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JOHN F. KENNEDY
SPACE CENTER

APOLLO PROGRAM MANAGEMENT
KENNEDY SPACE CENTER, FLORIDA

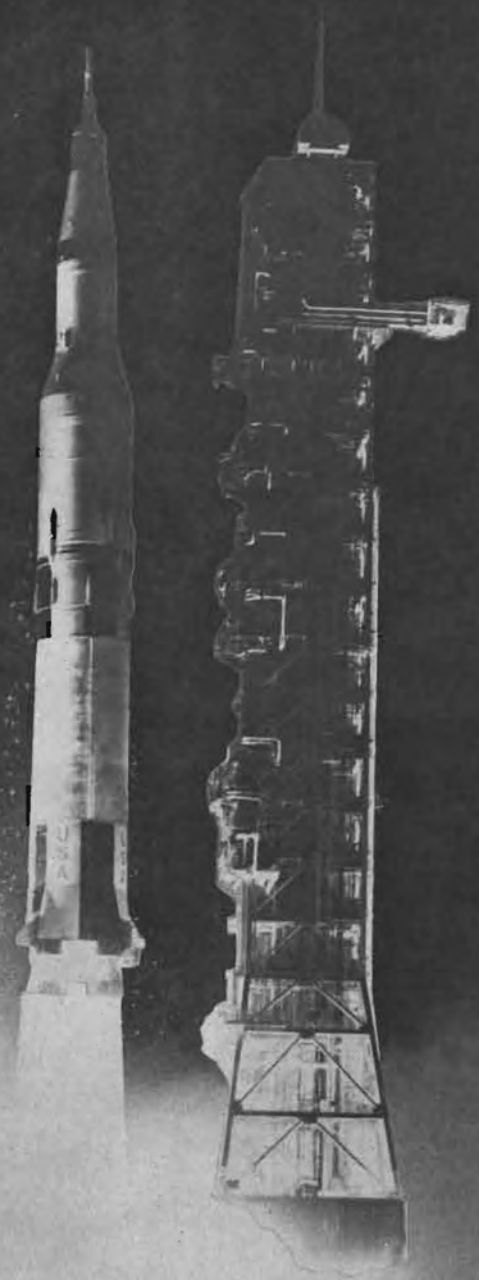
VOLUME 4

Prepared By Program Control Office

Apollo Program Office
John F. Kennedy Space Center

KSC FORM 16-12 (4/66)

"I believe this Nation should commit itself to achieving the goal before this decade is out (1970), of landing a man on the moon and returning him safely to Earth."



SUCCESSFUL LAUNCH OF FIRST APOLLO/SATURN V TEST MOON ROCKET IN NOVEMBER 1967.

THE APOLLO PROGRAM

MANAGEMENT SYSTEM AT KSC

JANUARY 15, 1968

PREFACE

The evolution of the Kennedy Space Center as the launch organization for Apollo/Saturn V involved the concurrent solution of numerous complex problems. A significant increase in manpower was involved. Large and complex checkout and launch facilities were to be designed and constructed. Expansion of operational capabilities required the establishment and integration of a Government-Contractor operational team.

From an initial cadre of approximately 200 civil service personnel of the Army Ballistic Missile Agency, transferred to NASA in 1960 following its establishment, expansion to the present civil service level of 2,900 occurred in the last seven years.

Established within NASA as a directorate of the Marshall Space Flight Center, KSC achieved center status in 1962. With its designation as a Center, KSC accomplished the development and staffing of an organization that could perform procurement, resources, financial, and other management requirements formerly provided by the parent organization.

In addition to continuing launch operations for established programs, KSC undertook the design and construction of large, new, and unique launch facilities for Apollo/Saturn V.

With the expansion of the civil service work force, KSC integrated contractor organizations employing 23,000 personnel at the Center to perform specific operational and support missions under the technical supervision and observation of the Government team.

The management techniques, organizational concepts, and continuing efforts utilized to meet the Apollo goals and challenges are discussed in this document.

Kurt H. Debus, Director
John F. Kennedy Space Center

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LIST OF ABBREVIATIONS

ADMIS	Apollo Documentation Management Information System
ADP	Automatic Data Processing
AFETR	Air Force Eastern Test Range
AMIRS	Apollo Management Information Retrieval System
AO	Administrative Operation
APD	Apollo Program Directive
APOD	KSC Apollo Program Office Directive
CCB	Configuration Control Board
CCBD	Configuration Control Board Directive
CDR	Critical Design Review
CEI	Contract End Item
CMAO	Contract Management Assistance Officer
CMO	Configuration Management Office
C of F	Construction of Facilities
COFW	Certificate of Flight Worthiness
CPAF	Cost-Plus-Award-Fee
CPFF	Cost-Plus-Fixed-Fee
CR	Change Request
CT	Crawler-Transporter
CTM	Contract Technical Manager
DCR	Design Certification Review
DRL	Document Requirements List
ECP	Engineering Change Proposal
ERS	Equipment Record System
ETR	Eastern Test Range
FACI	First Article Configuration Inspection
FEC	Field Engineering Change
FRR	Flight Readiness Review
GSE	Ground Support Equipment
KMI	KSC Management Instruction
KN	KSC Manacement Notice
KSC	Kennedy Space Center
LC-39	Launch Complex 39
LCC	Launch Control Center
LOP	Launch Operations Panel
LRR	Launch Readiness Review
LUT	Launch Umbilical Tower
ICD	Interface Control Document
INC	Installation Notice Card
IRN	Interface Revision Notice
MAR	Management Assessment Report
MDFRR	Mission Director Flight Readiness Review
ML	Mobile Launcher
MSFC	Marshall Space Flight Center
MSFN	Manned Space Flight Network

LIST OF ABBREVIATIONS (Continued)

MSS	Mobile Service Structure
NCN	Non-Concurrence Notice
OMSF	Office of Manned Space Flight
OSRO	Operations Support Requirements Office
PRB	Panel Review Board
PAD	Project Approved Document
PAFB	Patrick Air Force Base
PAR	PERT Analysis Report
PDR	Preliminary Design Review
PDFRR	Program Director Flight Readiness Review
PER	Preliminary Engineering Report
PERT	Program Evaluation and Review Technique
PFR	Preflight Review
PMC	Program Management Council
POP	Program Operating Plan
PSP	Program Support Plan
PSRD	Program Support Requirements Document
RAS	Requirements Allocation Sheets
RD	Requirements Document
R&D	Research and Development
RFP	Request for Proposal
R&QA	Reliability and Quality Assurance
SAB	Site Activation Board
SACC	Site Activation Control Center
SAO	Site Activation Office
SARP	Schedule and Review Procedure
SD	Support Directive
TR	Technical Representative
UCR	Unsatisfactory Condition Report
VAB	Vehicle Assembly Building

SECTION 1
INTRODUCTION

PURPOSE

This document provides a description of the management functions applied to the Apollo Program Management System at the Kennedy Space Center (KSC). The information contained herein is designed for use as a basis for presentation to government officials, professional management, and other interested organizations.

SCOPE

This is one of a series of documents discussing management functions for the Apollo/Saturn Program at the Apollo Program Directorate (NASA Headquarters) at the Center, and at the major contractor levels. This particular document represents the KSC scope of Apollo Program Management and addresses itself to the KSC organizational concepts, management philosophy, and the application of management system elements to respond to the impact of the Apollo Program and the successful accomplishments at this Center. An outstanding example of the effective use of these management techniques at KSC is fully discussed in Section 5, and plans for management improvements are highlighted in Section 6.

Since approximately 20,000 people (predominantly contractor personnel) located at KSC are organized in a common effort to assemble, test, and launch space vehicles, the problems facing them in the performance of this effort are many and varied in nature. Answers to the following and many more similar questions represent the scope of KSC Apollo Program Management:

How are 20,000 people motivated and their efforts pulled together toward common goals?

How are the multiple interfaces coordinated?

How does an agency like KSC handle the logistics involving over 3-1/2 million spare parts?

How can KSC assure that there are no overlaps in functions, duplications of effort, or unnecessary expenditure of funds?

What management can be effectively applied to design, reliability, test, and operations, etc. to assure performance integrity?

How is the mammoth flow of documentation that goes with a Research and Development project of this nature controlled?

How are daily and long range schedules of these 20,000 people developed to assure that there are physical rooms and work areas for them to work in during any given day to accomplish their jobs?

CENTER FUNCTIONS AND RESPONSIBILITIES

The role of the Kennedy Space Center in the Apollo Program is to provide overall management and administration of NASA activities at KSC and the Eastern Test Range (ETR). Basic functions identified as KSC responsibilities are those which:

a. Prepare, assemble, integrate, checkout, and launch NASA space vehicles.

b. Develop new launching concepts; design, construct, and install launch facilities, including ground support equipment (GSE).

c. Operate launch complexes and various technical services in direct support of launch team.

d. Assure configuration control of flight hardware to Development Centers.

e. Furnish base installation and administrative support for all NASA operations.

To say that KSC exists only to launch space vehicles is a gross oversimplification of fact. KSC presents a unique situation where all program variances come into focus. Management philosophy is applied to all levels and all disciplines to provide an optimum blend of products, materials, and personnel.

These multiple functions and responsibilities have necessitated management action by the Center Director in the development and implementation of an organization strong enough to fulfill center commitments yet flexible enough to respond to changing program requirements. Within this organization are found the technical expertise necessary to fulfill the Center obligations and the functional specialists through whom the management systems are implemented.

KSC RESOURCES

The Kennedy Space Center is located on Merritt Island adjacent to the Air Force Eastern Test Range (AFETR) mainland facilities in the East Central Florida Coastal Region as shown in Figure 1-1. The land area comprises approximately 88,000 acres, representing an initial acquisition cost of $78,000,000.

The Apollo Program goal providing for a landing upon the moon by man and his safe return to earth by 1970 has imposed severe management challenges upon KSC. The rapid expansion of manpower, operational activities, and facilities necessitated by the rigid time constraints involved have created management problems of unparalleled magnitude. The impact upon KSC resources is further identified in the paragraphs that follow.

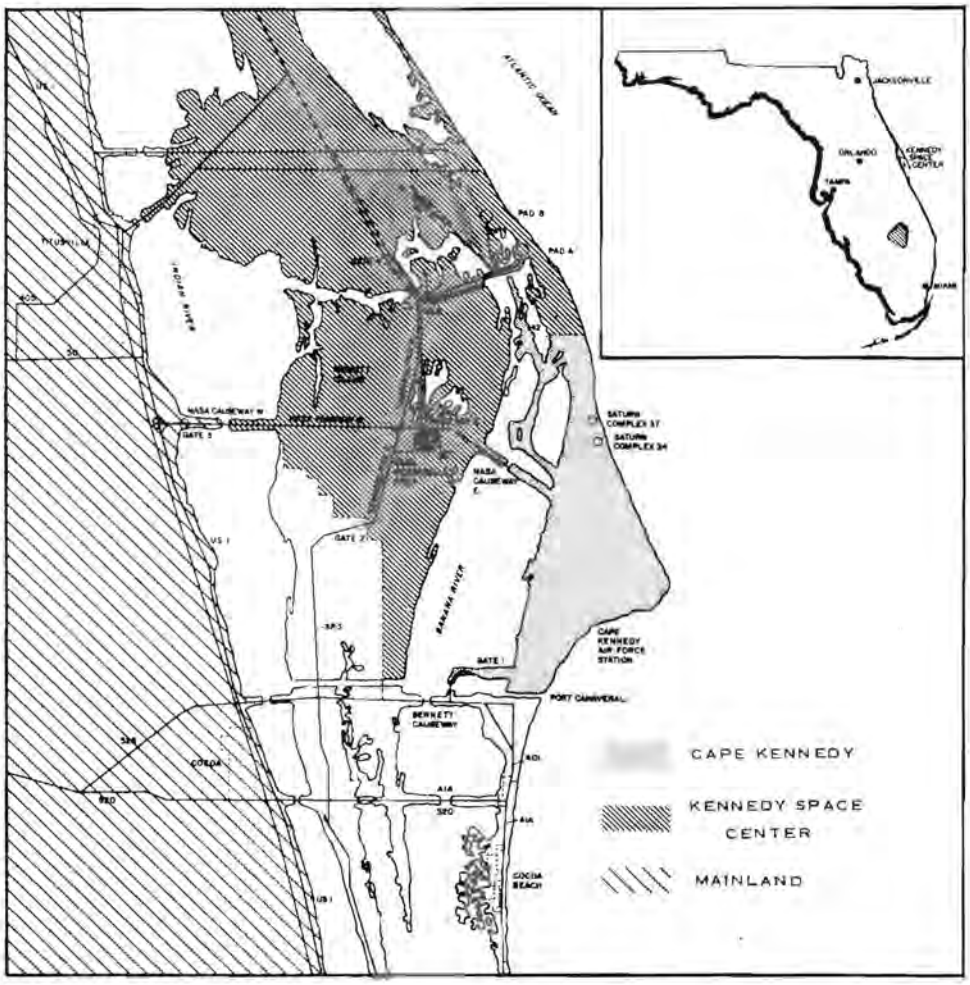


Figure 1-1. Location of Kennedy Space Center

MANPOWER

The work force at KSC is composed of Civil Service and civilian contractor personnel. The manpower mix results in a large majority of contractor personnel who predominate in the operational activities of the Center. Civil Service personnel, however, occupy the nuclei of key positions which provide management guidance and direction, drawing support from contractors as required. The phenominal rise in employment from approximately 420 to more than 20,000 in the short span of 7 years is shown in Figure 1-2.

Some of the manpower management challenges faced by KSC are to provide adequate control over such a diverse and changing population, to provide a flexible organization able to react quickly to changes in work requirements, to acquire the wide variety of required skills on a timely basis, and to avoid redundancy of effort and over-expansion.

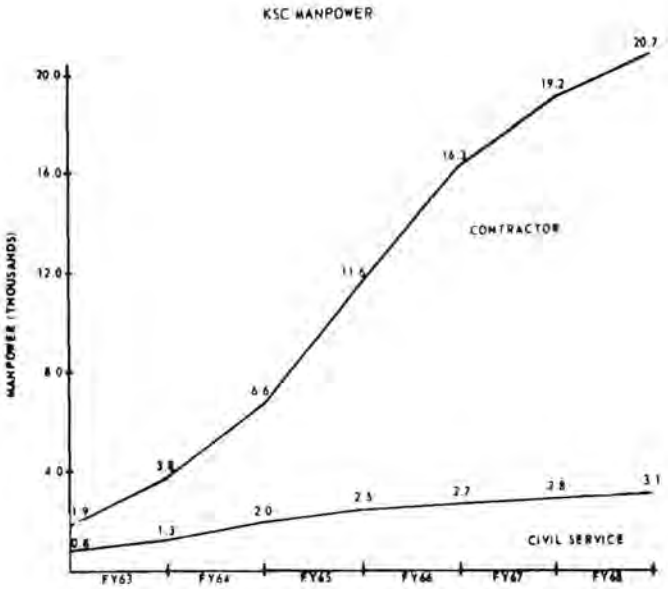


Figure 1-2. Employment Trends at KSC

Civil Service Participation

The Civil Service manpower consists of a preplanned structure of specific positions for which descriptions have been approved to formulate the policy of one job for one body. Control of contractors is effected through use of a contract which specifies a given increment of work to be performed within a predetermined period of time for a negotiated number of dollars.

In these efforts, the Civil Service complement plays a dual role. Approximately 40 percent direct their efforts to the task of managing and operating the Center. Wherever feasible the functions under this task are integrated to include program support, particularly in the accounting, procurement, contract and personnel administration, safety, and security functions. The remaining 60 percent are devoted to technical program management which includes the direction and monitoring of contractor efforts and the exchange of technical information with other NASA and government agencies.

Contractor Participation

During the construction phase the manpower majority was divided among many contractors and subcontractors associated with the building trades. As construction progressed to completion, this type of personnel was replaced with technicians for the installation and validation of the ground support equipment. These, in turn, are being phased out and the equipment operators plus the personnel engaged in assembly and testing of the space vehicles form the contractor population. This is resulting in a steady increase in the professional and specialist skills as system implementation receives more emphasis.

FINANCE

References to gross expenditures by NASA and KSC are misleading in that they do not distinguish between recurring and nonrecurring costs. The budget, however, as a management tool is effectively applied for isolating program costs from Center administration and construction. At KSC, as in any well-managed industrial plant, the budget is used to differentiate between the dollars needed for production (Apollo Program, etc.), for administration and maintenance, and for capital investment. The budget dollar at KSC is applied to three categories: Research and Development (R&D), Construction of Facilities (C of F), and Administrative Operations (AO). Apollo program tasks represent an application for research and development dollars. The individual budget items are carefully evaluated against the scope and justification described in the Program Operating Plan. Only when an item is considered necessary is it assured of being included in the budget. Subsequent to approval, the budget becomes the checkpoint for obligations. Basically, the same practice holds true for dollars needed to operate the Center. This budget, however, is less complicated since the administrative and maintenance costs can be accurately projected and are less vulnerable to radical changes in requirements. The construction budget represents a carefully considered program for the development of new facilities or the expansion or modification of installed facilities. The C of F budget is based on the requirements reflected in Center plans which are projected over a 5-year period and itemized by individual projects.

As the construction of facilities program nears completion, the bulk of the KSC budget is to be applied to operational support in the R&D category. A graphic portrayal of this is shown in Figure 1-3 with the crossover point occuring early in FY-66.

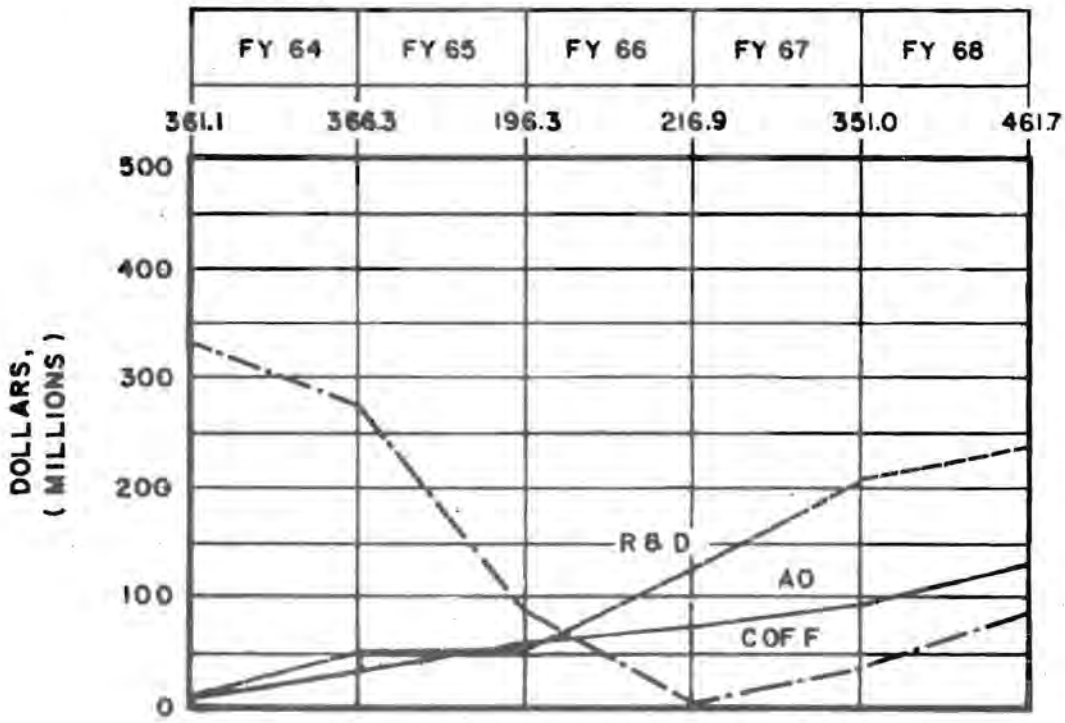


Figure 1-3. Funding Summary at KSC

FACILITIES

At KSC, facilities never before envisioned in the history of man have been developed to support the Apollo Program. A prime example of this type facility is Launch Complex 39 (LC-39) which contains the world's largest building (by cubic content) at time of construction. With a capacity for housing four fully-erected Apollo/Saturn V space vehicles, this building is the Vehicle Assembly Building (VAB) which is 525 feet high with overall dimensions of 716 by 518 feet. The complex also includes three Mobile Launchers (MLs) with individual platform areas larger than a football field, two Crawler-Transporters (CTs), one Launch Control Center (LCC) with capacity for four instrumented firing rooms, one Mobile Service Structure (MSS), and two Launch Pads (A and B). The various elements of LC-39 are pictured in Figure 1-4 which shows an Apollo/Saturn V Space vehicle being transported on the ML by CT to the Pad from the VAB.

Figure 1-4. LC-39 Facilities

The construction cost of approximately 500 million dollars for LC-39 is further evidence of the magnitude of this project. To achieve its completion on schedule within the budgetary constraints despite thousands of development changes during construction and to assure that all the equipment and hardware items interface properly to provide for effective integrated operation of the complex have presented problems of paramount proportions (see Section 5 for additional details) to KSC management. Some idea of the structural complexities involved is shown in Figure 1-5 which presents a close-up view

of the ML and MSS as they interface with the space vehicle to permit prelaunch check-out at the Pad.

Two additional launch complexes, 34 and 37, have been modified to launch Apollo/Uprated Saturn I space vehicles which also play a major role in the Apollo Program. Installations for communications, data processing, assembly and checkout of spacecraft, testing of components, flight crew training and preflight operations, maintenance of facilities and hardware, and accommodations for technical and administrative personnel comprise other facilities required to support the launch efforts at KSC.

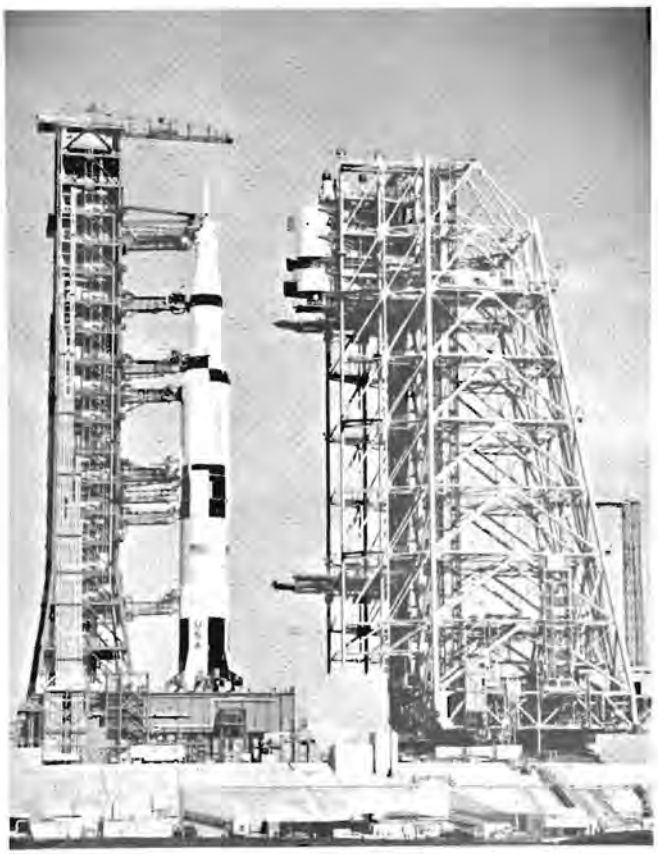


Figure 1-5. LC-39 Pad Configuration

The total capital plant investment of close to one billion dollars in KSC facilities (Figure 1-6) satisfies not only the requirements for the Apollo program, but also represents an investment for future space programs utilizing Apollo vehicles. An immense capability has been established that will serve this nation in the years to come.

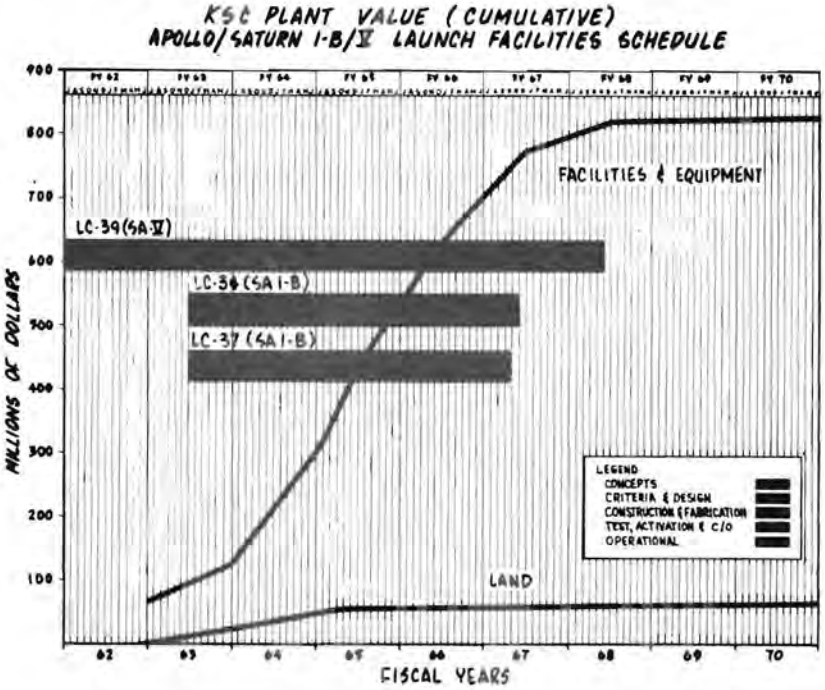


Figure 1-6. KSC Capital Plant Investment

SECTION 2
PROGRAM MANAGEMENT PHILOSOPHY

BASIC PHILOSOPHY

General Samuel C. Phillips, the Apollo Program Director, has stated that, "Program Management . . . in the final analysis . . . (is) doing what you said you would do." To accomplish this within defined program goals and parameters, a plan with measurable milestones is developed, a commitment is made to those milestones, and then the job is done. More specifically, Program Management is assuring that an organization meets its program goals, within defined performance specifications, costs, and schedules.

In a large complex program such as Apollo, a basic requirement is to effectively and efficiently couple the many diverse organizations and skills in most of the sciences and professions. Regardless of where the flight hardware is designed or fabricated, it all ultimately ends up at the Kennedy Space Center where it is assembled, tested and launched.

Here all of the stage contractors meet for the first time. Their hardware must accurately interface with hundreds of millions of dollars worth of ground support equipment and facilities. Over 20,000 people are organized in a common effort at this final site where the Apollo Program starts its final phase of placing a man on the moon - the launch! Figure 2-1 illustrates the uniqueness of this impact upon KSC.

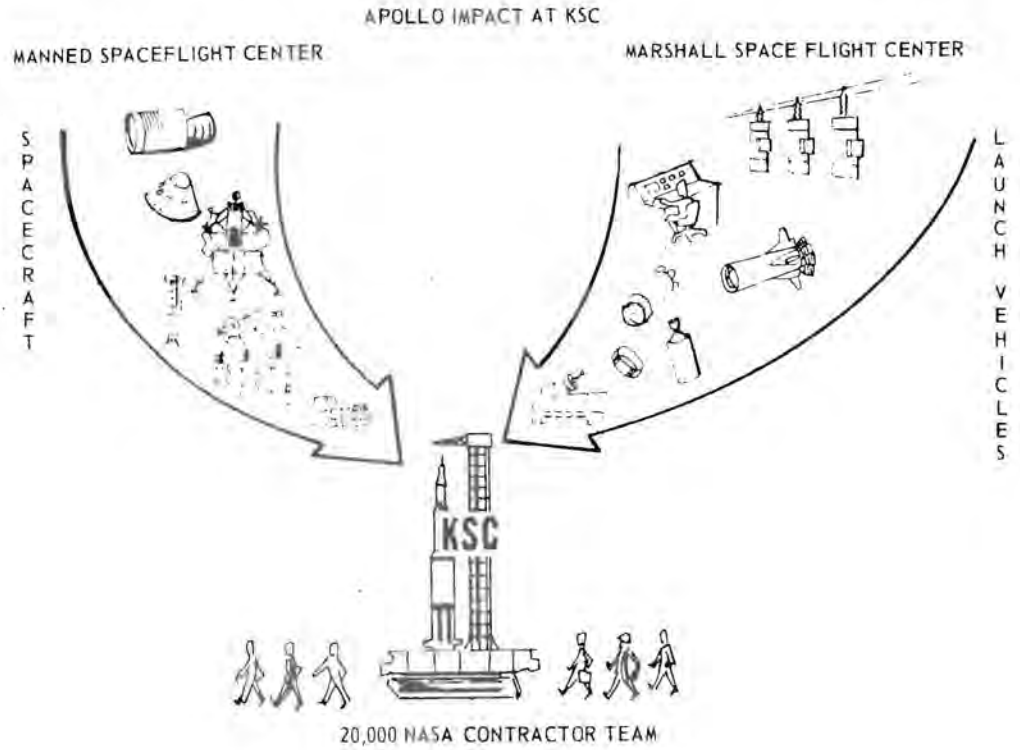


Figure 2-1. Apollo Impact at KSC

In the past, program management could be comparatively informal. There were many programs where a man could be an outstanding manager on the basis of his personal intelligence and personality as opposed to his knowledge of management techniques and availability of qualified staff. The current rate of change of technology, however, and the capability of organizations and people to exploit technology presents a considerable challenge to management. Management must know how to do bigger things faster. In these massive programs it is mandatory that the Manager formalize management systems to guarantee that the thousands of persons involved, within his sphere of responsibility, are implicitly aware of policy, policy changes, and program specifications and know what decisions have been made so that they may quickly become aware of what must be done to comply with program requirements. Deviation from procedures could have an adverse impact on the program. The space program, particularly a program of the magnitude of Apollo, is evidence of management ability to do bigger things faster and of the demand on managers to see that they are done. The challenge is to harness the technological capability and to use it to progress and produce results at a rate that is commensurate with the capabilities that technology represents.

In response to this challenge, KSC has applied a philosophy that allows management to keep pace within a continually changing environment. The philosophy is that of management by exception, that is, the concentration of management attention on problems while maintaining an awareness of those activities proceeding satisfactorily. This forms the basis for program management at KSC.

