Program;

e. Assessment of test results for conformance with established qualification and acceptance criteria.

SECTION 11

SAFETY

This section is not applicable to the Saturn IB Program.

SECTION 12

TEST PROGRAM

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SECTION 12

TEST PROGRAM

12.1 INTRODUCTION

12.1.1 GENERAL. The Saturn I/IB test program provides the means to establish the highest possible degree of engineering confidence in the performance of launch vehicle hardware and associated ground support equipment commensurate with budget and schedule constraints. This section summarizes the test program being conducted on the Saturn IB Launch Vehicle. The purpose of the test program is to develop and demonstrate, through extensive ground testing and limited flight testing, the operational capability of the Saturn IB Launch Vehicle. Ground tests are utilized whenever possible to minimize the number and cost of development flight tests.

12.1.2 GROUND TEST PROGRAM. The Ground Test Program is outlined in the Saturn IB Master Test Plan and the series of subordinate detailed test plans. The ground test program is oriented to verify the integrity of hardware design and materials, qualify production hardware and conduct sufficient acceptance and checkout testing to verify operational readiness. The "Building Block" philosophy of ground testing, i.e., testing at piece part, component, subsystem, stage and vehicle levels, is generally followed where possible. The ground test program is summarized in Table 12-I.

12.1.3 FLIGHT TEST PROGRAM. The Flight Test Program is outlined in the Saturn IB Master Test Plan and the Apollo Flight Mission Assignments Document, M-D MA 500-11. Flight testing utilizes the "all-up" philosophy and its purpose is to provide a high degree of confidence in the launch vehicle for man rating. The flight test program has been designed to yield this confidence with a minimum of unmanned flights. It is planned that critical flight hardware be verified by flight testing prior to use on a manned flight.

12.2 RESPONSIBILITIES

12.2.1 SATURN IB PROGRAM OFFICE. The Saturn IB Program Manager has the overall responsibility for the Saturn IB test program consistent with the requirements of the Apollo Program Level I documentation. The following Saturn IB stage and staff offices have been assigned responsibilities in conjunction with the planning and implementation of the Saturn IB test program.

TABLE 12-I. SATURN IB GROUND TEST PROGRAM SUMMARY

ELEMENT	TEST(S)	TEST SITE(S)	RESPONSIBLE AGENCY	TEST CONDUCTOR
S-IB	Qualification	MSFC, Michoud	MSFC	MSFC, CCSD
	Structural	MSFC, Michoud	MSFC	MSFC, CCSD
	Reliability Demonstration	MSFC, Michoud	MSFC	MSFC, CCSD
	Dynamic	MSFC	MSFC	CCSD
	Acceptance	Michoud	MSFC	CCSD
	Acceptance Firing	MSFC	MSFC	MSFC, CCSD
	Facility Checkout	KSC	MSFC, KSC	KSC
	L/V Checkout	KSC (Complex 34 & 37B)	MSFC	KSC
S-IVB	Qualification	Huntington Beach, Santa Monica	MSFC	DAC
	Structural	Huntington Beach	MSFC	DAC
	Reliability Demonstration	Huntington Beach	MSFC	DAC
	Dynamic	MSFC	MSFC	MSFC
	Acceptance	Huntington Beach, SACTO	MSFC	DAC
	Battleship	SACTO	MSFC	DAC
	Acceptance Firing	SACTO	MSFC	DAC
	Facilities Checkout	KSC	MSFC, KSC	KSC
	L/V Checkout	KSC (Complex 34 & 37B)	MSFC	KSC

TABLE 12-I. SATURN IB GROUND TEST PROGRAM SUMMARY (Concluded)

ELEMENT	TEST(S)	TEST SITE(S)	RESPON-SIBLE AGENCY	TEST CONDUCTOR
Instrument Unit	Qualification	Huntsville, Owego, etc.	MSFC	MSFC, IBM, etc.
	Vibration	MSFC (Wyle)	MSFC	Wyle
	Reliability Demonstration	Huntsville, Owego, CCSD, etc.	MSFC	MSFC, IBM, CCSD, etc.
	Structural	MSFC	MSFC	CCSD
	Breadboard	MSFC	MSFC	CCSD
	Dynamic	MSFC	MSFC	CCSD
	Acceptance	MSFC	MSFC	IBM
	Facilities Checkout	KSC	MSFC, KSC	KSC
	L/V Checkout	KSC (Complex 34 & 37B)	MSFC	KSC

12.2.2 SATURN IB TEST OFFICE. The Saturn IB Test Office is responsible for (1) coordinating the establishment of the Saturn IB general and detailed test plans and test requirements; (2) monitoring and evaluating test performance and launch vehicle checkout; and (3) establishing and maintaining the Saturn IB Master Test Plan for the launch vehicle and associated ground support equipment in accordance with the program requirements.

12.2.3 SATURN IB STAGES, INSTRUMENT UNIT, AND GSE OFFICES. These offices are responsible to the Program Manager for the conduct of all Saturn IB tests in the area of their responsibility. They direct the stage and GSE test program to ensure completion in a timely manner compatible with the overall program requirements.

