ANECHOIC CHAMBER - MSC

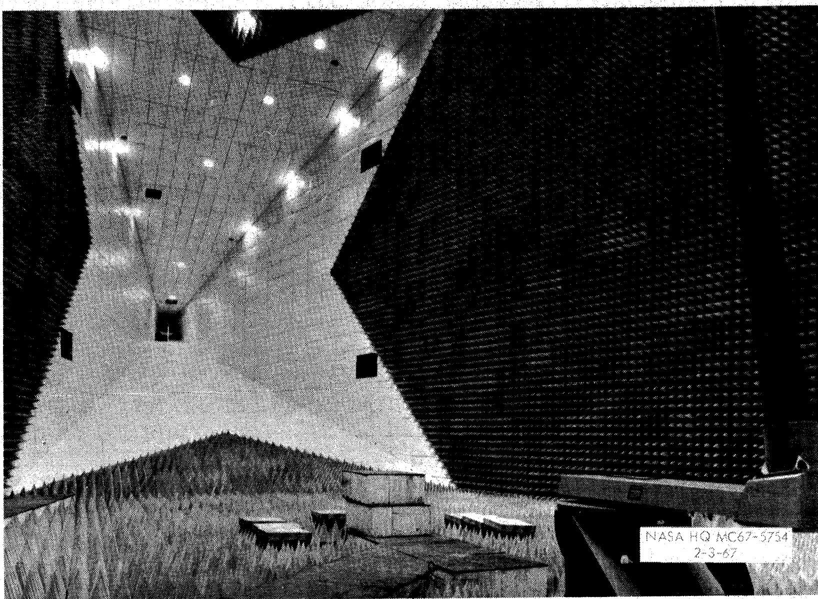

FIGURE 11

FIGURE 12

event any one of a vast number of contingency situations develop during a mission. The control center has the means for sending instructions and data to the spacecraft crew, and exercises operational control over all mission ground operational support facilities.

Another important grouping of facilities at MSC is the mission simulation and astronaut training complex. It includes a flight acceleration facility which features what is probably the world's largest centrifuge with a man-rated, environmentally controlled gondola at the end of a 50-foot arm (fig. 13, MC67-5757). Other buildings are for mission simulation and training, and flight operations.

The lunar receiving laboratory (fig. 14, MC67-5753) is now under construction. Its primary purpose is the initial receipt, processing, and safeguarding the integrity and biological containment of lunar material returned to Earth by Apollo missions; and biologically isolating the returned spacecraft, astronauts, and associated support personnel. The receiving laboratory will provide the means to certify the safe release of all materiel and personnel and to perform highly time dependent experiments such as radiation counting and gas analysis.

Most MSC facilities were completed during 1965. Additional major milestones occurring during 1966 were the activation of the environmental testing laboratory for spacecraft 008, the activation of the flight acceleration facility, and completion of the electronic systems compatibility facility.

Mr. FULTON. Mr. Chairman.

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON. I understand scientists have been appointed to examine this material. Will we be building through the country subsidiary lunar sample receiving stations or is this the only one?

Dr. MUELLER. This is the only receiving station. The samples will be handled there initially, then, allocated to the various experimenters who have been selected for carrying out the analysis of these samples.

Mr. FULTON. That would also run to the laboratory and equipment?

Dr. MUELLER. In general the selection process except for some limited, specialized pieces of equipment was based upon availability of people and facilities to carry out the analysis at the laboratories.

Mr. FULTON. At the Kennedy Center there are rooms with consoles and electronic equipment as well as various types of viewer equipment. When are you going to finish these? I understand there are to be three in operation. Is there one more?

Dr. MUELLER. Actually at the computer support complexes for the three high bays—I assume this is what we are talking about—are being put in operation. We do not at this time plan to complete the fourth bay.

Mr. FULTON. So that is not in this particular budget?

Dr. MUELLER. It is not in this particular budget.

Mr. FULTON. That is all.

Dr. MUELLER. Most MSC facilities were completed during 1965. Additional major milestones occurring during 1966 were the activation of the environmental testing laboratory for spacecraft 008, the activation of the flight acceleration facility, and completion of the electronic systems compatibility facility. Other completions were

MANNED SPACECRAFT CENTER CENTRIFUGE

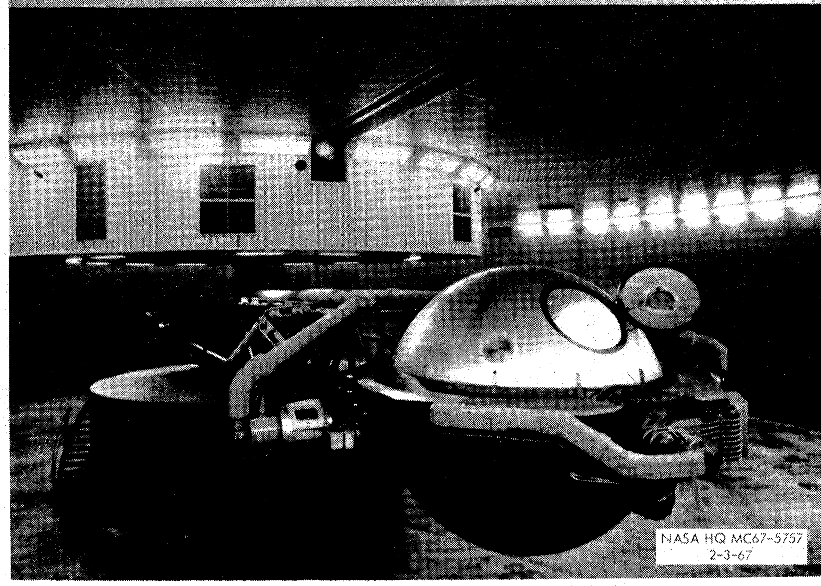

FIGURE 13

LUNAR RECEIVING LABORATORY
MANNED SPACECRAFT CENTER

FIGURE 14

the atmospheric reentry materials and structures evaluation facility, the lunar mission and space exploration facility; and a cafeteria, project engineering facility, and addition to the central heating and cooling plant.

The major portion of the phase I contract for construction of the lunar receiving laboratory was completed. This work comprises the foundations, structural steel, and building shell as well as the underground radiation laboratory structure and site utilities. Work to be completed this year includes phase II construction of the lunar receiving laboratory contract, comprising interior architectural work and installation of mechanical and electrical systems and laboratory equipment. Also to be completed are the technical services facility, spacecraft control technology laboratory, ultrahigh vacuum space chamber facility, and modifications to the environmental testing laboratory providing an extension to the solar simulation system and increased vacuum pumping capacity.

Our request for fiscal year 1968 at MSC calls for improvements to the environmental testing laboratory which will enhance safety and operational effectiveness. The requirement results from technological developments, new requirements, and experience gained from actual flights. Our request also includes a project which will increase sewage treatment plant operating efficiency, and an access road from a major off-site thoroughfare to the western boundary of the Manned Spacecraft Center.

The Marshall Space Flight Center at Huntsville, Ala., is responsible for the management of all activities leading to the design, development, production, test, and delivery of large launch vehicles and related systems. This includes the direction of the several contractors associated with development, fabrication, and test of all major flight vehicles, engines, and components at locations on the west coast, the Midwest, Louisiana, and Mississippi.

As of June 30, 1966, the capital investment in this facility amounted to $376,519,000. This figure represents the facilities acquired from the Army as well as those constructed by NASA over a period of years for space vehicle and propulsion systems development.

Test facilities for present and future programs range from stands for testing components up to the giant Saturn first stage vehicle. The comprehensive complex of scientific equipment and facilities constitutes one of the most complete aerospace research and development centers in the country.

Marshall's technical equipment and facilities range from a substantial investment in relatively standard bench equipment, such as oscilloscopes, recorders, microscopes, and measuring equipment through unique laboratory equipment such as environmental chambers, vibration and shock testers, and particle accelerators, to complete rocket vehicle testing stands. Large high bay areas with associated cranes, support shops, clean rooms and process development laboratories have the capability to accommodate any large hardware items such as complete payloads or rocket stages. This could include manufacture of prototypes or flight items. The R. & D. facility requirements for many of the potential aerospace projects could be largely satisfied by existing capability at Huntsville with relatively minor facility expenditures.

The testing structures (fig. 15, MC67–5732) at Marshall consist of static firing rocket test stands for flight readiness as well as development testing; dynamic test stands to determine compatibility of complete vehicles with their vibration environment; cold flow stands for development of vehicle fluid flow systems; ground support equipment testing apparatus; acoustic and structural testing positions.

An example of flexibility in facility application is the construction of a zero gravity drop test tower in an existing dynamic test tower (fig. 16, MC67–5733) which was built for the Saturn program. These modifications do not compromise the ability of the dynamic stands to do vibration testing on future vehicle payloads combinations such as Voyager.

Experience in the Saturn program has proved the importance of development and testing of the launch tower systems and their interface with the vehicle.

Marshall's high bay spaces with massive access doors, environmental control, and sensitively controlled high capacity cranes can be used in any aerospace program requiring stations for work on large hardware items (fig. 17, MC67–5730).

Mr. GURNEY. Mr. Chairman.

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. Why are we building this off-site access road? Why are the governmental authorities building this road?

Mr. LILLY. Is this at Houston?

1ST STAGE SATURN V
AND F-1 TEST STANDS - MSFC

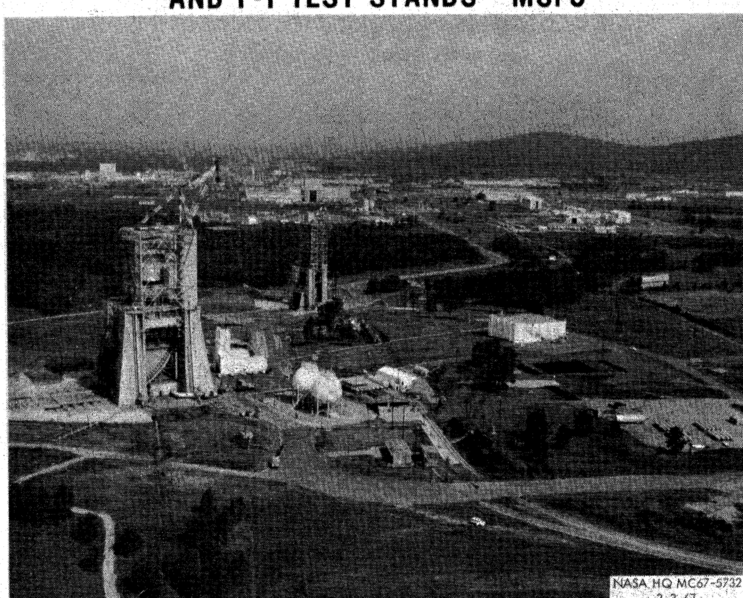

FIGURE 15

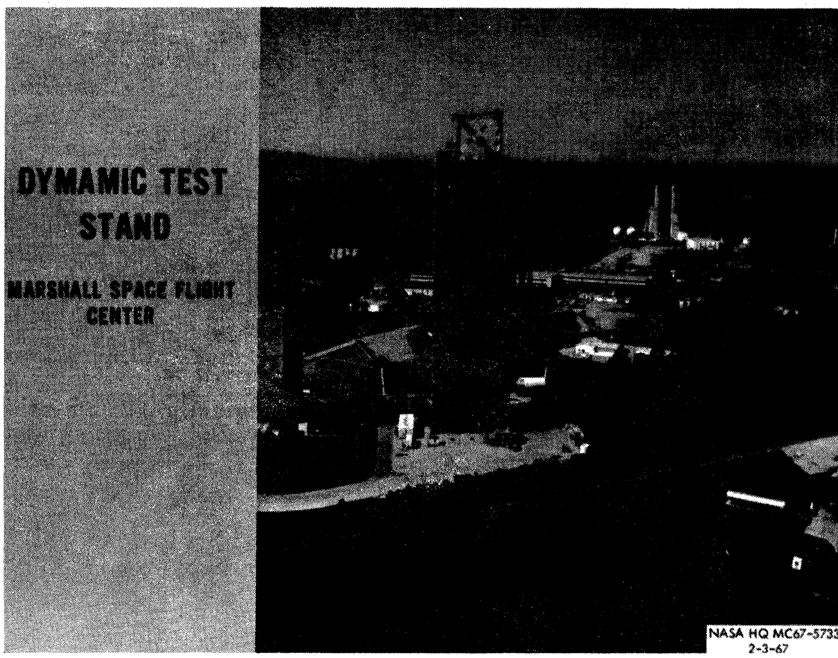

FIGURE 16

PROPULSION & VEHICLE ENGINEERING LAB

MARSHALL SPACE FLIGHT CENTER

FIGURE 17

Mr. GURNEY. Yes.

Mr. LILLY. The road that has been proposed there has been a combination of the county, the State, and Humble Oil to build a parallel road in back of the site. The Humble Oil Co. has paid for the road to our site. We are picking it up from there inward to connect to our own internal roads at MSC.

Mr. GURNEY. I don't know that I quite understand that now. It says this road will connect Avenue B which is your road to the Bay Area Building, which is apparently a main highway down there. Isn't it on the land owned by Uncle Sam? Is it at the Manned Spacecraft Center?

I have been reading from C.F. 7–8.

Mr. LILLY. There is a portion of it that is off-site, Mr. Gurney. It is the access from our gate on the site out to the road.

Mr. GURNEY. Why is this not done by the local governmental authorities?

Mr. LILLY. I think this is the normal procedure, that all access roads and thoroughfares are handled by the Federal Government if it is required by us. This is not any different from what we have done at any of the other locations.

Mr. GURNEY. In other words, we are following precisely the same procedure here that we have in all the others.

Mr. LILLY. That is correct. In fact, the Humble Oil Co. and county and State went even a little further in terms of donating some land for us to do that.

Mr. GURNEY. Thank you.

Dr. MUELLER. Returning to MSFC facilities, the adjoining complex of supporting facilities and equipment completes the capability required for Saturn vehicles and development of advanced manufacturing methods and processes (fig. 18, MC67–5731).

During 1966 we completed construction which provides additions, improvements, and extensions such as modernization of instrumentation and control systems, additions to components test facilities, and expansion of high pressure gas and propellant systems. In addition, basic construction of the transportation hangar in the Saturn support test area, and the acceleration, test, and calibration facility was completed. The instrument unit checkout station and the Saturn V system development facility were activated. Work yet to be completed includes utilities extensions for roads and telephones.

For our fiscal year 1968 program we are requesting a water pollution control project which will treat chemical wastes generated by MSFC testing and manufacturing operations. Also requested is a project to provide for a centralized fire detection and reporting system at the center.

The first or booster stages of the uprated Saturn I and the Saturn V are being produced by the Chrysler Corp. and The Boeing Co. respectively at the Michoud Assembly Facility near New Orleans (fig. 19, MC67–5734). This Government-owned plant, as of June 30, 1966, represented a capital investment of $134,450,000.

This 43-acre manufacturing building was constructed during World War II. Since NASA acquired the plant we have added a vertical assembly and checkout capability, together with storage and engineer-

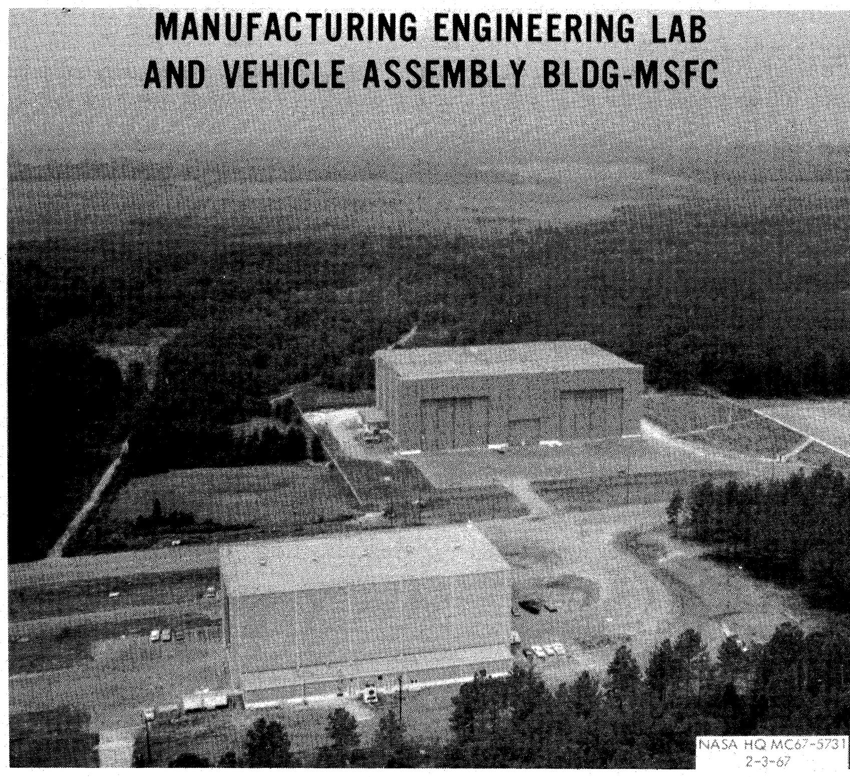

FIGURE 18

ing space to provide a facility that is well suited to the assembly of large space hardware.

During 1966 we completed construction and placed in operation the contractor services building, the vehicle component supply building, and an extension to the marine dock. Also completed were improvements to the storm drainage system, and repair of damage to the roof and other structures sustained during Hurricane Betsy. Additions to the computer facility at Slidell, La., were also completed. To be completed this year are the expansion and modification of the chemical waste disposal system, and utility modifications to sewer, steamplant, and water distribution systems.

For fiscal year 1968 we are requesting approval of a project for rehabilitation and improvements to the facility utility systems, equipment and roads. Also requested is a project to extend Saturn Boulevard to the State road system; thus connecting the Michoud complex with limited access highways now under construction by the city of New Orleans and the State of Louisiana.

Mr. FULTON. We had some question about the airstrip and what they were going to do with it.

What happened to that finally?

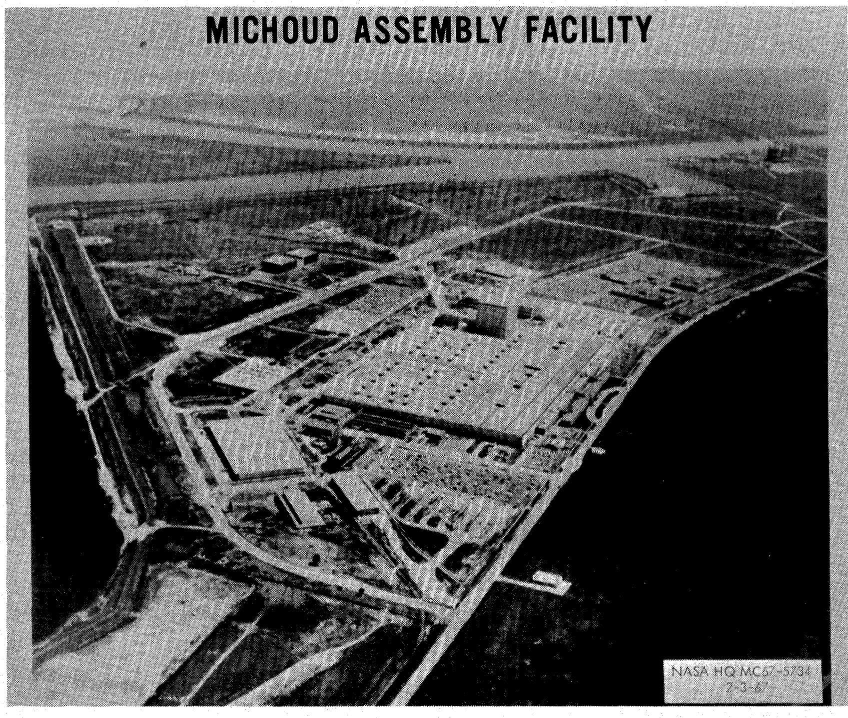

FIGURE 19

Dr. MUELLER. It is not now in use accept as a storage area.

Mr. TEAGUE. Isn't it used to transporting launch vehicles to the barges?

Dr. MUELLER. Mr. Lilly?

Mr. LILLY. Several years ago there was a proposal to modify and upgrade the old airstrip. This proposed project was turned down. We have used that airstrip as a part of our road running from the plant out to the shipping dock.

Mr. FULTON. My next question is along the lines that the chairman has asked. Is it necessary to deliver material and transport structures?

Mr. LILLY. Is it necessary for that?

Mr. FULTON. Is it necessary to do that?

Mr. LILLY. It is necessary to use it as a road to transport the stages out to the barges which carry them to and from Marshall, Miss., and the Cape.

Mr. FULTON. You don't need it for transporting equipment of any kind for examination or inspection as we envision at Michoud.

Mr. LILLY. So far, Mr. Fulton, the commercial airports have been satisfactory for our use in air transport.

Mr. FULTON. Has the fact that this committee turned it down caused you any trouble?

Mr. LILLY. It has not caused any delays, sir.

Mr. FULTON. That is all.

Dr. MUELLER. Final acceptance testing of the Saturn V first and second stages takes place at the Mississippi Test Facility. The capital investment in this complex reached $215,994,000 as of June 30, 1966. This figure represents a testing complex consisting of one Saturn V dual position test stand (fig. 20, MC67-5738), and two single position second-stage test stands (fig. 21, MC67-5735). Test support facilities include the test control center, data acquisition center, propellant facilities, water supply system, fuel transfer and storage facilities, and supporting laboratory facilities.

Last year, the first Saturn second-stage test stand was completed and test firings are now underway. The first position of the Saturn first-stage test stand became operational during this past December. Accomplishments during 1966 also include completion of a warehouse addition, security control facilities, mobile equipment operations building, and a components service facility. The Saturn second-stage storage and checkout facility was also completed and became operational. Essentially, all work has been completed at the center except for minor roads and the bridge over U.S. Interstate Highway No. 10.

There are no fiscal year 1968 funds requested for the Mississippi Test Facility.

Engine and vehicle fabrication facilities are operated by contract under the managerial cognizance of the Marshall Space Flight Center.

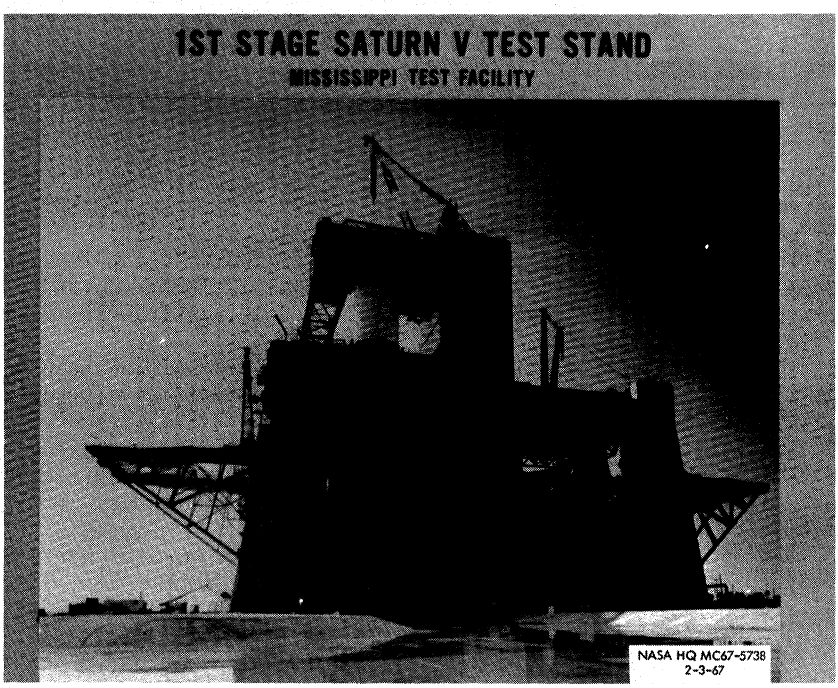

FIGURE 20

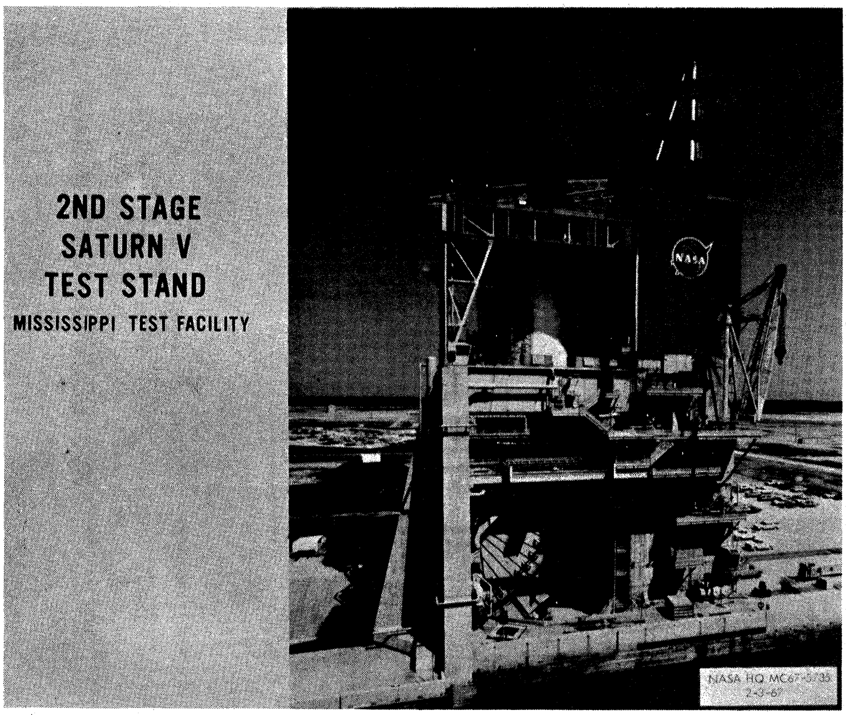

FIGURE 21

The total capital investment for these facilities as of June 30, 1966, exceeds $117,277,000.

The engines which are used in all space vehicles, the H–1, F–1, and J–2, are developed, fabricated, assembled, and tested by Rocketdyne Division of North American Aviation, Inc., at Government-owned facilities. The developmental testing takes place at Santa Susana (fig. 22, MC67–5741). The H–1 engine is fabricated, assembled, and tested at Neosho, Mo. The F–1 and J–2 engines are fabricated and assembled at Canoga Park, Calif. (fig. 23, MA64–9446). The acceptance testing for the F–1 engine is conducted in facilities constructed at the Edwards Air Force Base and the testing of the J–2 takes place in facilities provided at Santa Susana, Calif. In each instance, we have capitalized on basic resources provided by the Department of Defense with augmentation by NASA.

Two Saturn launch vehicles stages, the S–IVB and the S–II are fabricated and assembled on the west coast.

The S–IVB stage is manufactured by the Douglas Aircraft Co. (fig. 24, MC67–5759) in company-owned facilities at Huntington Beach, Calif. Acceptance testing of the completed stages takes place at Sacramento, Calif. (fig. 25, MC67–5760), where NASA has an operational test complex.

The fabrication and assembly of the S–II stage is performed in the NASA constructed facility at Seal Beach (fig. 26, MC67–5761) oper-

FIGURE 22

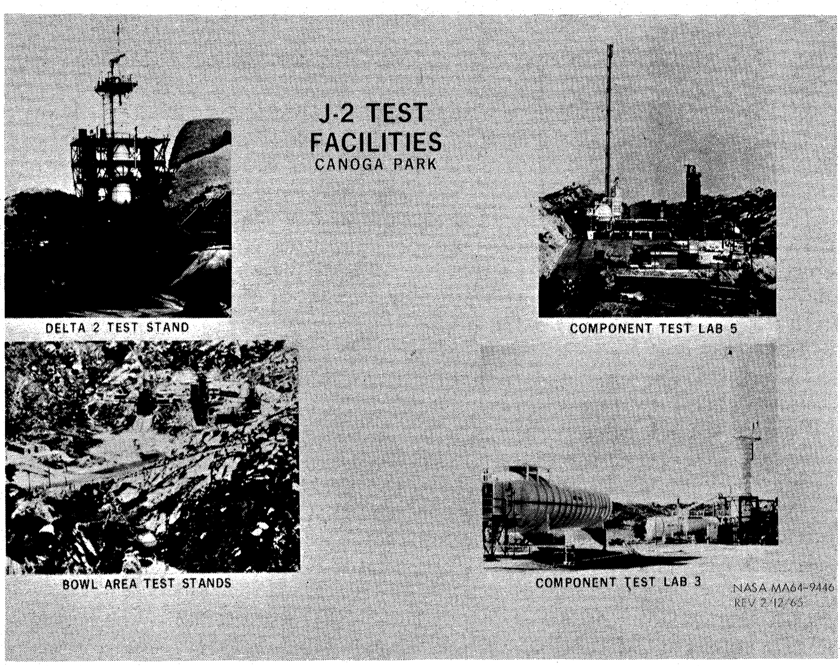

FIGURE 23

FIGURE 24

FIGURE 25

ated by the Space and Information Systems Division of the North American Aviation, Inc. The final acceptance testing and refurbishment of the S–II stage takes place at the NASA Mississippi Test Facility.

Activation of the first factory checkout station at Seal Beach, Calif., was completed in April 1966 to accept the arrival of the S–II–1 Saturn V second stage. Activation of the second facility checkout station at Seal Beach is underway and will be completed by mid-1967.

There are no fiscal year 1968 requests for various locations.

Spacecraft manufacturing and testing are accomplished under the managerial cognizance of the Manned Spacecraft Center. The Apollo command and service modules are manufactured by the North American Aviation Co. in the NASA industrial plant at Downey, Calif. This plant was acquired from the Air Force in 1964. We have added a number of facilities valued at $15,765,000 which are now complete and operational.

The Lunar Module is manufactured by the Grumman Aircraft Engineering Corp. at their Bethpage, N.Y., plant (fig. 27, MC66–5719). Some of the more important Grumman facilities are the electronic systems development laboratory, the fuel systems laboratory, the navigation and guidance laboratory, and the flight control systems laboratory.

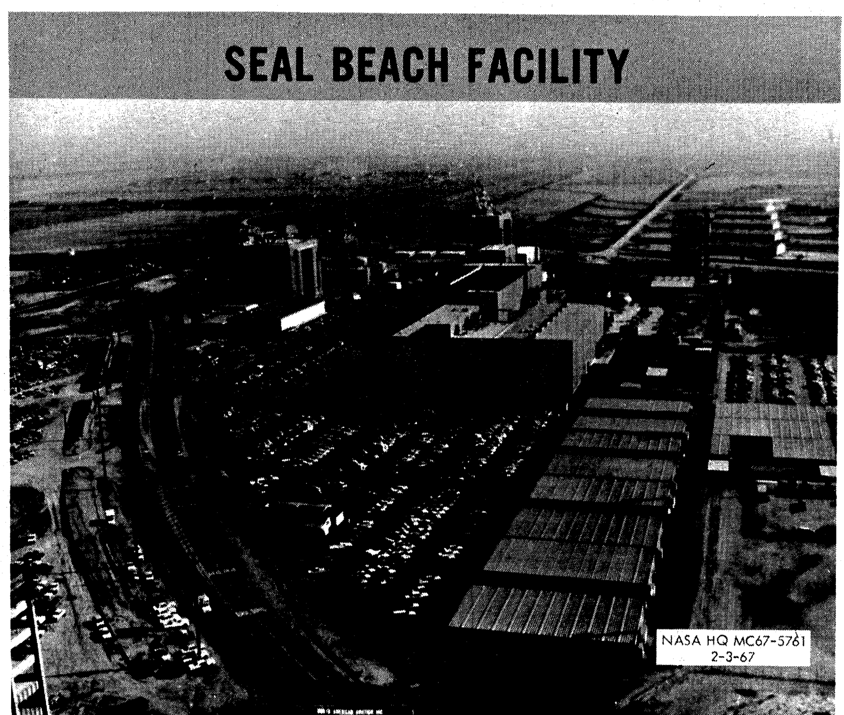

FIGURE 26

FIGURE 27

Development testing of the Apollo spacecraft propulsion systems is conducted at the NASA-operated White Sands Test Facility in New Mexico (fig. 28, MC67–5728) on land acquired from the Army by use permit. NASA has invested a total of $26,934,000 in this facility which has three major areas.

Mr. GURNEY. Where are you in the budget estimates so we can follow along?

Dr. MUELLER. Actually what I have been doing, Mr. Gurney, is reviewing what had been accomplished in the last year. I wasn't following the budget book.

In this particular case, there are no new requirements in this area so there is no entry in the budget book for it.

Mr. GURNEY. When I can turn to it, let me know.

Dr. MUELLER. I will do so.

Mr. FULTON. Mr. Chairman?

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON. What planning is being done for isolation of men and materials returning from the lunar mission? What are you doing in that field? Are you going to land the first men returning from the Moon at the White Sands Test Facility in New Mexico?

Dr. MUELLER. Our present plans provide for landing in the ocean, either in the Atlantic or Pacific, depending upon the time of year.

Mr. FULTON. You have no plans for any facilities at the point of landing?

Dr. MUELLER. No, sir; we will continue to use the Department of Defense recovery support forces for this operation.

FIGURE 28

Mr. FULTON. Why are you still landing on water rather than land?

Dr. MUELLER. Mr. Fulton, we are requesting funds as part of our fiscal year 1968 Apollo Applications program to begin development of a land-landing capability for the spacecraft.

Mr. FULTON. That is really what I am asking.

Dr. MUELLER. We literally need to design and develop a system to carry this out and in the course of that design and development effort, we will be able to define the requirements for the landing sites. None have been selected at this point in time.

Mr. FULTON. Is there any design engineering money in this 1968 budget?

Dr. MUELLER. The fiscal year 1968 Apollo Applications request includes funds for initiating the development of a land-landing capability for the Command and Service Module. I believe that is something like $18 million for fiscal year 1968.

Mr. FULTON. Would you put that in facilities?

Dr. MUELLER. I was referring to R. & D. money, Mr. Fulton. There are no funds for facilities at all.

Mr. FULTON. I am talking about facilities. That is all.

Mr. GURNEY. Mr. Chairman, I have one question. Is our own staff member checking out the requested new construction?

Mr. TEAGUE. Ed, as we made our trips around this year to the facilities and the centers and the countries, one staff member was assigned to spend his time while we were there going over facilities and there has been much work done.

Mr. FULTON. Is your flagpole sufficient at your Houston Manned Spacecraft Center, because some of us objected to the original one. Also, I might add that the cafeteria was a little large, although now that it is built, it is a very nice cafeteria.

That is all.

Dr. MUELLER. Let me return to White Sands, covering the Apollo Propulsion Systems Development Facility, the Lunar Module Test Facilities, and the Little Joe II Launch Facilities.

The Lunar Module Test Facilities are used for developmental testing of the ascent, descent, and reaction control propulsion systems. The test area has three structurally identical, single position, static firing stands.

The complex for flight qualification of spacecraft modules and systems prior to manned flight has now been deactivated.

There are no fiscal year 1968 C. of F. funds requested for various locations.

To summarize, the basic plant is now available to support the Apollo missions. The facilities which represent a major national investment by Government and industry are capable of significant contributions to the Apollo Applications and future programs. I believe that the United States has brought in being a firm foundation upon which the Nation can begin to realize substantial benefits from space activity and to reach toward the planets.

The fiscal year 1968 Manned Space Flight C. of F. request totaling $27.9 million, will be used primarily for the activity required to complete outfitting of Launch Complex 39 at the Kennedy Space Center in support of the Apollo program. The funding required for the Manned Space Flight centers also provides for modifications and improvements for safety and operational effectiveness and for modernization of utilities.

I would like to turn to a brief summary of Administrative Operations and then turn the questions and answers for both A.O. and C. of F. over to Mr. Lilly.

Mr. TEAGUE. George, there are a few questions I would like for you to answer.

Dr. MUELLER. Yes. I plan to stay as long as you like. I thought I might finish Administrative Operations before we go on to questions.

Mr. TEAGUE. Go ahead.

Dr. MUELLER. If we turn to Administrative Operations, I believe the committee has had an opportunity to look at what we have been doing at the centers during the recent hearings at KSC, MSFC, and MSC, so I won't try to go through it completely but will instead try to bring together an overview of what we are doing.

In the case of Administrative Operations for the three Manned Space Flight centers the fiscal year 1967 funding level is $315.4 million (fig. 29, MC67-5433). In fiscal 1968 the requirements are $323.5 million. The increase can be traced primarily to personnel compensation and benefits and support services.

About 60 percent of the funds in Administrative Operations are spent for the civil service personnel. About 25 percent are spent on

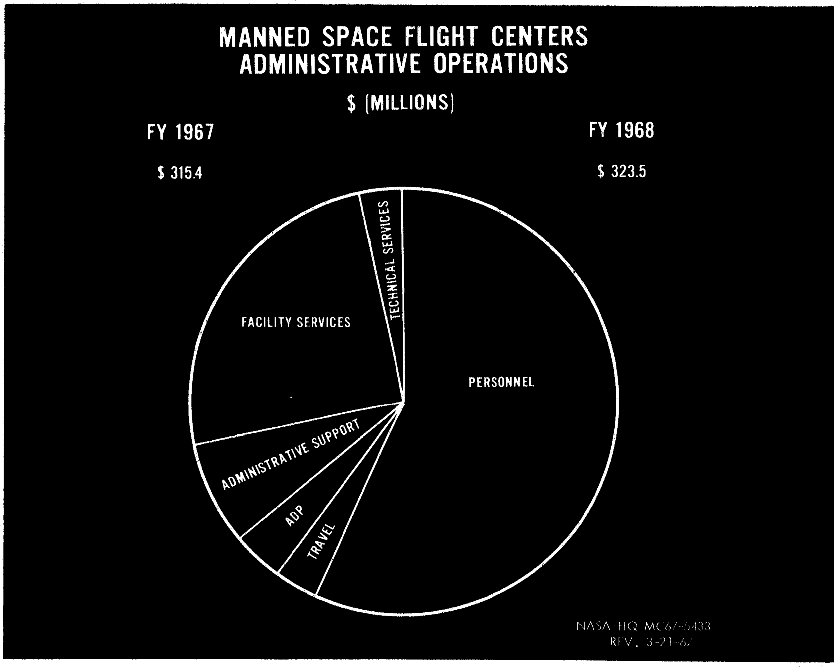

FIGURE 29

various services, both for operating facilities and for technical services. If I can turn to our civil service manpower resources at the three Manned Space Flight Centers, our civil service total this year (fig. 30, MC66–10,188) is 14,384. Of these 2,720 are at the John F. Kennedy Space Center, 4,634 at the Manned Spacecraft Center, and 7,030 at the George C. Marshall Space Flight Center.

Mr. FULTON. Are these permanent positions?

Dr. MUELLER. These are permanent civil service positions.

Mr. TEAGUE. As time goes on, do you see a shift in personnel or will they remain at about this level?

Dr. MUELLER. I expect that they will tend to decrease, but not markedly. One of the things that we anticipate is that we will be able, to some extent, to absorb the fluctuating workload by varying the number of people in the various categories.

In addition, of course, the number of people that we will have will depend upon the committee's action and the action of the Congress with respect to the Apollo Applications program, the Voyager program and eventually such follow-on programs as the NERVA.

Mr. FULTON. Would you comment whether the abolishment of certain positions has caused any delay in the Apollo program?

Dr. MUELLER. The 1,013 is for the agency as a whole, Mr. Fulton. We have taken a reduction on the order of 420 of this agency total in the Manned Space Flight program. I cannot say that this curtailment has affected the Apollo program, although it has caused con-

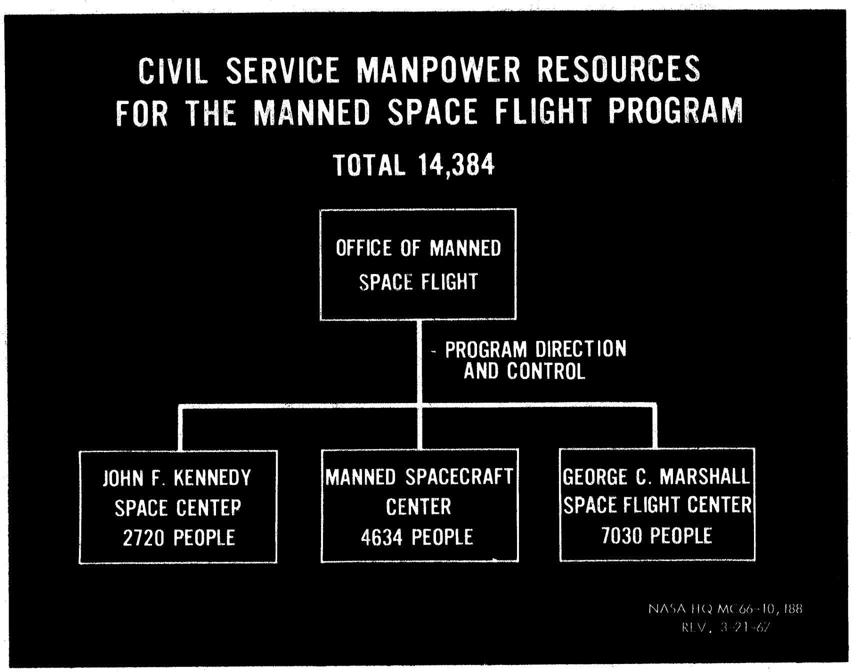

FIGURE 30

siderable problems, in the process of accommodating them, at both the mission control center at Houston and at our Kennedy Space Center.

Mr. FULTON. This retrenchment has not affected the safety factors of the Apollo program nor the technical factors so that we are not as technically adequate as we might be?

Dr. MUELLER. We have made no compromises in either technical performance or in any event in the safety of either the astronauts or the ground crew because of any retrenchment either in dollars or personnel in the Manned Space Flight organization.

Mr. FULTON. These personnel have not been taken out of inspection or control areas, have they?

Dr. MUELLER. Not unless they were no longer required.

Mr. FULTON. That is all.

Dr. MUELLER. Looking at the distribution of skills (fig. 31, MC 66–10,152) we have a relatively large percentage of scientists and engineers, some 46 percent of our organization being in that category. We do have a number of professional administrators, so that almost 60 percent of our organization are professionals of one sort or another.

Turning to the Manned Space Flight civil service manpower (fig. 32, MC67–6010), we had at the end of fiscal year 1966 some 14,597 people authorized to the Manned Space Flight program. By the end of fiscal year 1967, we expect to be down to 14,384 people at our three

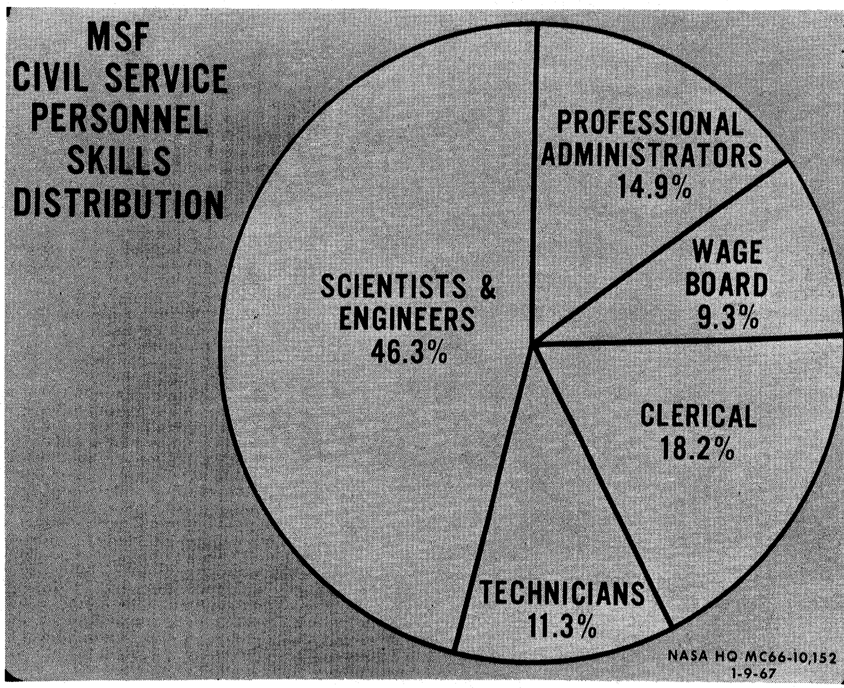

FIGURE 31

MANNED SPACE FLIGHT CIVIL SERVICE MANPOWER

	Year End FY 1966	Year End FY 1967	Year End FY 1968
TOTAL	14597	14384	14384

FIGURE 32

centers, and we expect to hold constant during fiscal year 1968 at this level.