HALLMARKS OF PROGRAM MANAGEMENT

Effective management is attainable through the use of integrated management systems which apply the four hallmarks of program management (Figure 2-2):

a. Plans and baselines
b. Communication
c. Management discipline
d. Visibility of status and progress

PLANS AND BASELINES

The prime foundation of any program is its complete description and goals. The first action taken is to define what is going to be done and to record it in a program plan. This is done to establish requirements and to serve as a baseline against which management can judge progress and take action as the program unfolds. In defining what is to be done it is necessary to say what -- establish the objectives and requirements; to say when -- not just final completion of the program, but detailed checkpoints all the way through so that the rate is established and progress can be measured; and also to say who is going to do it. The mechanism for doing this is to provide a simple work breakdown structure so that there is clarity of assignments and people can efficiently work on what they are supposed to do without overlapping efforts or gaps. Cost planning has to be worked

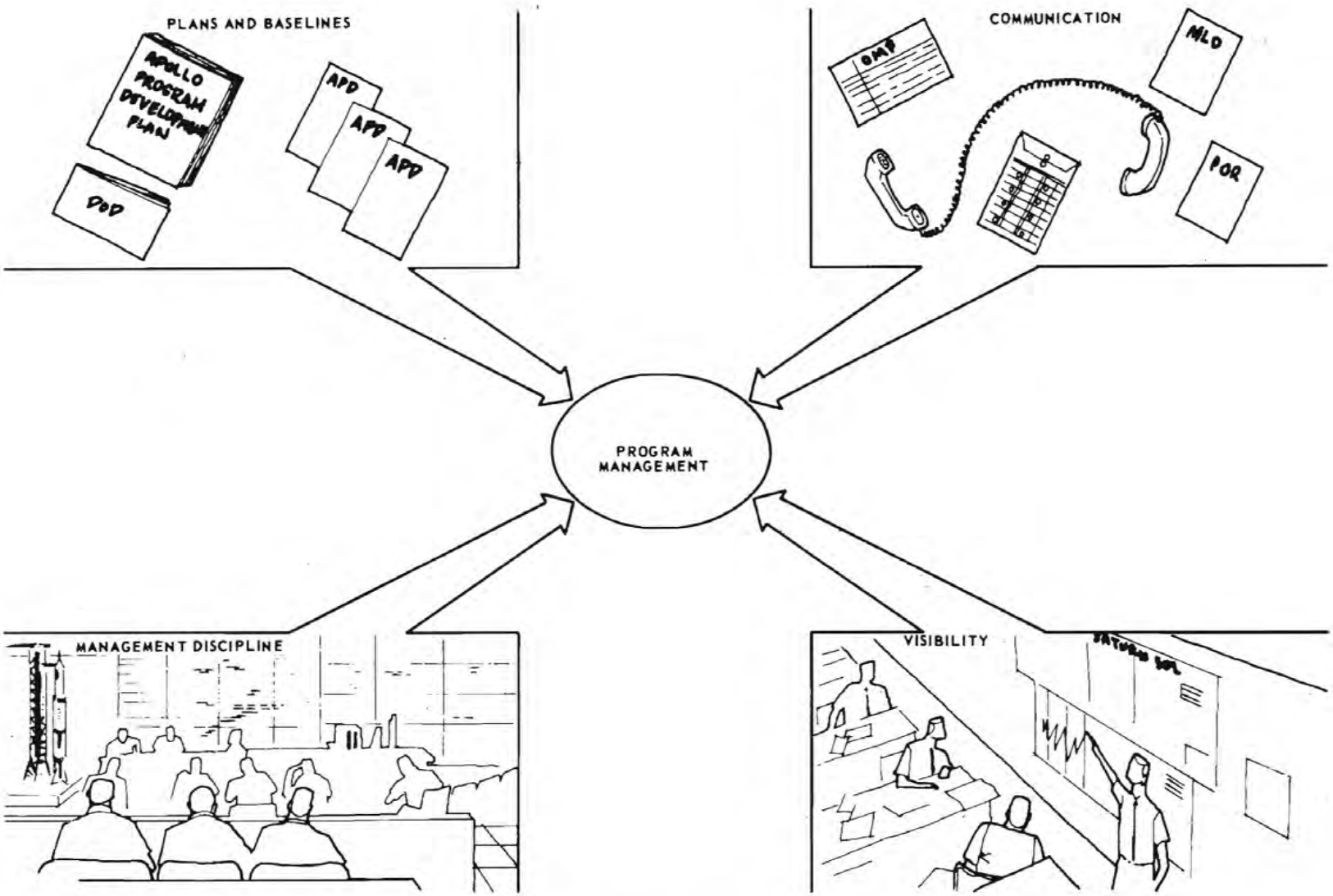


Figure 2-2. Hallmarks of Program Management

out sufficiently so management will not have to spend a lot of time fighting problems that could have been avoided by proper cost planning.

In defining what will be done at KSC, it must also be established how it is going to be done. Once the baseline is developed, decisions may be made for change from a stable point of origin, progress can be measured, and trends developed.

COMMUNICATION

After the program is baselined, the information must be disseminated to all participating employees at the various levels of activity. Further, all changes to that baseline must be communicated. The basic approach is achieved by:

a. Clearly defined organizational flows
b. Development of sub-plans
c. Controlled distribution procedures
d. Good inter-management relationships
e. Periodic program reviews
f. Dynamic Information Centers
g. A system of daily communications

With these, the program manager has the ability to bring his team together to work toward the common goal and has the ability to quickly inform his team of shifts in plans.

MANAGEMENT DISCIPLINE

Plans, baselines, and good communication mean nothing if the line organizations and middle management do not have an incentive to comply. In large programs it is difficult to have sufficient visibility to assure that approved implementation is taking place. As a result, guidance may be ignored by many people (by choice or incompetence) and not be detected until considerable program damage has occurred. Management discipline may be achieved by management control systems which provide:

a. Strong and consistent top management
b. Extensive implementing procedures
c. An environment of mutual respect
d. Clearly defined organization responsibilities
e. Compliance by effective "feedback"

Practices of discipline, called program definition, have emerged because there have been false starts or slow starts which did not produce. In many cases this was caused by management that was not committed to what it would do, what it would pay, when specific tasks would be accomplished, and when the program would be completed. Program

definition, however accomplished, compels management decision on these items at the outset. It forces the engineers and program managers to describe how they are going to accomplish the job.

VISIBILITY OF STATUS AND PROGRESS

Dynamic real time status information must be available to program management at all times. In a program that spends about $7 million per day, as Apollo does, the most minute delay or misdirection becomes costly. One cannot afford to discover a problem after it has occurred, but must predict it and eliminate it before it occurs.

A means developed to assure that management discipline exists and that plans and policies are being executed without significant deviation consists of:

a. Real-time summary management reports
b. Identifiable milestones
c. Baseline compliance reviews
d. Accomplishment measurement techniques

ORGANIZATION CONCEPT

Program Management at KSC is applied through an integrated relationship between the KSC Director, the KSC Apollo Program Manager, and the KSC line directorates. It includes the use of management techniques to provide organized disciplines and achieve mutual understanding and application of responsibilities. The complete organizational structure is delineated in Section 3 of this document.

The KSC Apollo Program Manager represents the KSC Director in matters pertaining to the Apollo Program. He functions through, and administers, the KSC Apollo Program Management Office. This organization is the program focal point and interfaces with counterparts for program functions at OMSF, MSC, and MSFC. It is the "mirror image" of the Apollo Program office in Washington, D.C. and is subdivided to organize related project tasks into manageable packages of work.

The management systems applicable to the KSC Apollo/Saturn projects are developed within the KSC Apollo Program Management Office. The planning of these systems includes definition of objectives, establishment of policies, and identification of responsibilities and standards. Measurement systems are devised to provide program and line management with visibility of the program posture, performance, and progress.

Each Center line directorate organizes the program tasks within its cognizance. It implements the Apollo/Saturn management systems and by its implementation plans identifies the methods by which the management objectives are realized. These implementation plans include provisions for measurement input to contribute to management visibility.

The program requirements, as established by the KSC Apollo Program Manager, include both tangible and intangible needs necessary for accomplishment of the program objectives at KSC. The word "requirement," as used within the Apollo Program Manager's responsibility, may include hardware, software and services. When applied to program management, requirements stimulate response within the stipulated cost, performance, or progress standards. For example, schedules impose requirements to accomplish defined tasks within a specified time frame. The definition of the task may impose requirements for the use of certain equipment and a stock of spare parts. The use of the equipment may impose a requirement for an operations and maintenance manual. Procurement of spare parts may inject a funding requirement. The need for visibility of results may impose a requirement for a report of progress.

It is this expanding series of requirements and the subsequent actions that produce the management relationships and interfaces. It is the skill with which requirements are planned and the subsequent actions organized, integrated, and measured that determine program effectiveness.

PROGRAM CONTROL

Program control is an integrated program management process which is delegated to appropriate organizations as required to assure the effective accomplishment of their responsibilities. The program control system establishes performance requirements, provides the guidelines for policy and control, and delineates parameters and criteria for effectiveness of measurements for all elements within its scope. The system provides for the identification of requirements, the delegation of planning and execution of responsibility, the validation of plans and resource requirements, and the development of a systematic means of monitoring progress, evaluating performance, analyzing variances, and establishing recovery patterns for review and resolution.

It is the KSC Apollo Program Control Office responsibility to develop and implement the management tools required to coordinate, monitor, and track the execution of requirements and the utilization of funds against approved plans and schedules. These tools are to provide continuous surveillance of performance against plans and, through a series of summarizations, provide both line and program management with visibility of program posture, performance, and progress at appropriate levels of detail.

The program control function is also primarily concerned with the early identification and resolution of potential problems which can interfere with the ability of KSC to meet scheduled commitments to other centers or to OMSF, as well as problems which create unanticipated requirements for Apollo funded resources. The developed control systems emphasize an anticipatory monitoring capability, with analysis techniques oriented toward projection and trending.

The existence of management control centers at various levels within the program control function are intended to provide an important assist in the review and assessment process.

These centers serve as working display and problem resolution areas to provide management visibility into the program and organizational strengths and weaknesses, and to enhance management communication at all levels.

Integrated Apollo/Saturn management (Figure 2-3), therefore, is the establishment of requirements, the monitoring and assessment of progress toward accomplishment of those requirements, and the management decision processes involved in assuring a balance of program needs against resource utilization.

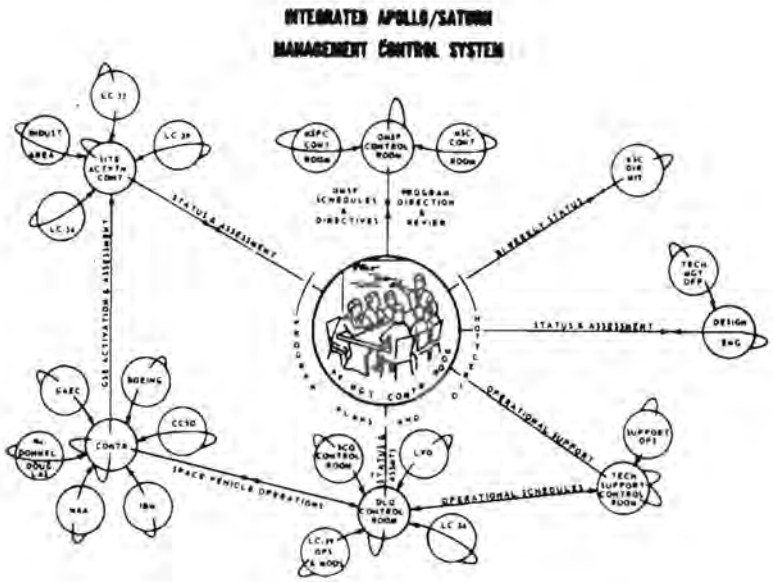


Figure 2-3. Philosophy of Integrated Management

SYSTEMS ENGINEERING

Another major job of management, which also relates to saying what it wants, is to establish and prepare at the outset a properly structured set of specifications and standards that set forth performance and design requirements, technical constraints and interactions, and a detailed description of the deliverable end item. Emphasis on specifications forces project personnel to establish clearly what is wanted, pin down the requirements, and get rid of the uncertainties. The producers and developers are provided with the information to proceed with design, building, and testing.

The Apollo Program consists of a series of successively more complex space flights culminating in the lunar landing mission. The systems engineering function blends the

fundamental, functional, and individual requirements and constraints into an Apollo Program Specification that defines the performance/design requirements for the various elements of the Apollo program. Apollo systems engineering is a process that identifies, defines, and specifies the hardware, software, facilities, personnel, training, and technical data requirements that form the baseline of all subsequent engineering activities. Through a continuing review and analysis of mission and system requirements, the Program Specification is maintained up to date.

DESIGN ENGINEERING

Design Engineering is organized to provide contract technical and area management to ensure functional readiness of specified areas to meet operational requirements, and the technical skills and knowledge necessary to ensure consistency and uniformity. The primary objective of Design Engineering at KSC is to provide a single design element to service user organizations with design, construction, fabrication, installation, and modification support.

Design Engineering provides for both management and technical oriented organizations. This type of organization strengthens the management and technical capability not only for present but also for future programs, and provides KSC with continuity and technical skills in depth.

TEST AND OPERATIONS

The test philosophy of the Apollo Program is to do the development on the ground, before the space vehicle is launched. This requires a rigorous ground test program from the component level through subsystem, system, stage, and vehicle levels, from early development through the qualification process. The ground test program assures that the flight hardware is capable of performing the mission objectives within established parameters. The tests performed at each level (component, subsystems, etc.) complement the tests at the preceding lower level and progessively decrease in numeric detail as systems are combined for manufacturing checkout through launch checkout.

Although each element (Launch Vehicle stages, Spacecraft) is determined ready for flight prior to delivery to KSC, it is the responsibility of KSC to conduct prelaunch checkout to determine that the assembled space vehicle is ready for launch. Prelaunch checkout assures that:

a. The flight elements and Ground Support Equipment interfaces are compatible and flight ready.

b. The conditions to which the elements have been exposed since the last test performed (transportation, erosion, humidity, etc.) have not deteriorated the functional and performance characteristics of the vehicle with particular emphasis on the continual integrity of launch and flight critical items.

Three key management checkpoints have been designated for the test cycle at KSC to determine the system integrity prior to flight. These checkpoints are oriented to the KSC-designed hardware development and mission phases of the Apollo Program and are selected at appropriate and progressive points in the testing cycle. The first checkpoint serves to validate the acceptance testing and provides a configuration baseline. The second certifies that each flight stage and module is a complete and qualified item of hardware accompanied by adequate supporting documentation. The final checkpoint validates the total system as operationally ready for launch.

The relationship of the KSC checkpoints to the total program span is shown in Figure 2-4. The total testing concept is described in Section 4 of this document.

APOLLO PROGRAM SPAN KEY MILESTONES

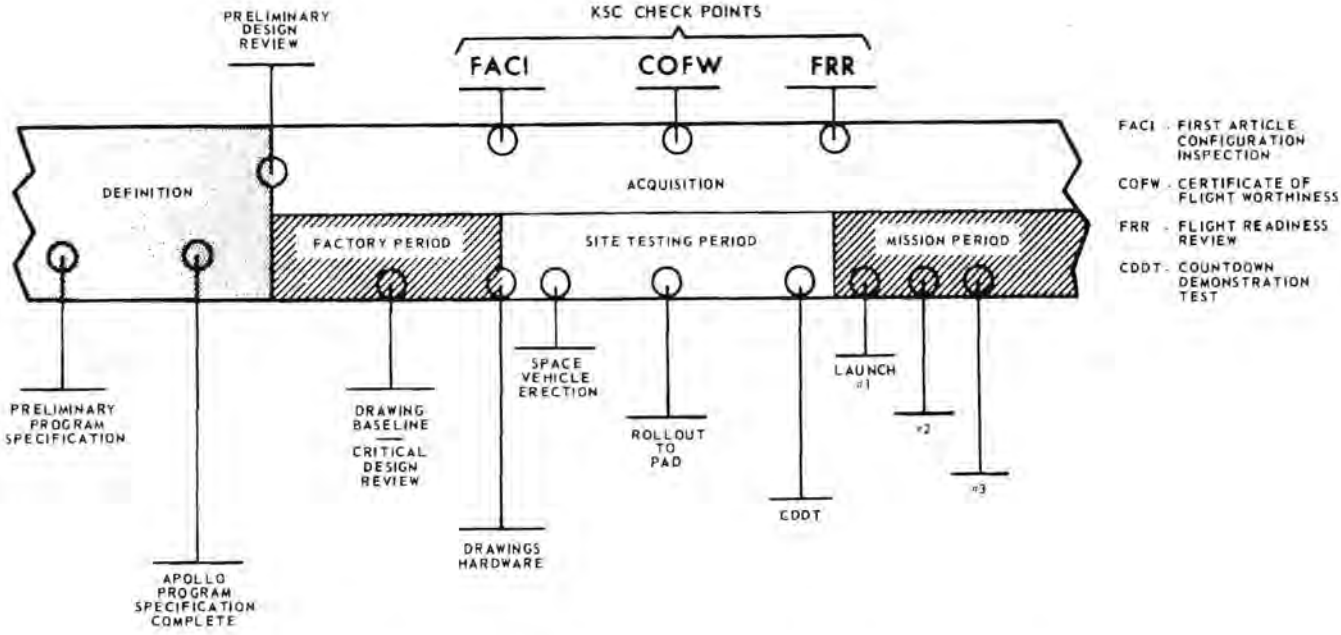


Figure 2-4. Apollo Program Span Key Milestones

RELIABILITY AND QUALITY ASSURANCE

Reliability and Quality Assurance is the discipline that insures all of the program elements perform as required. The prime goal of the R&QA program is that of achieving mission success without unnecessary risk of life or serious physical disablement on the part of the crew. The demands on men and equipment imposed by performance of the mission must be properly assessed to minimize the risk factor.

Reliability and Quality Assurance does not guarantee success, it merely incorporates safeguards to reduce the probability of failure. Trade-offs in design, performance, time, cost, and weight are made; abort sequences and alternate mission modes are determined; Failure Mode and Effects Analyses are performed; mathematical modeling activities are conducted; analyses of design, test, quality, etc., are continually performed; and training and motivation to instill an R&QA awareness among all program participants is undertaken. All actions possible are taken to build reliability and quality into the hardware products and to monitor and assess the probability of success.

The R&QA requirements of KSC are met by implementing a program emphasizing assessment, corrective action and program improvement rather than apportionment, prediction and demonstration. One hundred percent reliability is the goal at KSC. Therefore, a series of checks and balances on the line organizations concerned with test, checkout, and launch is provided to establish the disciplines and the means to evaluate, audit, and inspect to achieve this goal.

SAFETY

The existence of hazardous conditions and materials in and around the launch complexes, and in the receipt, inspection, maintenance, assembly, and preparation of space vehicles for launch requires the establishment of a continuing and aggressive hazard and accident prevention effort encompassing personnel, equipment, facility systems, and buildings. This safety program is provided to anticipate and eliminate hazards to personnel and property, and is implemented in equipment and system design safety, mission ground safety, and flight safety:

a. Equipment and system design safety is the application of safety engineering principles, criteria and specifications to the design of ground support equipment and facilities.

b. Mission ground safety (range safety) is concerned with the performance of the launch operations function prior to and during the launch countdown, including coordination with the Range Safety Office, ETR.

c. Flight safety is that portion of range safety associated with the hazards attributable to the flight trajectory and includes integration of the specific responsibilities of ETR and other NASA Centers.

The meticulous execution of safety principles in these three categories results in a comprehensive program to assure the rapid identification, evaluation, and resolution of safety hazards throughout KSC.

CONTRACT MANAGEMENT CONCEPT

At KSC, 14 major contractors furnish 85 percent of the total manpower. The task of motivating these people toward a common goal falls within the realm of contract management. Contracts at KSC are divided into two major segments, support contractors and direct stage contractors. The launch operations stage contractors supplement the basic MSFC and MSC contracts whereas the support contracts are the sole responsibility of KSC.

Contract management is an integral and important part of the KSC management process. Considering that contractor effort represents something in the order of 90 percent of the total KSC effort, the significance of contract management is quickly brought into focus. At KSC, this contract management effort is applied within the cost-schedule-performance framework of program management to cope with special problems, such as those identified in Figure 2-5.

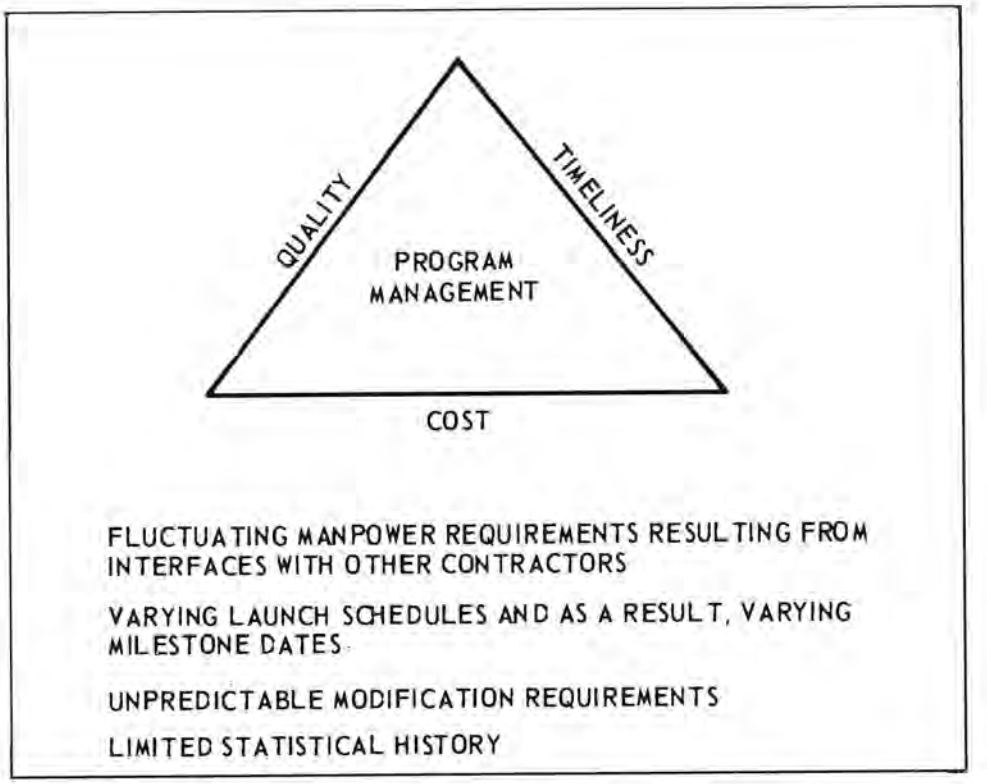


Figure 2-5. Contract Problems at KSC

KSC experience has proven that management of a contract can be influenced to a degree by administrative controls. These are important but leave considerable room for improving the contracting process and influencing the basic contractor motivations. Properly directed, motivations become a stronger force for good management than any policing action. One of the most effective ways of achieving this is through the use of incentive contracts. Making a constructive change in the contracting procedures involves complex factors. The cost-plus-fixed-fee (CPFF) contract serves a real need during the difficult period of predominately R&D effort. Because of the technological uncertainties involved, the majority of KSC contracts have been of the cost-plus-fixed-fee type. Unfortunately, under the CPFF contract, the contractor's profit is determined at the beginning of a program based on estimated cost. There are no financial penalties for poor technical performance, cost overruns, and schedule delays, just as there are no rewards for efficiency and success. However, in spite of some shortcomings, there is a continuing need for CPFF contracts when establishing the technical feasibility of a project involving preliminary designs, breadboards, and tests of new types of equipment where the results are quite uncertain. Under these conditions it is impracticable to obtain effective fixed-price competitive bids. Fixed-price contracts for this type of work present a high probability of excessive profits or losses. Further performance must not be compromised as a result of cost considerations. Nevertheless, industry must be induced to give the same attention to its contracts as it gives to fixed-price contracts obtained under highly competitive conditions, and profit must be tied to the ability of industry to produce the desired product while keeping to a minimum those variable costs over which it has control. The use of incentive contracts has proven an effective tool in establishing this relationship. Incentive contracts are well adapted to projects involving development, fabrication, and tests of hardware where the technical feasibility has already been established in phase 1 studies. The incentive principle holds that contractor profit should be related to the ability to turn out a product that meets all established performance goals, to improve on the contract schedule, to reduce the cost of the work, or to complete the project under a weighted combination of some or all of these objectives. There is further benefit in that the incentive arrangement forces a consideration by both parties of performance versus schedule versus cost throughout the program.

SECTION 3
CENTER ORGANIZATION

BACKGROUND

In order to appreciate the current KSC organization and its relations to Apollo Program management, it is necessary to reflect briefly on its history and growth. In July 1960, a Launch Operations Directorate was established in the Cape Canaveral area under the direction of the Marshall Space Flight Center (MSFC), Huntsville, Alabama. The initial complement was 314 Civil Service and 106 contractor personnel. This small work force, with support from the Air Force Eastern Test Range, was responsible to MSFC for launchings and launch-related activity.

In March 1962, the Launch Operations Center was created under the direction of the Office of Manned Space Flight (OMSF), Washington, D. C. with a complement of 323 Civil Service personnel. In November of the same year the Center was renamed the John F. Kennedy Space Center and became familiarly known as KSC. The first major support services contracts were let by KSC in June 1963. There were seven of these contracts with various industrial concerns and they provided for a wide range of supporting services to both the KSC personnel and the hardware and mission contractors. The total work force of the Center now approximated a combined total of 2500 personnel.

Another major milestone was reached in December 1964. At that time KSC absorbed the Florida Operations of the Manned Space Center. This was significant in that KSC now had responsibility for all manned spacecraft upon arrival at the Center and total responsibility for manned space vehicles. These added responsibilities expanded the work force to a total of 11,245 Civil Service and contractor personnel.

A final broadening and diversification occurred in October 1965, when KSC integrated into its organization the responsibility for NASA unmanned launch operations. This function had previously been directed by the Goddard Space Flight Center. KSC was now, for the first time, a true launch agency of NASA. The work force continued to expand until it reached a peak of 23,256 in 1967.

In summary, the KSC organization experienced a total Civil Service and contractor work force expansion of 5500 percent in the comparatively short span of 5 years. This fact alone emphasizes the management problems and the organization adjustments that have had to be faced.

KSC CENTER DIRECTOR

The KSC Center Director is totally responsible for the management of KSC and its related work programs. This position is directly accountable to the NASA Associate Administrator for Manned Space Flight. All basic internal KSC policies are established

and/or approved at this level. The Director is personally involved at specific critical points in key managerial processes and decisions. Included are matters pertaining to basic resources allocations, personnel selections or promotions to key management and administrative positions at the GS-14 level and above, major launch schedule changes caused by KSC events, new starts on KSC hardware developments, procurements in amounts above $1,000,000.00, and other areas where proposed KSC performance (or lack of performance) may impact on commitments of the Center or its external relationships.

The KSC organization provides for two Deputy Directors, one for Center management and the other for Center operations. In addition, the Director of the Executive Staff provides for the executive communication process. This triple combination provides greater depth of available leadership to assist the Director in the management and control of the total KSC activity as shown in Figure 3-1.

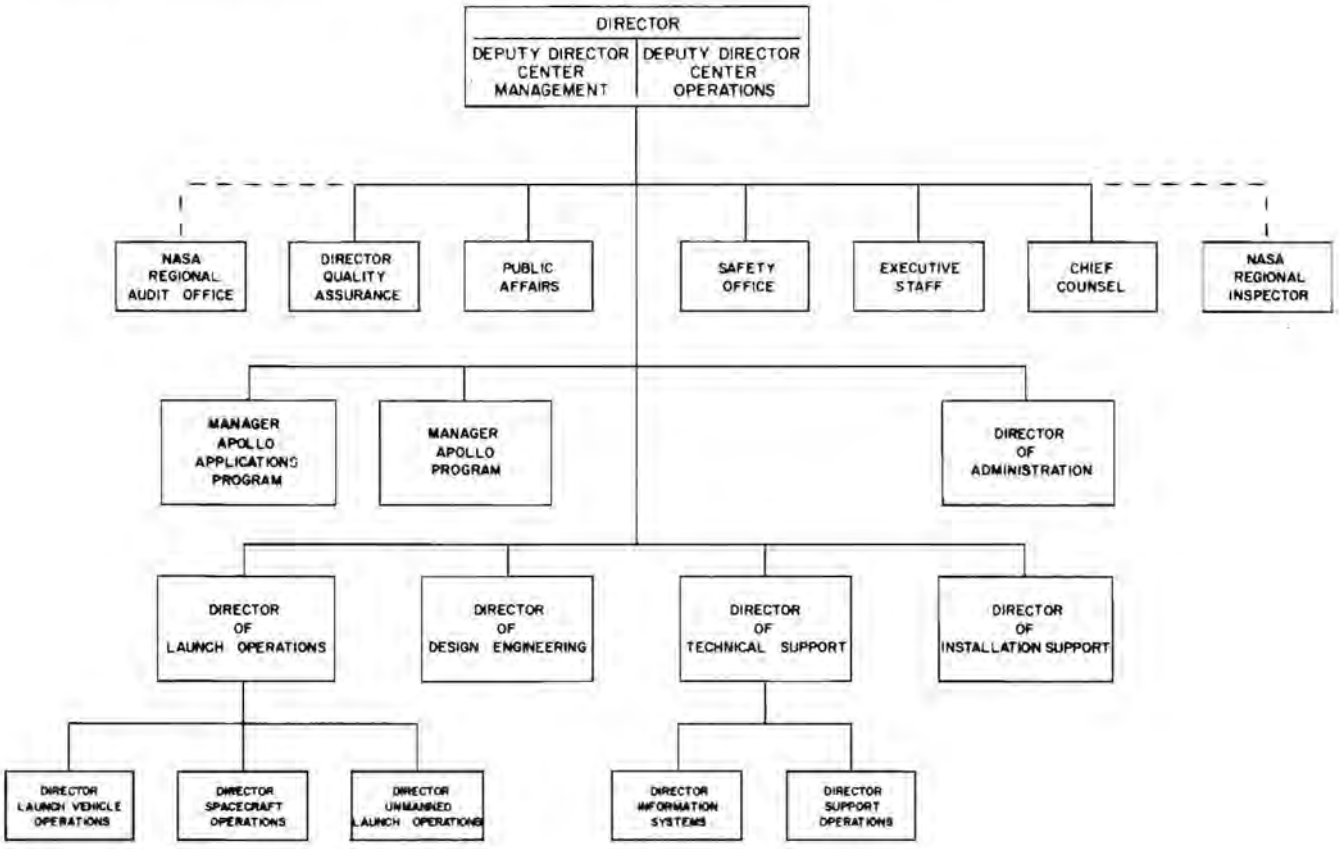


Figure 3-1. KSC Organization

The KSC Director decides which parts of the total responsibility are to be handled by the Deputy Directors. Based on these decisions, the progress reports and other routine informational data provided by other KSC elements can be expeditiously reviewed for management action. It is important to note that the Deputy Directors function as an

extension of the general management capability for the Director and are not an intermediate level of review or clearance. Direct access of the Director is expected when necessary for the resolution of unresolved issues.

