

ADMINISTRATIVE OPERATIONS

Question 1. The general understanding in the committee is that funds provided under the category, Administrative Operations, completely cover all costs of personnel, operation and maintenance. Past inspections indicate that certain operation and maintenance activities are actually funded from Research and Development appropriations. It is understood that the Mississippi Test Facility and the Michoud Assembly Facility are examples of NASA facilities where this type of funding is taking place.

(a) What is the overall NASA policy with regard to this type of funding?

Answer. Consistent with the recommendation of the first Hoover Commission, and the Budget and Accounting Procedures Act of 1950, the NASA budget is presented on a performance basis, which emphasizes the work to be done rather than the objects or services to be purchased. The various requirements for funds are grouped together on the basis of the purposes for which the funds are required.

Within this concept, funds for institutional requirements are presented under the "Administrative Operations" appropriation. Basically, these requirements are due to the presence of the in-house Government establishment (personnel, facilities, equipment) which is required to provide a generic NASA capability to plan, direct, and supervise the activities of other organizations through which the substantive program is executed.

On the other hand, funds for the technical or substantive program requirements are grouped under the "Research and Development" appropriations. Practically all of these funds are for support of activities of other agencies (industrial contractors, universities, other Government agencies) who are engaged more or less directly in specific research and development work.

Since the content of the two appropriations is determined by purpose, one can find the same kinds of items financed in both appropriations. In such cases, it is NASA policy (based on the performance budget concept) to identify fund requirements with the various NASA missions to the maximum extent reasonable and practicable. Items needed to respond to the requirements of research and development programs and projects belong under "Research and Development"; and items required for institutional and general support purposes should be financed under the "Administrative Operations" account.

There is one major case which is an apparent exception to this rule. The salaries and related benefits and travel expenses of all NASA employees are budgeted and funded under "Administrative Operations," whether the employees can be identified at any given time as engaged in direct project work or not. The reason for this is, that these personnel are employed for the purpose of carrying out the generic functions of the agency—and not for the sole purpose of executing a specific research and development project.

The salaries and expenses of contractor employees, however, are part of the costs of the contracts. They are, therefore, financed under the "Administrative Operations" or "Research and Development" appropriation depending upon the purposes of the contracts.

Question 1(b). Is the authority to fund administrative types of activities with Research and Development funds retained at the Headquarters level or is it delegated to the field?

Answer. Policy, guidelines and criteria for determination of fund sources for Manned Space Flight activities are established by NASA Headquarters.

Question 1(c). What sort of management controls are exercised over this area by Headquarters personnel? How often are inspections held?

Answer. Formal management control of fund source use is accomplished through the Manned Space Flight periodic review of Center funding requirements. These reviews are conducted as required but no less than twice a year.

Question 1(d). Does the fiscal year 1968 budget request identify all research and development funds intended to be used to support administrative activities?

Answer. The fiscal year 1968 budget includes specific amounts of research and development funds in support of administrative activities, but they are not identified in the budget document. The fiscal years 1967 and 1968 estimates for this requirement are approximately \$47 million each year. The Marshall Space Flight Center provides for contractor operation of the Mississippi Test Facility and the Michoud Assembly Facility. The operations of these two facilities are funded from research and development funds because the activities are in complete support of contractor operated production and test facilities.

Question 2. NASA plans to expend \$7.5 million more for Administration Operations in fiscal year 1967 than was appropriated.

(a) From what sources will this additional amount be obtained?

(b) On what basis was this source chosen rather than others?

Answer. For fiscal year 1967, NASA was authorized to expend \$655.9 million for Administrative Operations. The funds appropriated for this purpose were \$640 million.

In the preparation of the initial fiscal year 1967 Operating Plan, NASA reduced its Administrative Operations requirement to the authorized level but was unable to reduce further in the light of then anticipated and approved increases in personnel complement for the year. The Administrative Operations requirements were determined as part of a concurrent review of Research and Development and Construction of Facilities requirements where appropriations were also less than the levels authorized. It was concluded that the shifting of \$15.9 million from the available R&D appropriation to the AO appropriation would be necessary to the interests of the best overall NASA programing. Accordingly, the following R&D programs were reduced, as shown, from the authorized levels to provide the source of funds to be transferred.

	<i>Millions</i>
Gemini -----	-\$4. 70
Launch Vehicle Procurement-----	-3. 65
Space Vehicle Systems-----	-1. 10
Electric Systems-----	-1. 90
Basic Research-----	-. 50
Space Power and Electric Propulsion-----	-2. 75
Chemical Propulsion-----	-1. 30
 Total -----	 -15. 90

The reduction in Gemini funding was made possible by the early successful completion of the Gemini Program with no impact on the attainment of the program objectives. The reductions in the other program areas required a stretch-out in the accomplishment of supporting research and technology objectives but did not involve cancellations of any specific projects.

Subsequent to the reductions outlined above, NASA was directed to freeze its end-of-year employment strength at the actual levels that existed on July 31, 1966, to reduce its planned use of overtime by 25% below the FY 1966 level, and to achieve a total reduction in planned expenditures for FY 1967 of \$30 million. Consideration of the impact of the personnel ceiling and overtime limitations and the economy objectives lead to a reduction in the Administrative Operations Operating Plan from the authorized level of \$655.9 million to a revised program of \$647.9 million (including \$400 thousand transferred to GSA for rental of general purpose space). The \$8 million reduced from the Administrative Operations program was reverted to the R&D appropriation, from which it had been transferred, and was placed in reserve by the Bureau of the Budget along with \$52 million of additional R&D funds that were removed from the R&D program as part of the total anti-inflationary cut-back required in obligation authority to achieve the overall \$30 million expenditure reduction in FY 1967.

Question 3. During prior fiscal years, the manned space flight area was marked by transfers of substantial numbers of personnel between the field centers to accommodate the requirements of new or expanding programs. It is noted that the fiscal year 1968 request provides for each of the three manned space flight centers to be staffed at exactly the same level as in Fiscal Year 1967. How is such action possible at a time when launch operations and mission control activities are continuing to expand and manufacturing and testing activities should be levelling off and declining?

Answer. The manpower planning levels for end fiscal year 1967 for the Manned Space Flight Centers were established early in the fiscal year. This plan provided for a build-up of 131 spaces at Kennedy Space Center in fiscal year 1967 to accommodate the expanding launch operations and related activities, with offsetting reductions at both the Marshall Space Flight Center and the Manned Spacecraft Center. The reductions at these two centers considered the decline in manufacturing activities of the MSFC and the phase-out of the Gemini Program at MSC. This staff realignment is planned for completion by the end of fiscal year 1967. Fiscal year 1968 levels as now planned do provide adjustment of personnel within centers to accommodate shifts in program emphasis.

Question 4. The fiscal year 1968 budget request shows a requirement for \$65,172,000 to finance Administrative Operations at the NASA Headquarters level. Last year, NASA estimated that about \$13 million of the \$58.6 million Headquarters budget for fiscal year 1967 would be expended on manned space flight activities. What is the current estimate, by category, of the fiscal year 1967 and the fiscal year 1968 administrative budget attributable to manned space flight operations?

Answer.

	Total NASA (fiscal years)		MSF portion (fiscal years)	
	1967	1968	1967	1968
Personnel.....	\$37,179	\$38,377	\$7,024	\$7,161
Travel.....	2,921	2,939	940	940
ADP.....	1,264	1,149	250	210
Facilities support.....	1,453	1,622	300	300
Technical services.....	13,733	13,941	3,110	3,110
Administrative support.....	7,211	7,144	1,600	1,600
Total, fund requirements.....	63,761	65,172	13,224	13,321

Question 5. In his statement before the committee, Dr. Seamans pointed out that, as a result of Executive Department restrictions, NASA reduced its requested end-of-fiscal year 1967 personnel strength from 34,399 to 33,726 permanent positions. Obviously, the 613 positions which were not filled were intended to carry out specific programs and efforts.

a. In view of the inability of NASA to obtain its requested strength, what programs was NASA forced to defer or reduce?

b. What specific impact did this personnel restriction have on the manned space area?

Answer. a. NASA applied the directed reduction of 613 permanent positions on a basis which would cause the least possible impact on the program. The largest portion of the reduction, 259, was assigned to the Electronic Research Center. This action restricted ERC to 741 rather than 1,000, as previously planned. The effect of this action is to stretch out the buildup phase of the center's development to longer than originally planned.

The balance of the reduction was widely spread among the remaining installations, so that no specific program area would be significantly impacted.

b. The Manned Space Flight centers were reduced by a total of 262 positions planned fiscal year 1967 year and strength. The specific reductions were 50 at KSC, 84 at MSO, and 128 at MSFC. Generally, all areas were "squeezed" with a disproportionate share in support areas. Early success in the Gemini program which provided earlier than planned use of that staff minimized program impact in fiscal year 1967.

Question 6. During much of fiscal years 1966 and 1967, much uncertainty prevailed regarding NASA manned space flight activities following the lunar landing mission.

(a) To what extent did this uncertainty affect NASA's ability to retain or recruit critical talent?

(b) Were there any specific instances where such uncertainty seriously impeded NASA in their personnel management?

Answer. (a) (b). The degree of uncertainty over manned space flight activities beyond Apollo was probably not sufficient in fiscal year 66 and 67 to affect

our recruiting and personnel retention very much, since Apollo was reaching its peak levels of activity. Fiscal year 68 will be a much more critical year in this respect, particularly for the scientists and engineers already in the program, as they wait to see how the Apollo Applications program will take shape.

NASA has experienced an increasing attrition rate and strong industry competition in recruiting particularly among young professionals in scientific and engineering disciplines. The recent increase in salary for these people should help substantially in our ability to retain these critically needed young professionals.

Question 7. If the proposed Voyager and Apollo Applications programs are approved, large numbers of personnel will be required, some of which will be made available from the Apollo Lunar Landing program. However, there is a distinct possibility that these new programs will require numerous personnel at a time when the lunar landing mission effort is at its peak.

(a) Can NASA provide an estimate of the relative strengths at the Manned Space Centers attributable to Apollo, Apollo Applications, and Voyager for fiscal years 1969 and 1970?

(b) In view of the heavy involvement of the other two sectors of NASA in the Voyager and, to a lesser extent, the Apollo Applications program, is it probable that the total NASA strength may actually increase sharply over that currently approved?

Answer. (a) A number of shifts in the program assignment of our manpower which are now occurring will continue into fiscal years 1969 and 1970, and will be dependent upon the scopes of programs approved and the fund appropriated. The Apollo Applications program management structure has been established in the Manned Space Flight organization. The peak effort in the Apollo program will be reached in fiscal year 1967 and the assignment of the engineering skills to Apollo Applications has begun. As the phasing of the Apollo program permits, we will transfer other personnel into AAP activities. Generally, the later phasing will be in the launch and mission control activities. In the meantime, we are using such things as dual assignments to make some of our key engineering skills available to both Apollo and AAP and to assure a maximum of carry over of technical knowledge and experience on both programs.

(b) It is not expected that total employment for NASA will increase sharply above the level in the fiscal year 1968 budget in the next few years because of the Voyager and Apollo Applications programs. However, it should be noted that as these programs develop, shifts in personnel strength between installations may become necessary. The nature and extent of such shifts, if any, cannot be stated at this time.

Even though no increase in total agency employment is anticipated for the Voyager and Apollo Applications programs, some increase is anticipated in subsequent years because of the planned growth of the Electronics Research Center. Specific increases will be developed as part of the budget process and in accordance with the ERC master plan previously published.

Question 8. 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 meet unforeseen problems, workloads and contingencies. How serious has this problem been with respect to manned space flight activities and how is NASA meeting this problem now and intend to meet it in Fiscal Year 1968?

Answer. There is extremely limited flexibility within the AO appropriation. Sixty-two percent of the appropriation is related to pay of personnel and benefits. Unbudgeted increases such as salary increases without a corresponding increase in appropriation must therefore be generally accommodated by a transfer of funds from another appropriation since the funds in the AO appropriation for other than pay are related to many fixed cost expenses such as communication, electricity, gas, and other utilities and services.

Question 9. NASA is requesting a total of \$40,792,000 for automatic data processing under the Administrative Operations category for Fiscal Year 1968.

9(a). Of this agency-wide total, Marshall Space Flight Center is listed for over \$10 million. What functions are performed which require this center to receive over 25% of the total?

Answer. The automatic data processing functions performed at the Marshall Space Flight Center (MSFC) are similar to those performed at the other MSF Centers. Total estimated cost, regardless of appropriation, is \$11,591,000. Com-

parable costs at the Manned Spacecraft Center and the Kennedy Space Center are \$36,367,000 and \$10,334,000, respectively.

Question 9(b). How is the automatic data processing workload controlled at the three Manned Space Flight Centers?

Answer. The objective of the ADP workload control system is to furnish the means for planning, reviewing and approving ADP work requests and, as a result, controlling the work effort and expenditure of ADP resources. Each MSF Center utilizes essentially the same procedures for ADP workload control. The computation facility develops a workload projection and budget allocation in coordination with each user prior to the beginning of the fiscal year. Center management then sets a total allocation for the computer facility based on validated workload projections. Each user provides a work authorization to his management for computer work. The users' management reviews the work request against its assigned budget, the computation facility reviews the request for technical feasibility and performance. Periodic reports are provided showing allocations, expenditures, and balances to users.

Question 9(c). What reviews are conducted at the headquarters level of requests from field centers for additional data processing facilities and capabilities?

Answer. The program offices, including the Office of Manned Space Flight, are responsible for managing the acquisition and utilization of ADP resources at their centers in accordance with the policy and procedures promulgated in NHB 2410.1, "Management Procedures for Automatic Data Processing Equipment". Approval of overall ADP plans, as well as specific approval of general purpose of ADP equipment is the responsibility of the NASA Deputy Administrator, Office of Tracking and Data Acquisition. The program offices review ADP requirements on a center-by-center basis to insure that requirements are consistent with institutional and program objectives by conducting reviews of all center ADP acquisition plans and operating practices. Requests from field centers for acquisition of ADP equipment, with supporting documentation, are reviewed by the program offices and those requests which are validated are transmitted to the Deputy Administrator via the Associate Administrator for Tracking and Data Acquisition.

Question 9(d). Does NASA currently have a standard operation procedure for managing and supervising the automatic data processing areas? Furnish for the record, a brief description of such procedures.

Answer. In July 1965, NASA published NHB 2410.1, "Management Procedures for Automatic Data Processing Equipment." The provisions of this document are applicable to NASA Headquarters, NASA field installations, and NASA-owned contractor-operated facilities. The document prescribes the policies and procedures to be used throughout NASA in management of automatic data processing, including the assignment of responsibilities, the formulation of ADP plans, acquisition procedures, and guidelines for selection and utilization of general purpose ADP equipment. The document also assigns ADP responsibilities to the NASA Deputy Administrator, the Office of Tracking and Data Acquisition, the program offices and to the field centers. The NASA Deputy Administrator has been designated as the final approval authority of all policy and plans for acquisition, utilization and disposition of ADP equipment and services. The Office of Tracking and Data Acquisition serves as the ADP staff to the Deputy Administrator to develop ADP plans and procedures as well as review, evaluate and coordinate on a NASA-wide basis the utilization of ADP resources. Each program office validates ADP requirements and funding requests submitted by their centers who, in turn, are responsible for the local management and operation of the NASA computational capability.

Question 9(e). What progress is being made at the Manned Space Flight Centers to share automatic data processing equipment, personnel and programs?

Answer. Since its establishment in 1963, the MSF Resources Sharing Panel (RSP) has acted as the principal organization in the Manned Space Flight organization to coordinate sharing of ADP equipment, personnel and programs. Comprised of the directors of the computation laboratories at the centers, the MSF Resources Sharing Panel guides sharing activity by establishing standards and procedures, as well as sharing knowledge in specific computational techniques. In the recent past, the RSP has established a program sharing library, a standard for formatting telemetry calibration data, and a standard set of routines for driving output plotter devices. In the last year, MSF has shared 124 computer programs having an original development cost of approximately

\$2 million. In addition, the MSF Centers shared 5,930 man-hours and 5,540 hours of computer time. It is expected that the level of sharing will increase this year and that this trend will continue. The sharing of machine time and program exchange among the centers is being facilitated by the standardization of languages and installation of the same general type computers starting in fiscal year 1967.

Question 9(f). How does NASA administer and manage the computer and data processing service provided to contractors in the Louisiana-Mississippi area from the Slidell Computer Center?

Answer. At Slidell, La., the Marshall Space Flight Center (MSFC) has established a centralized computer facility to meet the needs of MSFC's contractors at the Michoud Assembly Facility and the Mississippi Test Facility. The computer center has a small group of NASA personnel who administer the center. The equipment is operated by a support contractor specializing in ADP operations. Programming is a user responsibility. The users are also responsible for estimates of computer usage.

Question 9(g). Why is the Manned Spacecraft Center replacing its general purpose equipment with "third generation" computers and what will be the impact of this action on current automatic data processing operations?

Answer. The principal objective of the ADP equipment replacement program at the Manned Spacecraft Center is to achieve a reduction in computer hardware cost that will result from the more efficient design of the third generation equipment. It is anticipated that this savings will approximate 30 percent of the lease cost of the second generation equipment being replaced. As a result of the change, work now requiring round-the-clock operation can be accomplished in less than two shifts, and eliminate the need for using outside ADP sources for workload overflow. Further, the less efficient decentralized operation of numerous small individual computers is being replaced, in the main, by a centralized computer complex.

Question 9(h). During last year's hearings, Congressman Rumsfeld requested a summary of computer operations which would help explain how the computer area was managed. Is such a study available?

Answer. Yes. A comprehensive Computer Systems Survey report was published in October 1966 and describes the complete spectrum of Manned Space Flight computational activities, including the way in which MSF manages its computer resources.

Question 9(i). What is the total estimated cost relating to automatic data processing equipment, by center, regardless of funding appropriation for Fiscal Year 1968?

Answer.

