APPLICATION OF NASA MANAGEMENT APPROACH TO SOLVE COMPLEX PROBLEMS ON EARTH

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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 supervision, must constantly audit the management procedures and techniques to assure that the job is being carried out in accordance with these procedures and techniques. For example, a person in an organization can, with all good intentions, perform a task different from the established procedures because 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 procedures 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 improved. Another example would be status information. 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 systems on a frequent basis to prevent problems before they occur. Another note here — walkthroughs and general site reviews by top management are a tremendous boost to worker morale.

Now, I would like to illustrate this management approach to program planning and control by reviewing 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 spacecraft Command and Service Module and Lunar Module (CSM and LM), and the many experiments and other equipment that support the launch vehicle and spacecraft systems. I also chose the site activation task because of my personal involvement, and this element 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 assembly, checkout, and launch operations from a fixed site, that is the launch pad. One of the major drawbacks to the fixed-site concept is that the pad is occupied for long periods of time while space vehicles are assembled and checked out for launch. The mobile concept allows you to check out the space vehicle in a building under better controlled conditions and then move the entire vehicle with its accompanying 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 arrive 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 Center (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 vehicles 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 facility 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 FREQUENT BASIS
    - OUTPUT OF SYSTEM NO BETTER THAN INPUT

Figure 1. Management approach.

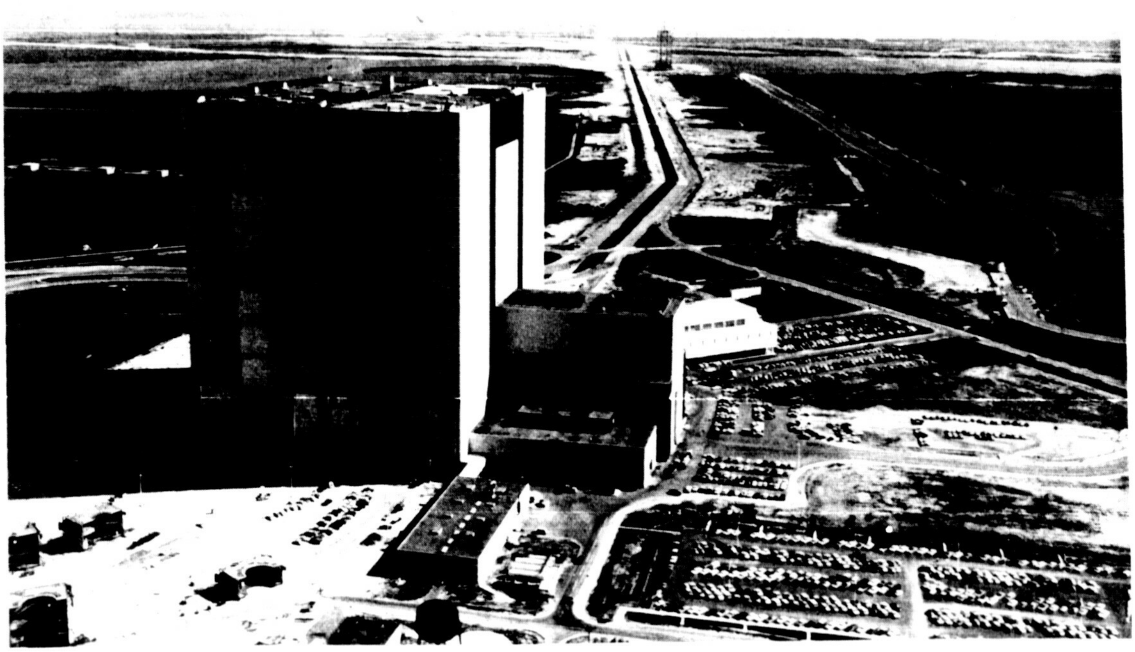

Figure 2. Vehicle Assembly Building.