KSC STAFF DIRECTORATES

In support of the KSC Center Director and providing specialized management functions are the staff directorates and offices. They include the previously mentioned Executive Staff, the Public Affairs Office, Chief Counsel, Director of Quality Assurance, Safety Office, Apollo Program Manager, Apollo Applications Manager, and Director of Administration. Each of these functional segments is managed within a scope of effort defined and delegated by the Center Director. The integration of these specialties with program management permits broad utilization of their skills. The major responsibilities and functions of these organizations are outlined below:

a. The Executive Staff acts as a central focus for the development, management, and control of the KSC executive communication process and for maintenance of a management status and review functions. Toward this end the staff prepares and disseminates decisions by the KSC Director and the Deputy Directors. The flow of action material within the Office of the Center Director is channeled, expedited, and scheduled with appropriate consideration given to relevant previous decisions and policies. Within the function of management status and review, the Staff acquires operating or programmatic information to identify possible incipient questions or issues which could require action or decision by the Center Director. The Executive Staff also includes, for administrative purposes only, the Senior Scientist and his staff which works directly with other KSC elements in technical matters including flight safety.

b. The Public Affairs Office manages the integration of both Center and program relations with outside public media. Specifically, it schedules and coordinates visits by foreign and domestic dignitaries and officials, arranges for programs involving public communication media, and assists the KSC Director in public relations participation by KSC officials.

c. The Chief Counsel represents and advises the Center Director and program management in legal matters pertaining to KSC operations.

d. The Director of Quality Assurance formulates the policy for and manages a quality assurance program for total Center operations. He evaluates quality assurance requirements imposed on KSC by Apollo and other programs and determines an effective method for KSC response. He also provides the Center Director with current measurements of the quality program effectiveness, and recommends adjustments in policy, techniques, or requirements to improve program results.

e. The Safety Office assists the Center Director by providing and maintaining a complete accident prevention program for all KSC activities. It develops, issues, and enforces safety standards pertaining to launch vehicles, spacecraft, launch complexes, ground support facilities, radioactive materials, building construction, explosives, hazards, motor vehicles, and related activities. This includes assurance that necessary safety controls are in effect during moving, assembly, checkout, static firing, and launch of all space vehicles at KSC or NASA facilities at Cape Kennedy.

f. The Apollo Applications Program Manager acts for the Center Director in the analysis and interpretation of requirements by advanced programs utilizing Apollo hardware and provides the management direction for translating these requirements into specific work packages. He also coordinates and compiles data to aid the Center in acquiring and controlling adequate resources for accomplishing program missions, and represents the Center Director for the interface with OMSF and inter-Center program counterparts.

g. The Apollo Program Manager functions as the central point for management of all Apollo Program activities for which KSC is responsible. He also develops or assures development of feasible plans to meet the program requirements within the available framework established by the Program Director (OMSF) and Center Director. This includes the responsibility for formulating, with the available resources, the necessary operating plans, program reliability and quality standards, mission descriptions and subsidiary specifications, and test plans. A more detailed explanation of this organization and its functions is discussed in subsequent pages of this Section.

h. The Director of Administration advises and assists the Center Director and the primary organizational heads of KSC in the development, maintenance, and improvement of management systems, organizational structures and functional relationships, manpower complements, budgetary planning, and resources management. Specific duties in support of the KSC and the Apollo Program include the management and administration of resources, management systems, procurement and contract administration, accounting, personnel management, labor relations, and activities related to patent and technology utilization. This Directorate also administers the KSC manpower utilization program and the allocation and utilization of space.

KSC OPERATING/LINE DIRECTORATES

The technical management of the Apollo Program at KSC is performed by four directorates. Two of these directorates are subdivided into five subdirectorates. This arrangement provides in-line management of large scale project tasks and at the same time provides integrated management under single control for those projects which have common objectives through hardware utilization. The four prime directorates are Launch Operations (including Launch Vehicle Operations, Spacecraft Operations, and Unmanned Launch Operations), Design Engineering, Technical Support (including Information Systems and Support Operations), and Installation Support.

Each of these directorates is assigned responsibility for an integral portion of the work breakdown structure at KSC. Each is supported in its tasks by one or more industrial contractors who provide a wide variety of specialized skills needed for the work effort. The management disciplines needed to integrate this combined effort are generated within each directorate but are compatible with the management concept established by the Center Director and the Apollo Program requirements. The major responsibilities and functions of these directorates are summarized as follows:

a. The Director of Launch Operations is responsible for the management and technical direction of preflight operation and integration, assembly, test, checkout, and launch of all space vehicles (both manned and unmanned) for KSC. He initiates, supervises, and coordinates the preparation of preflight and launch operations test plans and assures their effective execution. In support of the manned spaceflight program, this Directorate assists the Apollo Program Manager in negotiating the test and operational sequences, methods, and standards with cognizant Development Centers. It also provides advice for the correction of deficiencies by Development Centers and develops operational support, and resource requirements to respond to the program requirements for the execution of the assigned mission with approved schedule and/or funding limitations. The Director (including each subordinate Director) assumes responsibility for the effective management and operation of his organization within the approved budgetary allocation and oversees the management of specific contractor efforts allocated to his support.

b. The Director of Design Engineering manages the design and development of equipment and facilities provided by KSC in support of the Apollo program (except where otherwise directed by the Center Director). Included within this design concept are the functions for monitoring fabrication, installation, acceptance, testing, modification, and major refurbishment. This Directorate also provides for maintenance analysis and initial spares provisioning for KSC-designed hardware and conducts the implementation (within established guidelines) of configuration management, reliability, quality assurance, logistics, and system engineering. The Director is responsible for the effective management and operation of his organization within the approved budgetary allocation and oversees the management of specific contractor efforts allocated to his support.

c. The Director of Technical Support directs an organization engaged in providing a variety of technical support for KSC launches and responds to requirements for technical support to those Department of Defense launches requiring KSC assistance. This Directorate manages and directs the maintenance and operation of test and launch complex facilities and equipment. The single point of interface with the Air Force Eastern Test Range for the NASA entry of program requirements is also provided by this Directorate. The Director (including each subordinate Director) is responsible for the effective management and operation of his organization within the approved budgetary allocation and oversees the management of specific contractor efforts allocated to his support.

d. The Director of Installation Support provides for the general operation and maintenance of the Center. This includes programs for disaster control planning; health; security and law enforcement; photographic, reproduction, and publication services; Center logistics; and maintenance for all KSC buildings, permanent structures, and utilities except for test and launch complex facilities. This Directorate also exercises quality control surveillance over incoming KSC-procured material and equipment and provides administrative services for library, mail and distribution services, and issuance of directives. The Director is responsible for the effective management and operation of his organization within the approved budgetary allocation and oversees the management of specific contractor efforts allocated to his support.

CENTER APOLLO PROGRAM MANAGEMENT RELATIONSHIP

The relationship between Program Management and the KSC line organizations can best be characterized by stating that the KSC Apollo Program Manager is an initiator rather than an implementer. He provides appropriate assignments, guidelines, and resources so that those charged with the execution of specific aspects of the overall Apollo program move to get the job done. His NASA interfaces and relationships are briefly summarized in Figure 3-2.

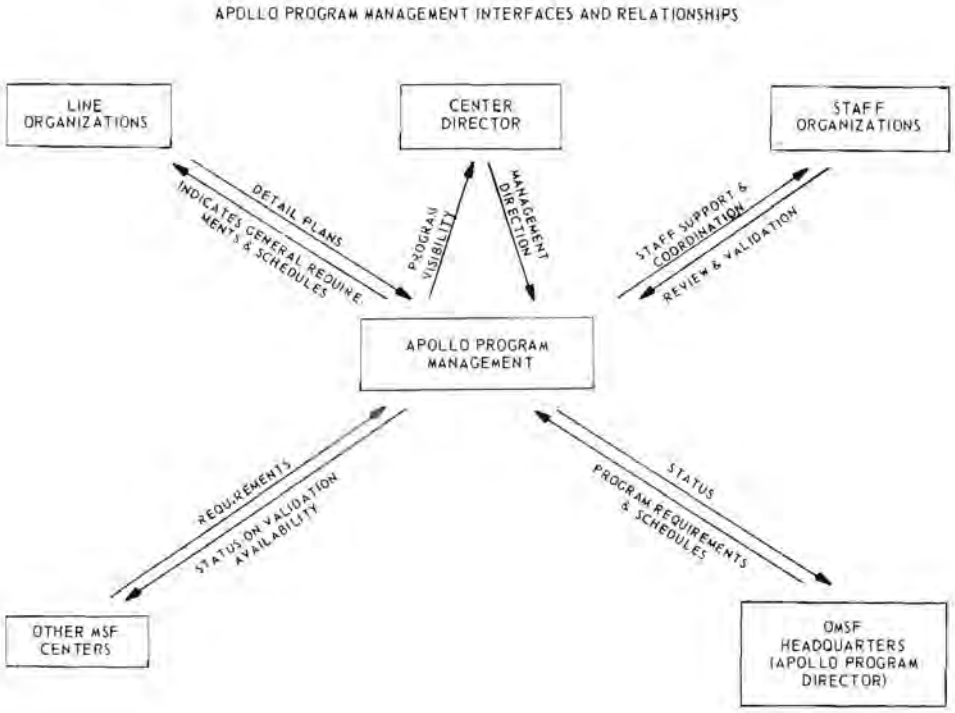


Figure 3-2. KSC Program Management Interfaces and Relationships

The KSC Apollo Program Manager is responsible for translating both general and specific program requirements and schedules received from the Program Director and other MSF Centers into discrete packages which he forwards to line organizations for preparation of detailed plans to meet such requirements. He receives, validates, and coordinates such plans of execution as prepared and priced by the line organization. He also analyzes these plans against total program needs and available resources, taking appropriate action to assure that these considerations are kept in balance. Upon approval and funding, such plans become a directive for execution by the line organizations. The KSC Apollo Program Manager is responsible for establishing site activation schedules and is required to assign responsibility to line organizations to resolve bottlenecks within established guidelines.

The KSC Apollo Program Manager coordinates, monitors, and tracks the execution of requirements and utilization of funds against approved plans and schedules. This monitorship is not concerned with day-to-day operations but does become involved in problems which interfere (or threaten to interfere) with the ability of KSC to meet any of its schedule commitments to other Centers, or problems which are likely to create unplanned or additional requirements for Apollo Program funds. The KSC Program Management Office does not issue direction or formal instructions to stage or support contractors whose activities are under the monitorship and management of other operational elements of KSC.

The KSC Apollo Program Manager formulates subsidiary specifications, test and operating plans, mission descriptions, program reliability and quality assurance procedures, and operating plans to accomplish these within available resources. Directives from the Apollo Program Director (OMSF) flow through the established organizational channels to the Apollo Program Manager at KSC.

KSC APOLLO PROGRAM MANAGEMENT ORGANIZATION

The KSC Apollo Program Management is organized (see Figure 3-3) to achieve maximum utilization of all available resources and to effectively carry out assigned responsibilities. Responsibilities delegated to subordinate offices of the KSC Apollo Program Office are as follows:

a. The Assistant for Systems Engineering manages studies, evaluations, and design reviews of Apollo/Saturn integration, launch,and test/checkout systems utilized at KSC to assure overall compatibility, suitability, and cost/effectiveness.

b. The Reliability and Quality Assurance Office administers and coordinates the Apollo reliability and quality assurance program and develops overall plans and procedures to implement the program requirements.

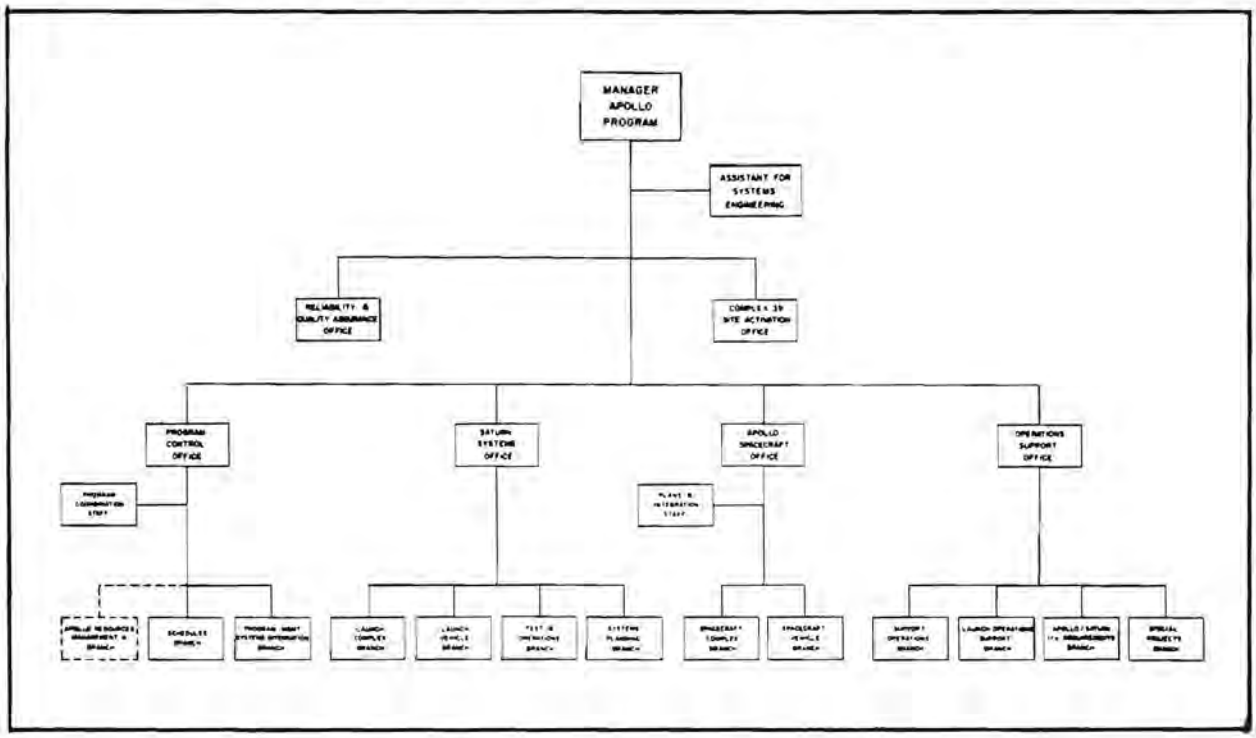


Figure 3-3. KSC Program Management Organization

c. The LC-39 Site Activation Office provides overall program management of the Apollo/Saturn V site activation effort at KSC through a review of the operational readiness for each group of launch facilities (off-site as well as on-site).

d. The Program Control Office provides Apollo program management systems and surveillance to assure that all information required for Apollo program management decisions is available and properly assessed. In this capacity the office programs and surveils Apollo resources to assure effective utilization.

e. The Saturn Systems Office provides for the program management and coordination of the test and systems integration for the Saturn launch vehicle activities at KSC and for the Apollo/Saturn launch complexes. Based on requirements for OMSF and MSFC, this office develops and assures implementation of KSC Saturn program requirements, test and operations concepts, and plans. It develops and controls the KSC Apollo/Saturn major milestone schedules.

f. The Apollo Spacecraft Office provides the overall control and coordination of Apollo Spacecraft activities at KSC and supports the KSC Apollo Program

Manager in spacecraft-related program activities. It approves KSC commitments involving Apollo Spacecraft, related activation, and spacecraft experiments. This office also functions as a single formal interface with other NASA Centers, Aerospace Industries, and local NASA organizations in matters related to the spacecraft program.

g. The Operations Support Office plans, initiates, and validates procedures and resources required for support of Apollo/Saturn missions. This support is defined as the means of sustaining operations with resources external to the space vehicle and its integral systems on the launch complex. The office also performs as a single interface with Operations Support Requirements Office (OSRO), other MSF Centers, and other government agencies on matters related to operational support.

FUNCTIONAL RELATIONSHIPS

The highly complex management task of integrating program requirements with functional capability and response requires KSC to operate with an organizational structure that can interface laterally as well as vertically within KSC and with other NASA, government, and contractor organizations. The Apollo Program requires the following four separate and distinct groupings of functional relationships which KSC must recognize, correlate, and effectively integrate with its activity, both independently and collectively:

a. Intra-Center Apollo Relationships
b. Inter-Center Apollo Relationships
c. Inter-Agency Apollo Relationships
d. Contractor Relationships

INTRA-CENTER APOLLO RELATIONSHIPS

The KSC Center Director delegates functional responsibilities to subordinate management officials at KSC through organizational charters and operating concepts. By this method each Director, Manager, and Supervisor (at all levels) is held responsible for both the substance of his assignments and their management aspects. With the KSC Apollo Program Manager identifying program requirements to the operating directorates, the officials involved designate task assignments within their own organizations.

Inter-directorate requirements are correlated through agreements among the officials involved at the applicable organizational levels. By this means lateral communication is encouraged and problem resolution accomplished at the appropriate level to which approval authority has been delegated. It is important to note that a subordinate cannot be delegated denial authority only. For example, when one KSC organizational element at a given level of management formally initiates an action which requires the approval of an official at an equal level in another KSC organization, the requested action shall not be denied by a subordinate of the approving official.

The KSC Center Director also chairs a KSC Senior Management Council. The membership of the Council includes the chief official from primary organizations reporting to the Center Director. The Council provides the principal forum for discussion and resolution of major problems which have broad application across several operational organizations.

Management Boards are organized at lower levels to insure that management decisions and policies are understood by all levels of management at KSC.

The KSC Center Director also uses Ad Hoc Committees to develop the best possible considerations and recommendations for specific activities.

INTER-CENTER APOLLO RELATIONSHIPS

To carry out its assigned responsibilities, KSC has several operating agreements with other NASA components and elements of other government agencies. For the most part, the KSC organization is structured to provide clean-cut relationships with counterparts in Headquarters and other NASA Centers.

With respect to the other MSF Centers (MSFC and MSC), the KSC Apollo Program Manager is the primary and official KSC point of interface in regard to Apollo program functions. Specifically, he is responsible for assuring that their requirements are valid, program funds are available, and that an effective system provides assurance to the Development Centers of adequate configuration control concerning implementation of directed changes to their hardware at KSC. He is also responsible for maintaining a close and cooperative working relationship with the other MSFC Center Program Managers with respect to mutual coordination and implementation of the Apollo Program.

INTER-AGENCY APOLLO RELATIONSHIPS

The Apollo Program requires support from government agencies other than NASA. This is characterized by the use of the facilities operated by the Air Force Eastern Test Range and the world wide tracking network. Within the provisions of the NASA/Department of Defense agreement, KSC obtains ETR services through an agreement negotiated with Patrick Air Force Base (PAFB). Similarly, this agreement also obtains PAFB support for those installations on Cape Kennedy for which KSC has tenant occupancy. The Director of Technical Support maintains a single-point interface with PAFB to consolidate and coordinate KSC requirements.

CONTRACTOR RELATIONSHIPS

Kennedy Space Center operates under government/contractor relationships through nonpersonal services contracts. These nonpersonal services contracts fall into three major groups:

a. KSC-Stage Contracts are those which render launch related services directly to KSC for Saturn Class vehicles (Uprated I and V) and their separate stages.

b. Other Launch Services Contracts identify those contractors of other NASA Centers which render launch related services indirectly to and at KSC for other launch vehicles (e.g., Centaur), manned spacecraft (e.g., Apollo), and unmanned flight hardware (e.g., Lunar Orbiter).

c. Support Services Contracts are those which render services of a supporting nature to one or more of the KSC Directorates. This group involves services concerned with functions such as communications, photography, instrumentation, reproduction, supply, environmental health, and computation.

Each contractor manages its own contract mission affairs, and KSC exercises its contract management responsibilities for the total operation by monitoring and/or instructing the contractor. KSC monitors or instructs the various contractors through the use of the following designated officials:

a. The Contracting Officer has the responsibility of administering the contract and rendering any required interpretations to it.

b. The Contract Technical Manager (CTM) is a key directorate official responsible for the technical planning and management of a directorate major mission which is executed through the use of a nonpersonal services contractor.

c. The Technical Representative (TR) is utilized by each designated CTM for each contract area of functional interest wherever the work statement of a contract has multiple functions.

d. The Contract Management Assistance Officer (CMAO) performs functions delegated by the Contracting Officer and serves as a representative of the operating directorate to which assigned.

The Apollo Program Manager has a key role in the generation of the scope, or change of scope, in the work of the stage and spacecraft contractors, or when the work impinges on Development Center relationships to a stage or spacecraft contractor. All technical instructions to the contractor within the scope flow through the line organizations. Since the Program Manager is responsible for keeping performance, schedule, and costs in an optimum balance throughout the preparation of flight hardware, he maintains a continuous overall surveillance of the stage or spacecraft contractors. However, he does not become involved with the contractor in his daily operational management within approved plans and guidelines. The major contractors at KSC are identified in Figure 3-4 which illustrates their proportionate share of the KSC contractor activities measured in terms of manpower.

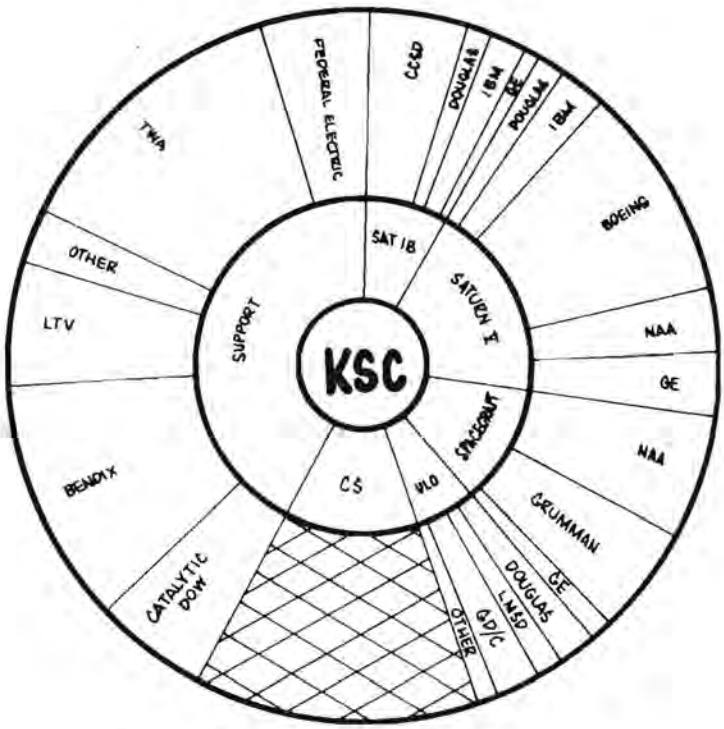


Figure 3-4. KSC Major Contractors

To provide an adequate description of the various activities and support efforts of the contractor elements at KSC would require several hundred pages of written work statements and contract definitions. However, a brief summary of the primary functions performed by the major contractors is shown in Figure 3-5.

STAGE	
BOEING	PREPARE, CHECKOUT AND LAUNCH THE S-IC STAGE; OPERATE, MAINTAIN AND PROVIDE DESIGN SUPPORT FOR COMMON MECHANICAL GSE; INTEGRATE LAUNCH VEHICLE INPUTS FOR LAUNCH AND MISSION RULES DOCUMENTS AND INTEGRATED TEST PROCUDURES; PERFORM OTHER RELATED LAUNCH SERVICES
CHRYSLER	PREPARE, CHECKOUT AND LAUNCH THE S-IB STAGE; OPERATE, MAINTAIN AND PROVIDE DESIGN SUPPORT FOR COMMON MECHANICAL GSE; INTEGRATE LAUNCH VEHICLE INPUTS FOR LAUNCH AND MISSION RULES DOCUMENTS AND INTEGRATE TEST PROCEDURES; PERFORM OTHER RELATED LAUNCH SERVICES
DOUGLAS	PREPARE, CHECKOUT AND LAUNCH THE S-IV STAGE AND PERFORM OTHER RELATED LAUNCH SERVICES
GE	GENERAL ENGINEERING AND FABRICATION SUPPORT
IBM	PREPARE, CHECKOUT AND LAUNCH THE I.U. STAGE; OPERATE AND MAINTAIN COMMON SATURN V LAUNCH VEHICLE ELECTRICAL GSE; PERFORM OTHER RELATED LAUNCH SERVICES
NAA	PREPARE, CHECKOUT, AND LAUNCH S-II STAGE AND THE APOLLO SPACECRAFT; PERFORM OTHER RELATED LAUNCH SERVICES
GRUMMAN	PREPARE, CHECKOUT, AND LAUNCH THE LM AND PERFORM OTHER RELATED LAUNCH SERVICES
SUPPORT	
BENDIX	MAINTAIN AND OPERATE MAJOR FACILITIES ON COMPLEXES AND IN INDUSTRIAL AREA
CATALYTIC/DOW	FACILITIES ENGINEERING SUPPORT SERVICES
FEC	OPERATE, MAINTAIN, INSTALL AND REPAIR OF INSTRUMENTATION COMMUNICATIONS EQUIPMENT
LTV	REPRODUCTION, PHOTOGRAPHY, COMPUTER SERVICES AND TECHNICAL WRITING
TWA	HOUSEKEEPING AND GENERAL INSTITUTIONAL SUPPORT SERVICES

Figure 3-5. KSC Contractor Functions

SECTION 4
MANAGEMENT SYSTEM ELEMENTS

Program management is the process of responsible, calculated control of iteration against progressive baselines that considers all operative factors during the evolutionary stages of development. In essence, the job of management is one of establishing a set of initial conditions, keeping track of progress in working to these conditions, and deciding on changes once that baseline is established. Managers either stand or fall on the astuteness and judgment with which they make these change decisions.

To be successful, management must enforce a set of program disciplines. Disciplines need to be enforced, both on management itself and on the collective organizations that have been given the job to do. These disciplines maximize the efficiency of the whole operation, of the individuals, and the collective organizations, and get the most productivity from the talent that is available to do the job. Development is an iterative process, and it takes a set of disciplines to make it successful.

What usually paces a space program when it comes down to the wire, when the big event that everybody is waiting for is ready to take place, is ground equipment -- perhaps a construction problem involving site activation, or getting the ground equipment installed and checked out. This is the responsibility of KSC. The prime equipment must first be designed, sized, etc., before facilities can be constructed to fit, and ground equipment designed to check out the prime equipment. KSC, therefore, had to wait until the prime hardware was well along the way before its contribution could begin on facilities, the size of which had never before been attempted and ground equipment, the complexity of which had never before been designed.

This unique challenge has and is being met by KSC in the implementation of proven management techniques and systems that pull together and utilize several government agencies and contractor organizations of diverse talents and skills. Each system at KSC, however, fits into Aerospace Management classic categories: Logistics, Configuration Management, Data Management, Schedules, Resource Control, and Reliability. The following paragraphs describe the utilization of these management techniques and systems at KSC and how the four hallmarks of program management are implemented.

IDENTIFICATION OF MAJOR ELEMENTS

A cursory analysis of a successful program reveals the existence of five basic management elements largely responsible for the success of that program. These elements may be referred to by many different names, but are basically:

a. Requirements definition
b. Requirements amplification and implementation

c. Management information and communication
d. Management decision process
e. Measure of management effectiveness

Further analysis identifies the application of these elements across the board, at all levels of management. These elements, in sequence, constitute the logical progression of management through the program phases of design, development, manufacturing, check-out, and operations. The inter-relationship of these elements and program phases to the basic program management elements is portrayed in Figure 4-1.

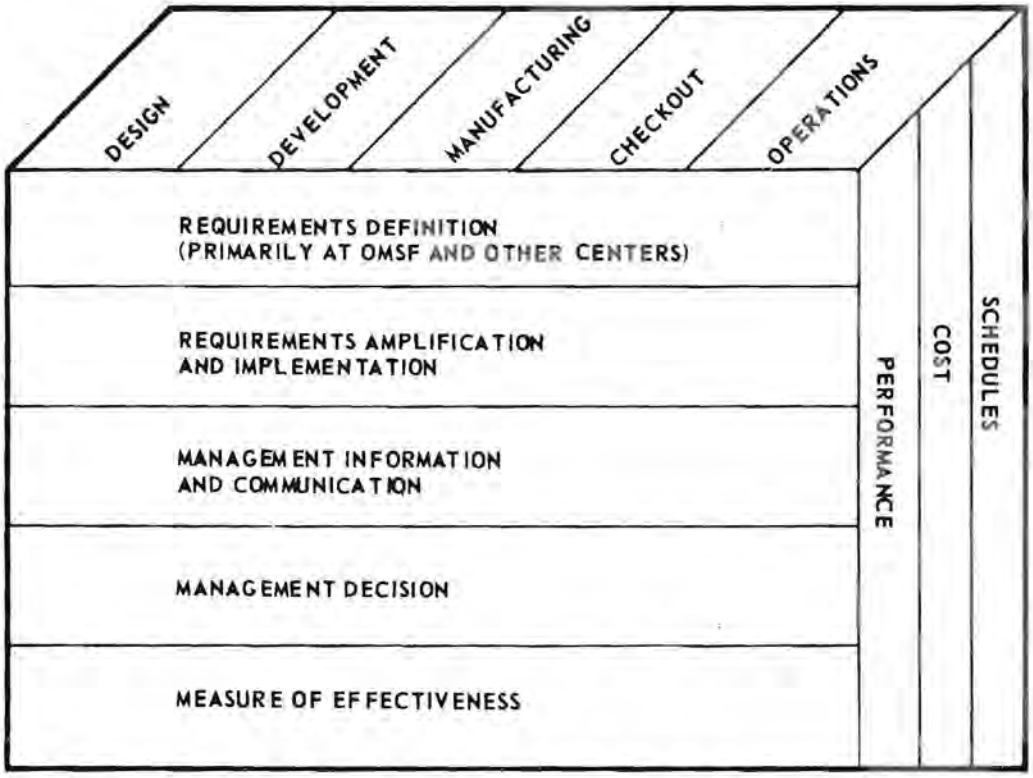


Figure 4-1. Management System Elements

In the Apollo program, program requirements are defined by the Apollo Program Office which in turn initiates the amplification and implementation of these requirements by the tiered definition of mission, project, system, subsystem, and component requirements, all based on the initial program requirements. The implementation of these requirements is manifested for the most part in the development of the equipment and facilities to support the program.