Manned space flight ADP total estimated costs, fiscal year 1968

[In thousands of dollars]

	Purchase	Lease	Maintenance	Support	Total
Manned Spacecraft Center.....	300	15,277	592	20,198	36,367
Marshall Space Flight Center (Huntsville).....	26	4,833	402	6,330	11,591
Marshall Space Flight Center (Slidell).....		4,472	75	3,711	8,258
Kennedy Space Center.....	2,048	1,556	441	6,289	10,334
Total.....	2,374	26,138	1,510	36,528	66,550

Question 10(a). Since the number of permanent positions at each of the three centers remains at exactly the same level as in fiscal year 1967, what is the reason for an increase in two centers and a decrease in the other?

Answer. The fiscal year 1967 budget provided for a personnel increase for the Kennedy Space Center. These new positions will be filled on a phased basis during fiscal year 1967; therefore, there will be a greater number of man-years realized in fiscal year 1968 even though the end-of-year ceiling is the same for both fiscal years.

The same explanation applies for the Manned Spacecraft Center increase for personnel costs in fiscal year 1968, except the vacancies to be filled during fiscal year 1967 are a carry over from a fiscal year 1966 authorization.

The decrease in personnel costs for the Marshall Space Flight Center in fiscal year 1968 results from a gradual phase down in personnel during fiscal year 1967. Although the end strength for each fiscal year is the same, the average level of employment will be lower in fiscal year 1968.

Question 10(b). The fiscal year 1968 request shows personnel costs slightly increased for Kennedy Space Center and the Manned Spacecraft Center with a slight decrease for Marshall Space Flight Center.

On a NASA-wide basis, support personnel make up 32 percent of the total permanent personnel complement. This percentage varies from 41 percent at Kennedy Space Center to 25 percent at the Manned Spacecraft Center and 21 percent at the Marshall Space Flight Center. What is the reason for this variation?

Answer. Support personnel represents the minimum complement necessary to support the role and mission of the center. In most instances, the number of support personnel is not directly proportionate to the number of direct personnel; therefore, the larger the direct force, the lower the percentage of support personnel. This would explain the Marshall Space Flight Center having a lower percentage of support personnel than the Manned Spacecraft Center.

Kennedy Space Center is unique in that the support personnel of this center provides support services to KSC direct personnel, personnel of other NASA centers, and stage and spacecraft contractor personnel involved in launch operations.

Question 10(c). The fiscal year 1968 request shows personnel costs slightly increased for Kennedy Space Center and the Manned Spacecraft Center with a slight decrease for Marshall Space Flight Center.

How many persons were made available from the phase-out of the Gemini program and how were they utilized?

Answer. The peak manpower on the Gemini program from the Manned Space Flight Centers was slightly over 1,050 in fiscal year 1966. This will be essentially phased out by the end of fiscal year 1967 and completely phased out in fiscal year 1968. This Gemini manpower was used principally to build up Apollo and Apollo Applications, with some assignments to meet requirements in other programs.

As an example, the final close-out of the Gemini program released 141 professional people who had been employed full time in the Gemini program office organization at MSC. Of the 141 released, 43 went directly to the Apollo program and 41 went to the Apollo Applications program. Then people located at the McDonnell Corporation in St. Louis were detailed to assist in the supervision of the Air Force Manned Orbiting Laboratory program contract for Gemini spacecraft. The balance of the Gemini work force were given assignments in mission operations, flight safety, engineering, or test activities.

Question 10(d). The fiscal year 1968 request shows personnel costs slightly increased for Kennedy Space Center and the Manned Spacecraft Center with a slight decrease for Marshall Space Flight Center.

To what extent has NASA employed retired military personnel in manned space flight activities; what types of positions are they holding; and what effect has their employment had on the career opportunities of regular civil service personnel?

Answer. About 2.2 percent of NASA's 34,000 civil service employees are retired military officers or enlisted men. The total in Manned Space Flight is 337 or about 2.3 percent of our total complement. We have found that there are many retired military people whose experience in military research and development programs is excellent background for our own programs. Most of the 219 retired officers we employ are being used in professional aerospace technology positions or in a professional administrative capacity. The 118 retired enlisted personnel are being used primarily in technician or technical support jobs. We believe that the relatively small percentage of retired personnel in the program has not constrained promotion or career development opportunities for the regular civil service work force, particularly in the light of the substantial growth situation of the last few years.

Question 11. It is noted that while there is a slight reduction from the Fiscal Year 1967 level, there is still \$3,596,000 requested for reimbursement of military manpower detailed to NASA. What is the ratio of support for such personnel as far as compensation is concerned, particularly in view of the obvious training benefits to the military services from such duty with NASA? Will not many

of these military personnel be lost as the Manned Orbiting Laboratory gains momentum?

Answer. It is NASA's policy to provide full reimbursement to DOD for military personnel serving on detail. However, there has been one significant exception to this policy with respect to the assignment of a number of Air Force Officers to the Manned Spacecraft Center. In this case the training benefits to the Air Force were considered sufficiently great to warrant a special agreement between NASA and DOD to share the cost of these officers on a 50/50 basis.

The number of military detailees is expected to stabilize at about the end of FY 1968 number. Since there is a continual turnover in such personnel, because of tours of duty ending and new personnel being assigned, the effect of the momentum of the Manned Orbiting Laboratory is not expected to be too large.

Question 12. On a NASA-wide basis, over 40% of NASA personnel are scientists or engineers. What is the percentage by manned space flight center of such critical personnel?

Answer. The percentage of scientists and engineers of the total permanent employment for the Manned Space Flight centers is as follows:

Kennedy Space Center:	Percent
Fiscal year 1967-----	48.0
Fiscal year 1968-----	50.2
Manned Spacecraft Center:	
Fiscal year 1967-----	56.6
Fiscal year 1968-----	57.2
Marshall Space Center:	
Fiscal year 1967-----	39.1
Fiscal year 1968-----	39.6

Question 13. Overtime and holiday pay is listed as more than \$10 million. What amounts will be programed for each of the Manned Space Flight Centers? Will there be any substantial amounts of such pay for activities other than those directly involved in launch and mission operations? If so, what are they and why are they necessary?

Answer. Overtime and holiday pay in fiscal year 1968 is programed for the Manned Space Flight Centers as follows:

	[In thousands]
Kennedy Space Center-----	\$2,212
Manned Spacecraft Center-----	2,621
Marshall Space Flight Center-----	1,988

The Manned Space Flight overtime is programed in recognition of mission operations, and is based on the following considerations: The bulk of MSF overtime is related to mission planning and control, spacecraft and launch vehicle checkout, launch facility preparation, and related launch support. Technical activities such as minor spacecraft or launch vehicle modifications, and trajectory modifications must be accomplished within a limited time period prior to flight. Pre-mission and post-mission activities such as simulations, astronaut and tracking crew training and post launch evaluation and report preparation are schedule critical and cannot be deferred.

The overtime requirements in this category are primarily tied to support of the Apollo test, launch, and flight schedule. Since continuity must be maintained in conducting these activities to achieve full integration of the test, checkout, or launch operations, it is not always possible to limit the shift-work to an eight-hour basis or to bring in a fresh crew. For example, acceptance testing, launch and flight operations support may require the technical crews who are doing the job to work beyond an eight-hour day and to provide support on a week-end. The work must be accomplished in a continuous sequence to meet the nature of the launch and test operations.

In addition, there will continue to be special situations and emergency problems that are not related to operations which will require some small amount of overtime at all the Centers.

Question 14. NASA is requesting \$2.3 million for personnel training. How is this training supervised to insure that such training is directly related to NASA programs and not to the acquisition of an advanced degree by an employee?

Answer. The responsibility and authority for providing training under the provisions of the Government Employees Training Act has been delegated to each NASA center with specific reference to the agency policy that such training must

contribute to an employee's ability to perform his official duties. This policy directive also specifically reiterates the requirement that agency sponsored training will not be approved for the primary purpose of assisting the employee in obtaining an academic degree. We stress, however, that if a degree is incidental to such training, it is highly proper and should be encouraged. In exercising this responsibility, supervisors and managers are actively involved at all levels of consideration and approval of training.

Question 15. It is understood that, whereas travel at the Marshall Space Flight Center will increase because of its involvement in the proposed Voyager and Apollo Applications programs, the total travel requirement will not increase due to cuts in other travel areas. What are these areas in which decreases will take place? NASA is requesting over \$1 million for overseas travel. What portion of this is for travel of manned space flight personnel and what is the reason for such travel?

Answer. The total fiscal year 1968 travel requirement for Marshall Space Flight Center remains at the fiscal year 1967 level. However, there are offsetting adjustments among the major categories within the total travel program. Specifically, the travel for direction and coordination of program activity will increase, but is offset by a reduction in administrative travel due to the planned purchase of an administrative aircraft during fiscal year 1968. Purchase of an administrative aircraft will reduce the number of charter flights required.

Forty percent of the NASA request for overseas travel to launch and tracking sites is for travel of manned space flight personnel. This travel is used to provide the additional operational personnel needed at overseas tracking stations during space flights.

Question 16. What is the average GS grade of NASA professional and scientific personnel and of those termed "professional administrative personnel"? How does this compare with the average grade level of other Government agencies?

Answer. Average grade of NASA professional scientific and engineering personnel is 12.58 in FY 1967 and 12.59 estimated for FY 1968. The averages for professional administrative personnel are 11.49 in FY 1967 and 11.40 estimated in FY 1968. The average grades available in the President's Budget for other Government agencies are for total GS strength only. Since there is no subdivision by major occupational grouping, the requested comparison cannot be made by NASA.

Question 17. By centers, list those facilities (with square footage) which will become operational either during Fiscal Year 1967 or 1968 which will cause an increase in the provision of utilities, communications, custodial services, repair and maintenance services and supplies and equipment.

Answer. 565,797 additional square feet of facilities will become operational at the Manned Space Flight Centers during FY 1967. In FY 1968 an additional 449,734 square feet of area are scheduled to become operational. These facilities are being provided through Construction of Facilities Projects and Minor Construction. Itemized lists of facilities with respect to fiscal year and center follows:

FISCAL YEAR 1967

	Area (square feet)
Kennedy Space Center:	
Propellant Systems Components Lab.....	50, 715
USAF facilities on Cape Kennedy being acquired.....	70, 000
Total.....	<u>120, 715</u>

Launch complex 39 (pad B)	
Manned Spacecraft Center:	
Atmosphere reentry materials and structures.....	14, 300
Technical services building.....	57, 800
Cafeteria—building 11.....	15, 400
Center support-mission support warehouse.....	48, 000
Printing and reproduction building 227.....	6, 000
Maintenance shop building 329.....	8, 000
Health physics laboratory extension building 263.....	960
Total.....	<u>150, 460</u>

White Sands Test Facility:

GSA maintenance building-----	2,304
Lumber storage building-----	1,152
Chemical storage building-----	554
Total -----	4,010

Marshall Space Flight Center:

Test engineering building (extension)-----	19,500
Gas storage and distribution system-----	5,540
Load test annex (extension)-----	54,558
Addition to Materials Laboratory-----	22,534
Non-destructive Test Laboratory-----	8,780
Total -----	110,912

Michoud Assembly Facility:

Contractor services building-----	75,000
Slidell computer facility addition-----	39,400
Total -----	114,400

Mississippi Test Facility:

Components service facility-----	60,700
Cryogenic calibration facility-----	4,600
Total -----	65,300

S-IC (B-2) Static Test Stand (one each.)

S-II (A-1) Static Test Stand (one each.)

Manned space flight for fiscal year 1967 total----- 565,797

FISCAL YEAR 1968

Kennedy Space Center:

Flight crew training building addition-----	32,180
Visitor information center-----	20,000
Dispensary addition-----	9,150
KSC headquarters addition-----	120,000
Central telephone office-----	2,000
Launch Complex 39-----	157,004

Vertical Assembly Building Bay 2----- 143,727

Launch Control Center—Firing room No. 3----- 13,277

Total----- **340,334**

Manned Spacecraft Center:

Lunar Receiving Laboratory-----	83,000
Flight crew training facility-----	22,200
Center support facilities-----	4,200

Total----- **109,400**

Manned space flight for fiscal year 1968 total----- 449,734

Question 18(a). What reductions in fiscal year 1968 are expected as a result of decrease in rental of real property as a result of availability of new construction.

Answer. MSF is presently leasing 101,547 square feet at \$308,744/year. No reductions in rental are expected in fiscal year 1968 as a result of new construction.

Question 18(b). What reductions in fiscal year 1968 are expected as a result of: (a) decrease in rental of real property as a result of the availability of new construction; and (b) decrease in the rental of ADP equipment because of purchases of such equipment?

Answer. No major purchases of ADP equipment are programed for fiscal year 1967 or fiscal year 1968. The major purchases of ADP equipment were affected in fiscal years 1965 and 1966. In last year's testimony, Manned Space Flight reported a savings in lease cost of \$3.7 million to have resulted from these purchases. In late fiscal year 1966, additional purchases were made, reducing lease costs by \$600,000 per year. Thus, the total decrease in rental costs in fiscal year 1968 is approximately \$4.3 million.

Question 19. What is the estimated square foot cost during fiscal year 1967 at each of the three manned space flight centers for: (a) maintenance and repair; and (b) custodial services?

Answer. The estimated cost per square foot of maintenance and repair and custodial services during fiscal year 1967 at the Manned Space Flight Centers is:

(Dollars per square foot)

	Maintenance and repair of buildings	Custodial services
KSC.....	\$0.44	\$0.66
MSC.....	.35	.37
MSFC.....	.22	.40

Question 20. NASA is requesting a \$1 million increase in maintenance, repair and rehabilitation funds to cover the NASA use of Ellington Air Force Base because of a transfer of the airbase to the Texas National Guard. What will be the new cost-sharing formula? When will NASA be able to vacate this space?

Answer. There will be about 23 tenants at Ellington who will share base operations and maintenance costs in proportion to their specific utilization of base facilities. Previously, NASA reimbursed the Air Force for only those costs which were peculiar to NASA. The additional \$1 million requested will pay for NASA's share of the base operations.

NASA intends to be a permanent user of the flight facilities at Ellington, because of the continuing requirement for astronaut flight activities. The temporary office-laboratory facilities at Ellington will be vacated as permanent office-laboratories facilities become available at the Manned Spacecraft Center.

Question 21. What types of management controls are being exercised by NASA over printing and reproduction activities? What factors are employed in deciding whether such operations will be carried out on an in-house or contractor basis at the same center?

Answer. We are constantly striving for ways to effect economies in the printing and reproduction activities of our field centers and contractors.

OMSF representatives, assisted by NASA's printing officer, recently conducted a study of printing and reproduction activities at the three Manned Space Flight field centers. Improvements in the form of better NASA printing standards and more effective utilization of equipment and personnel are in the process of being implemented.

In addition, Center printing and reproduction officers are reviewing these functions at major contractor plants to insure that their activities are operated economically.

The printing work which cannot be performed in-house because of special characteristics or size is acquired through contracts with commercial printing firms. Overflow work which cannot be accomplished in-house within the required time schedule is also obtained through this source.

Question 22. It is noted that NASA is requesting funds for maintenance, repair and other administrative functions under both the Facilities Service category and the Administrative Support category. What distinction is made between these two categories on the funding of identical types of functions?

Answer. The Administrative Support includes the general services which support overall installation operations. This includes administrative communications, printing and reproduction, administrative supplies, materials and equipment, administrative transportation (motor pool, administrative aircraft, services and operation, and movements by common carrier), and other related administrative services, such as medical services.

The Facilities Services includes the rental of lands and buildings, the procurement of electricity, water, gas and other utilities, and maintenance of buildings

and grounds, and minor construction; maintenance and repair of equipment; custodial services (security, janitorial, fire protection, laundry, cleaning, and other), and procurement of supplies and equipment related laboratory, shop, hardware, building materials, etc. Also covered is the requirement for major service contractual effort at the Merritt Island Launch Area and reimbursement to the Air Force for services provided the Kennedy Space Center (Range Operations).

The support included in each of these categories is not duplicated in the other. As shown above, the Administrative category covers those items of general support and not related to the physical plant, whereas, the Facility category covers those items of support related to the physical plant.

However, included in the Facilities Services are the "Range Operations" requirements for major service contractual effort at the Merritt Island Launch Area and reimbursement to the Air Force for services provided the Kennedy Space Center. The contractor effort covers facilities engineering and planning, maintenance, repair and operation of facilities and utilities, maintenance of roads and grounds, supply operations, fire protection, industrial health services, security, computer operations, publication and graphics support, photography and library services. Reimbursements to the Air Force, except for utilities, include maintenance and repair of buildings and equipment, security, exterminating, printing, medical services, photography and supply support at the Cape Kennedy Air Force Station complex. For convenience in understanding the "Range Operations", these requirements are consolidated under Facilities Services, and not distributed to Administrative Support and other functions.

Question 23. What results have been achieved by the manned space flight centers on the effecting of economies in supply operations, as directed by the President's letter of September 16, 1966? Specifically, what actions have been taken to make better use of the General Services Administration and the Defense Supply Agency as sources of supply as well as the maintenance of supply inventories at minimum levels?

Answer. The Office of Manned Space Flight and the Manned Space Flight Centers are making every effort to fulfill the objectives of the President's program to reduce costs in the supply area. We have established as goals for our centers a six-months level of supplies on hand and the identification of 90% of our common supply items with federal stock numbers. Before establishment of the goals, center inventories ranged as high as a 12 month level at one Center. The percentage of total center replenishments from GSA/DSA increased from 42% to 54% when comparing the first quarter with the last quarter of CY 1966. The goals which we have established will assist us in keeping our investment in inventories at the minimum levels necessary to accomplish our mission and enable us to effect economies by purchasing more of our supplies and materials directly from the GSA and DSA.

Our centers are also taking actions to redistribute and dispose of the supplies and materials which they no longer need to meet their requirements. In addition, they are pursuing active programs to make better distribution and use of available furniture, fixtures, office machines, typewriters, etc.

Question 24. One the the reasons given for the increase in utilities under the category "Range Operations" at the Kennedy Space Center is the transfer of "additional" facilities from the Air Force to NASA. What are these facilities and why are they being transferred at this late date?