12.3 TEST CONTROL DOCUMENTATION

Control documentation for the Saturn IB Program consists of the following:

Level I

- Apollo Program Development Plan
- Apollo Test Requirements
- Apollo Program Specification
- Apollo Flight Mission Assignments Document
- Apollo Configuration Management Manual

Level II

- Saturn IB Project Development Plan
- Saturn IB Master Test Plan

Level III

- Stage General and Detailed Test Plans
- Contractual Documents
- Contractor Specifications

12.4 GROUND TEST PROGRAM

The ground test program for the Saturn IB Launch Vehicle is outlined below and in Table 12-I. The test activity provides for extensive testing of components, sub-systems, complete stages, and launch vehicles to achieve a high degree of confidence and to insure the flight readiness of the stages and vehicles.

12.4.1 STAGE LEVEL TESTS

12.4.1.1 S-IB STAGE. The S-IB Stage Ground Test Program is defined in the Saturn S-IB Stage Test Plan, dated January 14, 1966. The plan has been written to conform to paragraph 6.2.4 of the Apollo Test Requirements, NPC 500-10. The S-IB Stage testing consists primarily of the following test categories:

a. Specific Ground Tests (Development Tests)

b. Qualification Tests

c. Reliability Tests

d. Acceptance Tests

e. Checkout

12.4.1.2 S-IVB STAGE. The S-IVB Ground Test Program is defined in the Saturn S-IVB General Test Plan dated December 1, 1965, Douglas Report Number SM-41412. The S-IVB Stage Ground Tests include at present six areas of test activities.

a. Research

b. Development Testing

c. Qualification Testing

d. Production Testing

e. Flight Testing

f. Formal Qualification Testing

12.4.1.3 INSTRUMENT UNIT. The Instrument Unit Test Program is defined in the Instrument Unit General Test Plan, dated October, 1966. The planned test programs provide for ground testing of piece parts, components, sub-systems, complete systems and modules to achieve a high degree of confidence that the design is adequate before committing the hardware to flight. The Instrument Unit Ground Tests are composed of the following phases:

a. Development

b. Qualification

c. Reliability

d. Acceptance and Checkout

e. Flight Test Program

12.4.1.4 GROUND SUPPORT EQUIPMENT. GSE is divided into two subdivisions, ESE (Electrical Support Equipment) and MSE (Mechanical Support Equipment). The Test Program for GSE is described in detail in two documents: ESE General Test Plan, dated May 1965, and the MGSE General Test and Documentation Test Plan No. 10M01811, dated March 23, 1966. The GSE Test Program consists of the following:

a. Development Tests

b. Qualifications Tests

c. Acceptance Tests

12.4.2 VEHICLE LEVEL TESTS

12.4.2.1 DYNAMIC TEST PROGRAM. The Saturn IB Dynamic Tests are follow-on tests for the Saturn I Program made necessary by vehicle configuration and mission changes. The vehicle dynamic flight characteristics of structural, guidance, and flight control system design must be verified prior to flight. Details of the Saturn IB Dynamic Test Program are contained in the following documents:

a. The Saturn IB Master Test Plan

b. Test Operations Plan, January 28, 1965

c. Test Requirements Document, February 8, 1965

12.4.2.2 FACILITIES TEST PROGRAM. The primary purpose of the facilities checkout is to insure the maximum degree of reliability and system compatibility between the vehicle and launch facility prior to the operational usage date of the complex. The facilities checkout will include handling and erection of the Saturn IB vehicle, verification of all connections to the launch GSE, operation of pneumatics, operation of the propellant loading systems, and environmental control system.

Delays in the facility modifications to Complex 34 and a portion of its associated GSE required that the Facility Test Program be revised to protect the SA-201 planned launch date. A revised facility checkout plan in conjunction with SA-201 Pre-Launch Checkout plan has been formulated. A summary of these plans is contained in the Saturn IB Master Test Plan.

12.4.2.3 EDS GROUND TEST PROGRAM. The EDS Ground Test Program is designed to provide the maximum practicable assurance that the Emergency Detection System and its components will operate in flight as needed and will not provide false abort signals.

The EDS Test Program consists of three phases:

Phase I	Component Qualification Test
Phase II	Component Reliability Demonstration Test
Phase III	EDS Breadboard Facility

12.5 FLIGHT TEST PROGRAM

The Launch Vehicle Flight Test Program consists of development and subsequent verification flight tests of launch vehicle systems, sub-systems and components. Overall Apollo Flight Test Requirements are specified by the Apollo Flight Mission Assignments Document, M-D MA 500-11, which defines each individual mission and establishes its primary objectives and vehicle configurations. Section 9 of this Saturn IB Launch Vehicle Project Development Plan summarizes the mission assignments for the Saturn IB Flight Program.

The unmanned SA-201 and SA-202 launch vehicles will provide research and development flight test data in support of the follow-on Saturn IB manned flights. The SA-203 unmanned vehicle will provide research and development flight test data in relation to the dynamics of liquid hydrogen under zero G environment as well as verification of the operational Saturn IB launch vehicle configuration. The SA-204 and subsequent launch vehicles are currently planned as the operational launch vehicles for use in the remainder of the Saturn IB Program. Detailed objectives and responsibilities are outlined for each mission in the MSFC Flight Mission Directive for that individual mission. Within the Mission Directive, vehicle configuration is described and referenced, flight trajectories, data acquisition and instrumentation requirements and detailed documentation requirements necessary to meet launch vehicle mission objectives are defined for overall test planning and control.