Throughout all program phases, effective communication within and across all levels of management is required. This is accomplished by the establishment of formal lines of communication in the form of reports, reviews, panels, boards, working groups, etc. to assure the proper and timely flow of management information. This information is reviewed and assessed at the appropriate management level, decisions are made, some which affect

the requirements baseline are established, and changes are implemented. The program management loop from initial monitoring through review, assessment, and eventual change to requirements provides the necessary feedback to the working levels to maintain program continuity and consistency.

REQUIREMENTS AMPLIFICATION AND IMPLEMENTATION

The initial action undertaken in the implementation of a program is to establish program goals and develop the baseline against which progress and performance may be determined. These baselines are defined as those minimum items or levels of achievement necessary to the attainment of both hardware and software objectives in the broad areas of schedules, cost, and performance. Program plans are then prepared that express the manner of achieving the program goals within the baseline constraints. The program plans at KSC include requirements, facility concepts, hardware specifications, operational flows, and documentation. The program project and system baselines are established and reflected in these plans at corresponding levels.

REQUIREMENTS DOCUMENTATION

Documentation consists of a series of integrated plans, each of which deals with a specific project, operation, or service. This is depicted by the official KSC Apollo Document Tree, as shown in Figure 4-2. The KSC Apollo Project Development Plan is the key document in this series. As such, it reflects (for top management application) the impact of Apollo Program requirements on KSC. Each supporting level in turn presents its subjects at a corresponding management level to an expanding degree of detail. A document at each level is in consonance with the document it supports at the next higher level.

The second level of the Document Tree is represented by three management plans. Each of these deals with a prime KSC project under the Apollo Program. These documents are identified as:

a. KSC Apollo/Saturn Operations Plan, K-AS-0
b. Apollo/Saturn Program Management and Support Plan, K-AM-0
c. Apollo/Saturn V Development/Operations Plan, K-PM-0

KSC Apollo/Saturn Operations Plan, K-AS-0

This plan is a management document establishing the responsibilities, authorities, and functions of elements of KSC for conduct of Apollo Launch Operations. It describes and assigns responsibilities for preparation of subordinate launch operations documents essential for assembling all resources for the effective and timely checkout and launch of Apollo/Saturn space vehicles. Its prime supporting documents consist of a launch plan for each successive space vehicle in the series. Within the scope of the launch plans are the functions of launch operations, flight readiness, ground safety, integration and launch site assessment, post-flight refurbishment, launch support operations, failure investigation, instrumentation, launch rules, flight safety requirements, post-launch reports, security, and public affairs. Each of these functions is further delineated in detail in separate documents.

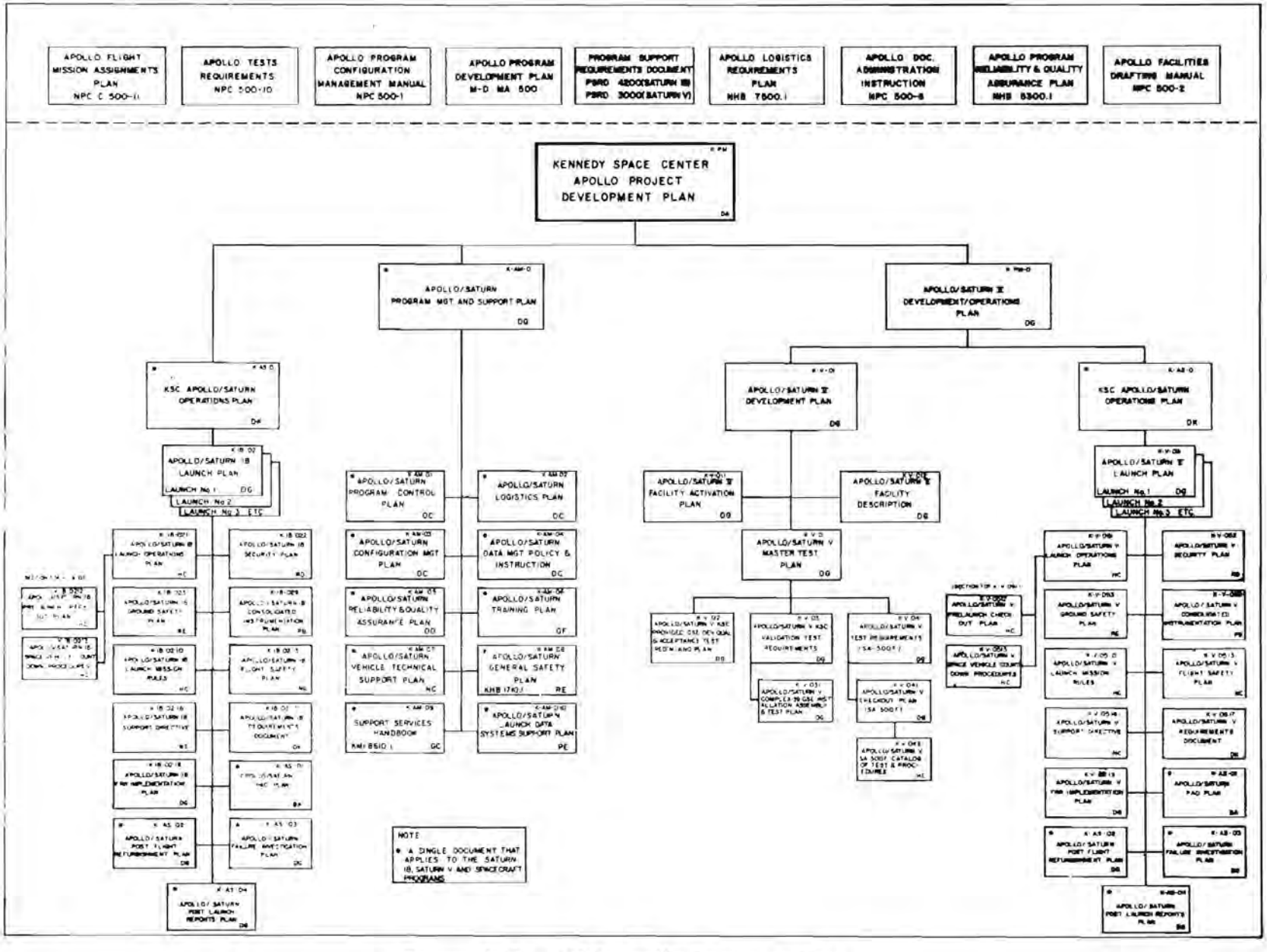


Figure 4-2. KSC Apollo Document Tree

Apollo/Saturn Program Management and Support Plan, K-AM-0

This document provides the management direction for the KSC implementation of control and support for the Apollo Program. It describes the general techniques by which KSC program management will maintain visibility of the program posture and respond to OMSF requirements. Its scope includes the subjects of program control, logistics, configuration management, data management, reliability and quality assurance, training, vehicle technical support, general safety, administrative support, and project development for launch instrumentation. The management direction for each of these subjects is presented in greater depth through a series of supporting plans.

Apollo/Saturn V Development/Operations Plan, K-PM-0

This plan identifies, defines, and documents the operational activities to be performed in support of Apollo/Saturn V launches at KSC.

The plan documents operations and support policies, defines Launch Complex 39 operational concepts, and identifies and defines the necessary test operations and operational aspects of the vehicle systems, associated GSE, and support systems.

Included in the test operations are the preparation, test, and launch of space vehicles (both launch vehicle and spacecraft, beginning with arrival of first stage at KSC); checkout and validation of GSE and support systems; test support operations, base support operations; and facility/GSE refurbishment.

Directives

Directives are used to provide management direction within a limited area of application or as a supplement to a plan. They serve to modify a provision of a plan between schedules updatings and to expedite actions in response to program requirements.

Three types of directives are considered applicable to Apollo Program direction at KSC:

a. Apollo Program Directives (APDs)
b. Mission Operations Directives (MODs)
c. KSC Apollo Program Office Directives (APODs)

Other directives which provide program information at KSC are:

a. MSFC Apollo Program Directives
b. MSC Apollo Program Directives

These are considered valid information but do not impose requirements on KSC, except by decision of the KSC Apollo Program Manager.

KSC administrative directives are issued to provide institutional direction. They are not program oriented, but may apply to the Apollo program. They are mentioned here in order to identify their relationship to the Apollo Program.

TEST AND OPERATIONS

The test and operations functions performed at KSC are intertwined. Test is the discipline while operations is the conduct of the discipline and all that it entails. Operations at KSC is the management and technical integration of the preparation, assembly, modification, test and checkout, countdown, and launch of the total space vehicle and is conducted by the Launch Operations Directorate. It also entails the installation, checkout, modification, maintenance, and operation of all vehicle-related GSE. The test requirements imposed upon KSC are a natural evolution of the total Apollo program test concept. These requirements include both ground and flight tests of vehicle stages and extend to the assembled vehicle for interface systems testing. In addition to the test related to the vehicle and its GSE, an extensive test program applies to the KSC-provided GSE and facilities. It is intended that the test program serve to exploit favorable test results, identify areas in which hardware does not meet performance specification requirements, and concentrate corrective actions in problem areas.

Development organizations are responsible for defining specific test and checkout requirements that must be performed on flight vehicles at the factory prior to acceptance and at the launch site prior to flight. Test and checkout requirements to demonstrate the performance of ground support equipment provided by the development organization are included. Test methods, hardware configuration, test sequence, and other constraints are identified to the extent necessary to assure attainment of test objectives, protect hardware from damage, and provide for the safety of personnel.

KSC directs the development, coordination, integration, and execution of the prelaunch checkout phase. Prelaunch checkout is the final test function to be performed on the space vehicle. KSC control of the mission begins with receipt of hardware at this Center and continues through the terminal countdown phase as shown in Figure 4-3. During this period, the development centers continue to exercise technical control but KSC is responsible to launch the vehicle from the pad. In the discharge of its responsibility, KSC conducts an abbreviated factory test sequence on each system, stage/module and the integrated launch vehicle and space vehicle, culminating in the Flight Readiness Review (FRR) and launch.

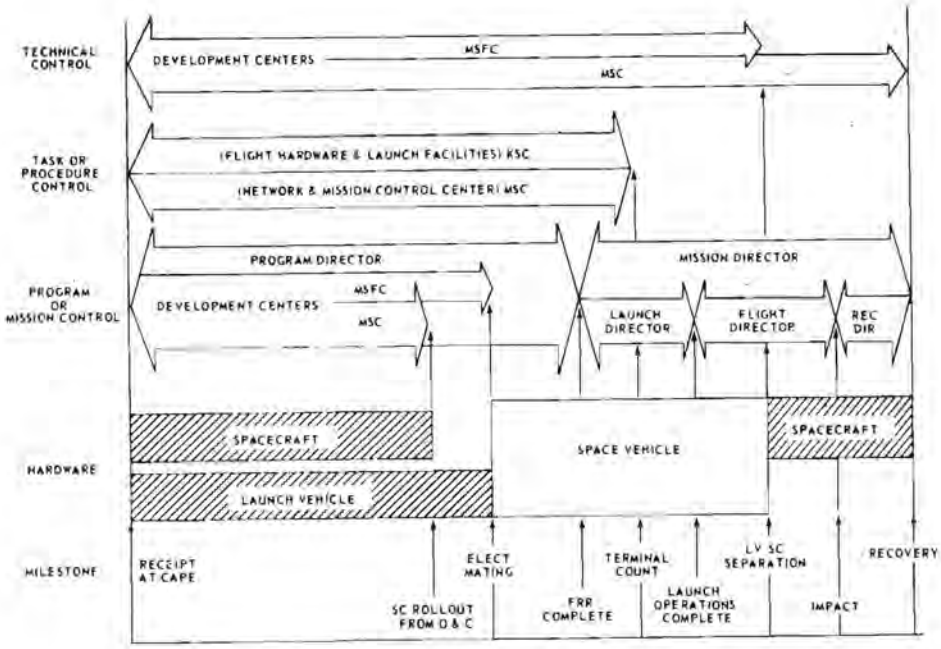


Figure 4-3. Mission Control

It is the responsibility of KSC to insure that the launch site test and checkout requirements provide an integrated flow of testing. The objective of this integrated test flow is to permit verification of the functional performance of essential systems and their integration into the space vehicle without unnecessary repetition of factory-level testing. To the extent practicable, the overall test flow permits correlation of data between factory and launch site testing for critical flight hardware components. The prelaunch checkout and launch operations requirements include tests that are:

a. Standard or repetitive (required for each vehicle)
b. Mission peculiar
c. KSC peculiar (can only be accomplished at KSC)
d. Special tests (based on specific vehicle test experiences)

Launch Operations

KSC launch operations are conducted at many facilities and involve a wide variety of payloads, both manned and unmanned. As the Apollo/Saturn V vehicle typifies the large scale operations of the future, management practices at this Center are perhaps best exemplified when related to this vehicle.

In its broad sense, launch operations includes all preflight activities at KSC as well as the countdown and flight mission. At this Center, the major effort is that of preparing the vehicle and facilities for launch. The Operations Flow Plan (Figure 4-4) illustrates the basic test requirements cycle.

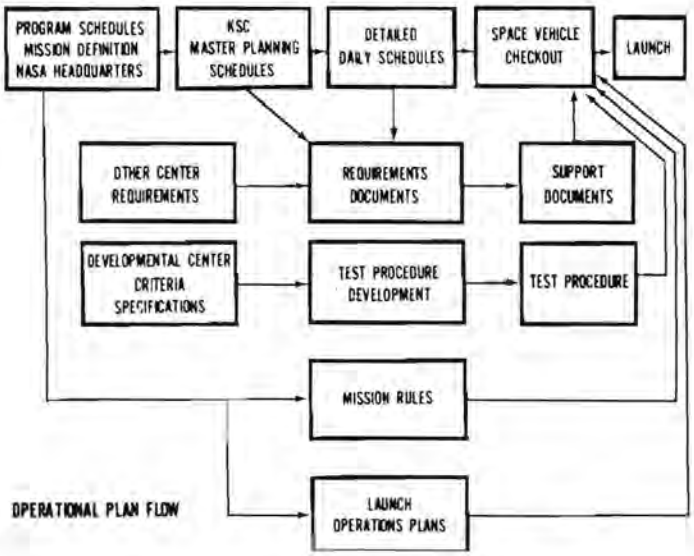


Figure 4-4. Operations Flow Plan

The Apollo Program Office establishes the test and operations requirements, plans, and schedules from an overall program standpoint. The Apollo Test Requirements Document identifies and requires the preparation of the lower level test program documents for the review and concurrence of the Apollo Test Director. KSC prepares the lower level test documents and maintains a technical interface with the Apollo Test Director.

The Development Centers prepare and provide the test and checkout requirements, specifications, and criteria that form the basis for KSC test planning. They also observe and monitor the test and checkout of the vehicle and provide consultant services as required. The control scheme and management plan for prelaunch checkout and launch operations between MSFC and KSC are shown in Figures 4-5 and 4-6. A similar agreement exists with MSC. Review and approval/concurrence authority is retained by the Development Centers to insure that the test requirements are satisfied.

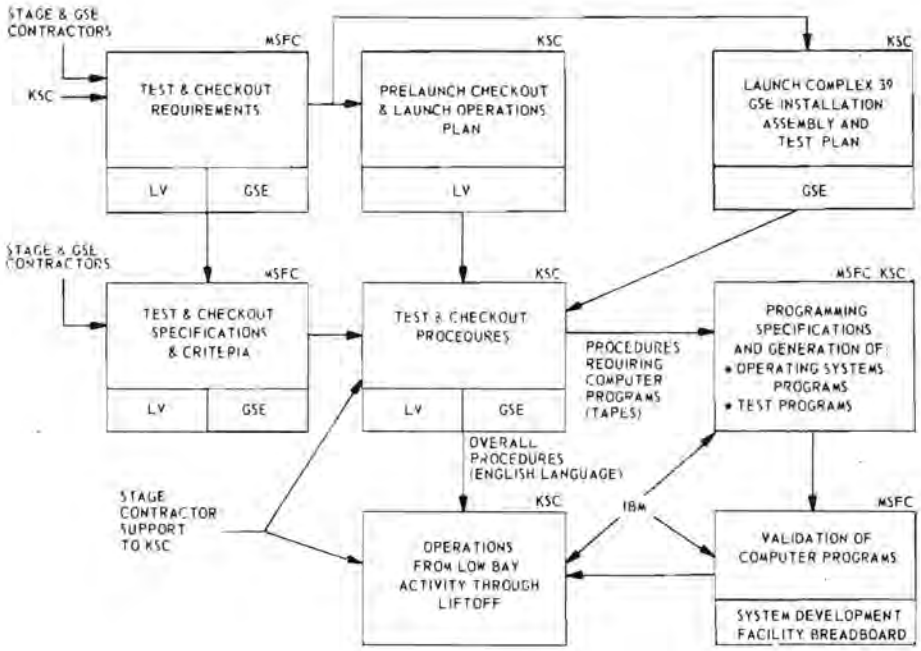


Figure 4-5. Prelaunch Checkout Control Scheme

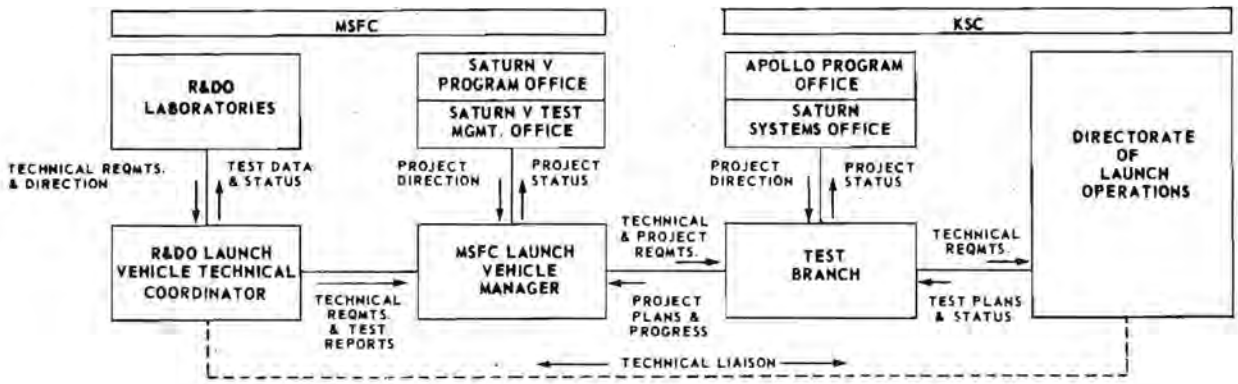


Figure 4-6. Prelaunch Management Plan

The KSC Apollo Program Manager is responsible for identifying and defining the Apollo/Saturn V test requirements at KSC. The management of this responsibility is performed by the Saturn Systems Office for the launch vehicle and its stages, the launch vehicle GSE, and the KSC-provided GSE and facilities. The Apollo Spacecraft Office performs a similar function for testing of the spacecraft, including the spacecraft GSE and facilities.

The Launch Operations Directorate initiates, supervises, and coordinates the preparation of preflight and launch operations test plans and is responsible for the execution of those plans. The Directorate assists the KSC Apollo Program Manager in negotiation with the cognizant Development Center concerning test and operational sequences, methods and standards; advises the Program Manager of deficiencies which require the correction/approval of a Development Center; and develops operational support and resource requirements needed to execute the assigned mission.

Requirements documents are generated to forecast the support needed from the AFETR as well as KSC. Support documents are initiated which detail how the requirements will be fulfilled. Detailed daily schedules are prepared which break down the large tasks into meaningful areas of work.

Hardware Specifications

The design of the Apollo program is based on a series of successively more detailed hardware specifications providing complete traceability from program to project to system. The technical and engineering considerations governing program design are determined by mission constraints, reliability and crew safety considerations, abort and alternate mission requirements, and mission operations objectives. The specifications may be classified as follows:

a. Program Specification. The Apollo Program Specification is the first level technical specification that delineates the performance, design, and test requirements for the various elements of the program. It provides the baseline upon which lower level specifications are developed.

b. Project Specifications. The next lower level is the Project Specification. KSC is currently assigned six Apollo projects: Saturn V, Uprated Saturn I, Apollo Spacecraft, Apollo Space Operations, Launch Support Operations, and Launch Instrumentation. The hardware specifications associated with these projects are delineated in the Apollo/Saturn Specification Tree, an example of which is shown in Figure 4-7. Due to the unique KSC requirements, however, these specifications are organized by launch and support facilities rather than accountable projects.

c. System Specification. The system specification is the lowest specification of the tree to be identified and it will include subsystem and component specifications

as required. The specifications of primary concern at KSC are those associated with facilities, GSE, and launch instrumentation. The vehicle specifications are the responsibility of the Design Centers and are of concern as they relate to KSC interfaces. These interfaces are specified and implemented as a result of Interface Control Documents (ICDs) developed by either the Design Centers or KSC and submitted to Inter-Center coordination panels for concurrence. Interface Revision Notices (IRNs) are used to revise or modify ICDs and the system/project specification as required.

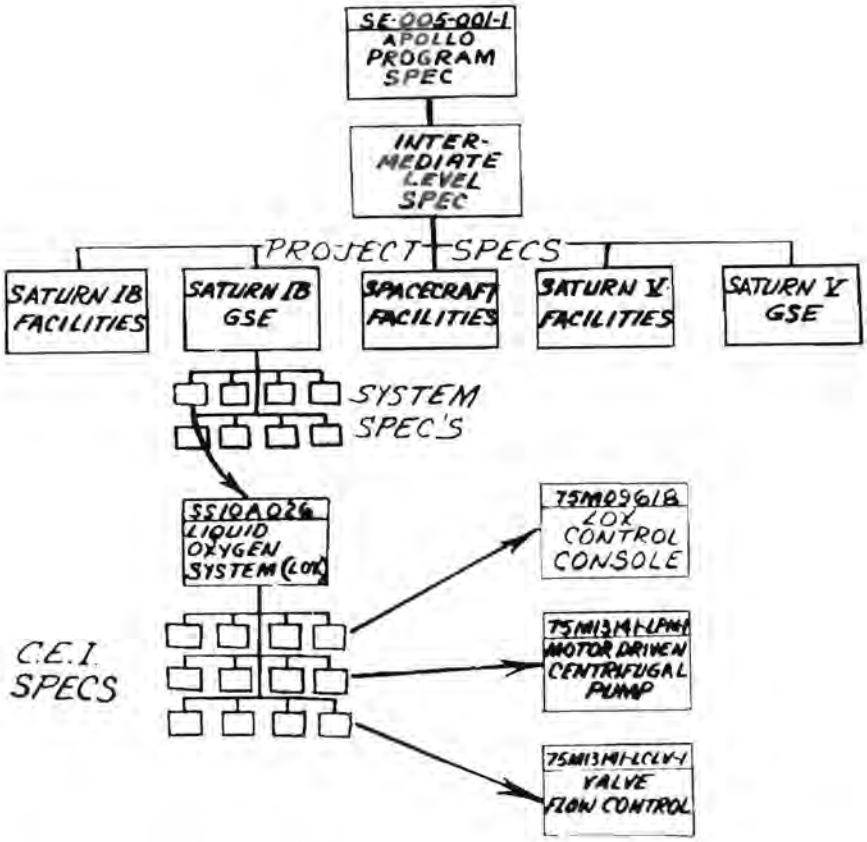


Figure 4-7. Sample Portion of KSC Apollo/Saturn Specification Tree

Test Plans and Procedures

Development organizations provide test specifications and criteria, or limits including redline values and associated configuration constraints, by which to judge acceptable performance of flight hardware and GSE as a result of optimum checkout operation and launch sequence studies conducted on that equipment for which they have design responsibility. KSC conducts similar studies on KSC-furnished equipment. These design

studies form the basis for the development of specifications and criteria to support the establishment of plans and procedures that complement factory testing and provide for a satisfactory level of confidence in the flight hardware.

Test and Checkout Plans are prepared by KSC in response to a Development Center Test Requirements Document. This Test Requirements Document is due at KSC 4 months prior to scheduled flight hardware delivery. The KSC Test and Checkout Plan includes an outline for accomplishing Development Center test requirements at the launch site and additional test requirements that KSC considers necessary to verify launch facility, manned space flight network, and launch crew readiness or to satisfy range safety requirements. The Test and Checkout Plan also includes, as a minimum, the following information:

a. A flow plan designating the sequence of test to be performed.

b. Identification of the test facilities involved in the overall test flow.

c. Cross-reference index to the Development Center test requirements.

d. A system to readily identify revisions.

e. A specific outline for each test that includes:

   (1) Test title and procedure number.

   (2) Test objectives.

   (3) Test location and facility.

   (4) Test description in sufficient detail to define the procedure in outline form.

   (5) Flight hardware and GSE requirements.

   (6) Significant support requirement (in summary only).

   (7) Identification of any hazardous operations.

   (8) Safety requirements, including any special equipment, personnel, procedures, or training required for the test.

   (9) A cross-reference to the Development Center test requirements where applicable.

   (10) Software requirements. (Programs utilized during testing.)

   (11) Identification of organizations outside of KSC that will be involved.

f. A detailed list of deviations from the Development Center test requirements and reasons for these deviations.

The Test and Checkout Plan is the master test document applied at KSC. This Plan is supported by additional plans as indicated by the KSC Apollo Document Tree (Figure 4-2). The plans in the Document Tree include the detailed guidelines and procedures necessary to accomplish the KSC launch operations functions while the Test and Checkout Plan is a technically oriented document. In total they represent the baseline for KSC operations and testing.

Test and checkout procedures prepared by KSC define the detailed step-by-step sequence of events in a specific test and are generated for each test associated with preparation and launch of flight hardware. The responsibilities and interfaces among KSC, Development Centers, and contractors in the preparation, revision, and execution of test and checkout procedures are clearly defined in supporting documentation.

Factory or test site test and checkout procedures which have been approved by the development organization are used as a baseline, where applicable, in the development of KSC test and checkout procedures. These factory test and checkout procedures, modified for use at KSC to fit unique facility requirements, safety considerations, and integrated space vehicle test requirements, fulfill the objectives of the Test and Checkout Plan in response to the Development Center test requirements, specifications, and criteria. To the extent practicable, the overall test sequence permits correlation of data between factory and launch site testing for critical flight hardware components.

The effective use of test and checkout procedures is best illustrated by Figure 4-8 which shows the activity in a highly instrumented Firing Room of the Launch Control Center during the actual launch of an Apollo/Saturn V Space Vehicle.

Figure 4-8. LCC Firing Room During Launch

Vehicle Checkout

Prelaunch checkout at KSC is conducted by stage contractors under the technical supervision of the Launch Operations Directorate. Requirements, plans, procedures, etc., are developed prior to the receipt of the hardware. Once the hardware arrives, stage contractors concurrently perform the inspection/checkout process in the VAB to ready the stage for erection on the Launch Umbilical Tower (LUT - same as Mobile Launcher) while the spacecraft (Command Service Module and Lunar Module) is undergoing checkout in the Operations and Checkout Building.

Following these checks, each stage is erected and mechanically mated in one of the VAB high bays. The compatibility of the smallest modules is verified by performing system checks since component level testing has already been accomplished at the various factories.

KSC has the responsibility of integrating the vehicle systems. Therefore, testing is aimed at verifying the total electrical mate of the space vehicle. These are systems tests, a series of tests which allow the checkout of the launch vehicle. The same checkout philosophy is used with the spacecraft, with one difference - the flight crew. The tests leading up to the altitude chamber tests are much the same as those for the launch vehicle.

The first tests involving the crew are performed in the altitude chamber where the spacecraft is tested at a simulated altitude of over 200,000 feet. These tests are laid out jointly between the astronauts and test team and are normally 12 to 16 hours at altitude. Next, additional hardware is installed to complete assembly of the spacecraft.

When the launch vehicle stages approach the required degree of readiness, they are erected on the LUT and integrated checkout commences. The completion of integrated launch vehicle checkout signifies the transfer of the spacecraft to the VAB where it is erected on the launch vehicle. Figure 4-9 illustrates stage erection and assembly operations in the VAB high bay area and shows the mechanical mating of a spacecraft to the launch vehicle.

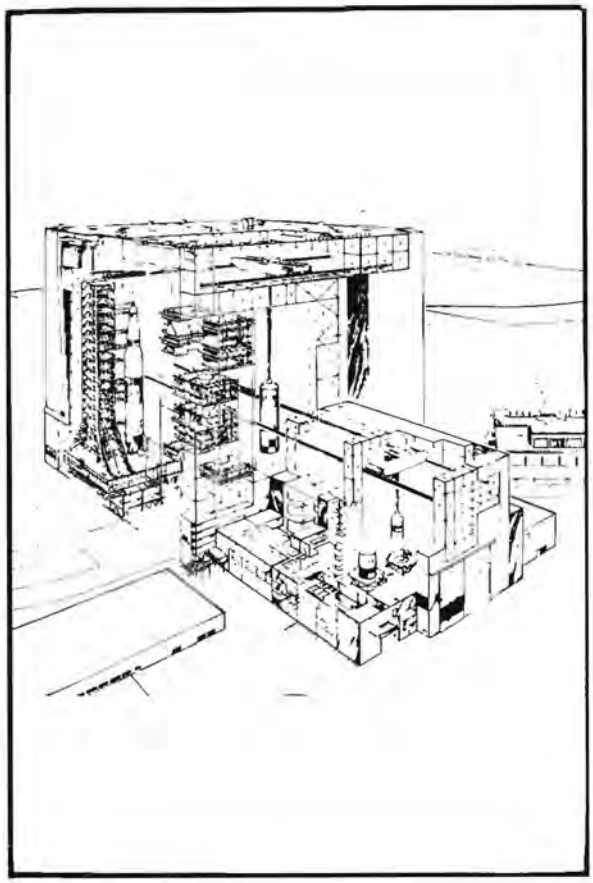


Figure 4-9. Stage Erection in VAB High Bay and Actual Mechanical Mate of Spacecraft to Saturn V Launch Vehicle

After the spacecraft has been erected and mated with the launch vehicle, all testing is combined, that is, first stage through the spacecraft. This integrated space vehicle testing provides further verification of all ground and airborne systems and includes simulated countdown tests. Testing within the VAB concludes with a simulated flight test which demonstrates that the vehicle is ready to be moved to the launch pad. At the pad, a further series of tests serves to reverify all systems. The one major test conducted only at the pad is the Countdown Demonstration Test in which the vehicle is actually fueled as for flight. This is a true dress rehearsal for the launch.

During the test process, assessments are continually made to determine the adequacy of technical, cost, and schedule performance. Key interface milestones are identified, e.g., Launch Vehicle Electrical Mate, Spacecraft Mechanical Mate, as indicators of accomplishment. Progress reviews are conducted daily, weekly, and monthly at appropriate management levels not only to review the current progress to the plan but to resolve and anticipate problems that interfere with mission accomplishment of this objective.