Answer. All or a portion of the following facilities, amounting to approximately 70,000 square feet, have been or are in the process of being transferred from the Air Force to NASA:

- Launch Complex 15 Blockhouses and Surrounding Fenced-In Areas
- Launch Complex 19 Only, no Launch Facilities
- Blockhouse of Launch Complex 29
- Hangar "C"
- Hangar "H"
- Hangar "L"
- Hangar "O"
- Cafeteria Building #1

These facilities are being acquired to provide the necessary space for personnel, equipment and material in support of the Apollo build-up. As there is insufficient area available within the Merritt Island facilities to house these activities, the above listed Air Force facilities will be utilized to alleviate these deficiencies.

SUMMARY OF MANNED SPACE FLIGHT SUBCOMMITTEE (MSF) FIELD TRIPS

IN CONNECTION WITH FISCAL YEAR 1968 AUTHORIZATION HEARINGS

The Manned Space Flight Subcommittee fiscal year 1968 authorization hearings in Washington, D.C., which commenced on March 14, 1967, were preceded by MSF Subcommittee field trips to and hearings at NASA Manned Space Flight Centers and Apollo-involved major contractors. The schedule of these trips was as follows:

January 20, 1967: Grumman Aircraft Engineering Corp., Bethpage, Long Island.

Feb. 9-11, 1967:

Marshall Space Flight Center, Huntsville, Ala.

Chrysler Corp. and the Boeing Co., Michoud Assembly Facility, New Orleans, La.

Mississippi Test Facility, Bay St. Louis, Miss.

Feb. 16-18, 1967:

North American Aviation Co., Los Angeles, Calif.

Douglas Aircraft Corp., Huntington Beach, Calif.

Jet Propulsion Laboratory, Pasadena, Calif.

February 24-25, 1967: Kennedy Space Center, Fla.

March 2-3, 1967: Manned Spacecraft Center, Houston, Tex.

The appendixes (A thru H) that follow this opening summary comprise the verbatim record of these field hearings.

In the succeeding paragraphs, selected highlights of interest are abstracted from the record of these hearings. More comprehensive coverage of this material is to be found in the appendix noted with each highlight.

APOLLO APPLICATIONS

Detailed presentations by the Marshall Space Flight Center, the Manned Spacecraft Center, and the Kennedy Space Center as well as Chrysler, Boeing, Grumman, North American, and Douglas are presented. Understanding of the value of the Apollo Applications program and a readiness to move on with the effort was noted. It is of concern to each firm that challenging work be provided to allow them to maintain the capability they have developed. This is especially true in engineering and is becoming increasingly critical in manufacturing and testing. It is important to them that the trained manpower not be lost as mainline Apollo effort falls off and the Nation's resources in this area are not allowed to erode.

HOME TELEVISION BROADCAST SATELLITES

(From appendix F; Dr. von Braun, MSFC)

In due time there will be full-time television broadcast satellites. If we put up a 50-kilowatt synchronous orbit satellite, we can go

directly into home antennae on the ground. All the people would have to do is put up about a 2-foot dish, pointing at one point in the sky, and they could receive the T.V. signals directly. This would be television broadcast by satellite. The present relays, by contrast, work through a large ground station with a big dish on the ground, which in turn rebroadcasts the television programs locally. David Sarnoff of RCA once said that with such an advanced television broadcast system, we could eradicate illiteracy from the face of the globe within 10 years.

NEED FOR A SPACE STATION

(From appendix F; Dr. von Braun, MSFC)

"If we want to utilize fully man's capability in space, we shall need a space station. We shall need a capability for man to stay in orbit for long periods of time so that he can work and rest and sleep and eat under conditions as similar as possible to what he is used to here on earth. You saw today our humble beginnings in this area in our Orbital Workshop, and we feel that this is really a bargain-basement deal to come to grips with the habitation problems in outer space. We don't propose to have all our future space stations built into empty tanks of rockets, but we feel since these Saturn-IB's are going up there anyway, this is the cheapest and easiest way to learn. Techniques on how to build space stations can very well be based on this learning too. Long stay-time in space involves not only building a space station, but also the provision of a logistics supply system. We can have a space station that is good for several years, but nobody would like to stay there for the life of the station. So we have to rotate crews; we have to fly new supplies up there; we have to bring data back to the ground; we have to update equipment; we have to support this entire system with logistic supply systems. It was actually this interrelationship between the logistic supply system and the conduct of science at the far end of this logistic supply system that motivated Robert Gilruth and Max Faget of the Houston Center and Ernst Stuhlinger and myself from the Marshall Center to take a trip to Antarctica a few weeks ago.

"We had long felt that there was a great deal of similarity between some aspects of the space program and the Antarctica program. Of course, we knew they don't wear space suits in Antarctica, and you can't wear a parka on the Moon. Also, they don't fly in rockets to the South Pole, but in turboprops. But other than that, we found our belief fully confirmed that many operational aspects of work in Antarctica and future work in space are similar enough to make fullest use of the tremendous body of practical experience accumulated down there over the years. When they have sudden emergencies on the ice, their logistics system must respond just as quickly as ours will have to respond in space. And, the scientists in those remote polar stations are just as vulnerable and just as dependent on the working of this long logistic supply system as an astronaut scientist would be in a space station. We just wanted to know how this interface between science and operational support looks and how it really works. We learned a great deal."

RENOVATION AND REUSE OF THE APOLLO COMMAND MODULE

(From appendix D; North American Aviation)

Renovation and reuse of the Apollo Command Module is discussed. It is brought out that studies have shown that this concept is practical, technically feasible and its accomplishment would not interfere with ongoing lunar program commitments. The contractor has limited himself to examining the accomplishment of a second flight in Earth orbit only as opposed to using a vehicle for a second lunar mission. Under this Renovated Command Module (RCM) program, existing facilities and GSE would be fully applicable with only very insignificant modifications. Under this concept, the Command Module is recovered in the normal fashion; i.e. by recovery ships. Some preliminary postflight operations would be performed, and the vehicle would then be returned to the contractors plant where inspection and tests would be accomplished. Certain subsystems would be removed, if necessary, and these would be returned to the subcontractors for refurbishment and/or replacement of individual elements. The vehicle would be reassembled, using the same primary structure, and after checkout would be shipped, with a new service module, a new launch escape system, and a new adapter, back to the Cape for a second flight. Cost studies show that over \$9 million could be saved by this refurbishment and flying again as opposed to production of a new vehicle. The flight experience on which this concept is based consists of two unmanned spacecraft flights of Apollo; i.e., spacecraft 009 and 011.

Another study effort described is that pertaining to advanced landing systems for Apollo Command Modules. With these systems—which would include steerable gliding chutes and landing retro-rockets—great mission flexibility and choice of landing areas would be realized. Landings could be made on land rather than on ocean areas, reducing recovery force requirements greatly. Reusability of the Command Module could be greatly enhanced. Lastly, it would be possible to carry three more men in the Command Module. If six men can be carried to a space station, instead of three, then the cost of transporting each man is cut in half. Reuse of the Command Module coupled with the ability to carry twice as many men will result in major economics.

FUTURE IMPROVED SATURN PROGRAMS

(From appendix C; Chrysler Corp.)

Means of filling the "payload gap" between Saturn I-B and Saturn V rockets are discussed. Strap-on solid rockets of five- and seven-segment construction can be used to raise the near earth orbit payload capability of Saturn I-B from 40,000 pounds to 78,000 and 106,000 pounds, respectively. Also escape capability is raised from 1,650 pounds to 1,800 and 28,500 pounds, respectively.

It was noted that the solid rockets strap-ons would be man-rated in connection with the DOD MOL program and that therefore, this effort would be within the current state-of-the-art.

FUTURE USES OF THE LUNAR MODULE (LM)

(From appendix A; Grumman Aircraft)

Use of the Lunar Module hardware for post-Apollo programs is discussed. One of the promising Voyager Mars landing capsule configurations under study uses significant portions of Lunar Module hardware and technology, including the LM descent engine. The resultant decrease in development costs could represent considerable dollar savings to the Government for a Mars lander type of vehicle.

The LM has over 2,300 cubic feet of available volume and can carry over 20,000 pounds of payload. Study has been made of many manned and unmanned LM configurations and modifications which use its large volume, payload and propulsion capability to satisfy the goals of lunar exploration, Earth and lunar orbital missions.

The LM derivatives can perform missions that provide the basis for further long-duration space stations, lunar bases, manned planetary vehicles, and lunar roving vehicles. The studies have shown the LM can perform all of the Earth orbital missions that have been proposed. The advantages gained in using LM hardware for these missions stems from the continued use of the experienced LM engineering, manufacturing, and test teams together with the existing clean room type assembly areas, special test facilities and the three operational ACE stations located at the contractor's plant. Another advantage stems from the use of existing astronaut crews who will be thoroughly trained in the operation of Apollo/LM vehicles.

For over 3 years a wide variety of LM derivation have been studied to fulfill the following missions:

- Extended Earth orbit with resupply:

 - To 45 days.

 - To 105 days.

- Extended lunar orbit: To 28 days.

- On the lunar surface: To 14 days.

- Lunar roving vehicle: To 14 days.

- Space rescue.

- Military.

- Scientific (astronomy etc.).

- Applications (communications, Earth resources, etc.).

A short list of a few of the vehicles studied are:

- Apollo telescope mount LM: To obtain solar astronomy data unobtainable from any other method.

- Earth resources LM: Survey Earth resources on a large scale, particularly in remote areas. Separate module for sensors could be used for other missions.

- Augmented lunar module: Increased payload capability with astronauts for mission up to 14 days on the Moon.

- LM truck: A modified LM descent stage capsule of landing over 10,000 pounds payload on the Moon.

- 3-Man LM: Used for space rescue, place more men on the Moon or in space. Used as a space shuttle.

VOYAGER PROGRAM

(From appendix F; Dr. von Braun, MSFC)

"Pending approval of the Voyager program by the Congress, we expect that the Marshall Center will play a major role in its development. Voyager is an unmanned spacecraft designed to go to Mars, explore the planet from orbit through photographic and remote sensor techniques, and send a lander to measure the Martian atmosphere and surface. The present plan is to fly four Voyagers, the first in 1973; the second in 1975; the third in 1977; and the fourth in 1979. Each mission would be launched by a Saturn V, and each flight will carry two independent planetary vehicles. Each of the planetary vehicles would consist of the spacecraft that goes in orbit around Mars and a lander that will soft land, unmanned, on the Martian surface.

THE EFFECTS OF SPACE FLIGHT ON MAN

(From appendix H; Dr. C. A. Berry, MSC)

Prior to Mercury and Gemini people in the biomedical community had some grave concerns about whether man could perform in a space flight environment. Not only that, but they had concern about whether he could even survive in it. There were predictions made about the environments, and about what was going to happen to man, and these are discussed.

For example, meteorite density and its effects were of concern, but this has not been a particular problem, as far as man has been concerned, thus far.

It has not been a problem to maintain pressure within the spacecraft and there has not been a loss by any spacecraft pressure except when done deliberately for EVA operations, nor has there been any inadvertent loss of any suit pressure.

There has not been encountered any significant radiation levels as yet, realizing that spacecraft haven't actually flown into the Van Allen Belt areas, with the exception of one flight where the area was just brushed by.

Isolation was predicted as a real problem. No confirmation of this has been seen. Physical confinement or restraint has been uncomfortable, but no serious effects have resulted.

The acceleration or gravity loads have been no problem. One problem that was not predicted to be a problem was the workload observed during extravehicular activity. Dysbarism or the bends was predicted, but this was prevented by denitrogenating the flight crew prior to launch by the use of 100 percent oxygen environment. No skill infection and skin breakdown was observed. There was some dryness and dandruff on some of the long-duration flights.

There was some minor interference with sleep, and some sleep cycles have been altered. There was some minor fatigue. No reduction in visual acuity was observed in a space-flight environment.

There were two effects that were not predicted, some eye irritation and some nasal stuffiness and hoarseness. These are thought to be related to the use of a 100 percent oxygen environment.

Disorientation and motion sickness were major predictions and this was not experienced within the spacecraft or in the extravehicular

situation. High or low blood pressure was not seen with the exception of some postflight which is discussed in some detail in the appendix proper. Some high heart rates were encountered, but abnormal rhythms of the heart were not observed. No actual fainting in the postflight situation was encountered. Some changes in blood volume were detected. Some weight loss occurred, and some minimal calcium loss.

None of the mental aberration that had been predicted was encountered. No infectious diseases developed in flight. On balance the results showed up considerably different than originally predicted. It has been shown that the space-flight environment has been better for man than the biomedical community had thought it might be, and man, in turn, has shown better response.

COST AND EFFECTIVENESS OF THE SPACE PROGRAM

(From appendix E; Douglas Aircraft Co.)

Twenty years from now, assuming that the number of dollars appropriated for space applications remains constant, those dollars will buy only half the product—by weight—that we get today. Inflation is one reason for this, but the second reason is increased sophistication of the product. Thus, the dollar cost per pound of space hardware will increase.

At first glance, you might think this means that the space budget has to double in the next 20 years to maintain our present pace. But that is not the case.

When you examine the progress to be made in 20 years, it turns out that the product this industry can provide 20 years downstream will be about 50 times more effective than what it produces today. This will come about because of increases in payload effectiveness, and increases in transportation effectiveness. Some of this will be shown in our presentation today.

With the gross national product increasing, if you again assume a constant level of space appropriations, then in 20 years we will be spending only about half the percentage of gross national product that we are now spending for space. Thus, if we spend our space appropriations wisely, and new programs are timed to start in the proper sequence for cost effectiveness, then the years ahead will give us a much improved yield on our investment.

At present, the space program produces dividends mainly in the area of scientific experimentation, and the value of this is already increasingly apparent. This new technology already contributes to everyone's personal well-being, and to the general economy. But as the space program approaches the 20-year mark, we should reach the point where true commercial utilization of space will start to predominate, as opposed to simple Government utilization for experimental purposes.

APPENDIX A

HEARINGS OF THE SUBCOMMITTEE ON MANNED SPACE FLIGHT, GRUMMAN AIRCRAFT ENGINEERING CORP., BETHPAGE, L.I., JANUARY 20, 1967

Appearances: L. J. Evans, J. G. Gavin, G. F. Titterton, C. W. Rathke, Grumman Aircraft Engineering Corp.; Representative O. Teague, Chairman, Representative R. Giaimo, Representative J. Waggoner, Jr., Representative L. Wolff, Representative E. Cabell, House of Representatives; J. Wilson (staff), P. Gerardi (staff), J. Felton (staff), R. Freitag (NASA headquarters), R. Callaghan (NASA headquarters, J. Cramer (NASA headquarters).

Mr. EVANS. Gentlemen, we have Joe Gavin, our program director, here with us this morning. He will essentially lead the briefing. George Titterton, you have all met, senior vice president of the corporation. I have George now supervising the LM project from my area, to assure that project full corporate support.

We have our program manager, Bill Rathke. I am confident he can answer any questions you may have.

I make one observation that troubles us, and I am sure you have heard it before. As we look downstream, we have built up a capability that you have had a chance to observe here this morning. Gentlemen, there are some 7,000 people on the project. We are talking roughly on just round figures, 40 percent of the current workload at Grumman. We can look 2 years ahead and say to ourselves fairly confidently that over 3,000 people, that have been trained over approximately 4 years now on current funding that we look at, will not be employed in the space area. Just to make a point; and I am sure you have been hearing that from a lot of other places.

Let me comment very briefly about the other bird—orbiting astronomical observatory—because this ties in with the projection of the corporation. Dr. Tripp is our program director on that project. The first bird flew late last spring—April 8, 1966—and was not a successful flight because of a power failure. It orbited for 2 days and finally was deliberately put into a tumble mode.

Now, the power failure reflected itself in the battery—the battery cells were overheating. There has been a very detailed study made both by Grumman and by Goddard and by a joint committee, who, in turn, reported to the associate administrator. We, in turn, have reviewed it carefully and have reached agreement with NASA as to the modifications required. The second flight has been delayed to assure we don't run into problems as we did last time. Arcing of the star trackers was another problem which is being corrected. Fortunately, several things were proved about the spacecraft operation before the failure became catastrophic.

We were very pleased with the stabilization that the vehicle achieved in the initial stabilization phase. I might point out that the specification for fine pointing may be characterized as follows: if you are sitting in Bethpage, roughly 40 miles from New York City, you could hold a target the size of a baseball in New York City. In technical terms, this is one-tenth of a second of arc.

Now, this vehicle achieved initial stabilization. It latched onto stars. It stabilized itself, held it for some time, and then the clock would reset itself due to the star tracking arcing.

Chairman TEAGUE. You say the next is due to fly next year?

Mr. EVANS. Yes; in the beginning of 1968. Now, the experiments are coming along very well. The first one flew with the Wisconsin experiment looking out one end and three additional experiments looking out the opposite end. The Smithsonian experiment will fly next time with the Wisconsin experiment package.

There is still a great need in the scientific area for this telescopic capability. One of the projects on the AAP, as you know, is how do we get a manned telescope out and stabilize it. I can say this to you, the know-how we have acquired, in OAO pointing toward the AAP, is very useful. This is the cross-pollination I think you achieve if you are fortunate enough to run a major unmanned and a major manned program at the same time. I don't know what it is worth in dollars and cents. I can tell you from the management confidence level, it is worth a great deal.

Chairman TEAGUE. Any questions, Bob?

Representative GAIAMO. Not yet.

Mr. EVANS. Why don't I let Joe launch right in then? He has a presentation to make and I am sure we will be able to answer all of your questions.

Chairman TEAGUE. Gentlemen, if you won't comment straight out, I will ask the question: What difference does it make as to whether you get a certain amount of money next year and relieve the pressure, so to speak, instead of this concentration?

Mr. EVANS. Joe, why don't you plunge right into answering this question?

Mr. GAVIN. The question has been asked, what happens if the press of the schedule is relieved and the program is allowed to stretch out? This has been studied a number of times in the past. I think that some of the things that come to mind immediately are that, first of all, we have done quite a bit of stretching out within the framework of the present dates. Periodically we have reviewed those things which either we are doing or which our subcontractors are doing, with the intent of pushing them as far downstream as will fit the program. So in this respect, a certain amount of elasticity has already been used up.