SECTION 13

ACTIVATION OF LAUNCH SITE FACILITIES AND EQUIPMENT

This section is not applicable to the Saturn IB Program.

SECTION 14

MSFC MISSION OPERATIONS

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SECTION 14

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SECTION 14

MSFC MISSION OPERATIONS

14.1 ORGANIZATION

An MSFC Mission Operations Office has been established to plan, coordinate, and direct from one single centralized point all activities involved with accomplishing MSFC's mission operations role pertaining to manned and unmanned launch vehicles during space flight mission, flight tests or similar operations. The manager of this office reports directly to the Director, Industrial Operations, and represents MSFC in mission operations reviews and assessments, and in specific coordination groups such as the Operations Management Group and the Flight Operations Panel. Figure 14-1 shows the organization of the MSFC Mission Operations Office.

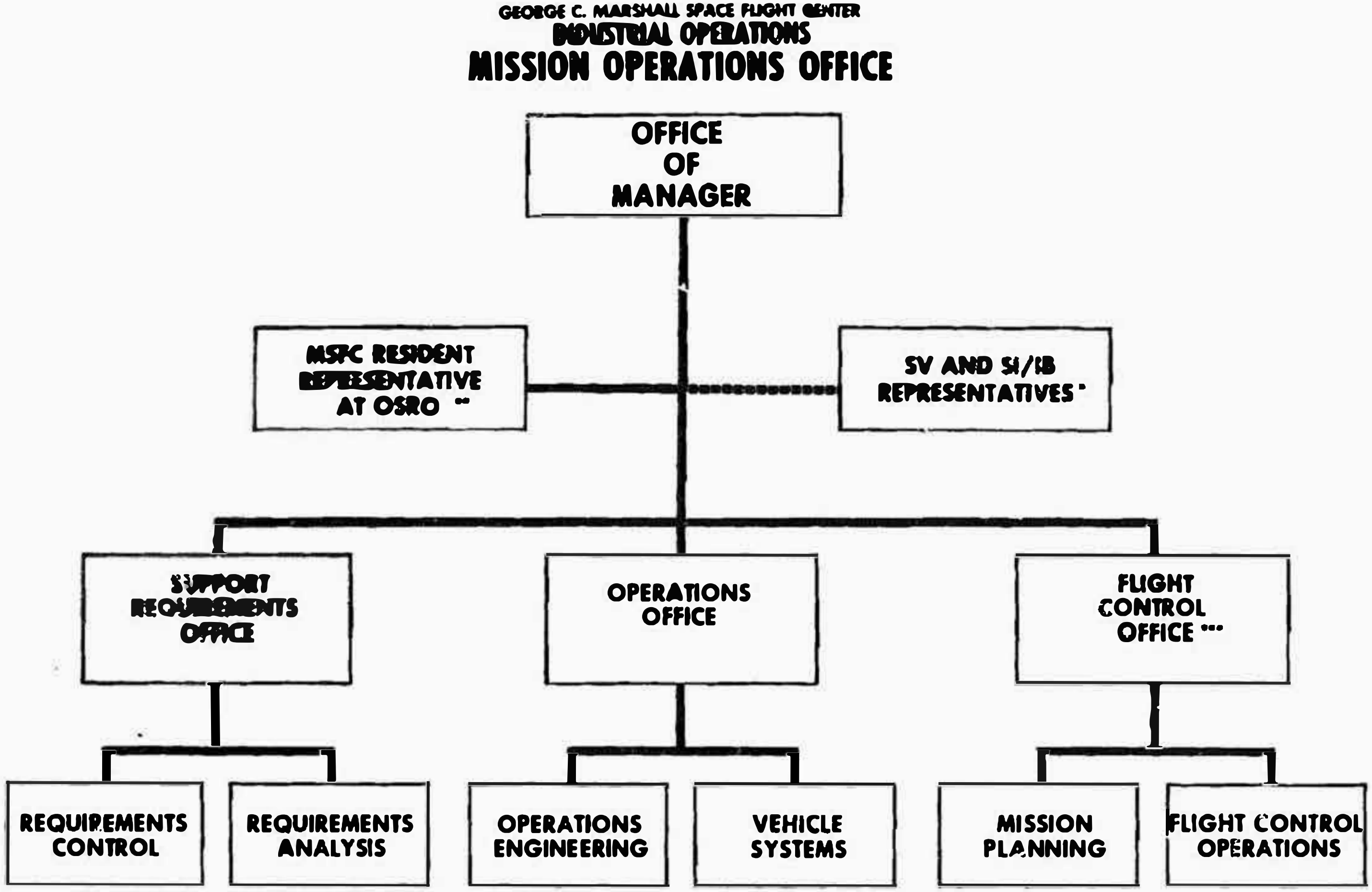
14.2 DOCUMENTATION

The MSFC Apollo/Saturn Program Operations Plan has been published to identify, define, and document the mission operations activities which are to be performed under the direction of MSFC in Apollo Programs. This plan is required by the Apollo Program Development Plan (NPC C500) to identify the operations activities performed under the direction of MSFC in the Apollo/Saturn program.

14.2.1 SUBSIDIARY DOCUMENTATION

14.2.1.1 GENERAL. In order to accomplish the Mission Operations activities of the Saturn program successfully, the following subsidiary operations documentation will be prepared as a requirement of the MSFC Apollo Program Operations Plan. The MSFC Mission Operations Office is responsible for the preparation, coordination and documentation of all subsidiary documentation.