Launch Team

It must be emphasized that carrying out launch operations is truly a team effort, particularly during the final countdown. Management of these operations is conducted through a task force drawn from the total NASA organization (see Figure 4-10).

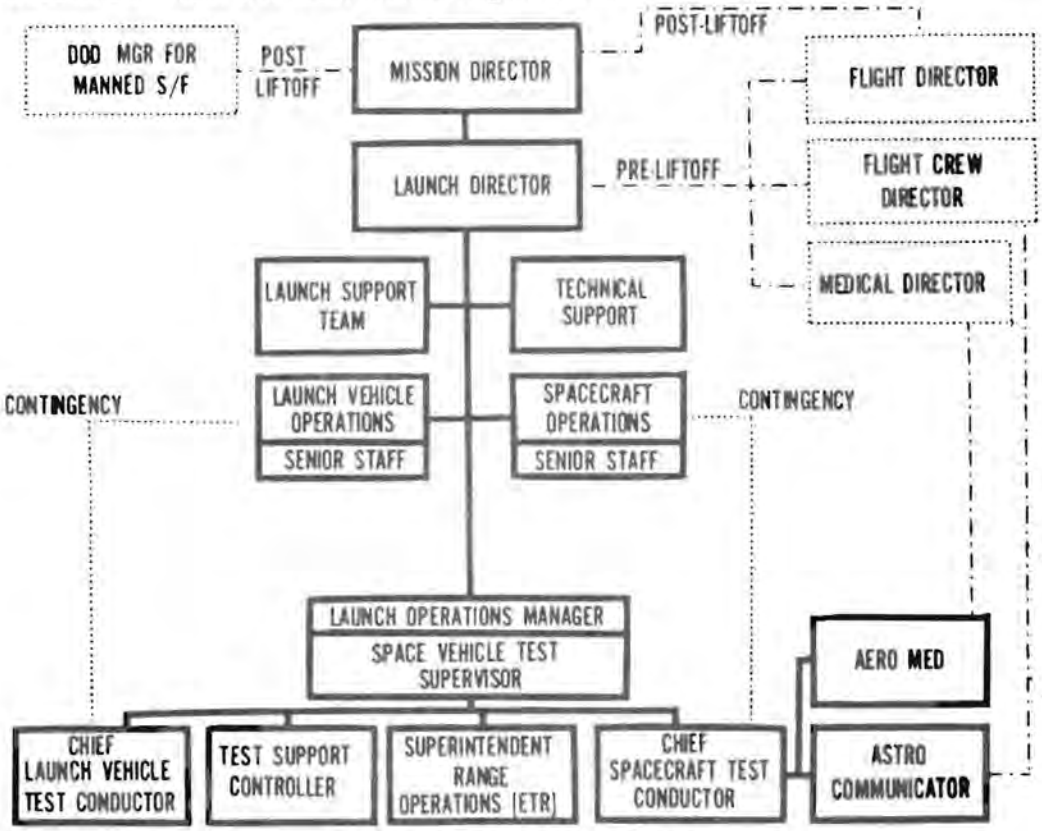


Figure 4-10. Launch Team

The Mission Director is assigned from NASA Headquarters and operates from both MSC and KSC until time of actual launch when he is located at Mission Control Center in Houston. The Launch Director at KSC exercises control of activities at the launch site and delegates certain responsibilities to the Launch Operations Manager and the Space Vehicle Test Supervisor. The Test Supervisor coordinates activities of the Launch Vehicle and Spacecraft Test Conductors, KSC technical support personnel, and other support elements such as the Eastern Test Range.

The test conductors respond to the direction of the Test Supervisor during checkout and countdown activities. NASA systems engineers are responsible for each stage and major system. Government members and contractor counterparts work together as a team for the conduct of prelaunch checkout and launch countdown operations. Although launch team members perform in accordance with planned and rehearsed activities, problems may arise that are beyond their capabilities or scope of efforts. When such contingencies arise, the resources of the Launch Vehicle Operations and Spacecraft Operations Directorates (Directors and Senior Staffs) are made available for assistance in solving the problems.

Support Operations

KSC has implemented a formal documentation system that provides a means by which all external agencies or internal elements of KSC, who need KSC support, can list their requirements and receive a formal reply. This reply represents a support plan and when published becomes directive in nature on the KSC elements involved. The requirements documents and support plans are flexible to permit periodic updating.

The documentation is separated into manned and unmanned systems at KSC. Discussion is limited to the manned system for this document.

The major documents for requesting support are as follows:

a. The Program Support Requirements Document (PSRD) is a publication of the NASA/DOD standardized document system and is prepared, issued, and maintained by the OMSF Operations Support Requirements Office. The PSRD establishes the gross requirements necessary for support of a manned program and its mission, and is issued early in the program to provide the support agencies with authorization to initiate procurement on long lead items.

b. The Requirements Document (RD) outlines in specific detail the requirements placed on KSC by internal elements, other NASA centers, and DOD to support a program, mission, or test. The RD is prepared in sufficient detail to permit supporting organizations to plan and budget support.

The major documents detailing the KSC support to be provided are as follows:

a. The Program Support Plan (PSP) is the response of support organizations that shows how the requirements of the PSRD are to be met.

b. The Support Directive (SD) is the KSC inhouse response to the RD and represents authorization to proceed.

c. The Work Order is a statement of services, repairs, or support required as nonrecurring or a secondary support effort. Work Orders also represent authority to proceed. They require no support commitment or prior planning, and are submitted directly to the supporting elements.

Although numerous interfaces and exchanges of information among KSC organizations are required in the derivation of operational support requirements and responses, the general flow of documentation is as shown in Figure 4-11.

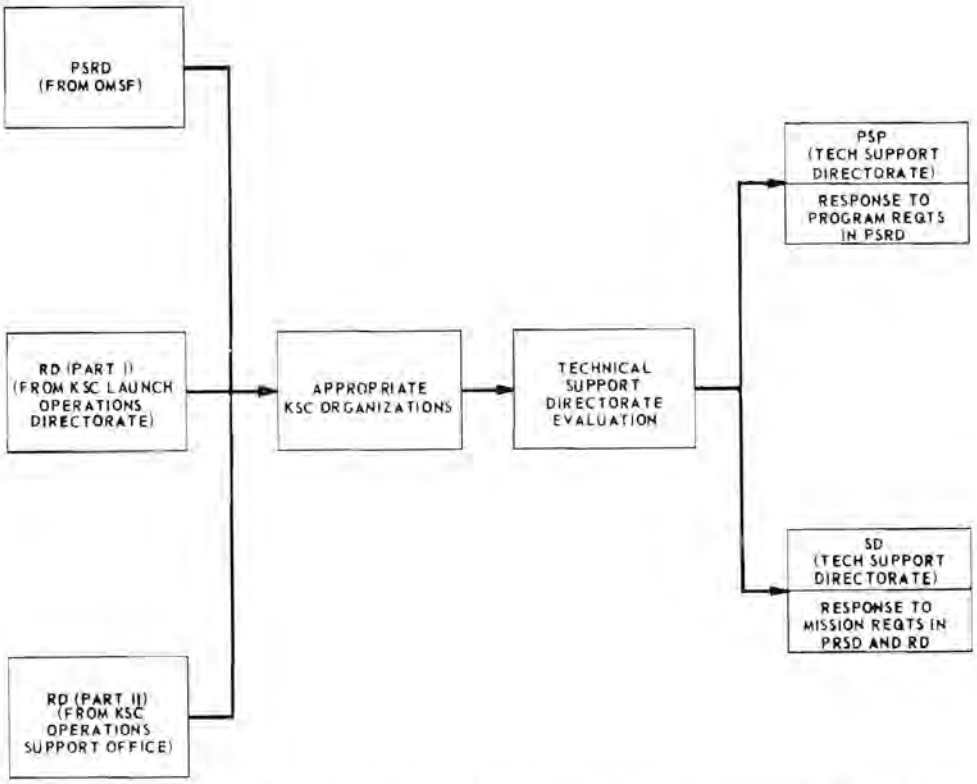


Figure 4-11. Typical Flow of Support Documentation at KSC

The KSC Operations Support Office is the responsibile KSC contact for operational requirements levied on KSC support elements and for the dissemination of the resulting KSC support plan. This office is also responsible for the preparation of KSC inputs to the PSRD and PSP, for keeping them current, and for the consolidation, publication, and distribution of RD, PSP, and SD documents.

The support mission of KSC is to make available to all programs those KSC facilities which have been developed for the Apollo program. The function of support becomes a method of defining requirements and providing a support response to requirements levied on the Center by external agencies or by a KSC element.

The major areas of support are summarized in Figure 4-12. The Informations Systems and Support Operations categories portrayed therein are the responsibilities of the Technical Support Directorate whereas the Administration and Safety categories are the responsibilities of the Installation Support Directorate.

- **EDV**

  DESIGN SERVICES
  MINOR CONSTRUCTION

- **INFORMATION SYSTEMS**

  TELEMETRY GROUND STATION
  DATA DISPLAYS
  COMPUTER OPERATIONS
  APOLLO LAUNCH DATA SYSTEMS (ALDS)
  METEOROLOGICAL MEASUREMENTS
  TIMING & COUNTDOWN
  CLOSE-IN TRACKING
  GROUND MEASUREMENTS

- **ADMINISTRATION**

  SECURITY
  MEDICAL
  FOOD SERVICE
  TRANSPORTATION

- **SAFETY**

  PAD SAFETY
  INDUSTRIAL SAFETY
  ASTRONAUT EGRESS
  EMERGENCY RESCUE

- **SUPPORT OPERATIONS**

  FIRE PROTECTION
  METEOROLOGICAL PREDICTION
  FIXED & MOBILE STRUCTURES
  POWER
  COMMUNICATIONS
  HEATING - AIR CONDITIONING - VENTILATION
  CLEANING SERVICES
  OIS - OTV - PAGING
  REPRODUCTION
  PHOTOGRAPHIC
  CALIBRATION
  PROPELLANTS & GASES
  HAZARDS MONITORING

Figure 4-12. KSC Areas of Support

Vehicle Technical Support

The Apollo/Saturn vehicle technical support activities (administered by the Technical Support Directorate) include the management of Apollo resources approved and allocated for the task, test support coordination with outside agencies, and the general management of support operations. The vehicle technical support activites realize the following objectives:

a. The management of launch support facilities and equipment to support a requirement for operational readiness.

b. The implementation of an integrated logistic program for response to the scheduled and unscheduled maintenance of launch support facilities and equipment including the provisions of propellants.

c. The management of test areas in support of spacecraft and launch vehicle tests.

Launch Data Systems Support

Launch Data Systems Support (also administered by the Technical Support Directorate) includes resources management, technical analysis of test and launch data, coordination of instrumentation requirements with outside agencies, and the development of measurement specifications and criteria. Implementation of this support function accomplishes the following objectives to:

a. Develop a KSC information system for the acquisition, handling, and distribution of data in support of launch systems.

b. Provide a focal point for the consolidation of instrumentation requirements other than that instrumentation onboard the flight vehicle and the related checkout equipment.

c. Supply secondary standards for the calibration of launch system measuring devices.

FACILITIES

The Apollo program created an extraordinary requirement for the acquisition of land and facilities at KSC. NASA received funding authority under the Construction of Facilities account to purchase 87,800 acres north and west of the existing range. The land has been purchased and construction is now essentially complete on the launch complexes and support facilities for the Apollo program.

Facility projects to be financed under the Construction of Facilities appropriation are subject to a four-phase programming cycle with approval to initiate each successive phase based upon the results of the preceding phase. These four phases are conceptual study, preliminary design, final design, and project execution.

The program concept for KSC facilities allocated to Apollo/Saturn operations include Complex 34, 37, and 39 for launch operations and the Industrial Area for testing of components and systems. These facilities represent a technological evolution developed from experience gained during earlier projects. By their design, they represent a highly sophisticated concept for the integration of facilities with the space vehicle and the severable ground support equipment.

The knowledge gained from the adaptation of conventional facilities to the increased dimensions presented by Saturn I and Uprated Saturn I vehicles provided the opportunity to evaluate new facility applications. The dimensional constraints presented by the Saturn V launch vehicle produced facility requirements to a scale never before attempted. The construction, activation, validation, and operation of these facilities present management complexities which impact both program-oriented and center-oriented organizations.

Conceptual Study

A conceptual study to establish the nature of the functional requirement may be undertaken at any time a facility requirement is identified, either in institutional management or in the course of conducting a R&D program or project. A conceptual study determines the feasibility of a requirement, selects a concept, and provides an approximate cost estimate. At KSC, conceptual studies are normally conducted by an Architectural/Engineering or support contractor under auspices of the Design Engineering Directorate.

Preliminary Design

On the basis of a completed conceptual study, a preliminary design effort may be undertaken either by the Center Director or the Program Director. Preliminary design embraces the most economical and sound engineering method to fulfill the functional requirement. It provides a basis for final design and detailed specifications and includes cost estimates to support subsequent budget submissions. The preliminary design effort is funded from the facility planning and design portion of the Construction of Facilities appropriation. Management of the effort is provided by the Civil Engineering Branch with an Architectural/Engineering contractor under contract to KSC or the Corps of Engineers. A Preliminary Engineering Report (PER) is prepared as a result of this effort.

Final Design

Approval to execute final design of C of F projects rests with the Associate Administrator. A PER is required to accompany the project proposal if it is to be included in the next FY budget request. An early approval is desirable to provide a basis for award of construction contracts as soon as possible after appropriation of funds.

Final design entails the development of detailed specifications, drawings, etc., to support the final bid package. Management and funding of the effort is identical to that of the preliminary design effort.

Project Execution

The execution of the project begins with the Center action to open bids and award a construction project. The completion of the final design package, evidenced by the opening of bids, signifies the transfer of responsibility from the Civil Engineering Branch to an Engineering Manager for the construction, fabrication/installation, and testing phase. After award of contract, the facility is activated by the support contractor under the cognizance of the Engineering Manager. Funding for the project is appropriated from the Center C of F budget.

ENGINEERING

Systems Engineering

Systems engineering activities are directed toward assuring the overall compatibility, mission suitability, feasibility, and cost effectiveness of the integration, launch, and test and checkout systems utilized at KSC. Activites include the initiation, direction, conduct, control, and management of analyses, studies, evaluations, and design reviews.

The systems requirements, in terms of technical parameters, are derived from the Apollo Program Director policies, directives, and specifications. From these parameters, Systems Engineering:

a. Defines hardware, software, facilities, personnel, and procedural data required to fulfill total system or project objectives.

b. Develops performance, design, and test requirements during early design on the basis of integration and trade-off of systems performance requirements, system elements (hardware, software, facilities, procedural data, and personnel), and end-item design constraints.

c. Interrelates the design effort with the development requirements for test, production, installation and checkout, acceptance, quality assurance, maintenance, and personnel throughout the life cycle of the system.

d. Provides the necessary criteria in the system performance/design requirements general specification and detail specifications for evaluating contractor design development and production effort against specified performance.

e. Provides the technical basis for configuration management activities, such as definition and justification of program requirements; establishment of the program requirements baseline, design requirements baseline, and product configuration baseline; development of specifications; and justification of engineering change proposals.

Systems Engineering Management Objectives

The management objectives of Systems Engineering are to:

a. Provide an overall functional system analysis for the total KSC complex devoted to prelaunch and launch of vehicles assigned to the Apollo program.

b. Make preparations, participate in, coordinate followup action, and submit proposals for improvement of systems.

c. Provide recommendations concerning major change proposals through the assessment of modifications.

d. Provide original and advanced plans for improvement of KSC systems while assuring that all changes remain within the boundaries of the programs.

e. Provide recommendations concerning the impact of new or modified programs proposed for KSC through analytical and practical evaluations of concepts, systems, procedures, operations, materials, and processes.

f. Provide engineering services through contractors to develop top-level KSC systems specifications to cover Apollo requirements.

g. Provide Ad Hoc Measurements Subpanel.

h. Provide contractor support for the administration of the Launch Operations Panel (LOP). This includes recording, preparing, and distributing LOP minutes/action items and final documentation. The contractor is responsible for the administration of the LOP ICD/IRN Program, including preparation of procedures, tracking of documentation status, maintenance of log book, and preparation of periodic reports.

Systems Engineering Techniques and Interfaces

The application of techniques and processes is subject to the constraints imposed by the Apollo Program Manager.

The first step of the process starts by identifying system requirements such as those contained in specific operational requirements, and translating the operational requirements into functional requirements.

These functions and associated criteria are analyzed and translated into design requirements. The design requirements comprise all requirements (including design constraints) that have a bearing on the functions being analyzed. These requirements are recorded on Requirements Allocation Sheets (RAS) and timeline sheets.

System/design engineering studies are performed to determine the selection of functions and functional sequence, and to determine the design, personnel, training, and procedural data requirements imposed by functions.

Utilizing the design approach determined from system/design engineering studies, the design requirements developed are integrated into contract end items (CEIs) and the CEI performance, design, and test requirements are recorded on a design sheet. These requirements sufficiently define engineering values with associated tolerances to provide criteria for the detail design, development, and test of the contract end item. The design sheets document the "design to" and "test to" requirements for contract end items and, subsequently, become sections three and four of the corresponding Part I detail specification.

When the fundamental cycle of the system engineering process is documented in the first level functional flow block diagram and RAS, Trade Study Reports, and design sheets have been completed, the second level functions are identified and the fundamental process repeated. The same procedure is followed for any additional levels required to define and design the system. A general summation of the systems engineering functions is depicted in Figure 4-13.

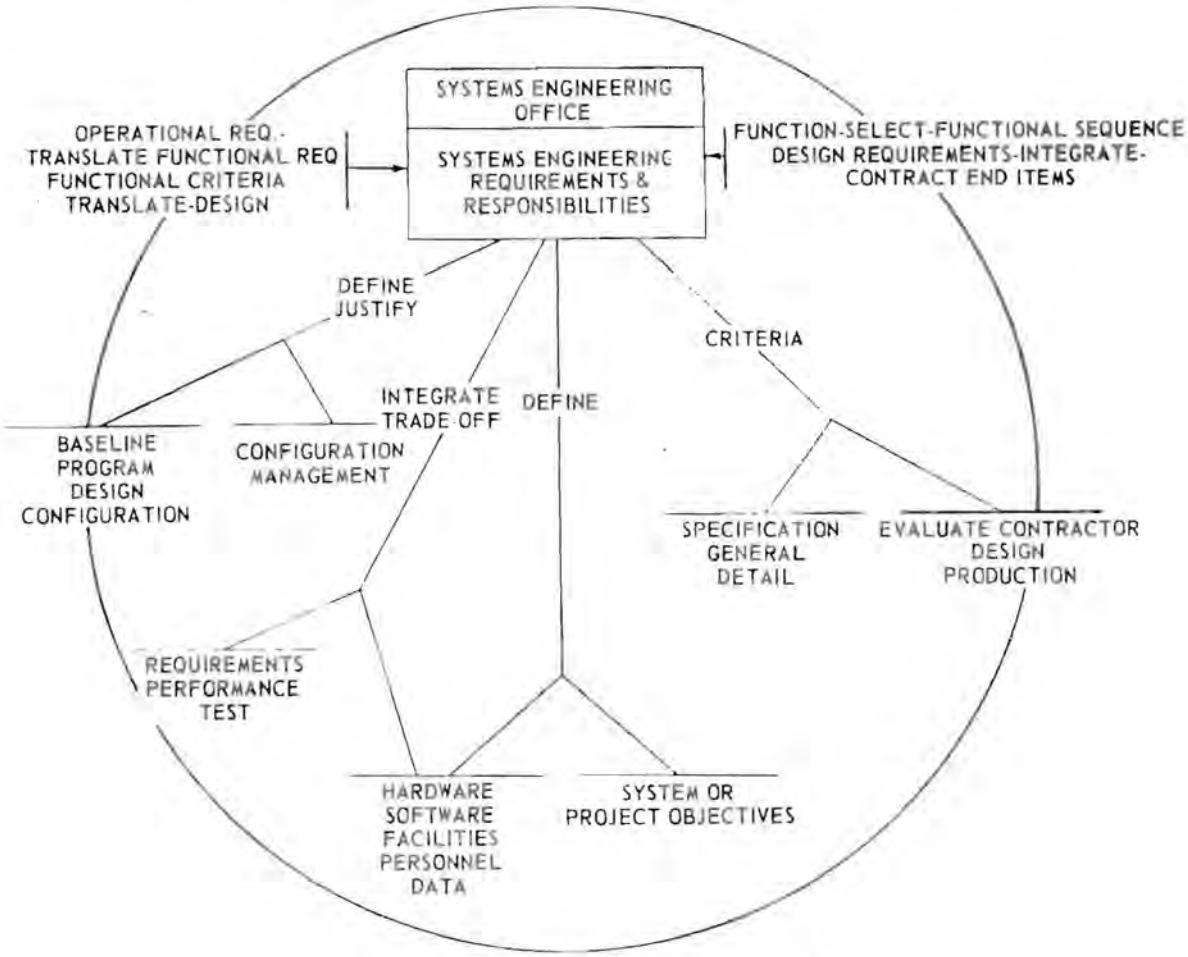


Figure 4-13. Systems Engineering at KSC

Design Engineering

Design Engineering functions as the single design element at KSC (responsive to the needs of user organizations) embodied in the line organizations. These user organizations (with the assistance of Design Engineering as required) establish, define, and justify requirements for inclusion in the KSC budget. Design criteria are then developed, specifications prepared, and detailed design undertaken. Checkpoints in the form of design reviews at the 30-percent, 60-percent, and 90-percent completion points are conducted jointly with the users.

Test and acceptance plans are developed by Design Engineering and, upon completion of the project, testing and final acceptance is performed in accordance with these plans.

Follow-on activities consisting of configuration management, technical surveillance of maintenance and operations, modifications, and corrective actions are performed by Design Engineering. Users obtain the required design response through Interface Revision Notices, Engineering Change Proposals (ECPs), Change Requests (CRs), Field Engineering Changes (FEC), and Unsatisfactory Condition Reports (UCRs).

Design Engineering Implementation

All technical direction within Design Engineering emanates from Engineering Managers. The Engineering Managers and Technical Divisions have a coresponsibility to ensure maximum utilization of the technical capability of the Technical Division.

The Engineering Managers and their areas of responsibility are as follows:

a. The Civil Engineering and Facilities Manager is responsible for the contract technical management of the Facilities Contractor and for controlling, scheduling, and budgeting of facilities within KSC.

b. The LC-34/37 Engineering Manager is responsible for the contract technical management of the Uprated Saturn I Mechanical Systems Contractor and for controlling, scheduling, and budgeting of mechanical systems within LC-34/37.

c. The LC-39 Engineering Manager is responsible for the contract technical management of the Saturn V Mechanical Systems Contractor and for controlling, scheduling, and budgeting of mechanical systems within LC-39.

d. The Electrical/Electronic Engineering Manager is responsible for the contract technical management of the Electrical/Electronic Systems Contractor and for controlling, scheduling, and budgeting of Electrical/Electronic Systems within KSC.

In compliance with appropriate KSC policies and directives, the Engineering Managers are the Configuration Control Board Chairmen and also the Chairmen of appropriate intercenter panels and subpanels. In order to provide the Engineering Managers with the necessary technical capability including the performance of cost evaluation studies, impact studies, and technical reviews, the Technical Divisions provide membership for the CCB, panels, and subpanels. Additional responsibilities are discussed in Section 3 of this text.

Design of major modifications or new systems projects are technically managed by the Technical Divisions normally through employment on contract of a designer or architect/engineer firm. Construction, fabrication/installation, and testing of such major

modifications or new projects normally is managed by one of the existing Engineering Managers or an additional Engineering Manager established for this purpose. Transfer of responsibility from this division to the Engineering Manager is at the point of completion of design. During the construction, fabrication/installation, and testing phase, the design engineers from the Technical Divisions provide support to the Engineering Manager in field engineering, surveillance of inspection, and in acceptance and qualification testing.

The Technical Divisions technically manage contracts (through completion) for the purpose of developing technology to advance the state of the art. This type of contract is obtained through KSC procurement and may be in the form of a work order to the laboratories or shops under other KSC organizations. When a development of technology contract results in a major modification or new project, the accomplishment follows the procedures outlined for major modifications to existing hardware or equipment or new projects in order that fabrication/installation is managed by an Engineering Manager.

Design Engineering Requirements and Change Actions Flow

Processing of changes are classified into five types of action as follows:

a. Receipt and Assessment. All requests for engineering changes are processed through the responsible Engineering Manager Configuration Management Office (CMO) or other assigned processing function for logging, processing, and suspense control. The Engineering Manager Technical Representative oversees the contractor development of an initial technical evaluation which consists of a preliminary engineering assessment of the engineering change, unsatisfactory condition, or initial program requirement.

   The Technical Division Design Project Engineer or the Engineering Manager Technical Representative determines the mandatory nature of the engineering change against approved mission requirements. For mandatory changes, the cognizant Engineering Manager issues a Configuration Control Board Directive (CCBD) to the contractor to proceed with design and submit a "record" ECP. The receipt of an ECP, or request for an ECP-designated emergency, produces an immediate engineering assessment by the contractor and an expedited ECP to the CCB. The Configuration Control Board (CCB) Chairman takes action on the expedited ECP immediately upon receipt. For this policy, Field Engineering Changes (FEC) are considered emergency changes unless otherwise identified by the CCB Chairman. Unsatisfactory Condition Reports and each emergency UCR are received and processed within the time constraints identified by MA 5320.1. Interface Revision Notices to Interface Control Documents are processed in accordance with the Launch Operations Panel Procedure No. 100-0001/1. New program requirements are processed

through the Requirements and Resources Office in accordance with the provisions outlined in the Design Engineering Handbook for Programming and Funding, or otherwise established by the Requirements and Resources Office.

b. Processing and Changes. When a preliminary engineering assessment has been made, the mission support contractor completes the ECP. On those changes not recommended for approval by the mission contractor, the mission contractor completes only the preliminary assessment. The completed ECP is forwarded by the support contractor to the appropriate Engineering Manager CCB for processing. If the proposed change has an impact on authorized schedules, approved budget Program Operating Plan (POP), or another Center, the engineering change is submitted along with a recommendation to the appropriate Level III Configuration Control Board. If the ECP has none of these impacts, it is processed and appropriate direction is provided to procurement or the installing agency.

c. Accomplishing Approved Changes. The responsible Engineering Manager processes approved actions through one of the following channels as appropriate.

(1) For work value below the limit established in the support contract, the action is normally processed directly to the cognizant support contractor.

(2) For work value over the limit established in the support contract, the action is processed through procurement channels.

(3) Facility actions are processed to the facilities support contractor through the facilities contract technical manager.

d. Installation of Work Packages. Schedule for installation of the work package is established through the operationally responsible organization. In the event the operations contractor is different than the engineering contractor, the work package is identified as a modification kit per K-AM-032/2. Should the operationally responsible organization or the contractor disagree with the recommended installation of the work package, the Engineering Manager CMO is informed. Contractor statement of disagreement is submitted on a Non-Concurrence Notice (NCN) form stating in detail all reasons for non-concurrence. Operationally responsible organization concurrence with the work package requires only an Installation Notice Card (INC) card submission after completion of work.

e. Programming and Funding Requirements. The cognizant Engineering Manager assures that all programming and funding criteria set forth in the Design Engineering Handbook for Programming and Funding or otherwise established by

the Requirements and Resources Office are met or that deviations from these criteria are obtained from the Requirements and Resources Office.

A simplified diagram to represent a typical change action flow is shown in Figure 4-14.

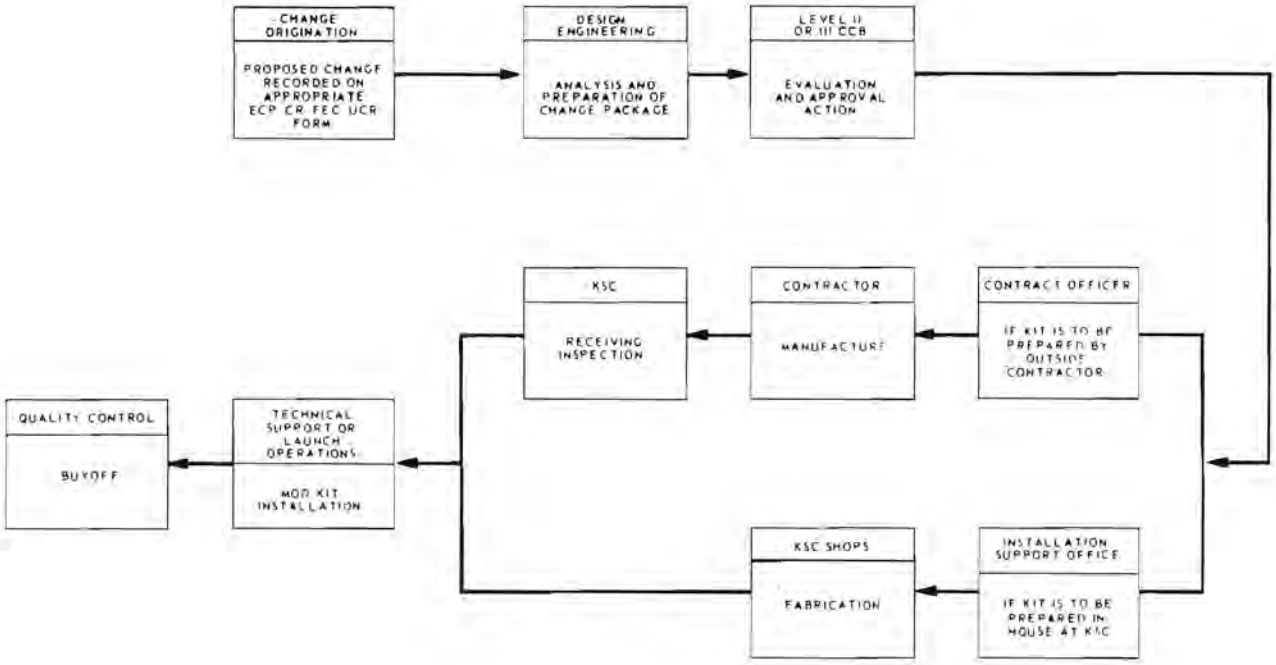


Figure 4-14. Typical Change Action Flow

RELIABILITY AND QUALITY ASSURANCE (R&QA)

The application of the R&QA program at KSC emphasizes the significance of accurate assessment, adequate and timely corrective action, and continuing program improvement. It provides to the line organizations the direction for establishing the checks and balances by which implementation of test, checkout, and launch disciplines are evaluated and audited.