Mr. Chairman, I would like to take one example of some of the work we have done in Administrative Operations. Actually, it was at least in part in response to some questioning by Mr. Rumsfeld with respect to our procedures and processes for automatic data processing. If I may read just a few passages from the summary and then enter into the record this document on our "Computer Systems Survey Manned Space Flight, NASA October 1966" I would appreciate it.

In the summary the document states:

> Computers are an integral part of the Manned Space Flight (MSF) program and support the missions and functions of each center. General support computers are used by the MSF centers in their day-to-day activities of engineering development and management operations. Other computers are linked together as elements of systems used to train flight personnel, check out launch and space vehicles, and control missions. The number and varieties of computer models used in the MSF program are illustrated in figure 1–1. (Cf. page 1.)

This figure is too complex to project on the screen, but you will see it in the report.

With respect to our management techniques, which is one of the various aspects of this survey, we have developed, in the course of our building up of our Manned Space Flight centers, a carefully implemented set of management techniques which have been applied by our own Manned Space Flight office in Washington and our centers to manage the computer resources. Let me quote from the document:

> Automatic Data Processing (ADP) planning documents which project intended ADP usage, are developed by each Center and transmitted to OMSF on a yearly basis with quarterly revisions. Program Operating Plans (POP) and quarterly submissions of revisions of the annual ADP budget are also intensively reviewed in OMSF.
>
> Procedures for the acquisition of computer hardware have been developed that involve both the Centers and NASA Headquarters. Following NASA Headquarters authorization, the Center initiates a procurement based on a firm specification of the required system (cf. page 4).

We have a broad participation by computer manufacturers in the Manned Space Flight program as a result of this process.

> In the centralized data processing facilities, a system of workload control procedures is utilized to provide the basis for controlling computer resources. Control is accomplished through user budgets. For operational systems, computer requirements are validated through program-management procedures.
>
> A significant amount of computer resources utilized in MSF is developed, operated, and maintained by contractor personnel. Procedures and management tools for monitoring contractor performance have been developed and are being applied.
>
> The OMSF and its three Field Centers actively promote computer-resource sharing arrangements through the MSF Resources Sharing Panel and through written agreements with the General Services Administration (GSA). Computer programs and machine time worth $7,000,000 were shared in MSF during calendar year 1965. Resource sharing has been further encouraged in 1966 by management action, such as the establishment of programming standards, standard data formats, and a computer program library at MSC (cf. page 4).

(The following is submitted for the record.)

COMPUTER SYSTEMS SURVEY

October 1966

Office of Manned Space Flight

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FOREWORD

In early 1966, Dr. George E. Mueller, Associate Administrator for Manned Space Flight, directed his staff to undertake a comprehensive survey of the management and utilization of manned space flight computational resources. The results of the survey were to be used as the basis for increased management visibility of computer operations with an aim toward ascertaining that all possible means were being exercised to assure that manned space flight computers were doing the best job at the lowest possible cost. The purpose of this document, then, is to describe and explain how the manned space flight organization manages and utilizes its computer resources.

On February 28, 1966, Lt. Gen. Bogart met in Washington with those people from each of the Manned Space Flight Centers and Headquarters having significant responsibilities in computer management to discuss the project and describe the dimensions of the task. At this meeting, Lt. Gen. Bogart designated the Manned Space Flight Automatic Data Processing Resources Sharing Panel to be the key intercenter coordinating group for the project.

Shortly thereafter, at a meeting in New Orleans, it was determined that the task could most expeditiously be accomplished in-house and that the starting point would be the collection of a data base in the areas of computational capability, organization and staffing, and management techniques. Key personnel were designated at each Center to spearhead the study effort and, in conjunction with several key NASA Headquarters people, formed a Joint Action Group to prosecute the collection and analysis of information.

After the data had been collected, a full-time working team, designated by the Joint Action Group, met in Washington at intervals during the months of September and October 1966 to analyze the data and prepare the survey report. The Manned Space Flight Automatic Data Processing Resources Sharing Panel, with technical assistance from several consultants, reviewed the work of this group and endorsed the presentation.

In summary, this report describes and explains the manned space flight computer capabilities, organizations, staffing, and management techniques used to control these resources. The report also describes the role of the computer in manned space flight and identifies the individuals responsible for the various operating elements. Funding levels and cost trends are shown. Several management developments, such as Automatic Data Processing Workload Control and the Manned Space

Flight Automatic Data Processing Resources Sharing Panel, which were instituted in manned space flight to support urgent program requirements, are also discussed.

The exploitation of the computer as an integral part of the manned space flight effort, as well as the high cost of attaining effective computer capability, makes it essential that management continue its intimate concern with these resources.

OFFICE OF MANNED SPACE FLIGHT

COMPUTER SYSTEMS SURVEY

OCTOBER 1966

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1.0 SUMMARY

Computers are an integral part of the Manned Space Flight (MSF) program and support the missions and functions of each Center. General support computers are used by the MSF Centers in their day-to-day activities of engineering development and management operations. Other computers are linked together as elements of systems used to train flight personnel, check out launch and space vehicles, and control missions. The number and varieties of computer models used in the MSF program are illustrated in figure 1-1.

1.1 COMPUTERS AT THE MANNED SPACECRAFT CENTER

The Manned Spacecraft Center (MSC) manages the development of manned spacecraft, trains flight crews, and controls space flight operations.

Spacecraft design and development work requires a large, general-purpose computational facility capable of solving engineering and scientific problems. This includes the Data Reduction Complex (DRC), where large volumes of telemetry (TM) data from previous missions are processed for analysis by engineering personnel. This facility also provides a capability for administrative and business data processing, including finance, payroll, logistics, and management-control applications.

Crew training is a key function at MSC. This function is primarily accomplished by computer-based simulation. Other simulations include the simulation of subsystems for developing checkout procedures and the simulation of space environments for checking the entire spacecraft.

A major portion of the computer capability at MSC is centered in the Real-Time Computer Complex (RTCC), which supports the Mission Control Center (MCC). Its primary function is to process and display, in real time, spacecraft data from approximately 20 remote sites for use by the mission director and his staff. The RTCC also has the capability to generate and transmit spacecraft commands during a mission.

1.2 COMPUTERS AT THE GEORGE C. MARSHALL SPACE FLIGHT CENTER

The George C. Marshall Space Flight Center (MSFC) designs, manufactures, and tests the vehicle stages used in the various manned, unmanned, and satellite missions.

The George C. Marshall Space Flight Center has a large, central data processing facility in the Computation Laboratory, which supports other Center divisions. However, most of the computers at MSFC are used to support design, checkout, and static firings of Saturn vehicle stages or systems associated with the Saturn V (S-V) instrument unit. These digital computers are integrated into larger systems that include analog devices and other special equipment used to control operations, such as stage firings or the gathering, cycling, and sequencing for feedback of data and commands. For example, in the MSFC Huntsville Operational Support Center (HOSC) during the powered-flight phase of a mission, a computer monitors vehicle parameters transmitted in real time from the launch site and drives displays for the use of MSFC engineers in providing technical backup during launch and flight operations.

The Michoud Assembly Facility (MAF) and the Mississippi Test Facility (MTF) are also supported by MSFC through a computational center at Slidell, Louisiana. This facility is used primarily by the Apollo stage contractors, that is, Chrysler Corp., the Boeing Co., and Mason-Rust. Computer capability is provided for scientific and general engineering applications, as well as for administrative and business applications.

1.3 COMPUTERS AT JOHN F. KENNEDY SPACE CENTER

The John F. Kennedy Space Center (KSC) is responsible for developing and managing the Merritt Island Launch Area (MILA); providing technical and administrative support for National Aeronautics and Space Administration (NASA) elements located both in the area of MILA and on the Eastern Test Range (ETR); and planning and supervising the integration, test, checkout, and launch operations at these facilities.

A major computer installation is the Central Instrumentation Facility (CIF). This facility can accept data from launch sites, process and retrieve it on request and display it on demand, providing a "quick look" TM station for space-vehicle engineers. A unique feature of this real-time computer installation is its ability, when not supporting a mission, to perform batch-processing of administrative and scientific data.

The checkout computer capability of KSC consists of a large number of computer systems which are an integral part of space-vehicle pre-launch and launch operation activities. Also, to support real-time data requirements during launch, computers are used in the Apollo Launch Data System (ALDS) to pre-process TM data from KSC and ETR sites prior to transmission to MCC at Houston.

1.4 MANAGEMENT RESPONSIBILITIES

Although operational computer control is vested in the directors of the respective Centers, the Office of Manned Space Flight (OMSF), Washington, D.C., maintains both organizational and functional control through the chain of supervision to each\Center Director. Overall program control is assured through the OMSF review and evaluation process and through the issuance of policy directives. The NASA Deputy Administrator, Dr. Robert C. Seamans, is the final authority on NASA computer resources. In this capacity, he draws on the Office of Tracking and Data Acquisition (OTDA) for staff assistance and on the Office of Programming for budget-policy execution.

Within overall NASA policy, MSF has delegated the day-to-day operational control of computer resources to computational elements within each Center. Each Center Director has final authority on delegated computer matters. Each director has further delegated this authority to operating heads in keeping with the differences that exist in the mission and organizational structure of each Center.

At MSFC, the Computation Laboratory plans, establishes, and conducts a program for application of high-speed computers and automation devices to the scientific and general engineering aspects of launch-vehicle research, development, test, and fabrication, as well as to the areas of management and project direction.

At KSC, the Data Systems Division maintains cognizance of the instrumentation systems used to obtain test data for manned and unmanned flight and fulfills all requirements for general-purpose scientific and data reduction computing, special-purpose checkout computing, concurrent real-time TM and display computing, and quick-look data-reduction applications. This assignment includes the planning and execution of test-data handling and management-information data processing for business applications.

At MSC, computation functions are controlled by two organizational elements. The Flight Operations Directorate is responsible for the computers used in the direct control of manned space vehicles; the

Engineering Development Directorate is responsible for general-purpose scientific and engineering (category A) computers, special-purpose (category B) computers, and the operation of these computers. (An inventory of MSF computers is included in the appendix.)

1.5 MANAGEMENT TECHNIQUES

Management techniques have been developed and applied by OMSF and its Centers to manage its computer resources.

Automatic Data Processing (ADP) planning documents, which project intended ADP usage, are developed by each Center and transmitted to OMSF on a yearly basis with quarterly revisions. Program Operating Plans (POP) and quarterly submissions of revisions of the annual ADP budget are also intensively reviewed in OMSF.

Procedures for the acquisition of computer hardware have been developed that involve both the Centers and NASA Headquarters. Following NASA Headquarters authorization, the Center initiates a procurement based on a firm specification of the required system. Figure 1-1 demonstrates the broad participation by computer manufacturers in the MSF program.

In the centralized data processing facilities, a system of workload control procedures is utilized to provide the basis for controlling computer resources. Control is accomplished through user budgets. For operational systems, computer requirements are validated through program-management procedures.

A significant amount of computer resources utilized in MSF is developed, operated, and maintained by contractor personnel. Procedures and management tools for monitoring contractor performance have been developed and are being applied.

The OMSF and its three Field Centers actively promote computer-resource sharing arrangements through the MSF Resources Sharing Panel and through written agreements with the General Services Administration (GSA). Computer programs and machine time worth $7,000,000 were shared in MSF during calendar year 1965. Resource sharing has been further encouraged in 1966 by management action, such as the establishment of programming standards, standard data formats, and a computer program library at MSC.

1.6 CONVERSION TO NEW GENERATION EQUIPMENT

During fiscal year (FY) 1967 and early 1968, the three MSF Centers will be engaged in making major equipment changes, primarily from second- to third-generation computers. At KSC, the GE 635 system installed in the CIF will be expanded to provide for simultaneous testing of multiple vehicles. The expansion will permit centralization of all computing that formerly required separate machines.

At MSFC in Huntsville and at Slidell, all of the existing general-purpose computers are being replaced by a central multiprogrammed-multiprocessor system at each location. Involved in the change are 39 computers that will be replaced by centrally located UNIVAC 1108 II computers being phased in by late 1968.

The third-generation general-purpose scientific and engineering computers at MSC will be installed in early 1967. The MCC is in the process of converting to IBM 360/75 computers, with the target for completion being early calendar year 1967.

1.7 COMPUTER COSTS

The total computer-equipment costs in MSF are illustrated in figure 1-2. Total equipment costs for FY 1967 are $7,800,000 less than those for FY 1966, and FY 1968 costs are $6,500,000 less than those for FY 1967. These reductions are a direct result of installing third-generation equipment, as well as of the centralization of computational capability wherever possible.

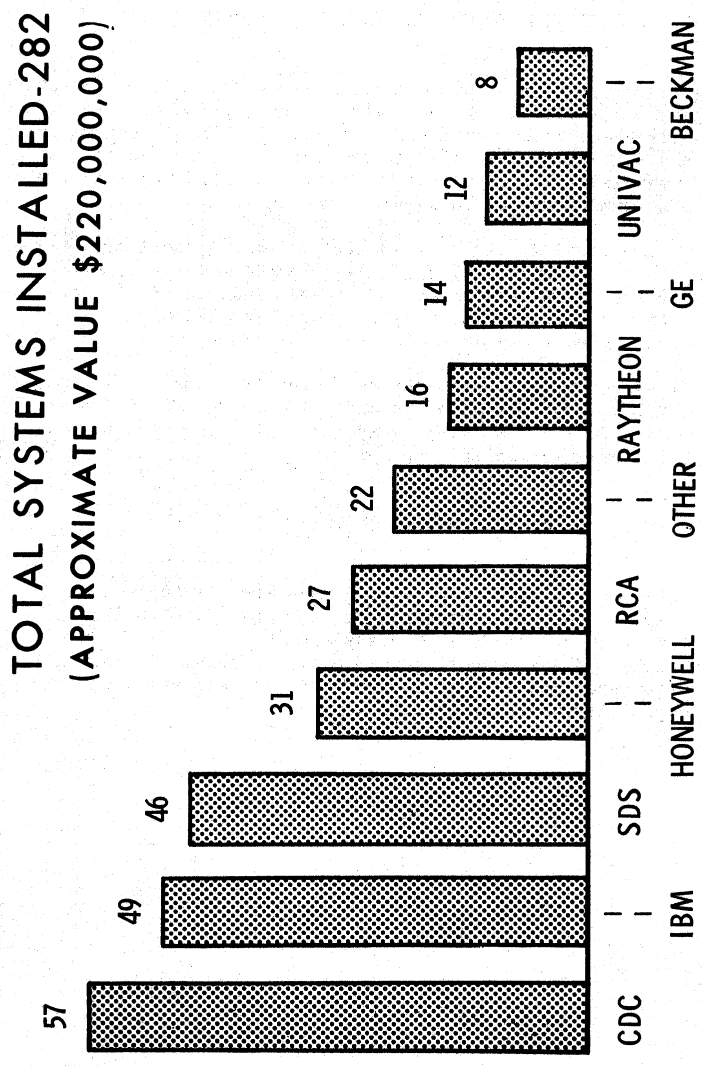

Figure 1-1.- Computers installed at Manned Space Flight Centers to October 1966.

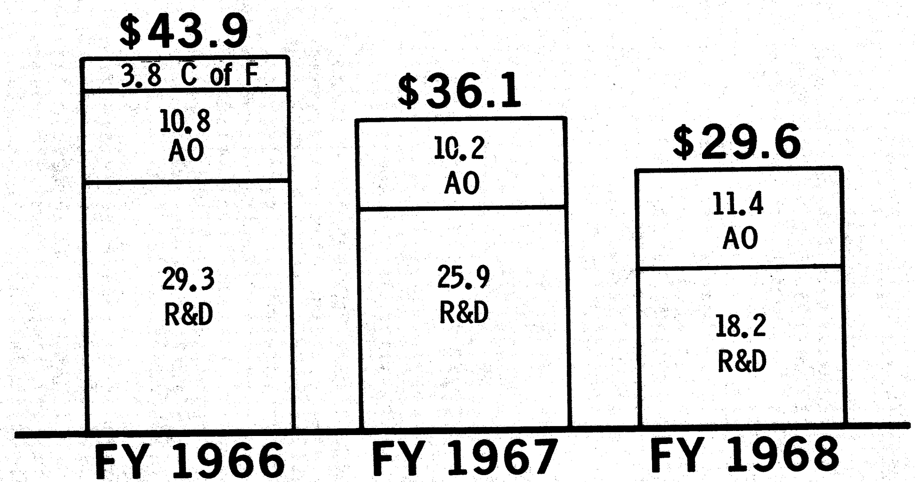

Figure 1-2.- Computer equipment costs at Manned Space Flight Centers by appropriations, in millions of dollars.

2.0 USE OF COMPUTERS

THE MANNED SPACE FLIGHT PROGRAM

The utilization of computers, both technical and administrative, extends into every phase of manned space flight operations. Computers are used to design, develop, test, and launch complex flight systems, and are, therefore, an integral part of manned projects. To meet the needs for computational capability, the MSF program has tended to use available commercial computer hardware wherever possible and to modify that hardware, as necessary, for special purposes. This has allowed MSF to remain abreast of the rapidly changing computer technology at a reasonable cost and to remain in a position to share hardware and software experience with many users. Further, the use of commercial systems has fostered multiprogram utilization, also with inherent advantages of flexibility and economy. In the following sections, the use of computers in the MSF program will be discussed on a center-by-center basis.

2.1 GEORGE C. MARSHALL SPACE FLIGHT CENTER

2.1.1 Huntsville, Alabama

The George C. Marshall Space Flight Center at Huntsville, Alabama, has a heavy computation need for data reduction and general scientific and administrative data processing. This need primarily stems from the computation required for research and development relating to launch vehicles and data processing necessary for the efficient administrative management of a large center. Facilities for simulation, while smaller in comparison to other computer functions at MSFC, play an important role in the development of vehicle simulation techniques required in the development of large launch vehicles.

In the data-reduction area, telemetry is received from static tests, launch vehicles, and satellites for preflight, real-time, and postflight analysis. A large amount of processing is required in decommutating data, and in calibrating, smoothing, and formatting measurements. For this purpose, an analog-to-digital converter system converts analog signals to sampled digital input form. A receiving and recording station receives and records telemetry and video signals via radio and microwave links from satellites, launch vehicles, and captive tests.

General scientific and engineering applications include problem studies such as aerodynamic analysis, flight mechanics, flight performance, vibration and acoustical studies, and general support of acceptance checkout. Typical administrative applications performed include an on-line inventory control system with an automated procurement cycle, and financial management applications, such as payroll, disbursements, and budgets. Personnel management applications include official file records, leave status, and transportation and travel.

Analog and hybrid computers are used to perform simulation studies in the areas of reusable boosters, engine start-up and cutoff, fuel flow, sloshing, heat transfer, flight simulation, lunar traverses, and other computations using physical and mathematical models.

In addition to computation work carried on in-house, contractual backup support with computation resources is exchanged, as needed, with two industrial firms in the Huntsville area, Northrop Corporation and Brown Engineering Company, Inc., and with the Army Missile Command located at Redstone Arsenal. Backup support to MSFC is also provided by the University of Alabama in Huntsville.

2.1.2 Slidell, Louisiana

The mission of the computation center at Slidell, Louisiana, is to provide centralized computation support to stage contractors at the MAF and MTF. Slidell also furnishes backup support in the administrative and scientific area for MSFC, Huntsville, and MSC, Houston, during overload conditions at those facilities.

Scientific computation at Slidell primarily supports structural design and evaluation and checkout of the various Saturn vehicle components during the manufacturing cycle at MAF. This computer equipment is operated on a three-shift, 6-day week basis. Computer equipment at Slidell also supports administrative functions of the contractors' operations and includes applications such as financial accounting, Program Evaluation and Review Technique (PERT), work-order control, configuration control, reliability, personnel, and procurement.

In late 1967, Chrysler will begin data reduction at Slidell of launches at Cape Kennedy. Simultaneously, Boeing and North American Aviation, Inc., will also commence data reduction at Slidell of test firings at MTF.

2.1.3 Launch Information Exchange Facility, Huntsville Operations Support Center

The Launch Information Exchange Facility (LIEF), HOSC, is a multipurpose data display, monitoring, and control facility that links KSC and MSFC and is operated during prelaunch operations, launch, and postlaunch evaluation to assist MSFC in providing technical support to KSC. The system was designed with visual output devices in place of conventional printer output.

2.2 MANNED SPACECRAFT CENTER

2.2.1 Manned Spacecraft Center, Houston, Texas

A significant number of computers are required to support the MSC activity with general scientific computing capability. Scientific and engineering needs are based upon requirements to develop models, evaluate engineering design, plan missions, predict failures, and so forth. The specific computing equipment used to support these applications is discussed in a later section. In the administrative and management area, there is a class of computers capable of processing and retrieving volumes of data in support of MSC administration, finance, logistics, and procurement activities.

2.2.2 Mission Control Center/Real-Time Computer Complex, Houston, Texas

The computer complex supporting the MCC is identified as the RTCC. Operational mission support required that the computing system automatically accept input data from ground-based tracking stations and from spacecraft and launch-vehicle TM systems. In addition, the system must accept display requests from flight controllers and manual input data from computer controllers. The RTCC processes the input data to provide support displays for flight dynamics and vehicle systems analysis; it also performs network support and vehicle command functions. The RTCC also has the capability to evaluate the mission flight plan in real time and to redesign the mission profile, as necessary, during the mission.

For Apollo missions, the RTCC will be the prime source of navigational data during the translunar phase of flight. The RTCC has provided backup guidance information to the spacecraft, including updates of targeting parameters in the spacecraft computer and backup computations for both nominal and abort maneuvers. The RTCC computers also support the flight-crew activities and experiments conducted during manned missions, and provide network support, such as command generation, data flow checkout, TM summary-message broadcasts, and acquisition-data transmissions to tracking stations. For flight controller and astronaut training in simulated missions, the RTCC duplicates the operational computing support, previously discussed, using simulated input data. In addition, the RTCC performs flight dynamics and vehicle systems analysis.

2.2.3 White Sands Test Facility, New Mexico

The Data Reduction Facility (DRF) at the White Sands Test Facility (WSTF) provides quick-look data processing and management logistics support for the White Sands Apollo Propulsion System Development Facilities (PSDF). The computer at this facility is compatible with the DRC equipment at MSC and also provides the exchange of utility and applications programs and backup capability in the event of computer breakdown at MSC. The DRF fulfills requirements for data reduction services to Grumman Aircraft Engineering Corp., the ZIA Co., North American Aviation, Inc., and The NASA Propulsion Engineering Office. The facility at White Sands is used to support the Apollo spacecraft and Lunar Module (LM) propulsion system testing and evaluation. The MSC Computation and Analysis Division (CAAD) has technical responsibility for the computer at WSTF.

2.3 JOHN F. KENNEDY SPACE CENTER, CAPE KENNEDY, FLORIDA

The KSC has a heavy and varied computation workload in the areas of general engineering and scientific, operational, administrative, and checkout data processing. The computer resources of KSC are not only used in support of the manned space programs, but also support NASA unmanned space projects, such as Project Centaur. Except for the normal administrative and general scientific computing workload at KSC, the total computing requirement is a function of the number of launch vehicles and spacecraft under test in the systems checkout areas, the number of space vehicles under test at the Launch Complex (LC) areas, and the number and duration of space vehicles actually launched. Since the early days of the space effort, computing capabilities at KSC have had to expand to accommodate the increasing number and complexity of space launches from MILA and ETR. Table 2-I provides a summary of estimated tests for FY 1967 for which computer support will be required.

TABLE 2-I.- SUMMARY OF TESTS AT KENNEDY SPACE CENTER DURING FY 1967[a]

Program	Launches	Simulated tests	Lab tests	Total
Gemini	3	4	8	15
Centaur	6	18	36	60
Saturn/Apollo (unmanned)	4	16	3	23
Saturn/Apollo (manned)	2	2	70	74
Lunar Orbiter	3	9	--	12
Atlas Agena	3	4	--	7
Totals	21	53	117	191

[a]Estimated.

Administrative and management data processing constitutes a portion of the total KSC computer workload. The major portion of this data processing is being done on an IBM 7010 and an IBM 7010/1440 system located in the CIF. This is the normal data processing load for the management of a large NASA Center, as well as support provided to contractors and to other NASA Centers for project-related activity.

The scientific application of computers at KSC provides capability for prelaunch testing and launch support of NASA space vehicles. The prelaunch requirements include computation of acquisition angles for tracking systems, safety curves, coordinate transformation, doppler frequencies, wind shear, and acoustical levels. Real-time computing capability is provided at KSC to support launch simulations and actual launches. Real-time requirements include the processing of meteorological, impact prediction, vehicle TM, guidance, communications, and display data. A quick-look data-reduction capability is maintained to allow immediate evaluation of launch data. The need for this capability becomes most important when malfunctions occur during the launch phase.

Special-purpose computer resources are utilized to perform systems test and checkout functions on spacecraft and launch vehicles from the time of arrival at KSC until actual launch. These special-purpose computers are part of an integrated checkout and display system. The primary mission of the checkout computers is to control, record, and process checkout data in a real-time test environment.

3.0 COMPUTER CAPABILITY

The computer sciences are newly emerging, and consequently, the terms, symbols, measures, and power ratings are either tentative or nonexistent. To compensate for this handicap, the questionnaire used during the collection phase of the computer-systems survey was designed to accumulate a great deal of descriptive information for each computer system and is compiled in a catalog of computer capability (MSF Computer Systems Study, Volumes II to IV). A narrative description of the contents of the catalog is presented in this section. An inventory of MSF computers is included in the appendix.

The large number of computers installed and the wide variety of their use in the MSF program have led to a classification of computer hardware that recognizes modality. Today, the large proportion of MSF computers operates in a single mode; however, recent advances in computer technology make possible multi-modal operations at sizeable savings in cost and manpower. The description of computer capability is arranged in consonance with the modes of computer operation.

3.1 MISSION CONTROL

The scope of activity and the role of computers in the launch and mission phases of manned flight are illustrated in figure 3-1. The function of mission control and of the computers that support the missions is included in this broad outline.

Computers installed in the RTCC of the MCC at Houston are integrated into a larger overall system which is not basically computational in nature. The RTCC consists of a variety of electronic data processing equipment, some of which is general-purpose equipment by nature of its manufacture, while other equipment has been manufactured for and is used for this special purpose, such as the System Selector Unit, Plotting Display Control Unit, Systems Status Display, Time Standard Unity, Computer Monitor and Control Console, Control Area Junction Unit, Standby Digital Driver Unit, and Computer Controller Multiplexor Unit. All of the equipment, both general purpose and special purpose, is integrated into the Ground Operations Support System (GOSS). The function is to acquire data from the spacecraft, transmit the data to a central control point, and convert the data to engineering units which can be displayed for flight controller use in making decisions concerning Gemini and Apollo mission control. The RTCC does not perform an independent data processing function.

An equipment phaseover schedule depicts the installation and removal schedule for all general purpose computers through early FY 1970 (fig. 3-2). The installation and removal dates are based on capabilities required to support the Gemini and Apollo Spacecraft Program flight schedules as they are presently known. The phaseover schedule is subject to change, based on the extent of the required changes. Every effort is made to have the RTCC hardware directly complement the required needs, and the configuration index portion of the supporting contract is structured to motivate the contractor to eliminate hardware whenever possible if the removals do not jeopardize mission objectives.

3.2 TEST AND CHECKOUT

The role of the test and checkout computers is to insure that the integrated space vehicle and its subsystems meet the standards required for conducting a space mission. The test and checkout functions are performed at manufacturers' installations, special facilities such as MAF or MTF, and at each of the MSF Centers. The major checkout functions are outlined in the following sections. In the case of the launch vehicle, the major checkout functions are broken down by vehicle stage due to the number and types of stages. A summary of test and checkout information is shown in table 3-I.

3.2.1 Marshall Space Flight Center

The major checkout systems at MSFC are used for test and checkout of the S-IB and S-IC stages, and the Instrument Unit. MSFC also utilizes facilities at MAF, MTF, and Douglas Aircraft Company, Inc., Sacramento, California, to test the S-II and S-IVB stages.

Saturn IB stage.- An RCA 110 computer is used at the MSFC static-test stand for S-IB checkout. The equipment translates computer commands into signals that monitor and check vehicle systems during static-test firing. The computer also acquires data during the tests, processes the data, and uses it as inputs to Cathode Ray Tube (CRT) monitor displays for evaluation by test personnel.

A system performing similar functions, but utilizing a Packard-Bell (now Raytheon) PB 250 computer, is used by Chrysler at MAF to test the S-IB during fabrication. A DEE 3 (SDS 910) is used with the PB 250 computer. The DEE 3 scans the discrete event lines to detect and record any status change for later evaluation by test personnel.

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Saturn IC stage.- The Mississippi Test Facility and MSFC each have an RCA 110A and DEE 6 (SDS 930) system for static firing of the S-IC. Similar systems for manufacturing checkout are located at MAF and the Quality Laboratory at MSFC. MSFC also uses a DEE 3 system for engine checkout at MSFC.

In these systems, the RCA 110A is used to control and monitor test and checkout procedures. During the tests, the computer compiles and records an events trail composed of command times and system responses for later evaluation. These data are displayed by computer driven CRT displays or recorded in a printed record.

Saturn II and IVB stages.- The S-IVB and the S-II stages use the CDC 924A computer as the controlling element during static tests. The DEE function is performed by a CDC 8090 computer. These computers perform functions similar to those performed by the S-IB and S-IC checkout computers. Computer systems for the S-IVB stage are located at the Douglas Huntington Beach facility for manufacturing checkout, at Sacramento for static testing, and at a separate facility at Sacramento for post-static-firing tests.

The S-II checkout uses the systems located at Seal Beach (North American Aviation) for manufacturing tests, and at MTF for static firing.

Instrument Unit.- The Instrument Unit (IU) contains the guidance, navigation, and control equipment used during flight by the launch and injection stages. It also contains the TM and communications equipment used to gather and transmit data and to receive information during flight. The complexity of the IU stage checkout task requires two breadboard facilities in addition to an International Business Machines (IBM) facility at Huntsville. The IBM facility contains two RCA 110A computers (one for the S-IB vehicle and one for the S-V vehicle) and two DEE 3 systems. In addition, a DDP 224 computer is used to drive a Sanders Display System associated with the RCA 110A computers. Additional off-line support in the form of a GE 235 computer supplies input data tapes containing parameters needed by the onboard Launch Vehicle Digital Computer (LVDC) and Launch Vehicle Digital Adapter (LVDA). The RCA 110A computer generates test sequences that activate the Electronic Support Equipment (ESE) that interfaces with and supplies test stimuli to the stage subsystems under test. The response of the tested system is then received, processed, and displayed for test personnel.

Instrument Unit, Saturn IB breadboard.- The breadboard facilities provide a simulation of a complete multi-stage vehicle. This simulation is used to debug the launch-vehicle checkout facilities. There is one breadboard for the S-IB vehicle and one for the S-V vehicle.

The S-IB breadboard contains two RCA 110A computers, one used to generate test sequences and control the ESE, the other to receive and process the telemetry. Also included is an RCA 110 used to generate inputs that simulate the functions of the spacecraft Acceptance Checkout Equipment (ACE) computer interface as it exists at KSC. There is also a DEE 6 computer as part of the system. To facilitate software checkout of the system, there are two additional RCA 110A computers used off-line to assemble and to debug programs.

Instrument Unit, Saturn V breadboard.- The S-V IU breadboard facility consists of two RCA 110A, two DEE 6, and two DDP 224 computers. The system functions in the same manner as the S-IB IU breadboard described above.

3.2.2 Manned Spacecraft Center

At MSC, the principal checkout functions are concerned with the verification and development of the spacecraft and its subsystems. These functions utilize three ACE stations. The first of these is an experimental ACE station. It is used in systems design of future checkout techniques and in the certification and checking out of current computer programs. It is similar to the ACE stations at KSC, but does not have the full range of electronic support equipment and only has a partial control room. The other two ACE stations are used for environmental chamber checkout of the Command and Service Module (CSM) and for the LM. The spacecraft is placed in the chamber and subjected to conditions as found in space. Various tests such as leak tests, pressure tests, equipment checks, and so forth, are conducted using the computers in the same manner as KSC.

3.2.3 Kennedy Space Center

Computers are used at KSC to control checkout of the functional systems associated with the launch vehicles and their associated spacecraft prior to mission launch. At the Saturn Launch Complexes (Pads 34, 37, and 39), MSFC designed systems containing two linked RCA 110A computers perform the real-time analysis of test parameters from the vehicle stages. The results are used as inputs to a display driven by a DDP 224 computer (located at the S-V complex) or to memory tube displays (located at S-IB complexes) for evaluation by the test engineers in the blockhouse. These computers permit test personnel to monitor stage systems and to control automatic checkout from vehicle erection through prelaunch activities and countdown to time of launch. In addition to these computers, a DEE 3 (SDS 910 computer) monitors the vehicle discretes during checkout. This information is displayed to test personnel in the Launch Computer Complex (LCC).

The ACE-Spacecraft was developed by MSC to permit efficient checkout of complex spacecraft subsystems. There are two separate ACE stations at KSC, one for CSM checkout, the other for LM checkout. Each system contains two CDC 160G computers, one used for command generation and the other used for processing the resulting telemetry. The Command System consists of test consoles, the command computer, and transmitting equipment. Using this system, test personnel manually initiate a wide variety of tests from controls on their consoles. The test commands are interpreted by the computer which sends the appropriate instructions to activate the equipment, as required, to perform the indicated tests.

3.3 TRAINING

3.3.1 Simulator Training Systems

All simulator computing is an integral part of a simulator and training system. The trainers are used for training flight crews and ground operations personnel in support of the Gemini and Apollo missions (fig. 3-3). The computer system equipment, DDP 024 and DDP 224, is used to provide a real-time solution for all mathematical and logic equations needed to realistically simulate vehicle dynamics and spacecraft-system performance. The computer system is interfaced with the trainer in such a way as to accept inputs from the simulated command module, instructor operator station console, and other simulated subsystems, and outputs in real-time all data required for actuation of the SCM and IOS displays, instruments, and visual drives. There are two Gemini mission simulators, one located at MSC and one at KSC, and there are two Apollo mission simulators at the same locations. When the Apollo trainers are modified to an Apollo Block II configuration, it is planned to add one DDP 224 to each trainer computer system. There are two LM Mission Simulators, one will be located at MSC and one at KSC. Another DDP 224 will be added to the present ones when these trainers are modified to the LM Block II configuration.

3.3.2 Simulation Checkout and Training System

The Simulation Checkout and Training System (SCATS) is used for the training of flight controllers in preparation for Gemini missions and the checkout of data systems at MCC, Houston.

3.3.3 Breadboard Terminal Landing System

The Breadboard Terminal Landing System (BTLS) uses an SDS 920 computer. The computer is installed in a mobile van and is part of the system being developed for experimentation and for development of techniques for the safe landing of spacecraft after reentry from orbit.

3.4 REAL-TIME DATA PROCESSING

3.4.1 Central Instrumentation Facility

In the Central Instrumentation Facility at KSC, the GE 635 computer system interfaces with the telemetry ground station (Data Core) and the CIF display system as is illustrated in figure 3-4. The real-time functions consist of data inputs, storage, computation, retrieval, and output. The system accepts data from the ground station at a transfer rate of 432,000 bits per second and is capable of servicing 12 simultaneous display requests within a period of 1 second. This computer, a multiprocessor multi-programmed system, performs general-purpose scientific computing and data reduction concurrent with its real-time data reduction and display functions.

3.4.2 Launch Information Exchange Facility

The LIEF/HOSC is a multipurpose data display, monitoring, and control facility which links MSFC with KSC. The system was built by overlaying a programmable control system on an existing integrated data reduction system and providing the data reduction system with visual output devices in place of conventional output devices. The visual output devices are mounted in or terminate in modular display consoles and a variety of television monitors. The consoles are equipped with discrete lights, meters, stripcharts, television monitors and a teletype input/output (I/O) connected to the Collector Distributor. Located at Huntsville, the system has full access to the KSC data system and can address any 400 10-bit words from the KSC Data Core at will.

The system currently handles prelaunch activities, flight operations support, and postflight data analysis. System coordination is accomplished through a very flexible telephone/intercommunications system. The LIEF/HOSC is operated during launch and postflight evaluation. Much of the equipment is used between flights to facilitate routine data handling and experimental systems development. The supporting data communications are extensively used between firings for computer sharing and exchange.

3.5 SERVICE CENTER DATA PROCESSING

At Slidell, Louisiana, MSFC has established a centralized computer facility to meet the needs of the MSFC contractors at MAF and the MTF (fig. 3-5). The computer center has resident NASA management and is operated by a computer specialist contractor. Programming is a user responsibility and programming languages are standardized.

Six Honeywell computers are available for business-type applications. Scientific applications use the IBM 7094 II or IBM 7040/7094 computers and their peripherals. A GE 205 computer is used for weather forecasting and sound propagation prediction in conjunction with stage testing.

The special purpose computers perform two functions: the digitizing of Saturn TM data (pulse amplitude modulation, pulse code modulation, and frequency modulation) and computational support involving the use of hybrid systems. The former application uses an SDS 930 and the latter a Raytheon 520 computer. The Raytheon 520 is combined with several EAI 231R analog computers to provide a capability for loading structural and control problems encountered during a mission.

3.6 GENERAL-PURPOSE DATA PROCESSING

3.6.1 Centralized Data Processing Equipment

The centralized data processing equipment installed in the Computation Laboratory at MSFC is used in the following areas: data reduction, scientific and engineering data processing, and business-type applications.

Data reduction activities.- The computers used in data reduction usually work in conjunction with analog-to-digital (A/D) equipment, either controlling equipment (Raytheon 440, Raytheon 520, SDS 92) or monitoring (SDS 92, DDP 116). They cover applications in lunar orbit simulation and modeling or may be used in hybrid (analog and digital) simulations. Their principal use, however, is in that of conversion and processing of TM data, reformatting of data, and engineering unit conversion. The data sources are wind tunnels, flights, or test stands.

Scientific application equipment.- Presently, most of the applications in the Computation Laboratory in this area are processed on two IBM 7094 II computers. These are supported by six IBM 1401 C3 peripheral computers used for printing, utility assembly, card handling, and tape preparation. The applications themselves are perhaps the most varied at MSFC, covering language study and research for trajectory, orbit and automatic checkout use, thermodynamic and engine performance studies, flight experiment sequencing, vehicle stage modeling and simulation, orbit and trajectory calculations, and mission simulation.

The projected increased workload and need for additional computational capacity will be provided by the recently completed procurement for five UNIVAC machines (three at MSFC, two at Slidell). These machines, through the use of remote terminals and time sharing, will optimize the utilization of Computation Laboratory capabilities and experience.

Business-type applications.- Three machines currently are used for these applications: an IBM 7740 and two IBM 7010 machines. One IBM 7010 and the IBM 7740 utilize 31 remote input terminals to support the on-line inventory system to provide complete electronic processing of all supply transactions from receipt of request to shipment of material. The other 7010 performs processing needed for PERT, charting the POP, contracts and change order, and control and engineering support applications. Business applications consist of payroll, labor distribution and costing, personnel records, and data management.

3.6.2 Computers in the Aero-Astrodynamics Laboratory

Computers are installed in the Aero-Astrodynamics Laboratory for data reduction and engineering and scientific calculations. They consist of the following machines:

CDC 3200.- This equipment supports aeroballistics research, lunar landing research, planetary orbit calculations, and heat studies.

GE 205.- This equipment supports a requirement for reduction of wind-tunnel data and general engineering calculations associated with wind-tunnel use.

GE 205.- This computer performs meteorology computations in support of the weather station by calculating atmosphere profiles and reducing weather data.

SDS 930.- These machines support light dynamic, thermodynamic, and aeroballistic studies.

3.6.3 Computers in the Astrionics Laboratory

Computers are installed in the Astrionics Laboratory to support requirements that exist in launch activity and checkout research and advanced studies in guidance and vehicle performance. The data processing is at an extremely high technical level. These requirements are met by a GE 235 and an IBM 1130.

3.6.4 Computers in the Propulsion and Vehicle Engineering Laboratory

The data processing equipment installed in the Propulsion and Vehicle Engineering Laboratory is used for calculations involving weight control and general-purpose scientific calculations.

IBM 1620.- The IBM 1620 computers are used by S-IB and S-V weight-control studies and structural analysis.

SDS 930.- The SDS 930 computers support S-I and S-V advanced vehicle programs.

3.6.5 Computers in the Quality and Reliability Assurance Laboratory

Computers are installed in the Quality and Reliability Assurance Laboratory for two functions: a study of checkout procedures for vehicles and training of personnel in checkout of computer systems. There are two computers currently being used, a GE 235 which will be expanded to a real-time system by interfacing with other computers and an RCA 110 which is being used by NASA and contractor personnel. Both computers are used in developing checkout programs needed for various components of the S-IC stage.

3.6.6 Centralized Data Processing Equipment at the Manned Spacecraft Center

The centralized data processing equipment installed at MSC is used in three areas: scientific application, TM data processing, and business application. All of the equipment is general purpose.

Scientific and engineering applications.- Scientific and engineering needs are based upon requirements to develop mathematical models, evaluate engineering designs, plan missions, and predict failure times. The computing equipment used to support these applications includes two IBM 7094 computers, a direct coupled system IBM 7044/7094, a UNIVAC 1108, and a CDC 3600.

Equipment supporting data reduction applications.- This category of applications involves a combination of both scientific/engineering and information retrieval/management techniques. The computers currently used to support this area include:

CDC 3600/3800: This computer is used to reduce decommutated TM data from the CDC 3200. The 3800 is an upgraded 3600.

CDC 3200 telemetry processor: One CDC 3200 computer is used to perform the decommutation of TM data after the hardware has performed the necessary signal conditioning and synchronization of data. This provides more flexibility at a lower cost than the previous technique of using programmable decommutation equipment.

CDC 3200 input/output computer: This computer is used for peripheral support to the 3600. It shares the tapes and input-output equipment attached to the CDC 3600, thus eliminating the manual handling of magnetic tapes.

Business applications.- This category deals primarily with computation involving data storage, retrieval, and report generation. Increasing emphasis is being placed on computers to store large quantities of information and to retrieve specific elements of data rapidly in a form that will permit effective management analysis. The element of information retrieval combined with the use of the computer for finances, logistics, and procurement has resulted in a significant increase in the MSC computing workload. The computers are: IBM 7010, management applications; IBM 7040, used for Apollo configuration, accounting, preferred parts listings, cost models, and so forth. For management applications, a UNIVAC 1106 currently being brought on-line is scheduled to replace the IBM 7010 in November 1966.

3.6.7 Computers in the White Sands Test Facility

The WSTF computer equipment (CDC 3200) performs digital computation and quick-look data reduction. The secondary function of this equipment is to perform high-volume logistics support data processing for test plan preparation and failure analysis. The total workload imposed upon the DRF system is composed of several unique combinations of equipment and software for the processing of pulse-code-modulation data. The general-purpose CDC 3200 computer performs the functions of formatting and process control. The same computer is used for data processing and, with additional storage capability, is capable of performing data processing concurrent with data conversion.

3.6.8 Computers at Kennedy Space Center

The KSC administrative and management computer resources consist of an IBM 7010/1440, an IBM 7010, and a GE 415. In addition to these systems, limited quantities of business-type work are processed on the GE 635 computer. This equipment is all centrally located in the CIF. The GE 635 system is being expanded to accommodate the real-time operational requirements. In doing so, computer capability will be available to absorb the administrative and management workload on the expanded system. As programs are converted to the GE 635 and full computer capability is realized, older equipment will be released.