14.2.1.2 SUPPORT REQUIREMENTS DOCUMENTS. Program Support Requirements Documents are submitted by MSFC for each program to identify each Saturn launch vehicle's operational support requirements. These documents are initially submitted to OSRO, approximately two years prior to launch, as MSFC inputs to the overall support requirements documentation, and are continually updated as required.



* ASSIGNED BY PROGRAM OFFICES
** HEADQUARTERS, WASHINGTON
*** MSC, HUSTON

FIGURE 14-1 ORGANIZATIONAL CHART: MISSION OPERATIONS OFFICE

14.2.1.3 LIEF OPERATIONS PLAN. The LIEF Operations Plan describes the activities associated with the Launch Information Exchange Facility (LIEF) operations for each mission. The approximate release date of this document is 1 to 3 weeks.

14.2.1.4 NON-MSFC DOCUMENTATION. The following major operations documentation published by other NASA Field Centers require MSFC Mission Operations Office inputs, review, and/or concurrence:

MSFC Flight Operations Plan
Launch Mission Rules
Flight Mission Rules
Mission Rules Guidelines

14.3 PRE-MISSION PERIOD

The pre-mission period is the period from mission inception or definition of primary mission objectives until successful completion of the Flight Readiness Review.

14.3.1 ORGANIZATION. During the pre-mission period all mission operation tasks are performed within MSFC by the appropriate line organization and coordination panels according to assigned functions. The following Sections briefly describe the major organizational relationships in the area of mission operations.

The MSFC Mission Operations Office is responsible for all mission operations planning for the center and serves as the focal point for the coordination and issuance of Operations Support Requirements and all Mission Operations Documentation. The office coordinates the selection and placement of all MSFC mission operations support personnel, the MSFC flight controllers at MSC, and all MSFC contractor mission support personnel to be deployed during the mission period. In addition the MSFC Representative to OSRO reports to the MSFC Mission Operations Office. The Mission Operations Office is also responsible for the planning and utilization of MSFC Mission Operations Facilities (e.g., LIEF), the conduct of MSFC Mission Operations, and MSFC participation in mission operations reviews.

The primary interface between the Saturn IB Program Office and the Mission Operations Office is the Flight Operations Office. Mission operations activities which affect the program resources, schedules, plans, requirements, or commitments are coordinated with the Saturn IB Program Office through the Flight Operations Office.

14.3.2 INTERFACE WITH OPERATIONS SUPPORT REQUIREMENTS OFFICE (OSRO). The Mission Operations Office coordinates and compiles the MSFC Program Support Requirements and is responsible for their transmission to OSRO. Program Support Requirements for MSFC include: Ground Support Instrumentation; Facilities, Materials and Services; Recovery; Meteorological; Medical; Public Affairs; Pre-launch Tests; and Operational Computer Program requirements. The requirements are combined with the assistance of the OSRO center representatives into a single coordinated MSF document and forwarded through the Mission Operations Director and Program Director to the Associate Administrator for Manned Space Flight. Finally, support plans and budget requirements are prepared by the implementing agencies or Centers and reviewed by OSRO. After approval by the Associate Administrator through the Mission Operations Director and Apollo Program Director, implementation directives are issued by OSRO.

14.3.3 FLIGHT CONTROL ACTIVITIES AT MSC. By Agreement of the Directors of the Manned Spacecraft Center (MSC) and the Marshall Space Flight Center (MSFC) the MSFC Flight Control Office (MSFC/I-MO-F) has been established and is located at MSC. I-MO-F is an element of the MSFC Mission Operations Office, responsible to represent and commit MSFC at MSC during the pre-mission periods, within program constraints and established MSFC policy, in technical matters concerning flight control of the MSFC designed Launch and Space Vehicles primarily designated for the Apollo program.

The MSFC/I-MO-F participates in the MSC pre-mission planning and preparation activities and ensures that MSFC is properly represented in the following areas:

(1) Launch Vehicle Mission Control Facilities at the Mission Control Center-Houston.

(2) Launch Vehicle Mission Control Vehicle System measuring programs.

(3) Launch Vehicle flight control mission rules based upon MSFC/MSC agreed criteria.

(4) Mission control documentation.

(5) Mission control operational problems.

(6) Launch Vehicle flight controller qualification training and simulation.

14.3.4 LIEF MANAGEMENT

14.3.4.1 GENERAL. In order to provide operations support to KSC in launch vehicle checkout and launch operations, to MSFC in launch vehicle flight operations, and to MSFC post-flight engineering evaluation, MSFC will maintain and operate the Launch Information Exchange Facility (LIEF). LIEF will include (a) communications terminal facilities in the MSFC Laboratories for exchange of design data, checkout computer programs, checkout test data, and related information; (b) the Huntsville Operations Support Center (HOSC), a central support facility for real time exchange and display of data during prelaunch tests, launch operations, and flight operations; and (c) a central communications switching and conferencing facility with communications lines for voice, data, facsimile, and video particularly to KSC but also the MSC and GSFC. For more detailed information on the LIEF purpose, scope, and facilities, reference is made to the Launch Information Exchange Facility (LIEF) Technical Plan, prepared jointly by MSFC and KSC and issued July 10, 1964.