The Quality Assurance Directorate is the KSC point of contact for all R&QA matters except those that are Apollo program related and, in this capacity, establishes the Center R&QA policy.

Apollo program or project requirements and procedures are channeled through the KSC Apollo Program Manager (R&QA Office) concurrently to the line directorates for implementation and to the Quality Assurance Directorate. The QA Directorate reviews these requirements and procedures for conformance to established Center policy.

The Apollo Program Specification delineates the performance requirements for Apollo to include the reliability goals for the major projects. The provisions of Apollo Program Reliability and Quality Assurance Plan (NHB 5300.1A), Reliability Program Provisions for Space Systems Contractors (NPC 250-1), Quality Program Provisions for Space Systems Contractors (NPC 200-2), and Inspection System Provisions for Suppliers of Space Materials, Parts Components and Service (NPC 200-3) constitute the basic requirements for the Apollo program.

The KSC Apollo Program Manager identifies the requirements for Apollo Program R&QA management at KSC. These requirements are documented in an official program document entitled the Apollo/Saturn Reliability and Quality Assurance Plan, K-AM-05. The management of the KSC Apollo Reliability and Quality Assurance Program rests with the Apollo R&QA office which:

a. Provides the direction for implementing the requirements delineated in the program plan, K-AM-05.

b. Interprets new requirements or changes to existing program R&QA requirements as received from the Apollo Program Director or other NASA Centers.

c. Organizes and integrates a reliability and qualification testing policy, a failure reporting system, and a criticality and related single failure point potential policy.

d. Develops and integrates a system to monitor and assess the effects of the checks and balances applied to operational functions.

e. Performs the program management review of line directorate and contractor R&QA plans.

The Operating Directorate responses to the R&QA program are:

a. To develop and organize a system for implementing the requirements delineated in the Reliability and Quality Assurance Plan with the operational responsibilities of the Directorate.

b. To monitor the application of the contractor R&QA plans to the Apollo Program policy and requirements.

c. To implement a reporting system to assure accurate documentation of failure experience and required corrective action.

d. To apply the effects of checks and balances to the assessment of hardware and the adjustment of techniques.

R&QA Implementation

Each KSC line organization develops detailed operating procedures for accomplishing the R&QA functions assigned. Review for compliance with Center policy and technical adequacy is the responsibility of the QA directorate. KSC program and project management elements review the line operating plans to assure that they meet the particular program or project requirement.

The QA Directorate monitors line organizations to assure adherence to approved plans and procedures and advises the appropriate management elements of its findings. Support of its mission is obtained from the Installation Support Directorate (Quality Engineering) and Control Division which provides:

a. Quality engineering review and analysis of engineering drawings, specifications, and procurement documents to insure incorporation of adequate R&QA requirements.

b. Consultation at bidder conferences, contract negotiation and pre-award conferences.

c. Contractor proposal evaluation and participation in contractual changes and modifications.

d. Quality surveillance of off-site hardware contractors, including government-agency delegated quality surveillance functions.

e. Receiving inspection of all technical equipment and materials.

f. Quality operating plans.

g. Quality surveillance of the mission support and on-site hardware contractors.

R&QA Constraints and Disciplines

The Apollo R&QA function at KSC assures the integrity of the Apollo program hardware by providing an organized application of the constraints and disciplines expressed in applicable NASA and Apollo Program documents. This is accomplished by emphasizing the significance of accurate assessment, adequate and timely corrective action, and continuing program improvement; and by providing to the line organizations the direction for establishing checks and balances by which the implementation of test, checkout, and launch disciplines are evaluated and audited.

The KSC Apollo Program Manager Reliability and Quality Assurance Office organizes and integrates the management function through the Apollo/Saturn Reliability and Quality Assurance Plan. The techniques by which this management is applied are subject to constraints imposed by the control plans of other KSC management functions as follows:

a. The implementation of requirements, the decisions affecting the acceptability of hardware, the proposal of changes which affect schedules, and the measurement of reliability and quality assurance testing are to be in accordance with resources authorizations and the provisions of the Apollo/Saturn Program Control Plan, K-AM-01.

b. The integration of failure reporting and the function of failure analysis includes recognition of the logistics requirements of the Apollo/Saturn Logistics Support Requirements Plan, K-AM-02, for spare parts provisioning and storage and the maintenance of equipment.

c. The proposal and application of changes resulting from failure analysis are in accordance with the Apollo/Saturn Configuration Management Plan, K-AM-03.

d. Documents developed for application to the Apollo R&QA program are produced in accordance with the Apollo/Saturn Data Management Policy and Instruction, K-AM-04.

e. The training of personnel in the procedures and techniques of failure reporting and analysis, reliability and qualification testing, and assessment is organized in accordance with the Apollo/Saturn Training Plan, K-AM-06.

f. The application of reliability and quality assurance testing and the measurement of the checks and balances are in accordance with the Apollo/Saturn Vehicle Technical Support Plan, K-AM-07.

g. The performance of tests is in accordance with the requirements of the Apollo/Saturn General Safety Plan, K-AM-08.

h. The coordination of contract and/or procurement actions and the utilization of KSC administrative support are in accordance with the General Services Handbook, K-AM-09.

i. The application of reliability and quality assurance testing and assessment include recognition of the capabilities defined within the Apollo/Saturn Launch Data Systems Support Plan, K-AM-010.

PROGRAM CONTROL

The KSC Apollo Program Control Office, in accordance with established Office of Manned Space Flight (OMSF) policies, functions as the central point within the KSC Apollo Program Office for the coordination, correlation, integration, implementation, and control of all Apollo Program requirements. The Program Control Office is responsive to directives, policies, guidelines, plans, and procedures issued by OMSF

through the Apollo Program Director Office. It also integrates other Apollo Program Office activities including initial planning; organization; implementation; and integration of effort relative to schedules, funding, resources utilization, contract coordination, logistics, configuration management, and data management. It provides program management systems and surveillance thereof to assure that all information for Apollo program management review and decision is available when required and properly assessed. The appropriate management systems and their application to KSC are identified in Figure 4-15.

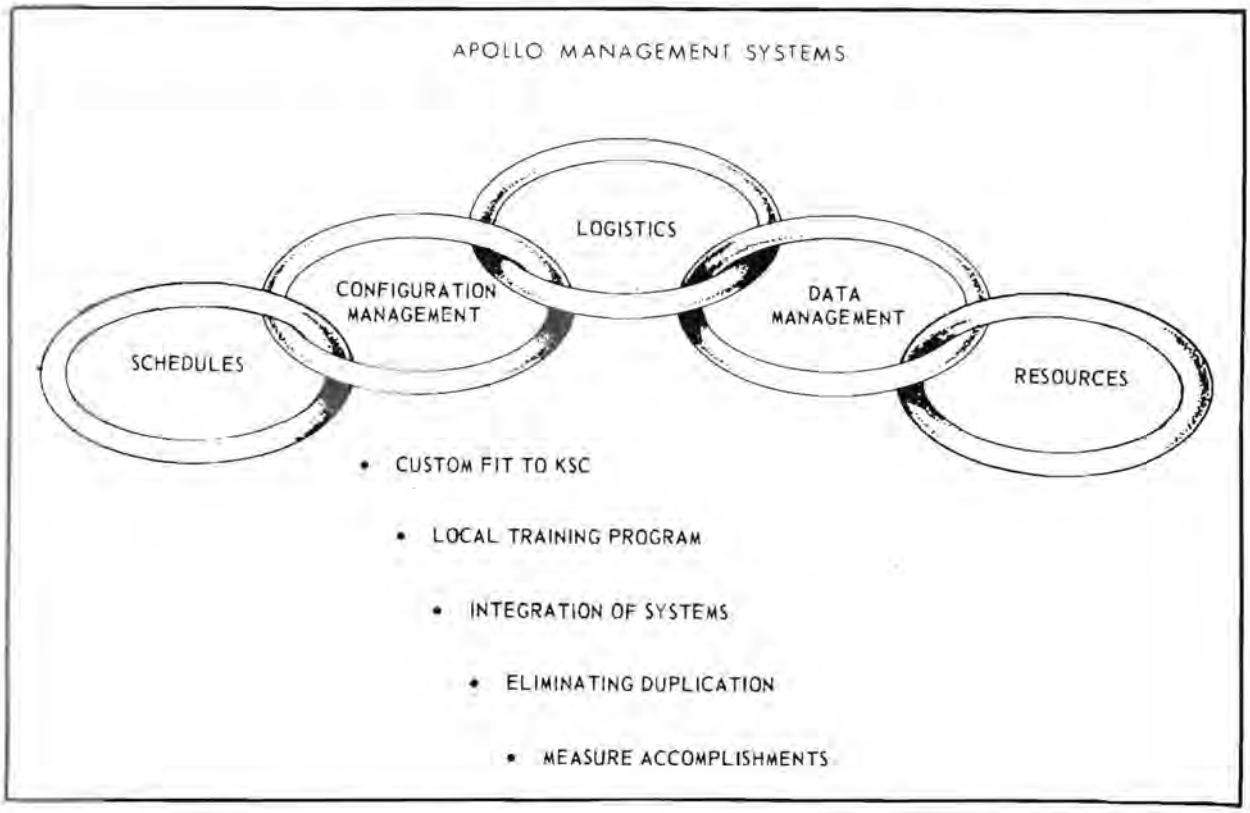


Figure 4-15. Apollo Management Systems

The objectives of program control are to establish methods and procedures for translating Apollo Program requirements and schedules into discrete packages for preparation by line organizations of plans to meet such requirements and to perform systematic analyses of these plans against total program needs and available resources. The Program Control Office, in effect, provides guidelines to the line directorates who interpret these guidelines, apply them to the management of their tasks, and report progress to the Program Control Office. Continuous performance monitoring and the resultant identification, evaluation, and resolution of problems is representative of the joint efforts applied by all organizations.

The implementation of the program control function affects to some degree virtually all organizations whose activities contribute to the conduct of the Apollo Program. The establishment of policy, implementing procedures, and management systems to maintain cognizance of the program posture injects program control into all aspects of program management. The Apollo/Saturn Program Control Plan, K-AM-01, delineates processes and methodology of applying management techniques to the accomplishment of the program control responsibilities. A description of the review, reports, measurements, etc., utilized by the KSC Apollo Program Control Office is discussed later in this section.

Control Systems

It is essential that Apollo control systems be formalized to guarantee that each of the thousands of persons involved is aware of policy, policy changes, and program specification within his sphere of responsibility. Each person must know so he may quickly respond to program requirements.

Control systems define working parameters for program implementation, require reporting of status and statistical information, and allow for management summaries which are used for trend and exception reviews. Each KSC control system fits into classic aerospace and management control techniques which are Configuration Management, Data Management, Logistics, Schedules, Reliability and Quality Assurance, and Resources.

Configuration Management

The application of Configuration Management for the Apollo Program at KSC provides a factual relationship between equipment and associated documents. Objectives of the Configuration Management Systems are threefold: identification, control, and accounting.

Identifying the configuration of a system, or CEI, is accomplished at the time of acquisition or by subsequent configuration audit. This identification becomes the baseline for the item and serves as a starting point for configuration control.

Configuration for an item is controlled through an organized review of all changes proposed for the item. This review and evaluation recognizes schedule impact, funding requirements, spare parts adjustments, and technical justification.

An accurate tracking and visibility system provides an accounting for configuration. Accounting starts with the baseline identified for the item or system, and documents each proposed change to the baseline. The tracking provides a step-by-step progress report of all actions pertinent to the change, both current and historical.

Configuration Management requirements are identified by the KSC Apollo Program Manager and documented in the KSC Apollo/Saturn Configuration Management Plan, K-AM-03.

Data Management

The Data Management System for the Apollo Program at KSC is organized to identify, justify, control, and disseminate the documents which are significant to the program. The basic objectives of the Data Management System are to:

a. Provide an integrated series of documents useful for program implementation.
b. Assure that proposed documentation satisfies a program need.
c. Control documentation at a minimum essential level.
d. Evalute the cost of a document with its management or technical value.
e. Present document posture visibility through organized scheduling.

Effective documentation management at KSC is accomplished by the use of contract data packages that provide the basis for formal contract negotiations with contractor elements. Contractually required data is identified on Data Requirements Lists (DRL) which serve as contractual statements of the quantity and kind of documents to be furnished by contractors to satisfy program requirements. Data Requirements Descriptions (DRD) describe the types of data required, their contents, and preparation information for items identified on DRLs. Document distribution in the required quantities to designated addressees is established by Document Distribution Lists (DDL). A DRL-DRD-DDL group constitutes a contract data package.

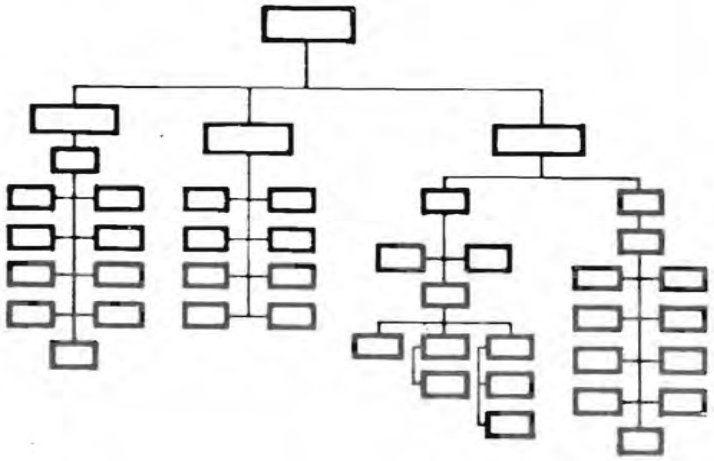
Requirements for data management at KSC are identified by the KSC Apollo Program Manager and documented in the Apollo/Saturn Data Management Policy and Instruction, K-AM-04. The essential elements are summarized in Figure 4-16.

Logistics

The management of logistic support for the Apollo Program at KSC includes the two basic functions of development of logistics products and services, and management of logistics resources. Logistics management supports program requirements in the areas of management information, equipment/facilities maintenance, spares provisioning, transportation, propellants and pressurants, ordnance, data processing, and technical logistics data. Logistic support requirements are identified by the KSC Apollo Program Manager and documented in the Apollo/Saturn Logistics Support Requirements Plan, K-AM-02. The basic logistics management flow is outlined in Figure 4-17.

MANAGEMENT DATA

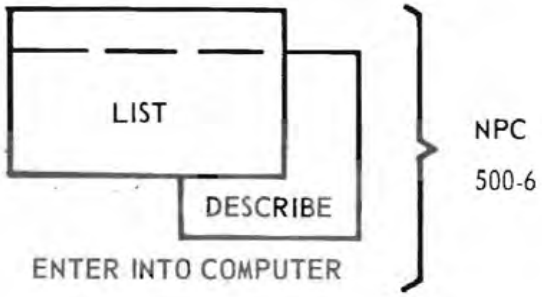
- PLAN
- LEVY REQUIREMENTS



- SURVEILLANCE
- CONTROL

CONTRACTOR DATA

- PLAN (AROUND FUNCTIONAL ASPECTS OF PROGRAM)
- JUSTIFY
- MANAGE REQUIREMENTS



- MONITOR RESPONSES
- PERFORM SURVEILLANCE
- CONTROL

Figure 4-16. KSC Apollo/Saturn Data Systems Program

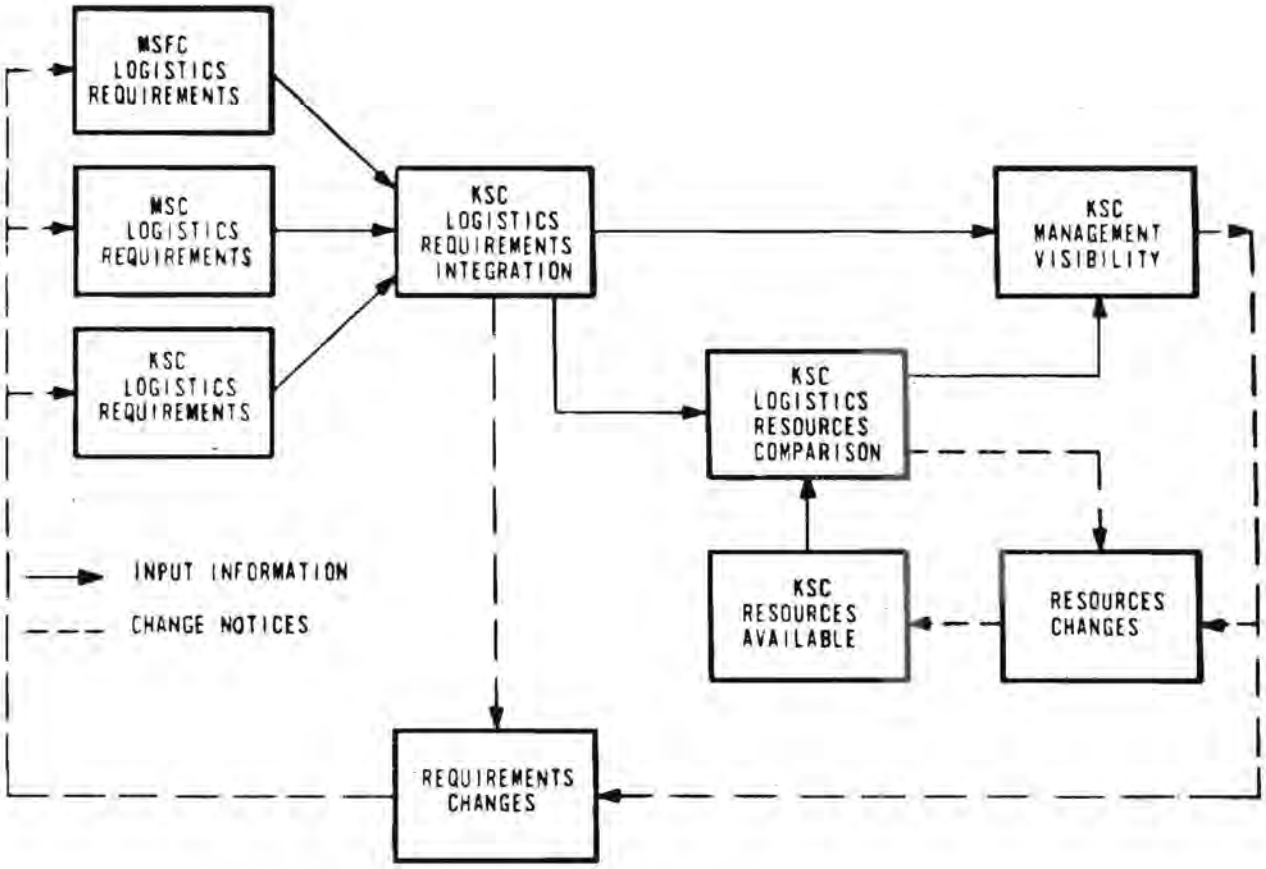


Figure 4-17. Logistics Resources Management Flow

Schedules

The achievement of the missions and objectives of the Manned Space Flight Program requires that all program efforts be undertaken on the basis of approved schedules and the time-phased application of authorized resources. Detailed plans and schedules are prepared by line organizations and reviewed by the KSC Apollo Program Control Office to insure compatibility with overall Apollo schedules. This office monitors the accomplishment of plans and schedules to ascertain the effect and impact of problems upon the KSC ability to meet its program commitments.

Work Schedules are developed within the Site Activation Office and the Directorate for Launch Operations to provide single point direction during the activation and operations phases.

The scheduling system is structured to ensure clear lines of accountability for program status and to provide a means of measuring progress in terms of milestones, funding,

cost, and manpower. The KSC Apollo/Saturn Milestone Schedules and PERT Networks are primarily related to the KSC efforts of design and development, site activation, and launch operations.

The multiplicity of facilities and long lead times associated with bringing these facilities to operational readiness has necessitated the concurrent accomplishment of activation and operation tasks. This concurrency of effort has created many problems, especially in the nature of work conflicts. To resolve these problems, Launch Operations personnel have been phased into activation working groups, and activations schedules are developed and issued on a 72-hour, 11-day, and total bases. At the daily Launch Operations meetings, the activation and operations work schedules are summarized and distributed to each NASA or KSC and contractor agency involved.

RESOURCES MANAGEMENT

Resources Management at KSC assures, through uniform standards and practices, adequate control of Center funds including allocation of manpower and physical space. The Director of Administration, through the Resources Management Office (RMO), manages the institutionally-related resources and is responsible for the center-wide administrative and resources management functions, including procurement and contract management. Program Managers are responsible for all program-oriented R&D and C of F resources.

Financial Management

Program Managers translate program requirements into specific tasks and provide appropriate assignments, guidelines, and funds to line organizations. The program managers and the line organizations are responsible for all phases of resources definition, justification, utilization, and control of resources assigned to their function. Assistance is provided by the RMO through the co-location of personnel to perform a variety of services dealing with budget allocations, utilization of funds, procurement scheduling, and subsequent tracking action (including manpower and physical space utilization). In essence, a continuing business management capability is provided by the RMO to the line and program organizations while maintaining control of the overall center-wide system by the imposition of uniform standards and practices.

The KSC Apollo Program Manager is responsible for the effective and economic management of all R&D and C of F funds allocated to the Apollo Program. As such, he is the official KSC interface with OMSF and other Centers for Apollo related matters.

The KSC Program Control Office has the overall responsibility of establishing procedures and processes to achieve the objectives of resources control. Resources availability is established and maintained on a continuing basis with complete definition of any limitations or constraints. Changes in requirements or plans are analyzed and evaluated for

impact on resource applications. Variances and deficiencies are investigated and assessed, and corrective action is initiated as required. The relative importance of tasks is constantly evaluated, and resources are reallocated as deemed necessary to meet changing requirements.

Contract Management

In accomplishing its Apollo Program mission, the Kennedy Space Center utilizes numerous contractors in a variety of functions. These include stage, spacecraft, and support contractors. Requirements received from OMSF and the Development Centers are translated into plans which provide the basis for the Procurement Plan and the Program Operating Plan.

The Procurement Plan is prepared by the Contracting Office with advice and assistance of cognizant technical personnel. It is a detailed outline of the method by which the Contracting Officer expects to accomplish the procurement task and provides a description of the procurement task, list of sources, discussion of the application of incentive contracting, recommendation as to type of contract, recommended method of proposal evaluation, and a realistic time schedule for each major phase.

The KSC POP states the resources requirements by appropriation and in terms of obligations and costs. Each applicable KSC Program Manager formally approves the plans, and changes thereto, for each line director and for that portion assigned him for execution.

The POP is used for updating obligation and cost estimates for all programs, projects, and activities; as a guide for resources authorization and funding; as a baseline for measuring performance; and for future budget planning.

The basic operations and interfaces of contract management are pictured in Figure 4-18.

Procurement Management

KSC procurement management encompasses all significant aspects of procurement activities required to supplement NASA and OMSF contract policies, regulations, and instructions, specifically including:

a. Procurement administration.
b. Functions, responsibilities and authorities of procurement offices and personnel.
c. Procurement management procedures.
d. Future procurement modes.

The Procurement Office of the Administration Directorate provides specialized activity in management of nontechnical portions of contracts, vendor selection, and processing of purchase orders.

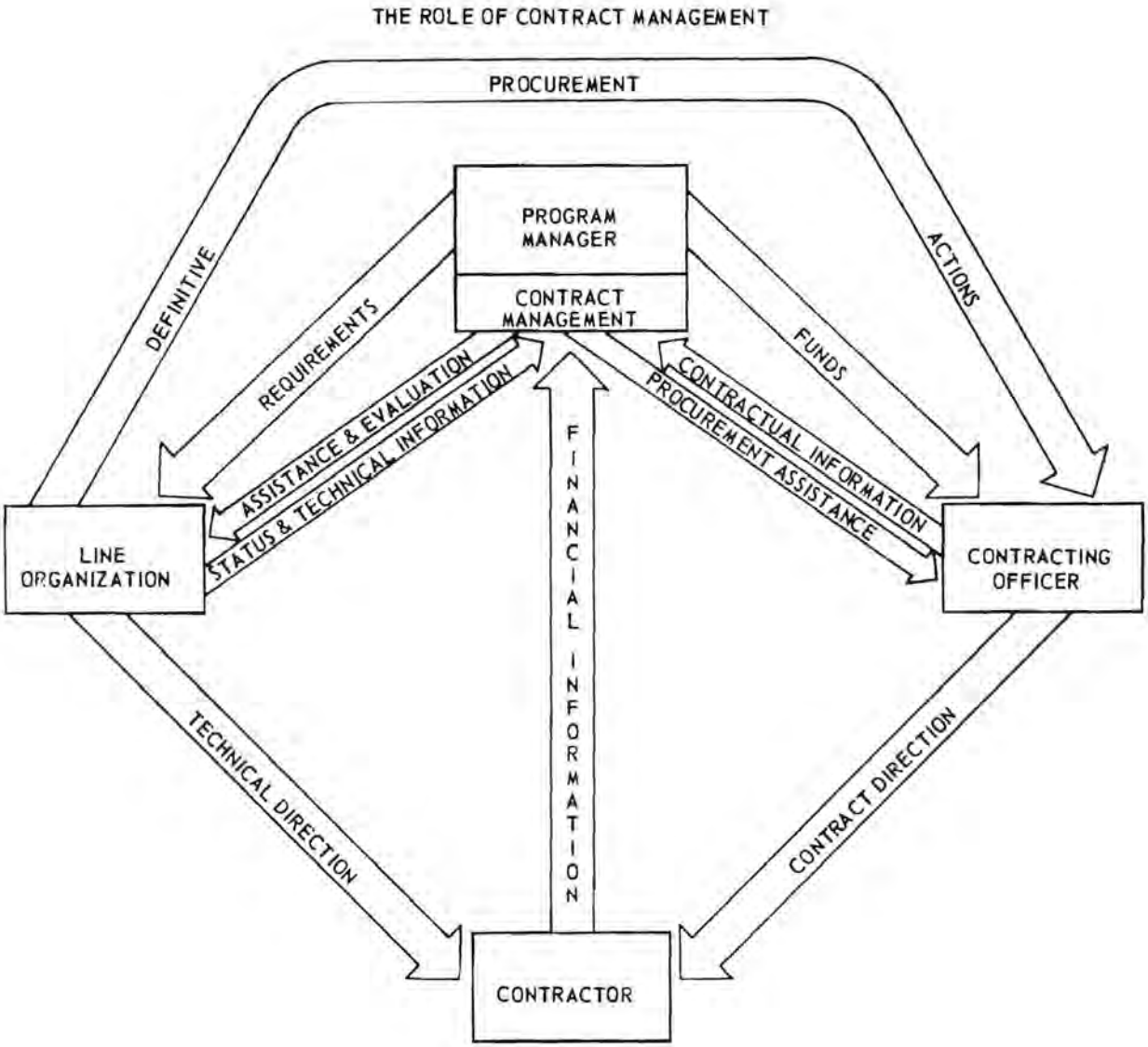


Figure 4-18. Contract Management at KSC

The KSC Apollo Program Manager provides assistance to technical offices for:

a. Preparation of procurement requests.

b. Development of procurement plans.

c. Preparation and review of Request for Proposals (RFPs).

d. Source evaluation.

e. Prenegotiation review, negotiation, approval, and award of contracts, modifications, deviations, and waivers.

The Director of Administration further assists, through the Resources Management Office, both the Apollo Program Manager and the KSC line directorates with Apollo tasks. This assistance is a staff support in planning procurement for the utilization of allocated resources.

Incentive Contracting

Of the various forms of incentive contracting, KSC utilizes the Cost-Plus-Award-Fee (CPAF) technique. Under CPAF contracts, the contractor is periodically awarded a fee as determined subjectively and unilaterally by the KSC Contract Fee-Award Board. The Board performs its responsibilities in determining the appropriateness of fee awards through the Contracting Officer and the Contract Technical Manager. The Apollo Program Manager and Stage Managers forward information which will contribute to the determination of the fee award directly to the Board.

The utilization of incentives on the classic funding controls in managing and integrating contractors is most effective. One of the greatest management benefits derived from the use of incentive-type contracts has been the increased efforts assigned to the pre-award planning phase of procurement. The greater risk assumed, particularly in KSC service contracts, has forced a discipline of better definition and better estimating on the part of both parties. Although a comparative new idea, incentive contracting has made a significant contribution to KSC program management.

MANAGEMENT INFORMATION AND COMMUNICATION

In the Apollo Program, management awareness is aided by a series of status summarizations from the lowest level of management to the highest level. These summarizations (in the form of reviews, reports, and presentations) provide the opportunity to apprise higher authority of program progress, problems, and requirements, receiving wide dissemination throughout the Apollo organization.

REVIEWS

Periodic staff meetings are conducted with key representatives of government contractors to assure a timely flow of information relevant to contract performance and progress. Problems are discussed, solutions proposed, and action assignments delegated as required.

Program/Project Reviews

A regularly scheduled weekly meeting is conducted by the KSC Apollo Program Manager to highlight significant program changes and to review program progress and the identification, evaluation, and resolution of problems. Presentations are prepared concerning specific problems and progress on the associated recovery actions.

A formal Apollo Program Review is conducted on a regular monthly basis which permits the evaluation and assessment of plans, progress, problems, and performance of all Apollo activities at KSC. The review provides for the establishment of status of all program functions and elements and the relationship of KSC activities and interfaces in proper context. The Apollo Program Office Review is an internal Apollo conference held monthly. The Program Director reviews (in detail) current status and problem areas.

The OMSF Saturday Review is a monthly conference normally held on the Saturday preceding the MSF Program Review. Senior officials of OMSF are in attendance.

The MSF Program Review is a monthly review. At this time, the Apollo Program Director, his staff, and Center Program managers present progress and outline problems to the AA/MSF.

The Associate Administrator Status Review is held monthly for each program. The AA/MSF and the Apollo Program Director present the current status of the Apollo Program to the Associate Administrator.

The Administrator Program Review consists of a series of reviews presented by OMSF program and major staff offices. General management and other senior officials are provided with a comprehensive description and status of each NASA program and selected management topics. The Apollo Program is reviewed annually at such sessions.

Baseline Compliance Reviews

Baseline compliance reviews insure that (at appropriate points in the program life cycle) sufficient visibility of progress is obtained to adequately determine the integrity of the system prior to mission accomplishment. These formal reviews represent the minimum acceptable criteria for program assessment and are supported by informal reviews at all levels of management and across all disciplines.