3.7 SPECIAL-PURPOSE DATA PROCESSING

3.7.1 RETRIEVER Data Acquisition System

The system, a DMI 620, is used on the recovery vessel, RETRIEVER, for spacecraft flotation tests in the Gulf of Mexico.

3.7.2 Automatic Testing Laboratory Acquisition System

This system, with a DMI 620 computer, supports spacecraft qualification testing. The system can accommodate eight stations which are performing different tests simultaneously, and each test engineer can input 25 channels of information.

3.7.3 Slow Speed Acquisition System

The system, with a PDS 1020 computer, is used for environmental simulation testing of spacecraft materials.

3.7.4 Special Information Processing Techniques

This system was developed for producing automatic on-line display format generation. This system, with a PDP 5 computer, is used by flight operations personnel to prepare static background information which will be used in real time for mission support in the MCC.

3.7.5 Electronic Systems Compatibility Facility

The Electronic Systems Compatibility Facility (ESCF) is equipped with a UNIVAC 642B/1004/1218 to provide compatibility verification of certain critical electronic systems which are required for the Apollo flights.

3.7.6 Manned Spacecraft Center Centrifuge Facility

In support of the MSC Centrifuge Facility, the Crew Systems Division operates a computer complex adjacent to the centrifuge. The control computer operates the facility and acquires data in real time. Each system of the centrifuge, such as arm velocity, gimbal and gondola position, temperature, and vacuum pressure, is controlled by the computer.

3.7.7 Manned Spacecraft Center Technical Services Division

The Technical Services Division at MSC utilizes a Honeywell 610 as a category B computer. This computer is used to control and monitor the central heating and air-conditioning plant located at MSC. Presently, this system controls the air flow into 19 buildings at MSC. An expansion will be necessary for control of air flow when additional buildings are constructed.

3.7.8 Kennedy Space Center Information Systems Directorate

At KSC, category B ADP equipment within the Information Systems Directorate (INS) is used by the Telemetry Branch. Two SDS 930 computer systems, that are an integral part of the ALDS TM subsystem, perform the function of selecting, buffering, and formatting real-time TM data for subsequent transmission to the MCC in Houston for flight control display purposes.

TABLE 3-I.- COMPUTERS USED IN CHECKOUT PRIOR TO ON-PAD PRELAUNCH ACTIVITIES

Space flight unit	Contractor	Computers		
		Factory checkout (a)	Static firing	KSC
CSM	North American Aviation, Inc.	[b]CDC 160G	(c)	[b]CDC 160G
LM	Grumman Aircraft Engineering Corp.	[b]CDC 160G		
IU	International Business Machines Corp.	[d]RCA 110A	(e)	[d]RCA 110A
S-IVB	Douglas Aircraft Corp.	[b]CDC 924A [b]CDC 8090	[b]CDC 924A [b]CDC 8090	[d]RCA 110A [f]SDS 930 [g]DDP 224 [f]SDS 920
S-II	North American Aviation, Inc.	[b]CDC 924A [b]CDC 8090	[b]CDC 924A [b]CDC 8090	
S-IC	Boeing Corp.	[d]RCA 110A [f]SDS 930	[d]RCA 110A	

[a]After static firing (or equivalent tests), a post-factory checkout takes place. This involves the same computers and computer programs (with possible minor modifications as a result of static firing tests).

[b]CDC, Control Data Corp.

[c]The last routinely scheduled rocket motor firing test takes place at factory checkout.

[d]RCA, Radio Corp. of America.

[e]Does not contain rocket motors; static firing tests are not applicable.

[f]SDS, Scientific Data Systems.

[g]DDP, Computer Control Corp.

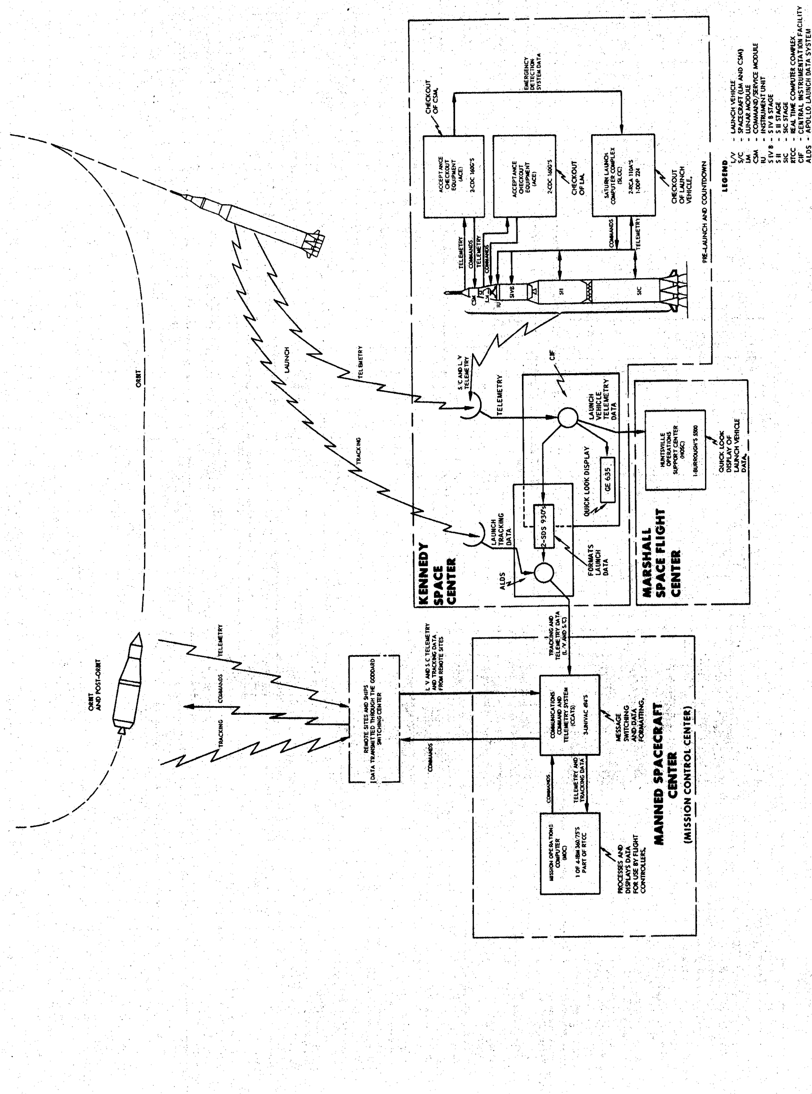


Figure 3-1.- Principal Manned Space Flight computers used in launch and mission operations.

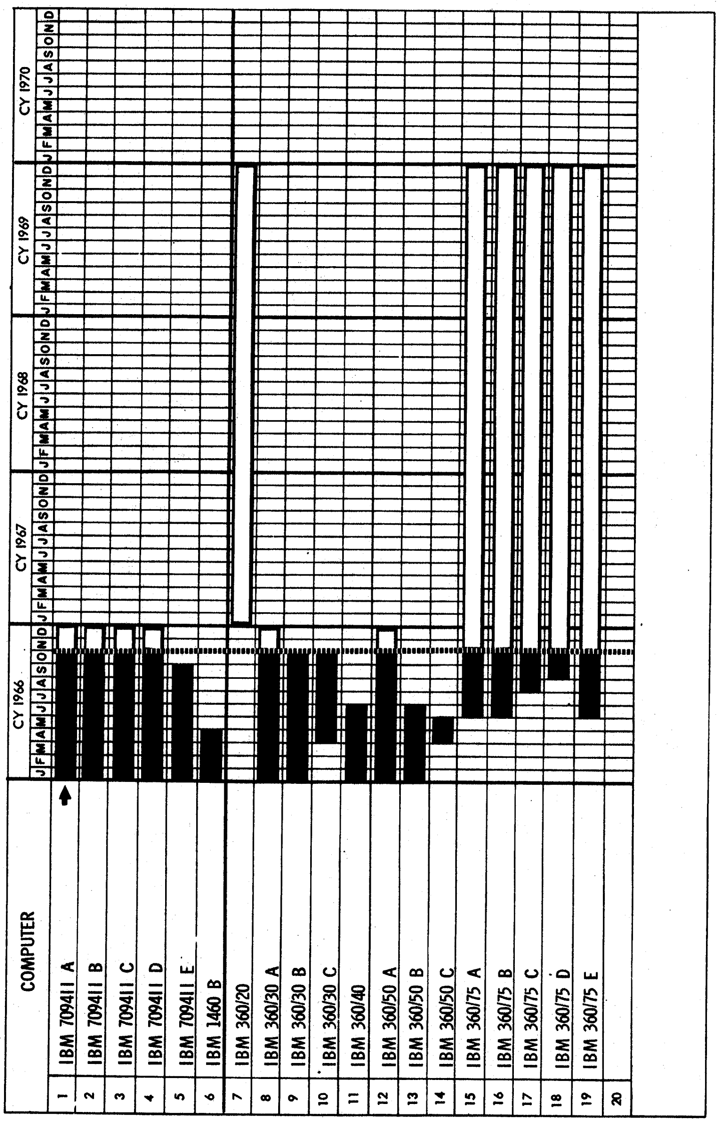
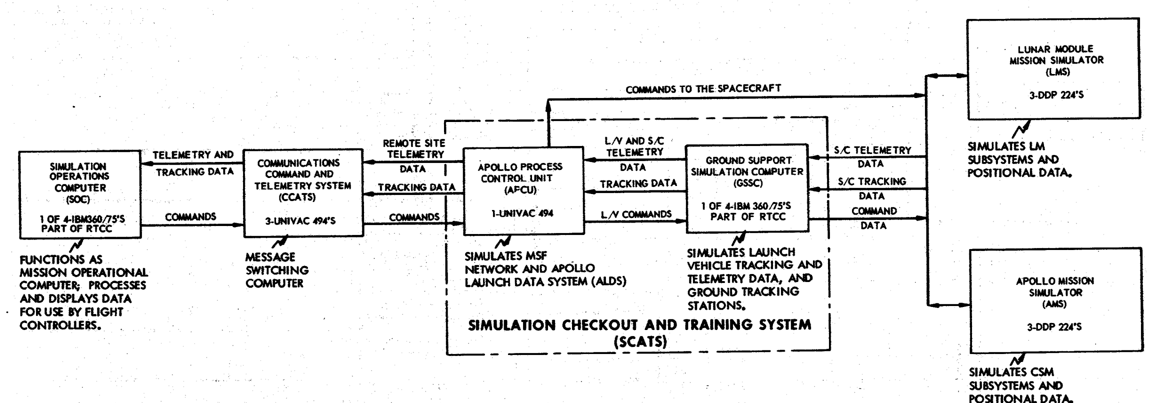


Figure 3-2.- Mission Control Center/Real-Time Computer Complex phaseover schedule.



NOTE:

THIS DIAGRAM SHOWS THE TRAINING MODE IN WHICH THE LM SIMULATOR AND THE CSM SIMULATOR ARE LOCATED AT MSC; THERE IS ANOTHER MODE IN WHICH THE SIMULATORS LOCATED AT KSC ARE USED. IN THE LATTER MODE, DATA ARE TRANSMITTED TO MSC VIA THE APOLLO LAUNCH DATA SYSTEM.

LEGEND

L/V - LAUNCH VEHICLE
S/C - SPACECRAFT (LM AND CSM)
LM - LUNAR MODULE
CSM - COMMAND/SERVICE MODULE
KSC - KENNEDY SPACE CENTER
MSC - MANNED SPACECRAFT CENTER
RTCC - REAL TIME COMPUTER COMPLEX

Figure 3-3.- Principal Manned Space Flight computer systems used in training.

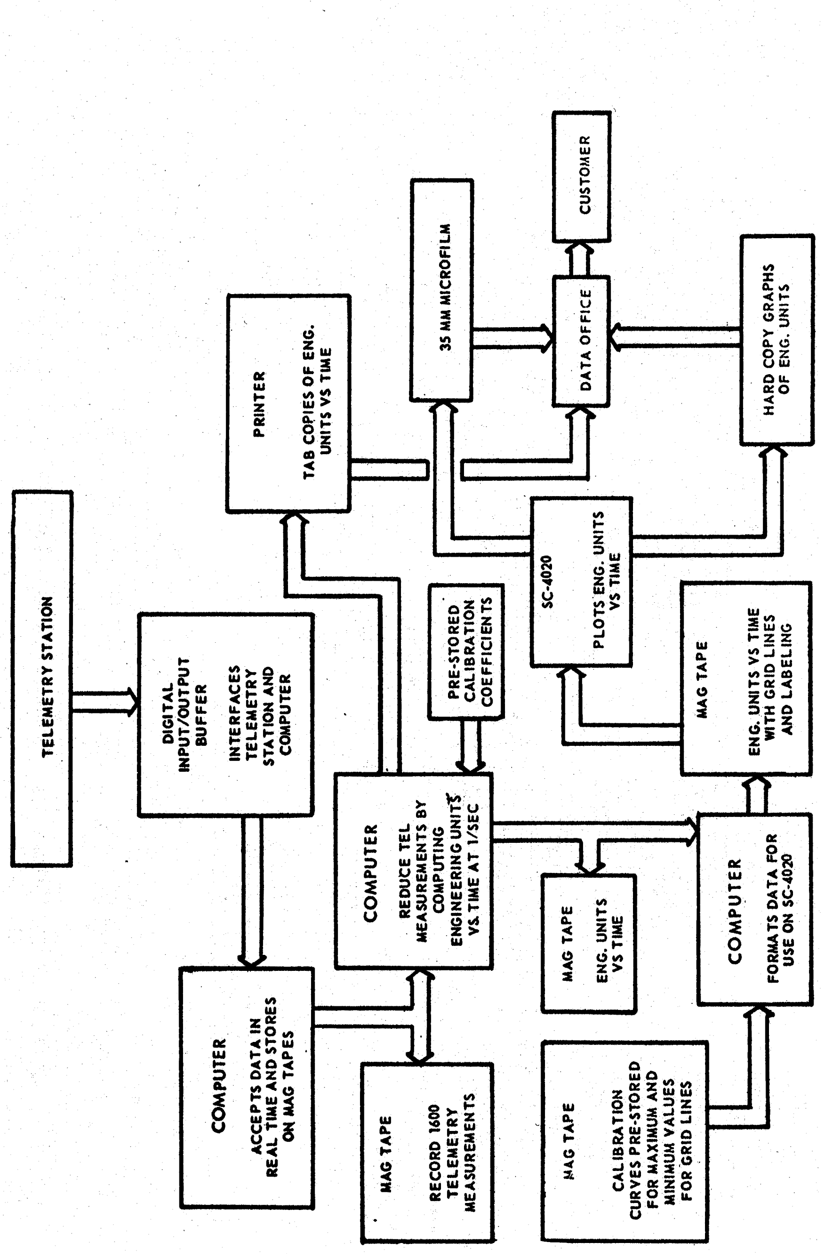


Figure 3-4.- Quick-look reduction data to engineering units.

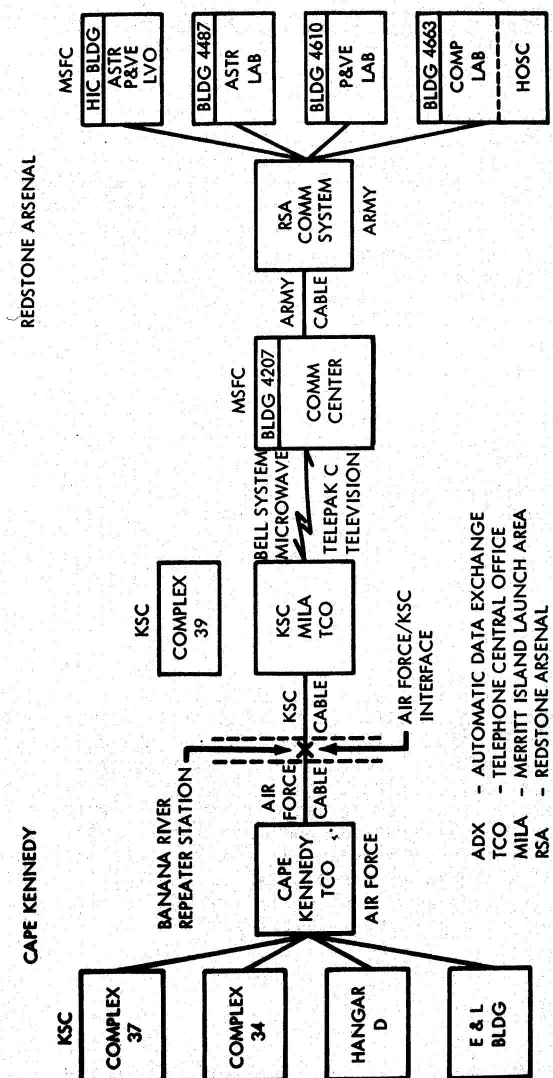


Figure 3-5.- Kennedy Space Center/Marshall Space Flight Center Launch Operations Support Center communications link.

4.0 RESPONSIBILITIES, ORGANIZATION, AND STAFFING

Just as it has been necessary to assign different portions of the total space effort to specific Centers for accomplishment, it has also been necessary to assign different computational responsibilities to elements within the Centers to insure the highest efficiency of both the space mission and the support functions performed by the computers. Standardization has been realized in many facets of computational support, and the Centers are working toward more standardization where and when practical. There are still, and probably always will be, unique requirements and non-standard operations that can and must be accomplished uniquely. Although the Centers tend toward standardization in organization and operations, standardization has not become a goal. Rather, mission efficiency has been adopted as a goal, with effective computer support at the least practical cost.

Because of differences in missions, then, differences also exist in computer organizations, in operations among Centers, and sometimes even within a Center. The remainder of this section will describe, step-by-step, the organizations that have been developed, the staffing for the computer elements, and the responsibilities that have been assigned to assure goal accomplishment.

4.1 ORGANIZATION

Within NASA policy, the OMSF has assigned operational control of computer resources to the lowest possible organizational level which is required to meet program objectives and to be consistent with economic utilization. Since MSF has practically no computational requirements at NASA Headquarters, the direct control of MSF computer resources rests with the three MSF Center Directors. Figures 4-1 to 4-4 provide an indication of the organizations utilizing and controlling computer resources at each Center and up through the NASA chain of command. Although not indicated on the attachments, obviously every element and individual in NASA is, in essence, an ultimate user of computer resources. The degree of utilization varies from the receipt of an automated payroll check through computer control over manned orbital flights.

4.1.1 George C. Marshall Space Flight Center

At MSFC, all general-purpose computers and a portion of the special-purpose equipment are located in the Computation Laboratory under the direction of Dr. Helmut Hoelzer. In addition to the equipment located in the Computation Laboratory, special-purpose equipment is located in the various Research and Development Laboratories, where it is utilized in mission-oriented applications. In these instances, Dr. Hoelzer maintains computer-oriented responsibility, while the various user laboratories maintain mission-oriented responsibility.

At the Slidell Computation Center, general-purpose and special-purpose equipment is under the direction of Mr. Robert Reeves. Organizationally, the Slidell Computation Center reports to MAF. The purpose of Slidell is to provide centralized computation support to the MSFC prime contractors at MAF and MTF on a time-sharing basis and to MSFC and MSC in scientific areas during peak workload periods at those Centers. The contractors also use this equipment for administrative/management applications. As in the Research and Development Laboratories, Dr. Hoelzer maintains computer-oriented responsibility for the Slidell Center. This is accomplished both through the activities of the Slidell Computer Board, which meets periodically to assess the Slidell Operation, as well as directly from Dr. Hoelzer to Mr. Reeves.

4.1.2 Manned Spacecraft Center

At MSC, all general-purpose application computers are located within the Computation and Analysis Division (CAAD) under the direction of Mr. Eugene H. Brock. The CAAD carries out functions related to administrative and scientific applications and data reduction.

Both general-purpose and special-purpose computers are included in the RTCC of the Mission Control Center. This function is administered by the Flight Support Division under the direction of Mr. H. E. Clements. This equipment is integrated into a real-time system used for Gemini and Apollo mission control.

The balance of the special-purpose equipment is located in several divisions. The Information Systems Division under the direction of Mr. P. H. Vavra maintains computer-oriented responsibility, while the various users maintain mission-oriented responsibility over this equipment.

The MSC Computation and Analysis Division has technical responsibility for the computer equipment at WSTF and maintains approval authority for all equipment acquisitions outside the MCC.

4.1.3 John F. Kennedy Space Center

At KSC, the general-purpose and special-purpose equipment, other than for checkout applications, is located in the Data Systems Division under the direction of Dr. Rudolf H. Bruns.

Special-purpose checkout equipment is located in Launch Operations. Each of the user groups operates checkout equipment in conjunction with the flight hardware supplier for the particular operation.

4.1.4 Intercenter Relations

The Office of Manned Space Flight and its three Centers work together on computational matters through the MSF Resources Sharing Panel which meets periodically on an informal basis. This group works in computer-related management problems such as standardization of programs between two or more Centers (e.g., the Launch Data Processing by KSC and subsequent data transmission to MSC and MSFC and exchange of programs among Centers to eliminate duplication of programming efforts).

In addition to participation in the MSF Resources Sharing Panel, each of the Centers is represented on the NASA Intercenter Committee on ADP. This group serves in an advisory capacity to Dr. Robert Seamans, NASA Deputy Administrator, in insuring compliance within NASA to other government-agency policies and regulations, in establishing intercenter and agency-wide policy, and in solving specific computer-management related problems.

Additional responsibilities in the area of computer resource sharing have recently been placed on MSFC and MSC. In establishing a government-wide Computer Resources Sharing System, GSA has, through mutual agreement, appointed MSFC as the Alabama, Mississippi, and Slidell Regional Exchange Center and MSC as the South Texas Regional Exchange Center. In this capacity, these centers act as the catalyst to further the sharing of government-wide computer resources within their areas and to coordinate requirements for computer resources from other areas.

To bring into focus the two trends of innovations in space flight technology and innovations in computer technology, there has been a critical need to devote effort to research and development in the computer sciences and to the performance of complex mathematical investigation into fundamental aspects of problems encountered during manned and unmanned space flight research. The MSF Centers have been instrumental in extending these frontiers of computer knowledge. Technical experts in each of the computational elements investigate computer solutions of problems encountered during space flight research. In addition, these people are available as consultants in selected areas of mathematics and physics. Dissemination of information takes the form of published papers and program sharing through the NASA Office of Technology Utilization.

4.2 STAFFING

In the MSF organization, programming and computer operation at the Centers is carried out primarily by contractor support personnel on a task-order basis. The use of contract support personnel is the result of several related circumstances. First, in order to maintain a dynamic staff at all times through the peaks and valleys of work requirements, it would have been necessary to recruit, train, and maintain a large staff and reservoir of programmers and operators on the civil service roles. By contracting on a non-personnel-services type contract, the Centers are able to have a readily available staff of personnel with these skills (see table 4-I). This action is not unlike the end item when contracting for space technology hardware. The civil service personnel are contract monitors over these skills. This arrangement accounts for the seemingly disproportionately high number of management-type assignments among the civil service personnel. This situation is especially noticeable in an organization such as MCC at the Manned Spacecraft Center (as shown in table 4-II), where no civil service personnel are used as operators, programmers, analysts, and so forth.

TABLE 4-I.- CONTRACTOR SUPPORT

Contractor	Scope of work	Location	Type contract	Effective	Number and type personnel
ITT/Federal Electric Co.	Programming and operating computers	KSC-Cape Kennedy	CPAF	June 1964	7 - Management 74 - Professional 31 - Operators 3 - Clerical
Computer Applications, Inc. (subcontractor to Ling-Temco-Vought)	Programming and operating computers	KSC-Cape Kennedy	CPAF	January 1964	10 - Management 113 - Professional 124 - Operators 7 - Clerical
Lockheed Electronics	Programming, operating, and maintaining computers	MSC-Houston	CPAF	November 1965	37 - Management 193 - Professional 134 - Operators 164 - Clerical
International Business Machines, Inc.	Engineering programming, maintenance, and operations to support Gemini and Apollo missions	MSC-Houston	CPAF/CPIF	September 1965	54 - Management 392 - Professional 89 - Operators 94 - Clerical
ZIA Co.		MSC-White Sands			
Computer Sciences Corporation	Programming, operating, and maintaining computers	MSFC-Huntsville	CPAF	July 1966	39 - Management 247 - Professional 128 - Operators 64 - Clerical
LTV Range Systems	Operation of the Slidell Computer Office	MSFC-Slidell	CPAF	January 1966	12 - Management 21 - Professional 135 - Operators 45 - Clerical

The following table categorizes the skill distribution of the full-time civil service personnel in the MSF organization.

TABLE 4-II.- MANNED SPACE FLIGHT

FULL-TIME CIVIL SERVICE IN ADP

Assignment	MSC			MSFC		
	KSC	MCC	CAAD	Huntsville	Slidell	Total
Management	12	77	12	40	6	147
Computation professionals (analysts, programmers, systems engineers)	32	0	97	106	0	235
Operators	0	0	0	2	0	2
Clerical, administrative (GS-9 and below)	3	7	61	43	2	116

All of the ADP contracts utilizing contractor personnel are for mission support services except at Slidell, where a management-type contract is used due to the "open shop" nature of the batch-type processing accomplished. The contractors' organizations at the Centers in the support situation parallel the civil service structure. The integrity of the contractors' supervisory chain is maintained, and task assignments result from definitive work orders issued under the terms of the contract.

The following table illustrates the numbers and corresponding categories of contractor personnel:

TABLE 4-III.- MANNED SPACE FLIGHT

FULL-TIME CONTRACTOR PERSONNEL IN ADP

Assignment	KSC	MSC		MSFC	Slidell	Total
		MCC	CAAD			
Management	18	54	37	39	12	160
Computation professionals	177	392	193	247	21	1030
Operators	259	89	134	128	135	745
Clerical, administrative (GS-9 and below)	12	94	164	64	45	379

In addition to the civil service and support contractor personnel assigned on a full-time basis to computer operation and management, others are involved with computer use in situations in which a computer supports professional activity on a part-time basis (for example, design engineering, test, checkout, and so forth). A recent sample indicates that 126 civil service and 718 contractor engineers are so occupied.

4.3 RESPONSIBILITIES AND FUNCTIONS

In linear-type charts (figs. 4-5, 4-6, and 4-7), some of the major computer actions that are taken in each of the Centers have been assigned action codes ("develop," "concur," "approve"). These charts indicate the computer-related responsibility levels at each of the Centers. Overlaying this, however, is the prime responsibility of the user — that of determining that there is need for computation support.

Basically, there are two methods for obtaining computational support. The first is the authority to obtain and operate a computer complex in support of a definite and continuing mission. The second is to obtain day-to-day computer support from a computer organization that has been established for the computation needs of a Center in general.

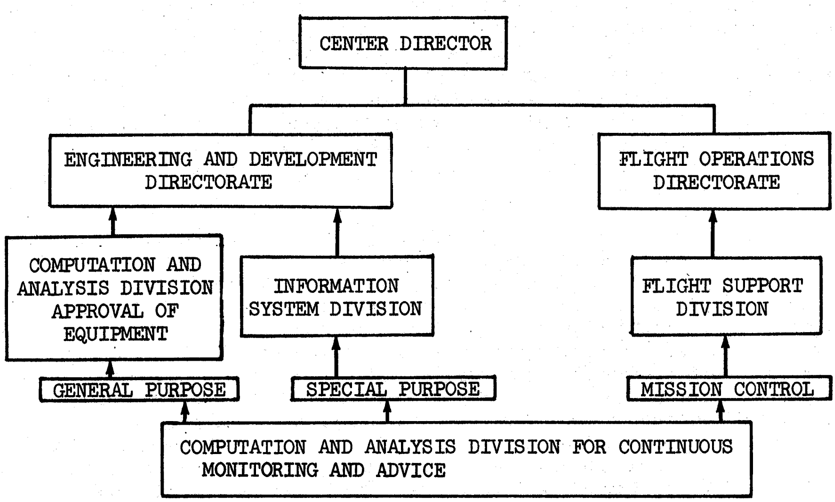
The most obvious example of the first method is the RTCC at Mission Control Center at MSC. In this instance, a need was established at the Gemini, Apollo, and Mission Operations Program Office level within MSF. Once the need was established, all levels through the NASA Administrator were in the chain of approval. After approval, operational responsibility was assigned through the chain of supervision to MSC, to a directorate, and thence to the Flight Support Division. In circumstances such as this, the responsibility is clearly established and applications are monitored by the organizational structure.

Not so obvious, but certainly as vital, are the hundreds of thousands of run requests, printouts, computations, and tabulations that are the day-to-day applications placed by the scientific, engineering, and management personnel of each Center. These responsibilities are not so clearly defined, and thus not so easily traced through a chain of supervision or to a clearly required function. The management techniques, such as the resource control systems, job order assignments, and budget allocation, are discussed in the "Management Techniques" section of this report. They supplement and make possible the application of responsibility for these many and varied applications. From a responsibility point of view, it was most important that each system be carefully designed to insure a firm chain of audit from the expenditure of any and all computation resources to a responsible individual in each and every case.

In addition to the two basic methods of obtaining computer support discussed above, there is a need to use a computer as a supplement to another piece or pieces of equipment. In those instances, the user organization deems it necessary to have computer equipment (special purpose) as an integral part of a mission-related system. The user must first obtain cognizant mission-authority approval. Then, as an example, the Computation Laboratory at MSFC enters the picture to determine which hardware and software best satisfy the user requirements, follows through with the user in the procurement process, and maintains computer-related responsibility throughout the installation and operational phases. This same pattern exists for the launch vehicle (MSFC cognizance) and spacecraft (MSC cognizance) checkout equipment located at KSC, even though the users perform actual operation of the equipment.

A very important responsibility at each of the Centers is the establishment of computational objectives as related to the scope of the computer operations. These objectives involve short- and long-range planning, organization, and staffing of all elements associated with computers or computer operations, centralized or decentralized concept of computer operations, degree of support to outside operations (including contractors), and civil service and contractor support personnel requirements.

There are variations in the responsibility assignments for the establishment of computational objectives among the three Centers. In each case, the user or customer of the computer operation forms the preliminary basis by establishing his long- and short-range computational requirements. At MSFC, the Computation Laboratory establishes the computational objectives for approval by the Research and Development Operations Director and the Center Director. At KSC, this responsibility starts with the Data Systems Division, with ultimate approval by the Center Director. As a graphical presentation, the following chart depicts the responsibility chain for the establishment of computational objectives at MSC.



The Office of Manned Space Flight exercises control over the Centers primarily through a review and validation process. As stated earlier, the NASA policy of assigning responsibility at as low a level as possible results in each Center essentially being in control of its own computer resources. The OMSF reviews and evaluates computer requirements on a center-by-center basis and coordinates with appropriate program offices (Apollo, Gemini, and so on) to insure the consistency of requirements. Additionally, OMSF consolidates budget and funding requirements for the three Centers for transmittal to the Office of Programming and monitors operations at each Center for compliance with NASA and other agency policies.

The NASA Office of Programming is responsible for consolidating all budgetary requirements which have been approved by the Associate Administrator and submitting the NASA requirements to the Bureau of the Budget for further approval.

The Office of Tracking and Data Acquisition (OTDA) is responsible for the development of NASA-wide policies, plans, and procedures approved by the Associate Administrator. The OTDA serves as the single focal point between NASA and other government agencies for computer matters; reviewing, evaluating, and coordinating on a NASA-wide basis the computer requirements, acquisitions, utilizations, and operations of computer resources.

The NASA Intercenter Committee on ADP is responsible for advising NASA management on the establishment of procedures, reviews, and controls necessary to insure compliance with other government policies and regulations on the selection, acquisition, and management of NASA computers. Further, the committee aids in the establishment of Intercenter and agency-wide policy and operational procedures for NASA computers.

The NASA Deputy Administrator, Dr. Robert C. Seamans, Jr., is the final authority for computer resources in NASA. In this position, he provides final approval of NASA policy and plans for acquisition, utilization, and disposition of computer equipment and services based on the objectives of the agency and the government. He has assigned the Assistant Administrator for Administration as the NASA Headquarters ADP Program Officer to assist with the management information systems involved in this task.

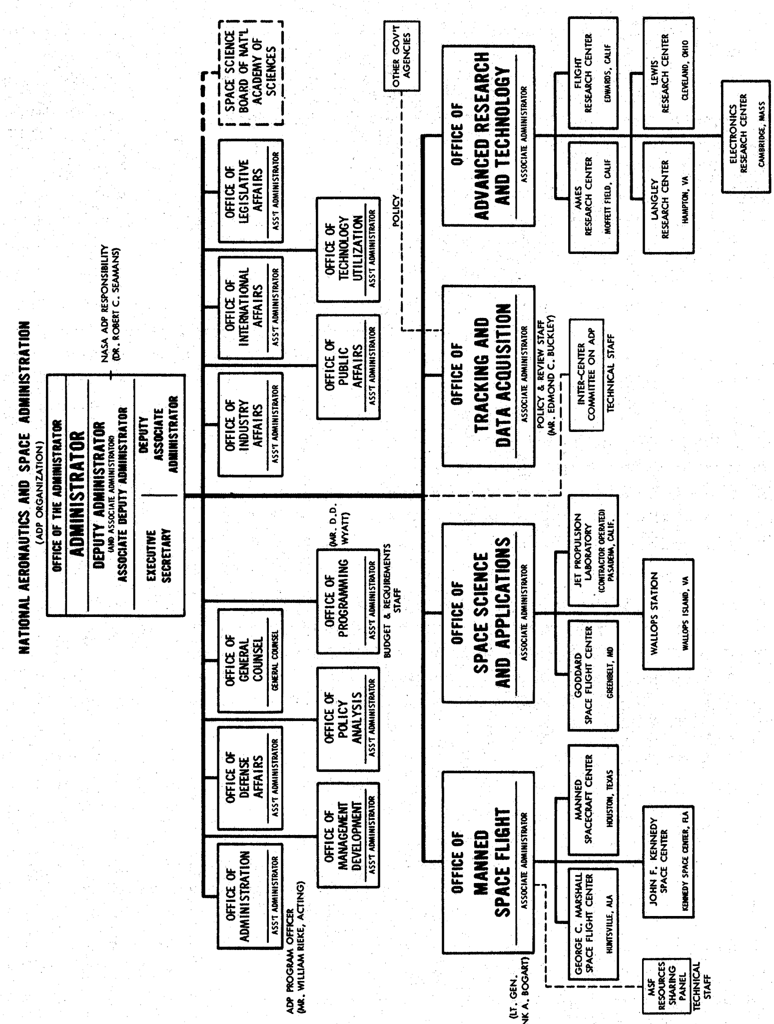


Figure 4-1.- National Aeronautics and Space Administration automatic data processing organization.

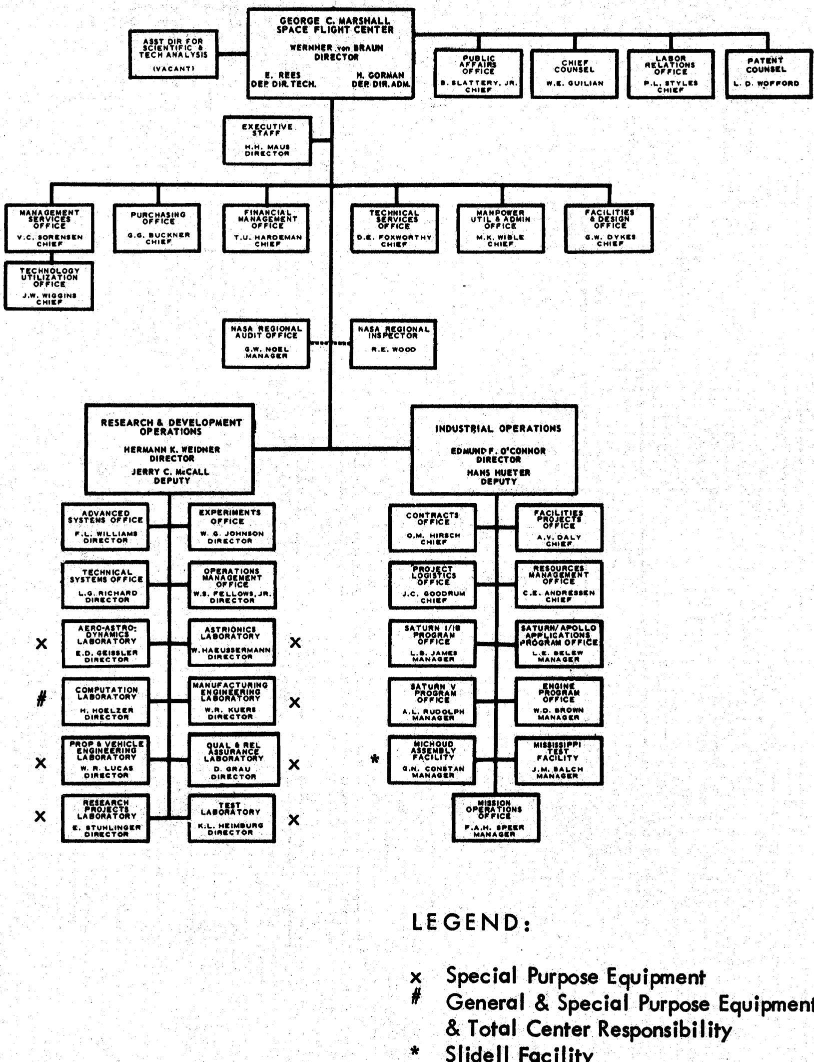


Figure 4-2.- George C. Marshall Space Flight Center automatic data processing organization.

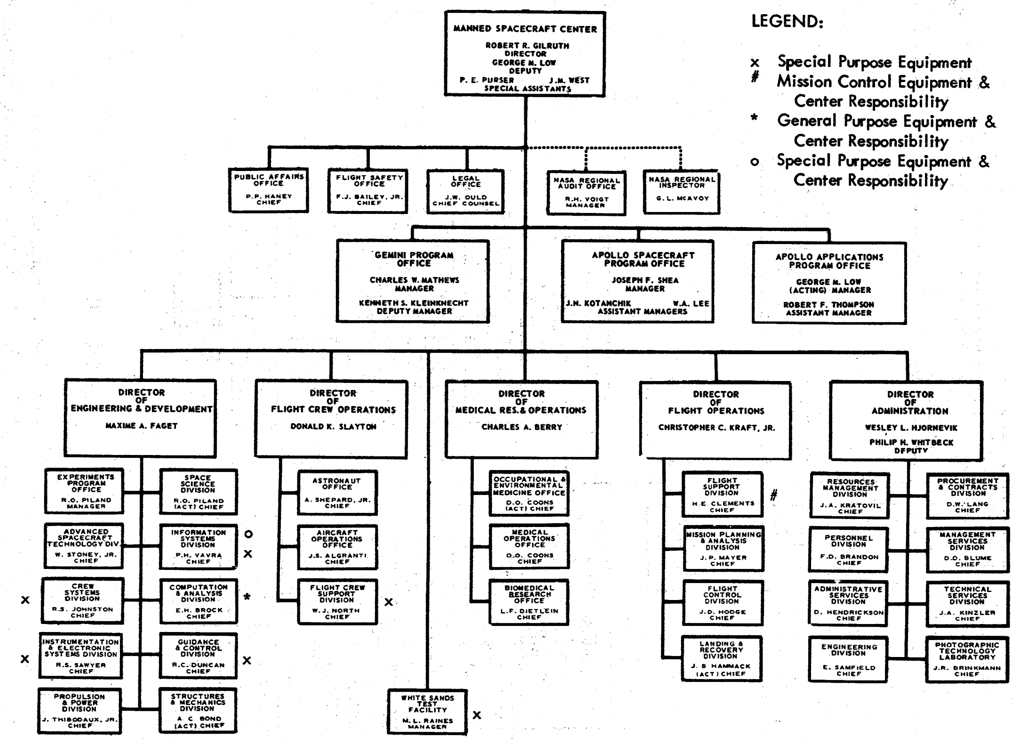


Figure 4-3.- Manned Spacecraft Center automatic data processing organization.

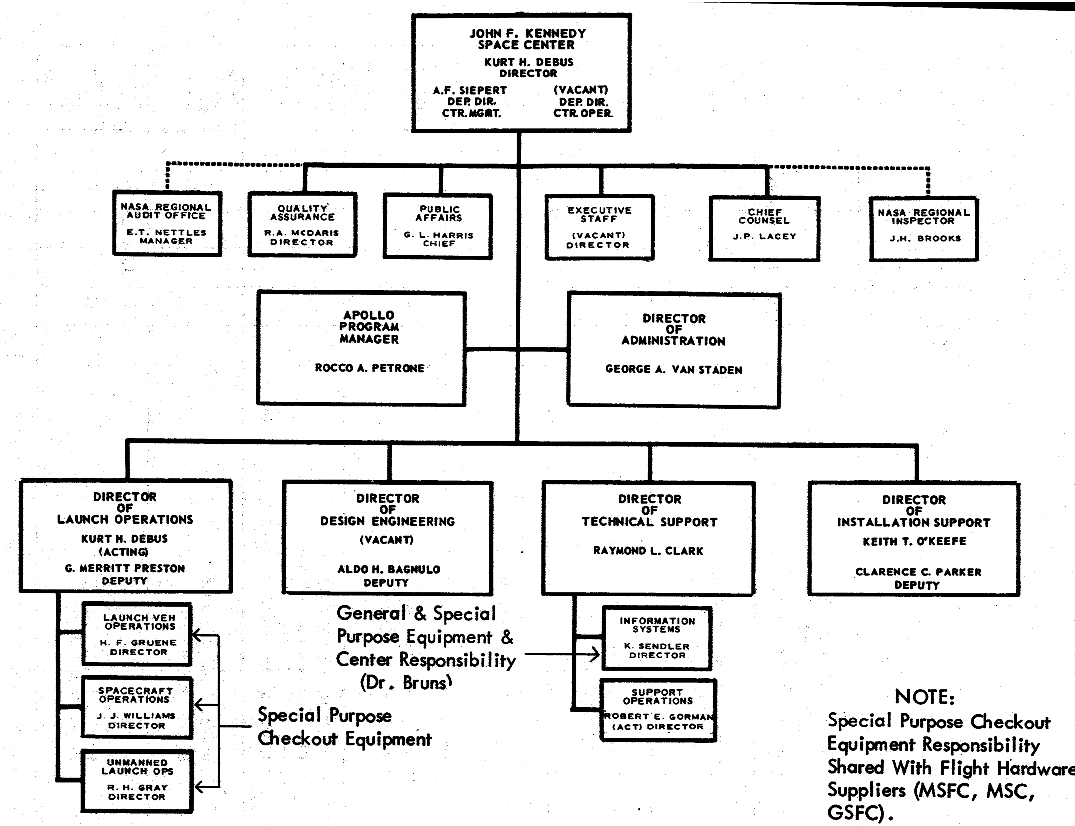


Figure 4-4.- John F. Kennedy Space Center automatic data processing organization.