This has been done in order to keep the cost rate from peaking any more than it has.

The second thing that comes to mind is that if a stretchout in dates occurs, there are certain fixed costs which seem to continue on for this additional time. The studies which I am sure that NASA has made or we have made or our subcontractors have made, all seem to show this up as a factor, which tends to make stretching of this schedule cost more in total.

Now, I think there is some argument as to whether the penalty is 10 cents on the dollar or whether it is 15. I think this is a very difficult thing to determine, but it appears that the fixed portion of the cost adds up when the schedule is extended. There are some savings, of course. In other words, there could be some immediate savings in overtime pay, this sort of thing.

Now, unfortunately, these studies tend to look at it in an ideal sense, where you can talk in terms of manpower applied and schedules that you meet and so forth. I think there is another thought that should be considered, and that is, the time which elapses between the substantial completion of the vehicle and the time that it is launched, is already quite considerable, and I believe that if there is a significant stretchout in the speed with which things happen, there is going to be a demand for additional intermediate testing to see whether, in fact, the vehicle is still in sound condition. This is a difficult thing to evaluate, but by comparison with any of our aircraft experience, the longer a vehicle sits without a subsystem being exercised, the more doubt begins to grow as to whether that subsystem is indeed ready at the time you put the switch on.

So as I look at this from the astronaut's point of view, I would say that I want the vehicle checked out just before I go. From that point you would backtrack to the factor sequence, and I think that in a stretchout, it could be expected some additional testing would make sense from the operational point of view. This then represents additional work.

I think that it has been made clear in previous studies that either speeding up or stretching out tends to increase the cost. It is my own feeling, that the valley is somewhat flatter than perhaps has been said in the past.

That isn't a very definitive answer, but these are the things that come to mind, Mr. Teague, when you ask me my opinion as to what would happen if you string things out.

Chairman TEAGUE. The operation that we have just seen, you are running 7 days a week and 24 hours a day?

Mr. EVANS. Yes.

Chairman TEAGUE. Is that because IM is a pacing item or because that is the best way to run the program?

Mr. GAVIN. The around-the-clock operation has to do with the first delivery vehicles and the reason for that is that we are running behind, as I will comment on later.

We are trying to make sure that we do not impact the rest of the program, because there is such a train of events in progress that we just cannot afford to become a limiting element.

Mr. EVANS. During a checkout, it is probably desirable anyway. If you were to run an 8-hour shift only, startup discontinuity would take additional time. Each shift, when it starts up, would just have to look back to find out what had happened.

Chairman TEAGUE. What we are doing today will be printed as a hearing, if you want to revise or put any additional material in.

Mr. GAVIN. I think, Mr. Teague, I would like to consider that question carefully before answering it.

Chairman TEAGUE. Bob, do you have a question?

Representative GIAIMO. Do I understand that you are estimating cost for fiscal 1967 of \$350 million and now they are going to be \$400 million?

Mr. GAVIN. Fiscal 1967?

Chairman TEAGUE. Excuse me, Joe, we have asked the staff to give us an approximate figure. I am sure they won't exactly jibe, but they should be very similar to ours and close to ours.

Mr. GAVIN. I was going to pick up the question later, but since it's been asked, let me answer it. At some point in the past, and I would have to check on this, I believe the \$350 million figure was forecast. However, when your staff visited last August, we were projecting at that time \$382 million for fiscal 1967.

Representative GIAIMO. That's without any thought of a stretchout?

Mr. GAVIN. Yes, that's just actual cost increases.

Representative GIAIMO. Without changing the schedule?

Mr. GAVIN. Yes. Shortly thereafter we reviewed with MSC, on a work package basis, the work for the fiscal year, and we revised our projection downward to \$373 million, and at this point we are struggling to attain that number. The more trouble we have with the vehicles you saw out there this morning, the more difficulty, the more unlikely the probability becomes with regard to that number. I think that we should certainly hit it within 3, 4, 5 percent. I think this is possible.

We are in the position where a great deal of work is behind us and where the character of the work remaining is not as diversified or as problematical compared with some of the things we have contended with in the past.

Representative GIAIMO. Then that leads me to my main purpose of asking the question. Going back to Mr. Teague's question with regard to stretchout and how it would affect you and how it would affect cost—if your costs seem to be increasing anyway, without a stretchout, why would the stretchout increase cost to the Government rather than decrease them for this year? Realizing that there is a certain problem with built-in expenses, and so forth, there is also the savings from a stretchout. I don't quite clearly understand that.

Mr. GAVIN. I failed to make that clear. It is true that the cost for a given time period can be reduced, but I was referring to a growth in total cost. I was looking at the cost to complete the job. In other words, it is possible to decrease the cost rate in any particular time period, but you then have to complete the job, and the point that I was making had to do with the effect of a stretchout on the completion.

Representative WOLFF. The overall cost?

Mr. GAVIN. That's correct.

Representative GIAIMO. And do you have any way of estimating what that would be?

Mr. GAVIN. Well, I think that would depend.

Representative GIAIMO. It would depend on how long a stretchout is.

Mr. GAVIN. It would depend on the stretchout, but I am sure for any proposed set of conditions, that could be estimated.

Mr. TITTERTON. May I respond to Congressman Teague's question? There is another factor bearing on stretchout which becomes important if any followon program such as AAP is intended. If you were to look at your handout, figure 1 lists recommended reorder dates. This shows that our subcontractors—and this refers to all the major systems, which would be approximately some 80 to 90 percent of the total outside cost—the end of their line is in the very near future. They are only talking 3 to 4 months from now, and all of these people, if they are going to have any continuity, must have a reorder.

Now, if you go to the figure before that, it shows you (fig. 2-3) fiscal 1966 and 1967 expenditures, major subcontractors, it shows you here—

Chairman TEAGUE. What do you mean by reorder?

Mr. TITTERTON. Well, they would have delivered all requirements for the present 15 LM's. If there are to be any followup LM's or equivalents, they will be breaking down their lines and have to start over fresh until they got an order at that time.

Representative WAGGONER. Actually, isn't this predominant in all your thinking about stretchout? Isn't this the real reason for additional cost—the breakdown of continuity?

Mr. TITTERTON. Yes. This is the point that Joe was making, but I would like to make another point, that your major cost will have been expended as of 3 or 4 months from now. If you look at page 46 of the statement it shows you the rate of expenditures of the subcontractors. You will find that presently they are running about \$15

RECOMMENDED RE-ORDER DATES

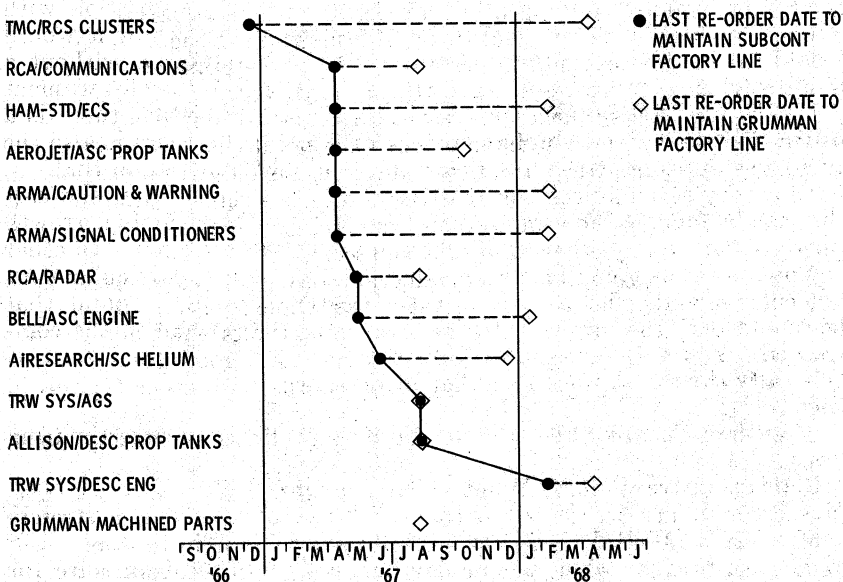


FIGURE 1

FISCAL '66 & '67 EXPENDITURES: MAJOR SUBCONTRACTORS

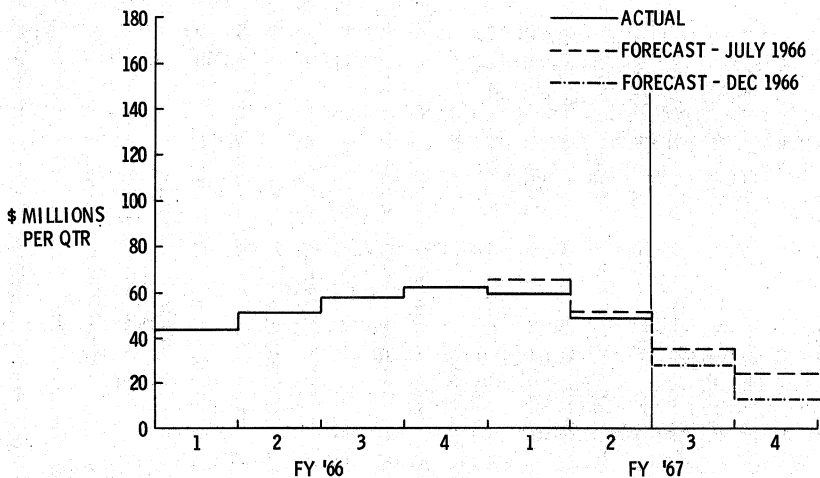


FIGURE 2-3

million a month. By the fourth quarter of this fiscal year, by May and June, they are down to \$3 million per month.

What you are looking at there is a quarterly expenditure. In other words, in the fourth quarter of fiscal 1967, which is only 3 to 4 months from now, you are running at a rate of \$10 million a quarter.

In other words, the expenditures, if you stopped them today, you would save a few assembly operations. If you stopped them a few months from now, you would have all your hardware.

Mr. EVANS. Let's take a for instance, an inertial platform, and you order 15 of them, and you have reached the point that the production line has stopped and 15 units flown out, you don't fly for a year—you have a very serious problem of maintaining the repair capability of the repair facility, how many men you will need, the overhead applied to it and many other problems, you see.

Now, as far as going back to production, having a year's break, and you come in and order 15 more of them, the whole facility will have to be reborn onto the project. In the meantime, the talent has to be retrained. You will have some of it available, but a good deal of it has generally shifted, if not to another project, even to another organization.

Chairman TEAGUE. Yes; I understand that. Do you have any questions?

Representative WOLFF. What about changes? Have any changes caused you to increase the cost in the vehicle itself?

Mr. GAVIN. Well, I think yes. I will have to explain in some level of degree, because when people say "changes," this covers a lot of ground.

For example, in the LM, as in other parts of the Apollo program, there is an extensive effort to control the configuration of the vehicle

down to a very fine level of detail. So, consequently, anything which changes is a change and, therefore, of the total number of changes, there are a great many rather minor changes. Some of them even as small as correcting the paperwork. But on the other hand, there are from time to time, significant functional or engineering changes, which do produce a change in the vehicle, which do cause additional effort on our part and which do result in changes in how it works. I would say that in the past year, something on the order of—certainly over a year—something on the order of \$15 to \$17 million worth of significant changes were made. Does that answer your question, Mr. Wolff?

Representative WOLFF. Yes.

Representative GIAIMO. One other question, the \$372 million, plus or minus, that you mentioned for fiscal 1967, that gives us how many LM's?

Mr. GAVIN. How many LM's?

Representative GIAIMO. Units?

Mr. GAVIN. We will have delivered LM-3 by the end of the fiscal year, LM-5 by the end of the calendar year.

Representative GIAIMO. Well, by the end of the 1967 fiscal year, one will be delivered?

Mr. GAVIN. No.

Representative GIAIMO. Two?

Mr. GAVIN. Through LM-3.

Representative GIAIMO. Through LM-3?

Mr. GAVIN. In other words, we would have the ground-test vehicle, such as the ITA-8, plus LM's 1, 2, and 3.

Mr. RATHKE. Also the status of the following vehicles will be advanced.

Mr. TITTERTON. Yes; LM-4 and 5 will be in the final test area at that point.

Mr. GAVIN. Perhaps I should explain that right today you can go to one of our plants and find pieces and parts of LM-7, subassemblies, this sort of thing, and LM-6 is starting and LM-5 is further along than that.

Representative GIAIMO. Well, I am just trying to get a picture in my mind, as to what costs remain in the future. Your contract calls for approximately 15 altogether, does it?

Mr. GAVIN. Fifteen is correct.

Representative GIAIMO. So what costs remain for the balance of the 15 in general, if you can give me that?

Mr. GAVIN. Well, there is a chart in the handout.

Representative GIAIMO. I know some of them are probably in the preliminary stages and some costs of the future ones are in the 1967 budget.

Mr. GAVIN. That's correct, and in your handout, there is a curve which shows by quarter what the trend is for the total cost; and if you look forward to that, it looks as though the next fiscal year is going to be something on the order of \$150 million. I think that gives you your comparison.

Representative GIAIMO. But then roughly for fiscal 1967, we would have completed two, I understand, in final testing at this time?

Mr. GAVIN. Yes.

Representative GIAIMO. And what else?

Mr. RATHKE. Four more identifiable.

Representative GIAIMO. Four more identifiable?

Mr. RATHKE. Yes.

Mr. GAVIN. And parts.

Mr. RATHKE. And parts for everything.

Mr. GAVIN. You see, there will be pieces, assemblies, at roughly 2½ month intervals.

Representative GIAIMO. Well, the only thing I am trying to get at is that there is an awful lot of money yet left to be expended for the completion of this entire project.

Mr. GAVIN. I think that you should also bear in mind that the operation at Cape Kennedy is at this point just approaching full scale, and that this will continue on through the launch period for the program, and we have tended in this discussion to concentrate on what is happening in the production end of the business, without saying very much about that.

Representative WAGGONNER. I think that charts on this handout (fig. 2-3, p. 620) for the total expenditures and for the subcontractors, really reflect what is happening there and what is going to happen better than anything else because they show that at the end of the first quarter, we had peaked as far as actual expenditures are concerned, and it is a downhill proposition.

Mr. EVANS. Yes, the project is over the peak and it is going downhill.

Representative WAGGONNER. The one thing that interests me in this chart is that during the first quarter of fiscal 1967, the actual expenditures were just a wee bit below forecast.

Mr. EVANS. That is exactly what we have been reviewing in great depth in the last 2 weeks. I am confident of it, but we are going to follow through and check to see that that is what has happened.

Incidentally, the relationships are great with these people and we have been working pretty much to midnight to make sure that there are good cost projections on this project, and still make the schedule. We are, at the moment, at the critical stage. This is it right now, and I think you will hear more as to that from Gavin.

Representative WAGGONNER. Not only is that true with the total expenditure, it is true for the first and second quarters with the subcontractors, too.

Mr. GAVIN. That's correct.

Mr. EVANS. Yes, sir.

Mr. GAVIN. Shall I go back, Mr. Teague, and see if we can't get back to the schedule?

Chairman TEAGUE. Any other questions from anybody else?

Representative WOLFF. In the event that there would be any additional vehicles that would be ordered, what would be the outside date before you would have the start of the cost all over again?

Mr. GAVIN. Well, this is indicated back on figure 1 of the handout, and it falls into two categories. It involves the startup time reflected on our subcontractors, the equipment manufacturers. As you would suspect, they reach this point before we do, because of the fact that there is a leadtime of the equipment with respect to the construction

of the vehicle. The date that looks like the key date to Grumman is August of this coming year.

Representative WAGGONER. Joe, isn't it true that at any time you have this kind of an interruption, the costs really do become excessive?

Mr. GAVIN. Well, that's right. Any time that you have an interruption in the sequence of operations, you are faced with either tying up people or facilities unproductively, and this then represents a direct cost for keeping them, or if you dismantle them, you then face the restart problem.

Representative WOLFF. Mr. Chairman, the reason I asked that question is because of the fact that during the hearings when I questioned General Schriver about the duplication which existed at the IM project, there was some question as to whether or not, some of the old experiments could be carried out on existing vehicles, and I believe that this was a point made, that a goodly percentage of them could be carried. Therefore, if it was a question of duplication, a question of cost is something which might be considered.

Chairman TEAGUE. Yes, sir. Thank you for inviting us to your district and good to be here.

Representative WOLFF. Thank you, sir.

Chairman TEAGUE. One other question: I have forgotten what you people told us about your post-Apollo program. I would hope that these subcommittee hearings may force this post-Apollo problem to a head, where if there are some decisions made before the middle of the year, that you would know whether there are going to be other orders. Can you tell us of any other proposals for use of the IM on down the road in the space program?

Mr. EVANS. Looking ahead, in general, we are actively looking at things like Voyager. We are probably the only company that has the soft-lander capability for Mars.

We have had roughly 60 men working on this for about a year now. One of the promising Voyager Mars lander capsule configurations under study uses a significant amount of Lunar Module hardware and technology, including the IM descent engine. The resulting decrease in development costs would represent a considerable dollar saving to the U.S. Government for a Mars lander type of vehicle.

We have studied many manned and unmanned IM configurations and modifications which use its large volume, payload and propulsion capability to satisfy the goals of lunar exploration, earth and lunar orbital missions. The IM derivatives can perform missions that provide the basis for future long duration space stations, lunar bases, manned planetary vehicles and lunar roving vehicles.

We have examined over 100 scientific and applications experiments which included the use of several types of telescopes and a wide variety of sensors. The IM, as you know, has over 2,300 cubic feet of available volume and can carry over 20,000 pounds of payload.

Quite frankly, we had been looking, as I think any progressive company does, along the very lines that Congressman Wolff has just brought up.

These studies have positively concluded that the IM can perform all of the earth orbital missions, both scientific and military, that have

been proposed. The obvious advantage to be gained from using IM hardware for these missions stems from the continued use of the experienced IM engineering, manufacturing, and test teams together with the existing clean-room type assembly areas, special test facilities, and the three operational ACE stations now located at Bethpage.

Another advantage stems from the use of existing astronaut crews who are now being thoroughly trained in the operation of Apollo/LM vehicles. These men, many of whom have had extensive Air Force flight training, as well as NASA instruction, will not require any further training to accomplish these proposed missions.