14.3.4.2 OPERATIONS OFFICE. The Operations Office (I-MO-O) is responsible for the overall planning, funding review, scheduling, and control of LIEF. This office is an element of the Mission Operations Office and will review requirements placed on LIEF, established plans for their implementation, and direct all HOSC operations. It also coordinates and establishes requirements upon other NASA elements for operations of LIEF.

Specifically, the Operations Office is responsible for:

(1) Evaluating present and future needs for LIEF support functions and insuring facilities to supply those needs.

(2) Preparing LIEF operations plans to control support for specific missions.

(3) Coordinating the assignment and utilization of MSFC personnel for LIEF operations.

(4) Performing post-mission critiques of LIEF operations and accomplishing actions to improve economy and efficiency of operations.

14.3.5 REQUIREMENTS OFFICE. The Requirements Office (I-MO-R) is responsible for the control, coordination and analysis of MSFC and contractor operations support requirements. This office is an element of Mission Operations Office and submits Program Support Requirements documentation to OSRO.

Specifically the Requirements Office is responsible to:

(1) Analyze MSFC operations support requirements.

(2) Coordinate MSFC and contractor operations support requirements.

(3) Perform and coordinate overall network planning.

(4) Coordinate and establish onboard tracking system requirements.

(5) Insure data delivery and adequacy.

(6) Coordinate and issue MSFC post mission support critiques.

14.4 MISSION PERIOD

The mission period extends from the end of the pre-mission phase through recovery and preliminary post-flight activities.

The mission period begins with successful completion of the Flight Readiness Review. The deployment of personnel to the operating sites for the mission period may vary between missions, depending on the personnel function and the geographical location. However, the deployment normally occurs subsequent to the Mission Director's determination that the operations organization and the flight and ground equipments are able to meet a scheduled launch date.

14.4.1 ORGANIZATION. The MSFC Mission Operations Organization and its interface with the Apollo Mission Period Organization is shown in Figure 14-2. The Apollo Mission Period Organization Structure is taken from Section 14 of the Apollo Program Development Plan and shown only partially as required.

The MSFC Launch Vehicle Representative is appointed by MSFC management for a specific mission and is the official MSFC spokesman to the Launch Director and the Launch Vehicle Test Conductor in any matters affecting launch vehicle systems.

The MSFC LIEF Operations Manager is assigned by the MSFC Mission Operations Office and is responsible for the conduct of all support operations from MSFC, Huntsville. He is responsive to the Launch Vehicle Test Conductor and the MSFC Launch Vehicle Representative in all launch operations support activities. During the Flight Period, he is responsive to and is the MSFC point of contact for the Booster System Engineer at the Mission Control Center, Houston (MCC-H).

