The subject of management has probably been written about as much as any other subject in the English language. One can obtain a host of books in any library on the subject. I think the reason for this is that management techniques must be applied to the particular job at hand and, therefore, there are many different approaches depending on the nature of the job and the management structure of an organization. Many fine management techniques have been developed in this country and NASA did not set out to invent new ones for Apollo, but rather they adapted the techniques to fit the particular needs of Apollo.

The subject of my talk is "Application of NASA Management Approach to Solve Complex Problems on Earth." Solving complex problems of any nature requires two major items. First, a commitment by responsible authorities is needed to solve the problem and a date for reaching that goal. Second, organization of the team and definition of the plan are required for achieving the goal. Of course, in Apollo we had a national commitment that President Kennedy established in May 1961 that this nation would land a man on the moon and return him safely to earth in the decade of the sixties. NASA then proceeded to organize a government, industry, and university team which, at its peak, involved 400 000 people, hundreds of universities, and 20 000 special industrial companies.

I would like to discuss with you in a short time what I consider the key elements of the management approach that NASA used for the Apollo program. I will concern myself with the management approach in the program planning and control area which is the heart of any program management system. Time will not permit me to discuss the management approach for other systems which are used in Apollo in managing the pure technical aspects of the programs, such as engineering specification systems, configuration management systems, reliability and quality systems, and others primarily concerned with obtaining a quality product in the configuration necessary to meet program objectives.

I have listed in Figure 1 four key elements in the management approach taken for program planning and control in Apollo. First, you must develop a good program or project plan. The level of detail must provide good understanding of the job to be done. Various techniques have been used to break down the job — familiar names, such as work breakdown structures, are commonly used on most projects. The important thing is to develop this structure so that there is a clear understanding of the job from the worker up through top management. The elements of the plan must allow efficient monitoring of schedules and cost progress. This is a difficult task to achieve since there are many scheduling techniques and cost accrual systems. Once you have developed a detailed plan for a large program or project, it is so voluminous that management cannot review all activities in the time available. Therefore, the detail plan must be summarized in levels so that problem areas can be readily identified and management attention can focus directly on the problem areas and not be hindered by constant and voluminous status reviews on tasks that are proceeding smoothly.

The second key element I have chosen is titled "manage by exception." This means simply that management must apply the greatest attention to those areas of highest criticality identified by the scheduling and cost systems. I think this is the key element in our management approach because, for a large system, the most difficult task is to use the management talent in the most effective manner.

The third element is titled "establishing a competitive attitude among organizations." This can be done in many ways. One of the most effective methods we have used is to list critical problem
areas and display them in an area visible to all, with
the organization and individual manager responsible
for the problem.

The fourth element is titled "audit systems on a
frequent basis." It almost goes without saying that
the output of a system is certainly no better than the
input. Management, down to the lowest level of su-
pervision, must constantly audit the management
procedures and techniques to assure that the job is
being carried out in accordance with these proce-
dures and techniques. For example, a person in an
organization can, with all good intentions, perform
a task different from the established procedures be-
cause he feels: "Well, that change really would not
affect anything, and this certainly is a better way to
do the job." He does not recognize that the proce-
dures have been developed and reviewed by levels of
management as the best way to do the job. Certainly
the employee should identify to management those
areas where he feels the procedure could be im-
proved. Another example would be status informa-
tion. Your system reports a piece of equipment is
installed, so you schedule the next item of work and
find that the status was erroneous. In summary,
what I am saying is that management mistakes can
be made based on bad information from a system.
Therefore, it is most important to audit your sys-
tems on a frequent basis to prevent problems before
they occur. Another note here — walkthroughs and
general site reviews by top management are a tre-
mendous boost to worker morale.

Now, I would like to illustrate this management
approach to program planning and control by review-
ing with you the Saturn V site activation of Launch
Complex 39 located at Cape Kennedy, Florida, which
is used to launch the Apollo/Saturn V vehicles. I
have chosen this site activation task to illustrate the
management approach but I could have well chosen
many other complex Apollo tasks that all had to be
accomplished on time and within cost to support the
success of Apollo, such as the development of the
Saturn V launch vehicle, development of the space-
craft Command and Service Module and Lunar Module
(CSM and LM), and the many experiments and other
equipment that support the launch vehicle and space-
craft systems. I also chose the site activation task
because of my personal involvement, and this ele-
ment of the Apollo program had by far the greatest
number of external interfaces. All of the hardware
had to come together at Kennedy. First, I think it
is in order for me to go through, briefly, the major
facilities involved in Launch Complex 39 and discuss
briefly the mobile concept so that you understand
the complex task which confronted NASA.

In previous missile programs, the conventional
method of launch preparation was to conduct assem-
bly, checkout, and launch operations from a fixed
site, that is the launch pad. One of the major draw-
backs to the fixed-site concept is that the pad is oc-
cupied for long periods of time while space vehicles
are assembled and checked out for launch. The mo-
bile concept allows you to check out the space vehi-
cle in a building under better controlled conditions
and then move the entire vehicle with its accompany-
ing launch stand to the pad for final checkout and
launch. This allows you to plan more closely spaced
launches, which gave NASA a much more flexible
launch system to meet the challenges of Apollo and
future programs.

The Vehicle Assembly Building (VAB) which is
used to assemble and check out the Saturn V space
vehicles is the heart of Launch Complex 39 (Fig. 2).
This building consists of a high-bay area and a low-
bay area and is approximately 525 ft high and 700 ft
long. When the three Saturn V booster stages ar-
rive at Launch Complex 39, the second and third
stages undergo checkout in the low-bay area, then
are erected on the first stage in the high-bay area.