Key hardware inspection, review, and certification checkpoints have been designated in the Apollo Program applicable to the flight hardware, ground support equipment, and facilities. The KSC responsibility encompasses the facilities and GSE portion of the Apollo Program; however, a vested interest is maintained in the flight hardware. These

reviews progress from design through manufacturing, test, and operations to validate accomplishment/readiness of applicable specifications, drawings, hardware, test results, quality and historic records, reliability and failures, crew and associated elements, and operational elements as follows:

a. The Preliminary Design Review (PDR) is a technical review of the basic approach, establishes the design requirements baseline, and constitutes a starting point for configuration control. It is conducted prior to or very early in the detail design phase. This review signifies the completion of the project and system specification, the contract end item specification (Part I) and the start of end item design development.

b. The Critical Design Review (CDR) is the technical review of specifications and drawings including interface specifications and interface control drawings, and is conducted ideally prior to release of drawings to manufacturing.

c. The First Article Configuration Inspection (FACI) in an examination of selected (earliest possible) manufactured end items against the specification requirements and released engineering drawings. It validates the acceptance testing, resulting in the establishment of a firm product baseline of specifications and drawings and signifies the completion of the CEI specification (Part II). Additional FACIs are conducted on each major departure from the basic hardware definition.

d. The Certificate of Flight Worthiness (COFW) certifies that each flight stage and module is a complete and qualified item of hardware prior to shipment and is accompanied by adequate supporting documentation.

e. The Design Certification Review (DCR) certifies the design of the total space vehicle and the mission ground and facility equipment and systems.

f. The Preflight Review (PFR) is conducted by and at MSFC to assess the condition and readiness of the launch vehicle for its mission.

g. The Launch Readiness Review (LRR) is conducted by and at KSC to assess the condition and readiness of the launch complex and the ground support equipment to perform its launch functions.

h. The Flight Readiness Review (FRR) is conducted to validate the operational readiness of the total Apollo system, and it includes assessment of any residual requirements by previous reviews. The FRR is conducted in two phases, by the Program Director (PDFRR) and by the Mission Director (MDFRR).

(1) The PDFRR is conducted for the purpose of ascertaining the readiness of the launch vehicle, spacecraft, and launch complex to perform their launch mission. This certifies the space vehicle as flightworthy prior to turnover to the Mission Director.

(2) The MDFRR determines the readiness of the operational elements, i.e., flight control and Manned Space Flight Network (MSFN) readiness, crew readiness, medical, security, recovery, and public affairs assessment. Satisfactory completion of this review assures the Mission Director that all elements are "GO."

Documentation Reviews

The KSC Data Management effort begins with the development of a Request for Proposal with the objective of assuring that minimum documentation at minimum cost is acquired. Preliminary Document Requirements Lists (DRL) are prepared and justified for inclusion in the RFP.

a. Precontract document reviews are performed by the Center Apollo Data Manager and the Center Ad Hoc Data Review Team who review each DRL for management and technical justification. When approved, the requirements become part of the RFP.

b. Project reviews are performed by the Center Apollo Data Manager and the KSC Apollo Program Manager who review the accumulation of subordinate documents at the project level to assure minimum essential management and contractor documentation, and the implementation of proper document relationships and standardization in the preparation and distribution process.

c. Program reviews are performed by the Center Director and the Center Apollo Data Manager who review the Apollo program documentation periodically to determine the performance of the Data Management function.

d. Formal document reviews are required by the Apollo Data Management System which requires a formal documentation review for all contracts exceeding $500,000.00. The scope and degree of review is in relation to the cost of the documentation.

Facilities Reviews

At KSC, a facilities review board (Ref. KMI 1150.12) has been established with representation from the Program Manager and concerned directorates for the purpose of the review, analysis, and evaluation of facility projects exceeding $2,000.00. Facilities projects may be funded by AO, R&D and C of F funds, with specific funding limitations on Center authority. The estimated cost of the proposed facility, therefore, determines the line of approval authority.

Reviews conducted by the facility review board are Design Concept Review, Preliminary Design Review, and Final Design Review. The Design Concept Review determines the justification for and technical adequacy of the conceptual study (the completion initiates the preliminary design effort). The Preliminary Design Review determines the feasibility of inclusion of the new facility/modification on the approval facilities lists. Approval to implement final design will be dependent on the amount and type of funding determined by this review. C of F projects are submitted to the associate administrator in the Center budget request. The Final Design Review (100 percent) is conducted on the package to be submitted for bids. Reviews are conducted prior to this time at 30 percent, 60 percent, and 90 percent completion points between the design engineering function and the ultimate user of the facility to assess progress toward completion and adequacy of design.

At KSC, reviews that are normally associated with hardware (only) are conducted for facilities. These reviews incorporating GSE and instrumentation associated with the facility (and the facility itself) to assure compliance with design intent include:

a. The Design Certification Review (DCR), Assessment of the capability of the facility to accommodate the space vehicle.

b. The First Article Configuration Inspection (FACI), Examination of facility against the specifications and released drawings.

c. The Launch Readiness Review (LRR), Assessment of the condition and readiness of the launch complex to perform its launch function.

d. The Flight Readiness Review (FRR), Update of the LRR with increased scope to include GSE, the Space vehicle, and operations.

REPORTS

The program review process brings together a forum of data, concepts, and judgments on a continuing basis to keep the KSC Apollo Program Manager abreast of plans, progress, and problems on the Apollo program at KSC. It provides summarization, consolidation, and correlation of information for reporting to the OMSF management level.

The achievement of the missions and objectives of the Apollo program requires that all effort be undertaken on the basis of approved schedules, the time-phased application of authorized resources, and a continuing review process by which potential problems can be identified, assessed, and channeled to the proper decision-making levels.

A single coordinated reporting system is implemented throughout OMSF and the Centers to insure the proper integration of all phases of the Apollo Program and to provide a uniform communicable base for measuring progress in terms of schedule milestones, funding, costs, manpower, and technical performance. This uniform data base provides for the unbroken flow at decreasing levels of detail of timely, accurate, and responsive data from contractors to top MSF management. This system is structured, documented, and

maintained on a basis that insures clear lines of accountability for program status and for the control of all changes or actions.

Milestone Reports

The uniform data base on which all milestone reporting is provided is the PERT system. Its implementation in a program forces a planning discipline at all levels of management. The logical step-by-step portrayal of program project and system milestones instills management confidence and communicates to all program participants the necessity to accomplish their planned objectives. This realization that each job, each activity performed, though only a small portion of an overall plan, induces strong motivation to meet or exceed the commitments of the plan.

Program Evaluation Review Technique (PERT)

PERT is implemented in the Apollo program at the contractor, project, Center, and MSF levels and, through a summarization process, enables management at all levels to control its portion of the total effort and to anticipate and solve problems before they become critical and affect the next higher level. KSC has leaned heavily on PERT concepts and has found them to be effective in two areas, Site Activation and Operations. With the help of operational flow plans, the Operations PERT net is being developed. The Site Activation program, however, would have been impossible to accomplish efficiently without PERT. The construction of over $500,000,000.00 in facilities and the integration of another $100,000,000.00 of equipment from other Centers into these facilities was handled by PERT. Figure 4-19 depicts the PERT flow from the MSF level to contractor level.

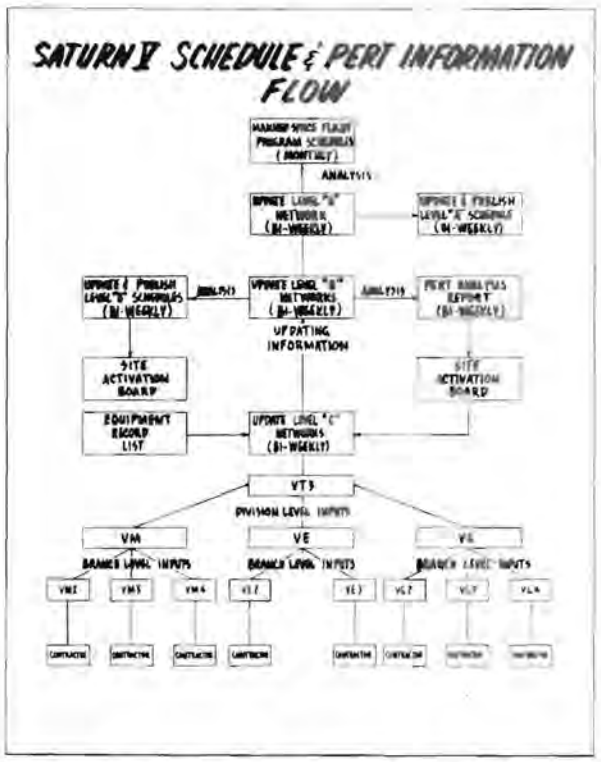


Figure 4-19. KSC Saturn V PERT Flow

Schedule and Review Procedure (SARP)

The Manned Space Flight Program Schedule and Review Procedure (SARP) is the means employed to visually portray the PERT output summaries to management on a regularly scheduled basis (monthly). The total document consists of six volumes and a program summary with content selected to provide total visibility into the status of the program. Contractors and Centers provide monthly status reports to the Apollo Program Office via this route and the Apollo Program Office summarizes them into a program volume which is distributed to provide total program visibility at all levels.

The content of the SARP volumes is arranged to provide key elements of information in four levels of detail on the program work breakdown structure. Control is exercised by the establishment of key milestones and indicators throughout the system and the limiting of authority to change these milestones. The identification and description of these milestones and indicators are as follows:

a. Controlled Milestones are those milestones which are of major significance to the program. Changes in completion data of controlled milestones must be approved by cognizant OMSF Program Directors.

b. Supporting Milestones are those milestones that can be rescheduled at the discretion of the individual having responsibility, normally the Center Director or the Apollo Program Manager. Supporting milestones are those significant completion points constraining controlled milestones.

Each controlled and supporting Milestone (at a minimum) is provided with an expected and a latest allowable completion date derived from the PERT runout. Expected late completions are danger signals which receive increased management attention. When the expected completion date exceeds the latest allowable date, the item is considered critical and definite actions are taken to bring it under control. In these cases, reporting frequency is increased until assurances are received that the item has dropped from the critical list. Other representative reports at KSC are identified as follows:

a. Resources Planning and Tracking Reports are issued monthly and identify each organization plan, as approved by the Program Manager, and the actions (commitments, obligations and costs) taken to date. They are utilized for conducting program reviews at the line directorate and program levels and as a basis for OMSF reporting.

b. Flash Reports are issued when a problem of major importance exists (outside the scope of those who recognize the problem) or jeopardizes a controlled or supporting milestone accomplishment. The flash report apprises the next

level of management of events which require attention. The flash report contains sufficient information (description and assessment of the problem, milestone affected, a recommended course of action and time constraint for this action) to permit an intelligent decision on the part of the manager with the responsibility. The flash report is used by the KSC Apollo Program Manager to apprise the Apollo Program Director of events which require his immediate attention.

c. Weekly Project Status Reports are submitted by the KSC Apollo Program Manager to the Apollo Program Director. They summarize progress, current status, and problem areas. These with other reports prepared by each OMSF Apollo Program Office functional directorate, are summarized by the APO into an overall Apollo Program Status Report.

d. Weekly Apollo Program Status Reports together with reports prepared by each OMSF/APO functional directorate, are summarized by the APO into overall program reports. These reports are formally published and receive wide distribution. They summarize program status and list current program problems including a description of the problem, evaluation of the cause, and program impact.

e. Monthly Apollo Program Status Reports are prepared by the APO as a summary compilation of progress, schedule effectiveness, and problem areas.

f. Contractor Financial Management Reports are submitted to the APO on all major cost contracts. They are utilized to create a data bank upon which to draw for detailed information on the programs, contractor efforts, and the relationships between the various types of resources.

g. Annual Reports to Congress are prepared by the APO and combined with other OMSF inputs as part of the total NASA report and budget justification. The Apollo portion is summarized from the weekly reports prepared during the appropriate time period.

h. Assessment Reports identify assessment activities that are continously performed across the total program sphere. The results of these assessments are periodically documented in assessment reports that keep management aware of program progress and problem areas. These assessment reports provide management visibility at all levels in the Apollo Program. Assessment activities cannot be limited to only those elements for which KSC has design responsibility. To properly assess the activation of a facility, the installation and checkout of GSE, instrumentation, etc., KSC considers the need date for completion of these actions in relation to program utilization. Assessment activities, therefore, are conducted against two sets of baselines that are not necessarily compatible at a given point in time. The first baseline consists

of those Center commitments made as a result of original and/or officially revised program requirements and the second baseline is that which is related to real-time requirements. The process of converting real-time requirements into program requirements constitutes a finite period of time.

At KSC, the assessment of problem impact is only a partial solution. An assessment report is considered incomplete unless a recovery plan is presented and specific corrective and followup actions are assigned. Adequate assurances are provided for recovery, or sufficient justification for a relaxation of the requirement are made available.

The most significant and widely disseminated assessment reports provided at KSC are the Management Assessment Report (MAR) and the PERT Analysis Report (PAR). The combination of these reports permits the maintenance of a communications loop at KSC that provides the means to monitor the complete progress of the program and takes a giant step toward assurance of its success.

(1) The Management Assessment Report is the top level document that embraces total KSC Apollo activities. The content of this report is the basis for the weekly KSC Apollo Management review of the program. It represents a status summary of the efforts under way at KSC, a listing of major problems, proposed or in-process work-arounds, action responsibilities for each problem, and an overall top level assessment of progress against requirements.

(2) The PERT Analysis Reports, published bi-weekly, are analyses of the progress of site activation of the launch complexes (34, 37, and 39) and the spacecraft industrial area. The basis for these analyses are the site activation PERT networks. These PAR reports reflect the results of PERT machine runouts which establish the critical paths and limiting paths that approach criticality and provide the necessary management visibility to undertake corrective action where required.

VISIBILITY AND STATUS

The discipline that must be carefully built into a program management organization is a means of providing management with visibility that will enable it to take action in terms of progress against plan, time, dollars, and performance. In the Apollo Program, this visibility is provided by a variety of means and at all levels of prime contractors and their subcontractors, Centers, and the Headquarters Program Office. Progress reviews are held at fairly close intervals and items such as reliability practices and quality control are audited periodically.

This subject of visibility, to provide a means for action, is one of the key areas where managers can improve operations. Visibility demands effective communication and a close working relationship between competent people with the responsibility and authority on both sides of the management interface. Inevitably, one man at each level understands the picture and all the balances and relationships. However, it is extremely difficult to portray to an organization so that all its talent can be brought to bear. One of the prime responsibilities of program management is to assure that proper action is taken by individuals and organizations to detect and correct problem areas before they become critical.

Visibility provides management the time to manage... less time is spent on "fire drill" actions; problems can be anticipated and corrected before they occur, and management can spend time doing more productive work. Visibility is attained by the establishment of management organization and discipline, and the proper use of management systems.

The use of computers and data processing techniques permit the collection and storage of almost unlimited quantities of data. The organization, correlation, manipulation, and extraction of this data in intelligible form (prohibitive under normal conditions) is facilitated by use of management control systems. Automatic data processing (ADP), applied to management control systems, injects standardization and disciplines into the data collection process, permits significant reductions in the support requirements for an equivalent manual system, and provides management visibility of the total program through the use of summarization and search techniques.

ADP Applications

The feasibility of applying automatic data processing techniques to the management elements of the Apollo program is determined on a case-by-case basis. The automation of a pure engineering function, for example, is not as appropriate as a scheduling function. At KSC, automation techniques are being considered for the following functions:

a. Schedules
b. Configuration Management
c. Logistics
d. Reliability and Quality Assurance
e. Site Activation
f. Resources Management
g. Data Management

The employment of management systems in these areas is a gradual process, evolving from feasibility through concept and development to implementation. The development phase consists of the preparation of guidelines, policies, instruction, input/output, formats, etc., for the individual systems and then, ultimately, the integration of the individual systems into a common system.

Information Centers

The KSC Apollo Program Office operates and maintains Management Control Centers which serve as working display and problem resolution areas for internal program review. In addition, these centers provide high visibility of problem isolation, definition, and elements for assessment, determination of impact, and establishment of recovery actions. The Program Control Office provides all supporting services in the publication of agenda and documentation of proceedings in meetings, and disseminates formal minutes of weekly program reviews. In addition, all data received in the review process is evaluated, assessed, and analyzed for effective display presentation in accordance with established standards. The KSC Apollo Program Managment Center is pictorially represented in Figure 4-20.

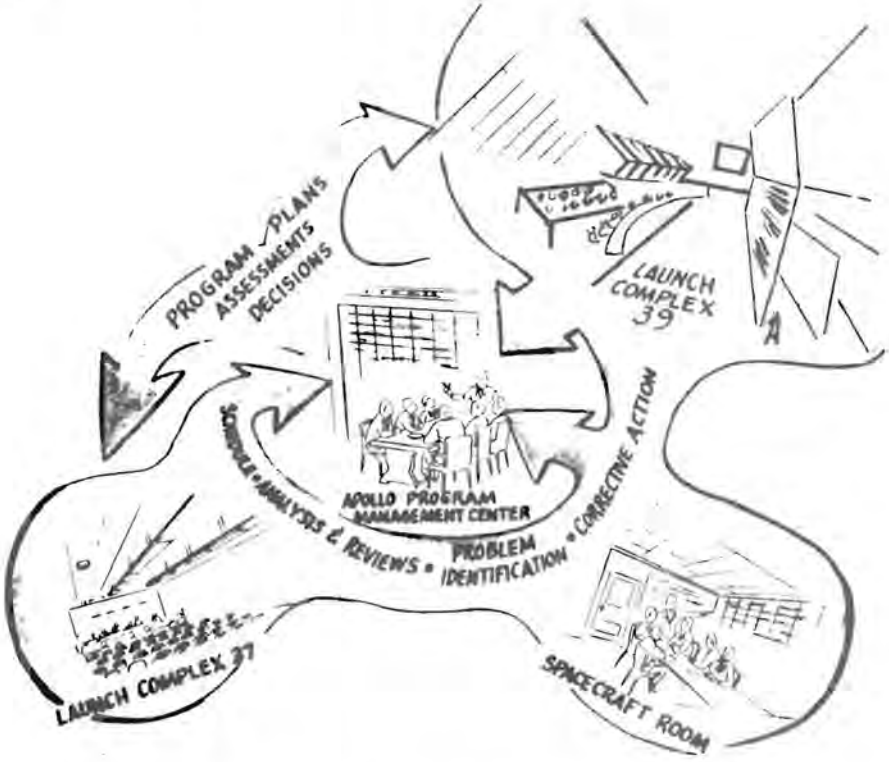


Figure 4-20. KSC Program Management Center

MANAGEMENT DECISION

The management decision process is the management evaluation and action (or inaction) resulting from this evaluation that takes place during and after the collection, organization, correlation, integration, summarization, analysis, and assessment of the management data.

This process is employed in the three primary control areas of schedules, cost, and technical performance. The series of reviews conducted in the Apollo program provides the stimulus necessary for management action at the proper level.

The initial activity of problem identification is followed by an assessment of the problem, the determination of alternate courses of action available, and the impact of these alternatives. The job of management is to evaluate the alternatives and select the best course of action, considering the three primary control areas.

Many problems of a program nature cannot be solved by the action of one Center only but require the concerted effort of all participants. The Apollo Program Organization was so structured for this very reason. Although each Center Apollo Program Manager reports organizationally to the Center Director, he is responsive to program direction from the Apollo Program Director under overall direction of the Program Management Council (PMC). The PMC consists of the AA/MSF and the Directors of the three MSF Field Centers. The PMC was formed to establish Apollo Program policy and plans, to review progress, and to evaluate performance.

Inter-Center Coordination Panels have been established to define and solve the technical interface problems relating to the launch vehicle, spacecraft, facilities, and associated equipment. Basically, these panels are engineering and working groups, composed of personnel, who are responsible, through their panel chairman, to the Panel Review Board (PRB). The panels are responsible, within their area of responsibility 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 MSF Centers or the various contractors; establish sub-panels as required; recommend solutions of problems outside their assigned responsibility to the PRB for action by the proper panel and organization; and identify and generate Interface Control Documents within established Program Requirements.

The PRB membership consists of personnel from the OMSF/APD, MSFC, MSC, and KSC. The KSC representative has technical cognizance of the subject under review and will have directorate responsibility or above. The PRB organization consists of the Board, an Executive Secretariat, 8 Panels, and 23 Sub-Panels. The Sub-Panels are composed of knowledgeable personnel in technical disciplines of the following categories:

a. Crew safety
b. Electrical
c. Flight evaluation
d. Mechanical
e. Instrumentation and communications
f. Flight mechanics
g. Launch operations
h. Flight operations

Inter-Center Working Agreements have been negotiated by KSC with other Centers. These are flexible agreements and are modified as necessary to meet the demands of effective communications and close working relationships.

MEASURE OF EFFECTIVENESS

The final measurement of accomplishment for the Apollo program will be realized when a manned Apollo/Saturn V space vehicle successfully transports men to the moon and returns them safely back to earth. This feat, which just a decade ago was only a dream, is within the grasp of this nation.

Although this long-range program objective must be kept in sight as Research and Development programs progress from concepts to hardware, it would be unrealistic to conclude that the establishment of this single objective is all that is required to achieve success. In a program the size of Apollo, literally thousands of well defined, calculated, and deliberate goals must be set at all levels and for all endeavors that permit the determination of adequate progress. These signposts of progress along the road to success represent the means to satisfactorily assess the program posture at any given point in time, and contribute toward the accomplishment of the ultimate program goal.

The measurement of accomplishment is done in many ways, affects many and distinct disciplines, and is composed of three inseparable elements. The satisfactory accomplishment of a schedule or performance milestone, for example, loses some of its success if it is done at twice the intended cost. The three basic elements of measurement, therefore, are schedule, cost, and technical performance (Figure 4-21). To accomplish one or two only is not an indication of satisfactory effectiveness.

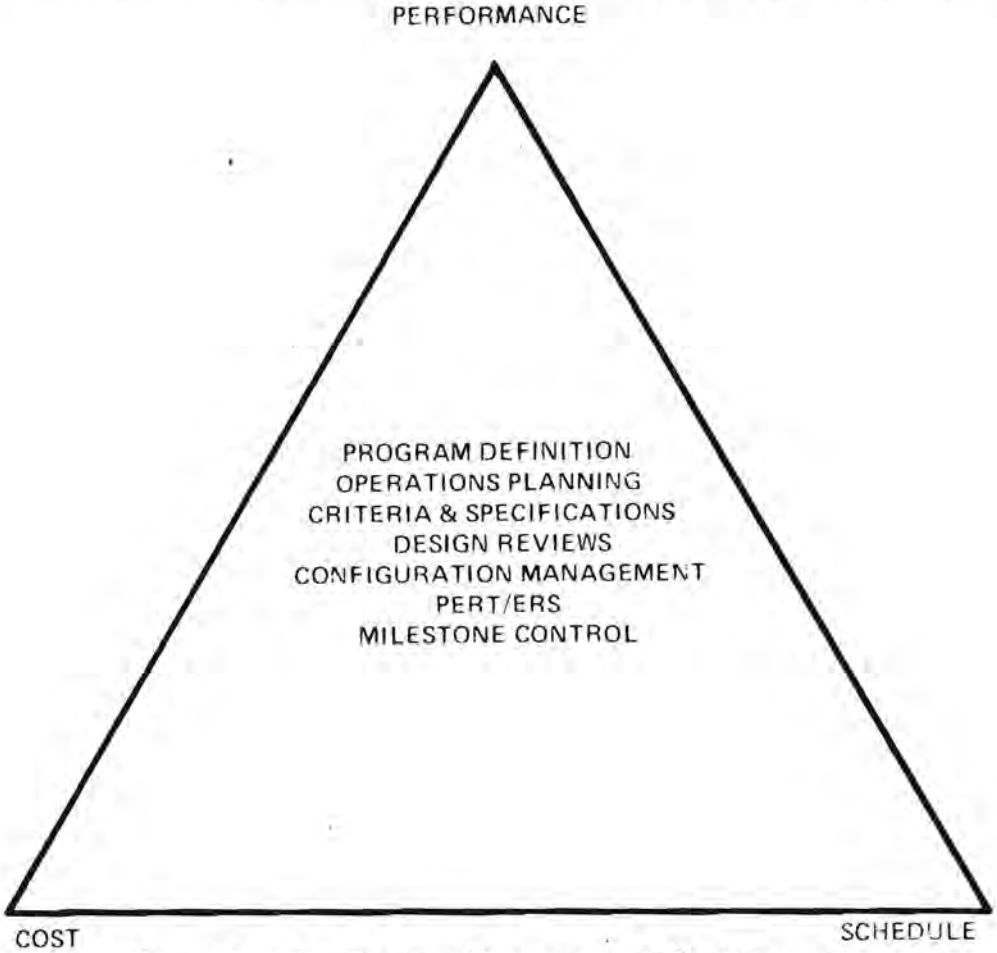


Figure 4-21. Program Management Effectiveness

It is the responsibility of program management not only to assign but also to insure that program objectives are accomplished in a timely manner, at a reasonable cost, and within the technical limits established. In order to gain this assurance of adequate progress, requirements are established, plans are developed to meet the requirements, and a series of periodic reviews and reports monitor progress toward plan.

Previous sections of this document discuss the plans and baselines established at KSC; identify the disciplines, control systems, procedures, etc., used to monitor the efforts under way; explain the methods used to communicate status and progress against plan; and describe the means implemented at KSC to provide management visibility of the total effort. To measure accomplishment requires the efficient concerted use of all these ingredients.

The KSC responsibility encompasses the design, construction, activation, and operation of facilities; the design, fabrication, installation, checkout, operation, and maintenance of ground support equipment and instrumentation; and the checkout and launch of space vehicles. The accomplishment of this responsibility is measured by the criteria discussed below.

Schedules

Each activity is to be accomplished in a time frame compatible with the established program goals expressed in terms of controlled milestones. The supporting milestones, devised as those significant accomplishments that provide assurance of meeting the controlled milestones, are imposed at all levels throughout KSC, including contractor organizations, and provide an indicator of overall schedule progress through the process of summarization provided in the project and program reviews.

These milestones, however, are not so inflexible as to be irrevocable. They represent guidelines which are in a sense negotiable, provided the next higher level milestone is not endangered. It is realized that an installation or test sequence, for example, can be accomplished in more ways than that which is considered ideal. Since these milestones are established well in advance of the actual activity, they are normally representative of an ideal work flow. During the actual performance of the planned work, however, circumstances may prevent the accomplishment of the planned objective on the original schedule. The milestone, therefore, is "worked around" and accomplished at a later date. These work arounds are a true indication of management in action with on-the-spot, day-to-day decisions that have made the KSC Apollo effort the success that it is.

Cost

The cost aspect of the program is the element that is perhaps under the closest scrutiny. The application of cost measurements is the most extensive, the most inflexible, and the most universal of the three basic elements. Long range commitments are made for the program projects (including primary and subordinate systems) and are reconfined each fiscal year, along with shorter range commitments that run from year to year. The need to justify all expenditures (past, present, and future) and the need to secure funds for program continuance each fiscal year require detailed accounting and control of all funds provided.

Measurement of accomplishment is based on more than a plan which can permit variance and still reach its end objective. Cost measurement, the bulk of which is based on government obligations to contractors and contractor commitments to government, is more precise. It is expressed in terms of the expenditures in pursuit of a defined end product which may be hardware, facilities, or services.

The somewhat intangible aspects of schedule and technical performance do not exist for cost performance. An end product is to be provided at a stipulated cost, and the measurement of accomplishment is whether or not that end product is delivered within that stipulated cost. Once the cost of an end product is acceptable to both government and industry, that cost is fixed unless there is a change of requirments, scope, etc. If a change occurs, negotiations are reopened and a new cost is established to reflect the change.

The methods used in the Apollo Program to measure cost accomplishment are the Schedule and Review Procedure, the NASA procurement systems, and the Resources Management System.

The NASA fund and manpower requirements established in the Project Approval Document (PAD) include a five-year projection of funding requirements by fiscal year and total requirements until completion of the project. Through the Project Approval Document, the Associate Administrator authorizes the responsible Program or Institutional Director to initiate and implement the project within the scope defined in the document and within funding approvals established through the NASA system for resources authorizations and allotment of funds.

Program Operating Plans are prepared by the KSC Apollo Program Manager and the Center Director and include the cost estimates and fund requirements for projects under their cognizance. The POP is a quarterly report and serves as an update to the Project Approval Document. Both documents form the basis for NASA budget submissions and are the baseline for cost performance measurement.

Technical Performance

The third major accomplishment measurement is in the area of technical performance. The Apollo Program Specification and its attendant project and system specifications and criteria delineate the requirements for equipment performance in the program. A continuous requirement/performance analysis program is maintained to:

a. Provide assurance that the vehicle design is progressing within the prescribed control limits.

b. Allow for early detection of problem areas and provide recommended remedial actions.

Management audits of contractor activities are conducted to ascertain their performance toward objectives, effectiveness, and necessary remedial actions. The Baseline Compliance Reviews provide the formal measurement of accomplishment in the technical area. These reviews are supported by informal evaluations of technical progress throughout the design, manufacturing, and test phases of hardware development. SARP also furnishes a means of measuring technical performance through the monitoring of major program constraints such as control weights, payload capability, etc.

The Inter-Center Coordination Panels, formed to define and solve interface problems among the various program elements, are good sounding boards for technical progress. The jurisdiction of these panels encompasses all disciplines within the program and the panel activities, therefore, serve as excellent indicators of technical performance.

Technical performance requirements are comparable to schedule requirements in that there is a degree of flexibility related to accomplishment. Technical parameters are normally expressed in quantitative terms including a mean value with a plus and minus tolerance. This tolerance factor exists as far down as the component level. The measurement of accomplishment, therefore, also contains this tolerance factor. The relationship of components, subsystems, systems, etc., to the total space vehicle allows additional flexibility in satisfying objectives. If the S-II Stage, for example, is in an overweight or under-thrust condition, compensation can be provided by increased thrust or decreased weight on the S-IC or S-IVB Stages. The technical performance of the S-II Stage would be adjudged inadequate, but the overall launch vehicle performance would be within specifications. Technical tradeoffs such as this are not isolated instances but are considered part of the research and development process.

The measurement of technical accomplishment, therefore, is not necessarily related to the specific end product under examination but rather to the total scope of the effort. Through the coordination of all of the activities involved, and the review and evaluation processes in place, technical performance is assured.

SECTION 5
LC-39 SITE ACTIVATION AS EXAMPLE OF APPLICATIONS

SCOPE AND BACKGROUND

New and bold thinking has been required for creation of the necessary ground facilities at KSC to launch the massive Saturn V rocket system. The conventional fixed concept of launch preparations - assembly, test, and checkout, and launch from the same pad or complex - ties up the total facility from the moment the first stage reaches the pad until the vehicle is launched. This significantly limits the launch frequency since months are required for the painstaking work of assembly and checkout (14 months in the case of one NASA experimental vehicle). In addition, these long stays on the pad expose the rockets to storms of near hurricane strength and to the corrosive effects of the salt atmosphere.