CODE: * DEVELOP
x CONCUR
APPROVE

	Center Director	Dir of Admin	Directorate	User	Division	Branch	Type of Equip.
DETERMINATION OF HARDWARE REQUIREMENTS AND IMPLEMENTATION (C & A DIV APPROVES)	X		X		#	*	GENERAL PURPOSE
	X		X	*	#		SPECIAL PURPOSE
		ALL LEVELS INVOLVED					MISSION CONTROL
DETERMINATION OF SOFTWARE REQUIREMENTS AND IMPLEMENTATION				*	#	*	GENERAL PURPOSE
				*			SPECIAL PURPOSE
		SEVERAL DIVISIONS					MISSION CONTROL
EVALUATION AND APPROVAL OR DISAPPROVAL OF COMPUTER APPLICATIONS				*	#	*	GENERAL PURPOSE
				*			SPECIAL PURPOSE
		SEVERAL DIVISIONS					MISSION CONTROL
DESIGN OF COMPUTER HARDWARE SYSTEMS					#	*	GENERAL PURPOSE
					#	*	SPECIAL PURPOSE
						#	MISSION CONTROL
PROCUREMENT OF COMPUTER HARDWARE SERVICES	#	*	X		X	*	GENERAL PURPOSE
					#	*	SPECIAL PURPOSE
						#	MISSION CONTROL
INSTALLATION OF COMPUTER HARDWARE SERVICES					#	*	GENERAL PURPOSE
				*			SPECIAL PURPOSE
						#	MISSION CONTROL
DETERMINATION OF COMPUTER UTILIZATION REPORTS DESCRIBING EFFECTIVENESS AND COST OF HARDWARE AND SOFTWARE SYSTEMS	#	*	(COST)		X X	*	GENERAL PURPOSE
				*	#	*	SPECIAL PURPOSE
			#		X	*	MISSION CONTROL
PREPARATION OF COMPUTER UTILIZATION REPORTS		*	(COST)		#	*	GENERAL PURPOSE
					#	*	SPECIAL PURPOSE
						#	MISSION CONTROL
ANALYSIS AND ACTION RELATED TO COMPUTER UTILIZATION REPORTS	#	*	(COST)		X X	*	GENERAL PURPOSE
					#	*	SPECIAL PURPOSE
						#	MISSION CONTROL

Figure 4-5.- Manned Spacecraft Center computer responsibilities.

CODE: * DEVELOP
x CONCUR
APPROVE

(BOTH GENERAL AND SPECIAL PURPOSE EQUIPMENT)	COMP. LAB. DIR.	USER &/OR COMP LAB PROJ OFF	COMP. LAB. DIV.	BRANCH	
DETERMINATION OF HARDWARE REQUIREMENTS AND IMPLEMENTATION	#	*	X	*	
DETERMINATION OF SOFTWARE REQUIREMENTS AND IMPLEMENTATION	#	*	X #	*	
EVALUATION AND APPROVAL OR DISAPPROVAL OF COMPUTER APPLICATIONS			#	* #	
DESIGN OF COMPUTER HARDWARE SYSTEMS	#	*	X	*	
PROCUREMENT OF COMPUTER HARDWARE SERVICES	#	*	X	*	
INSTALLATION OF COMPUTER HARDWARE SERVICES			#	*	
DETERMINATION OF COMPUTER UTILIZATION REPORTS DESCRIBING EFFECTIVENESS AND COST OF HARDWARE AND SOFTWARE SYSTEMS	#		X	*	
PREPARATION OF COMPUTER UTILIZATION REPORTS	#		X	*	
ANALYSIS AND ACTION RELATED TO COMPUTER UTILIZATION REPORTS	#		X	*	

Figure 4-6.- Marshall Space Flight Center computer responsibilities.

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CODE: * DEVELOP
x CONCUR
APPROVE

Task	Center Director	Dir. of Admin.	Apollo Program	Design Eng.	Info. Systems	Data Sys. Div.	Branch	Type of Equip.
DETERMINATION OF HARDWARE REQUIREMENTS AND IMPLEMENTATION	#	x	x	x	x	*		GENERAL PURPOSE
						#	*	SPECIAL PURPOSE
	#		*					CHECKOUT
DETERMINATION OF SOFTWARE REQUIREMENTS AND IMPLEMENTATION			x			* #		GENERAL PURPOSE
						#	*	SPECIAL PURPOSE
			*					CHECKOUT
EVALUATION AND APPROVAL OR DISAPPROVAL OF COMPUTER APPLICATIONS			#			*		GENERAL PURPOSE
	#				x	*		SPECIAL PURPOSE
			(OTHER CENTERS)					CHECKOUT
DESIGN OF COMPUTER HARDWARE SYSTEMS	#	x	x	x	x	*		GENERAL PURPOSE
						#	*	SPECIAL PURPOSE
			(OTHER CENTERS)					CHECKOUT
PROCUREMENT OF COMPUTER HARDWARE SERVICES	#	x	x	x	x	*		GENERAL PURPOSE
						#	*	SPECIAL PURPOSE
			(OTHER CENTERS)					CHECKOUT
INSTALLATION OF COMPUTER HARDWARE SERVICES						* #		GENERAL PURPOSE
						#	*	SPECIAL PURPOSE
			(OTHER CENTERS)					CHECKOUT
DETERMINATION OF COMPUTER UTILIZATION REPORTS DESCRIBING EFFECTIVENESS AND COST OF HARDWARE AND SOFTWARE SYSTEMS			#			*		GENERAL PURPOSE
	#					*		SPECIAL PURPOSE
			*					CHECKOUT
PREPARATION OF COMPUTER UTILIZATION REPORTS			#			*		GENERAL PURPOSE
						#	*	SPECIAL PURPOSE
			(OTHER CENTERS)					CHECKOUT
ANALYSIS AND ACTION RELATED TO COMPUTER UTILIZATION REPORTS			#			*		GENERAL PURPOSE
						#	*	SPECIAL PURPOSE
			(OTHER CENTERS)					CHECKOUT

Figure 4-7.- Kennedy Space Center computer responsibilities.

5.0 MANAGEMENT TECHNIQUES

5.1 MANAGEMENT REPORTING

The Office of Manned Space Flight and its Centers have applied classical management techniques and, where necessary, developed new ones for the management of computer resources. These techniques include methods for the acquisition, control, utilization, and sharing of computer resources. In order to administer the computer resources and meet overall objectives, management review and reporting systems have been established at all levels of management throughout NASA Headquarters and its field installations.

"Management Procedures for Automatic Data Processing Equipment," NHB 2410.1, issued by OTDA, establishes the policies and procedures for use throughout NASA for the management of computer resources. This document defines the responsibilities of the Deputy Administrator, the Associate Administrator for Tracking and Data Acquisition, the Headquarters Institutional Directors, and the directors of the field installations. It also promulgates requirements for the Annual ADP Planning Document and the ADP Equipment Acquisition Plan, as well as establishing guidelines for the selection, acquisition, and utilization of category-A equipment.

The three major reporting systems currently in existence for controlling computer resources are the ADP Annual Planning Document, Bureau of the Budget (BOB) Circular A-55 Reports, and the Program Operating Plans (POP).

The most comprehensive of the computer reporting systems is the Annual ADP Planning Document. This document covers all known equipment actions for the current and budget years, identifies all costs associated with the equipment, and includes complete justification for its use and need. It provides the actual utilization for the past year and estimates for the current and budget years. It shows funding requirements for all 3 years and includes a section for long-range plans.

The BOB Circular A-55 submission is an annual report required by BOB. This report is also updated with quarterly summaries. This document, which is prepared at the Centers, shows the status of each computer for the past, current, budget, and budget-plus-one years. This status shows cost range, whether the computer is purchased or leased, and the actual or estimated (for future years) average number of hours in service. In addition, it supplies planning data in the areas of personnel and cost on a 3-year basis and reflects the type of applications currently being performed by the Center computers.

The POP is an internal quarterly funding report which is submitted by all field Centers to NASA Headquarters. A separate plan is submitted for each appropriation. In the case of the Research and Development and Construction of Facilities appropriations, the costs are shown by program and project. For the Administrative Operations appropriation, the costs are reflected by BOB object and sub-object classification. The sub-object class is further shredded-out to cover the area of computers. It contains the purchase, lease, and maintenance costs of equipment and shows contractor costs for operations and programming of NASA-owned machines. The plan contains past-year actual dollar totals and current- and budget-year estimates. The current-year estimate shows 6-month projected cumulative obligations with quarterly cumulative totals and totals for the fiscal year. There are other planning documents which are part of the computer reporting system, such as the individual acquisition plans and special reports and studies which are prepared for top management, the BOB, and Congress. These reports also provide information related to the overall planning of computer systems in Manned Space Flight.

Computer management reports forwarded to OMSF from a Center Director's office are sent through channels to the MSF Technical Support Branch for evaluation. The only exception to this procedure is for individual reports and acquisition requests for real-time and checkout computers, which are evaluated by the Mission Operations group and the Operations Support Systems and Checkout Branches, respectively. The reports or plans are reviewed for such items as need, technical feasibility, funding requirements, facilities requirements, and utilization. Where overall reports contain data on project requirements, they are coordinated with appropriate project offices. Funding requirements are coordinated with the MSF Resource Control Office.

The completed evaluation, including the detailed analysis, is forwarded to either the Director of Management Operations, Mission Operations, or the Apollo Program Office, as appropriate, for recommendation to the Associate Administrator for MSF, either to be approved at that management level or to obtain concurrence where reports or plans must be approved at a higher management level.

Each field Center, as well as NASA Headquarters, conducts overall reviews of the entire computer system operation. These reviews generally take the form of detailed reports or briefings. For example, at MSFC and MSC, the Center Directors annually receive a presentation on all aspects of the computer systems. The Office of Manned Space Flight conducts periodic reviews both at the Centers and at NASA Headquarters.

These reviews may be in conjunction with POP reviews or studies of individual areas of the computer picture. In addition to established management reviews both at NASA Headquarters and field Centers, reviews, both formal and informal, are conducted as specific requirements or situations may dictate.

5.2 COMPUTER RESOURCE ACQUISITION

The basic computer acquisition procedures for NASA are derived from BOB Circular Nos. A-54 and 60-6 and from NASA Document NHB 2410.1 and are defined in more detail in individual Center policies and procedures.

In essence, these procedures require that the selection of equipment to meet a given need be based primarily on the capability of the equipment to fulfill system specifications and on the most economical method of acquisition, installation, and operation.

The computer acquisition procedure is divided into two major steps. As depicted in figure 5-1, the user at a Center must have his requirements validated and get approval from Center and NASA Headquarters management prior to initiation of the acquisition process for a computer. As shown in figure 5-2, after approval, the Center establishes a Source Evaluation Board (SEB) and enters the acquisition cycle.

Early in the acquisition process, the requesting installation prepares a computer acquisition plan. This document is submitted through channels to the Associate Administrator for approval. Prior concurrence of the Associate Administrator for Manned Space Flight and the Associate Administrator for Tracking and Data Acquisition is required for all computers covered by these procedures before the acquisition plan is approved and the procurement process initiated.

The acquisition plan includes an evaluation to show clearly that computer requirements cannot wholly or partially be met by:

(1) The use of existing computer resources, available either within NASA, from other government agencies, or from contractors

(2) The use of computers that may be excess to the needs of other elements of NASA or other government agencies and which are available or will become available by the planned installation date

(3) The augmentation of an existing ADP facility

The acquisition plan also contains a written justification for the equipment, citing the specific requirements that will be satisfied. This justification gives an estimate of utilization, special input/output (I/O) requirements, backup needs, operational constraints, and so forth. Specifications for the equipment are included which describe the equipment proposed for acquisition in detail. The plan must also include estimated dates for readiness review, software checkout, training, and program conversion.

The computer acquisition procedures are designed to give management the ability to carefully assess and review computer acquisitions. Following this assessment, review, and approval, the Center then proceeds to enter the procurement cycle. First, qualified computer manufacturers are invited to submit proposals on the specifications developed for the computer to be acquired. Criteria are developed, defined, and weighted by the SEB and are used as the basis of the SEB's statement of facts to the selection official. Depending on the dollar amount of the acquisition, the procedure for selection as depicted in figure 5-2 is followed. A more detailed explanation of the SEB may be found in NASA Document NPC 402, Source Evaluation Board Manual.

5.3 COMPUTER RESOURCE CONTROL

The expenditure of computer resources is controlled in MSF by methods of workload control for all computing efforts and contract monitoring for contracted efforts involving computer resources.

5.3.1 Workload Control in the Computation Facilities

The objective of the established workload control system in the MSF computational facilities is to furnish the means for planning, reviewing, and analyzing work requests and, as a result, controlling the work effort and expenditure of resources in the MSF computation facilities.

The MSF computational facilities involved in this formal system are the general-purpose computer support organizations at KSC, MSC, and MSFC.

A prime benefit of workload control is to reduce to the minimum degree the possibility of expending computer resources on marginal tasks. In essence, discipline in the use of computer services is achieved by assigning each user element a dollar budget against which computer usage is charged. If the user exceeds this budget during the fiscal year, he must justify the need for additional funds from Center management.

The computer workload control system:

(1) Assigns to each user the responsibility of achieving efficient computation

(2) Provides the Centers with a data structure for their annual ADP budget preparation

(3) Assists management in evaluating requests for additional computational capacity

(4) Provides NASA Headquarters information for ADP budget reviews and evaluations

Each computational facility in MSF utilizes essentially the same procedure for workload control, although details may differ slightly. The procedure is described in the following paragraphs using the MSFC system as an example.

The computation facility develops a workload projection and budget allocation with each user prior to the fiscal year. Center management then sets a total allocation for the computer facility based on the workload projections. Each user must submit a written request for all support. This request form provides the basis for record keeping, including dollar accounting. The user's management reviews the work request against the assignment for that organization and the availability of computing funds and approves or disapproves the request, as appropriate. The computation facility also reviews the approved request and, if technically feasible, performs the work. The user receives periodic reports showing allocation, current expenditures, and remaining balance (for an example, see figure 5-3). Center management also receives periodic expenditures reports per user division. If necessary, the customer requests additional budget allocations from Center management.

The MSFC and KSC systems differ in one respect from the MSC system. In MSFC and KSC, the computation support dollars show up in the computation facility's budget. The facility, in turn, allocates the dollars to the customer as needed. At MSC, the computation dollars are gathered in a carrier account, which is charged for the Computation and Analysis Division's reimbursable costs and credited by charges against the customer for support rendered. The charges are based on operating cost data developed by the Center's Resource Management Office.

The MSFC, KSC, and MSC workload control systems were implemented as of July 1964. The MSFC Customer Dollar Allocation was operational July 1965. The MSC Carrier Account was effective July 1966.

Further action will be taken to improve workload control by expanding its coverage, and disseminating information to other interested parties. One area that will have to be studied closely is the effect of third-generation time-sharing computers on budget allocation methods and cost determination.

5.3.2 Workload Control in Operation Systems

The task of controlling the expenditure of computer resources in operational systems, such as real-time systems for the support of a mission, checkout, and training, is somewhat different than resource control in the computational facilities. Each such system has a significant role to play in overall mission accomplishment and puts extensive demands on the computer within the system. In some instances, computer requirements cannot be completely defined at the inception of a program and must be increased during the course of system development. Basically, this increase results from one of two causes: (1) the requirements for the system become better defined as time progresses; (2) the users of the system may impose requirements with a factor of redundancy to assure accomplishment of that element of the entire mission profile. In the case of the former, there is little to say; the requirements must be met if the mission is to be successful. The latter is a problem that is handled in various ways in MSF. Procedures for requirements control are set by the organizational element responsible for the development of the overall system. New requirements are evaluated to determine their necessity, their impact on existing contracts, their effect on interfaces with other systems, and so forth. The methods for evaluating such requirements must, by necessity, vary from project to project. In the Apollo spacecraft program, for example, systems are under the control of the Apollo Configuration Management System described in detail in NASA Document NPC 500-1, "The Apollo Configuration Management Manual." Configuration management procedures have thus been developed to control changes to all elements in a system, including those that utilize computers.

5.4 CONTRACT MONITORING

A significant amount of the computer resources utilized in MSF is either developed, operated, or maintained by contractor personnel. The use of contractors in this manner is in keeping with NASA policy to utilize wherever possible the resources of private industry, and enables MSF to obtain what might otherwise be the unobtainable services of highly skilled personnel. Contract monitoring from both a technical and management point of view, therefore, constitutes a considerable activity in MSF. Organizations, procedures, guidelines, and techniques for this activity have been developed by the Office of Manned Space Flight, Center Directors, and individual Center divisions.

5.4.1 Scope of Contract Types

The scope of contracted efforts in MSF is broad, running from support keypunching services for Center computation facilities to contracts for the delivery of complex computer based systems. Depending on the nature of the effort, the contract may be of any type, such as incentive, fixed fee, award fee, and so forth. Support contractors may be located on NASA premises or off site. Responsibilities for a particular effort may be divided between several NASA organizations. Contracts may call for the delivery of hardware or software (computer programs) or both.

Each contract in this broad spectrum of requirements requires a tailored approach to achieve effective control. For the purposes of management control, contracts awarded in MSF can be considered generally as one of two broad types: support services contracts or mission support contracts. Support services contracts are those in which a NASA organization obtains the services of a contractor on a level-of-effort basis. Individual tasks are assigned on a task-order basis to contractor personnel working closely with NASA personnel. This type of contract is used when a NASA Center determines it will need a certain amount of manpower support but cannot completely identify the required end items in advance. A specific example is the contract between MSFC and the Computer Sciences Corporation (CSC) in which CSC provides programming and computer operating services to the MSFC computational facility.

A mission support contract is one in which NASA contracts for a particular end item to be used in support of a mission. Requirements for the end items are included as part of the contract; there is usually a separate contractor-managed group set up to perform the task. Formal NASA monitoring by way of reviews, written reports, and acceptance tests characterizes these efforts with minimum day-to-day contact between the NASA users and contractor personnel. The unique technical considerations of the contract make it mandatory in many instances that the techniques used to monitor these efforts be tailored to the individual system. An example of a mission contract is the contract for the Real-Time Computer Complex at Houston. In this contract, IBM provides computers and computer programs that are used in the Houston Mission Control Center to assist flight controllers during a manned space flight.

5.4.2 Management Tools

An extensive set of management tools has been developed by OMSF and its centers to aid in contract monitoring. The following are typical examples:

Work statements, task orders.- Each contract contains a work statement which serves as the basis for contractor support and for evaluation of such support. For mission contracts, the work statement defines the end products to be produced, management requirements, required contractor tasks, and schedules. The exact content and detail of the work statements vary in OMSF according to application, particularly for software contracts. For support contracts, work statements define the general task and management requirements. Detailed descriptions of required end items and delivery dates are incorporated into individual task orders during the period of the support contract. These task orders serve as "little work statements," so to speak, to monitor the contractor's performance.

Incentive contracts.- It is MSF policy to lend incentive to contracts to the greatest degree practical. This policy has also been applied to contracts that utilize computer resources. Typically, these contracts encourage improved contractor performance by paying fees according to the quality of the product, performance, total cost, and delivery date. Both support and mission contracts either have been or are being made into incentive contracts in MSF wherever possible.

At MSC, for example, the support contract for the computational facility has been made into an incentive contract (Contract NAS 9-5384), as has the mission contract for the RTCC (Contract NAS 9-995). Computer resource contracts have also been made into incentive contracts at MSFC and KSC. The RTCC contract is an interesting and particularly significant one in that it contains incentives for the production of large-scale computer programs, the first time this has been done in NASA and, quite possibly, in government.

Management guidelines.- The Office of Manned Space Flight and its Centers have issued an extensive set of guidelines to be used in the management of contracts. A typical example is the MSFC Support Contract Management Manual which provides guidance for the management of all support contracts at the MSFC. This manual covers such items as surveillance of services, travel and security regulations, incentive award fee evaluation, acceptance of products, manpower control, and so forth.

Monitoring organizations.- Total contract monitoring is usually accomplished by several organizations. In general, technical monitoring is done by the organization which utilizes the contractor's services and end products. This monitoring is accomplished by design reviews, evaluation of test results, inspections, and so forth. The purpose of the monitoring is to insure that the technical work of the support rendered meets the requirement stipulated.

Each Center has contractual offices to monitor contracts in a legal and fiscal sense. These organizations work closely with the technical monitoring groups to insure total adherence to contractual requirements by the individual contractors. For incentive contracts, performance evaluation boards are established to determine the incentive fee due the contractor. The board may consist of personnel from organizations other than those directly responsible for monitoring a particular contract. For example, in the RTCC contract, the Incentive Evaluation Board consists of the Center Director; the Center Deputy Director; the Director of Flight Operations; the Chief, Flight Support Division; and the Chief, Procurement and Contracts Division. This board, in turn, is supported by an Incentive Evaluation Committee which is composed of those technical and contractual personnel most closely associated with the contractor's effort. In certain mission contracts, change control boards have been established. These boards evaluate proposed changes to determine if they should be incorporated in the system. The boards are cognizant of the activities of all contractors who may be affected by the proposed changes. The board members are technically oriented personnel. If an action of a board requires a change in scope, the change will be negotiated by the contractor and the responsible contracting officer.

Workload control.- Support contractors are included in the computer workload control systems in effect in the computational facilities. This system provides visibility of contractor expenditures for use in contract monitoring and controls a contractor to keep resources for computer expenditures to a minimum.

Computer resources as management aids.- A major advantage of contracts that utilize computers is that the computers themselves may be used as a management aid. This is done throughout MSF, as illustrated by the following typical examples:

(1) Computers are used to help in lease versus purchase determinations.

(2) Computers are used to compute and store up-to-date budget and allocation records in the workload control systems.

(3) Computers are used for the generation of PERT reports and schedule predictions.

(4) Computers are used to keep track of the specifications and documents that describe complex computer-based systems.

(5) Computer simulations are used to aid management in making decisions regarding alternate strategies.

5.4.3 Special Considerations for Mission Contracts

Several factors of a technical nature tend to make the management control of mission contracts more complex and more individualized than management control of support contracts. In many of these contracts, the end items (computer hardware, computer programs) are parts of large systems which contain complex interfaces. The development of each end item must be controlled so that the items will work together when the system is assembled. Since a change to an end item may affect a number of other items, different groups and levels of management in a Center may be affected. Further, the equipment and computer programs developed may be extremely complex and require the efforts of several MSF elements in the monitoring task. For example, the RTCC effort requires the production of a program with more than 1,000,000 instructions. The requirements for this program are developed in one branch (which is assisted by a support contractor), technical monitoring is done by another branch, and contractual monitoring done in yet another branch.

In many of these mission contracts, software development is a major consideration. The traditional methods of management available for hardware development have to be modified or abandoned for software and new techniques developed. Most of the resulting management techniques have been tailored to individual software requirements. Despite these considerations, some progress has been made in simplifying and standardizing management techniques for mission contracts.

One significant development is the initial effort in the Apollo spacecraft program to bring certain computer-based systems into the

Apollo configuration management system. This procedure provides control of the technical requirements, which define a large system. The Apollo Configuration Management Manual has been amended to provide for the specification and control of these computer programs, and the new procedures are currently being phased into on-going projects. Also, the Apollo Program Office has sponsored a study of management procedures for computer programming efforts (Bellcomm Report No. TR 66-320-2, "Procedures for the Management Control of Computer Programming in Apollo").

5.4.4 Future Efforts in Contract Management of Computer Systems

There is a continuing effort in OMSF and its Centers to improve the level of contract management of computer systems. Several areas are presently under study, such as:

(1) How to collect, code, and disseminate the experience gained in software management so it can be applied to future efforts

(2) How to more effectively use computers to manage other computers

(3) How to effectively incentivize selected software contracts

(4) How to develop standard milestones to provide all levels of management with increased visibility when monitoring computer contracts

(5) How to more effectively identify computer costs in contracts that cover both computer and non-computer elements.

5.5 COMPUTER RESOURCE SHARING

5.5.1 Policy

Computer resources (computer time, programs, program outputs, personnel, program descriptions) are shared extensively in MSF, both in formal programs and on an informal basis. Sharing is encouraged by stated NASA and government policy (NASA Document NHB 2410.1, "Management Procedures for Automatic Data Processing Equipment") and controlled through Center participation in special panels developed for this purpose. In addition to inter-MSF sharing, resources are shared with other NASA Centers, government agencies, and private organizations.

5.5.2 Sharing Organizations

Several organizations within MSF have been established for resources sharing:

(1) The MSF Resource Sharing Panel is comprised of the Directors of the MSF Computational Laboratories; Bellcomm, Inc.; and NASA Headquarters representatives and was established in late 1963 to promote the sharing of computer resources in MSF and to exchange ideas on the management of large computer complexes. The current membership of the panel includes C. L. Bradshaw, Deputy Director, Computation Laboratory, MSFC; E. H. Brock, Chief, Computation and Analysis Division, MSC; R. H. Bruns, Chief, Data Systems Division, KSC; J. Costantino, Chief, Technical Support Branch, OMSF; B. G. Griffin, Chief, Computation Branch, KSC; H. Hoelzer, Director, Computation Laboratory, MSFC; I. D. Nehama, Director, Analysis and Computer Sciences Division, Bellcomm, Inc.; E. P. O'Rourke, Technical Support Branch, OMSF; and R. L. Reeves, Chief, Computer Operations Office, Slidell. The panel meets periodically to discuss and recommend policy standards that will aid sharing. In addition to its regular meetings, the panel has sponsored and directed a study by Bellcomm to develop specific standards and procedures for resource sharing in the Manned Space Flight Centers. Bellcomm is providing continuing support in this area; and MSF Centers, by direction of the Associate Administrator for Manned Space Flight, are implementing the standards developed by the panel.

(2) Project COSMIC has been established by NASA Headquarters Technology Utilization Division and MSFC, utilizing the services of the University of Georgia on a contract basis, to disseminate information at minimum cost to all interested parties concerning the availability of computer programs developed by all NASA Centers and contractors. (The central library for this project is maintained at MSC as described in item (4).)

(3) Both MSC and MSFC have been designated as ADP Sharing Exchanges for their respective geographic areas by the General Services Administration (GSA). The computational elements at these Centers coordinate ADP sharing for all government agencies in the designated areas and provide current information on available ADP resources.

(4) A central librarian for the sharing of computer programs has been established at MSC.

5.5.3 Sharing Accomplishments

It is estimated that $7,321,200 in computer resources were shared in 1965 (see table 5-I). The most significant saving resulted from the use of available computer programs, or parts thereof, in lieu of producing a new program. Several factors indicate that the level of sharing will increase in 1966 and that this trend will continue. For example, the MSC and MSFC computational facilities will be using the same general type computers starting in FY 1967. This will aid greatly the exchange of machine time and computer programs between the two Centers.

As a result of both individual initiative on the part of the Centers and efforts of a Resources Sharing Panel/Bellcomm study, a number of significant innovations have been made to aid further sharing. These are reported in a NASA Document, "Procedures for Computer Program and Telemetry Resource Sharing," October 1966, and include:

(1) The establishment of a program sharing library at MSC — Abstracts, describing computer programs available for sharing in MSF, are produced by the responsible programmers and transmitted to a central librarian. The central librarian disseminates the abstracts to MSF personnel. An interested potential user contacts a local librarian at the programmer's Center to get a copy of the program and its descriptive documentation. The effect of this system is to provide a wider dissemination of information concerning available programs in MSF.

(2) The establishment of a standard form for a computer program abstract — This form is used in the program library as described above; it is also used as the abstract for program documentation and as a header to all program card decks and tapes.

(3) The establishment of guidelines for computer program documentation in the MSF computational facilities — The use of standard documentation techniques will facilitate one Center's using programs developed at another Center.

(4) The establishment of standard computer languages in the computational facilities — FORTRAN IV is standard for scientific and engineering applications; COBOL is standard for business applications. All programmers in the MSF computation facilities must use one of these languages unless technical considerations require otherwise. The use of common language will ease the problem of one Center's running a program written at another Center. This procedure will aid sharing of computer programs between Centers and the use by one Center of available machine time at another Center.

(5) The establishment of a standard for the formatting of telemetry calibration data — This standard will reduce the amount of programming required to handle telemetry processing requests made by engineers and scientists in MSF.

(6) The development of a standard set of routines for driving output plotter devices — A standard program reduces program maintenance requirements at the Centers and reduces the total programming effort required to handle printout requests made by MSF engineers and scientists.

5.5.4 Future Efforts

The development of methods and standards to facilitate resource sharing is continuing. Several areas are currently under investigation, including:

(1) The further development of a unified documentation procedure for use in the MSF computation facilities to replace the present documentation guidelines

(2) The establishment of a telemetry data tape standard

(3) The identification and development of standard programs to fulfill common needs at each Center (for example, payroll and accounting programs may be standardized to minimize updating and maintenance costs)

(4) The establishment of standardized programming practices to make programs produced at one Center more usable at another Center.

TABLE 5-I.- SUMMARY OF OMSF ADP RESOURCE SHARING

IN TERMS OF TOTAL VALUE

[January 1, 1965 - December 31, 1965]

	KSC	MAF	MSC	MSFC
Programs requested by other NASA Centers, dollar savings	0 0	0 0	(20) $440,900	(33) $666,500
Programs requested by non-NASA government agencies, dollar savings	0 0	0 0	(4) 12,000	(6) 52,500
Programs requested by government contractors, dollar savings	0 0	0 0	(25) 255,300	(151) 549,000
No-man days shared on other support, dollar savings	(145) $6,900	(320) $15,300	(138) 6,600	(417) 19,900
Computer hours shared, dollar savings	(6,500) 810,000	(1,290) 467,100	(7,547) 2,473,900	(11,247) 1,455,300
	$816,900	$482,400	$3,188,700	$2,743,200
Total resource sharing value	$7,231,200			
Total program sharing value	$1,976,200			

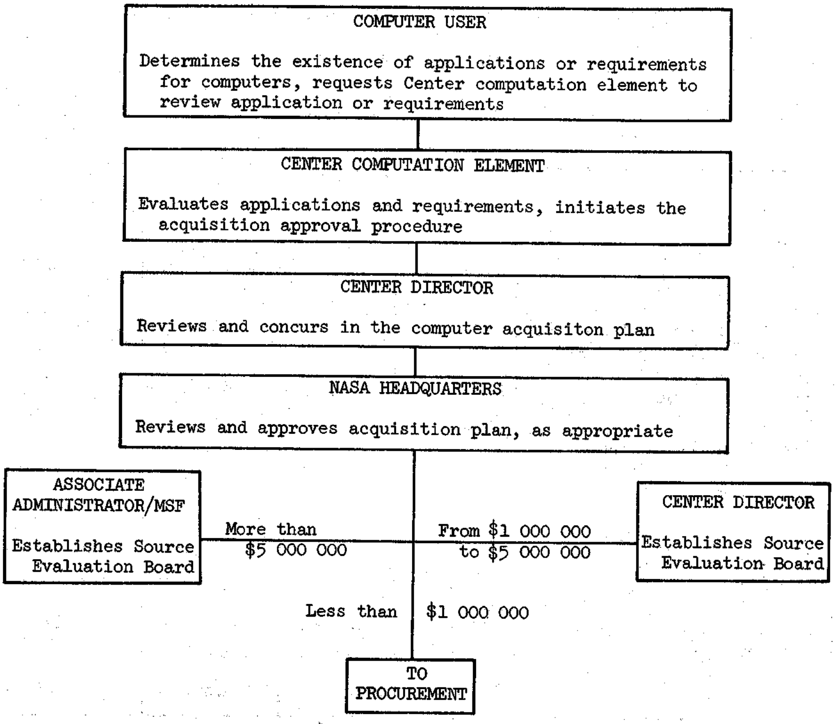

Figure 5-1.- Computer acquisition plan cycle.

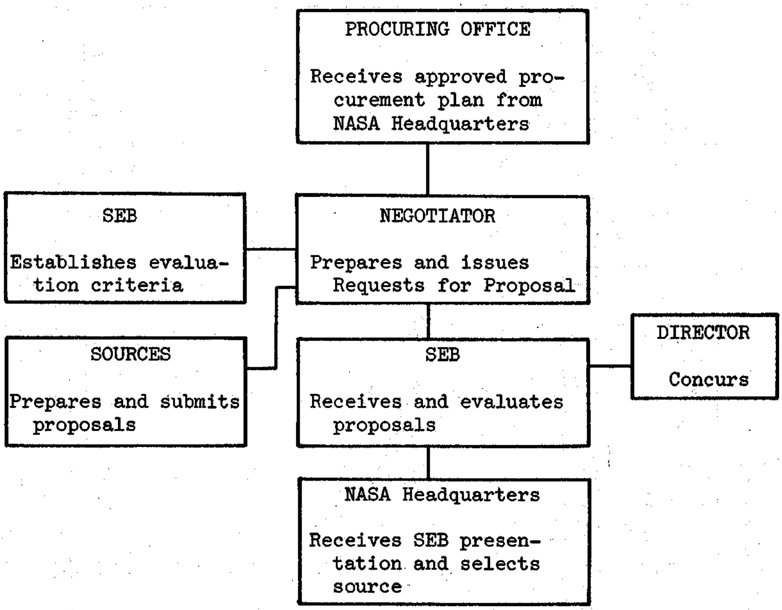

Figure 5-2.- Procurement cycle (source selection through the Source Evaluation Board (SEB)).

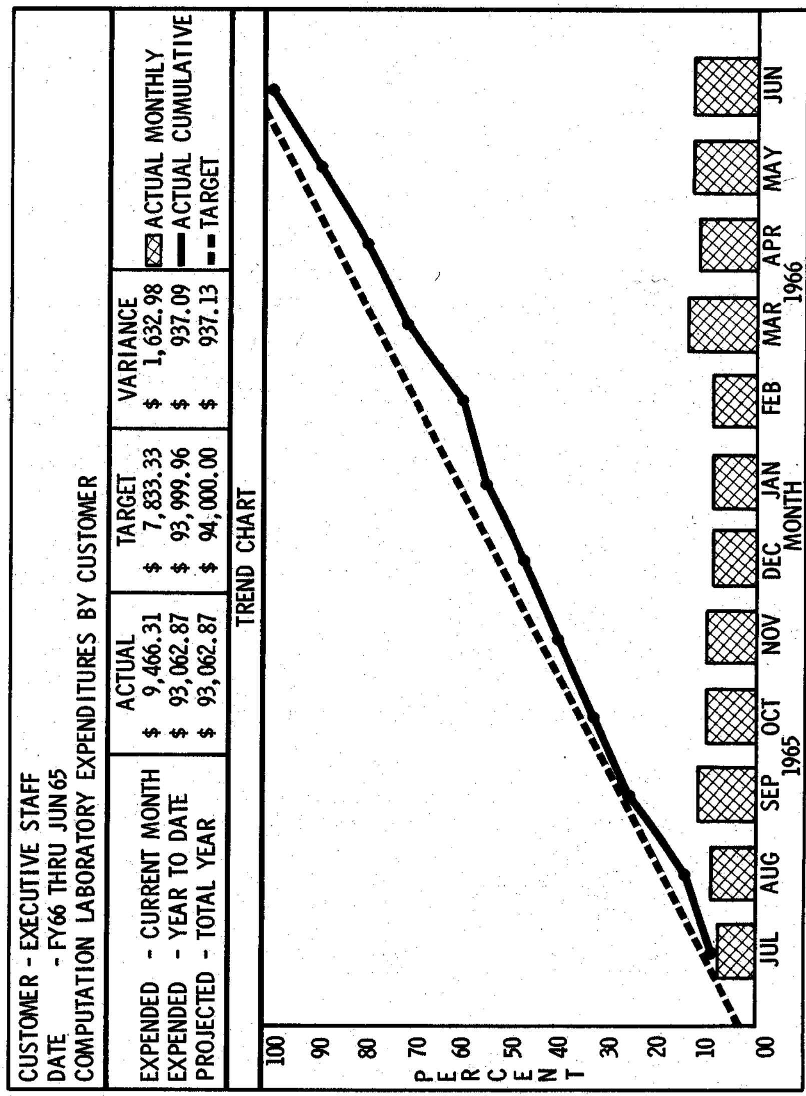

Figure 5-3.- Customer periodic report.

6.0 FUNDING SUMMARY

During FY 1967 and early 1968, the three MSF Centers will be engaged in making major equipment changes. At Kennedy Space Center, the GE 635 system installed in the Central Instrumentation Facility will be expanded to provide for simultaneous testing of multiple vehicles. The expansion will permit centralization of all data processing and will accommodate the business-type applications that formerly required separate machines.

At Marshall Space Flight Center in Huntsville and at Slidell, all of the existing general-purpose computers are being replaced by a central multiprogrammed-multiprocessor system at each location. Involved in the change are 39 computers and 48 remotes that will be replaced by the UNIVAC 1108 II computers being phased in by late 1968.

The general-purpose scientific and engineering computers at Manned Spacecraft Center are being installed in early 1967. The RTCC Mission Control Center, where computer capabilities are required for mission monitoring, inflight mission planning, and simulation, is in the process of converting to IBM 360 computers for use in the Apollo Spacecraft Program.

Attached are summary statistical schedules (tables 6-I to 6-III) by fiscal years 1966, 1967, and 1968 for both category A (general-purpose computers) and category B (special-purpose computers). These schedules reflect costs by appropriation and by purpose of funding (purchase, lease, and maintenance). The total equipment costs for FY 1966, 1967, and 1968 are $43,900,000, $36,100,000, and $29,600,000, respectively. Figures 6-1 and 6-2 depict equipment costs for the past, current, and budget years. Figure 6-1 illustrates OMSF equipment costs in relation to the other Program Offices. Figure 6-2 shows the costs of each Center by funding method. (Refer to figure 1-2 for a breakdown of the equipment costs by appropriation.)

One trend that can be seen from reviewing the total equipment costs is the continuing reduction in fiscal years 1967 and 1968. Fiscal year 1967 total equipment costs are $7,800,000 less than those for FY 1966, and FY 1968 costs are $6,500,000 less than those for FY 1967. These reductions in costs are the result of the installation of third-generation equipment and the centralization of the computational capability.

TABLE 6-I.- MANNED SPACE FLIGHT AUTOMATIC DATA PROCESSING EQUIPMENT, CATEGORY A

(a) Fiscal year 1966 (thousands of dollars)

Centers	Purchase	Lease	Maintenance	Total
Research and Development:				
Kennedy Space Center	--	$792	$347	$1,139
Manned Spacecraft Center	$13	11,335	--	11,348
Marshall Space Flight Center	1,320	6,380	21	7,721
Total, R & D	$1,333	$18,507	$368	$20,208
Administrative Operations:				
Kennedy Space Center	--	$947	--	$947
Manned Spacecraft Center	$370	4,974	$288	5,632
Marshall Space Flight Center	--	3,869	314	4,183
Total, AO	$370	$9,790	$602	$10,762
Construction of Facilities:				
Kennedy Space Center	$3,759	--	--	$3,759
Manned Spacecraft Center	--	--	--	--
Marshall Space Flight Center	--	--	--	--
Total, C of F	$3,759	--	--	$3,759
Summary All Appropriations:				
Kennedy Space Center	$3,759	$1,739	$347	$5,845
Manned Spacecraft Center	383	16,309	288	16,980
Marshall Space Flight Center	1,320	10,249	335	11,904
Total	$5,462	$28,297	$970	$34,729

TABLE 6-I.- MANNED SPACE FLIGHT AUTOMATIC DATA PROCESSING EQUIPMENT, CATEGORY A - Continued

(b) Fiscal year 1967 (thousands of dollars)

Centers	Purchase	Lease	Maintenance	Total
Research and Development:				
Kennedy Space Center	--	$450	$300	$750
Manned Spacecraft Center	--	12,973	--	12,973
Marshall Space Flight Center	--	6,638	53	6,691
Total, R & D	--	$20,061	$353	$20,414
Administrative Operations:				
Kennedy Space Center	--	$1,151	--	$1,151
Manned Spacecraft Center	--	4,397	$487	4,884
Marshall Space Flight Center	--	3,672	299	3,971
Total, AO	--	$9,220	$786	$10,006
Summary All Appropriations:				
Kennedy Space Center	--	$1,601	$300	$1,901
Manned Spacecraft Center	--	17,370	487	17,857
Marshall Space Flight Center	--	10,310	352	10,662
Total	--	$29,281	$1,139	$30,420

TABLE 6-I.- MANNED SPACE FLIGHT AUTOMATIC DATA PROCESSING EQUIPMENT, CATEGORY A - Concluded

(c) Fiscal year 1968 budget (thousands of dollars)

Centers	Purchase	Lease	Maintenance	Total
Research and Development:				
Kennedy Space Center	$2,048	$364	$441	$2,853
Manned Spacecraft Center	--	9,352	--	9,352
Marshall Space Flight Center	--	3,574	63	3,637
Total, R & D	$2,048	$13,290	$504	$15,842
Administrative Operations:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	--	$5,437	$460	$5,897
Marshall Space Flight Center	--	5,063	329	5,392
Total, AO	--	$10,500	$789	$11,289
Summary All Appropriations:				
Kennedy Space Center	$2,048	$364	$441	$2,853
Manned Spacecraft Center	--	14,789	460	15,249
Marshall Space Flight Center	--	8,637	392	9,029
Total	$2,048	$23,790	$1,293	$27,131

TABLE 6-II.- MANNED SPACE FLIGHT AUTOMATIC DATA PROCESSING EQUIPMENT, CATEGORY B

(a) Fiscal year 1966 (thousands of dollars)

Centers	Purchase	Lease	Maintenance	Total
Research and Development:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	$6,802	$1,788	$179	$8,769
Marshall Space Flight Center	--	283	18	301
Total, R & D	$6,802	$2,071	$197	$9,070
Administrative Operations:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	--	--	--	--
Marshall Space Flight Center	--	$5	$82	$87
Total, AO	--	$5	$82	$87
Summary All Appropriations:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	$6,802	$1,788	$179	$8,769
Marshall Space Flight Center	--	288	100	388
Total	$6,802	$2,076	$279	$9,157

TABLE 6-II.- MANNED SPACE FLIGHT AUTOMATIC DATA PROCESSING EQUIPMENT, CATEGORY B - Continued

(b) Fiscal year 1967 (thousands of dollars)

Centers	Purchase	Lease	Maintenance	Total
Research and Development:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	$2,150	$2,825	$232	$5,207
Marshall Space Flight Center	--	302	18	320
Total, R & D	$2,150	$3,127	$250	$5,527
Administrative Operations:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	--	--	--	--
Marshall Space Flight Center	--	$60	$97	$157
Total, AO	--	$60	$97	$157
Summary All Appropriations:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	$2,150	$2,825	$232	$5,207
Marshall Space Flight Center	--	362	115	477
Total	$2,150	$3,187	$347	$5,684

TABLE 6-II.- MANNED SPACE FLIGHT AUTOMATIC DATA PROCESSING EQUIPMENT, CATEGORY B - Concluded

(c) Fiscal year 1968 budget (thousands of dollars)

Centers	Purchase	Lease	Maintenance	Total
Research and Development:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	$300	$1,588	$132	$2,020
Marshall Space Flight Center	--	274	12	286
Total, R & D	$300	$1,862	$144	$2,306
Administrative Operations:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	--	--	--	--
Marshall Space Flight Center	--	$60	$81	$141
Total, AO	--	$60	$81	$141
Summary All Appropriations:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	$300	$1,588	$132	$2,020
Marshall Space Flight Center	--	334	93	427
Total	$300	$1,922	$225	$2,447

TABLE 6-III.- MANNED SPACE FLIGHT AUTOMATIC DATA PROCESSING EQUIPMENT, CATEGORIES A AND B

(a) Fiscal year 1966 (thousands of dollars)

Centers	Purchase	Lease	Maintenance	Total
Research and Development:				
Kennedy Space Center	--	$792	$347	$1,139
Manned Spacecraft Center	$6,815	13,123	179	20,117
Marshall Space Flight Center	1,320	6,663	39	8,022
Total, R & D	$8,135	$20,578	$565	$29,278
Administrative Operations:				
Kennedy Space Center	--	$947	--	$947
Manned Spacecraft Center	$370	4,974	$288	5,632
Marshall Space Flight Center	--	3,874	396	4,270
Total, AO	$370	$9,795	$684	$10,849
Construction of Facilities:				
Kennedy Space Center	$3,759	--	--	$3,759
Manned Spacecraft Center	--	--	--	--
Marshall Space Flight Center	--	--	--	--
Total, C of F	$3,759	--	--	$3,759
Summary All Appropriations:				
Kennedy Space Center	$3,759	$1,739	$347	$5,845
Manned Spacecraft Center	7,185	18,097	467	25,749
Marshall Space Flight Center	1,320	10,537	435	12,292
Total	$12,264	$30,373	$1,249	$43,886

TABLE 6-III.- MANNED SPACE FLIGHT AUTOMATIC DATA PROCESSING EQUIPMENT, CATEGORIES A AND B - Continued

(b) Fiscal year 1967 (thousands of dollars)

Centers	Purchase	Lease	Maintenance	Total
Research and Development:				
Kennedy Space Center	--	$450	$300	$750
Manned Spacecraft Center	$2,150	15,798	232	18,180
Marshall Space Flight Center	--	6,940	71	7,011
Total, R & D	$2,150	$23,188	$603	$25,941
Administrative Operations:				
Kennedy Space Center	--	$1,151	--	$1,151
Manned Spacecraft Center	--	4,397	$487	4,884
Marshall Space Flight Center	--	3,732	396	4,128
Total, AO	--	$9,280	$883	$10,163
Summary All Appropriations:				
Kennedy Space Center	--	$1,601	$300	$1,901
Manned Spacecraft Center	$2,150	20,195	719	23,064
Marshall Space Flight Center	--	10,672	467	11,139
Total	$2,150	$32,468	$1,486	$36,104

TABLE 6-III.- MANNED SPACE FLIGHT AUTOMATIC DATA PROCESSING EQUIPMENT, CATEGORIES A AND B - Concluded

(c) Fiscal year 1968 budget (thousands of dollars)

Centers	Purchase	Lease	Maintenance	Total
Research and Development:				
Kennedy Space Center	$2,048	$364	$441	$2,853
Manned Spacecraft Center	300	10,940	132	11,372
Marshall Space Flight Center	--	3,848	75	3,923
Total, R & D	$2,348	$15,152	$648	$18,148
Administrative Operations:				
Kennedy Space Center	--	--	--	--
Manned Spacecraft Center	--	$5,437	$460	$5,897
Marshall Space Flight Center	--	5,123	410	5,533
Total, AO	--	$10,560	$870	$11,430
Summary All Appropriations:				
Kennedy Space Center	$2,048	$364	$441	$2,853
Manned Spacecraft Center	300	16,377	592	17,269
Marshall Space Flight Center	--	8,971	485	9,456
Total	$2,348	$25,712	$1,518	$29,578

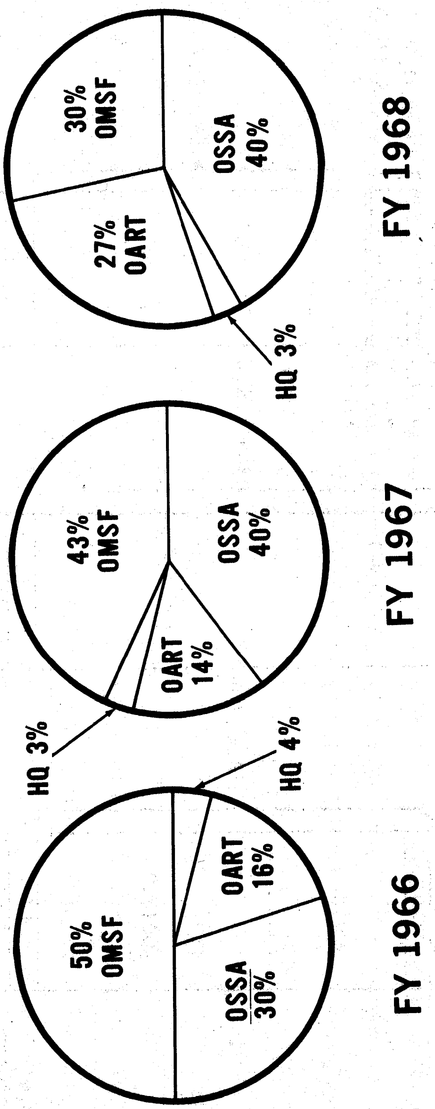

Figure 6-1.- Computer Equipment Costs, percentage by program office.