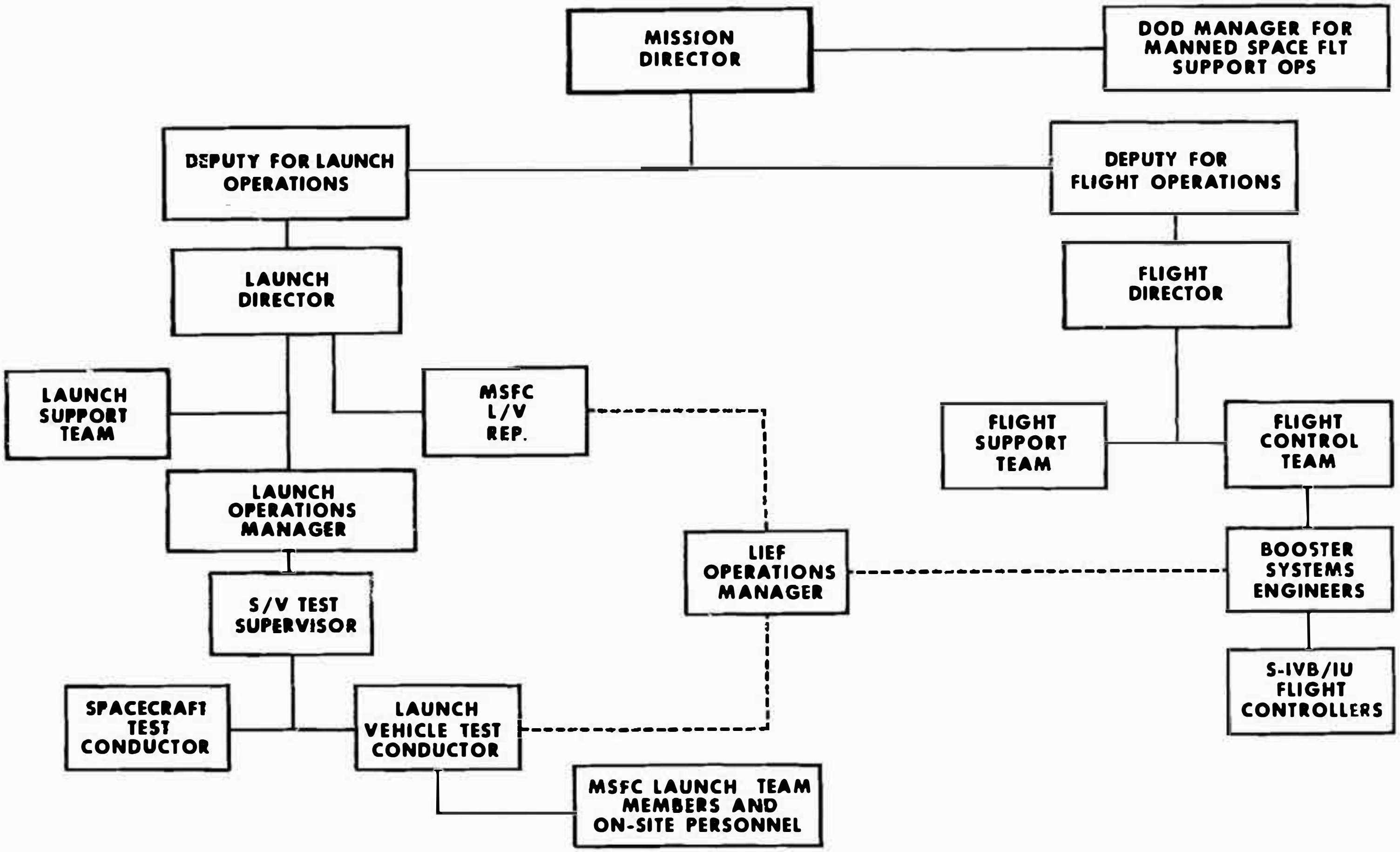


FIGURE 14-2 ORGANIZATIONAL CHART: APOLLO MISSION DIRECTORS ORGANIZATION

During the Mission Period the Launch Vehicle Program Manager continues to be responsible for configuration control. He has access to the MSFC operational support organization through the LIEF Operations Manager.

The Booster Systems Engineer (BSE) and the supporting S-IVB/IU Flight Controllers are assigned for flight control functions to the Flight Director by the MSFC Mission Operations Office as required. These assignments are subject to approval by the Flight Director.

The MSFC Launch Team Members and on-site support personnel provide technical support for vehicle systems to the Launch Vehicle Test Conductor as required by the Launch Operations Organization.

For non-Apollo Missions and payloads or experiments under MSFC management, modifications to the depicted Apollo Mission Operations Organization may be required on an individual mission basis.

14.4.2 OPERATIONAL SUPPORT TO KSC. During the Mission Period, MSFC supports the Launch Director for configuration control and other engineering aspects of hardware and software which MSFC provides for the mission. Because of the time element involved during the final phases of operations, fast response to any KSC requirements is necessary.

Technical support at the launch site is provided by MSFC upon request by KSC. This includes participation in major mission period tests and the launch countdown. In addition, all technical resources of MSFC are available to KSC through the Launch Information Exchange Facility.

14.4.3 FLIGHT CONTROL ACTIVITIES AT MSC AND MSFC SITES. Participating MSFC flight control personnel at MSC are responsible for the following real time activities during the mission period at the indicated locations:

a. Mission Control Center - Houston (MCC-H)

(1) Mission Operations Control Room (MOCR)

(a) Monitor Saturn launch vehicle operating systems during launch phase, report results of malfunctions to Flight Director and execute corrective action regarding time critical functions, and submit recommendations regarding conditions requiring coordinated action of the MOCR flight control team.

(b) Monitor crew safety systems during launch phase, take action for malfunctions that are time critical, and submit recommendations to the flight director.

(c) Monitor S-IVB/IU stage systems during earth orbit and submit recommendation for major go, no-go situations regarding major mission events.

(d) Perform earth orbital vehicle systems checkout in preparation for translunar flight of the Saturn V configuration.

(2) Staff Support Room (SSR)

The Staff Support Room provides a real time support to the Booster Systems Engineer (BSE) in the MOCR. Support is provided by vehicle systems specialists who provide detailed system analysis which would require gross amounts of data or excessive time. The SSR is supported by the KSC Launch Support and the Huntsville Operations Support Center (HOSC) in the following S-IVB/IU vehicle systems:

(a) Guidance, Navigation, and Digital System
(b) Attitude Control and Stabilization System
(c) Propulsion System
(d) Electrical Network System

(3) Manned Space Flight Network (MSFN)

MSFC flight controllers will be deployed to remote sites of the MSFN as required on a mission by mission basis to monitor overall S-IVB/ IU operation. They will normally assist the remote site team leader in aspects of S-IVB/IU flight control. In cases of communications failure between MCC-H and MSFC remote site, the remote site S-IVB/IU flight controller will take independent action within the limits of the flight control mission rules and flight operations procedures.

14.4.4 LIEF SUPPORT

14.4.4.1 SUPPORT FUNCTIONS

14.4.4.1.1 GENERAL. MSFC will utilize the Launch Information Exchange Facility (LIEF) to support KSC in pre-launch checkout and launch operations, to support MSC in flight operations, and for MSFC postflight engineering evaluation.

14.4.4.1.2 SUPPORT FUNCTIONS TO KSC. The following support functions will be provided to KSC:

(1) Monitor and evaluate vehicle response to pre-flight wind measurements.

(2) Locate personnel for any teleconference required.

(3) Advise on unexpected and off-nominal vehicle conditions.

(4) Advise on effect and remedy of malfunctions.

(5) Amend incomplete launch instructions.

(6) Respond to range safety problems.

(7) Advise on impact of measuring and tracking failures.

(8) Interpret launch restrictions.

(9) Provide background data on problems.