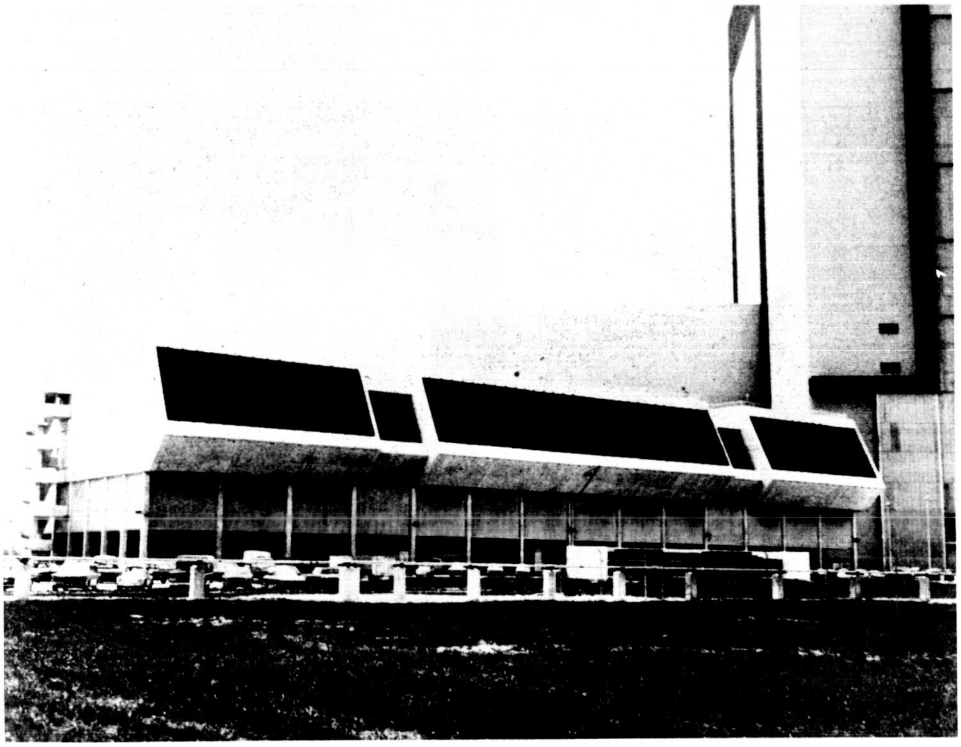

Figure 3. Launch Control Center.

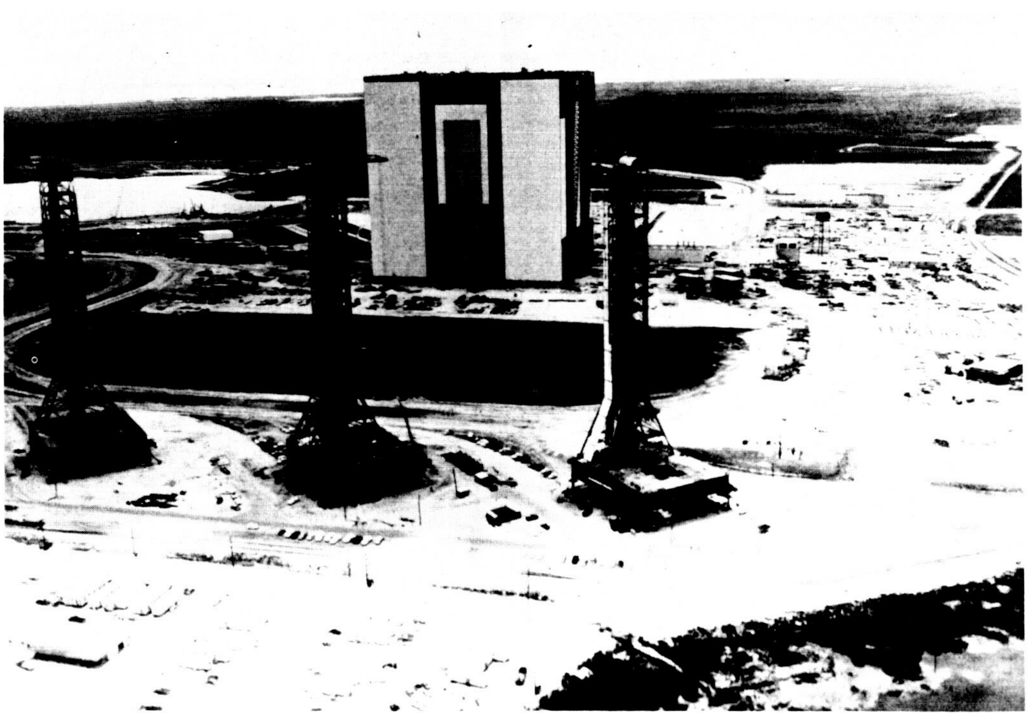

Figure 4. Mobile Launcher of LUT.