Adjacent to the VAB is the Launch Control Cen-
ter (LCC) (Fig. 3). The LCC houses the electronic
brains that control the checkout of the space vehicle
(there are over 500 consoles and displays in the LCC).
The total checkout and launch of the Saturn V vehi-
cles is controlled from this center.

Perhaps the most unusual facility in the launch
complex is the mobile launcher or LUT which weighs
in excess of 12 million pounds (Fig. 4). This facili-
ty provides the launch stand and the equipment for
support of the preflight checkout and servicing of the
special facilities. This entire structure, along with
the erected space vehicle, is transported from the
VAB to the launch pad with the crawler transporter.

The transporter weighs nearly 6 million pounds
and is capable of supporting over 12 million pounds
(Fig. 5).
The launch pad shown is roughly octagonal and covers an area of about 0.5 square mile (Fig. 6). Adjacent facilities store propellants and gases for servicing the Saturn V vehicle.

The 402-ft mobile service structure (Fig. 7) permits 360-deg access to the space vehicle while it is at the pad. The mobile service structure is transported to the pad for mating with the space vehicle. The mobile service structure stays in position at the launch pad until approximately 15 hours before launch when it is removed and placed back in its erection area.

Figure 8 shows the total complex with the space vehicle in configuration for launch.

Figure 9 depicts the organizational relationships for the site activation effort. To provide centralized management of the site activation effort, a site activation control center was organized and located in the LCC in an unused firing room.

Figure 10 is a pictorial view of the control center which consists of four functional areas. Number 1 is the Site Activation Board meeting area which also displays the master management information. Areas 2 and 3 house the detail plans and personnel from contractors (13 aerospace, 10-15 crafts) and three NASA Centers - KSC, MSFC, and MSC. The fourth area is an audiovisual support area. Let me summarize the scope of the site activation effort. Over 63 000 items of equipment had to be installed and checked out. In addition, over 60 000 individual cables, connecting the various facilities within the launch complex, had to be installed and checked out. All of this had to be done in a very finite sequence.

NASA selected the PERT system as the primary planning technique. PERT, which stands for Program Evaluation and Review Technique, had been used by the Navy on the Polaris program. It also had been used on other programs. NASA modified this system to its specific needs. Figure 11 outlines the PERT system used for Launch Complex 39. The PERT system is simply a logic diagram outlining all tasks to be done in their proper sequence. As I mentioned earlier, one of the major management tasks is to summarize the detail plan into levels. We choose three levels of summarization. The detail plan consisted of 40 000 separate activities, which were summarized into approximately 7500 activities, and then further summarized into a master level of approximately 150 events. The numbers shown on the chart indicate the traceability between the Level B and Level C networks.

The particular event number of the Level B and Level C networks were identical. One activity on the Level B network represented up to 20 activities on the Level C network. This technique of summarization and unique traceability was a unique adaptation by NASA of several management techniques. The PERT system allowed management to identify the most critical problems by analyzing the output of the Level B network. The output consisted of a computer calculation and listing of all activity paths that were behind schedule in the order of criticality.

Figure 12 depicts a summary output of the Level B network. As you can see, the activity paths are listed in order of criticality. Once the problems were identified through the Level B network, management then went to the Level C network which contained the detail activities that were causing the problem. A review of the detail activities would result in a workaround method or resequencing the activities to eliminate the problem area.

One of the important systems supporting the PERT system was the equipment record system (Fig. 13). This system provided rapid status of the delivery of over 123 000 items of cables and equipment. The delivery status was then fed into the PERT system which determined if the delivery date would meet its required date. If not, steps were taken to improve the delivery status or resequence the project plan to accept a later delivery.

Figure 14 ties in with my earlier statement concerning establishing a competitive attitude among organizations. We used a master problem display in the control center. This display listed the 10 most critical problems in site activation and identified the responsible contractor and manager. This type of display was most effective. There was a tremendous competition among contractors and organizations to keep off the problem board.

I would like to close my presentation with the following thoughts. Large complex problems can be solved with a good systems approach, which I feel the Apollo program has demonstrated. The systems approach simply means you make all elements and disciplines belong to a total system which must function as a team to achieve a common goal. Unfortunately, many government-industry-university elements and disciplines have not had to operate in this
environment in their past work. I feel it is paramount that we change this if we hope to solve other complex problems in the future. There is one point I did not mention thus far: that is that any successful management approach must have, above all, good people. There is no substitute.

- **DEVELOP A GOOD PROGRAM OR PROJECT PLAN**
  - Level of detail must provide good understanding of job to be done
  - Elements of plan must be chosen to allow effective monitoring of schedule and cost progress
  - Detailed plans for each organization or task must be summarized into summary plans so that top management attention can be focused directly on problem areas and is not hindered by constant and voluminous status reviews of tasks that are proceeding smoothly

- **MANAGE BY EXCEPTION**
  - Schedule and cost system must identify problem areas in order of criticality
  - Management must apply greatest attention to areas of highest criticality

- **ESTABLISH COMPETITIVE ATTITUDE AMONG ORGANIZATIONS**
  - Identify critical problem areas to organizations and individual managers

- **AUDIT SYSTEMS ON FREQEUNT BASIS**

  - Output of system no better than input

  Figure 1. Management approach.
Figure 3. Launch Control Center.

Figure 4. Mobile Launcher of LUT.
Figure 5. Transporter.

Figure 6. Launch pad.
Figure 7. Mobile service structure.

Figure 8. Total launch complex.
Figure 9. Site activation organizational relationships.

Figure 10. Program Control Center.

Figure 11. PERT systems.
Figure 12. Critical path summary LC-39 site activation.

PROVIDES AN AUTHORITATIVE SOURCE FOR IDENTIFICATION AND STATUS OF 60,000 ITEMS OF GSE

Figure 13. Equipment Record System.
<table>
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Figure 14. Master problem display.