(10) Support MSFC personnel in LCC.

14.4.4.1.3 SUPPORT FUNCTIONS TO MSC. MSFC will utilize LIEF to provide the following support functions to the Saturn Launch Vehicle Flight Control Team at MCC-H:

(1) Answer detailed technical questions concerning systems operation originating with the Saturn Booster Systems Engineer (BSE) or his supporting staff in the Staff Support Room (SSR).

(2) Recommend alternate ways of mission performance in case of partial failure.

(3) Point out potentially dangerous vehicle developments based on data monitoring and analysis.

(4) Comment on validity of "no-go" indications.

(5) Confirm key operational decisions (e.g., validity of guidance indications).

14.4.4.1.4 SUPPORT MSFC ENGINEERING FLIGHT EVALUATION. MSFC engineering evaluation personnel will utilize LIEF to perform real time monitoring of launch vehicle problems during terminal countdown and of flight test data. Based upon this monitoring a preliminary assessment of flight success and identification of problem areas will be made and priorities assigned in data delivery, data reduction, and post-flight analysis.

14.4.4.2 LIEF SUPPORT ORGANIZATION. The launch vehicle operations support organization during mission periods is shown in Figure [illegible]-3. MSFC line organizational responsibilities are as follows:

(1) Mission Operations Office (MO)

The Mission Operations Office will direct and coordinate LIEF operations to insure timely and authoritative response to KSC-MCC support requests and proper functioning of communications, display, and other support facilities. The Mission Operations Office will assign the LIEF Operations Manager, who will be responsible for conduct of all support operations.

(2) Technical Laboratories and Program Offices

The MSFC Technical Laboratories and Program Offices will provide systems support engineers and management representatives as required for performance of support functions, and operate any laboratory facilities required in support of operations.

(3) Flight Evaluation Working Group

The Flight Evaluation Working Group will assign evaluation personnel for real time flight monitoring and coordinate LIEF real time mission assessment activities with the post-flight engineering evaluation.

14.4.4.3 MISSION ASSESSMENT. A preliminary assessment of launch vehicle mission success and problem areas will be made immediately post-flight by LIEF operations personnel based on real time data monitoring. This report will be issued by the LIEF Operations Manager and transmitted to the Mission Director as required.

The Mission Operations Office will perform a post-mission critique of LIEF operations and make recommendations for conduct of subsequent missions.