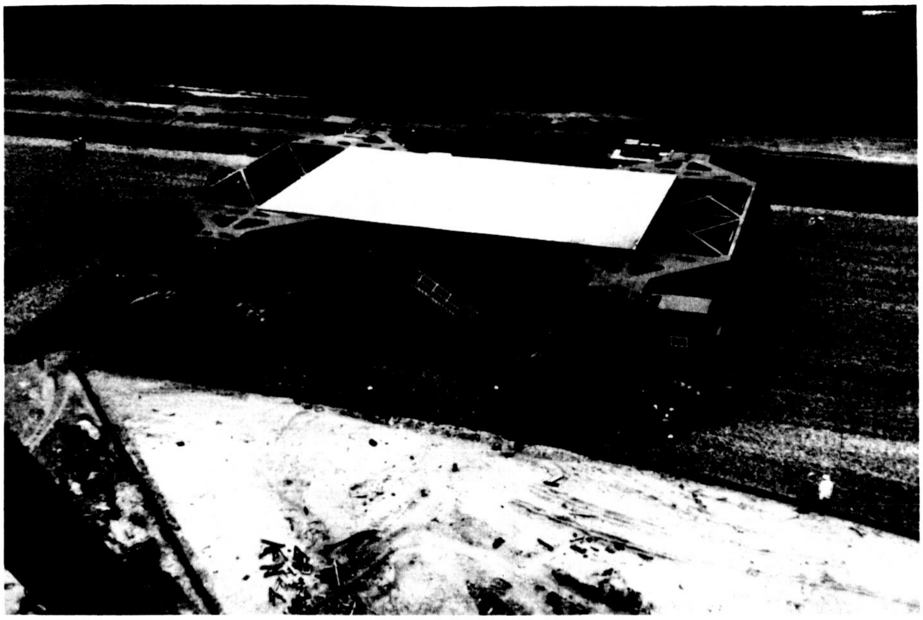

Figure 5. Transporter.

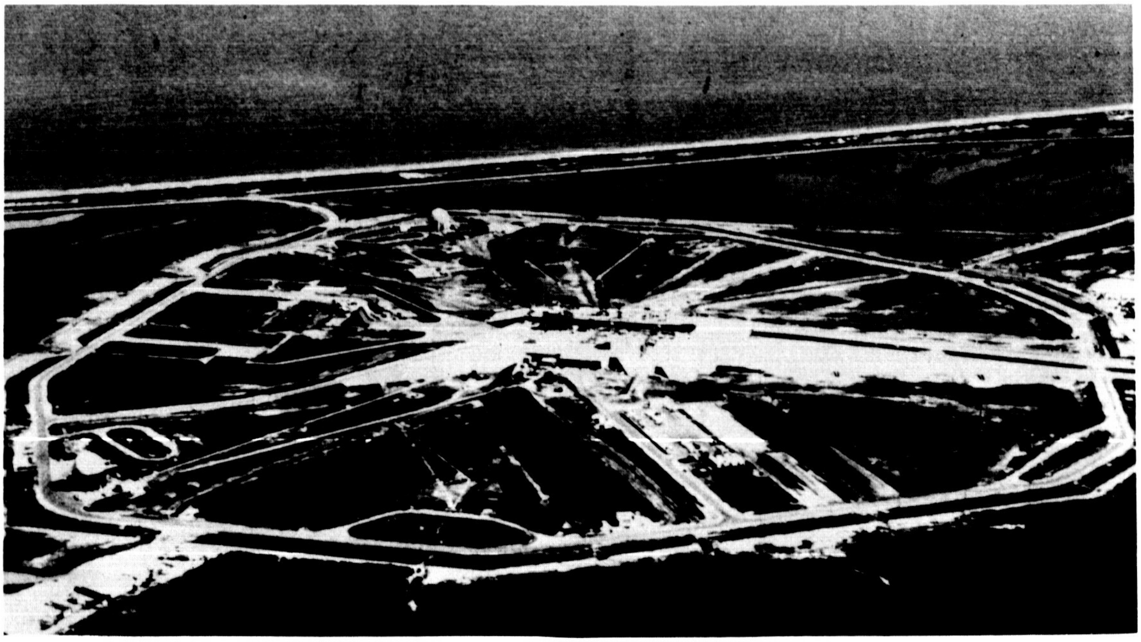

Figure 6. Launch pad.