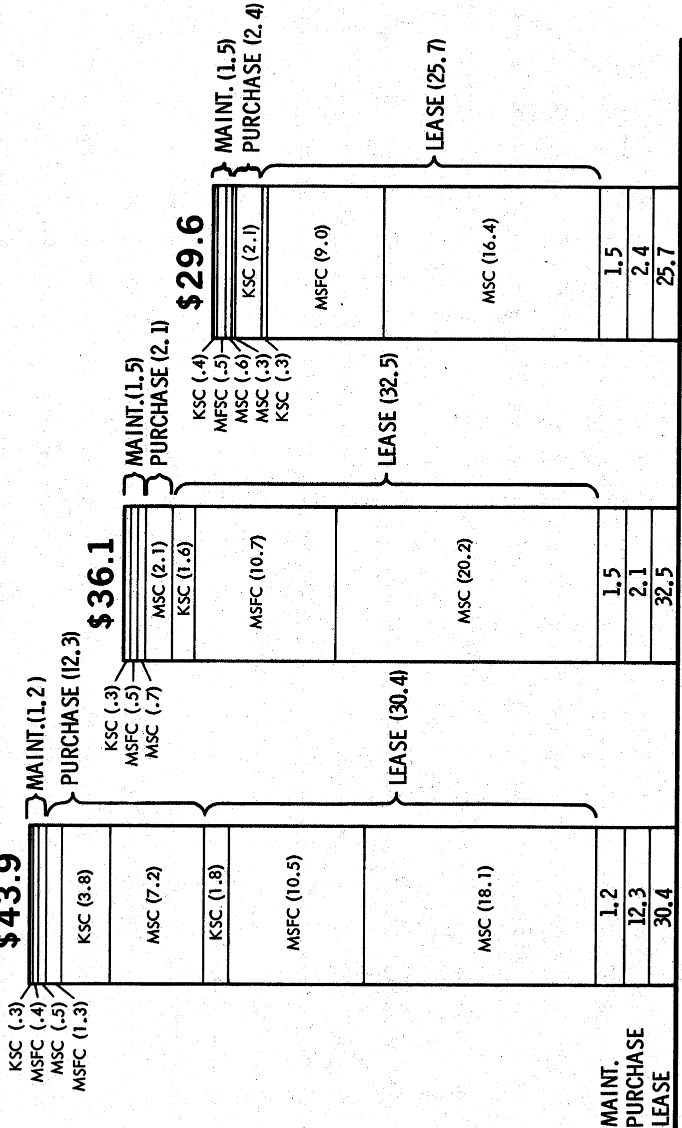

Figure 6-2.- Manned Space Flight computer equipment cost by center and funding method in millions of dollars.

7.0 CONCLUSIONS

This survey was conducted to provide information on Manned Space Flight computer systems in terms of their use, capabilities, and the techniques used to manage these systems. It has become clear that the computer systems being used in the MSF programs are an essential part of the overall NASA mission, and the sustained growth of computers in MSF reflects the continual blending of this tool into on-going research and development programs. Not only has automatic data processing shown a growth in magnitude in MSF, but by its very nature, the diversity of its applications has also increased. Although, in many government agencies, emphasis still seems to be placed on the business and management applications, only 5 percent of the digital computers in Manned Space Flight are used for that purpose; the remaining 95 percent are used in scientific and technical research and development activities, including real-time mission control. The task of managing the computer systems in the MSF organization, then, has by necessity been tailored to the preponderance of the research and development computational activities.

The large number of computers in use in the Manned Space Flight program and the wide range of their applications have led to a classification of computer hardware that recognizes the functional area in which the equipment operates. As a result, computers in this survey report have been described in terms of mission control, test and checkout, training, and data processing, including real-time, general and special purpose, and service center operation. The capability of MSF computers has been carefully structured to match the missions and workload of the organization. Special efforts, as in the Mission Control Center, have been made to take optimum advantage of advanced techniques in planning the procedures and resources needed for the most advanced system design. Thus, the MSF organization has, by necessity, operated on the frontiers of computer technology to achieve an orderly and coordinated program of computer capability.

An inventory of computers has been included in this survey (appendix A). This inventory identifies each system, whether it is purchased or leased, the average monthly hours it is in service, and its location in the MSF organization. The inventory has been expanded over previously published inventories to include those special-purpose computers which, in the past, did not meet reporting criteria, since they were integral parts of total systems whose usage was dependent on total-system utilization. Although the computers have been categorized as being in category A (general purpose) or category B (special purpose), this

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classification has many shortcomings stemming from the fact that computers do not fit neatly into such narrow classifications, and there are many cases where a single computer installation functions within both categories in meeting varying program demands. Further, the utilization figures are not necessarily a meaningful comparison between computers, since they are not an adequate description of the utility of the computers in their diverse applications. However, in the absence of a universally accepted computer classification system, which would not only reflect the different purposes for which computers are used but also the operating requirements surrounding their uses, the present A and B categorizations have been used as a reasonable basis for making appropriate distinctions in applying policies.

The Manned Space Flight organization for managing its computer resources has been structured to carry out overall programs of which the computers are an integral part. Because of the differing missions at each of the MSF Centers, the computer organizations which have been developed are also different. However, in all cases, the thread of similarity which runs through each of the Center's organizations is that the director of the Center is the final authority for computer policies at that Center. All computer acquisitions must be approved at his level prior to submission to NASA Headquarters for final approval.

Programming and computer operation at each center is carried out primarily by contractor support personnel on a task-order basis. The contractor method of supporting computers in MSF has provided a highly trained staff through the peaks and valleys of work requirements. The total number of contractor personnel used by the MSF Centers in computer support of all programs is approximately 2200.

While the capability of MSF computers is expanding to meet increased program requirements, with equipment changes to third-generation hardware, the FY 1967 and FY 1968 costs show a significant decrease. This reduction can be attributed to both the third-generation hardware, which has a greater computation per dollar ratio, as well as to the centralization of computational capability. Both of these trends are continuing.

The natural growth that has been characteristic of the computer industry has resulted in a whole new generation of computer equipment that has necessitated frequent re-appraisals of existing management techniques and the development of new procedures, such as the ADP Resources Sharing Panel, which have immeasurably improved our ability to carry out manned programs.

There is a continuing awareness in the MSF program that the computer is inextricably entwined with the achievement of manned spaceflight goals. The application of computers must be viewed in terms of their relationship to the total mission-oriented structure of the agency. The basic policies and procedures by which the MSF organization manages its computer resources are a prudent course which will be continued on a high-priority basis with such modifications and refinements as may be suggested by future experience.

APPENDIX A

COMPUTER INVENTORY

NASA has adopted a two-part categorization of computers. Category A computers are general purpose in character and make up the large centralized computer service facilities at the Centers. Major management effort is directed to this category with emphasis on utilization and cost. Acquisitions are individually approved by the Deputy Administrator and operations are subject to detailed management reporting. Category B computers are special purpose in character. These computers are dedicated to a single use and are usually part of a larger system with special interface requirements included in the installation. Special purpose computers are normally purchased and acquisition is accomplished through normal program management channels. Management reporting is confined to an annual inventory. The inventories for category A and category B computers for Marshall Space Flight Center, the Manned Spacecraft Center, and Kennedy Space Center are given in tables A-I to A-VI.

TABLE A-I.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER

[Category A equipment]

Center location	Computer type	Owner-ship (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSFC - Bldg. 4200	CDC 3200	L	42	87	9/65	12/67	Scientific data processing
	IBM 1620	L	125	12	10/62	10/66	Meteorological data processing
	SDS 930	P	41	49	9/65	--	Scientific data processing
	SDS 930	P	45	70	9/65	--	Scientific data processing
MSFC - Bldg. 4202	SDS 930	L	45	75	9/65	2/68	Scientific data processing
MSFC - Bldg. 4351	UNIVAC 422	P	60	--	9/65	--	Training
MSFC - Bldg. 4481	IBM 1620	L	250	--	11/65	10/66	Scientific data processing
	IBM 1620	L	200	--	7/65	2/68	Software development
MSFC - Bldg. 4485	IBM 1401	L	137	11	8/62	9/67	IBM 7010 support
MSFC - Bldg. 4487	GE 235	L	82	22	1/65	4/68	Scientific data processing
	GE 235	P	200	--	12/64	--	Scientific data processing
MSFC - Bldg. 4487	IBM 1130	L	N/A[b]	N/A	1/66	2/68	Scientific data processing
MSFC - Bldg. 4491	IBM 1401	L	307	10	5/61	3/68	Business applications
	IBM 7010	L	320	94	9/65	9/67	Business applications
	IBM 7010	L	320	94	1/66	3/68	Business applications
	IBM 7740	L	160	17	7/64	3/68	Business applications

[a]Leased is indicated by an L; purchased by a P.
[b]Not available.

TABLE A-I.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER - Continued

[Category A equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSFC - Bldg. 4610	IBM 1620	L	112	39	9/62	11/66	Saturn weight control
	IBM 1620	L	58	23	12/62	10/66	Scientific data processing
	SDS 930	L	46	37	9/65	12/67	Scientific data processing
MSFC - Bldg. 4663	B 5500	L	250	136	7/65	9/67	Data processing
	IBM 1401	L	120	70	8/61	9/67	Support to 7094 II
	IBM 1401	L	120	70	1/64	9/67	Support to 7094 II
	IBM 1401	L	120	70	2/65	9/67	Support to 7094 II
	IBM 1401	L	450	--	10/63	7/67	Data processing printing
	IBM 1401	L	450	--	11/61	7/67	Data processing printing
	IBM 1401	L	450	--	4/62	7/67	Data processing printing
	IBM 7094 II	P	300	200	1/60	--	Scientific data processing
	IBM 7094 II	P	300	200	1/60	--	Scientific data processing
MSFC - Bldg. 4708	GE 235	L	65	135	12/64	3/68	Scientific data processing
MSFC - Bldg. 4728	RECOMP	L	100	--	1963	4/68	Scientific data processing
MSFC - Bldg. 4732	GE 205	P	112	--	12/64	--	Scientific data processing with wind tunnel
MSFC - 3016 University Drive	RCA 110	P	N/A[b]	N/A	6/62	--	Training in programing and maintenance

[a]Leased is indicated by an L; purchased by a P.

[b]Not available.

TABLE A-I.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER - Concluded

[Category A equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSFC - MAF	GE 235	L	144	38	7/65	9/68	Scientific data processing
MSFC - MAF	IBM 1440	L	385	0	6/65	9/68	Data processing
MSFC - Slidell	HON 200	L	547	6	10/64	9/68	Data processing
	HON 200	L	535	2	12/64	7/67	Data processing
	HON 800	L	290	90	12/62	5/67	Data processing
	HON 800	L	119	164	9/64	11/68	Data processing
	HON 1800	L	228	60	1/65	7/67	Data processing
	HON 1800	L	230	63	4/65	9/68	Data processing
	IBM 1401	L	402	24	8/62	7/67	Support IBM 7094
	IBM 7040	L	171	230	3/65	9/68	Data processing - scientific DCS 7094 II
	IBM 7094 II	P	177	193	11/62	--	Data processing - scientific DCS 7040
	IBM 7094 II	L	315	95	1/64	7/67	Data processing - scientific

[a]Leased is indicated by an L; purchased by a P.

TABLE A-II.- INVENTORY OF COMPUTERS, MANNED SPACECRAFT CENTER

[Category A equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSC - Bldg. 12	CDC 3200	P	281	174	12/64	--	TM conversion
	CDC 3200	P	197	318	12/64	--	DCS with CDC 3800 data processing
	UNIVAC 1108	P	285	135	2/66	--	Scientific data processing
	CDC 3800	P	275	198	2/64	--	Data processing DCS with CDC 3200
	IBM 360/30	L	225	201	10/65	5/67	Data processing support to DCS
	IBM 7040	L	275	132	8/63	10/66	Scientific data processing
	IBM 7044	L	364	176	2/64	5/67	Data processing DCS 7044/7094
	IBM 7094 II	L	364	176	2/64	5/67	Data processing DCS 7044/7094
	UNIVAC 1106	P	250	133	2/65	--	Business data processing
MSC - Bldg. 16	CDC 3600	L	270	195	6/65	3/69	Scientific data processing
MSC - Bldg. 30	IBM 1401	L	235	195	9/63	12/66	Data processing support to 7094 I
	IBM 7094 I	P	401	164	7/65	--	Scientific data processing
MSC - TRW, Nassau	IBM 360/30	L	237	173	11/65	Indef.	Data processing support to 7094 I
	IBM 7094 I	P	398	167	10/61	--	Scientific data processing

[a] Leased is indicated by an L; purchased by a P.

TABLE A-II.- INVENTORY OF COMPUTERS, MANNED SPACECRAFT CENTER - Continued

[Category A equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSC - Ellington AFB	IBM 360/30	L	180	150	4/66	11/66	Business data processing
	IBM 7010	L	287	185	6/65	11/66	Business data processing
MSC - White Sands	CDC 3200	P	320	95	1/65	--	Data processing and TM reduction
MSC - Bldg. 30	IBM 360/30	L	385	--	9/65	12/66	Peripheral support of RTCC computers (printer, tape/print, etc.)
	IBM 360/75	L	--	511	5/66	2/70	RTCC program development
	IBM 360/75	L	--	376	6/66	2/70	RTCC program development
	IBM 360/75	L	--	438	6/66	2/70	RTCC program development
	IBM 7094 II	L	--	564	7/64	11/66	Mission control and program development
	IBM 7094 II	L	--	576	1/63	12/66	Real-time mission control
	IBM 7094 II	L	--	515	5/63	1/67	Real-time mission control
	IBM 7094 II	L	--	559	9/63	7/65	Mission simulation for flight operations training
	IBM 7094 II	L	--	412	1/64	1/67	Real-time mission control and program development

[a] Leased is indicated by an L; purchased by a P.

TABLE A-II.- INVENTORY OF COMPUTERS, MANNED SPACECRAFT CENTER - Concluded

[Category A equipment]

Center location	Computer type	Owner-ship (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSC - Bldg. 30	IBM 1460	L	--	295	9/64	8/66	Peripheral support to RTCC computers
MSC - Beta Bldg.	IBM 360/30	L	--	563	12/65	10/66	Peripheral support of RTCC computers (printer, tape/print, etc.)
	IBM 360/50	L	--	583	1/66	8/66	RTCC program development

[a]Leased is indicated by an L; purchased by a P.

TABLE A-III.- INVENTORY OF COMPUTERS, KENNEDY SPACE CENTER

[Category A equipment]

Center location	Computer type	Owner-ship (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
KSC CIF	GE 635	P	247	191	11/65	--	Data processing and TM data reduction - on-line
	GE 235	L	120	20	8/63	6/67	Scientific data processing and TM data reduction - on-line
	GE 415	L	605	31	5/64	6/67	Data processing - support card to tape/tape to card/tape to print
	UNIVAC 1004	P	180	9	6/65	--	Data processing - printing and LIEF support - on-line
	UNIVAC 1004	P	180	9	6/65	--	Data processing - printing and LIEF support - on-line
	UNIVAC 1004	P	480	--	5/65	--	Data processing - printing
	IBM 7010	L	538	39	4/66	6/67	Data processing and real-time supply system DCS 1440
	IBM 1440	L	538	39	5/65	6/67	DCS 7010, Data processing and real-time supply system
	IBM 7010	L	500	110	2/66	6/68	Business data processing

[a]Leased is indicated by an L; purchased by a P.

TABLE A-IV.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSFC - Bldg. 4436	No. 1 RCA 110	P	N/A[b]	N/A	12/63	--	Simulation in Saturn IB breadboard
	No. 503 RCA 110A	P	450	--	3/65	--	Saturn IB breadboard
	No. 504 RCA 110A	P	450	--	3/65	--	Saturn IB breadboard
	No. 1 SDS 910	P	285	--	12/64	--	(DEE 3B) Saturn IB breadboard (PTCS simulation)
	No. 2 SDS 930	P	450	--	8/64	--	(DEE 6) Saturn IB breadboard
	SEL 810	P	350	--	12/65	--	Used with Saturn IB breadboard
MSFC - Bldg. 4487	DEC PDP 5	P	240	--	5/64	--	Checkout inertial components
	DEC PDP 5	P	240	--	5/64	--	Checkout inertial components
	DEC PDP 5	P	240	--	5/64	--	Checkout inertial components
	DDP 224	P	N/A	N/A	2/66	--	Saturn V display program debug
	RAY 250	P	N/A	N/A	7/60	--	Function generator in hybrid system
	RAY 250	P	N/A	N/A	12/62	--	Function generator in hybrid system

[a]Leased is indicated by an L; purchased by a P.
[b]Not available.

TABLE A-IV.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER - Continued

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSFC - Bldg. 4487	RAY 250	P	N/A[b]	N/A	1/63	--	Function generator in hybrid system
	No. 501 RCA 110A	P	450	--	9/65	--	Saturn IB and V breadboard support program debug
	No. 522 RCA 110A	P	450	--	2/66	--	Saturn IB and V breadboard support program debug
	SEL 810	P	N/A	N/A	7/65	--	Used with GE 235 as display driver
MSFC - Bldg. 4566	GE 235	L	250	--	11/64	1/68	On- and off-line acoustic data processing
MSFC - Bldg. 4570	No. 3 BEC 420	P	215	--	3/65	--	Used with engine test stands
	No. 4 BEC 420	P	215	--	3/65	--	Used with engine test stands
	No. 5 BEC 420	P	215	--	2/66	--	Used with engine test stands
	No. 6 BEC 420	P	215	--	2/66	--	Used with engine test stands
	No. 5 RCA 110	P	170	--	11/63	--	Saturn IB and S-IVB static-firing checkout

[a]Leased is indicated by an L; purchased by a P.
[b]Not available.

TABLE A-IV.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER - Continued

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSFC - Bldg. 4570	No. 3 SDS 910	P	120	--	5/65	--	(DEE 3) Saturn IB and S-IVB static-firing checkout
MSFC - Bldg. 4583	No. 2137 SDS 920	P	170	--	5/65	--	S-IV and S-IC component checkout
	No. 2141 SDS 920	P	170	--	5/65	--	S-IV and S-IC component checkout
MSFC - Bldg. 4619	No. 1 GE 235	P	200	--	7/64	--	On-line with stress test stands
	No. 9 GE 235	P	200	--	5/64	--	On-line with stress stands
MSFC - Bldg. 4626	GE 205	P	125	12	12/64	--	Meteorology
MSFC - Bldg. 4646	No. 2145 SDS 920	P	170	--	5/65	--	S-IC and S-IVB component checkout
MSFC - Bldg. 4663	ASI 2100	P	170	--	7/65	--	Used in hybrid system
	DDP 116	P	N/A[b]	N/A	5/66	--	Used in hybrid system
	DDP 224	P	N/A	N/A	10/65	--	Processes TM for input to B5500 (part of LIEF system)
	RAY 440	P	160	--	7/65	--	Used in hybrid system (TRICE)
	RAY 520	P	N/A	N/A	4/66	--	Used in hybrid system (TRICE)

[a]Leased is indicated by an L; purchased by a P.

[b]Not available.

TABLE A-IV.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER - Continued

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSFC - Bldg. 4663	SDS 92	P	130	--	2/66	--	Part of TM reduction system
MSFC - Bldg. 4674	No. 15 PDP 1	P	215	--	2/64	--	Used with engine test stands
	No. 16 PDP 1	P	215	--	2/64	--	Used with engine test stands
	No. 47 PDP 1	P	215	--	7/64	--	Used with engine test stands
	No. 46 PDP 1	P	215	--	7/64	--	Used with engine test stands
	No. 4 RCA 110	P	100	--	11/65	--	Simulation of S-IC, also software development
	No. 512 RCA 110A	P	190	--	7/65	--	S-IC static-firing checkout
	No. 9 SDS 910	P	N/A[b]	N/A	4/65	--	(DEE 3) S-IC static-firing checkout
MSFC - Bldg. 4708	DDP 224	P	650	--	2/66	--	Saturn V breadboard display processor
	No. 502 RCA 110A	P	215	--	1/65	--	S-IC checkout

[a]Leased is indicated by an L; purchased by a P.

[b]Not available.

TABLE A-IV.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER - Continued

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSFC - Bldg. 4708	No. 007 RCA 110A	P	650	--	6/65	--	Saturn V breadboard
	No. 013 RCA 110A	P	650	--	7/65	--	Saturn V breadboard
	No. 1122 SDS 910	P	220	--	9/63	--	(DEE 3) part of vehicle checkout station
	No. 1 SDS 910	P	330	--	11/64	--	(DEE 3A) part of S-IC checkout station
	No. 003 SDS 930	P	450	--	4/65	--	(DEE 6C) Saturn V breadboard
	No. 006 SDS 930	P	N/A[b]	N/A	1/66	--	(DEE 6D) Saturn V breadboard
	No. 3118 SDS 930	P	215	--	1/65	--	Used for stage checkout
	No. 1001 SEL 810	P	N/A	N/A	11/65	--	Used with GETS to simulate TM
	No. 1004 SEL 810	P	N/A	N/A	12/65	--	TM processor
MSFC - 3016 University Drive	No. 1179 SDS 910	P	N/A	N/A	1964	--	Trainer for ATOLL language training

[a] Leased is indicated by an L; purchased by a P.
[b] Not available.

TABLE A-IV.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER - Continued

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
NAA - Downey	CDC 924A	P	N/A[b]	N/A	8/63	--	Program development facility
	CDC 924A	P	N/A	N/A	10/63	--	Program development facility
	CDC 8090	P	N/A	N/A	5/65	--	Program development facility
NAA - Seal Beach	CDC 924A	P	N/A	N/A	7/65	--	S-II checkout station no. 8
	CDC 924A	P	N/A	N/A	7/66	--	S-II checkout station no. 9
	CDC 8090	P	N/A	N/A	10/65	--	S-II checkout station no. 8
	CDC 8090	P	N/A	N/A	4/66	--	S-II checkout station no. 9
MSFC - MAF	RCA 110A	P	N/A	N/A	4/65	--	S-IC checkout
	RCA 110A	P	N/A	N/A	7/65	--	S-IC checkout
	RAY 250 (7 each)	P	N/A	N/A	1964	--	Factory checkout of S-IB station no. 1 and station no. 2
	SDS 910	P	N/A	N/A	1964	--	S-IB checkout (DEE 3)
	SDS 910	P	N/A	N/A	1964	--	S-IB checkout (DEE 3)
	SDS 910	P	N/A	N/A	10/64	--	S-IC checkout (DEE 3)
	SDS 910	P	N/A	N/A	10/64	--	S-IC checkout (DEE 3)
MSFC - Mississippi Test Facility	GE 205	P	199	--	12/64	--	Scientific data processing

[a]Leased is indicated by an L; purchased by a P.

[b]Not available.

TABLE A-IV.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER - Continued

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSFC - Mississippi Test Facility	No. 1 BEC 420	P	N/A[b]	N/A	11/65	--	Test monitoring and control checkout
	No. 2 BEC 420	P	N/A	N/A	11/65	--	Test monitoring and control checkout
	No. 3 BEC 420	P	N/A	N/A	11/65	--	Test monitoring and control checkout
	No. 4 BEC 420	P	N/A	N/A	11/65	--	Test monitoring and control checkout
	CDC 924A	P	N/A	N/A	9/65	--	S-II static test no. A2
	CDC 924A	P	N/A	N/A	2/65	--	S-II static test no. A1
	CDC 8090	P	N/A	N/A	8/65	--	S-II static test no. A2 (DEE)
	CDC 8090	P	N/A	N/A	1/65	--	S-II static test no. A1 (DEE)
	No. 516 RCA 110A	P	N/A	N/A	8/65	--	S-IC static-firing checkout
	No. 10 SDS 910	P	N/A	N/A	5/65	--	(DEE 3) S-IC static-firing checkout
	SDS 930	P	N/A	N/A	8/66	--	On-line processing of TM

[a]Leased is indicated by an L; purchased by a P.
[b]Not available.

TABLE A-IV.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER - Continued

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSFC - Mississippi Test Facility	SDS 930	P	N/A[b]	N/A	8/66	--	On-line processing of TM
MSFC - Slidell	No. 203 RAY 520	L	660	--	3/66	5/69	Part of hybrid system (EAI 231R)
	No. 90 SDS 930	P	155	--	2/65	--	Part of TM processing system
Miscellaneous							
S-V Dynamic Test Stand	SEL 840	P	N/A	N/A	2/66	--	Used on-line with dynamic test stand
Douglas Aircraft Company							
Huntington Beach	CDC 924A	P	N/A	N/A	7/64	--	EDSIL
	CDC 924A	P	N/A	N/A	7/64	--	S-IVB checkout station no. 1
	CDC 924A	P	N/A	N/A	7/65	--	S-IVB checkout station no. 2
	CDC 8090	P	N/A	N/A	7/65	--	EDSIL (DEE)
	CDC 8090	P	N/A	N/A	8/65	--	S-IVB checkout station no. 1 (DEE)
	CDC 8090	P	N/A	N/A	10/65	--	S-IVB checkout station no. 2 (DEE)
	No. 517 RCA 110A	P	N/A	N/A	8/65	--	IU 500 FS checkout

[a]Leased is indicated by an L; purchased by a P.

[b]Not available.

TABLE A-IV.- INVENTORY OF COMPUTERS, MARSHALL SPACE FLIGHT CENTER - Concluded

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
Huntington Beach	SDS 930	P	N/A[b]	N/A	1965	--	IU 500 FS checkout (DEE 6)
Sacramento	CDC 924A	P	N/A	N/A	10/65	--	Vertical checkout laboratory
	CDC 924A	P	N/A	N/A	9/65	--	Beta 1 static test stand
	CDC 924A	P	N/A	N/A	9/65	--	Beta 3 static test stand
	CDC 8090	P	N/A	N/A	8/65	--	Vertical checkout laboratory (DEE)
	CDC 8090	P	N/A	N/A	7/65	--	Beta 1 static test stand (DEE)
	CDC 8090	P	N/A	N/A	9/65	--	Beta 3 static test stand (DEE)
IBM - Huntsville	DDP 224	P	N/A	N/A	7/66	--	Display processor - S-V IU checkout
	GE 235	P	200	--	7/65	--	G&C simulation
	No. 505 RCA 110A	P	345	--	5/65	--	S-IB IU checkout
	No. 506 RCA 110A	P	345	--	8/65	--	S-V IU checkout
	No. 2 SDS 910	P	280	--	2/65	--	(DEE 3A) S-IB IU checkout
	No. 3 SDS 910	P	280	--	2/65	--	(DEE 3A) S-V IU checkout
	SEL 810	P	N/A	N/A	7/65	--	Used with GE 235 as display driver

[a] Leased is indicated by an L; purchased by a P.
[b] Not available.

TABLE A-V.- INVENTORY OF COMPUTERS, MANNED SPACECRAFT CENTER

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSC - Bldg. 4	Two CDC 160G	P	250	--	2/63	--	Computer program development for ACE (spacecraft checkout)
	Two CDC 160A	P	250	--	9/62	--	Computer program development for ACE (spacecraft checkout)
MSC - Bldg. 5	DDP 024	L	200	176	6/65	11/66	Gemini mission simulator (astronaut training)
	Two DDP 024	P	440	30	11/64	[b]2/67	Stations for Gemini mission simulator (astronaut training)
	Two DDP 024	P	400	100	11/65	--	Support of Apollo mission simulator
	Three DDP 224	P	124	370	12/65	--	Flight crew trainer (Apollo mission simulator)
	SDS 930	L	150	--	2/65	6/67	Real-time flight simulation for program development
MSC - Bldg. 12	UNIVAC 418	L	--	210	3/66	6/67	Communications processor to switch remote terminals
MSC - Bldg. 15	PDP 5	P	176	10	11/64	--	Real-time flight systems acceptance testing
	SEL 840	P	176	--	3/66	--	Transducer checkout of Apollo spacecraft
MSC - Bldg. 16	DDP 24	P	175	47	12/65	--	Real-time system simulation guidance and control system

[a] Leased is indicated by an L; purchased by a P.

[b] Release to Air Force on completion of Gemini Program.

TABLE A-V.- INVENTORY OF COMPUTERS, MANNED SPACECRAFT CENTER - Continued

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSC - Bldg. 16	Raytheon 250	P	160	--	12/64	--	Control of TRICE
	Raytheon 250	P	160	--	12/65	--	Digital differential analyzer
	Raytheon 440	P	160	--	5/64	--	Simulation guidance equipment and TRICE control function
MSC - Bldg. 24	SDS 910	P	650	40	4/64	--	Real-time system control - maintenance equipment for base facilities
MSC - Bldg. 29	Two DDP 24	P	60	60	4/65	--	Real-time control of suit and spacecraft systems acceleration tests
MSC - Bldg. 30	DMI 620	P	--	120	3/66	--	Development of data acquisition systems
	UNIVAC 1218	P	110	35	3/65	--	Development of flight operations displays for RTCC
	UNIVAC 1218	P	340	300	8/64	--	Quick-look processing of TM for command history
	UNIVAC 494	P	220	205	4/66	--	Communications processor - RTCC
	UNIVAC 494	P	220	205	6/66	--	Communications processor - RTCC
	UNIVAC 494	P	220	205	6/66	--	Communications processor - RTCC
	UNIVAC 418	L	180	40	10/65	12/66	Flight controllers simulation in MCC

[a]Leased is indicated by an L; purchased by a P.

TABLE A-V.- INVENTORY OF COMPUTERS, MANNED SPACECRAFT CENTER - Concluded

[Category B equipment]

Center location	Computer type	Owner-ship (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
MSC - Bldg. 32	Four CDC 160G (identical systems)	P	--	600	2 on 1/65 2 on 12/65	-- --	Spacecraft checkout (CSM and LM) and test program development
MSC - Bldg. 33	PDS 1020	P	--	250	5/65	--	Vacuum chamber monitoring
MSC - Bldg. 440	UNIVAC 1218	P	180	190	2/65	--	Certify S-band communications and remote site equipment
	UNIVAC 642B	P	180	190	3/66	--	Certify S-band communications and remote site equipment
	UNIVAC 1004	P	180	190	4/66	--	Certify S-band communications and remote site equipment
NAA - Downey Bldg. 290	Six CDC 160G (identical systems)	P	--	600	2 on 6/64 2 on 8/64 2 on 11/64	-- -- --	Eight more systems are at MILA and four more at MSC for spacecraft checkout (CSM and LM)
GAEC - Plant No. 5	Six CDC 160G (identical systems)	P	--	600	2 on 5/65 2 on 8/65 2 on 6/64	-- -- --	Eight more systems are at MILA and four more at MSC for spacecraft checkout (CSM and LM)
Pleasantville, New York	Two DDP 024	P	440	100	11/65	--	Support CSM and LM simulators
Fort Hood, Texas	SDS 920	L	100	--	3/65	12/71	Terminal landing calculation for space flights
Recovery Vessel - RETRIEVER	DMI 620	P	--	170	11/65	--	Processing of spacecraft telemetry data

[a]Leased is indicated by an L; purchased by a P.

TABLE A-VI.- INVENTORY OF COMPUTERS, KENNEDY SPACE CENTER

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
KSC - LC-34	0009 RCA 110A	P	420	90	6/65	--	Uprated Saturn I checkout
	0010 RCA 110A	P	420	90	6/65	--	Uprated Saturn I checkout
KSC - LC-37	0019 RCA 110A	P	420	90	2/66	--	Uprated Saturn I checkout
	0020 RCA 110A	P	420	90	1/66	--	Uprated Saturn I checkout
KSC - LC-39, LCC-1	0015 RCA 110A	P	420	90	11/66	--	Saturn V checkout
KSC - LC-39, LCC-2	0021 RCA 110A	P	420	90	10/66	--	Saturn V checkout
KSC - LC-39, LUT-1	0018 RCA 110A	P	420	90	12/65	--	Saturn V checkout
KSC - LC-39, LUT-2	0017 RCA 110A	P	420	90	10/66	--	Saturn V checkout
KSC - LC-39, VAB	0014 RCA 110A	P	420	90	4/66	--	Saturn V checkout support
KSC - LC-39, LCC-1	DDP 224	P	420	60	4/66	--	Saturn V checkout display processor
KSC - LC-39, LCC-2	DDP 224	P	420	60	10/66	--	Saturn V checkout display processor

[a]Leased is indicated by an L; purchased by a P.

TABLE A-VI.- INVENTORY OF COMPUTERS, KENNEDY SPACE CENTER - Continued

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
KSC - LC-39, VAB	DDP 224	P	420	60	10/66	--	Saturn V checkout support
KSC - MSOB	CDC 160G	P	230	228	3/65	--	CSM and LM checkout
	CDC 160G	P	230	228	3/65	--	CSM and LM checkout
	CDC 160G	P	230	228	8/65	--	CSM and LM checkout
	CDC 160G	P	230	228	8/65	--	CSM and LM checkout
	CDC 160G	P	230	228	6/66	--	CSM and LM checkout
	CDC 160G	P	230	228	6/66	--	CSM and LM checkout
	CDC 160G	P	230	228	8/66	--	CSM and LM checkout
	CDC 160G	P	230	228	8/66	--	CSM and LM checkout
KSC - CIF	SDS 930	P	160	120	8/65	--	TM processing, part of ALDS
	SDS 930	P	160	120	8/65	--	TM processing, part of ALDS
KSC - Bldg. AE	SDS 930	P	70	50	12/65	--	TM processing
KSC - LC-34	SDS 930	P	520	24	7/65	--	DEE 6E uprated Saturn I checkout
KSC - LC-37	SDS 930	P	520	24	2/66	--	DEE 6E uprated Saturn I checkout
KSC - LUT-1	SDS 930	P	520	24	3/66	--	DEE 6C Saturn V checkout

[a]Leased is indicated by an L; purchased by a P.

TABLE A-VI.- INVENTORY OF COMPUTERS, KENNEDY SPACE CENTER - Concluded

[Category B equipment]

Center location	Computer type	Ownership (a)	Production, hr/month	Test, hr/month	Date installed	Planned release	Application
KSC - LUT-2	SDS 930	P	520	24	9/66	--	DEE 6C Saturn V checkout
KSC - LUT-3	SDS 930	P	520	24	1/67	--	DEE 6C Saturn V checkout
KSC - Bldg. 409	DDP 224	P	124	370	5/66	--	Apollo flight crew trainer
	DDP 224	P	124	370	5/66	--	Apollo flight crew trainer
	DDP 224	P	124	370	5/66	--	Apollo flight crew trainer
KSC - Bldg. 40	DDP 024	P	440	30	12/64	--	Gemini flight crew trainer
	DDP 024	P	440	30	12/64	--	Gemini flight crew trainer
KSC - LC-34 (service structure)	SDS 910	P	450	--	5/65	--	Onboard instrumentation checkout
KSC - LC-34	SDS 910	P	90	24	11/65	--	Part of propellant tanking computer system DEE 3
KSC - VAB	SDS 910	P	--	--	--	--	Data processing and checkout computer support
KSC - LC-37	SDS 910	P	90	24	11/65	--	Part of propellant tanking computer system DEE 3
KSC - LC-39, Pad A	SDS 910	P	90	24	11/65	--	Part of propellant tanking computer system DEE 3
KSC - LC-39, Pad B	SDS 910	P	--	--	11/66	--	Part of propellant tanking computer system DEE 3

[a] Leased is indicated by an L; purchased by a P.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ACE	Acceptance Checkout Equipment
A/D	Analog to Digital
ADP	Automatic Data Processing
ADX	Automatic Data Exchange
AGS	Automatic Ground Station
ALDS	Apollo Launch Data System
AMS	Apollo Mission Simulator
APCU	Apollo Process Control Unit
ASTR	Astrionics Laboratory
B	Burroughs Corporation
BOB	Bureau of the Budget
BTLS	Breadboard Terminal Landing System
CAAD	Computational and Analysis Division
CCATS	Communications Command and Telemetry System
CDC	Control Data Corporation
CIF	Central Instrumentation Facility
COBOL	Common Business Oriented Language
COMP	Computation Laboratory
CRT	Cathode Ray Tube
CSC	Computer Sciences Corporation
CSM	Command and Service Module
DAF	Data Acquisition Facility
DCS	Direct Coupled System
DDP	Digital Data Processor (originally manufactured by Computer Control Corporation acquired by Honeywell, Inc.)
DEC	Digital Equipment Company
DEE	Digital Event Evaluator
DMI	Decision Machine Inc. (subsidiary of Decision Control Corp.)
DRC	Data Reduction Complex
DRF	Data Reduction Facility
EAI	Electronic Associates, Inc.
EAM	Electronic Accounting Machine
ESCF	Electronic Systems Compatibility Facility
ESE	Electronic Support Equipment
ESTP	Electronic Systems Test Program
ETR	Eastern Test Range
FM/FM	Frequency Modulation (signal on an FM carrier)
FY	Fiscal Year

GAEC	Grumman Aircraft Engineering Corp.
G&C	Guidance and Control
GE	General Electric Company
GETS	Ground Equipment Test Set
GOSS	Ground Operations Support System
GSA	General Services Administration
GSSC	Ground Support Simulation Computer
H	Honeywell, Inc.
HON	Honeywell, Inc.
HOSC	Huntsville Operations Support Center
IBM	International Business Machines Corporation
INS	KSC Information Systems Directorate
I/O	Input/Output
IU	Instrument Unit
KSC	John F. Kennedy Space Center
L	Leased
LC	Launch Complex
LCC	Launch Computer Complex
LIEF	Launch Information Exchange Facility
LM	Lunar Module
LMS	Lunar Module Mission Simulator
LUT	Launch Umbilical Tower
L/V	Launch Vehicle
LVDA	Launch Vehicle Digital Adapter
LVDC	Launch Vehicle Digital Computer
LVO	Launch Vehicle Operations
MAF	Michoud Assembly Facility
MCC	Mission Control Center - Houston
MILA	Meritt Island Launch Area
MOC	Mission Operations Computer
MPAD	Mission Planning and Analysis Division
MSC	Manned Spacecraft Center
MSF	Manned Space Flight
MSFC	George C. Marshall Space Flight Center
MSOB	Manned Spacecraft Operations Building
MTF	Mississippi Test Facility
NASA	National Aeronautics and Space Administration

OART	NASA, Office of Advanced Research and Technology
OMSF	NASA, Office of Manned Space Flight
OSSA	Office of Space Sciences and Applications
OTDA	Office of Tracking and Data Acquisition
P	Purchased
PB	Raytheon (formerly Packard-Bell)
PDM	Pulse Duration Modulation
PDP	Digital Equipment Corporation
PERT	Program Evaluation and Review Technique
POP	Program Operating Plan
PSDF	Propulsion System Development Facility
P&VE	Propulsion and Vehicle Engineering
RCA	Radio Corporation of America
R&D	Research and Development
RF	Radio Frequency
RFP	Request for Proposal
RSA	Redstone Arsenal
RSDP	Remote Site Data Processor
RTCC	Real-Time Computer Complex
SCATS	Simulation Checkout and Training System
SDS	Scientific Data Systems
SEB	Source Evaluation Board
SLCC	Saturn Launch Computer Complex
SOC	Simulation Operations Computer
S-V	Saturn V
TCO	Telephone Central Office
TM	Telemetry
TRICE	Telemetry System
TRW	Thompson Ramo Wooldridge
UNIVAC	UNIVAC Division of Sperry Rand Corporation
VAB	Vehicle Assembly Building
WSTF	White Sands Test Facility

The total computer equipment costs in Manned Space Flight have been going down. They are, in fiscal year 1967, $7,800,000 less than the fiscal year 1966 costs and the fiscal year 1968 costs are $6,500,000 less than those for fiscal year 1967.

Mr. FULTON. On the general purpose of computers rather than specifically built components, what is your policy—do you favor the Government owning the particular computer or do you favor leasing, everything else being equal?

Dr. MUELLER. We have some careful guidelines prepared by the Bureau of the Budget and by the General Accounting Office which provide criteria for making a selection depending upon which is the least expensive total cost for the Government and we are applying those procedures to each of our purchases.

Mr. FULTON. Did you ask each individual computer whether it should be bought or leased and did it reply to you: "Buy me or lease me?"

Dr. MUELLER. We ask another computer to arrive at the answer to this rather complex question.

Mr. FULTON. That is all.

Dr. MUELLER. We want to avoid a conflict of computer interest.

Mr. FULTON. That is all.

Dr. MUELLER. That is all I had, Mr. Chairman.

Mr. TEAGUE. I am sorry Mr. Rumsfeld wasn't in here. It was his question.