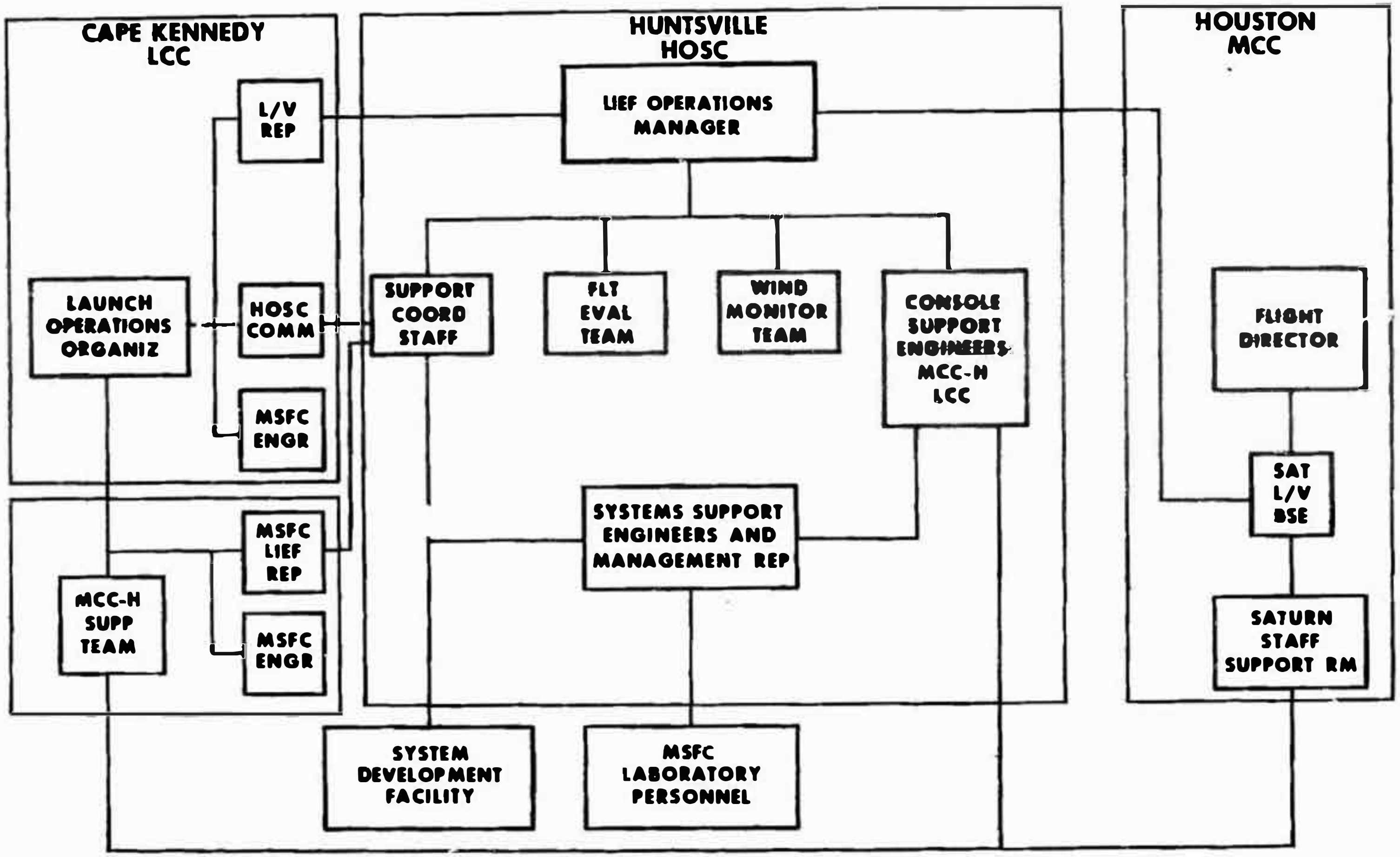


FIGURE 14-3 ORGANIZATIONAL CHART: MSFC OPERATIONS SUPPORT

SECTION 15

MISSION TRAINING

This section is not applicable to the Saturn IB Program.

SECTION 16

RELATED PROGRAMS

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SECTION 16

RELATED PROGRAMS

16.1 SCOPE

This section describes those activities which are not a part of the Saturn IB Program but which are expected to contribute significant information to aid in accomplishing the Saturn IB missions. Basically, three programs contribute the bulk of data needed for Saturn IB engineering decisions: the Saturn I Program, the Saturn V Program, and the related Engines Program. However, in addition, the requirements imposed on the Saturn IB launch vehicle by the Apollo spacecraft payload must be considered. This section also considers information resulting from the Saturn IB Program which may be useful to other programs and to the scientific community at large.

16.2 RESPONSIBILITIES

To assure timely, yet economical, accomplishment of the objectives of the launch vehicle portion of the Apollo Program, efficient channels of communication must exist among the Saturn I, the Saturn IB, the Saturn V, and the Engines Program Managers. These channels are in existence, and a close working relationship has evolved at all levels among these Program Offices. Each of these Program Offices is in proximity to the others at Marshall Space Flight Center.

With respect to the Apollo spacecraft interfaces to the Saturn IB launch vehicle, the Saturn IB System Engineering Office is responsible for coordination, interpretation, and dissemination of the required data.

16.3 INPUTS TO SATURN IB

16.3.1 GENERAL. This section briefly discusses programs which provide data or hardware needed for the Saturn IB Program.

16.3.2 SATURN I LAUNCH VEHICLE PROGRAM. The Saturn IB launch vehicle draws to a great extent on the knowledge and experience gained in the Saturn I Launch Vehicle Program. The Saturn IB first stage is an improved version of the first stage of the Saturn I. Knowledge gained in the S-I project is carried over directly into the S-IB project, as both projects are managed by the same project office at MSFC, and CCSD is the contractor for all industry built S-Is and S-IBs. The H-1 engines are used for both the S-I stage and the S-IB stage. The S-IV, the second stage of the Saturn I, was built by Douglas and is similar in many major respects to the Douglas-built S-IVB of the Saturn IB and Saturn V. Both the design and the manufacturing techniques used in the production of the S-IVB rely heavily on large, liquid-hydrogen-fueled stage experience gained in the S-IV Project. The Saturn IB/V instrument unit design draws from component and system philosophy and design used in the Saturn I instrument units. Both the Saturn I and the Saturn IB Instrument Unit Projects are managed by the same Project Office at MSFC.

16.3.3 SATURN V LAUNCH VEHICLE PROGRAM. Much of the development necessary for the Saturn IB Program is the responsibility of the Saturn V Program; development of Saturn IB-peculiar items on these units is, of course, Saturn IB Program responsibility. Since these two projects are common to both the Saturn IB and Saturn V, extremely close working relationships have evolved between the S-IVB/IB Project Office and the S-IVB/V Project Office and between the I. U./IB Project Office and the I. U./V Project Office.

16.3.4 ENGINES PROGRAM. The development of the engines required for the Saturn class of launch vehicles is the responsibility of the Engine Program Office. Needed channels of communication have been developed between the Project Offices within the Engines Program and the respective Project Offices with the Launch Vehicle Program Offices. The H-1 Engine Project Office and the S-I/S-IB Project Office have established needed communication channels, as have the J-2 engine Project Office and the S-IVB Project Office.

16.4 OUTPUTS FROM SATURN IB

Information gained in the Saturn IB Program will have significant effects on phases of both the Saturn V Program and the Apollo Spacecraft Program. The Saturn IB Program will flight-test the S-IVB, the instrument unit, and the Apollo spacecraft a year before these articles can be flown by the Saturn V vehicle. These flight tests will provide design confirmation or will dictate necessary design changes for these articles a year in advance of the date this information could be gained through Saturn V flight tests. In addition, the Saturn IB Program will make possible Apollo crew-training missions prior to Saturn V availability dates.

Technological information on large launch vehicles resulting from the Saturn IB Program will be useful to the scientific and engineering communities, the Department of Defense, foreign programs, and interplanetary programs.

SECTION 17

ADVANCED MISSIONS

This section is not applicable to the Saturn IB Program at the present time.

SECTION 18

EXPERIMENTS

This section is not applicable to the Saturn IB Program at the present time.