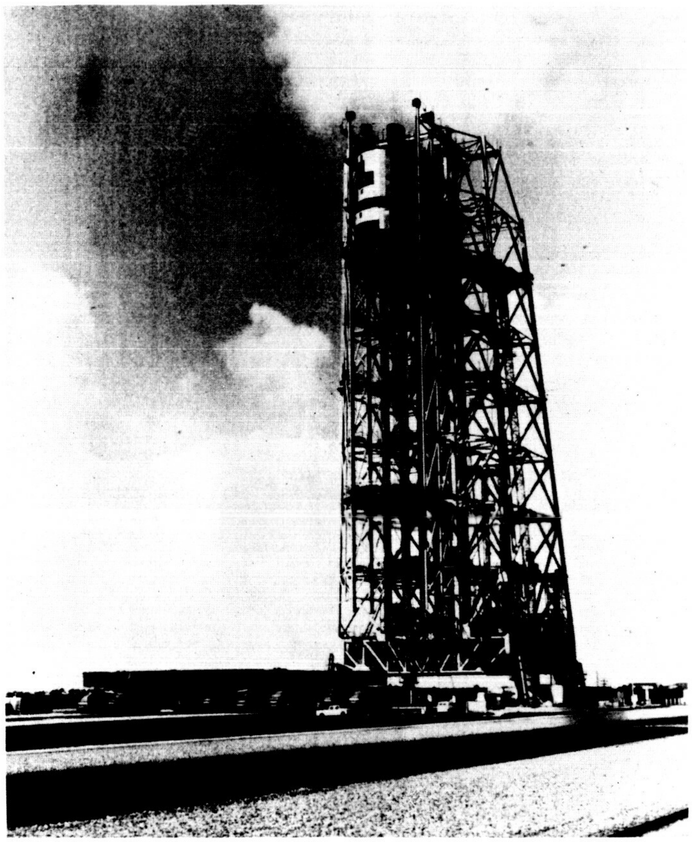

Figure 7. Mobile service structure.

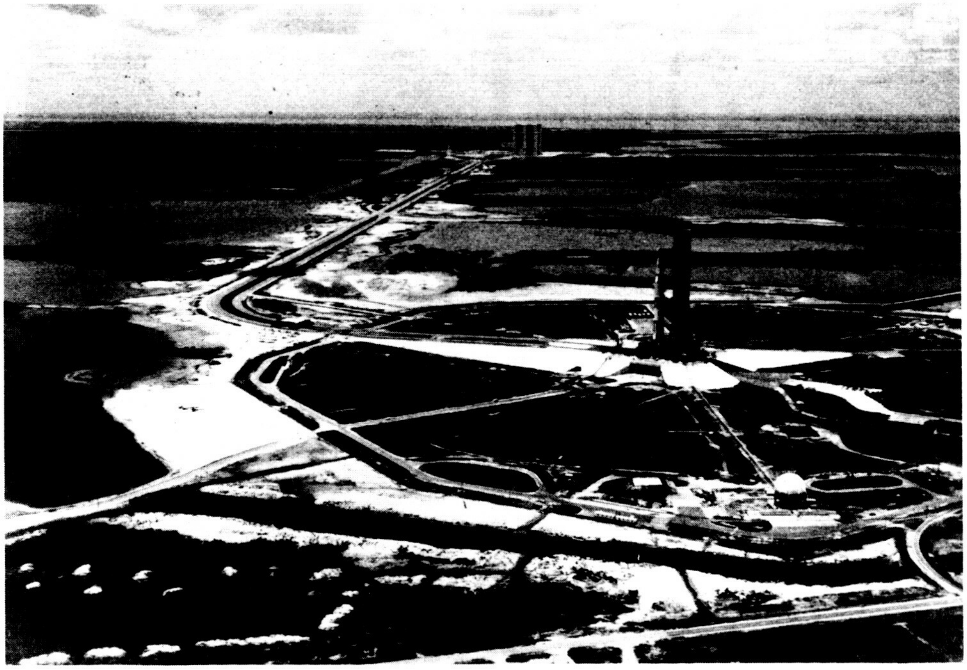

Figure 8. Total launch complex.