For over 3 years, a wide variety of LM derivatives have been studied to fulfill the following mission:

Extended Earth Orbit—to 45 days

With resupply—to 105 days

Extended Lunar Orbit—to 28 days

On the Lunar Surface—to 14 days

Lunar Roving Vehicle—to 14 days

Lunar Scientific Stations

Space Rescue

Military

Scientific (Astronomy, etc.)

Applications (Communications, Earth Resources, etc.)

A short list of a few of the vehicles studied are:

Apollo Telescope Mount LM: To obtain solar astronomy data unobtainable from any other method.

Earth Resources LM: Survey earth resources on a large scale—particularly in remote areas. Separate module for sensors could be used for other missions.

Augmented Lunar Module: Increased payload capability with astronauts for mission up to 14 days on the moon.

LM Truck: A modified LM descent stage capable of landing over 10,000 pounds payload on the moon.

3-Man LM: Used for space rescue, place more men on the moon or in space. Used as a space shuttle.

Now, that to me derives a lot of technology from LM, but is quite obviously not an LM vehicle. I don't know whether that answers your question.

Representative WOLFF. Mr. Chairman, thank you for the opportunity of sitting in.

Chairman TEAGUE. Come back later.

Mr. GAVIN. Mr. Teague, in view of the fact that we took the tour first, I am going to shortcut some of the initial remarks I had planned that are purely descriptive and go on rather more quickly into where we stand (figs. 4-8).

I do think it is worth commenting, however, that the principal functions of the LM vehicle stand at a much higher confidence level than perhaps they did at the beginning of the design, or even at the time of your last visit. For example, the NASA's greatly successful Gemini program seems to have conclusively disposed of questions concerning rendezvous and docking. With respect to the question of the lunar landing, we think that the NASA programs involving Ranger, Orbiter, and Surveyor, have dispelled a great many of the questions which people were asking back when we really got started. I think these represent real support to the manned space operation from the unmanned side of the house.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

**REPORT FOR THE
SUBCOMMITTEE ON MANNED SPACE FLIGHT**

20 Jan 1967

FIGURE 4

AGENDA

- **INTRODUCTION**
- **FORMAL PRESENTATION**
 - **REVIEW CY 66**
 - **CURRENT STATUS**
 - **PROGRAM SUMMARY**
- **INFORMAL DISCUSSION**
- **TOUR**
- **LUNCH**
- **DEPART**

FIGURE 5

OUTLINE OF FORMAL PRESENTATION

- INTRODUCTION
- GENERAL FAMILIARIZATION
- REVIEW CY 66
 - MAJOR MILESTONES
 - SIGNIFICANT ENGINEERING ACHIEVEMENTS
 - SIGNIFICANT MANAGEMENT ACTIVITIES
- CURRENT STATUS
 - SUBSYSTEM STATUS
 - OPERATING PLAN
 - PLANNED MAJOR MILESTONES CY 67
- MANPOWER
- COSTS
- CONCLUSION

FIGURE 6

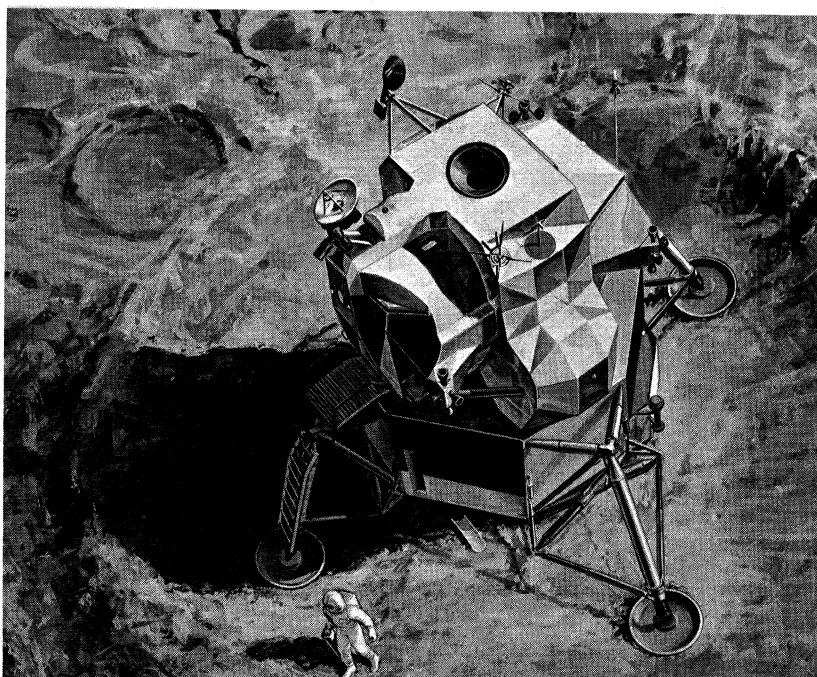


FIGURE 7

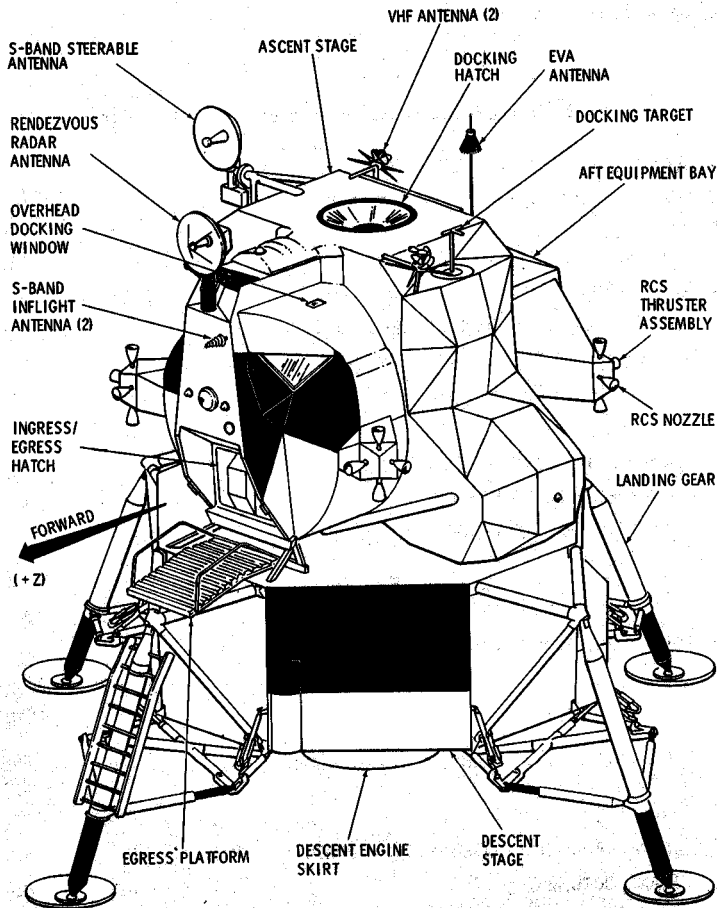


FIGURE 8

It is rather interesting to note that none of these results have demanded a significant change in the LM vehicle. In talking about the status that we have at present, I would like to first take up the significant accomplishments during the past year, calendar 1966.

Now, in your handout, we have presented several slides that involve accomplishments at Bethpage, White Sands, the Manned Spacecraft Center and Kennedy Space Center, and I think that I will not go into each one of these in detail. I think you can read these easier than I can speak of them. I would like to highlight several of these. At Bethpage (figs. 9-10) the buildup and testing of the spacecraft electrical subsystem was accomplished first on a mockup, the electronic system integration rig, and then on the LTA-1 house spacecraft.

Now, this activity represented a very necessary background to the design, the manufacture and checkout of the spacecraft, the sort of thing that is now in progress, which you saw this morning. It has confirmed the basis for circuit design, for working out the problems of

1966 BETHPAGE MILESTONES

<u>NAME</u>	<u>CONTRACT DATE</u>	<u>ACTUAL</u>
• IES BETHPAGE TESTING COMPLETED		12/22
• TM-2A/R A/S REFURBISHED FOR LTA-5D PROP. TESTS SHIPPED TO WSTF	11/30	12/15
• LTA-1 COMPLETED FEAT ON FIRST TRY	---	11/30
• INTERIM COMPONENT QUAL TESTING (90% COMPLETE)	11/15	11/15
• IES FIRST MANNED SIMULATION TESTING COMPLETED	---	11/8
• M-5 SHIPPED TO MSC FOR DISPLAY	---	11/7
• LTA-5D SHIPPED TO WSTF	10/1	10/21
• LMS-1 SHIPPED TO MSC	11/1	10/14
• LTA-3 COMPLETED IN-HOUSE VIBRATION TESTING	---	10/4
• TM-6 A/S RR TEST MODEL SHIPPED TO MSC	9/1	9/6
• LTA-10R REFURBISHED FOR FLIGHT - SHIPPED TO KSC	9/15	9/15

FIGURE 9

1966 BETHPAGE MILESTONES (Contd)

<u>NAME</u>	<u>CONTRACT DATE</u>	<u>ACTUAL</u>
• M-3 (FVV) REFURBISHED FOR FACILITY VERIFICATION SHIPPED TO KSC	7/30	8/12
• LTA-3D TRANSFER TO TEST	8/19	8/25
• TM-8 LANDING RADAR TEST MODEL SHIPPED TO MSC	7/1	8/10
• LTA-3A TRANSFER TO TEST	7/15	7/24
• LTA-1 HOUSE S/C NO. 1 COMPLETION OF SUBSYSTEM INSTL & READY FOR INTEGRATED TESTING.	5/27	6/15
• ESI OCP's COMPLETED - 31; 4 IN WORK, 4 NOT STARTED		
• TM-7 ASCENT STAGE RENDEZVOUS RADAR TEST MODEL SHIPPED TO MSC	4/1	5/6
• TM-4 ASCENT/DESCENT STAGE INTERFACE COMPLETED	---	4/27
• TM-2A START THERMAL VACUUM TESTING	12/30/65	3/3/66
• TM-2D COMPLETED FIRST THERMAL VACUUM RUNS	---	2/2
• INCENTIVE CONTRACT SIGNED	---	1/14

FIGURE 10

the ground support equipment and developing the techniques for running these operational checkout procedures.

In late November we succeeded in carrying out the final engineering acceptance test sequence on the LTA-1, the house spacecraft, on the first try.

Another thing which looms large in our mind from the past year, has to do with the LTA-3, a structural test vehicle. This is the next

slide that you see (fig. 11). This is a picture of the LTA-3 as it was hung on a spring mount in our testing laboratory while we ran a vibratory survey to determine the response of the structure of the spacecraft to the rocket engine, and also the reaction control thrusters. This was of particular importance, because it defined more clearly the type of environment which much of our equipment is subjected to during the course of the actual mission.

I will speak a little bit more about this vehicle when we come to the things which have been going on at Houston.

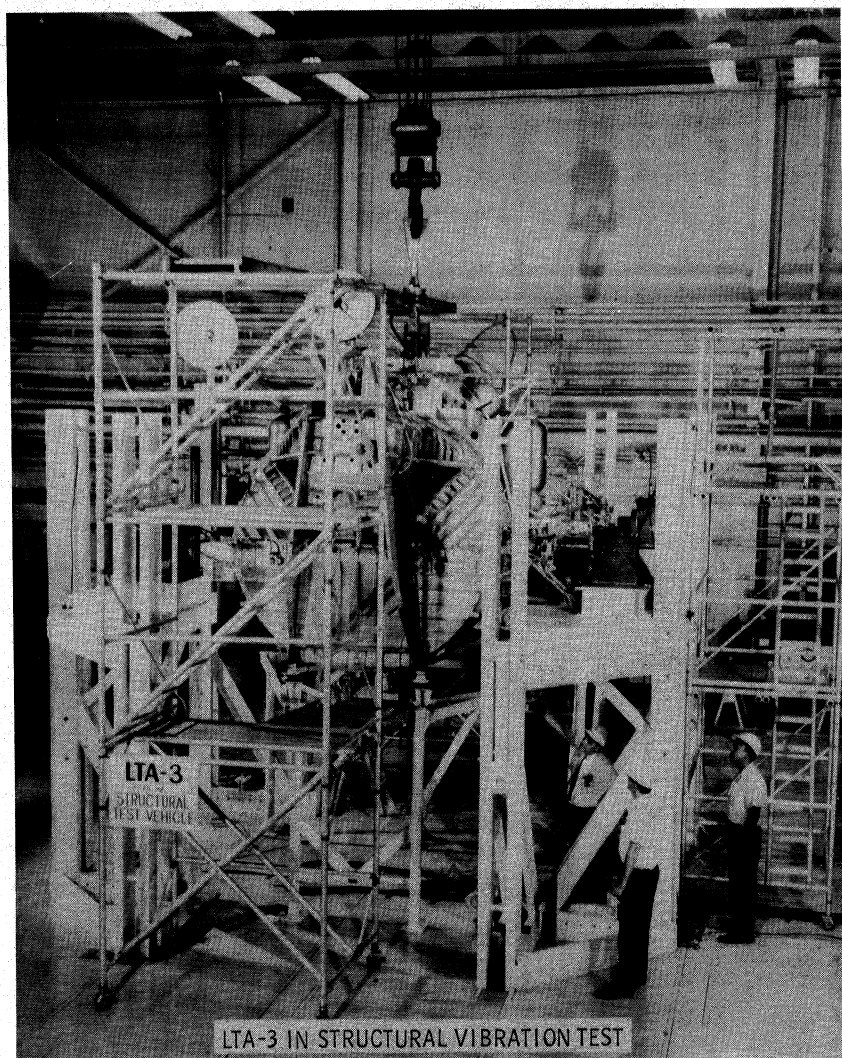


FIGURE 11

The next slide (fig. 12) shows the first thermal vacuum test article, TM-2, which is shown here being lowered into Grumman's thermal vacuum chamber, to determine the heat transfer characteristics of the vehicle. This is a very important vehicle because it provided the design information that was necessary to proceed with the lightweight thermal skin insulation and other features which determine the heat balance in the vehicle.

Chairman TEAGUE. What temperatures are involved there, approximately?

Mr. GAVIN. Well, we have to look at this vehicle from the standpoint of the lunar surface in full sunlight, to the lunar surface in full shadow, which is a range of plus or minus 300° F., approximately. When it is hot, we are trying to keep the heat out; and when it is cold, we are trying to keep the heat in. We are trying to do this in a sufficiently efficient fashion that we do not put too large a demand on the environmental control system in the vehicle.

It is a little bit like having a well-insulated house, I suppose. In any event, these lists which you can pursue in more detail by yourself, tell you what we did at Bethpage during the past year, and I suppose that we should point out a couple of things that we didn't do. We did not succeed in delivering LM-1 and LTA-8 by the end of the year, which was something that we were striving mightily to do. But also, I want to point out the list of things, which were happening at Bethpage does not include the fact that we have had astronauts here almost



FIGURE 12

every week, certainly at least every other week during the past year, who have participated in our design discussions, who have reviewed the program on the vehicle, and who have spent time in evaluating the cockpit portion of the vehicle, the adequacy of everything from, say, circuit breakers to provisions for stowing the back pack and how they can reach the various controls.

With regard to the activity at White Sands (fig. 13), I would like to highlight several other things which have been accomplished there. After a difficult starting-up period, we have been able to accomplish a vastly improved operation, whether it is measured in terms of test schedule or on the basis of runs per unit time.

The first slide (fig. 14) in the sequence shows an ascent stage test vehicle, PA-1 being lowered into the vacuum can at White Sands. The tests run on this vehicle represent the demonstration of the adequacy of the propulsion system, including the propellant feed system. Also, this series of tests provides us with a demonstration of the supporting ground service equipment. These tests have included mission simulation firings, and off nominal condition firings. We have also evaluated the reaction control system, and in particular, the supercritical helium pressurizing system in this case, for the descent stage.

Representative WAGGONER. How much altitude can you simulate with this?

Mr. GAVIN. This brings us up to something like 150,000 feet, which is adequate from the standpoint of developing the full expansion in the rocket engine nozzle.

This next shot of the facility shows the can with the cover on (fig. 15). Down at the bottom is the business end of the steam ejector, which provides the pumping to keep the can at the low pressure when the engine is running. From our point of view, this is an indispensable operation because it is the only way that we are able to test the

WSTF MILESTONES ACCOMPLISHED: 1966

COMPLETED:

- | | |
|---|----------|
| ● PRE-PRODUCTION DESCENT PROPULSION SYSTEM TEST SERIES (PD-1) | 4/27/66 |
| ● PRODUCTION DESCENT PROPULSION SYSTEM TEST SERIES IN SUPPORT OF LM-1 (PD-2) | 11/22/66 |
| ● PRE-PRODUCTION ASCENT PROPULSION SYSTEM TEST SERIES (HA-3) | 9/23/66 |
| ● PRODUCTION ASCENT PROPULSION SYSTEM ALTITUDE TEST SERIES (PA-1), INCLUDING: | 12/28/66 |
| - COLD FLOW | |
| - REACTION CONTROL SYSTEM | |
| - FIRE-IN-HOLE | |
| - MISSION DUTY CYCLE | |

FIGURE 13

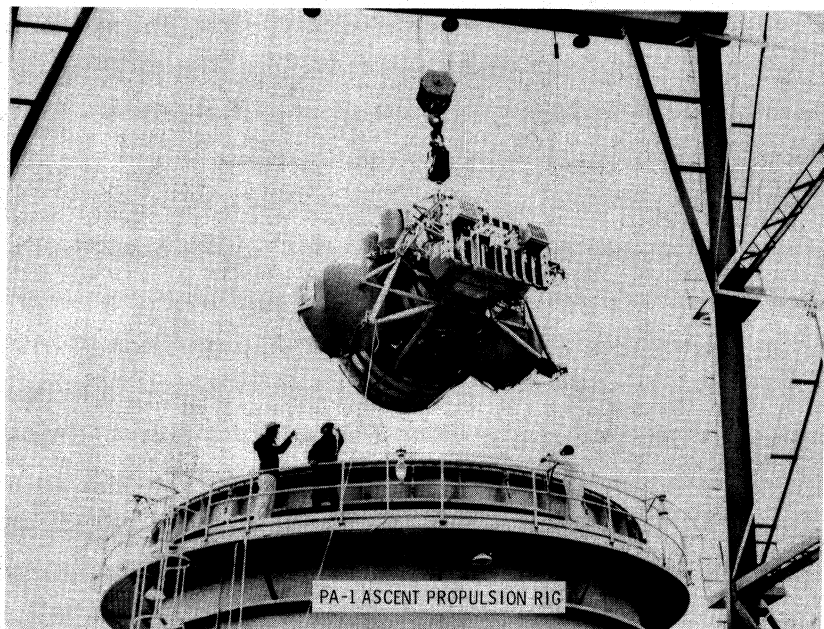


FIGURE 14

propulsion aspects of the vehicle on the ground in anything approaching the conditions that would be encountered in space. It is the practical solution of what we can do on the ground to get ready for space flight. This shows up, of course, in the propulsion system itself, but it also shows up in those things which are affected by the propulsion system. We have actually taken instrumented readings of the reaction of the structure, for example, to the energy output of the engine. I think that perhaps I am jumping ahead a little bit, but I will mention that we have one very interesting series of tests where we fired the ascent stage adjacent to the descent stage to simulate the condition at lunar launch.