George, while Don is out, I wish you would discuss support services at the different centers. Every time you change your procedure, all of us get swamped with letters and calls from contractors all over the country. They all come to see us. Would you comment on how you make a determination for contracting the in-house support service functions? Are they uniform in each center?

Dr. MUELLER. Most of the changes that we have been instituting have been in the direction of bringing uniformity of applications of our support services contractors between the centers. Of course, their missions are different so you can't get absolute uniformity, but, as you recall about 2 years ago, we established a new support contractor structure and those structures were deliberately different at Marshall, MSC and KSC because we were trying to learn how best to utilize support contractors in the operation of these facilities. We have been learning from this process. In general, we have adopted the use of a contract involving a determination of an award fee, and insofar as we could do so, objective fee criteria. We are using an incentive fee structure for our support contractors and this has worked quite well. We are in the process of consolidating certain of the contracts in order to provide for both better management on our part and also to reduce the administrative overhead which it would appear, because of the way the contract structure has developed, could be done by consolidating certain contracts.

Mr. TEAGUE. Take Cape Kennedy. What do you go to? Eight to four down there?

Dr. MUELLER. From seven to four.

Mr. TEAGUE. Seven to four.

Dr. MUELLER. Yes.

Mr. TEAGUE. Each one of those contractors have been working for a number of years down there?

Dr. MUELLER. Yes.

Mr. TEAGUE. You know which ones do a good job and which one does a poor job?

Dr. MUELLER. Yes.

Mr. TEAGUE. You ask for a proposal. Some spent $50,000 on a proposal and some spent $100,000. The rumors come to us that the companies put all their good people on the proposal. They know unless they have a good proposal they don't get the job. So a poor company spends $100,000 on its proposal, and sends it in. The good company spends only $50,000 on its proposal. How does a staff of yours come out with a decision on which company gets the job?

Dr. MUELLER. There is, Mr. Chairman, a very carefully developed set of procedures which are established by NASA regulations for the letting of contracts which we have implemented.

Based on these procedures we establish Source Evaluation Boards comprised of qualified individuals who evaluate those proposals. We are required to compete for these contracts and we comply with the existing regulations.

Mr. TEAGUE. Do you have any evidence that you have achieved greater efficiency and saved money by your enforced consolidation?

In one part of Government we encourage small business and small companies and NASA appears to be emphasizing fewer business firms and bigger companies.

Dr. MUELLER. We do have some experience at the Marshall Space Flight Center where we did accomplish some consolidation with considerable savings.

Mr. TEAGUE. You went to what? From 80-some odd companies down to what?

Mr. LILLY. We had 77 support contracts, Mr. Teague, at Marshall. In January 1965, the value of the 77 contracts was estimated at $76 million. We consolidated these contracts to 11. The actual cost for the first year of operation, including the award fee, was $60,298,000. We also reduced the contractor personnel by approximately 882. Based on substantially the same contractor workload, though I couldn't prove it exactly, the savings would appear to have been about $15,000,000.

Of course, we have not yet completed the consolidation at KSC. Since KSC is still growing, I couldn't give any firm figures of the estimated savings there.

Mr. TEAGUE. You consider the $15 million a true figure resulting from your consolidation at Marshall?

Mr. LILLY. I consider the consolidation a contributing factor. I think 77 was too large a number of support contracts to really manage efficiently.

Mr. TEAGUE. At Kennedy, you are consolidating your fire department and police department. Yet, so far as I know, in no place in our whole country has any city combined their police and fire department activities.

Dr. MUELLER. Both services are currently provided at KSC by one contractor, TWA.

Mr. TEAGUE. Is that correct at present?

Mr. LILLY. Let me ask Chuck Bingman, who is in our Management Operations office, to comment on this arrangement.

Mr. BINGMAN. They are combining the fire and safety contract and the security guard contract at the Manned Spacecraft Center in Houston. The two services are now performed together by TWA at the Kennedy Space Center.

Mr. FULTON. For example at Marshall Spaceflight Center, were their reductions in the operating personnel or management?

Mr. LILLY. The personnel that I referred to at MSFC were the support contractor personnel and were a combination. I don't have a breakdown here on how many were management and how many were operating.

Mr. FULTON. The question would certainly arise as to whether you could have accomplished the same purpose by simply putting pressures on for economy and cutting out certain overlapping and certain things that needed to be done, so that you achieve this efficiency. Because I can't see that the simple fact of having one contractor or two or a certain type of contract would have that big an effect on operations. It just doesn't seem logical to me.

Could you explain that?

Dr. MUELLER. One place where savings would become immediately apparent is in the area of reducing the number of people supporting those who do the actual work.

Mr. FULTON. George, that wouldn't involve $15 million.

Dr. MUELLER. That factor could account for a relatively large fraction of the saving inasmuch as the paperwork involved in the commercial enterprises in terms of keeping the tax forms filled out and all the other things that are needed is an appreciable fraction of the cost of labor.

Mr. FULTON. You are saying that small business operations inherently are not efficient and that since large ones are more efficient, NASA should deal with them?

Dr. MUELLER. No, sir; I didn't mean to imply that. We have a very active small business program in each of our centers. Each of these consolidations is very carefully worked out with the local Small Business Administration and with their representatives.

Mr. FULTON. With the chairman's permission, I would like a statement put in the record of the factors that caused the saving; if you would do that.

That is all.

While it is extremely difficult to develop a precise measure of the individual factors which resulted in a reduced cost after consolidation of the service contracts at MSFC from 77 to 11, we believe the following factors contributed significantly to the first year's savings of over $15 million:

1. More efficient work assignment and greater flexibility in the use of the work force;
2. Elimination of duplication and overlaps;
3. The reduction of interface problems.

For example, there were seven contractors providing various kinds of engineering and fabrication support. After the consolidation, a single contractor was able to provide the total support with fewer people by having complete flexibility in the use of the machine operators and technicians and by more efficient work assignment.

Mr. GURNEY. Dr. Mueller, getting back to the chairman's question about the high cost of preparing proposals for furnishing services. As I understand it now, you are required by law to periodically recontract for these services, is that correct, every 3 years?

Dr. MUELLER. Actually, we are required by law to compete on contracts.

Mr. COTTON. We generally set different periods for the renewal of our contracts so that they don't all phase out at the same time.

Dr. MUELLER. What is the limit?

Mr. COTTON. Including renewal provisions, these contracts generally run for 5 years. We are contracting from year to year for planned periods running from 3 to 5 years without formal recompetition, as long as performance is good.

Mr. GURNEY. You are legally bound to negotiate a contract for no longer than 5 years, is that correct?

Dr. MUELLER. The legal requirement is to have maximum practicable competition in all our procurements.

Mr. GURNEY. Then regardless of whether you have a good operation or not, you have to negotiate for a new contract?

Dr. MUELLER. Our Agency policy is to recompete at the end of the total planned period of contract performance.

Mr. GURNEY. Do you have any suggestions to improve this? Obviously if you had a good and efficient operation, it would be a useless exercise to seek new contracts.

Now I am aware that one reason why you do this is to prevent a contractor from being locked in forever.

Do you have any other suggestions as to how this could be done? What is your own idea?

Dr. MUELLER. In this area as well as in other areas, I think that there is a very real problem in maintaining a competitive industrial situation. You can, in fact, create a situation where there is no further competition.

Mr. GURNEY. I wasn't suggesting that there shouldn't be any further competition. Suppose you had no limitation at all as far as a contract is concerned, that the law said nothing about it and suppose you negotiated a contract for 1 or 2 years and you were continuously looking at it. If you wanted to, you could at the end of 6 months or a year, throw it open because you didn't think the contractor was doing a good job.

On the other hand, if he was, you could continue this almost indefinitely.

Would that make any sense?

Dr. MUELLER. As a matter of fact, our contracts are written in such a fashion that that is in fact possible. Each of our contracts provides, at the convenience of the Government, for rebidding. NASA policy provides limits for various types of contract and program situations. The principle is this: if the contractor who is doing the work is good, then he ought to win the next competition.

Mr. GURNEY. Then you run into what the chairman says. A lot of people have to go through expensive exercises as well as tying up your own people.

Dr. MUELLER. We have tried to improve the situation through our phased procurement procedure in our R. & D. activities. This approach was designed to reduce the cost to industry of preparing proposals.

I don't think that has worked to actually accomplish this. Again, the competition is very large. The desire for getting new business is very great and it is difficult to actually limit the amount of money that the company will put into proposals.

Mr. GURNEY. Do you have any ideas on how the present method can be improved upon?

Dr. MUELLER. No, sir; I do not.

Mr. TEAGUE. I have seen some of those proposals and they stack up about 1 or 2 feet in height.

How do you relate performance to proposal?

Dr. MUELLER. It takes 3 or 4 weeks for 70 people to go through one set of proposals.

Mr. TEAGUE. You have that many people down there doing this function?

Dr. MUELLER. Yes, so it takes a great deal of time on the part of the Government to carry out a real evaluation of these proposals. It takes a great deal of time on the part of the companies involved to prepare the proposal.

Mr. TEAGUE. What are you going to say to a company you have given a superior rating to when he doesn't get the renewal contract and you award the new contract to another company that didn't receive a superior rating?

How will you explain it? There is no law that tells you what to do. It gets down to somebody saying: "This company gets the job."

Dr. MUELLER. Each of the source evaluation boards takes into account past performance in their evaluation of the suitability and ranking of the contractor.

I am sure that the people that lose one of these competitions feel very bad.

Mr. TEAGUE. All companies do.

Dr. MUELLER. I found that I felt bad every time I lost one when I was in industry. On the other hand, I have observed the operation of the letting of contracts in Europe, for example, where quite often the work is contracted by the Government and is divided among a set of companies in order to build basic capability and maintain that capability. My own observation is that our system works about as well as any system. It is far from ideal and that is simply because there is no absolute measure of competence. There is no absolute measure of performance in the future.

You can always say what the performance was in the past, but there are a few key people that have actually caused the past performance to be good and if you transfer 20 people out of any organization, the right 20 people, you will find that its performance will decrease.

That doesn't say that the performance level won't get good again, but the performance pattern will change.

Mr. TEAGUE. You have really had a very satisfactory performance particularly at Cape Kennedy. Couldn't you save a heck of a lot of money and wear and tear if you put all the names of qualified companies and choose them by lottery?

Dr. MUELLER. Mr. Teague, if the Congress would like to authorize that procedure, I am sure we will comply.

Mr. TEAGUE. I have a suspicion you will come out as well because I think you have got seven good companies down there.

Dr. MUELLER. I certainly agree because the work has been very good in this support contract area.

Mr. TEAGUE. Those proposals must consist of 10,000 pages.

Dr. MUELLER. Yes.

Mr. TEAGUE. What does the contract negotiator know when he gets through with a proposal that he didn't know when he started?

Mr. FUQUA. This has intrigued me for some time. I think you will find in many cases that the firms' capability to write proposals probably far exceeds their ability to perform the task that you set out for them. Is not this true?

Dr. MUELLER. It is often difficult to have the proposal writers actually working on the project that they write for. One thing that we try to do, is to be sure that the same people who are working on the proposal will be the same people actually working on the project itself.

Mr. FUQUA. Some universities are being accused of "grantsmanship" in getting grants. Some people have a better ability to express themselves on paper and maybe these companies find themselves getting into "proposalships." Like the chairman I think you would be bettter off to choose from among qualified contractors by lottery. It would save 70 people a lot of time and paperwork.

Mr. TEAGUE. Any questions?

Mr. Rumsfeld, you were out when we were going into your favorite subject, automatic data processing.

Do you want to go back to it and ask some questions?

Mr. RUMSFELD. I would rather review what I understand will be put in the record and spend some time on it.

If I have any questions I can get in touch with NASA.

Mr. TEAGUE. All right.

Mr. RUMSFELD. On this question of contractors, how precise a system do you have for recording the past performance of contractors in the area of technical performance?

I can understand how you can evaluate a number of things about a contractor, but as far as the real hard area of technical performance, do you actually have a system for this?

Dr. MUELLER. In the case of the support contractors, yes. We break it down so that there are essentially supervisors in particular areas of work who monitor what is being done and hold periodic meetings with the contractor management.

Mr. RUMSFELD. Is this recorded?

Dr. MUELLER. It is recorded. There is a scorecard of performance which is given to the contractor about once a month so that he knows how he is doing against the various items in this evaluation and so, in turn, that he can improve.

The objective, of course, is to get the support contractor to do as good work as it is possible by providing him an award as an incentive. The problem you have with a supervisor evaluating the performance in a given area is that he always compares the work that another individual does with what he thinks he could do, and we generally tend to have a rather high opinion of what we think we can do.

Mr. RUMSFELD. Is this also true of your R. & D. contract?

Dr. MUELLER. With our R. & D. contractors we do not have that precise an evaluation system. There, performance is assessed on the basis of the performance evaluation system. We are a member of the program that DOD has set up for evaluating past performance. In R. & D. it is a more objective thing. The R. & D. hardware contractors are essentially operating independently and the Government is measuring the end product rather than monitoring what they are doing on a day-to-day basis. There is a danger in trying to do too much monitoring with respect to the evaluation. We do have a fair handle in the technical performance area from our incentive contract structure because that was carefully written out to identify key items that had to be done. You can pretty well evaluate at the end of the contract by just looking at performance on key points.

Mr. RUMSFELD. With respect to the R. & D. contract; is that recorded?

Dr. MUELLER. Yes.

Mr. RUMSFELD. In each case, it is made available to these boards?

Dr. MUELLER. Yes.

Mr. RUMSFELD. When they review the collection of recorded information, do you find a substantial disparity among companies working in similar areas with regard to their ratings?

Dr. MUELLER. Generally there are not wide variations in the scores of the evaluation groups on the companies. You will find, however, typical variations of maybe 25 percent of the total points from the best to the worst—maybe a little more. But that is not surprising bceause you are dealing with a number of competent people who are trying to get the same work. It is about like grading students, in a sense. You have the same problem. If you have a highly select group of college students, how are you going to differentiate between the man who is making the highest grade and the man who is going to flunk the course? You have to determine the difference between an A and B when this difference may not be very large in terms of scores on tests.

Mr. RUMSFELD. When you are grading students or contractors, depending on how you set the standard, you can have a greater or smaller disparity, depending upon the scale you use and how you adjust it.

Dr. MUELLER. Precisely.

Mr. RUMSFELD. Have you drawn a cutoff line?

Dr. MUELLER. Yes.

Mr. RUMSFELD. Have you moved that line from time to time, as the program matures? Are you requiring a higher standard?

Dr. MUELLER. Well, we tried not to move the line but rather to provide an incentive for the contractor to do better. You see, if you move the line, you tell the man when he enters into the contract, that this is where the line is.

Mr. RUMSFELD. I mean that if they fall below the line in performance, they are not going to get more contract work.

Dr. MUELLER. If they fall below it in performance on an existing contract, then we get a new contractor, immediatly. That is what we do.

Mr. RUMSFELD. But do you move that line? I take it you haven't.

Dr. MUELLER. No, we have not. The minimum performance that we expect is say 75 percent. I believe that is an average number for performance in all of the categories.

Mr. RUMSFELD. What happens specifically when some contractor falls below it and they get no more contract work? Do the employees from that company go to work for the other companies?

Dr. MUELLER. Actually, we have not had an example of a company that has fallen below the minimum for 2 months consecutively. That is simply because there is a very large incentive for them to stay above. The fees for below minimum performance are very low, and consequently there is a large incentive for them to try to stay up around 95 percent. We haven't been so unfortunate, as I recall, to have a case where the contractor stayed down around the minimum region. There was one company that was there for 1 month. The company changed its management and improved spectacularly.

Mr. RUMSFELD. Thank you.

Mr. TEAGUE. Mr. Roudebush.

Mr. ROUDEBUSH. The thought occurred to me as to what system do we have of encouraging individual contractors for making suggestions on saving money for the Government? In other words, let us assume a hypothetical case, say TWA will come to you at Kennedy and say, "Look, Dr. Mueller, we can save $50,000 by combining some services." What do we do? Cut their contract by $50,000 or do we give them some sort of inducement?

Dr. MUELLER. We cut their contract by $50,000. There is essentially a cost-saving sharing which increases their profit.

Mr. ROUDEBUSH. They would make money by making such a suggestion?

Dr. MUELLER. Yes.

Mr. ROUDEBUSH. When you combined these 77 support contracts, Mr. Lilly, to a much lesser number with a saving of $15 million, why wasn't someone aggressive enough to make some suggestions? Obviously there was overlapping and duplication of services. Why didn't someone make a suggestion?

Mr. LILLY. When we reduced the number of support contractors at Marshall from 77 to 11, we converted to the incentive contract structure. The physical processes of monitoring these award contracts represents a considerable burden on the Government structure. It was not feasible. We didn't have enough people with the right training to be able to monitor and manage 77 support contractors.

Mr. ROUDEBUSH. Did anybody suggest a combination of services when the reduction of a number of contractors was accomplished? Did anybody turn in any suggestions saying we can do this? Do you follow my line of questions?

Mr. LILLY. Yes.

Mr. ROUDEBUSH. Were any suggestions received which recommended a combination of services?

Dr. MUELLER. I can recall one instance of a contractor at MSC that did suggest a combination of services because he thought it would reduce the cost. I believe we accepted the suggestion. Unfortunately in the ensuing competition, he lost the bid.

Mr. ROUDEBUSH. That answers my line of questions.

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. Dr. Mueller, I would like to renew my annual request for a complete breakdown of the public relations of NASA. There is nothing in this budget book anywhere which shows how much is being spent for public relations and how it is being spent. I asked for this last year and NASA was extremely unresponsive. It didn't furnish any information in detail. I think this committee ought to be informed especially as to how much is being spent and where. I remember one year NASA requested funds for Columbia University in an attempt to learn how to do public relations or how to improve it. We got that stricken out of the budget. I know two newspaper editors from my home district who have said: "Can't you get NASA to stop flooding us with all this enormous paper they send out," which these two people said "they constantly dump in the wastebasket."

I am interested in how much NASA is spending on public relations and a breakdown of how it is being spent. In fact, I think it might be well if you furnished us with your inhouse public relations budget as it may be accepted by the Administrator and in turn put into your budget when you send it over to the Director of the Budget so that we actually know what this public relations money is.

Mr. TEAGUE. Shouldn't that properly go to Mr. Webb?

Mr. GURNEY. Yes, I think probably it should. I don't care who furnishes it as long as we get it.

Mr. TEAGUE. We will send the request to Mr. Webb.

(The following is submitted for the record.)

National Aeronautics and Space Administration agency-wide public affairs budget estimates, fiscal year 1968—Summary

[Dollars in thousands]

	Headquarters	Field	Total
Personnel:			
Professional	73	128	201
Secretarial and clerical	44	72	116
Salaries and benefits	$1,596	$2,337.8	$3,933.8
Travel	114	201.7	315.7
Information/educational publications preparation, printing, and distribution	440	492.5	932.5
News photographic services	150	510.6	660.6
Information/educational motion pictures production, processing, distribution, and depository operation	930	1,362.3	2,292.3
Radio and television production, distribution, and service	510	221.4	731.4
Educational programs	205	100.0	305.0
Spacemobile program	1,260		1,260.0
Exhibits design, construction, display maintenance, transportation, and warehousing	1,843	674.4	2,517.4
Community relations and local activities		195.0	195.0
Supplies, materials, and equipment	17	219.7	236.7
Total	7,065	6,315.4	13,380.4

Dr. MUELLER. We don't happen to have that part of the NASA budget under our jurisdiction and control.

Mr. GURNEY. I understand that. I was using this opportunity because it has to be brought out somewhere in committee.

Mr. TEAGUE. How do you guard against a very large company charging off all kinds of costs in the proposal preparation, as against a small company who can't charge off anything in a proposal?

Dr. MUELLER. In our support contracts and also in our large contracts, but in our support contracts particularly, we normally have a separate cost center which gathers all the costs associated in that center. They are special kinds of things. We don't want to carry the overhead rate of the company as a whole. There are standard accounting practices, and unless the company is willing to spend its profits on this operation, they won't permit them to divert costs to another operation. You can't have a loose division in Government contracting unless it is a fixed price contract and most companies aren't willing to put their profits into this kind of an operation.

Mr. TEAGUE. I have one or two more questions on facilities. Last year this committee authorized $96 million for construction of facilities. NASA had requested something over $101 million. Then the Appropriations Committee reduced this to $83 million. What was the impact of these reductions and were there serious delays as far as this program was concerned?

Dr. MUELLER. I will turn that over to Mr. Lilly.

Mr. LILLY. The total amount requested for the Agency's fiscal year 1967 construction of facilities program was $101.5 million; $95.9 million was authorized by the Congress. The Appropriations Committee reduced this amount to $83 million. As you know, in your Authorization Committee you made certain specific cuts in the fiscal year 1967 Manned Space Flight construction of facilities request. You made two in which you reduced the Lunar Receiving Lab from $9.1 million down to $8.1 million and denied the project at Marshall for the enlargement of the Hazardous Operations Lab. Those were the two specific cuts.

The other cuts from the Appropriations Committee are not specified against any particular project. It is up to the Agency as to how it now rebalances or utilizes the appropriated funds, whether it comes back for a supplemental amount or comes back with the request in the following year. In terms of the fiscal year 1967 construction of facilities history, Manned Space Flight was authorized by your committee approximately $53.8 million for facilities, and ended up with $43.8 million. Now, our criteria in trying to determine which ones would have the least adverse effect on our operations led us essentially to defer facilities which were primarily in the administrative area. We have been able to accomplish each of the facilities that you authorized, except for four at this point. Those four are the warehouse at KSC; the engineering building at MSC; and two other projects: one for rehabilitating and keeping up to date the test facilities at Mississippi and the same type of project for the S–IVB facilities in Sacramento, Calif. We have not found a way to fund these projects. We have not given up on the requirement. We still think they are required. It is costing us more money to operate without the warehouse at KSC. It is a gradual kind of thing and I still have hopes of getting additional warehouse space.

We have taken certain actions to alleviate part of our problem. By converting space in the Vehicle Assembly Building, we have found ways to pick up about 20,000 square feet. It is not efficient but it allows us to continue to operate. We also picked up some more space from the Air Force on the Cape Kennedy side which we had to pay for. However it is still not an efficient arrangement. The prior residential structures used for storage on which there was considerable discussion last year are continuing to cost us more money. There is more security surveillance involved. Some of the studies that we have done show that the operation and maintenance is costing us about $3.50 a square foot under these circumstances whereas the cost is less than a third of that amount in our regular warehouses. Now, in terms of technical facilities at the Mississippi Test Facility and at the S–IV B SACTO location, we may well be back to the Congress for those facilities as a special reprograming action this year if we are not able to live without them. At Mississippi, one of the things we are waiting for is the first test firing of the S–IC flight stage. We know we have to change the cooling holes and so forth in the deflector plate for the S–IC test stand. I will have to wait and see if we have to come back for a large amount. In the case of the S–IV B as you know, we had the S–IV B accident out at Sacramento. We are evaluating that problem to determine whether or not we will replace the damaged stand or if there is a different way of meeting our requirements. I wouldn't be surprised if we didn't have to use the emergency authority provided to us by the Congress to go ahead and repair the S–IV B at SACTO. That will mean that we will have to take R&D funds, which are already tight in order to carry out the repairs.

I can't say specifically that the items that we have deleted so far have delayed us. Since we wouldn't have had the facilities completed yet anyway, I can't really tell. However, I feel that these items are a requirement and should be done.

When the Lunar Receiving Lab was reduced from $9.1 to $8.1 million we had to take certain specific actions. In restudy, we did reduce the total area of the proposed facility, which was around 87,000 square feet. We were able to reduce this down to about 83,000 square feet, but our major planned saving so far is that whereas we had originally proposed having what is called a dual vacuum system, we have now removed one leg of that vacuum system so that we have a single vacuum system in the Lunar Receiving Lab. As far as we can tell right now, the major disadvantage of the change will be some delay in being able to process the lunar samples and get them out to the universities. That will be the major result.

When you are running widely spaced trips to the lunar surface it won't have such an adverse effect on the handling capabilities, but if you have two, say, within a 3 or 4 month interval, you could be accumulating a backlog in the Lab without getting the samples out quickly. The major drawback would be the delays in the handling of the samples.

However, the change does not degrade the quality of the facilities in terms of the quarantine function.

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. I have a question here on communication costs. I notice you have provision for an increase of about a third of a million dollars. Why should your communications go up?

Mr. LILLY. Is this communications that went up in Administrative Operations?

Mr. GURNEY. Yes.

Mr. LILLY. Was the figure you read for the agency as a whole?

Mr. GURNEY. I don't know if this is all for the Manned Space Flight area.

Dr. MUELLER. These budget books were put together, they present Administrative Operations for the agency as a whole, they are not all broken out separately for Manned Space Flight. A lot of those figures in the budget statements are for the agency as a whole.

Mr. LILLY. I don't have the number in front of me at the moment, but I can give you reasons that cause Manned Space Flight communications to increase.

Mr. GURNEY. All right.

Mr. LILLY. During fiscal year 1968 there is an increase in man-years of work. For example, KSC is increasing its man-years during this time. They are not yet up to the 2,720 strength shown for the end of fiscal year 1967. They are now about 139 below that end year level, and are still in a build up situation. By the end of fiscal year 1967, KSC will have 2,720 permanent civil service personnel. Therefore we will have for all of fiscal year 1968 the manpower that you had only for part of fiscal year 1967. As a result, your total manpower increases. That situation is also true at Houston, and it increases your personnel costs as well as other related categories, such as communications. In addition the previously authorized buildings that are being completed and are coming into operation at our Manned Space Flight centers must be accommodated. In fiscal year 1967, we will increase the square footage occupied at our centers by 535,000 square feet. In fiscal year 1968, buildings coming into operation will increase this figure by another 400,000 or so square feet. That factor adds to the operational costs, janitorial, communications, et cetera.

Specifically, in terms of communications, my recollection is that there has also been some change in the Federal Telecommunications what is called the System (FTS) rate. I have the numbers here on the communications costs at our centers. At the Manned Spacecraft Center the fiscal year 1967, requirements are $2,337,000, and will go up to $2,343,000 in fiscal year 1968.

The basic increase here is in several areas, but mainly in terms of the local telephone and exchange service where you need more people and more instruments.

At the Marshall Space Flight Center, where the number of people has declined, requirements go down to an estimated $1,695,000 in fiscal year 1968. We get our largest reduction in the local telephone and exchange services. The leased lines and the long distance calls have not really changed.

Mr. GURNEY. How do you monitor the long-distance calls to make sure that people aren't wasting the Government's money? Do you have any effective way of doing it?

Mr. LILLY. I would have to answer that I don't believe that the agency has any definite way to determine whether or not an official call that an engineer, for instance, would make really was necessary, other than to continually keep in front of these people the cost of this service. We assess, at our centers and headquarters, what the communication costs should be. We monitor the number of instruments that are installed at the centers, in other words, to prevent having two or three instruments for one man and things of this nature. We also have a procedure that requires long-distance commercial calls to be certified by a supervisor to assure that these were official calls. We follow up to see that all long-distance commercial calls are made in the cheapest manner and any deviation from that procedure comes back to the supervisor, who has to check into the reasons for the deviation.

Mr. TEAGUE. Any questions?

Dr. Mueller, I think I should tell you that I had a little experience in World War II that caused me to ask a number of questions on contracts. I had a battalion of a thousand men. Ed Gurney will well understand that. I soon learned that the decorations I was recommending were not being approved. The battalion personnel officer who would write up the citation for a decoration originally had been a contractor. I searched around and located a journalism major to write up the citation for the decorations. The situation completely changed. I knew we were doing as much fighting as anyone. Very quickly, all the recommended decorations came back approved. If I were a contractor, I would hire a capable proposal writer.

Any other questions?

Dr. Mueller, we have scheduled the markup of the bill for the 4th and 5th of April and we hope that you and Mr. Lilly will be available at that time either up here or at your office so we can get in touch with you.

Dr. MUELLER. Thank you.

Mr. TEAGUE. Any further questions?

If not, we will be adjourned.

(Whereupon, at 11:40 a.m., the subcommittee was adjourned.)

ANSWERS TO QUESTIONS FOR THE PUBLIC RECORD IN EXECUTIVE SESSION BY MEMBERS OF THE SUBCOMMITTEE ON MANNED SPACE FLIGHT, APRIL 4, 1967

Question No. 1:

Mr. GURNEY. You say the experimental program is mainly funded through a university who in turn engages contractors. What universities are these and what are they doing?

The answer to this question is partially contained in the answer to Mr. Teague's question "I would hope on Apollo Applications you would put out in much more detail for our hearings than what we have in our backup books for the ordinary layman to know what the vehicles are you are using and what the experiments mean and that type of explanation," on pp. 334–335 of the March 20, 1967 fiscal year 1968 authorization hearings and the answer to Mr. Daddario's question on pp. 310–312 in the March 20 hearings: "In the area of manned earth orbital telescope activity, Dr. Mueller, will you briefly name some of those members of the astronomical community who have advised you in this and supported this?"

Question No. 2:

Mr. DADDARIO. As I understand from Mr. Wilson, we will not get copies of this (the Apollo Applications amplifying statement) until it is put in galley proofs, because that is a costly procedure; I make this request that this all be provided to us prior to this going into galleys so that it can be put into fixed form and so we need no supplement to complicate the matter for us.

Answer. The answer is identical to the question posed by Mr. Teague, during the March 20 hearings (see pp. 334–335), Mr. Teague: "I would hope on Apollo Applications you would put out in much more detail for our hearings than what we have in our backup books for the ordinary layman to know what the vehicles are you are using and what the experiments mean and that type of explanation."

Question No. 3:

Question by Mr. RUMSFELD:

What I am trying to do is get some feeling for the types of total sums for different categories that NASA is going to be spending that are not going to show up in a beefed-up space program such as the accident, such as wage increases, such as the effect of strikes. Some of these things I would think would be helpful to me in understanding the absolute level of funding, if I can use that word as opposed to the budget figure which will either stay the same or show a slight increase from last year or slight decrease.

There is a gap between that and what we are really getting because of these various things such as the accident, wage increases, strikes, and possibly these things that you are funding through NASA that DOD and Congress used to fund. I would be interested in having a list of these things with an estimated dollar amount so that we can get some feel. Tiger, does that make sense to you?

Mr. TEAGUE. Yes, sir, it does.

* * * * * * *

Mr. FULTON. Could we have an estimate put in the record on that?

Dr. MUELLER. Yes, sir.

Mr. FULTON. If you will put that in the record for us, it would be the best thing. Why don't you make a complete survey and put it in the record.

Is that all right, Mr. Chairman?

Mr. TEAGUE. Yes.

Answer. Known or potential increased funding requirements, excluding those that will result from the 204 accident, that were not included in our fiscal year 1967 or fiscal year 1968 budget requests are shown below.

The unbudgeted requirements in fiscal year 1968 could reach $150 million if the cost of doing business continues to increase at near 8 percent per year and if it is decided that we must replace the S–II structural stage. A more optimistic outlook would place the increase between $75 and $100 million.

Known or potential increased funding requirements

[Dollars in millions]

	Total	Fiscal year 1967	Fiscal year 1968
Total	$291.0	$141.8	$149.2
S–IVB explosion	16.5	2.5	14.0
Stage replacement	14.0		14.0
Stand repair	2.5	2.5	
S–II stage losses	33.6	5.6	28.0
Structural stage replacement	33.0	5.0	28.0
Stand repair	.6	.6	
Service module 017 tank rupture	5.0	5.0	
LC 39 LOX line failure	1.2	1.2	
Increased Eastern test range reimbursements	12.0	12.0	
Civil service pay raises	7.7	.5	7.2
Engineers and scientists	1.7	.5	1.2
General civil service raise	6.0		6.0
Potential increase in contractor wages and other costs of doing business	215.0	115.0	100.0

ADDITIONAL QUESTIONS FOR THE RECORD; REPLIES SUBMITTED BY DR. GEORGE E. MUELLER, ASSOCIATE ADMINISTRATOR, OFFICE OF MANNED SPACE FLIGHT, NASA

Apollo Program

Question 1. What are the major launch schedule changes since 1961 in the Apollo program for Saturn I and Saturn V? (Without consideration of current rescheduling for the Apollo 204 accident.)

Answer 1. The first firm Manned Space Flight schedule was established in November 1962, based on the Lunar orbital rendezvous decision of July 1962.

The first major rescheduling action occurred in the fall of 1963, when both uprated Saturn I and Saturn V launches were delayed approximately 6 months to accommodate the "all up" concept, to compensate for elimination of six Saturn I flights, and in consideration of existing funding constraints.

The second major rescheduling action took place in January 1965 after a prolonged assessment of program milestones. Early development flights were slipped due to the impact of ground test problems and the operational flight program was stretched out because of funding considerations.

Question 2. What rescheduling has been made for either Saturn I or Saturn V unmanned flights based on the Apollo 204 accident?

Answer 2. To date no rescheduling of the only planned Saturn I unmanned flight (LM–1) has been made due to the AS–204 accident. However, a review of LM systems is being conducted based on the AS–204 accident and this review may result in the rescheduling of LM–1 launch. Areas that will be reviewed are materials, environmental control system wiring, minor schedule adjustments to the two unmanned Saturn V launches et cetera. We are now examining the need to make (AS–501 and 502) to flight test proposed modifications in the spacecraft.

Question 3. What is the net effect of the $60 million deferral of funds on fiscal year 1967–68 program plans?

Answer 3. Of the $60 million which was withheld from NASA by the President last year, only about $8.8 million was allocated from the Apollo program. This is being absorbed in the ALSEP program. The net effect of this deferral of funds is to reduce our carry-forward funding at the end of fiscal year 1967.

Question 4. What effect on fund requirements has been determined to date, on rescheduling unmanned Saturn I and Saturn V flights? When do most increases based on rescheduling because of the Apollo 204 accident begin to affect the total program?

Answer 4. The fiscal year 1967 and fiscal year 1968 resource planning will be analyzed to determine the full impact of the accident on both the Apollo unmanned and manned flights. This analysis will be completed subsequent to the final report of the AS-204 Accident Review Board.

Question 5. What is the estimated cost of investigation of the Apollo 204 accident in dollars and man-hours?

Answer 5. There are about 1,500 people now engaged in one aspect or another of investigating the accident who will have worked about 2 months, 3,000 man-months, or 250 man-years. At $17,000 per man-year, the cost is estimated to be about $4 million. (Better estimates will be available when the Board has completed its report.)

Question 6. Does NASA expect to alter its manufacturing techniques in fabricating the tank walls of the S-II stage? If so, when?

Answer 6. We do not anticipate any further changes in the manufacturing techniques for the S-II stage tank walls. As a result of the liquid hydrogen tank cracking that was experienced in mid-1966, a number of small changes were made in the manufacturing of the tank wall panels, and in the handling and assembly procedures of these panels to form the actual tank. These changes included such items as welding techniques, tooling, and handling fixtures and handling procedures.

Since the implementation of these improved and refined fabricating methods the LH_2 tank cracking problem is now considered to be under control.

The manufacture and assembly of the S-II stage has presented new development problems. These problems have been due mainly to the very large structural components involved as well as the use of the 2014 aluminum alloy material for the pressurized portion of the stage. Although this material was successfully used for the S-IV and S-IVB stages, it had never before been used in the large size sections required for the S-II. The use of the 2014 material was dictated in order to achieve the optimum thrust to weight ratio required for the entire Saturn V launch vehicle.

Regarding the tank wall insulation, we are evaluating a spray-on foam to replace the present bonded honeycomb material. If tests presently underway are successful, this foam material will be applied to the liquid hydrogen tank walls of S-II-8 in late 1967. This stage should be delivered to KSC in August 1968.

Question 7. What are the most feasible current alternatives to the life support system currently designed for the Apollo Command Module?

Answer 7. The Environmental Control System is being reexamined with emphasis on materials, failure modes, choice of fluids and maintenance and servicing.

Particular attention is being devoted to improving fire resistance by careful selection of materials used and the types of plumbing connections with the aim of minimizing the potential of leakage or joint failure as well as improving the maintenance and servicing of the system.

Tradeoff studies are being conducted to determine the feasibility of eliminating the present coolant fluid from the crew compartment.

A second approach is replacement of the glycol in the cabin by water while leaving the mixture of water and glycol in the service module.

A third approach involves the examination of the flammability characteristics of other mixtures of water and glycol.

Finally, the design of the environmental control system is being reviewed with a view to improving its maintainability and serviceability.

With regard to spacecraft atmosphere we are continuing tradeoff studies on spacecraft atmosphere for each operational phase of the Apollo program. These studies include one versus two gas tradeoffs, evaluation of the prelaunch atmosphere and a fire resistant oxygen system.

Question 8. What have been the major contributions of the Apollo engine development program in the past 4 years?

Answer 8:

F–1 Engine:

1. Successfully developed the largest thrust engine fired to date in the free world (1,522,000 pounds thrust) enabling United States to launch significant payloads.
2. Completed flight rating test qualifying the engine for flight test.
3. Completed tests qualifying the engine for manned flight and continued intensive reliability analysis and test.
4. Successfully solved the high frequency combustion oscillation problem which has long-range benefits for other programs as well as the Apollo program.
5. Successfully completed three S–IC acceptance stage firings where all five engines are fired for the full duration of 150 seconds.
6. Advanced state of the art: (a) achievement of combustion stability of a large rocket engine, and (b) development of the turbopump machinery to pump the large volume of lox and RP–1 required.

J–2 Engine:

1. Successfully completed flight rating tests qualifying the engine for flight.
2. Successfully completed tests qualifying the engine for manned flight and continued reliability testing.
3. Successfully flight tested this engine.
4. Solved the problem of testing at sea level, conditions that exist at altitude.
5. Solved the fuel pump stall problem by prechilling the pump and chamber and to limit the temperature conditions of each under which a start will be effected. This will have long-range benefits for other programs.
6. Largest hydrogen fueled engine in the free world with long-range benefits for future programs due to high performance demonstrated during static and flight tests.
7. Exceeded specific impulse and thrust to allow greater payload (2,200 pounds in Saturn IB, 4,700 pounds in Saturn V).

8. Demonstrated restart capability on AS-203.

H-1 Engine:

1. Uprated from 188,000 to 200,000 to 205,000 pounds thrust.

2. Developed a method of furnace brazing critical parts, a much better and more economical system of production.

3. Improved turbopump and injector performance (specific impulse increased from 255 to 263 seconds).

4. Successfully completed Saturn I flight program and demonstrated one engine out capability.

5. Successfully completed three uprated Saturn I flights.

6. Successfully completed man rating of the H-1 engine at 205,000 pounds thrust level.

RL 10-A3:

1. This engine was the first turbopumped hydrogen-oxygen engine to be developed.

2. Successfully completed flight rating tests qualifying for flight.

3. Successfully completed six Saturn I flights and demonstrated the first flight use of a hydrogen-fueled rocket stage.

4. Successfully powered Centaur flights, including engine restart in space.

Question 9. What work will be accomplished within the engine development program in fiscal year 1968? Has part of the costs of this effort been transferred to other parts of the budget? If so, where and how much?

Answer 9. Engine development project funding for fiscal year 1968 provides propellants and test support to continue performance and reliability verification, J-2 engine restart capability assurance and related efforts. All effort by the prime contractor after engine qualification is carried in the appropriate launch vehicle account (Saturn IB for H-1 and Saturn V for J-2 and F-1). H-1 funding for supporting activities involved $4.1 million for fiscal year 1967. Saturn V funding for fiscal year 1967 includes $38.9 million for supporting work.

In fiscal year 1968, funding for engines within the vehicle projects covers production and test of engines plus supporting activities such as the following:

1. Flight support of the launch program.
2. Improved engine reliability.
3. Flight worthiness verification. This is a series of tests to verify that the engine reliability has in no way deteriorated as a result of shipping and handling, environmental conditions, and elapsed time from manufacture to flight.
4. Investigation and reduction in material rejection costs.
5. Continue elimination of possible failure modes to increase reliability.
6. Effective cost savings in refurbishment programs.

Question 10. What is the composition of the Advanced Missions program, by study area, and cost, for fiscal year 1968? How does this differ from fiscal year 1967?

Answer 10. Requested fiscal year 1968 funding for Advanced Missions, by study area, and comparable data for fiscal year 1967 is shown below:

[Dollars in thousands]

Study area	Fiscal year 1967	Fiscal year 1968
Earth orbital	$3,100	$3,800
Lunar	450	1,400
Planetary	1,500	1,200
Launch vehicles and general program	1,150	1,600
Total	6,200	8,000

Question 11. What has contributed most significantly to delay in delivery of the lunar module? When will this delay adversely affect the flight schedules? To what extent have program costs been increased by the delayed deliveries?

Answer 11. Schedule delays which began in early manufacturing have continued through subsystem installations and integrated checkout. We experienced some development problems in such systems as the ascent engine, descent engine, abort guidance and rendezvous radar. Tooling, manufacturing problems, and late delivery of subsystem hardware by vendors have had their effect. No single factor can be pointed to as a predominant contributor to the delay, but rather it has been a combination of factors which are normal to first of a kind flight hardware at this stage of development.

It is possible that we will experience some impact in our lunar module development program as a result of the AS–204 accident. We have deferred detailed consideration of the lunar module until a basic understanding of the AS–204 accident could be developed. We will reevaluate the lunar module cost and schedule in the context of changes required in the command module and expect to complete this review in the next 6 weeks.

Question 12. Since only block II command modules will be used for manned flight, what is the disposition of block I command modules? How does this affect program schedule and costs?

Answer 12. The program plan provided for six block I command module flight articles. Two unmanned command modules (009 and 011) were flown as AS–201 and AS–202, respectively. An additional two unmanned command modules (017 and 020) are programed for flight on AS–501 and AS–502, respectively. Command module 012 was destroyed in the AS–204 accident at KSC. Command module 014 was shipped to KSC to support the AS–204 Accident Review Board and was disassembled. Since the block II configuration spacecraft will be used for manned Apollo flights, the disposition of block I command modules will not directly affect the program schedule or costs. The flight schedule will depend on the availability of the block II spacecraft.

Question 13. What are the cost and manpower requirements in Apollo quality assurance and reliability in the fiscal year 1968 budget plan? How does this compare with fiscal year 1967? Has the Apollo 204 accident caused a shift of emphasis or modified operations of the Apollo quality assurance and reliability program?

Answer 13. Quality assurance and reliability has been an active and integral part of the Apollo program. Throughout the Manned Space

Flight organization a primary function performed is the management of contractor effort. Under this criterion approximately 15,000 man-years of government and center support contractor effort are involved in quality assurance and reliability related activities. For example, the review of program changes by the various levels as outlined in the Apollo management presentation to the committee involves quality assurance and reliability activity. Other examples are to be found in the working groups and test programs conducted at the centers.

In fiscal year 1967 effort of Apollo personnel specifically classified as quality assurance and reliability is divided between Government personnel, who are performing 2,200 man-years, and contractor personnel who are performing 8,200 man-years.

The fiscal year 1968 budget plan, which was formulated before the AS-204 accident, provided for a level of effort corresponding to the planned decline in overall engineering, manufacturing, and test effort. We are now in the process of conducting a thorough review of our current R. & Q.A. program. The results are expected to be available in April 1967.

Question 14. What effect will recent loss of a S-IVB stage have on the flight vehicle delivery schedule?

Answer 14. Actions are underway with Douglas Aircraft Co. to reallocate existing flight stages. S-IVB-503 will be replaced by S-IVB-504 for launch vehicle AS-503. Subsequently each flight stage will be advanced to replace the preceding stage.

Question 14(a). Will it affect the unmanned Apollo flight schedule?

Answer 14(a). No. S-IVB planned deliveries were ahead of schedule at the time of the loss. S-IVB deliveries will support KSC need dates.

Question 14(b). At what point in time would it affect the manned Apollo flight schedule when it is resumed?

Answer 14(b). We expect S-IVB deliveries will support the manned flight Apollo schedule.

Question 15. To what extent is NASA hardware and technology available and utilized by the Department of Defense space effort?