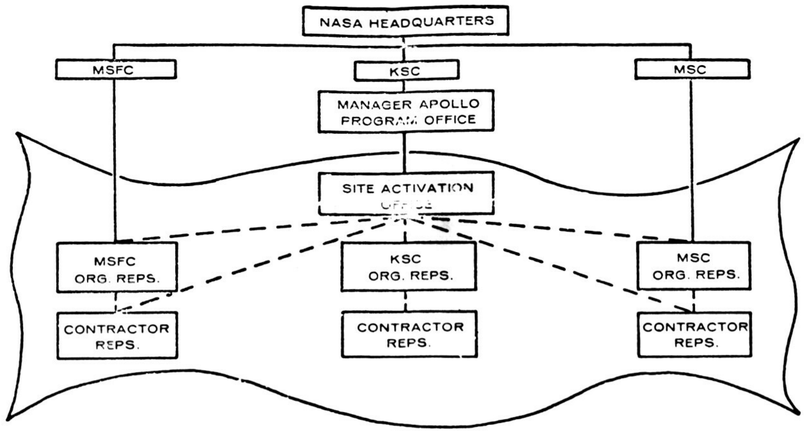

Figure 9. Site activation organizational relationships.

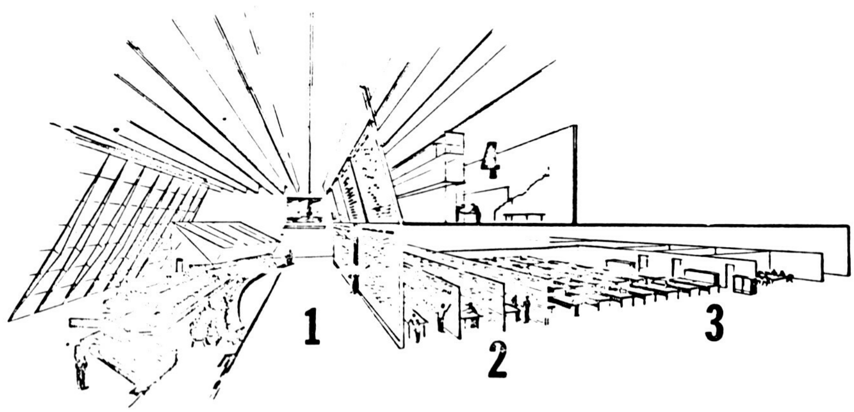

Figure 10. Program Control Center.

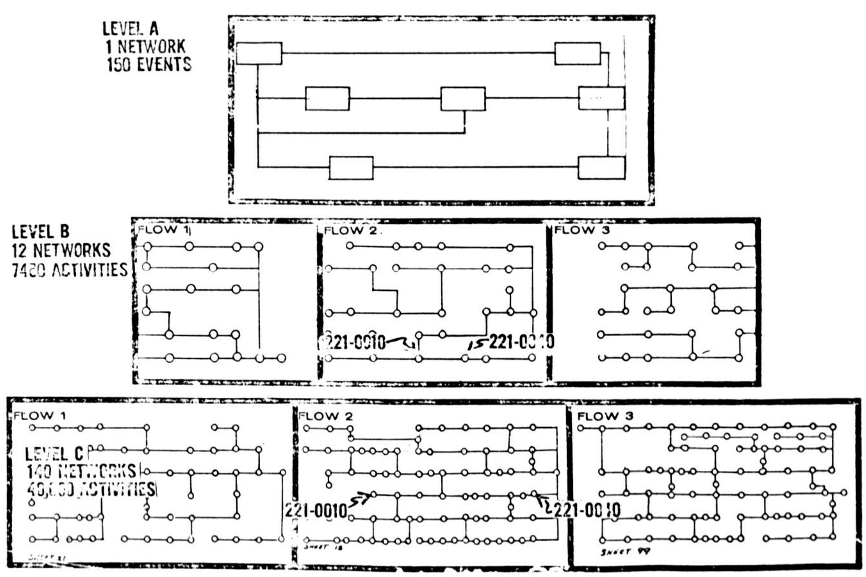

Figure 11. PERT systems.