This has been something that we have been analyzing and running model tests on for a good portion of the program, and has given us an indication of the pressures that exist along the base heat shield of the ascent stage. This is an area where we are still carrying out some work to resolve the interaction of the engine starting pressures and the base heat shield. This is the sort of thing, that as far as I can see, just couldn't be accomplished without this kind of a facility to do it in.

Representative WAGGONER. Is this the only facility of this sort that we have, or does this facility exist in a number of other places other than White Sands?

Mr. GAVIN. I believe at AEDC there is a facility which might possibly do this.

Mr. FREITAG. There is a similar facility at Tullahoma, and there are similar tests going on at Tullahoma for this program.

Representative WAGGONER. Who is conducting those tests?

Mr. FREITAG. The Air Force is conducting them for us.

Representative WAGGONER. Is there any correlation between the two to give one the advantage of any advance the other might have?

Mr. FREITAG. I would say that the data itself is not too related. The techniques and testing techniques are, and they are correlated, yes.

Mr. GAVIN. Well, I guess that we should make the point, that in the course of the engine development, both engines have been run at AEDC in order to make sure that correlation was established, because of the fact that AEDC did have a background in testing many other engines. We have had short sequences at Tullahoma for that purpose.

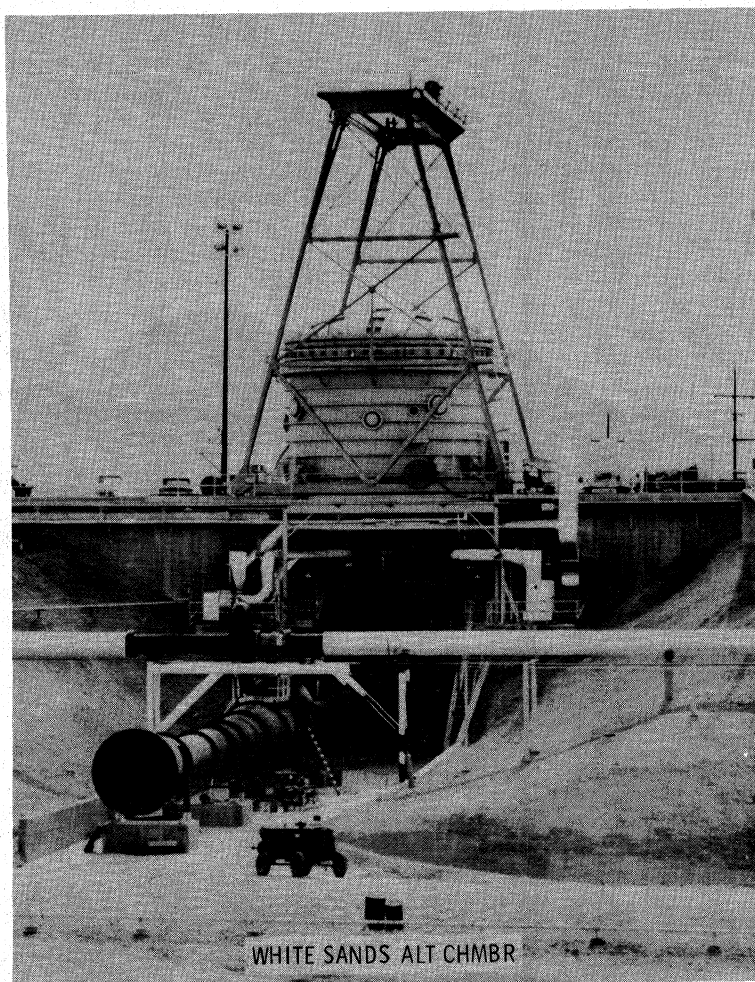


FIGURE 15

Now, we have another list of things which have been done in the past year, which has to do with the Manned Spacecraft Center at Houston (fig. 16). One of the key items which I would like to highlight is the same LTA-3 structural test article I mentioned earlier (fig. 17). Once we had run the series of tests here at Bethpage, the vehicle was shipped to Houston. There a simulated external thermal skin was applied, and the whole vehicle was mounted in a spacecraft adapter. That is that conical device with the patches on it; then the whole assembly was shaken and vibrated.

You see, in the tests here at Bethpage, we were pursuing the effect of the engine on the spacecraft, the engine firing portion of the mission, and at Houston, we were pursuing the question of the environment during launch and boost when the LM is inside the stack.

Now, the next picture (fig. 18) shows the upper end of the facility; and here I guess I am speaking more for MCS than for Grumman, because it is their facility. This is a huge set of loudspeakers which pour acoustical energy down the funnel. Inside the funnel has been mounted the spacecraft adapter, the LM within it; and then on top of that, the command and service module portions, so that we had the spacecraft stack inside this funnel. Then acoustical energy was poured down it to simulate the launch boost conditions. From this we were able to read from the instruments on the LM the reaction of the LM vehicle to that environment. This was of very great significance to us because it allowed us to obtain a better indication of the environment to which we would have to subject the equipment in the LM; and in many cases we were able to reduce some of the earlier overconservative assumptions which we had made. This was a major step ahead in bringing to completion the development of some of the LM equipment.

There are several other items of note that went on at Houston. The next picture (fig. 19) shows a mock-up of the ascent stage which was provided to MSC to support radar range testing of the rendezvous antenna.

MSC MILESTONES COMPLETED: 1966

● TEST PREPARATION AREA: COMPLETED MECHANICAL FACILITY MOD	10/15/66
● RENDEZVOUS RADAR TESTING, TM-7	10/13/66
● VIBRATION TESTING, LTA-3	11/17/66

FIGURE 16

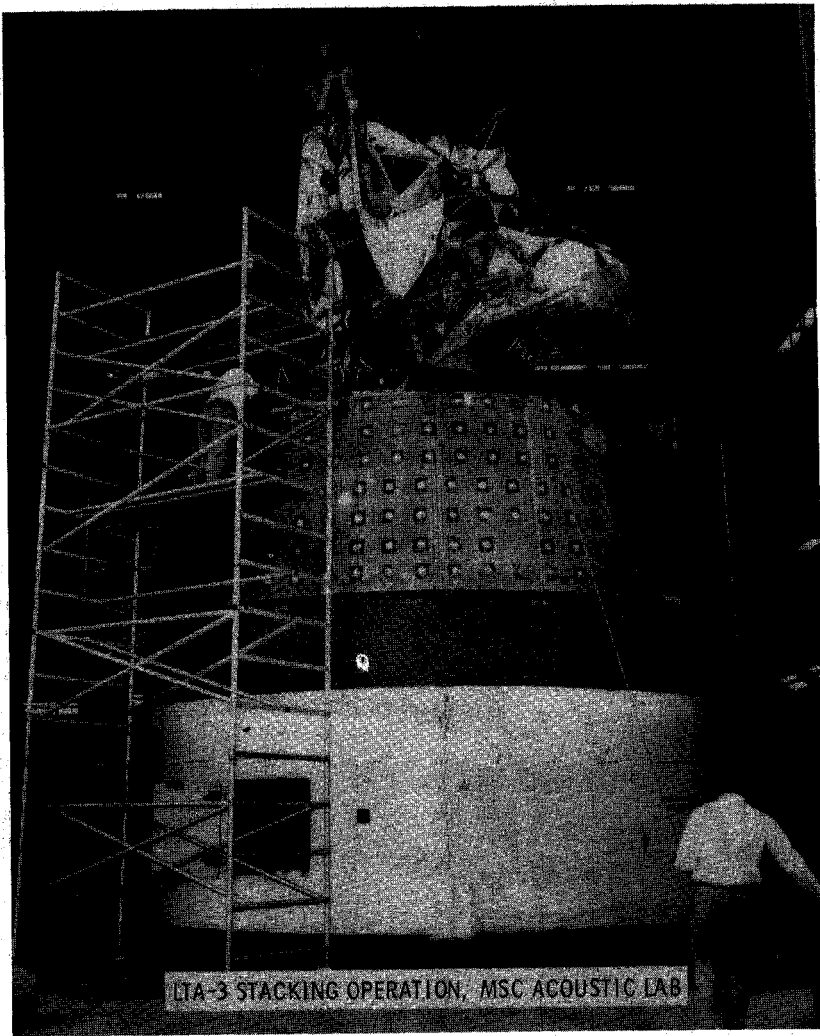


FIGURE 17

The next slide (fig. 20) shows the antenna involved. This picture was taken on another vehicle out in the final assembly area.

The next slide (fig. 21) shows a very crude representation of a piece of the descent stage. That's one landing gear sticking up in the air. This was used also to examine, on the radar range, the landing radar, which is mounted on the descent stage.

We have also delivered to MSC the first of the LM mission simulators, which is now approaching operational status. This is the Link simulator. It provides MSC with a LM companion for the Apollo mission simulator that is also there.

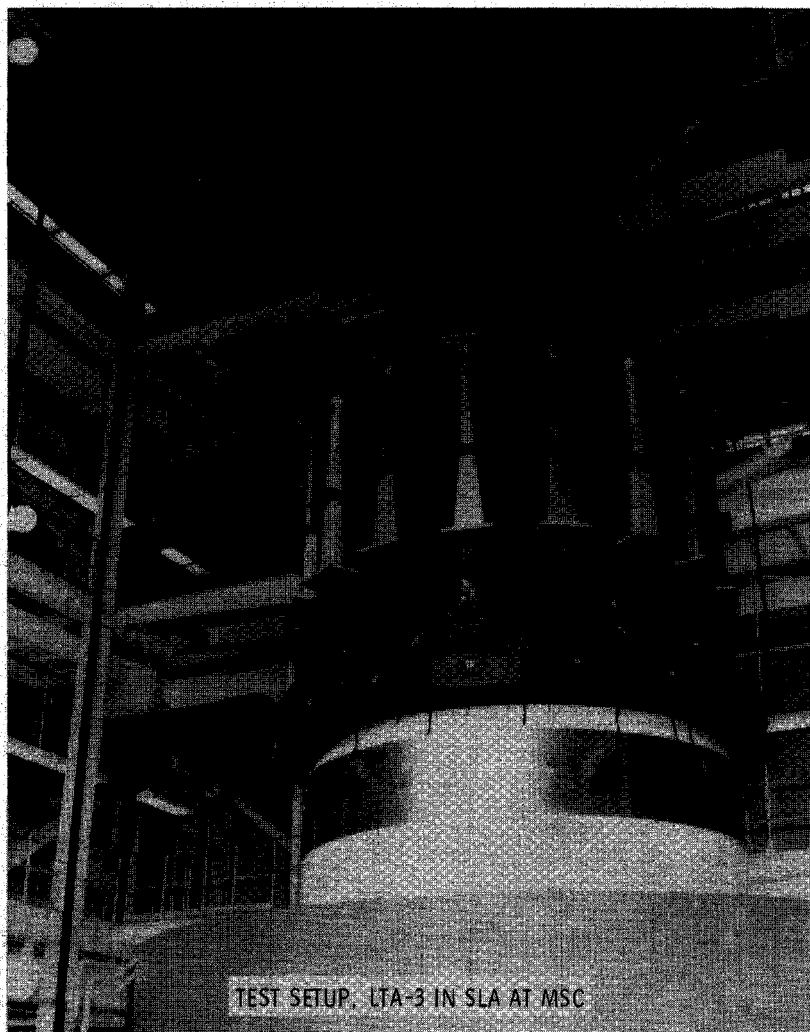


FIGURE 18

With respect to what has been going on at Cape Kennedy, we have provided you with yet another list (fig. 22). The first slide shows the LTA-10R vehicle being picked up here (fig. 23) at Grumman by the Guppy, which is an operation which always amazes those of us who once were concerned with aircraft programs. All of the vehicles have been delivered in this fashion, and it has proved very useful.

The next slide (fig. 24) shows LTA-10R in the assembly area at Cape Kennedy. The base is a representative descent stage. The ascent stage is merely a mass simulation.

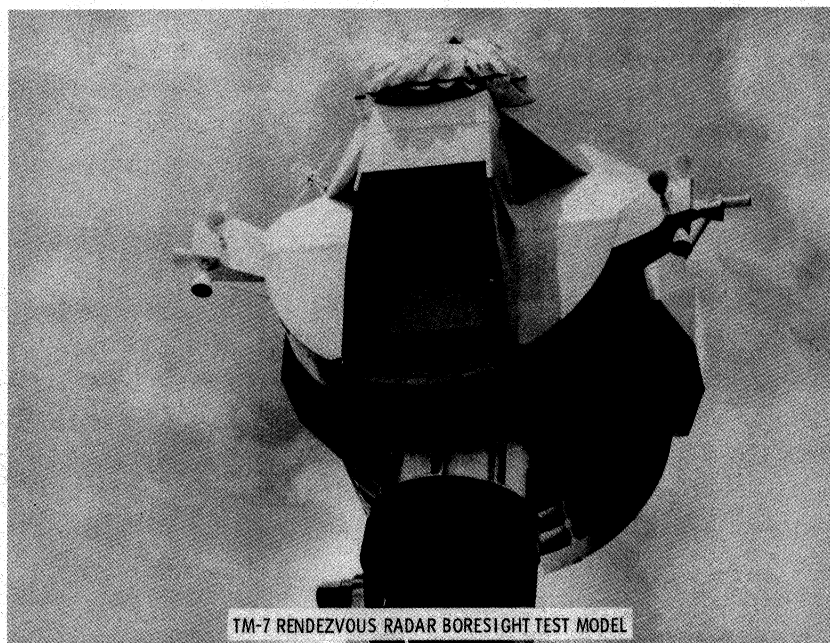


FIGURE 19

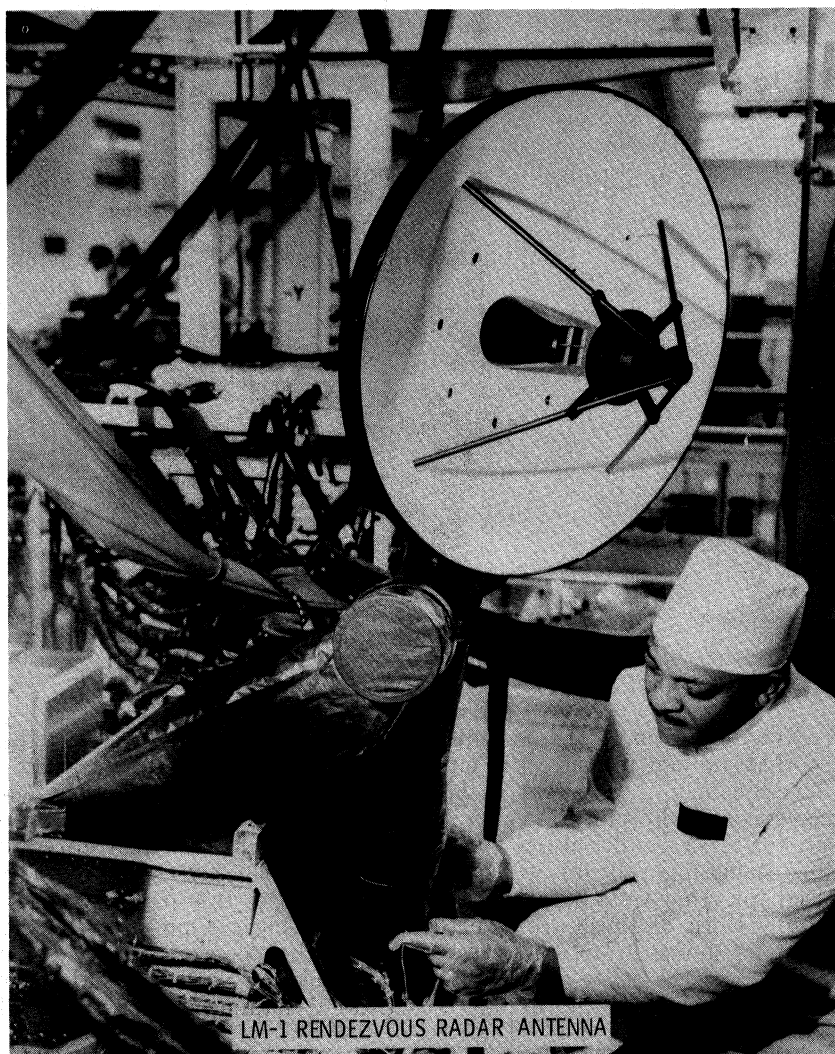
Now, the purpose of this vehicle is to ride the first Saturn V booster, so that we can measure the environment produced by that booster. Consequently the descent stage is instrumented to show what the stresses and the vibrations are. There is a similar test vehicle lined up for the second Saturn launch. Both of these vehicles represent an interesting program economy in view of the fact that they were used for other tests before they were assigned to this particular purpose. Both of these are structural test articles. One of them was used in conjunction with the testing of the spacecraft adapter at Tulsa, and the other one was used in connection with the evaluation at MSFC, Huntsville, of the structural dynamic characteristics of the whole stack.