Answer 15. Much NASA hardware and technology have already been made available to the Department of Defense with respect to the Gemini program (question 17). In addition, elements of the U.S. Air Force are working for, or closely with, the NASA organization in prosecuting the Apollo program at both headquarters and our field centers. For instance, a large number of Air Force officers are employed in the Mission Control Center, Houston, contributing, as well as gaining, experience in the operating area. We have carried, and plan to carry, DOD experiments on NASA space flights.

It is NASA's policy that all technology gained is available to anyone requiring it.

The policies regarding hardware which governed disposition of Gemini equipment will prevail in the Apollo program as well.

Question 16(a). Is experimental space available in the Apollo program?

Answer 16(a). Yes. Payload space has been made available and is being used in all uprated Saturn I Apollo Earth orbital flights. These consist of medical, scientific, and technological experiments. Additional space can be made available on certain flights. However, the feasibility of flying experiments on Apollo operational flights depends on other factors such as weight, crew participation, and propellant usage. Proposed additional experiments will be judged against the operational constraints.

The experiment complement for Apollo lunar missions consists of the Apollo lunar surface experiments package and the lunar geologic experiment tools and equipment. Other in-flight experiments could be carried but none have been recommended or approved. If recommended they would again be judged against operational constraints.

Question 16(b). To what extent is experimental space utilized when available by the Department of Defense?

Answer 16(b). There are three DOD experiments currently assigned to Apollo program earth orbital flights. These are: (1) D008 radiation in spacecraft (AS–207); (2) D009 simple navigation (AS–207); (3) D017 carbon dioxide reduction (AS–209). It should be noted that the flight designations are the current flight mission assignments. They are now being reevaluated. Additional DOD experiments in support of DOD's Manned Orbital Laboratory (MOL) are being included by the Apollo Applications program in the S–IVB workshop missions.

Question 17. What has been the disposition of equipment available from the Gemini program? To what extent has this equipment been made available to the Department of Defense?

Answer 17. Gemini hardware is finding its way into many programs and activities. One of these is the Air Force Manned Orbiting Laboratory which is making use of significant amounts of both flight and ground equipment. As an example, certain of the crew trainers and simulators with modifications were applicable as part task trainers to the Manned Orbiting Laboratory program of the Air Force and have been transferred to them.

Two Gemini spacecraft have been transferred to the Air Force and a third will be transferred soon. One of these has since been flown by the Air Force in a test in which a crew access hatch had been installed in the heat shield. This access hatch is utilized as part of the Manned Orbiting Laboratory to and from the spacecraft. The Gemini fuel cells have found application in the NASA biosatellite program and have also been transferred to the Navy's Marine Engineering Laboratory for their experimental use. The Federal Aviation Agency is putting flight computers to such diverse usage as components of a collision avoidance experiment.

The Apollo and Apollo Applications program will use significant amounts of Gemini equipment in direct support of their activities. Finally, the Gemini spacecraft are being exhibited both here and abroad and will be displayed at the Canadian International Exposition in 1967.

The specific disposition of Gemini spacecraft is as follows:

Gemini 1: Not recovered.
Gemini 2: MOL program.
Gemini 3: MOL program.
Gemini 3A: MOL program.
Gemini 4: Smithsonian Institution.
Gemini 5: On display at MSC.
Gemini 6: In storage at St. Louis.
Gemini 7: Expo–67.

Gemini 8: In storage at St. Louis.
Gemini 9: In storage at MSC.
Gemini 10: In Australia on tour.
Gemini 11: In storage at St. Louis.
Gemini 12: In storage at St. Louis.

Question 18(a). To what extent will other Government agencies furnish experimental payloads for Apollo?

Answer 18(a). In addition to Department of Defense experiments mentioned above, Dr. Eugene Shoemaker of the U.S. Geologic Survey is the principal investigator for the lunar geologic experiment. Except for limited photographic analysis by the Department of Interior no other agency is involved in Apollo in-flight experiments at this time. Many agencies including Commerce, Interior, and Agriculture are expected to participate in the Apollo Applications experiment program.

Question 18(b). What mechanisms are available so that promising experiments can be incorporated in Apollo flights by other Government agencies and private sources?

Answer 18(b). NASA has periodically issued a general publication titled "Opportunities for Participation in Space Flight Investigations" (NHB–8030.1) in which we outlined the entire scientific experiment participation program and procedures for manned as well as unmanned flights. This has been supplemented by the Apollo Experiments Guide, dated June 15, 1965. Presentations have been made at many technical society meetings to alert the scientific community to the opportunity for participation. In addition, special notices are issued from time to time to all interested parties when relatively short notice events become available for experimental participation. By this means, all Government agencies, universities, and private individuals showing interest are notified of the opportunity to propose scientific experiments for Apollo through a NASA program office to the Manned Space Flight Experiments Board. After a feasibility study all submitted scientific experiments are considered by the board and, when selected, are assigned to the appropriate program office for implementation. In the case of experiments requested by private sources they are submitted through the Office of Grants and Research Contracts (recently renamed Office of University Affairs) for distribution to the appropriate NASA program office.

Question 19. Based on current planning, what is the flight-by-flight mission assignments for the Saturn I and Saturn V in Apollo (and Apollo Applications)?

Answer 19. The basic logic of our flight program incorporates seven major phases for the Apollo/Saturn flight schedule. This plan employs both the uprated Saturn I launch vehicle and the Saturn V.

The first Apollo/Saturn I program phase included unmanned launch vehicle and Command-Service Module flights and was completed with the successful AS–202 mission in August 1966. Remaining phases include unmanned Lunar Module development, manned Command-Service Module long duration operations, and manned missions involving orbital operation of the Command-Service Module with the Lunar Module.

The first Saturn V phase consists of unmanned launch vehicle and spacecraft development flights. The second phase will be manned lunar mission simulation flights. The Apollo flight program will culminate in the Apollo/Saturn V missions achieving manned lunar landing and return.

The five major Apollo milestones are:

1966: First Apollo uprated Saturn I unmanned flight.
1967: First Apollo uprated Saturn I manned flight.
1967: First Apollo Saturn V unmanned flight.
1968: First Apollo Saturn V manned flight.
1969: Apollo Operations.

The exact number of flights in each phase depends on the degree of success achieved on each mission.

Question 20. What has been the disposition of the $41.9 million provided in fiscal year 1967 for long-leadtime procurement for the Apollo Applications program? Have other funds been used to supplement this effort in fiscal year 1967? If so, what was the use of these funds?

Answer 20. The disposition of the $41.9 million provided in fiscal year 1967 is as follows:

Long-lead procurement of follow-on Uprated Saturn I	$24.0
Design and development of spacecraft systems modifications	14.6
Experiment definition	3.3
Total	41.9

No other funds have been used to supplement this effort in fiscal year 1967. The development of experiments for AAP is covered by other line items.

Question 21. Early flights in the Apollo Applications program are based on a success schedule in the Apollo program. What are the schedule alternatives available in Apollo Applications flights and what are the cost effects of these alternatives?

Answer 21. Many problems that might arise in the Apollo program would not impact AAP. For example, a problem associated with the Saturn V/Apollo flights may not impact Saturn I/Apollo hardware used by AAP for early missions. As a matter of fact, the AAP planning and scheduling is consistent with and would not be changed by moderate difficulties or moderate success in the basic Apollo program.

In the event that Apollo hardware is not available for AAP usage, the AAP payloads for the early missions will be stored for later usage on follow-on missions. The alternative schedules for AAP will be determined after analysis of the situation at that time. The storage and maintenance of the AAP hardware will involve increased cost. However, the AAP payloads will be available for modifications and improvements while in storage, thus permitting the experiments in the payload package to be kept abreast of the state of the art. Thus the experiments will be maintained in a configuration to obtain the quality and quantity of data consistent with the latest scientific and engineering techniques.

Question 22. What effect does the availability of tracking ships and aircraft have on the Apollo and early Apollo Applications programs?

Answer 22. The availability of tracking ships and aircraft is adequate to support the current Apollo and Apollo Applications schedule.

APOLLO APPLICATIONS

(Set No. 1)

Question 1. Because the delay in the Apollo program will cause, undoubtedly, a similar delay in the first flight of the Apollo Applications program, why does NASA still need, in fiscal year 1968, all of the funds it has requested for hardware modifications, experiments, and mission support in the Apollo Applications program?

Answer 1. A delay in the Apollo program will not necessarily impact the AAP program which has been deliberately structured so as to be able to absorb some possible Apollo problems. The Apollo program has not yet determined the extent to which their delay will affect the 1968 Earth orbit flights. It is likely that several AAP flights will be possible in calendar year 1968. Fiscal year 1968 funds are needed for AAP experiments, hardware modifications, and mission support to be available for calendar year 1968 flights that are not required for Apollo lunar mission simulations.

As was pointed out in the answer to question No. 21 (Apollo program), certain problems may arise in the Apollo program that might not necessarily affect AAP. For example, a problem associated with the Saturn V/Apollo flights may not impact Saturn I/Apollo hardware used by AAP for early missions.

Question 2. In fiscal year 1968 how much money is programed for actual spacecraft and launch vehicle modification of equipment still in the mainstream Apollo program as opposed to design and development efforts relating to "how to modify" such hardware?

Answer 2. The fiscal year 1968 funds programed for modification of equipment still in the Apollo mainstream are associated with spacecraft only and are as follows:

CSM: $1,900,000.
LM: $5,700,000.

The CSM modifications are related to the orbital workshop mission and the LM modifications are related to the Apollo telescope mount mission. No modifications are planned for the mainstream Apollo launch vehicles.

The definition efforts relating to "how to modify" such hardware are included in the fiscal year 1966 and fiscal year 1967 study activities.

Question 3. The PSAC report on "the Space Program in the Post-Apollo Period" recommends (p. 25) that the orbital workshop should proceed because of the opportunity for 28 to 56 day flights in 1968. In view of the Apollo fire, does NASA still expect an AAP flight in 1968?

(a) If a flight does not occur in 1968, should NASA still proceed with the orbital workshop?

Answer 3. Yes. NASA has a reasonable expectation that it will be able to release uprated Saturn I launch vehicles and spacecraft for AAP Earth orbit flights in 1968.

(*a*) The orbital workshop is an important step in developing the capabilities for long duration space flight; it should be prosecuted even if delayed somewhat.

Question 4. The PSAC report infers that NASA should use the Titan III/MOL for flights up to 60 days' duration and develop a more permanent ground-built space station for longer flights. Please comment on this proposal discussing also what studies NASA has made concerning use of the Titan III/MOL and the relative launch vehicle and development costs involved?

Answer 4. During the past year NASA has considered carefully whether the Titan IIIM launch vehicle or the Titan IIIM–MOL system should be used in the post-Apollo nonmilitary manned space flight program in lieu of the uprated Saturn I-Apollo system. The key questions have been:

1. Possible use of the Titan IIIM instead of the uprated Saturn I to launch the Apollo system.

(*a*) Would it be technically feasible?

(*b*) Would it be less expensive?

(*c*) What would be its advantages and disadvantages?

2. Possible use of the Titan IIIM-MOL system in place of the uprated Saturn I-Apollo system:

(*a*) Could essentially the same objectives be accomplished?

(*b*) Would it be less expensive?

(*c*) What would be the advantages and disadvantages?

Several specific possible programs and alternatives were studied in some depth by NASA, with the collaboration of the Department of Defense in providing data and cost estimates with respect to the Titan IIIM and MOL systems. Ground rules for performance and cost comparisons were worked out jointly by NASA and DOD. In the studies, NASA used without modification or independent validation the technical data and cost estimates on the Titan IIIM and the MOL systems provided by DOD.

These studies have led to the following main conclusions with respect to the questions listed above:

1. With respect to the possible use of the Titan IIIM instead of the uprated Saturn I to launch the Apollo system:

(*a*) The use of the Titan IIIM to launch the Apollo system appears to be technically feasible, but its feasibility would have to be confirmed by further ground and flight testing. Use of the seven-segment Titan IIIM from ETR would provide capabilities approaching but not equal to those of the uprated Saturn I-Apollo system. The low orbit payload performance penalty would be about 10 percent per launch. At least 3½ years would be required for systems integration, facility modifications at ETR, and flight qualification of the Titan IIIM-Apollo configuration.

(*b*) Funding requirements for the first several years for programs using the Titan IIIM would be substantially higher than for corresponding alternative programs using the Saturn IB-Apollo system because of the nonrecurring costs of about $250 million for systems integration, facility modifications at ETR, additional checkout equipment, control center modifications, and two unmanned launches to qualify the new Titan IIIM-Apollo system. The Titan IIIM-Apollo system would have lower recurring costs than the uprated Saturn I-Apollo system by about $15 million per launch, and after about 17 launches the savings would amortize the initial nonrecurring costs. Compared to a corresponding program using the uprated Saturn I-Apollo system, and assuming four launches per year in both cases, it is estimated that the crossover point at which a lower total program cost would result from introduction and use of the Titan IIIM-Apollo system would not occur until 7 years after a decision to proceed with it.

(*c*) Use of the Titan IIIM-Apollo system would have several disadvantages as compared to the uprated Saturn I-Apollo system. These include: (1) the payload penalty of about 10 percent; (2) the problems of integrating the Apollo system with Titan IIIM; (3) the program discontinuities involved in shifting to the Titan IIIM-Apollo after 12 uprated Saturn I-Apollo launches; (4) the delay of about 2 years in the time at which a post-Apollo nonmilitary low earth orbital manner program could get underway; and (5) the fact that the Titan IIIM cannot be used to place S–IVB stages in orbit for use and reuse with the airlock in the approach to the development of long duration flight capabilities which now appears to have significant advantages.

The only advantage in using the Titan IIIM to launch the Apollo system appears to be the lower ultimate total program cost if the total number of launches is large enough so that the potential long-term savings can be realized. In view of the experimental nature of the nonmilitary post-Apollo Manned Space Flight program now under consideration, and the possibility of a decision sometime in the next several years that a new system should be developed to meet the requirements as seen at that time, it does not appear prudent to make a decision at this time based on the assumption of high-volume or long-term use of either the Saturn IB-Apollo or Titan IIIM-Apollo system.

2. With respect to the use of the Titan IIIM-MOL system in place of the uprated Saturn I-Apollo system:

(*a*) An unmodified Titan IIIM-MOL system could meet some NASA post-Apollo objectives but would not be capable of achieving the longer duration flight and related experiment objectives which are a primary post-Apollo goal. An extensively modified Titan IIIM–MOL system suggested by the DOD (designated the uprated MOL system) might accomplish some of the long-duration flight objectives now envisaged, and this configuration has been used for comparison with the uprated Saturn I-Apollo system. Development of the uprated MOL system is estimated to require almost 4 years from the time a decision is made. With a vigorous program entailing a launch rate of six per year, a milestone of 1 year in orbit might be achieved about 1 year later than with continued use of the uprated Saturn I-Apollo system. DOD has no plans at this time to proceed with such a development for DOD purposes.

(*b*) The uprated MOL system would necessitate DOD and NASA nonrecurring costs for development and facilities modifications estimated at about $480 million. Recurring costs would be higher for each 1-year mission than with the uprated Saturn I-Apollo system since a larger number of launches (six versus four) would be required. Achievement of the same number of man-days in orbit would require an even greater number of launches with the Titan IIIM-MOL system.

(*c*) Use of the uprated MOL system in lieu of the uprated Saturn I-Apollo system has several disadvantages, including: (1) the two-man-per-launch limitation on ferrying operations as compared to three with the possible increase to six men per launch with the Apollo; the 2-to-3-year delay and hiatus in low Earth orbital application of the technology being proven in the Apollo program; and (3) the lack of direct compatibility with Saturn V-launched systems which means that (*a*) the advantages of common use of S–IVB stages, including the spent stake "workshop," would be lost, and (*b*) there would be no economical capability to test in low earth orbit the same systems to be used with the Saturn V in high and synchronous orbits or out to the Moon or beyond.

Use of the uprated MOL system would have the advantages of (1) compatibility with the DOD Titan IIIM-MOL system, and (2) a capability for polar orbit from WTR launch facilities being built for the basic MOL.

In view of the above, it has been concluded in summary that:

1. A decision at this time to discontinue use of the uprated Saturn I-Apollo system and to introduce in its place either the Titan IIIM launch vehicle or the Titan IIIM-uprated MOL system for use in the nonmilitary post-Apollo Manned Space Flight program would not be technically desirable or clearly cost effective.

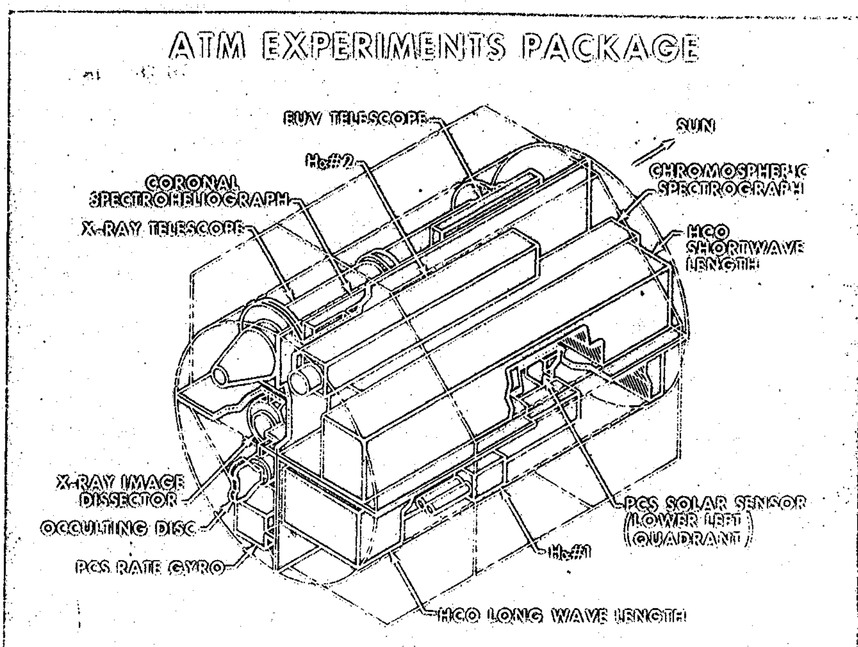
2. Use of the uprated Saturn I-Apollo system will take advantage of and maintain continuity with the Apollo program and avoid the prospect of a hiatus which might jeopardize the U.S. position in space.

3. Assuming success in the experimental program now planned, a capability for long-duration flight of 1 year or more could be available sooner and at less cost by proceeding in fiscal year 1968 and subsequent years with the uprated Saturn I-Apollo system.

4. If the experiments to be undertaken by NASA with the uprated Saturn I-Apollo system and by DOD with the MOL system indicate a requirement for a nonmilitary program involving a large number of missions within the capabilities of the MOL system, the use of the Titan IIIM–MOL or a modification thereof should receive careful consideration.

*Question 5. If the solar telescope cannot be launched during the height of the solar activity in the 1968–69 time period, would it still be worthwhile to launch the solar telescope after that period?**

Answer 5. The forthcoming period of maximum solar activity is expected to range from 1968 through 1970. This period is probably the most interesting period of the 11-year solar cycle, however, there is still much to be learned about the Sun's behavior during the remaining portion of the cycle. Scientific returns from the ATM experiments package mission (ML67–5558) during the 1970 portion of solar maximum, and on into the period of degrading activity would be extremely beneficial to the scientific community.



*Question 6. What is the estimated total cost of the solar telescope, and how much is being funded in fiscal year 1968?**

Answer 6. The total cost of the ATM experiments package is estimated at $19.5 million. Of this amount, $7 million is planned for fiscal year 1968. The ATM experiments package contains five experiments. Two of the five experiments are specifically for telescopes with a total of $7.9 million, of which $2.7 million is planned for fiscal year 1968.

* It is assumed that solar telescope refers to the Apollo Telescope Mount (ATM) experiments package.

*Question 7. How many solar telescopes does NASA plan to build, and has a contractor been selected?**

Answer 7. The ATM experiments package carries five scientific experiments containing nine separate telescopes. The total cost of the five ATM experiments is estimated at $19.5 million. Of this amount, $7 million is planned for fiscal 1968. Two of the five experiments are specifically for telescopes with a total of $7.9 million, of which $2.7 million is planned for fiscal year 1968. The principal investigators are contractually responsible for the development of their instruments. In some instances, they subcontract major portions or all of the instrument development and fabrication to an industrial organization. In the case of the ATM experiments package, three of the investigators (Harvard College Observatory, High Altitude Observatory, and the Naval Research Laboratory) have given major portions of their instrument development effort to the Ball Brothers Corp.; one investigator (American Science and Engineering) is doing their own development work in-house; and one (GSFC) is having their instrument developed by MSFC. These solar telescopes complement those instruments which have been flown and planned for flights on balloons, rockets, and the orbiting solar observatories.

Question 8. In view of the comments concerning ATM in the PSAC report, what efforts are going on within NASA to develop an "optimized" space astronomy program?

Answer 8. Initial steps are being taken by NASA to develop an optimized space astronomy program. Studies have been made in this regard and others are currently in process. NASA is working with the National Academy of Sciences and with some of the leading astronomers to develop the best approach to a space-borne astronomical observatory.

Included in such an observatory could be a large astronomical telescope and a number of smaller ones including solar, planetary, X-ray and radio types. It might be automated with remote operation by astronomers on the ground. It is expected that it would be mantended in that man would maintain it, focus and repair instruments, replace parts as required and change and return film.

The ATM and OAO are current development steps being conducted in parallel, leading toward this objective. In gathering data regarding solar phenomena the ATM incorporates man into the data gathering loop and also provides for the use of photographic film for obtaining high resolution data at a high data rate. The OAO, being an automated spacecraft carrying instrumentation to study stellar astronomy, provides experience in long-term operation of astronomical scientific instrumentation in a space environment. The combination of these two programs provides the logical development know-how to obtain the currently viewed optimum astronomy program.

Question 9. When does NASA plan to use operationally the lunar mapping and survey system?

Answer 9. NASA plans two missions in 1968—one an Earth orbital test mission, and the other a lunar contingency mission, if required

* It is assumed that solar telescope refers to the Apollo Telescope Mount (ATM) experiments package.

for operational support of the Apollo program. For AAP lunar orbital missions, contingent on the success of the manned lunar landing mission, we will be ready to fly one mission a year beginning in 1969.

Question 10. Assuming that the mapping and survey system will not be used until after the manned lunar landing, why does the system have to be funded in fiscal year 1968 and flown on the first Apollo Applications flight?

Answer 10. Both Apollo and Apollo Applications lunar surface missions require surveys and mapping of candidate landing sites. Operational requirements may not be fully satisfied by unmanned Surveyors and Lunar Orbiters. The Apollo Applications requirements may be more rigorous than Apollo because extended duration exploration sites can be at high latitudes or near rugged geological features. A larger area must be studied in detail to suppport large area surface traverses, and safe landing areas must be found in close juxtaposition to interesting, therefore potentially dangerous, surface features. Funding in fiscal year 1968 is needed to provide for an Earth test mission in mid-calendar year 1968 to prepare for subsequent lunar missions in the 1968–71 time frame.

Question 11. In Dr. Mueller's prepared statement, the LMSS is referred to as "Apollo-developed." Please explain what you mean by "Apollo-developed," and when was it developed?

Answer 11. The LMSS has been under definition since 1964 with feasibility studies started in 1963. The system is funded by Apollo since it is being developed to meet Apollo contingency requirements for site certification and landmark location. Apollo Applications requirements are also covered, and the capability to meet general scientific objectives is now being incorporated.

Question 12. Was the LMSS reviewed by the President's Science Advisory Committee in connection with its report, "The Space Program in the Post-Apollo Period"?

Question 12(a). Do you consider it significant that LMSS is not mentioned in the report?

Answer 12. The LMSS was not formally reviewed by PSAC, but several members of PSAC and their staff have been kept informed of its development.

Question 13. Will NASA use the lunar mapping and survey system in conjunction with earth resources surveys? If so, have the Departments of Interior and Agriculture been consulted regarding the design, development, and use of LMSS?

Answer 13. No, there are no present plans to use the LMSS for earth resources survey. The system is designed and configured for lunar missions. The earth test mission in 1968 will be a lunar simulation mission.

Question 14. Will the L. M. & S.S. provide both photographic and infrared coverage?

Answer 14. We are planning to use primarily fine grain, panchromatic emulsions imaging in the 4000–7000 Angstrom range, but infrared emulsions, sensitive out to approximately 1 micron can also be used. Color emulsions can also be used with the L.M. & S.S.

Question 15. How many L.M. & S.S. will be built and has a contractor been selected? What is the estimated total cost of the L.M. & S.S.?

Answer 15. Five systems are being developed, and contractors have been selected by the DOD, which is NASA's agent for this effort. The estimated total cost of procuring, integrating, operating, and reducing that data from L.M. & S.S. for five missions is approximately $76 million.

Question 15(a). What portion of the $454.7 million requested for AAP in fiscal year 1968 is devoted to L.M. & S.S.?

Answer 15(a). The LMSS development will require $17.9 million in fiscal year 1968, to be included in the Apollo budget. The AAP request includes approximately $2 million for L.M. & S.S. mods to increase its scientific capability.

Question 16. Is the Department of Defense developing or funding any portion of the mapping and survey system? If so, what is its interest in the system?

Answer 16. DOD, pursuant to a NASA–DOD agreement, is developing the L.M. & S.S. flight hardware to meet NASA lunar mission requirements, under NASA funds transferred for this purpose. DOD is not funding any portion of the L.M. & S.S. development.

Apollo Applications

(Set No. 2)

Question 1. Of the $51,247,000 budgeted for AAP in fiscal year 1966, how much has been committed and how much has been costed as of February 28, 1967?

Answer 1. As of February 28, 1967, the latest date for which data is available $45,147,000 of the $51,247,000 had been committed. Actual obligations were $41,787,000.

Question 2. Of the $80 million budgeted for AAP in fiscal year 1967, how much has been committed and how much has been obligated as of February 28, 1967?

Answer 2. As of February 28, 1967, $44,323,000 of the $80 million had been committed. Obligations totaled $35,382,000.

Question 3. The back-up books (p. RD 2–2) refer to the long duration flight capability of AAP as a key requirement for most of the significant advances in Manned Space Flight. Does this indicate that NASA will wait until it has demonstrated the ability of man to survive in space for at least 1 year before recommending the approval of new space goals such as a manned Mars flyby or landing?

Answer 3. Full assurance that the crew would not only survive, but would function effectively throughout the mission, is, of course, a prerequisite to embarking on a manned planetary mission and will require extensive test operations and demonstrations in orbital flight, as well as a comprehensive ground test program. A goal such as a manned planetary mission could be established on the basis of considered judgment against well-defined risks, taking into account the state of knowledge at the time, with demonstration and confirmation of key capabilities at their proper time in the development program. In the planned AAP Earth orbital series, we expect to have results during 1968–70 from flights of progressively longer duration, ranging initially from 1 month up to 1 year. These results will provide either increased assurance of the feasibility of manned planetary flight or early indications of problems to be solved. NASA is recommending that the United States go ahead with a vigorous program of long duration manned flight in the Apollo Applications program so that the United States will have the basic data for major decisions beyond the post-Apollo space program as early and completely as possible.

Question 4. Will shielding against radiation hazards and micrometeoroid penetration have to be added in orbit to the walls of the S–IVB stage in order to make it safe for astronauts?

Answer 4. It is possible that shielding may have to be added to the S–IVB stage to lower the probability of micrometeoroid penetration. The probability of penetration during planned occupancy is quite low, and the danger to the astronauts from such a penetration has not been fully evaluated yet because the habitability quarters design is not complete. If it is considered advisable to use a micrometeoroid shield, it will be installed prior to launch.

Studies based on available data show that the trapped radiation environment at the altitude of the orbital workship mission will not present a radiation hazard to astronauts within the workshop. Solar flares do not significantly raise the damaging radiation level at this altitude. The Command Module, with its inherent radiation shielding capability, will function as a radiation "storm shelter" for the orbital workshop crew in event of a massive solar flare.

Question 5. What are the relative merits regarding building the orbital workshop in space versus making the necessity modifications to the S–IVB stage on the ground and then launching into space?

Answer 5. Some of the modifications required to make the S–IVB stage habitable cannot be made prior to launch if the stage is to be used also for propulsion. On the other hand, complete assembly of the habitability structures and equipment in orbit would require an inordinate amount of astronaut time. A balance has been established between these extremes. A basic structure will be installed prior to launch that will not interfere with the propulsion characteristics of the stage. Experimental equipment and partitions will be packaged externally for launch and will be brought into the S–IVB hydrogen tank and assembled in orbit.

Question 6. Will systems or subsystems being developed for the MOL program find application in NASA's AAP program?

Answer 6. This question should be answered in terms of mutual benefits of the MOL/AAP programs. The NASA and the DOD now have agreements in operation that provide an interchange of personnel and technical data. The majority of the MOL systems are basically the Apollo and Gemini systems or extensions of those systems to obtain an orbital capability of 30 days. Any developmental improvements of those systems by the MOL program will certainly be evaluated for utilization in the AAP. One area, as an example, is the electrical power system. DOD is sponsoring the improvement of the Apollo fuel cell by incorporating ceria coated/cobalt activated electrodes to obtain a longer life. Though the MOL operational characteristics will differ, AAP is seriously considering the application of this technology development in the use of the improved fuel cell for AAP missions.

In the experiments area, the DOD is sponsoring several experiments for flight in the AAP orbital workshop. This will give the MOL preliminary flight evaluations prior to finalization in the MOL flights. These experiments deal with in-space maintenance and repair tools; crew activities such as suit donning and sleep station evaluation; expandable airlock technology; and recoverable expandable structures.

Question 7. Will a Lunar Module ascent stage be diverted from the Apollo program to provide for mating to the ATM? If so, how long before the launch of the ATM must such a module be diverted?

Answer 7. Yes. If the Apollo program goes well. Present plans identify the need for the assignment of an ascent stage which will be delivered approximately 1 year prior to the ATM launch date. LM/

ATM design definition to date indicates that the LM ascent stage should be assigned to AAP approximately 9 months prior to launch in order to make the necessary modifications and to conduct tests.

Question 8. What is the orbital lifetime for the CSM on AAP–1?

Question 8(a). If for some reason the AAP–2 orbital workshop cannot be launched as expected, can the L.M. & S.S. be left in orbit for later use?

Question 8(b). Why isn't the launch of the unmanned orbital work-shop the first mission in the Apollo Applications program since it can remain in orbit and is not dependent upon an immediate second launch?

Answer 8. The orbital lifetime of the CSM on AAP Mission 1 at a nominal altitude of 120 miles is governed by the electrical power capabilities of the CSM. Depending upon the exact power profile to be used during the mapping and survey system test, the total lifetime may run from 8 to 12 days.

Answer 8(a). The L.M. & S.S. cannot be resumed in its present configuration.

Answer 8(b). The orbital workshop is established by a series of venting and passivation actions accomplished partly by automatic sequencing and partly by the crew on the spent S–IVB stage. These take place during the first few days after launch and while the assembled vehicle is under the control of the CSM. For this reason it is important that the CSM be in orbit and ready to rendezvous at the time of the orbital workshop launch. We also plan to have several days of low Earth orbit qualification with the L.M. & S.S. prior to initiation of the orbital workshop mission.

Question 9. The established production capability for the Apollo program is six uprated Saturns and six Saturn V's per year. In the Apollo Applications program, it is expected to launch four Saturn IB's and four Saturn V's per year. What effect will this reduction have upon your organization?

Question 9(a). Since such items as facility overhead remain relatively constant, what effect will this reduction have on the cost per vehicle?

Question 9(b). What is the current cost of an uprated Saturn and a Saturn V?

Question 9(c). What is the estimated cost per vehicle for those being funded in fiscal year 1968?

Answer 9. There will be no substantive effect on the total organization, only a possible shifting of some personnel away from the hardware production area to the experiments area.

Answer 9(a). The Apollo schedule requires a maximum delivery rate of four uprated Saturn I's and six Saturn V's per year although a production capability of six of each vehicle has been established. The average cost of the initial Saturn V's procured for AAP will increase significantly in the transition to a four a year rate. The affect on uprated Saturn I unit costs is minimized by the continuation of essentially the same production rate as Apollo and the recognition of cost savings introduced in this more mature project.

Answer 9(b). The current recurring production cost for an uprated Saturn I and a Saturn V delivered to Cape Kennedy is $42 million and $163 million respectively.

Answer 9(c). The estimated cost per vehicle for those funded in fiscal year 1968 for Apollo Applications is $39 million for the uprated Saturn I and $193 million for the Saturn V. The unit cost is greater for the Saturn V than in Apollo since the follow-on production rate is lower than Apollo.

Question 10. How many uprated Saturn I and Saturn V flights does NASA currently envision for the Apollo Applications program?

Answer 10. The total scope of the Apollo Applications program is not measured in a specific number of flights but in a planned rate of mission capability over the next several years. The total number of missions in the program will depend upon progress and successful achievement of sequential objectives, upon problems encountered, and upon the resources available.

Question 11. Is it expected that follow-on orders for Saturn/Apollo hardware will be fixed price contracts or will NASA continue to use incentive contracts?

Question 11(a). What was the nature of Saturn/Apollo hardware contracts awarded with fiscal year 1967 funds?

Answer 11. It is expected that NASA will continue initially to use incentive contracts for follow-on orders for Saturn/Apollo hardware in order to continue to motivate the contractors to increase their efficiency and reduce costs, while producing the best possible items.

It must be noted that as yet many of the Apollo and Saturn engines, stages, and modules have not been flown a sufficient number of times to establish the production configuration. Changes are still anticipated and drawings and specifications are constantly undergoing revision. As experience is gained in the production and performance of these items, and when cost data permits an accurate forecast of costs, full consideration will then be given to firm fixed price (FFP) contracts for later follow-on orders.

Answer 11(a). The major AAP hardware contracts presently utilizing fiscal year 1967 funds are:

(1) *S–IB stage.*—Contractor, Chrysler Corp.: Cost plus fixed fee (CPFF) type contract for long leadtime materials, components, and parts, including engineering support, necessary to maintain a follow-on capability at the rate of four uprated Saturn I's per year. The next procurement phase which will specify the fabrication, assembly, and delivery of stages will utilize incentive contracts.

(2) *S–IVB stage.*—Contractor, Douglas Aircraft Corp.: CPFF type contract for long leadtime materials, components, and parts, including engineering support, necessary to maintain a follow-on capability at the rate of four uprated Saturn I's per year. The next procurement phase which will specify the fabrication, assembly, and delivery of stages will utilize incentive contracts.

(3) *H–1 engine.*—Contractor, North American Aviation, Rocketdyne Division: Fixed price incentive (FPI) type contract for production and delivery of 60 H–1 engines.

(4) *Apollo telescope mount-pointing control system (ATM-PCS.*—Contractor, The Bendix Corp., Navigation and Control Division: Cost plus fixed fee contract with option to later convert to cost plus incentive fee (CPIF). For three units plus test support equipment and critical subassemblies.

(5) *Airlock.*—Contractor, McDonnell Co.: Firm fixed price (FFP) type of contract for design, development, fabrication, test, checkout, and delivery of one airlock module for flight.

Question 12. Discuss the relationship of the Department of the Interior's EROS (Earth Resources Observation Satellite) program to NASA's AAP program. What functions will NASA perform in regard to the EROS program?

Answer 12. The Department of the Interior's EROS program is understood to be in the conceptual stage aimed toward the eventual establishment of an *operational* space system for Earth resources observation. The NASA effort in Earth resources observation is directed toward establishing the feasibility of such observations and developing the most cost-effective systems for multiple-use applications; in this effort it is expected to carry out both manned and automated experiments. In the Apollo Applications program, NASA is planning several payloads that will both test the instrumentation for Earth resources observations and define the most effective use of man in such an effort—as an observer, equipment operator, data collector and discriminator, or maintenance and repair engineer. The data from both manned and automated systems will be made available to all potential user agencies to guide their definition of requirements and capabilities for operational systems.

Specifically with regard to EROS, NASA has responded to the Department of the Interior's request to analyze the feasibility of the concept and to provide the necessary R. & D. background for such an approach to Earth resources observations.

Question 13. How does NASA plan to handle the tremendous amount of photographs and other data that will be obtained in the Apollo Applications program? Will a new data-handling mechanism have to be created or are present facilities, personnel, and systems sufficient?

Answer 13. During the high data Gemini 7/6 mission the existing NASA data collection, handling, and reduction facilities were adequately employed and provided the major portion of the support. In the determination of facilities, personnel and systems requirements for AAP, consideration is being given to frequency, timelines (how quickly is reduced data needed) and quantity of data. It is anticipated that the data rates for AAP will be not too much greater than those currently employed in the unmanned programs which are being adequately handled with present capabilities. The Space Science Data Center at GFSC is receiving data at the rate of 100,000 tapes per year; 300,000 tapes have already been stored there. This storage facility will be expanded to accommodate the additional quantity of data generated in AAP.

In summary, a large portion of the data-handling mechanism necessary to support AAP requirements is in being. In certain areas where additional facilities, personnel and systems are required, they are being identified and implementation started. The initial AAP experiments will be supported by existing capability.

Question 14. If the AAP program uncovered information concerning another country that is or may be of military significance, how does NASA propose to handle such information?

Answer 14. The scientific results of the NASA flight programs are openly available to all nations, either directly or through the publication of research results. Any Government agency including the Defense Department has complete access to such data from our flight experiments. The Apollo Applications program experiments now planned and foreseen will produce information of great value to the scientific and engineering community on the role that man can best play in space systems, on solar and stellar astronomy, and on many techniques and approaches for the utilization of space systems for furthering the welfare of this Nation and of mankind. Such information, while of potential significance to the defense capabilities of the United States, is intended to provide tests of crews and instrumentation in Earth orbit and at the Moon.

Question 15. The Department of Defense is using a mixture of oxygen and helium in the MOL program whereas NASA indicates that it will use a mixture of oxygen and nitrogen in the AAP program. Would you discuss the reason for the oxygen-nitrogen selection?

Question 15(a). Will it be used operationally on the first AAP flight or will NASA rely on a pure oxygen environment?

Answer 15. The Apollo Applications program presently plans to use a 5 pound per square inch absolute, two-gas atmosphere of 69-percent oxygen, 31-percent nitrogen in the airlock module and S–IVB spent stage workshop for planned mission durations in excess of 30 days. The 5 PSIA pressure level selected for this mission was dictated by present Apollo pressure vessel capability and system compatibility considerations.

The primary consideration in utilization of the two-gas system for long-duration missions is a desire to avoid physiological uncertainties and the possibility of atelectasis or collapse of the alveoli of lungs from ready absorption of oxygen and concomitant lack of inert gas. Nitrogen is not metabolized by the tissues of the body and the addition of a small percentage of the gas appears to prevent the clinical effects attributed to the absorption of oxygen.

The oxygen-nitrogen atmospheric composition was selected as being physiologically equivalent to the Earth environment in most essential aspects.

The orbital workshop concept permits Apollo astronauts to work and perform experiments and enables us to investigate the feasibility of using a launch vehicle spent stage in orbit as a large habitable space structure. It provides an early capability for a large, controlled environment to evaluate human performance in long-term zero gravity.

Man's evolution on Earth in an atmosphere consisting primarily of oxygen and nitrogen provides us with a massive amount of baseline data for comparison with biomedical observations to be made in the AAP Workshop. The baseline data on man's behavior in atmospheres containing primarily oxygen and helium is significantly less. While there is no question of harmful effects of an oxygen-helium atmosphere, the interpretation of biomedical data obtained in space with this atmosphere is more complicated.

Answer 15(a). A two-stage (oxygen-nitrogen) atmosphere will be used on the first AAP orbital workshop mission.

Question 16. If it becomes necessary to reprogram additional funds into the Apollo program as a result of the accident, will the funds be taken from AAP? If so, what part of the AAP program will be cut back?

Answer 16. No determination has been made that funds will be required from AAP to cover Apollo costs resulting from the accident until the report of the review board has been received and analyzed. Should AAP funds be required for this purpose later, the decision on which parts of the AAP program to cut would be made at that time on the basis of minimizing impact to work already underway while maintaining the best possible balance for future effort.

APOLLO APPLICATIONS

(Set No. 3)

Question 1. According to figures previously presented by NASA, four AOSO satellites would have cost about $167.4 million, or about $42 million each. The PSAC report states (p. 74) concerning ATM "the expected value of scientific return may be no greater than would have been obtained with one of the original 9-month AOSO flights."

(a) What information will ATM provide that could not have been provided by AOSO?

(b) Why was AOSO canceled?

(c) At the time of the PSAC review, what was the estimated cost of each ATM, exclusive of launch cost?

(d) What is the current estimated cost for ATM?

(e) How many ATMs will be built?

(f) What is the estimated launch cost per ATM, including the cost of the launch vehicle?

(g) If there has been an increase in cost since the PSAC review, what was the reason for the increase?

(h) Why, in terms of scientific return, is the ATM worth the increased cost over what AOSO would have provided?

Answer 1.

(*a*) The scientific objectives of the ATM experiment are not identical to those of the AOSO. The instrumentation was tailored, in each case, to the unique capabilities of the respective missions.

The ATM, using film as the basic means of data acquisition, will provide wide bandwidth, high-resolution studies to be made of rapidly fluctuating solar phenomena. As an example, the rise time of solar flares, measured in seconds can be photographed by the ATM. AOSO would have provided long-term studies of the sun, but with a low data rate capability.

Launches for both ATM and AOSO were planned during the next period of maximum solar activity because data from both types of space telescopes are essential to understand solar activity and solar flares.

(*b*) The AOSO was canceled because of budgetary considerations. In particular, the AOSO imposed heavy constraints upon the fiscal year 1966 and fiscal year 1967 budgets since development funding requirements for the program peaked during this time period.

(*c*) At that time (September 1966), the estimated cost of the first ATM, exclusive of launch, was $36 million.

(*d*) The current estimated cost of the first ATM is $38.4 million.

(*e*) The fiscal year 1968 budget request includes funds for continued development of the first ATM and the initiation of development of a second. Both will be configured for solar astronomy missions. A third ATM, for a stellar astronomy mission, is planned, however, no funds are contained in the fiscal year 1968 budget for initiating this development.

(*f*) The estimated launch cost for the first ATM, including the cost of the Uprated Saturn I launch vehicle and Lunar Module, is approximately $130 million. However, this launch will provide other benefits besides the solar obtained with the ATM. The mission will provide data on man and his capabilities in space, on a family of other technological and scientific experiments, and on the utility of the ATM concept as well as direct solar data during a scientifically important period. Furthermore, the ATM is planned to be reuseable.

(*g*) Estimates have increased by $2.5 million since the PSAC review. All of this is in development efforts of the ATM itself and consists of additional work related to the solar cell array and the pointing control system.

(*h*) The ATM and AOSO programs are complementary from a scientific standpoint. The ATM, by using film as its basic means of data acquisition, will return hi-resolution, wide bandwidth data of rapidly varying phenomena. Launching ATM during the next period of maximum solar activity will increase the probability of photographing a greater number of solar events, thereby improving its cost effectiveness. AOSO was to have flown during the same time period, but for a longer duration, and would have telemetered data of slowly varying phenomena, thus complementing ATM.

Question 2. The PSAC report makes three criticisms of ATM on pages 73 and 74 of the report (items listed as (a), (b), and (c)). Please answer these criticisms if they are valid and explain how the problem has been corrected. If invalid, tell why they are invalid? Please also respond to PSAC's criticism concerning the workload of the astronauts (p. 74).

Answer 2.

(*a*) From an ATM operational viewpoint it makes no difference whether the astronaut is 10 or 100 feet away from the instruments just as long as he is above the obscuring atmosphere and in the same orbital viewing position as the instruments. From an astronaut safety and comfort point of view, it is far better to have him operate within the cluster. This arrangement not only gives the astronaut more maneuverability and flexibility, but also from a safety consideration keeps him within physical reach of his return vehicle. At the time that the PSAC committee was briefed on the ATM there was concern regarding manned motion or activity within the cluster and the effect this would have upon the accuracy of pointing and stabilizing the instrument platform. A vernier gimbal system has since been added to the ATM control system which will eliminate any impact of manned activity or motion upon the instrument pointing accuracy.