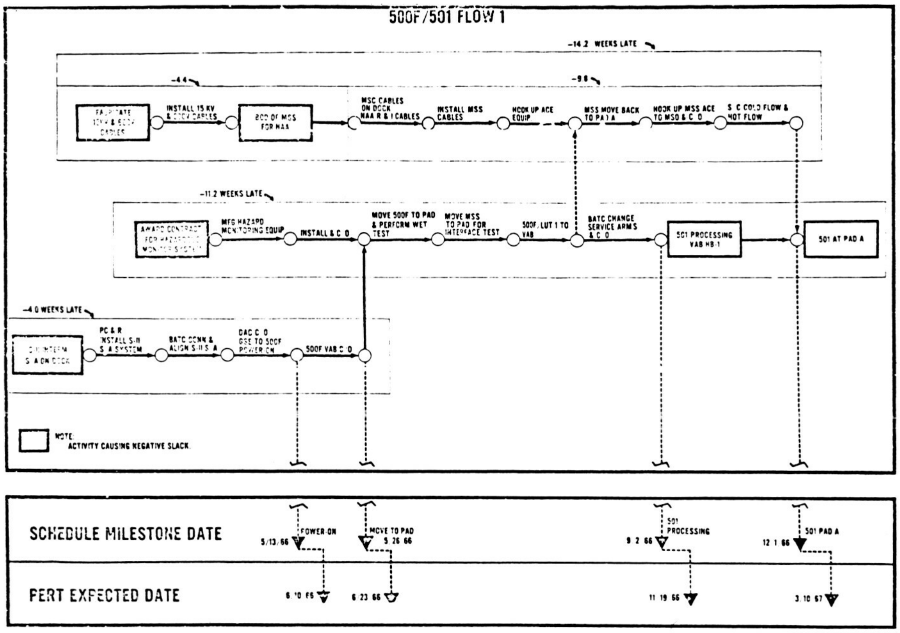

Figure 12. Critical path summary LC-39 site activation.

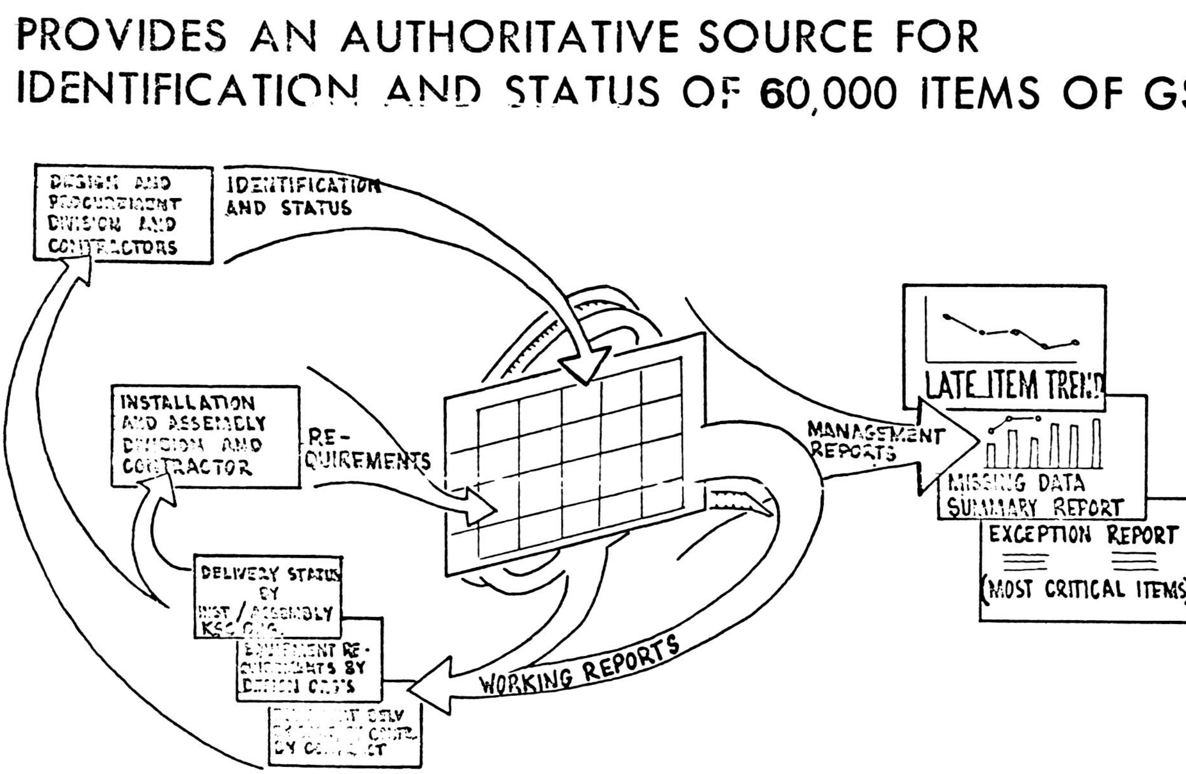

Figure 13. Equipment Record System.

PROBLEM	SCHEDULE POSITION (SLACK)	CONTRACTOR	MANAGER
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Figure 14. Master problem display.