Representative WAGGONER. These structural test items are made to conform with presently adjusted overall weights, when you launch them, when you use them as structural test items?

Mr. GAVIN. Yes, sir.

Representative WAGGONER. Is this the proper point or later, or put it in anywhere, but are you going to give us some idea of what the weight picture has been from the outset?

Mr. GAVIN. Yes. As a matter of fact, that's exactly the next thing I was going to come to. I'd like to highlight just a couple of engineering accomplishments during the past year, the ones that stand out to us (fig. 25). The first of these is the fact that we have been successful in bringing the weight under control. This has been a long,



LM-1 RENDEZVOUS RADAR ANTENNA

FIGURE 20

troublesome problem, and this chart (fig. 26) which will take a little bit of study, shows what has happened.

We are plotting weight against time. The term "SWIP" means super weight improvement program. We didn't invent it for this program. We inherited it from one of the other programs.

What this means is that we put a highly talented team in to review all of the designs which have occurred, and we literally scraped the ounces out. We have campaigned all the structure, all the equipment, and all the requirements.



FIGURE 21

KSC MILESTONES COMPLETED: 1966

- KSC BECAME AN OPERATIONAL SITE.
- 547 GSE END ITEMS RECEIVED ON SITE; 474 VALIDATED
- LTA-10R: LAUNCH COMPLEX 39 ACTIVATION: 15 DEC '66
- LM-1

- OPERATIONS & CHECKOUT BUILDING

- ✓ STAB & CONT LAB
- ✓ SPARE PARTS & TOOL ROOM
- ✓ MODIFICATION SHOP
- ✓ BATTERY MAINT LAB
- ✓ ACE S/C STATION, 3
- ✓ ACE S/C STATION, 4
- ✓ CALIBRATION LAB

- SPACECRAFT SPARES BUILDING

- PYROTECHNIC INSTL FACILITY

ORD ACCOMPLISHED

12/15/66
 8/30/66
 8/30/66
 10/26/66
 6/10/66
 8/12/66
 12/30/66
 6/29/66
 9/16/66

- COMPLETED SIMULATION STACKING OPS WITH SLA

FIGURE 22

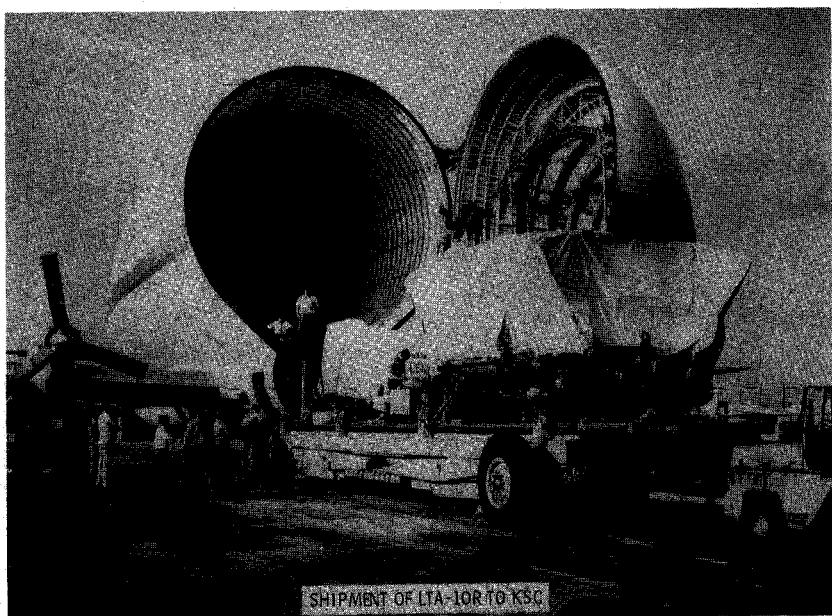


FIGURE 23

In short, there is some weight margin in the vehicle as it stands today. One of the problems that faces us at this point is that we have to fend off the people who would like to use up some of the weight margin. Between MSC and ourselves, we think that we can make it through the remaining months.

We have shown this chart for LM-4, because not all the vehicles have this weight saving in them. We picked up these weight savings in LTA-3 from a structural point of view, so that we would have a representative test article. We picked up the LM-2 descent stage, and the LM-3 ascent stage. From that point on, the vehicles are all of the same lightweight configuration.

Representative WAGGONER. If that chart means or what it appears to me it means, you didn't have any choice back in 1965 except to create that superweight improvement program, did you?

Mr. GAVIN. Yes. In retrospect, it was a very trying period, and it was obvious that something effective just had to be done. There was no choice, so we took the bull by the horns and did it. I would point out that this particular undertaking, while it has been successful, has been very expensive in terms of effort and time; and I also would like to point out that we have been able to save weight without compromising our operation capabilities, or for that matter, the qualification tests which both the vehicle and the equipment have been required to pass.

Representative WAGGONER. Time as related to weight in the first column, it doesn't show what that target weight is and what the current weight is. Do you have those rough figures?

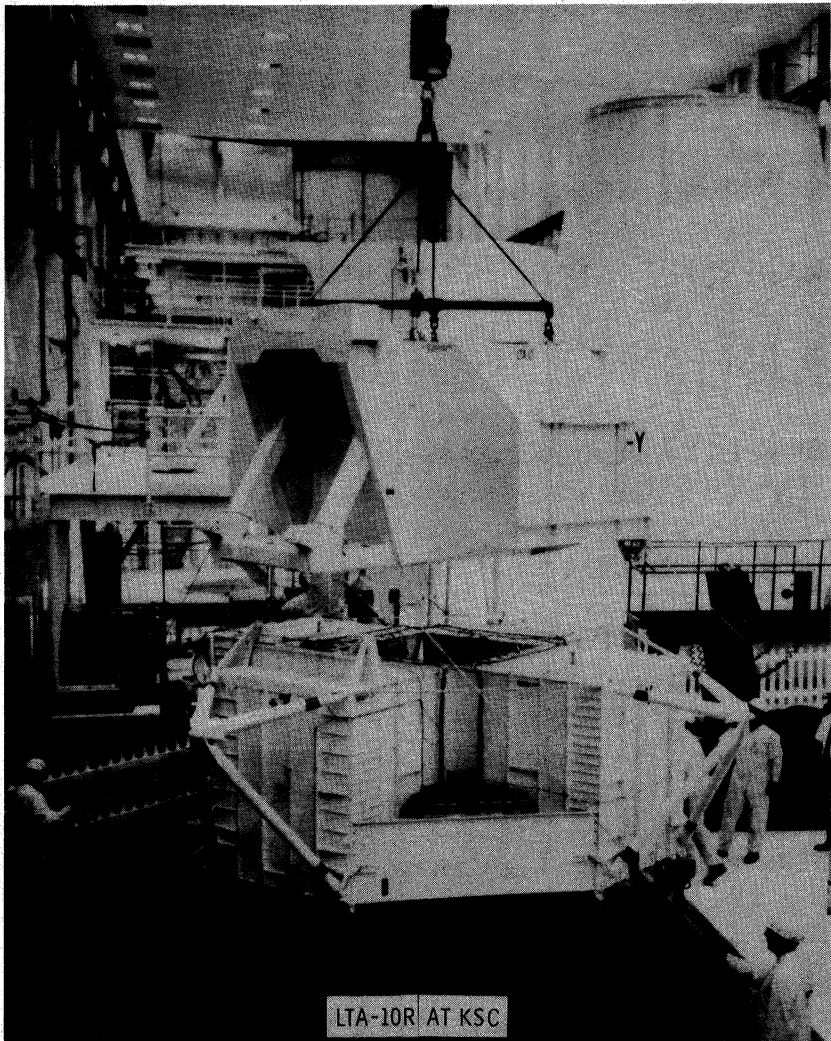


FIGURE 24

Mr. GAVIN. Yes.

Mr. RATHKE. Control weight is 32,518 pounds at separation, current reported weight is 30,953 pounds, or 1,565 pounds difference.

Mr. GAVIN. Thank you, Bill. I might point out a very interesting sidelight to this whole thing. The surface of the vehicle contains a surprising number of square feet. When we started out on this weight-saving campaign, it became obvious that, if we were not extremely careful with respect to the thermal shielding, we would use up weight hand over fist. One of the major contributing factors to weight savings

SIGNIFICANT 1966 ENGINEERING ACHIEVEMENTS

- WEIGHT UNDER CONTROL
- DESCENT ENGINE MET REQUIREMENTS
- GSE PRODUCTION ON SCHEDULE
- EQUIPT QUALIFICATION 90% COMPLETE

FIGURE 25

LM-4 WEIGHT (AT LUNAR ORBIT SEPARATION)

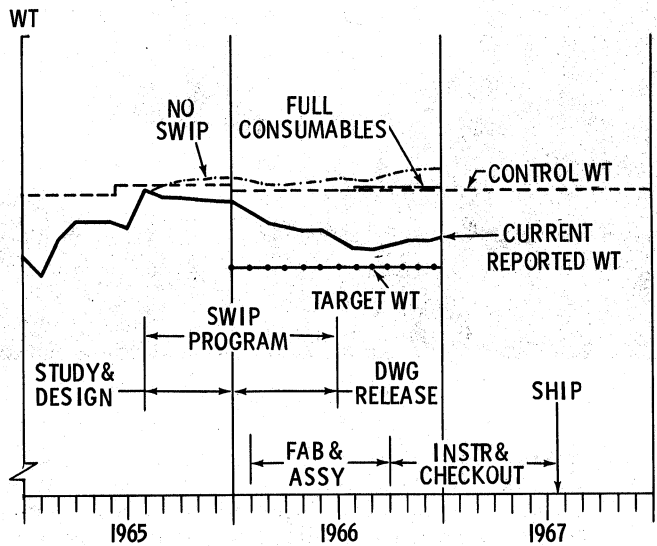


FIGURE 26

has been the development of a lightweight thermal shielding and outer skin.

Representative WAGGONNER. I commented when we were over at the facility over there, that this was surprisingly thin.

Mr. GAVIN. That's right.

Representative WAGGONNER. And delicate.

Mr. GAVIN. That's right. One of the things which is connected with this, of course, is the fact that this is a true spacecraft. We are still the only manned spacecraft which does not have to reenter the earth's atmosphere, and this gives us a fair degree of freedom in what we do with the outside of the vehicle, which the others don't enjoy. I also point out that a good portion of the spacecraft is designed for less than 1 g, and this, of course, is because of the lunar environment.

I would like to speak a little bit about the ascent and descent engines. After a very extensive development testing program, we have evolved configurations suitable for qualification testing. However, at this time both engines are in a two-phased qualification test program. The first phase provides release for early flight use and the second completes the full operational qualifications.

On the ascent engine (fig. 27) the principal effort during the past year has been focused on obtaining superlative chamber durability and on manufacturing welding procedures. I might point out that the ascent engine is a part of the vehicle which is not redundant. We obviously must have the highest confidence that it is suitable for the mission. This has led to being very careful about being satisfied with chamber durability. This has involved a great deal of injector development; and I must give credit to the Bell Aerospace Corp. for the job they have done in working out the compatibility between the injector and the chamber.

I think that the one remaining problem, which was alluded to briefly earlier, is the work remaining in settling the question of the startup pressures produced by the engine with respect to the base heat shield.

ASCENT ENGINE

- SATISFACTORY PERFORMANCE AVAILABLE FOR EARLY MISSIONS
- PROBLEM OF START TRANSIENT UNDER INVESTIGATION:
- WILL BE CONFIRMED IN QUAL B TESTS & TESTS AT WHITE SANDS
- ASCENT ENGINES DELIVERED FOR LTA-8 & LM-1
LM-1 ENGINE RETURNED FOR MODIFICATION &
WILL BE DELIVERED IN MID FEB WITH LM-2 ENGINE

FIGURE 27

This is under active work right now, and it appears there are a couple of solutions. Our problem is to pick the one which we are content to live with.

With respect to the descent engine (fig. 28) the principal effort has involved obtaining consistent and acceptable performance and acceptable throat erosion. Again I have to give credit to TRW for developing a configuration which takes into account the complexities of the throttling requirement, for acceptable operation over a wide range of operating conditions. This has finally been done, and we seem to be, at this point, through the worst.

Another area which I would like to comment on, which is partly engineering and includes management and manufacturing, has to do with the ground support equipment. Here I want to point out that just about a year ago, we were in rather difficult straits. Today we are on schedule with a supporting program, and it is difficult to imagine today what a struggle it was to get that way. But fundamentally, we have come a long way in this area, and we don't have too much further to go.

This is a list of the end items which have been made (fig. 29). This is just the top of the iceberg really. Underneath all this lies the fact that we have to install this equipment usually at a field site, although we have still this activity at Bethpage, and then we have to check it out and make sure it works before we can use it to support the vehicle. So really, you have to look at GSE as being first a problem of finding out what the vehicle really needs to support it, which is difficult to do until the vehicle is pretty well designed, and then quickly you have to produce it so that it is ready when the vehicle is ready; but then before you use it, you have to get it installed and checked out to make sure that it doesn't cause more trouble than the vehicle does.

Fortunately, this is largely behind us.

DESCENT ENGINE

- SATISFACTORY PERFORMANCE AVAILABLE FOR EARLY MISSIONS - PHASE A QUAL
- PROBLEM OF REPEATABILITY (RE: PERFORMANCE) & EROSION HAS BEEN DIAGNOSED. TEST RESULTS INDICATE ADEQUATE CORRECTION IN CRITICAL MISSION SEGMENTS OF DUTY CYCLE
- PHASE B QUAL WILL CONFIRM THIS IN A SERIES OF FORMAL TESTS
- DESCENT ENGINES DELIVERED FOR LTA-5, LTA-8, LM-1, & LM-2

FIGURE 28

Another area which I would like to comment on has to do with equipment qualification testing. This slide (fig. 30) shows the testing which was accomplished in 1966. The milestone of November 15 was very important to us. We were able to complete 90 percent of the qualification requirements on that date. I think it is interesting that of the tests run, a rather minor percentage produced significant design

GSE STATUS

● DELIVERIES THRU 10 JAN 1967

	<u>END ITEMS</u>	<u>CABLES</u>
MAKE	1, 119	4, 444
BUY	937	1, 459
GFE	302	-
TOTAL	2, 358	5, 903
DELINQUENT AHEAD OF SCHED	0 102	0 773

● FUTURE DELIVERIES

MAKE	102	710
BUY	72	0
GFE	11	-
TOTAL	185	710

FIGURE 29

QUALIFICATION TESTS

● TOTAL REQUIRED IN 1966:	217
● SATISFACTORILY COMPLETED:	208
● REQUIRED PENALTY RUNS:	5
● SIGNIFICANT DESIGN CHANGES RESULTING FROM TESTS:	15

FIGURE 30

changes. I can't go past this item without pointing out that it has required a great deal of cooperation on the part of MSC to live through these tests with us, to understand these pieces of equipment as the development tests progressed, so that, as time went by, we could adjust the qualification testing to prove that which was necessary.

I think I should explain that a little bit more and point out that as a piece of equipment is tested and understood, what was originally set up as its qualification requirements evolves and, because a qualification test is a formal demonstration of the acceptability of the equipment, this then leads to approvals of these procedures. It has taken quite a bit of cooperation to cause all this to happen in a timely fashion.

Representative WAGGONER. What do you mean by "required penalty runs"?

Mr. GAVIN. When you have a test which doesn't quite seem to meet the requirements, rather than go back and rerun the whole test, it frequently makes sense to make the adjustment necessary and rerun only that portion of the test involved.

Generally, the results have been quite encouraging. The flight hardware looks very good, and it seems to bear out the design approach. There are a small number of important things which have not yet fully completed qualification. There are also some which are scheduled for the 15th of February, and this is another date of importance to us. We expect the qualification program will support the LM flight schedule.

I'd like to speak a little bit at this point about some of the significant management activities in the past year (fig. 31). Looking back, many of the things we take for granted or understand today, were speculative a year ago. Going from the concept to a well-defined design took time and effort and a number of difficult choices. The exacting requirements on all elements have caused a continued struggle be-

SIGNIFICANT MANAGEMENT ACTIVITIES

- GSE DESIGN & MANUFACTURING STRENGTHENED
- STRENGTHENED SUBCONTRACTOR MANAGEMENT CONTROL
- ADOPTED WORK PACKAGE CONCEPT
- INSTALLED 3RD ACE STATION
- INCREASED COLD FLOW TESTING CAPABILITY

FIGURE 31

tween confidence in design, schedule, and cost. We assign the priority in just that order. When the chips are down, whatever is necessary to make it work well is the choice. I think this is an attitude which the astronaut appreciates. I think that no matter what else occurs, we have to be responsible for the successful operation of the vehicle.

This past year has seen a continuous rearrangement, as test results became available, of test programs, test articles, and test requirements, all aimed at improving the schedule and the cost without impairing the operational quality. The very tight funding situation has made this rather difficult, with a minimum of the trade-off freedom which you would ideally consider to be the consequence of incentive fee contracting.

I might say that the effort to reduce costs has been virtually continuous. There are a couple of things which are listed on this slide which stand out, looking back at the past year. I have already shown in some detail the GSE story. This involved a strengthening of our planning, designing, manufacturing, and procurement activities and, as I mentioned earlier, it required a great deal of effort to proceed from a position which was holding the program back, to one which supported the program.

The tide was turned in midsummer. We were effectively on schedule in mid-October, and we have been supporting the schedule from that time forward.

The second vital program action taken by about midyear to help counter the mounting cost and schedule problems, involved a massive strengthening of our subcontract management group. What we did was to apply more full-time talent, with clearly understood authority, to the management of our subcontractors and interfaces with them. The result has been better insight into and control of the operations in supporting LM.

This slide (fig. 32) indicates the manner in which the subcontract project manager—he is the man in charge of a specific contract—acts for the program manager in bringing the various Grumman groups to bear on a particular subcontract.

A third management action which we think was significant, was the introduction of work packages. The next slide (fig. 33) summarizes as briefly as possible what a work package is, and the fact that we have it in use within our house and at our critical subcontractors. I think the key point here is the fact that, by associating the output with the manpower estimated to do the job, we obtained a more direct indication of progress, and this allows better control of what is going on and we have found it effective and useful. We find, of course, that the effectiveness varies, depending upon the nature of the operation, but we think it does one other thing, and that is that it enhances the sense of responsibility of the work package manager, the person who is the organizational leader in charge of a group of people who have a responsibility for getting the task accomplished. We think it is a step forward.