(*b*) It should be noted that ground observations and commands and electromechanical acquisition and pointing systems do not provide the most suitable arrangement to acquire solar activities in a timely manner. Accordingly, such interesting solar events as flare buildup patterns (rise time), are not obtained due to the time required for instrument pointing and acquisition by those other means.

(*c*) The concept of repair and maintenance of the scientific instrumentation is being investigated in the development program. It is considered, however, that this concept can be pursued to only a limited degree without overburdening our capabilities in both extra-vehicular activity (EVA) and instrument complexity. This feature is one of desire but not necessarily required in obtaining success in our early manned observatory missions.

(*d*) Operational time-lines are currently being investigated to determine the best and most feasible operational arrangement for acquiring data and optimumly using the astronauts capabilities. One example of such an arrangement could be the operation of the ATM instrumentation during four orbit shifts, approximately three times a day. Each orbit would consist of approximately 50 minutes; 10 for orientation and 40 for data acquisition. With three astronauts to conduct this effort, no undue hardship appears to be imposed. Approximately 300 hours of experiment operation time could be achieved in such a manner.

Question 3. Please distinguish between AAP studies and Advanced Mission studies—where is the dividing line? For example, during Dr. Mueller's AAP discussion on March 16, 1967, he referred to one chart which was entitled "Extended Lunar Erploration." The question is where does extended lunar exploration leave off, and where does advanced lunar mission studies begin?

(a) Is it fair to say that unlike when everything other than the Apollo program was automatically considered Advanced Missions, today there is no real difference between AAP studies and Advanced Mission studies; and that for all practical purposes, Advanced Missions should be a line item under AAP and refer to all studies and concepts other than those programs which are being actively pursued in the fiscal year for which the funds are requested?

Answer 3. The Apollo Applications program (AAP) is distinguished from Advanced Manned Missions by the approval status of the projects being considered. AAP engineering and planning is limited to that family of missions which utilize modified Apollo systems and which have been approved for detailed planning by the Deputy Administrator. Advanced Manned Missions studies include overall systems engineering, planning and definition of manned mission studies and projects, until these projects are approved for inclusion in the NASA program. However, Advanced Manned Missions studies do include consideration of major alternatives or additions to approved projects.

Advanced Lunar Mission studies cover those potential approach to the extension of lunar exploration beyond the capabilities of both Apollo and AAP.

In reply to the suggestion that Advanced Mission studies be a line item under AAP, we would not consider that good management. The AAP effort should be directed toward specific missions without diverting responsibilities. Advanced Manned Missions efforts provide the base on which to plan and select other future missions, which may involve new systems. Such advanced studies, in the past, provided the definition of the Apollo and the Apollo Applications programs. Studies of space stations, lunar exploration beyond AAP, and planetary missions are more appropriately identified and managed as Advanced Manned Missions rather than as a part of AAP.

Advanced Missions

Question 1. Of the $10 million budgeted for Advanced Missions in fiscal year 1966, how much has been obligated and how much has been expended as of March 1, 1967 (or the latest date for which figures are available)?

Answer 1. Latest information available from a canvass of NASA Centers shows $8 million of the fiscal year 1966 funds have been obligated. The remaining $2 million has been committed on study contracts now under negotiation. Of the obligations, about half has been costed.

Question 2. Of the $6.2 million budgeted for Advanced Missions in fiscal year 1967, how much has been obligated and how much has been expended as of March 1, 1967 (or the latest date for which figures are available)?

Answer 2. The consolidated fiscal year, 1966–68 Advanced Mission Study program is a progressive set of phased studies directed to provide the in-depth technical and fiscal data required for major program decisions. In keeping with the phasing of this study program, fiscal year 1967 funds have not yet been obligated. However, they are earmarked for specific studies which we are proceeding to implement by the end of this year. The fiscal year 1966 program is currently phased for obligation as a followup to the fiscal year 1967 program and we are planning full commitment during fiscal year 1968.

Question 3. Why was the Advanced Missions budget reduced by NASA in November 1966 $1.8 million below the $8 million authorized by the committee for fiscal year 1967? Would not the same level of funding ($6.2 million) be adequate for fiscal year 1968?

Answer 3. The reduction of $1.8 million resulted from the President's directive to the Agency to reduce expenditures as part of his anti-inflation measures. A total of $60 million in obligational authority was withdrawn from NASA.

The Advanced Manned Missions study program investment provides a progressive set of phased studies directed at providing the in-depth technical and fiscal data required for future major program decisions that are anticipated in connection with fiscal year 1969–70 budget submissions. The soundness of the Agency's proposals will depend upon the quality, scope and timeliness of the fiscal year 1966–67–68 study program results.

The fiscal year 1968 study program takes cognizance of the $1.8 million reduction in fiscal year 1967 and, in our judgment at this time, represents the minimum budget necessary for the 1966–67–68 study program to properly support major management decisions.

Question 4. What studies have been conducted by NASA relative to using solid strap-on rockets on the uprated Saturn, and what does NASA foresee as possible missions for such vehicles?

Answer 4. In fiscal year 1964, NASA initiated feasibility studies of improvements to the uprated Saturn I (Saturn–1B) which included consideration of strap-on solid rocket motors (SRM's) for increased performance. The same contractors were funded in fiscal year 1965 for studies of promising configurations in greater depth. These follow-on fiscal year 1965 studies were the "Saturn–1B Improvement Studies" with Chrysler (contract NAS 8–20260) and Douglas (contract NASA 8–20259). These contractual efforts included consideration of Minuteman and 120-inch (five and seven segment) strap-on SRM's. For a 100-nautical-mile circular orbit the resulting strap-on SRM configuration ranged in payload capability from approximately 50,000 pounds with four strap-on Minuteman to approximately 110,000 pounds with four strap-on 120-inch SRM's (seven segments).

Missions for which the uprated Saturn I (Saturn–1B) with strap-on solid rocket motors might be used include earth orbital manned and unmanned experiments, orbital injection of small, short duration space stations, and logistics support of large, long-duration space stations. Other possibilities included high energy, unmanned missions, usually with an upper third stage such as Centaur.

Question 5. What studies have been conducted by NASA relative to manned weather satellites and what is the outlook for such satellites at this time?

Answer 5. Investigations related to meteorology and weather satellites conducted in connection with our space station studies have been concerned with manned support of meteorological experiments. These studies did not address themselves to the creation of operational weather satellites in the sense of TIROS, Nimbus, and so forth, but rather toward manned facilities to conduct experiments and develop operational systems. The studies examined the spectrum of meteorological research objectives, instruments required for experiments in support of these objectives, flight mission requirements, and accommodation of the instruments aboard the conceptual station configurations.

Question 6. How are the fiscal year 1967 funds budgeted as between the four classes of Advanced Mission studies?

Answer 6:

Study area:	*Fiscal year 1967 (thousands)*
Earth Orbital	$3, 100
Lunar	450
Planetary	1, 500
Launch vehicle and general program	1, 150
Total	6, 200

CONSTRUCTION OF FACILITIES

General Questions

Question. The Subcommittee on Manned Space Flight has made five field trips to NASA field centers and contractors in the last 2 months. Based on these trips, it is obvious that the current NASA request does not include many construction requirements originally considered necessary by the field centers. It is recognized that budgetary considerations often preclude acceptance of many field requests. However, it would be illuminating to be apprised of such field projects. What was the total reduction by the manned space flight area and by field center, of field requests by NASA headquarters? What were some of the major projects eliminated by NASA headquarters and by any Bureau of the Budget action?

Answer. The total reduction in the proposed fiscal year 68 C. of F. program for each Manned Space Flight Center occurred at two levels, first at the OMSF level and then at the NASA headquarters level. The following table summarized these reductions. The figures are in millions.

[In millions of dollars]

Center	Center submission	OMSF submission	NASA headquarters submission
Kennedy Space Center	53.1	26.7	22.6
Manned Spacecraft Center	15.1	4.4	3.3
Marshall Space Flight Center	1.0	.9	.9
Michoud Assembly Facility	1.1	2.2	2.0
Mississippi Test Facility	2.0	0	0
Various locations	10.3	4.1	0
Total	82.6	38.3	28.8

The major projects eliminated included such facilities as:

Engineering Laboratory Addition	Kennedy Space Center.
Engineering Building	Manned Spacecraft Center.
Spacecraft Recovery Environmental Test Facility	Manned Spacecraft Center.
Upgrading and Modifications to Test Stand Facility	Mississippi Test Facility.
Optical Experiment Facility	Various.

The BOB review resulted in the reduction of one OMSF project. This was the Automatic Checkout System Experimental Facility, Manned Spacecraft Center.

Question. In the past, NASA officials have expressed concern over the lack of flexibility in the Fiscal Year 1967 budget level and the difficulties built into budget constraints which do not provide a margin of funds to adjust to unforeseen technical problems. How serious has this problem been with regard to NASA construction projects; how is NASA meeting this problem; and what is the outlook for Fiscal Year 1968?

Answer. The lack of flexibility in the budget levels for construction has caused NASA to reduce the size of its construction program through the elimination of projects which improve our technical capacity, which improve our ability to adequately house personnel on our centers as well as the elimination of those projects which improve and rehabilitate our physical plant. NASA has made do with the budget levels provided and anticipates making the same adjustments during Fiscal Year 1968.

Question. Last year, the Congress authorized a total of $95,919,000 for construction and facility planning and design activities, instead of the $101,500,000 requested by NASA. This amount was further reduced to $83,000,000 by appropriation action. What was the specific impact of these reductions? What serious delays in flight or test programs can be attributed to these actions?

Answer. Reduction of the NASA authorization request from $101,500,000 to $95,919,000 resulted in deletion of the Marshall Space Flight Center Hazardous Operations Laboratory Addition, and a reduction of $1 million in the authorized cost of the Manned Spacecraft Center Lunar Receiving Laboratory. Subsequent appropriation action reduced the NASA Construction of Facilities total from $95,919,000 to $83.000,000. As a result of this reduction four MSF projects have been deferred. These projects are:

Extension to Central Supply, Kennedy Space Center	$600,000
Engineering Building, Manned Spacecraft Center	2,600,000
Facs to Support S–IC & S–II Test Prog Mississippi Test Facility	1,700,000
Fac for S–IVB Stage Program, Various Locations	1,100,000

The deferral of institutional projects such as warehouse and engineering building additions will have a decided impact upon operational effectiveness and costs. This will result from continued overcrowding of personnel, equipment and supplies, and the use of dispersed substandard facilities. The deferral of technical facilities will particularly impact field center ability to react rapidly to the solution of complex problems, and in some cases equipment will be operated above capacity so that overhaul or replacement cycles will be reduced significantly.

Question. Based on present missions, including those proposed in the FY 1968 request, what is the latest NASA estimate to complete all new construction requirements in support of manned space flight activities, and what is the estimate of such requirements by field center? What is the current value of the NASA physical plant of the NASA manned space flight centers? Include a breakout of new construction or other CofF requirements, by Center, specifically needed for Apollo Application activities assuming currently requested programs are approved.

Answer. It is expected that the Apollo Applications Construction of Facilities requirements will be limited to modifications of existing facilities. These modifications are now in the process of definition. Essentially the funds have been provided for the completion of all major technical facilities required to support current programs approved through FY 1968. Approximately $25 million will be needed on a yearly basis for the next several years, to meet requirements as yet unidentified for the rehabilitation, repair, modification and upgrading of technical facilities. In addition requirements for support facilities such as warehouses, office space, and shops will continue to be identified as appropriate to meet deficiencies which have resulted from reduced appropriations. The following is an estimate of distribution:

	Million
Kennedy Space Center	$15–20
Manned Spacecraft Center	5
Marshall Space Flight Center, including various locations	5

The current value as of June 30, 1966, of the NASA physical plant by MSF centers is as follows:

Kennedy Space Center	$808,549,000
Manned Spacecraft Center	294,709,000
Marshall Space Flight Center	376,519,000
Michoud Assembly Facility	134,450,000
Mississippi Test Facility	215,994,000

Question. Last year, NASA estimated that about $2 million of FY 1967 facility planning and design moneys would be used in support of manned space flight activities. Is this estimate still valid? If not, what factors caused the changes? What portion of the $3 million requested for FY 1968 facility planning and design is to be used in manned space flight areas?

Answer. Current plans call for Manned Space Flight to utilize about $813,000 of Fiscal Year 1967 Facility Planning and Design Funds. Last year's estimate that about $2.0 million would be required, was based upon a projected FY 1968 C. of F. Program of about $40.0 million, in lieu of the present $27.9 million. In addition to a smaller program, significant elements of FY 1968 projects, such as Launch Complex 39 contract settlements, do not require design. Consequently, FY 1967 FP&D requirements have been reduced from $2.0 million to the present estimate of $813,000. However, the requirements for planning and design funds by OART and OSSA have increased correspondingly. It is estimated that about $1.25 million of the $3 million requested for FY 1968 will be utilized for facility planning and design in support of Manned Space Flight requirements.

Question. Have there been any work stoppages or strikes at any of the Manned Space Flight Centers during Fiscal Year 1967 and, if so, where and what duration? What has been the impact, if any, of such labor problems?

Answer. Information concerning work stoppages and strikes is maintained by calendar year. During Calendar Year 1966 a total of 36,276 man days were lost due to work stoppages. In 1965, 72,288 man-days of work were lost. This reflects a significant improvement in the labor relations area. The following tabulation shows location and duration of work stoppages:

Lost man-days—Calendar Year 1966

KSC	20,139
MSC	4,283
MSFC	450
MAF	0
MTF	11,053
WSTF	351
Various locations	0
Total	36,276

The improvement of 1966 over 1965 is due primarily to a program of preventive labor relations initiated by NASA. This program provides for detailed anticipatory planning on the part of NASA to avoid or work out labor problems before they reach the critical stage. The success of the program may be determined by an analysis of lost man days at the Kennedy Space Center. While this location had the highest number of lost man days during 1965 and 1966, it is significant to note that no work stoppages have occurred at this Center since September 8, 1966.

During Calendar Year 1966 there has been no impact on launch or test schedules resulting from work stoppages.

Question. What types of maintenance services are currently contracted out by the Manned Space Flight Centers? What is the value of such contracts by center for Fiscal Year 1967, and what is the estimate for Fiscal Year 1968?

Answer. The following is a listing of the types of maintenance services currently contracted for by the Manned Space Flight Centers:

Engineering in Support of Maintenance Activities
Maintenance and Repair of Buildings, Structures, and Equipment
Maintenance of Roads and Grounds
Custodial Services
Maintenance of Utility Systems
Fire Protection

The estimated contractual value for Fiscal Year 1967 and Fiscal Year 1968 is as follows:

Center	Fiscal year 1967	Fiscal year 1968
Kennedy Space Center	$13,908,000	$17,586,000
Manned Spacecraft Center	9,484,000	10,125,000
Marshall Space Flight Center	3,179,000	3,300,000
Michoud Assembly Facility	4,512,000	4,213,000
Mississippi Test Facility	4,100,000	4,300,000
White Sands Test Facility	2,304,000	2,385,000

Question. During last year's hearings NASA estimated that it would spend about $3,147,000 of Administrative Operations funds for minor construction and modification during FY 1966 and about $3.5 million for similar work during FY

1967. What was the final figure for FY 1966, the latest estimate for FY 1967 and the current estimate for FY 1968?

Answer. During Fiscal Year 1966 Manned Space Flight Centers expended $3,372,600 for minor construction and modifications. During Fiscal Year 1967, current plans call for a reduction to $2,480,000, while Fiscal Year 1968 is expected to be $2,258,200.

Question. Have all the NASA manned space flight centers fully developed their master plans and are they being kept current? What inspections were conducted by NASA Headquarters construction management personnel of the field centers during FY 1967?

Answer. The facility master plans for each of the NASA MSF Centers are kept current through a continuous process of reviewing, analyzing, upgrading and updating so that reliable documents are in effect when required. It is NASA policy to have the facility master plans officially updated by September 1 of each year. The timing is such that the updated documents are available at the time of the CofF budget preparation.

During FY 1967 construction management personnel periodically visited all MSF Centers and participated in design reviews, reviews of construction progress and adherence to approved projects, review of project funding requirements and to assure compliance with NASA construction and safety standards. Also included was the review of master plans. Field trips were made to provide appropriate guidance on master planning, and to assure that the plans are being properly implemented.

Question. Last year, there was considerable discussion on the Lunar Receiving Laboratory at the Manned Spacecraft Center. What progress has been made on this facility and will the original deadline date for its completion be affected by the recent accident at Cape Kennedy? Did the reduction in last year's request by the appropriation action result in any cutback in the construction for this facility; and if so, did such cutbacks reduce the capability of the facility to perform its function and in what way?

Answer. As of March 13, 1967 the overall construction of the Lunar Receiving Laboratory was approximately 65 percent complete, and all elements of work are on schedule. The following work has been completed: foundations; substructure; erection of structural steel; precast concrete wall panels, and aluminum window walls; roofing; underfloor utilities, and concrete floor slabs; utility tunnel and piping; and site utilities. The mechanical and electrical systems and interior partitioning are currently being installed. The vacuum systems and radiation counting equipment are in the fabrication phase.

The recent accident at Cape Kennedy will not impact the construction completion date of August 1967. However, the deadline date for operational readiness will be adjusted based on any changes which might be made to the Apollo Program as a result of the accident.

As a result of the $1.0 million reduction for the Lunar Receiving Laboratory which was imposed, it was necessary to delete one branch of the dual vacuum system, and reduce the square foot area of the facility from 86,800 to 83,000 square feet. The vacuum system is required for processing lunar samples with minimum terrestrial contamination while insuring against the release of biological organisms in the samples to the surrounding environment. In limiting the facility to a single vacuum system the operational flexibility to process samples was reduced. Although the quarantine period will not be affected the total sample processing time will be extended, thereby delaying release of samples to the scientific community.

Question. Last year, the committee expressed concern over the large amount of authorization not funded for facility planning and design. In fact, the surplus authorization through FY 1967 amounted to about $11.6 million. What disposition is to be made of this surplus authorization? How much of it will be automatically rescinded under the three-year expiration rule by the end of FY 1967?

Answer. For the Agency, approximately $9 million of the unfunded authorization for facility planning and design will automatically be rescinded at the end of FY 1967 under the three-year expiration rule.

Question. Of the total construction of facilities funds appropriated to date, how much has been obligated and expended to date? What are the obligations and expenditures to date on facility planning and design funds provided by

Congress? What are the obligations and expenditures to date on the FY 1967 funds provided for Manned Space Flight construction of facilities and facility planning and design?

Answer. Of the total construction of facilities funds allocated to date (FY 1961 thru FY 1967) to Manned Space Flight, the following amounts have been obligated and expended as of January 31, 1967.

	Million
MSF Program	$1,596.5
Obligations	1,544.3
Expenditures	1,423.6

The status of obligations and expenditures for facilities planning and design funds provided by Congress thru FY 1967 as applied to Manned Space Flight Projects as of January 31, 1967, is as follows:

	Million
MSF program	$27.9
Obligations	26.3
Expenditures	25.0

The status of obligations and expenditures as of January 31, 1967 for FY 1967 funds provided for Manned Space Flight construction of facilities and facilities planning and design is as follows:

[In millions of dollars]

	Construction of facilities	Facility planning and design
Funds available	$43.8	$0.6
Obligations	22.7	0
Expenditures	2.0	0

Question. Now that the major new construction program for the manned space flight centers is nearing completion, what measures has NASA taken to establish, maintain, and supervise an effective facilities maintenance program? In view of continuing rising costs for labor and materials, what steps have been taken by NASA to hold the line on maintenance costs without jeopardizing the effectiveness of the NASA mission and operation?

Answer. The establishment, maintenance and supervision of an effective maintenance program at each NASA Center and location was recognized as a major requirement early in the construction program. Within the Manned Space Flight Facilities Office, a maintenance group was established which has been augmented concurrent with the growth of the program. The basic purpose of this group has been to provide guidance and assistance to the Centers. It provides management with a review and evaluation group which strives continuously to improve center maintenance programs.

At each MSF Center or location, the maintenance structure includes a civil service management organization. Since five of the six MSF locations utilize contractual services to perform maintenance, this civil service entity provides guidance to control and evaluate the contractors' efforts. At the Marshall Space Flight Center, maintenance is performed primarily by civil service craftsmen with some augmentation by a support services contractor.

Each location has implemented effective procedures for budget planning, execution and work scheduling. Central work control offices have been established at each installation to insure: effective utilization of resources, centralized control of work, improved coordination between the accompaniment of maintenance work and interference with normal operations and better cost control systems. Maintenance work order flow procedures which recognize the need for approval processes are now a part of each Center's program. Preventive Maintenance programs are in effect as are maintenance stores and spare parts control methods. An equipment management program to determine the capability of each piece of equipment and to insure its effective utilization has been implemented at certain installations and is being initiated at the other sites.

Each of the foregoing techniques undergoes periodic reevaluation and review by both the Centers and the Manned Space Flight Facilities Office. These reviews are augmented by periodic reports which provide performance data and serve as a basis for a continuous total analysis of the maintenance program.

In view of continuing rising costs for labor and materials, definite steps have been taken to insure more effective utilization of maintenance resources while holding the line on maintenance costs. Significant improvements in maintenance management techniques have been accomplished resulting in improved efficiency and a reduction in costs. Examples of areas where cost reductions have taken place are as follows:

a. Utility Conservation—Savings have been effected by the institution of comprehensive conservation programs, and by scheduling activities to avoid high peak electrical demand periods, thereby reducing electrical utility costs.

b. Reduced Frequency of Custodial and Grounds Maintenance Tasks— Reduced costs have been effected by reducing the frequency of cleaning cycles, and reducing the intensive care areas for grounds maintenance. These reductions have not been made without due consideration to the possibility of increased deterioration of the facilities. Essentially, those services that were reasonable but were not essential to safety, health or necessary to the long-term preservation of condition were the only services reduced in frequency.

c. Supply Support—Annual purchase contracts for the purchase of standard maintenance supplies and materials have been negotiated at each location covering several thousand items. This technique reduces the cost of preparing numerous purchase orders throughout the year at obvious savings in clerical and processing costs. It has been found that a potential annual contract has led to spirited bidding by suppliers with resulting savings to the Government. Also the schedule of deliveries, agreed to by vendors, has permitted a reduction in storage requirements.

d. Instrumentation Pooling Program—As a part of the equipment management program, instrumentation pools are being initiated at several MSF installations. Savings are being derived due to improved utilization of existing instruments, and consolidation of Center-wide requirements for common-usage instruments resulting in "quantity procurements" at significant discounts.

e. "Off Season" Award of Service Contracts—Analysis of market conditions has led to the award of "one-term" repair projects, such as building repainting, repaving and reroofing, during the "off season". The cycle of these activities has been rescheduled now to take advantage of lower rates and competitive market conditions prevalent during these slow periods of construction and maintenance activities.

f. Reduction in Emergency Crews—Careful monitoring of the need for emergency crews during evenings or weekends has disclosed that significant reductions could be made in the size of crews required to provide this service. Emergency back-up is now provided by individuals who are designated to remain "on-call" in the event of an emergency during off-hours. This decision has led to significant reduction in costs but still provides for effective response in the event of an emergency.

g. More Effective Use of ADP Equipment—As the maintenance work load began to stabilize at each MSF Installation, positive steps were taken to reduce clerical scheduling and posting through the wider use of available ADP capability. As soon as sufficient information was accumulated, determinations could be made as to the most effective operation of facilities, better scheduling of preventive maintenance and more effective utilization of maintenance resources.

h. Increased Use of Automatic Monitoring Systems—As a part of the design of utility systems, cost studies are made to determine the "cost trade-offs" of operator monitoring of equipment operation versus automatic monitoring systems. The installation of the monitoring systems has led to significant operator cost savings as well as increased efficiency of the utility plant equipment. For example, at one MSF Center, the installation of a heating and cooling plant monitoring system has led to a force of roving operators numbering 54, where an unmonitored system would require 108 operators. The cost of acquisition and installation of the automatic monitoring system has been amortized in less than four years. At some of the older MSF installations, where such devices were not originally provided in the utility systems, analysis of cost studies has led to the installation of these devices with attendant cost savings.

Question. What is the estimate, by field center, for the FY 1968 cost of maintaining the NASA manned space flight field centers? What is the breakout by R&D and AO funds? How many personnel, by center, are involved in the maintenance function?

Answer. The estimate for maintaining the NASA Manned Space Flight Center Facilities during FY 1968 is:

Kennedy Space Center	$25, 661, 000
Manned Spacecraft Center	12, 495, 000
Marshall Space Flight Center	11, 532, 000
Michoud Assembly Facility	8, 746, 000
Mississippi Test Facility	5, 320, 000
White Sands Test Facility	2, 500, 000
Total	66, 254, 000

The breakout by R&D and AO funds is:

R&D Funding	$21, 524, 000
AO Funding	44, 730, 000

The number of Civil Service and contractor personnel involved in maintenance functions is as follows:

Kennedy Space Center	1, 647
Manned Spacecraft Center	857
Marshall Space Flight Center	641
Michoud Assembly Facility	261
Mississippi Test Facility	342
White Sands Test Facility	91

KENNEDY SPACE CENTER

Project: Launch Complex 39

Question. The FY 1967 NASA estimate of final runout costs on this launch complex was given at $475 million. How much of the $16.66 million request is for new construction as contrasted to modifications and alterations? Does this amount when added to the $473 million of prior year funds approximate the FY 1967 runout cost estimate? Is it anticipated that any further funds will be requested for new construction in the Launch Complex 39 area? Does NASA have any estimate for annual repair, rehabilitation and modernization costs?

Answer. Of the $16.6 million contained in this request, the following items are considered as new construction:

Launch Umbilical Tower Refurbishment Area	$482, 000
Gaseous Helium Storage	678, 000
Photo Support System	900, 000
Instrumentation	830, 000
Total	2, 890, 000

Currently we do not anticipate a requirement for major new construction in the Launch Complex 39 to meet the currently planned operational capability. It is estimated that approximately $10 million of CofF funds will be required on a yearly basis for rehabilitation and modernization of the complex.

Question. What is the specific basis that NASA used in estimating the funds required for contract settlement? How much has been paid in contract settlements to date on the work at Launch Complex 39? Is some of the money required for settlement of new claims as contrasted to settlement of appeals from contractors on unilateral settlements by NASA? If so, what portions are estimated for each category? Is the estimate in the FY 1968 request considered adequate to cover all present and potential claims under the contracts for work on Launch Complex 39? Furnish a few typical examples of cases where there were differences in interpretation of specifications, and project delays.

Answer. In estimating the funds required for the settlement of claims, a factor was applied against the contractors request as set forth in his original filing. This factor which gives a realistic appraisal of the final settlement, is based on experience with similar major construction projects of both NASA and DOD. It took into account claims which were filed and later denied, claims filed and subsequently withdrawn, together with those on which settlements were negotiated and paid.

As of March 1, 1967, $2.434 million had been paid for the settlement of claims connected with work on LC 39. It is estimated that an additional $10.6 million will be required for the payment of claims during Fiscal Year 1968, $7.2 million of which is required for claims which are presently on file and $3.4 million for anticipated filings. Of the latter, approximately $2.7 million will be required for the settlement of appeals from contractors on unilateral settlements by NASA and $0.7 million for the settlement of new claims on work that is presently in process.

The funds requested should satisfy our requirements through FY 1968. Since contractors are not limited as to the time in which they may file a claim there is a possibility that some claims might be filed and settled after FY 1968.

The following examples of claims that have been filed where there were differences in interpretation of specifications and/or project delays:

Provision of Hurricane Protection During Construction of VAB	$1,000,000
Correction of Deflection in Horizontal Rolling Door Guide Rail—VAB	59,138
Definition of Electrical Interface Between Crane and Construction Contracts—VAB	186,000
Late Delivery of Amended Contract Drawings and Specifications	20,000
Delays in Defining Discrepancies in Contract Drawings	10,000
Delays in Resolving Problems on Heat Sensing Devices—Jib and Bridge Cranes—VAB	11,070

Question. Will the Launch Umbilical Towers be refurbished after each launch? Is it anticipated that all three towers will use Launch Umbilical Tower Park Position No. 3 for refurbishment?

Answer. The Launch Umbilical Towers will be refurbished after each launch. All three towers will use Launch Umbilical Tower Park Position No. 3 in connection with refurbishment operations.

Question. What type of storage is KSC presently using for helium? If railroad cars are being used, is KSC paying demurrage for such storage and what are the estimated annual costs of such demurrage? Does NASA anticipate that the permanent storage requested will pay for itself over a period of time? If so, what is the time period estimate?

Answer. KSC currently has permanent facilities capable of storing 2,720,000 standard cubic feet of helium. This storage capability is being augmented through the use of railroad tank cars. We are presently paying $25.00 per day per car for demurrage or about $130,000 per year. The actual expenses from December 10, 1965 through December 31, 1966 was $138,425. These additional permanent storage facilities will pay for themselves in approximately 5 years.

Question. Funds are being requested to remove pockets of clay below the surface of crawlerways and to replace them with suitable fill material. Did not KSC or the contractor take core samples of the area before the crawlerways were initially built? If so, why were such clay pockets permitted to remain? Why was not this work considered before the surfacing operations in FY 1966 and 1967? Will the funds requested complete, in NASA's opinion, all of the necessary subsurface work?

Answer. Deep core borings were made at 1,000 foot intervals on the crawlerway to Pad A. Intermediate, shallower borings were taken at 250 foot intervals and at 100 foot intervals in areas where the borings indicated poor subsoil conditions might exist. The unsuitable material discovered as a result of the boring data was removed and back filled. The pocket in question is quite localized, is not in an area where the borings indicated questionable subsoil conditions existed, and was discovered when the crawlers underwent fully loaded tests in May 1966. As a result, the work included in this request could not be considered before the surfacing operations took place. The funds requested are expected to complete all necessary subsurface work.

Question. During last year's hearings, NASA estimated that the final runout costs on the Marion Power Shovel contract (for the crawler-transporters) would amount to $13.9 million (including a $4 million overrun from the original contract *price) and that the overall costs for the transporters would amount to about $15.1 million. Are these estimates still valid?*

Answer. The overall estimated cost of $15.1 million for the transporters is still valid.

Project: Alteration and Rehabilitation of Launch Complex Nos. 34 and 37

Question. What is the age of the launch towers and associated equipment and were they specifically designed for the Saturn I and uprated Saturn I vehicles? If not, what shortcomings exist relative to adequate handling of currently planned launches?

Answer. The launch towers and associated equipment for Launch Complex 34 were completed in 1961. LC 37 was completed in 1963. Both stands were designed for the Saturn S–1 vehicle. Since then both complexes have been modified to provide an uprated Saturn I capability. Both complexes are capable of supporting the presently planned launches; however, certain structural and other repairs and modifications must be undertaken to retain this capability.

Question. Does the proposed repair and rehabilitation work conform to the experience of the Air Force both at Patrick and Vandenburg bases? Are the estimates for repair and rehabilitation in consonance with cost factors used by the Air Force on their older launch complexes?

Answer. The non-recurring maintenance costs experienced by the Air Force as well as NASA on similar structures were considered in the development of the cost estimate for the subject project.

Question. What has been the impact of the Apollo accident on repair requirements and what is the current estimate of the amount of damage caused?

Answer. The alterations and rehabilitation which are included in this project request did not stem from the Apollo accident. The latter is currently under investigation by a Board of Investigation. The estimated cost of modifications resulting from the accident will not be known until the Board has completed its work and filed its report.

Question. Specifically, what are the reasons that environmental control systems must be replaced and where are such systems now located?

Answer. The environmental control systems, which are located on the service structure and umbilical tower at both complexes, have been in continuous operation for over five years and have reached the point where major repairs and the replacement of some key elements is, or will be necessary. While normal maintenance has been provided, a program of major repair and rehabilitation has not been accomplished previously on these systems. Such a program wherein major elements such as compressors, valves, and controls are rebuilt or replaced, is normal for equipment of this type and must be accomplished at approximately five year intervals. An engineering investigation of the condition of the environmental control systems has established that major repairs will be necessary during FY 1968.

Question. Why is it necessary to replace or install structural members? Was this caused by inadequate design on the umbilical tower and the launch structure?

Answer. The replacement of structural members is not the result of inadequate design. The need to replace or install new members stems from the effects of past launches on the structures and the corrosion which has resulted from the salt laden atmosphere at Cape Kennedy. Some new members will be added to provide for additional loads imposed by platform mounted ground support equipment.

Question. If the obsolete drum type elevators need to be replaced, is it because they are inadequate or simply worn out? If inadequate, why did the original design provide for such slow elevators and is not such lack of speed a potential danger hazard in the event of an emergency at the capsule level of the tower? How many elevators are involved at each complex and on what time basis does NASA intend to replace such elevators?

Answer. The existing obsolete drum type elevators are at or nearing a point where they will be beyond economical repair. A phased replacement program is therefore necessary. The speed of these elevators was considered adequate for the support of unmanned launches. Higher speeds will be incorporated in the replacement items. These elevators will compliment the high speed elevators that provide the astronauts ingress and egress at the capsule level. There are three slow speed elevators on Launch Complex 34 and two on Launch Complex 37. One elevator will be replaced on each Complex during FY 1968. The remainder are scheduled for replacement starting in FY 1969.

Project: Utility Installation

Question: It is understood that the interconnecting (or looping) of the three hot water systems is required in the event of a break in the main line serving any one area. How critical would such a break be in the carrying out of a launch mission? If uninterrupted service is of highest priority, why was such an interconnection not included in the original design and program for the utilities for the area?

Answer. A break in the main line serving any one area could result in the loss of the environmental control in one of the launch critical facilities and could cause a cancellation of a planned test or launch. The original design provided an economical and efficient high temperature hot water system. Cross connections were not included as the possibility of a major break in a supply main was considered to be remote. Subsequent studies have been completed which dictate the need for redundancy on certain systems to reduce the possibilities of single point failures. This requirement for cross connections is considered to fall within this category.

Question. Are there any other utilities systems (e.g., electrical, communication) that may require interconnection at some time in the future to insure continuous service? If so, identify such needs and provide related cost estimates.

Answer. Currently there are no known requirements for further interconnections of existing utility systems.

Manned Spacecraft Center

Project: Modifications to the Environmental Testing Laboratory

Question. Will this request complete all major modifications based on known technological needs? Did MSC request additional funds over and above the $1.9 million?

Answer. The request for Modifications to the Environmental Testing Laboratory will complete all major modifications based on known technological needs. However, due to the complex and sophisticated nature of this facility it will be necessary to accomplish future modifications to incorporate technological advances and retain the operating efficiency.

The MSC budget request was for $2,695,000 as compared to $1,900,000.

Question. How does the $410,000 for the conversion of the single manlock to a double manlock compare with the initial cost of the existing single manlock?

Answer. The existing manlock, with its supporting systems, was included as an integral part of the Chamber A structure. The contractor priced this work on the basis of the overall project and his bid information does not provide a basis on which the several elements of the manlock can be isolated and priced. A comparison of costs between the original work and the planned conversion would therefore not be realistic. However, the proposed modifications to provide a double manlock are in essence a duplicate of the existing installation and to this degree the costs should be comparable.

Question. About $1.5 million is requested for the rehabilitation of the solar simulation system and it is stated that by FY 1968 this system will have been operated for about 1,500 hours which is the limit of its life expectancy. Is it to be understood that at the 1,500 level there will be a recurring need for complete rehabilitation of this system? If so, is it expected that it will involve another $1.5 million and when is it anticipated that the next rehabilitation cycle will take place?

Answer. Although rehabilitation of the solar simulation system will provide certain improvements, it is expected that a major rehabilitation will be required after every 1,500 hours of operation. The rehabilitation costs are expected to remain in the area of $1.5 million unless significant improvements to the carbon arc system are developed. It is anticipated that the next rehabilitation cycle will take place in 2 to 3 years after completion of the proposed work.

Project: Center Support Facilities

Question. It is stated that the local authority, the Clear Creek Basin Authority, has ruled that all sewage treatment plants in the area must be operated at the highest level of efficiency. What specific deficiencies now exist that do not meet the effluent requirements of the local authority? What are the current operating effluent levels of other sources feeding into Clear Lake? What are the relative *turbidity levels and BOD contents of the effluents feeding into the lake as compared to that of the Manned Spacecraft Center sewage treatment plant? When was the latest requirement placed on the users of the lake as a point of discharge? Are all other parties now complying?*

Answer. MSC is meeting the current requirements imposed by the Health Department of Harris County. The current operating effluent levels of other sources feeding into Clear Lake meet, or are below, the 20 ppm BOD and 20 ppm of suspended solids as established by the Harris County Health Department. There are no turbidity requirements. Periodic inspections by the County Health Department are made to enforce compliance. The Clear Creek Basin Authority was established in 1965 with charter of preventing the eventual contamination of Clear Lake through further improvements in sewage disposal methods. The modifications which are included in this request are needed to improve the operating efficiency of the sewage treatment plant. These improvements will also assist in the control of water pollution in the Clear Creek-Clear Lake area in accordance with the long range program of the Clear Creek Basin Authority.

Question. It is stated that the present highway system creates delays during rush hours of up to 30 minutes. What percentage of the traffic during this period is actually delayed as long as 30 minutes? Why should the traffic volume during rush hours (presumably when the work day is starting or finishing) exceed the number of NASA and contractor employees located in the Manned Spacecraft Center? How often has the average daily traffic volume exceeded 21,000 vehicles per day?

Answer. State-NASA Road 1, which serves as the principal access to the Manned Spacecraft Center, is a major four-lane highway which interconnects the Gulf Freeway with the State Highway 146 which leads to LaPorte, Texas City and Galveston. As such, this route carries the traffic entering or leaving MSC, as well as that generated by the local communities and residential areas, and the cross country traffic which leaves the Gulf Freeway to enter the LaPorte Highway. It is this condition which adds to the delay of employees entering or leaving MSC. The average daily traffic volume which was stated in this project request, and the 1970 projections, were developed by the Bureau of Public Roads. It is estimated that up to 50% of the traffic entering or leaving MSC encounters delays of up to 30 minutes.

Marshall Space Flight Center

Project: Water Pollution Control

Question. The construction of new holding basins and the enlargement of existing basins implies that the creation of wastes from manufacturing and testing activities is going to increase. Is this true, particularly in light of the activation of the Mississippi Test Facility and the qualification of the various engines through numerous past tests? Why should there be any substantial amount of industrial wastes generated "in the manufacturing complex"? Isn't the manufacturing phase almost finished in the Marshall Space Flight Center? If not, what activities are being carried out?

Answer. The construction of new holding basins and the enlargement of existing basins is not associated with an increase in manufacturing and test activities at MSFC. These improvements are needed to provide a means whereby wastes which are generated by the present Center research, development and test activities can be held during periods of low stream flow, can be properly diluted or processed, and disposed of at times when conditions are favorable to the preservation of fish and wildlife. A substantial amount of industrial wastes are generated in the "manufacturing complex as a result of the research which is conducted on improved fabrication and manufacturing techniques as well as the development of prototypes of new parts and equipments. While the principal manufacturing efforts at MSFC has been reduced, research and development is being continued in consonance with the Center mission.

Question. It is stated that untreated wastes from the Center is a matter of concern to the Tennessee Valley Authority and the U.S. Public Health Service and that these agencies concur with the need for corrective action? Have either of these agencies at any time requested that the Center take corrective action? If so, when and in what way was such action to be taken?

Answer. Both the Tennessee Valley Authority and the U.S. Public Health Service have requested the Department of Army to take corrective action on wastes generated within the Redstone Arsenal reservation. The Army, has in turn, made the Marshall Space Flight Center responsible for taking corrective action on wastes generated in the NASA portion of the reservation.

The Department of Health, Education, and Welfare requested that they be furnished information on a plan of action which would control pollution in accordance with established criteria including: the start and completion date of the necessary engineering reports; an indication of the time and conditions of the authorization of the respective agency; the fiscal year in which the agency proposed to finance facilities; a time schedule for the commencing and completion of construction; and, the date operation of the facility is scheduled to commence. MSFC was requested to give serious consideration to providing holding facilities of sufficient capacity to provide protection from the adverse effects of accidental spills in test or component development areas.

Project: Fire Surveillance System

Question. How critical is the absence of a central fire detecting system? Have there been any instances where a fire was undetected for some time and would have caused intensive damage had it not been detected accidentally? How much damage would have resulted if the fire cited as occurring in the basement of the F–L Engine Test Stand had not been noticed?

Answer. The absence of a central fire detection system is critical to the quick suppression and control of fires. It is a generally recognized fact that fires which are detected during the initial stages can be extinguished with a minimum of damage whereas fires which are undetected up to the point where they have gained substantial headway frequently result in a complete loss of the structure and its contents.

In one instance a burning motor on an air conditioning system serving the film vault in one of the major MSFC warehouses was detected by sheer accident. Had this fire, which was started through an electrical short circuit, not been discovered a major facility and the supplies stored therein could have been lost. Had the fire in the basement of the F–1 Engine Test Stand not been noticed and been brought under control it could have resulted in damage to the S–IC test stand as well as the F–1 stand since both are interconnected through an underground tunnel leading to the Test Control Center. The Government's investment in these facilities exceeds $35 million, all or part of which could have been lost.

Question. What other NASA centers employ a centralized fire detection and reporting system? Are such systems used in other Government installations? (Name a few representative installations). Does industry employ such systems and, if so, which companies as an example?

Answer. Other NASA centers employing a centralized fire detection and reporting system include the following:

- Mississippi Test Facility
- Michoud Assembly Facility
- Manned Spacecraft Center
- Kennedy Space Center (Three separate centralized systems due to the large area to be covered)
- White Sands Test Facility
- Goddard Space Flight Center
- Ames Research Center
- Langley Research Center (Partial)
- Lewis Research Center (Partial)

Such systems are used in Government installations including the following:

- Arnold Engineering Development Center, Tullahoma, Tenn.
- Warner-Robbins SAC Base, Macon, Ga.
- Fort Gordon Army Base, Augusta, Ga.
- Fort Jackson Army Base, Columbia, S.C.
- Dobbins Air Force Base, Marietta, Ga.
- Turner Air Force Base, SAC, Albany, Ga.
- Fort Benning Army Base, Columbus, Ga.
- Charleston Air Force Base, Charleston, S.C.
- Fort Sill Army Base, Oklahoma
- Fort Bliss Army Base, Texas
- Carswell Air Force Base, Fort Worth, Tex.
- Milan Arsenal, Tennessee

Large industrial corporations also employ fire detection and reporting systems such as the Ford Motor Company and the General Shoe Corporation.

Michoud Assembly Facility

Project: Extension of Saturn Boulevard to State Road System

Question. It is stated that vehicular traffic to and from Michoud averages 12,600 vehicles per day with peak surges exceeding 3,000 vehicles per hour. Has any attempt been made to stagger starting and closing hours at the Facility? What is the average delay during peak hours of traffic?

Answer. A staggering of the starting and closing hours at Michoud has been in effect for an extended period. Currently the work force arrives in five staggered groups between 7:00 am and 8:18 am. The outgoing traffic is similarly staggered from 3:30 pm to 4:48 pm. A recent survey showed the average peak period delay to be 30 minutes per vehicle.

Question. What is the estimated traffic volume when the Chrysler and Boeing production rate is reduced from six vehicles per year to a maximum of four per year? Might not much of the current traffic congestion be eliminated by virtue of lower employment levels in the near future?

Answer. If Chrysler and Boeing production is reduced, our analysis indicates the traffic volume will average approximately 11,400 vehicles per day with peak surges exceeding 2,800 vehicles per hour. This traffic has to enter or leave the facility into the high speed network being constructed by the city and the State to accommodate the increasing traffic in the Michoud vicinity. Therefore, the safety hazards and the congestion will still exist even if the employment levels were to be reduced in the future.