With preparation or "pad time" related to the size and complexity of the vehicle, it became evident that a radical change in the operational mode of launches would be required for space transportation systems such as the Saturn V and future systems. It was further recognized that after initial test flights the Saturn V system would become operational in much the same sense as modern jet aircraft and would require a spaceport to serve the needs of the space program as a national resource for many years.

The above considerations resulted in the development of a mobile concept wherein the rocket would be assembled and checked out with the spacecraft in the protective environment of a building, and taken to the pad only when almost ready for flight. This would permit uninterrupted work in the erection and checkout process, provide greater assurance against countdown problems, and materially increase the frequency of launches from the same pad. The means of transporting the vehicle to the pad could also be used in an emergency to return the vehicle to its hangar with all connections intact and again transport it to the pad when the storm is over.

Such a concept embodies much more than just a brick and mortar construction effort. It requires a complex with principal features to include:

- a hangar big enough to house the Saturn V rockets, each standing 364 feet tall.

- a mobile launch base on which the rockets will be assembled and from which they will be launched.

- a method of transporting rockets and launchers weighing 12,000,000 pounds a distance of 3.5 miles to the firing site.

- a service structure that enables technicians to complete preparation of the Apollo spacecraft at the launch site.

- a control center from which all these operations can be monitored and controlled.

To bring such a concept into operational reality presented one of the major technological challenges of the century. Each of the principal features mentioned above had to be designed and constructed concurrently to meet the time restraints imposed by the Apollo Program.

In addition, the vehicles to use these vast facilities were not even in existence. The Saturn V launch vehicle and Apollo spacecraft were only in the design stage and would be built at the same time - yet the launch facilities (a new concpt in themselves) must function properly for the first test vehicle to be launched.

As previously stated, management philosophy at KSC may be expressed as....."doing what you said you would do". The results of this philosophy in actual practice, as achieved by the government/industry team at KSC, are dramatically portrayed in Figure 5-1.

Artist's Concept Prior to Construction

Actual Facilities (1967) in Use During First Saturn V Launch

Figure 5-1. Launch Complex 39

Site Activation entails the construction, outfitting, installation, and checkout of facilities and ground systems. By their nature, these activities are rather prosaic when compared with the drama and excitement of a launch countdown. Nevertheless, the activation of Launch Complex 39 at KSC has been an exceedingly complex and monumental effort, one which has taxed the imagination and managerial skills of all.

The basic task has been that of providing new facilities to support and launch a space vehicle many times larger than any previously developed. Major facilities include the Vehicle Assembly Building, Mobile Launchers, Crawler-Transporters, and Launch Pads. The sheer size of these facilities stretches the imagination, yet the precision

of a watchmaker is noted in the harmonious blending of technical skills which created the tremendous structures pictured in Section 1.

Consider, for example, the size of the VAB. This structure has an enclosed volume of 129 million cubic feet, nearly as large as the combined volumes of the next two largest buildings in the United States, the Pentagon, and the Chicago Merchandise Mart. Seventy-two edifices the size of the Washington Monument would easily fit within the High Bay area, barely protruding at the top.

The enormity of LC-39 facilities is not the only factor contributing to the complexity of the task. Installed within these facilities are thousands of components and subsystems. Some 34,000 individual end items and 60,000 cables are contained within the basic LC-39 structures. Due to advancement in the development of launch vehicle and spacecraft systems, many engineering changes and new requirements have been imposed during site activation. It has been essential to promptly incorporate these requirements into the continuing activation task.

The design of LC-39 facilities and equipment was accomplished by many NASA organizations and contractors at widely diverse locations. Further complicating the task has been the requirement to integrate the efforts of fifteen craft contractors, five aerospace contractors, and eight mission support contractors. To meet schedules, conserve resources, and achieve positive control, it was necessary to integrate and properly phase many individual efforts into the Apollo/Saturn V Program Schedule. Only through a high degree of teamwork were these efforts successfully converted into the imposing elements of the launch complex, such as the Crawler-Transporter shown in Figure 5-2.

Figure 5-2. Crawler-Transporter

TECHNIQUES

PLAN....ORGANIZE....EXECUTE....ASSESS. These are the steps undertaken in any well-managed effort. The plan for LC-39 activation had been established; the next step was that of organizing to carry out the plan.

SITE ACTIVATION OFFICE

The concurrency of construction and development of LC-39 coupled with the large number of participants, required a single agency to manage the activation task. To meet this need, the Site Activation Office (SAO) was formed under the KSC Apollo Program Office to provide centralized overall management of the Apollo/Saturn V activation effort.

Specifically, it was charged with the responsibility to:

a. Develop and maintain activation schedules and Program Evaluation and Review Technique (PERT) networks.

b. Identify problems and effect their resolution.

c. Furnish the Apollo Program Office with periodic reports on activation progress.

To assist in its responsibilities, a Site Activation Board (SAB) was created under the jurisdiction of the SAO (see Figure 5-3). Essentially, a management team drawn in task-force fashion from key KSC NASA organizations, support contractors, and stage and spacecraft contractors, the members of the SAB represent top-level management, and, as such, speak and act authoritatively for their organizations. Single point management direction is achieved by appointing the SAO Chief as Chairman of the SAB.

Figure 5-3. Site Activation Board

The upper tier was now organized to meet the challenge, and things began to get done, problems got solved. However, because of the scope of the tasks involved and its high-level management participation, the SAB could only function efficiently by attacking the most significant problems. To resolve problems of a detailed nature, or those requiring extensive followup, the SAO Chief created a number of Working Groups.

Any craftsman must have tools with which to work, and, in this respect, a manager is indeed a craftsman. In performing its function, the SAO has utilized certain management tools which are based on the concept of management by exception. Thus, management attention is focused directly on problem areas or "exceptions" and is not hindered by constant, voluminous status reviews of tasks which are proceeding smoothly. Obviously, this concept is of utmost value in a large, complex, diverse situation, and its use in activating LC-39 proved most valuable.

PERT

Perhaps the most important of the tools utilized was the Program Evaluation and Review Technique which in various forms has become fairly widespread in government and industry. Just about everyone even remotely connected with the aerospace or defense industry has at least heard of PERT; it is either praised highly, or soundly cursed. For the activation of LC-39, one of the very real benefits has been that IT MADE PEOPLE PLAN THEIR WORK. If there had been no other benefits, this alone would have been worth its cost. The PERT operating characteristics are illustrated in Figure 5-4.

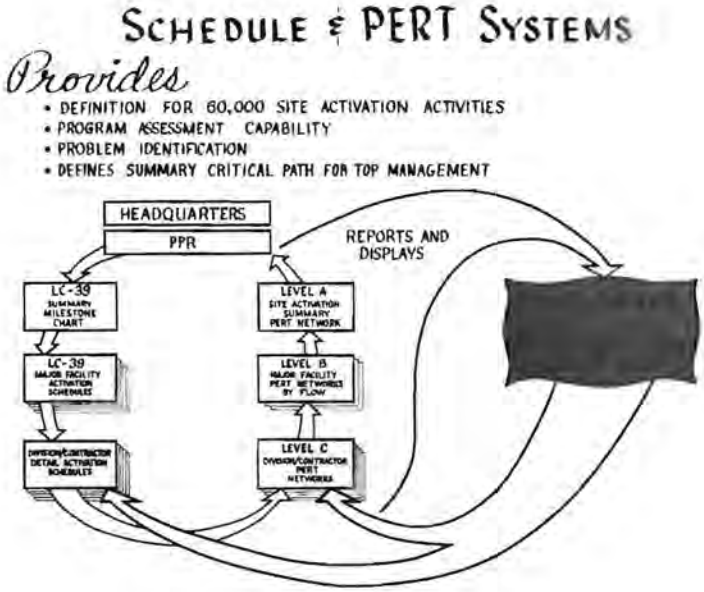


Figure 5-4. PERT at LC-39

Site Activation Office PERT utilized three levels (Level C, B, and A) of networks progressing from detailed to summary level. To implement the system for LC-39, the SAO developed summary milestone networks (Level A) from the Master Program Schedules established by the Apollo Program Office. Level A networks provide top management with visibility of the Master Activation Schedule. Level B networks were created to further define and identify approximately 2,900 significant events whose satisfactory accomplishment would assure timely completion of the activation effort. Within these guidelines, Level C networks were developed by each of the aerospace, mission support, and craft contractors to identify in detail those tasks for which each was responsible. A cyclic review and updating between Level B and C networks was begun, and effective integration of contractor work became possible. Because of schedule and planning changes, review cycles continue to be necessary and are now conducted biweekly.

By means of PERT, more than 40,000 activities required to accomplish program objectives on time have been defined and the summary critical paths identified for management. PERT has allowed the SAO, as focal point for all status and change reporting, to continuously monitor progress, schedule major activation tasks, maintain current schedules, and isolate problem areas requiring attention from management. Having integrated the many activation tasks into logical networks, the SAO is able to continually analyze the program and, where necessary, take appropriate corrective action.

One thing that PERT is not is a panacea for all management problems. This was recognized during the activation phase, and it was found desirable to direct management attention to many specific areas of concern. For example, in any installation which involves many electrical connections, the question of cable identification is a serious one. The problem at KSC was particularly acute due to the complexity and advanced technological state of LC-39. Consequently, a Cable Tracking System was instituted which listed 60,000 individual cables, their physical description, routings, and use. This was a very difficult task which required rigid discipline to ensure total identification by designer and user, but upon completion, it was found to have exceptional value.

EQUIPMENT RECORD SYSTEM

The identification and tracking of GSE to be installed within and upon the basic launch complex structures presented a similar problem. The installed GSE was ordered from many different sources, was both government and contractor furnished, and was needed on hand at specific times within the activation schedule. It was difficult to secure a basic identification of equipment end items which were within the planning responsibilities of the many diverse organizations. Each unit was fulfilling the requirements of its own organization, but information concerning its equipment was not readily available to other organizations for interface purposes.

To correct this situation, an Equipment Record System (ERS) which listed approximately 40,000 individual end items was implemented. The ERS is designed to list the requisites for LC-39 activation and provides a computer-prepared data record for all

launch complex hardware required. The prime purpose of the ERS is to provide a standardized means for the identification and control of deliverable GSE end items. Specifically, the ERS allows SAO management to monitor total allocation of GSE at KSC, to maintain a record of use-location assignments, and to establish the required on-hand dates for all GSE. Site activation planning is enhanced by segregating GSE according to installation, assembly, and test. Also, the ERS allows the monitoring of delivery status, provides a source of current data for use with contractor PERT networks, and supports configuration management by listing applicable drawings and specifications associated with each deliverable end item (see Figure 5-5.)

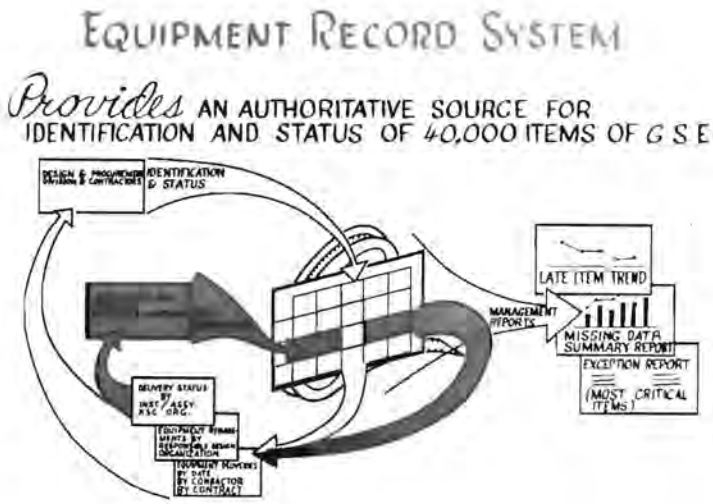
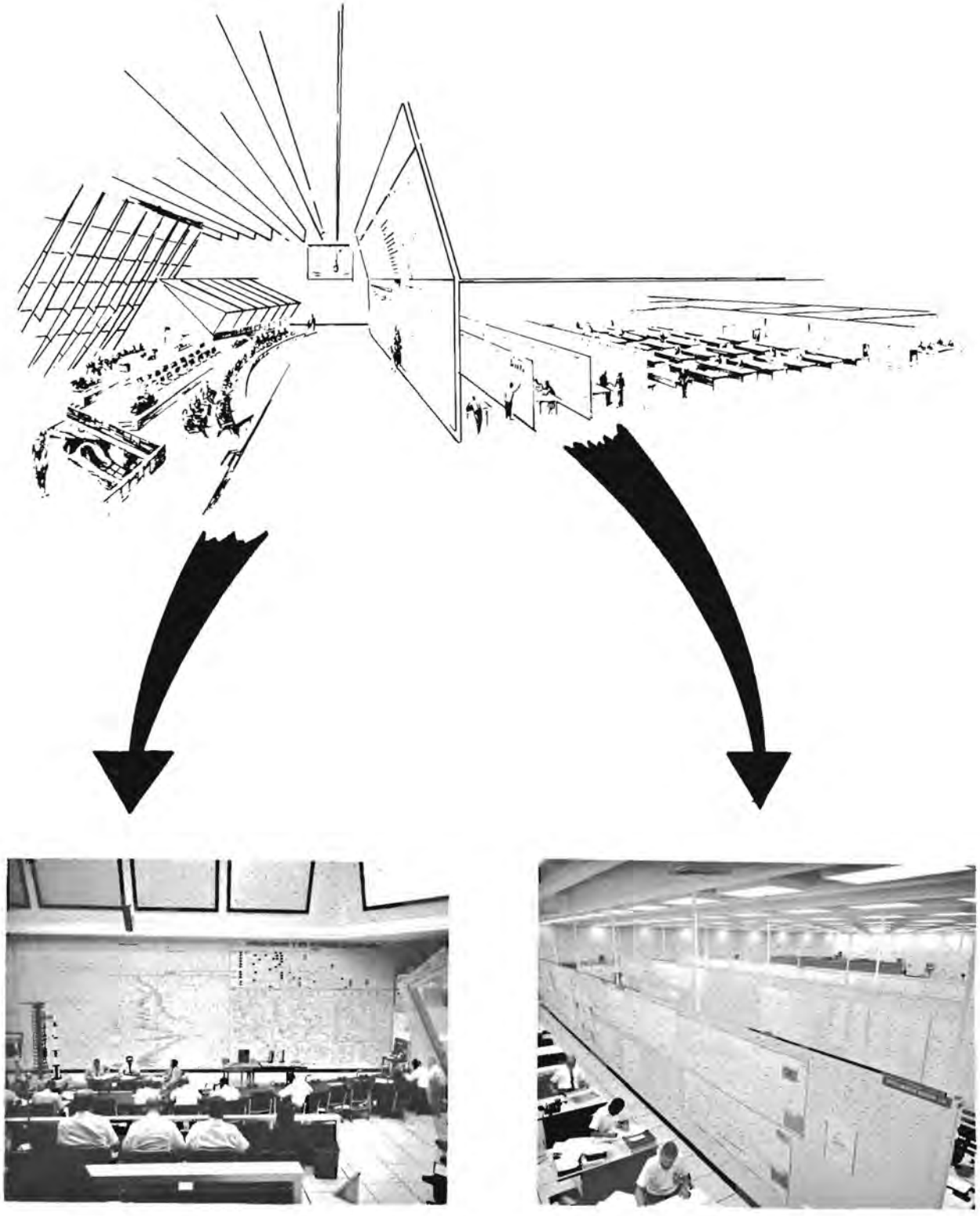


Figure 5-5. Equipment Record System

CONTROL CENTER

To provide a proper environment for performing the management function, a Site Activation Control Center (SACC) was established by temporarily reconfiguring Firing Room 4 of the Launch Control Center. This center provides one area in which all aspects of the activation effort are integrated, both physically and functionally. Specifically, the SACC provides a management information display and analysis area, and a work and conference area. The SACC is also equipped with audio and visual aids, displays, and models to permit VIP briefings, familiarization lectures, and subgroup meetings. Because of the great national interest in the program, the control center has rendered an extremely valuable service in providing visiting dignitaries with a quick-look understanding of the activation effort and goals as shown in Figure 5-6. The efforts of many individuals are required to analyze, process, and record the data that is displayed.



Level A and B Networks

Level C Networks

Figure 5-6. SACC Display Room

CONTROL AND COMMUNICATION

"The best laid plans of mice and men gang aft agley," said Robert Burns. At Launch Complex 39, some very good plans have indeed often gone awry. This, however, was to be expected and is recognized by management at KSC as being the nature of its dynamic industry. Therefore, the SAO has been well prepared to deal with abrupt changes in plans and has taken the necessary steps to deal with the greatest inherent danger, lack of adequate control and communication.

To assure effectiveness, the SAO Chief directed internal and external assessments of his efforts. The external assessment provides an overall analysis of the management system while internal assessment is achieved by trend charts depicting, in summary, equipment installation status, and scheduled event completion status.

Protective measures are instituted to ensure that the mechanics of the PERT system function properly. Audits are conducted periodically to verify the rationale being used to develop or modify the networks. Procedures are established to document exceptions and to coordinate their revision with the applicable contractors. Spot critiques are made by the SAO to assure uniform functioning of the system. These critiques view the lowest level networks from a standpoint of network logic and mechanical accuracy.

As previously noted, working groups were formed to carry out the day-to-day duties of the SAO. Seven such groups operate as entities under SAO control and have greatly facilitated communications throughout the total organization. These groups utilize a lower management level as specialized representatives of the various participating units. Thus, the team concept has been retained in a practical manner with membership reaching into each of the many groups involved in LC-39 activation. Having first hand knowledge of interface complexities has been vital to the effectiveness of the working groups. For continuity of management, the chairmen of the groups are participating members of the SAB.

A limited number of formal meetings are held on a periodic basis in accomplishing the functions of the SAO. Communications between the many organizations are thus improved, and focal points are established for documented formal replies to action assignments. Characteristic of such meetings is the SAB which meets biweekly. Activation status is presented, management problems discussed, and problem resolution effected when possible. To assist in problem resolution, a system of action assignments is evolved whereby major problems are clearly defined and assurance of timely response is given. To keep all members informed of subsequent developments, the status of action assignments is presented at each meeting and documented in the minutes of the meeting.

At the direction of the SAO, a number of special reports are issued from time to time to to satisfy specific needs. For example, particular management emphasis has been required in resolving technical problems in the Mobile Launcher Service Arm System. A daily status report of changes being incorporated in the system was utilized to achieve the proper degree of management attention.

Certain basic reports have been essential in the day-to-day functioning of the SAO, and these have become an integral part of the management system. Typical of these is the PERT Analysis Report (PAR) which is based on a detailed analysis of those problems determined as critical by computer rums. The analysis highlights problem areas, determines their magnitude and impact of major objectives, and indicates organizational responsibility. The PAR functions as the official SAO status report of activation progress and provides a system-oriented evaluation for each of the major facilities.

MEASURE OF ACCOMPLISHMENT

The commercial fisherman has a very simple means of measuring his accomplishments. At KSC, management, too, can show visible measures of its accomplishments, pointing with pride to the VAB, to the awesome sight of 17 million pounds of Launcher, Crawler, and Space Vehicle moving ponderously to the Launch Pad, where just 5 years ago there was nothing but sand, palmetto, and a quiet brackish lagoon. Certainly, the effectiveness of management is not measured so simply, and a somewhat more sophisticated yardstick must be used. Looking, therefore, to the goals established by the Apollo Program Office, it is evident that a high degree of success has been achieved. Those facilities required for the first Apollo/Saturn V launch, that is, the LCC, the VAB, LUT 1, Pad A, MSS, and CT 1 have all been activated. The remaining facilities at LC-39 are nearing completion on schedule, and it is expected that the entire complex will be completed during the latter portion of 1968.

Specific achievements of the concept of management by exception included the meeting of two key milestones which were established at the inception of the site activation effort. These were the move of LUT 1 into a high-bay cell of the VAB in order to erect a facilities verification test vehicle, and the subsequent move of this vehicle to the Pad, one day ahead of schedule on May 25, 1966. This test vehicle was used to check for possible physical interferences and to validate the propellant loading systems prior to first use by a flight vehicle. These events occurred on schedule primarily due to the fact that the SAO was able to integrate and coordinate the activities of many NASA organizations and contractors into one cohesive effort.

The management concept and techniques proven during site activation are now being phased into the operational portion of the Apollo/Saturn V program. As additional facilities become activated, the requirement for site activation diminishes. Thus, individuals are being phased into operations. Portions of the presentation and display area have already been turned over to operational personnel to display space vehicle processing schedules and status.

What has been achieved at LC-39 was accomplished primarily through the application of advanced management concepts and techniques adapted to the very latest space technologies. The facilities at LC-39 required a substantial governmental investment. The management system described assured that this investment was well protected by allocating manpower and other resources such that the particular facilities required for each flight vehicle were the first activated in a time sequence consistent with the launch schedule requirements.

SECTION 6
MANAGEMENT SYSTEMS IMPROVEMENTS

NEED FOR IMPROVEMENT

There is no "best way" in aerospace management. Many of the problems and management challenges at KSC have been identified in this document. Since problem areas change rapidly as the state of the art improves, it follows that the old methods are not adequate to solve them. Thus, it is required that constant effort be applied to the design and development of new and better management systems as well as the improvement of existing systems.

Due to the rapid development of technical operations and facilities at KSC, it has been necessary to develop and implement the various management techniques as concurrent efforts by different groups of individuals. The magnitude and complexity of these efforts have been compounded by the dynamic and changing nature of the activities. Because of this, the degree of implementation has varied and some redundancy has developed in the acquisition and use of data commonly used by more than one organization. This example is one of many with a potential for improvement that could be cited and that has resulted from the growing pains of KSC.

In the effective exercise of management through the four basic applications of plans, organization, implementation (execution), and assessment at KSC, great progress has been noted in the first two with considerable achievement in the latter two. Plans and techniques have been developed to cope with the management problems and the organization has been established for fulfillment of these plans. As noted above, however, implementation of the management techniques is not yet complete and assessment practices are faced with problems of expanding scope as the volume, sources, complexity, and types of data continue to increase. Therefore, the major emphasis for improvement at KSC will be in those areas of greatest need and potential although efforts will continue for the improvement of all phases of management.

PLANS AND ACTIVITIES TO IMPROVE MANAGEMENT

The varied KSC activities for which improvement efforts are planned can best be summarized under the one general classification of management visibility which will receive concentrated attention with respect to providing management with more adequate, timely, and significant information upon which to base management decisions. Some of the areas to be included in planned improvements at KSC are discussed in the paragraphs that follow.

GENERAL IMPROVEMENTS

The unceasing need for improved systems and techniques to enhance management effectiveness is recognized and will be fulfilled as follows by continuing efforts to:

a. Study, improve, and refine existing management disciplines and practices at KSC. Particular attention will be directed to strengthen areas of weakness, clarify vague and overlapping definitions of responsibilities, promote effective response to management directions, and generate plans adequate for implementation with minimum changes.

b. Complete the effective implementation, use, and coordination of existing KSC management techniques within organizational elements at all levels where such efforts are appropriate.

c. Revise the KSC organizational structure, as required, to provide flexibility for adjustment to changes of policy, technology, operations, and general problem areas.

d. Standardize and simplify the technical language (terms, expressions, abbreviations, inputs, outputs, formats, charts, displays, etc.) and processing techniques, striving for reasonable consistency with Apollo Program Directorate guidelines, in the communication of management visibility at KSC. This would provide a greater common basis for understanding and reduce the compounding complexity of information and data disseminated among the management interfaces at KSC. In addition, it permits an easier transition to the use of automated electronic processing methods.

e. Research and evaluate management systems and techniques used elsewhere in government agencies and private industry (both aerospace and non-aerospace) for applicability to KSC management activities.

f. Design and develop new management techniques and systems, as required, to cope with new challenges imposed by state of the art changes in aerospace technology.

INTEGRATION OF MANAGEMENT SYSTEMS

Uniting the various management systems (separately implemented at their inception) at KSC into an overall integrated system will be one of the major improvement goals at this Center. An integrated system will do much to reduce redundancy of efforts and promote more efficient exchange and use of interrelated information. It will blend the judgements, assumptions, and decisions of management into the dissemination of management information that reflects quality, accuracy, timeliness, relevancy, and contents

sufficient to permit effective program management. In addition, it will minimize the risks of decisions based on incomplete and inaccurate data.

As one of the more tangible benefits to be realized from an integrated management system, it is envisioned that management visibility will be improved by a system of reports (with redundancies, errors, and nonessential data removed) that will provide information geared to the needs of each management level requiring written information. It is further envisioned that these reports will be issued on a timely basis to provide (in advance) answers to the questions normally asked by each level of management. Provisions should be made to provide the ability for quick response to reflect the impact of a contingency or change in any one report area upon all other report areas affected. A real-time updating capability for the sources of such information is required. Because of the mass data that must be processed and analyzed to achieve these characteristics, it is presupposed that a significant use of Automatic Data Processing equipment will be required.

The implementation of an integrated management system will be in accordance with established organizational and functional responsibilities. Existing organizations, processes, procedures, standards, and plans will be utilized to the fullest extent, including extraction of data from existing management systems to minimize duplication and additional reporting requirements. Under the direction of the KSC Apollo Program Manager, the Program Control Office will coordinate and integrate the development of this system and assist in the establishment of proper policies to assure continuity and compatibility of plans, procedures, and processes. The implementation of procedures and processes, including data validation and interpretation, will be the responsibility of user organizations.

USE OF AUTOMATIC DATA PROCESSING (ADP) EQUIPMENT

ADP means computers, a magic word in the technological age of today! They have the capability of processing huge volumes and varieties of data with extreme speed and accuracy. They can search, sort, retrieve, rearrange, calculate, apply logic decisions, solve problems, perform countless iterations, and produce varied outputs from data fed into them. Yet computers are electronic morons without the guiding genius of human intelligence which is required to plan each instruction to be executed by these machines in their processing actions. Computers can make mistakes and create erroneous information thousands of times faster than man if they are not properly used. This point is emphasized to identify the need for the systems and methods work (commonly associated with Industrial Engineering) required for accomplishment of the improvements suggested in the preceding paragraphs of this section. With proper use, computers can be used as a powerful tool in conjunction with (but not without) the management systems efforts mentioned above to improve the exercise of management at KSC.

Computers make possible the automation and integration of systems (both soft-ware and hardware) that would be impractical, inaccurate, unwieldy, too slow, and too costly for implementation by manual methods. For this reason much of the management systems integration effort at KSC is expected to be closely associated with the use of ADP. Not only will this result in improved management visibility through coordinated, timely, and integrated written reports, but it will make available the capability of real-time display of pertinent information at control centers and key management locations for more effective management decisions and assessments.

Another area of improvement to be gained through the use of ADP is the development of practical and effective search and retrieval systems to permit real-time exchange of technical data and information among the MSC Centers and NASA Headquarters. Through the use of data banks at each installation, each installation can interrogate the other for data and/or answers that are part of the information reservoir (in memory) at that location. The Apollo Management Information Retrieval System (AMIRS) and the Apollo Documentation Management Information System (ADMIS) are two of many systems currently under development and consideration for these purposes. KSC expects to play a vital role in such efforts.

Microminiaturization of computer components is expected to have a profound influence upon KSC operations. The resultant savings in weight will make possible the use of onboard computers in each space vehicle stage for preflight self checkout and inflight stage control with backup redundancy by the tieing together of such computers. This would provide the potential for elimination of hundreds of pieces of ground support equipment. Such an eventuality would result in less people required for checkout and launch with a corresponding decrease in coordination and communication problems. It would also result in a domino effect as a reduction in facility, power, communications, and support would be achieved. Higher reliability would be obtained by employing triple modular redundancy techniques. Imagine the impact of such developments upon KSC management!

Not only is the use of ADP at KSC expected to aid in the solution of current problems as they arise, it is to be used for trend analysis to alert management to potential problems before they occur. By using prediction techniques, it will be possible to avoid costly emergency actions, schedule slippages, cost overruns, and potential disaster situations.

In summary, the increased use of ADP at KSC will result in achievement of the following management systems goals:

a. Common integrated data banks.
b. Selective and flexible retrieval.
c. Timely response.

d. System integrity with implementation and compliance.
e. Uniformity of information and expedited communication.
f. Government and contractor management visibility at all levels.
g. Cost minimization.

BIBLIOGRAPHY

KSC Apollo Project Development Plan, K-PM

Apollo/Saturn Program Management and Support Plan, K-AM-0

KSC Apollo/Saturn V Development/Operations Plan, K-PM-0

Apollo/Saturn Program Control Plan, K-AM-01

KSC Apollo/Saturn Operations Plan, K-AS-0

Apollo/Saturn Logistics Support Requirements Plan, K-AM-02

KSC Apollo/Saturn Configuration Management Plan, K-AM-03

KSC Apollo/Saturn Data Management Policy and Instruction, K-AM-04

Apollo/Saturn Procedure for Preparation of DRLs and DRJs, K-AM-043/2

KSC Apollo/Saturn Reliability and Quality Assurance Plan, K-AM-05

KSC Apollo/Saturn Reliability and Quality Assurance Requirements, K-AM-05A

Apollo/Saturn Training Plan, K-AM-06

Apollo/Saturn Vehicle Technical Support Plan, K-AM-07

Apollo/Saturn General Safety Plan, K-AM-08

General Services Handbook, K-AM-09

Apollo/Saturn V Launch Operations Plan, K-V-051

Apollo/Saturn V Facility Description, K-V-012

Apollo/Saturn V Master Test Plan, I-V-0

Saturn V Program Requirements and Responsibilities for Preliminary Checkout and Launch Operations, I-V-TD No. 6

KSC Management Instructions (KMIs)

BIBLIOGRAPHY (Continued)

KSC Management Notices (KNs)

KSC Apollo Program Directives

KSC Test and Checkout Plan

KSC Procurement Plan

KSC Program Operating Plan

Requirement Document

1968 NASA Authorization, Hearings Before the Committee on Science and Astronautics

Apollo Program Development Plan, M-DMA 500

Apollo Program Reliability and Quality Assurance Plan, NHB 5300.1A

Apollo Tree Requirements Document

Program Scheduling and Review Handbook, NHB 2300.1

Program Support Requirements Document

Reliability Program Provision for Space Systems Contractors, NPC 200-1

Quality Program Provision for Space Systems Contractors, NPC 200-2

Inspection System Provisions for Suppliers and Space Materials, Parts, Components, and Servides, NPC 200-3

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