The fourth management action that I would like to refer to is clearly to the credit of MSC. This was the decision taken late in the summer to reassign priority, to divert and install at Grumman a third ACE sta-

SUBCONTRACT ORGANIZATION

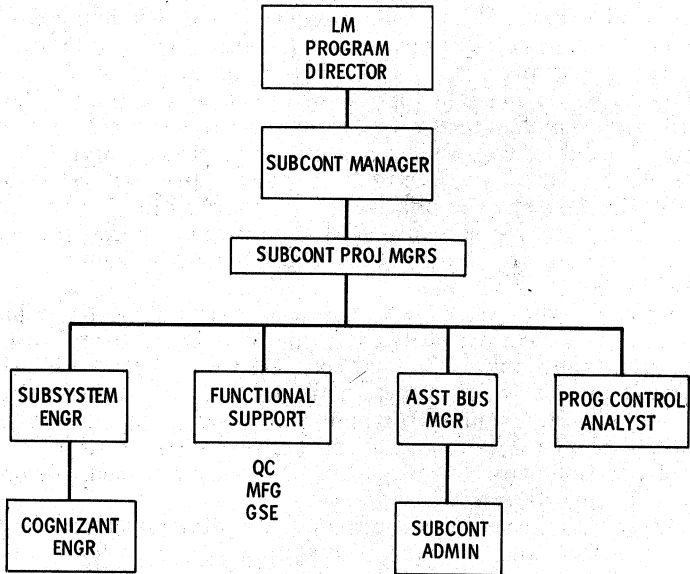


FIGURE 32

WORK PACKAGE

- DEFINES TASKS & SCHEDULED OUTPUT IN TERMS OF ORGANIZATIONAL UNIT PERFORMING THEM
- PROVIDES BUDGETARY CONTROLS VISIBLE TO PROGRAM MANAGEMENT & UNDERSTANDABLE & USABLE BY PERSONS RESPONSIBLE
- APPLIED IN-HOUSE & AT MAJOR SUBCONTRACTORS

FIGURE 33

tion. This was done in anticipation of the overlapping of vehicles under electrical test, as indeed has developed.

On the assembly floor this morning, you noted that we had three vehicles in the vertical assembly fixtures. All three of them were in various stages of electrical tests. This is being accomplished and can be accomplished because of the fact that this decision was taken, to divert the third ACE station to Grumman.

The fifth management action that I might list here, mostly because it represents a case of rapid revision and an addition to some of our major testing facilities, is the cold flow facility. A decision was made to introduce, just before shipment, an additional sequence of pressure checking of the fluid systems. This hadn't been previously planned, but we have adjusted to this. The changes to the facilities have been made and the LM requirements will be met.

Representative WAGGONER. Before we leave this area of management activity, you said that you had been successful in supervision over subcontractors by putting more full-time personnel to work with these subcontractors. Are you, in effect, saying that administrative costs have risen in the program as a result of that?

Mr. GAVIN. I think that's correct to say, that we have added a net of some 20 people to this operation, but I think the return has far outweighed the cost of the 20 people.

Representative WAGGONER. Percentagewise, what do you estimate at the outset of this program your top sheet administrative percentage cost to be, as related to the overall cost of the program, and what has it, in fact, turned out to be?

Mr. GAVIN. According to the way we structured our accounting prior to the change in operations administrative costs in terms of direct labor accounted for less than 4 percent of the total. At the time that we strengthened our program control and subcontractor management, we effectively added less than 20 people which represented a change of approximately 0.2 percent in the total administrative manpower.

I would like to spend just a brief time speaking about the status of the various LM subsystems. The next slide (fig. 34) is a very

LM SUBSYSTEMS STATUS

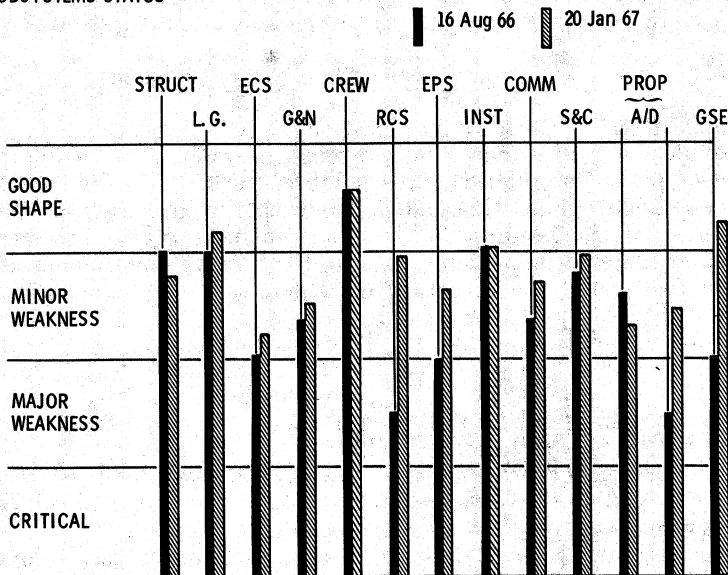


FIGURE 34

highly simplified bar chart showing how we think the various subsystems stand. Perhaps I would better say this represents my opinion of how the subsystems stand, because I believe that almost anybody would vary it slightly, according to his own notions. The coding indicates the position as evaluated last August and the present. There has been progress in almost every case, and I should point out that some of the improvement indicated represents the net result of both setback and recovery. Not all of this progress has necessarily been steady and constant.

I don't intend to go through every one of these, but I think I should highlight a couple. In the case of the structure, which is the first bar, I noted earlier the fact that we were still working with the interaction of the ascent stage base heat shield and the engine starting pressures. I also have indicated a slight retrogression because the thermal shielding has proved to be a more difficult job than was originally visualized. In the case of the environmental control system, its evaluation is based on the fact that we still have not completed qualification of all of the components.

We also have not conclusively proved that we are free of problems with the water boiler and we are living with a very tight hardware availability. It will be several months before the situation makes a major improvement, but we expect to be able to live with it and do not expect the vehicles to be held up.

The guidance and navigation category includes the rendezvous radar and the landing radar. This evaluation reflects the concern which has existed for sometime as to the rate of development of the landing radar. I think recently we have seen some improvement in this, and believe that we are over the hump.

Representative WAGGONER. At one point you had some erroneous altitude information from this radar. Has that been corrected?

Mr. RATHKE. If that relates to the reflection off the heat shield, yes.

Mr. GAVIN. There have been basically two problems with the landing radar that concern us; one was the matter of reflections off the vehicle itself. We have explored this and it turns out that we can provide a sort of a fence that prevents the radar from seeing the bell of the descent engine, which is a vibrating body as far as the radar is concerned. The other had to do with the direction in which the antenna of the landing radar was pointing. After evaluating the various trajectories which form the likely envelope of operation, we have readjusted the direction in which it points, and we are now satisfied that this will work quite well.

Representative WAGGONER. The information made available from previous flights and photographs have been sufficient then for you to conclude that you are not going to get any erroneous altitude information from this landing radar, as a result of reflection, for example, from the surface of the moon itself?

Mr. GAVIN. The testing we have done doesn't lead us to be concerned about the reflections from the lunar surface. We have been struggling with reflections from the vehicle itself.

Mr. RATHKE. NASA has acquired data that indicate that the reflectivity of the lunar surface is somewhat better than we had jointly

presumed in the design of the radar. Our landing radar is a more sophisticated cousin of that used on Surveyor, so we have acquired some confidence, because of the fact that the Surveyor has been successful. The testing that has resolved our more pressing problems on the radar has been the various ground tests run with portions of the vehicles, tests run with the radar being vibrated, and so forth.

Representative WAGGONER. Maybe Mr. Evans is the person who mentioned it earlier, but someone mentioned earlier that you had, above all others, a soft landing capability that nobody had; and it seems that I recall at one point in the soft landing program, in our early efforts to solve the soft landing package on the moon, there was some speculation on the part of some—and I don't know what they finally concluded—but there was some difficulty with the soft landing, because maybe the radar was giving erroneous information as to the penetration point into the surface before the reflection back, and that measurement signal was giving erroneous information.

Mr. RATHKE. I think that I have heard of such thoughts. It is my impression that these have been largely put aside in view of the success of Surveyor.

Mr. GAVIN. I think that one of the significant improvements shown here is in the case of the reaction control system. Now, this is sort of interesting, because the thruster involved is a common usage item between North American and ourselves. The basic thruster was developed for North American and we are using it in identical form.

The accomplishment here is largely one of getting past a series of development and qualification tests which have given us a better understanding of the operating limit of the engine under varying temperatures.

In the case of the electrical power system, we still have to complete the qualification of the batteries. We have had a considerable amount of difficulty with both relays and circuit breakers, and we are working our way out of these difficulties at present.

In the case of the communications category, the S-Band steerable antenna is the longest lead item and getting past the qualification on that will represent a significant improvement in our evaluation of this category.

I have mentioned already the situation with regard to the engines. I think that the significant point there is the improvement in our confidence with regard to the descent engine. A lot of testing and results have been obtained since the August evaluation.

Well, I could go on into this in much more detail, but I think I have hit the highlights. I would like to say before passing from this, however, that what doesn't show on this chart is the fact that our subcontractors in general have done very well in meeting their weight requirements and also their performance requirements. I think this is showing up in the performance of the vehicle and the confidence level attached to its operation.

Representative WAGGONER. What it does show that in the 5 months since August, in every area except the structure itself, you have made some real progress.

Mr. GAVIN. That's correct.

Representative WAGGONER. And you related the problem of the structure to the thermal shield, which you apparently have solved?

Mr. GAVIN. We are in the middle of solving that right now. I will now speak about the current status of the program, and I am going to cover some of the ground you have seen this morning.

Chairman TEAGUE. Before you go on, any of this you have just been talking about apply to the MOL problem, the subsystems?

Mr. GAVIN. Mr. Teague, my interest—

Chairman TEAGUE. And if so, is the information you have available to people working on the MOL program?

Mr. GAVIN. To the best of our knowledge, some of the LM technology has found its way into the MOL program. A recent survey of some of the LM major subcontractors indicated that 75 percent of them have made use of LM technology in one way or another in support of the MOL. It is interesting to note that one-fourth of the LM subcontractors surveyed had actually been awarded MOL contracts of one sort or another.

Mr. FREITAG. I might comment briefly and say that several of these subsystems are used directly. For example, the reaction control engines are being used, and common tests are being planned on that. There are other systems which even we are not too familiar with, but the transfer of technology is quite great, and as you saw last year at Douglas, this was being done.

Representative WAGGONER. But Bob, is that as a result of willingness on the part of the parties, or is that as a result on the part of the Air Force being inquisitive?

Mr. FREITAG. You mean the transfer of technology?

Representative WAGGONER. Yes.

Mr. FREITAG. No; it is pure and simple. The equipment is there. It does the job; and what's the use of developing it a second time? They just use it directly. If I recall last year, Douglas stated that something like 60 percent of the components of their equipment are direct transfers. The tanks and the fuel cells are direct transfers, and you have another 20 percent of just reshaping of the equipment.

Mr. GAVIN. I think Tom Kelly mentioned when you were out in the final assembly area, that both LM-1 and LTA-8 were in or approaching the final engineering acceptance test. This is a hurdle which we should have accomplished by this time and, therefore, we are behind on these. LM-1, once it gets past final engineering acceptance test, goes through a final fluid pressure check prior to shipment. LTA-8 does not require final fluid pressure checking, but the installation of its instrumented skins represents a hurdle that is unique to that vehicle.

I mention this because you couldn't have picked a more critical time to be here with regard to those two vehicles. There is no question but what the whole operation here is focused on getting these two vehicles through their test sequences and delivered.

We have progressed reasonably well in the manufacturing areas, but as I have just pointed out, we haven't done as well as we should in completing the operational checkout procedures.

I have a slide which gives you a rough scorecard on the number of these procedures required per vehicle and where we stand as of yester-

day (fig. 35). I think a little explanation is in order on what an operational checkout procedure is. We call them OCP's. These can vary from a pressure or circuit check, which can be accomplished in perhaps 3 to 5 hours, to a complex sequence of circuit checks which can run hundreds of hours. What is done here is not just a casual checking of a system, or combination of systems. This is a formal checkout procedure, where the test director works from a small telephone booth, which has in it, in exquisite detail, what is to be done, what is to be measured and what the criteria are for proceeding.

To boil it down to its simplest form, it is a—well, you hear talk these days of programmed learning. This is programmed testing. The first instruction could be "turn switch A to on." The second one would read "read meter B." The third one would be "If the reading on meter B lies between two limits, proceed to the next step."

And the reason that this has to be done in this fashion is that some of the systems that we are dealing with have many alternate modes of operation. And without doing it formally, there is the danger of not really checking out the system and still thinking you had. This is a painstaking process, and once it is accomplished, it lends considerable confidence to the fact that the system which has passed that test is indeed satisfactory. It turns out that the time taken on these tests is distributed between running the test and troubleshooting to find out why the test doesn't run smoothly. At this point, naturally, we are trying to cut down the amount of time devoted to troubleshooting, in order to improve the efficiency of the testing.

With this background, I would like to go on to the next slide (fig. 36) which is a statement of where the operating plan stands for the early vehicles. The diamonds represent the contract ship dates, and from this you can see that LTA-8 and LM-1 are indeed behind.

OPERATIONAL CHECKOUT TEST STATUS

<u>VEHICLE</u>	<u>TOTAL TESTS</u>	<u>TEST COMPL.</u>
LTA-8	43	30
LM-1	62	40
LM-2	77	26
LM-3	76	3
LM-4	68	0

FIGURE 35

OPERATING PLAN

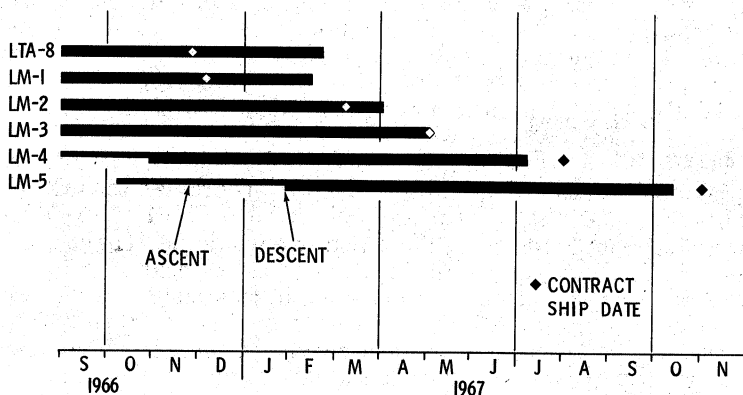


FIGURE 36

LM-2 is less behind. The responsibility that faces us at this point is that we just must get LM-1 and LTA-8 out as soon as possible. I then have to go on to say that because I have emphasized LM-1 and LTA-8 so far in these comments—and this is important, because solving their problems is a prerequisite for later vehicles—I should point out that LM-2 is in many respects a vehicle more vital to the entire Apollo program, because it must meet a launch date, to provide the first manned flight testing of the combined spacecraft.

What we have done to help ourselves with respect to the earlier vehicles is equally applicable to LM-2. At this point, we are convinced that LM-2 can gain from this experience, and we are expecting to support the Apollo launch schedule with LM-2.

I think that it is obvious from the chart that at least these next 6 weeks are going to be very critical ones to us.

The next several (figs. 37-44) lists in your handouts summarize the milestones which we see coming for fiscal 1967. I don't intend to go through them in detail. I would point out that the key events are these vehicle deliveries. This slide shows the assignment of the early vehicles (fig. 40). The corresponding delivery dates that go with these vehicles were described on the previous slide (fig. 36). It looks like LM-1 can be accomplished in late February, LM-2 in early April, LM-3 in May, LM-4 the first of August, and LM-5 by the first of November; so that gives you an indication of the rate at which these things face us; and I think it is also clear from this that the hump is with us right at the moment.

Representative CABELL. What was your projected delivery for LM-3?

Mr. GAVIN. LM-3 is May.

Representative CABELL. May?

Mr. GAVIN. Yes.

Representative WAGGONER. Joe, how does it develop that you can be as far behind on the LTA-8 and as far ahead on the LM-2 that

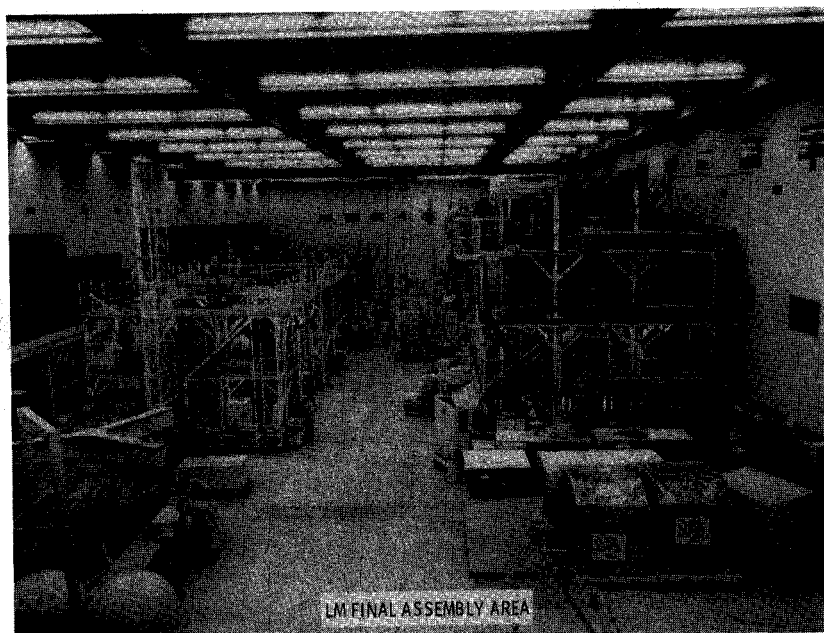


FIGURE 37

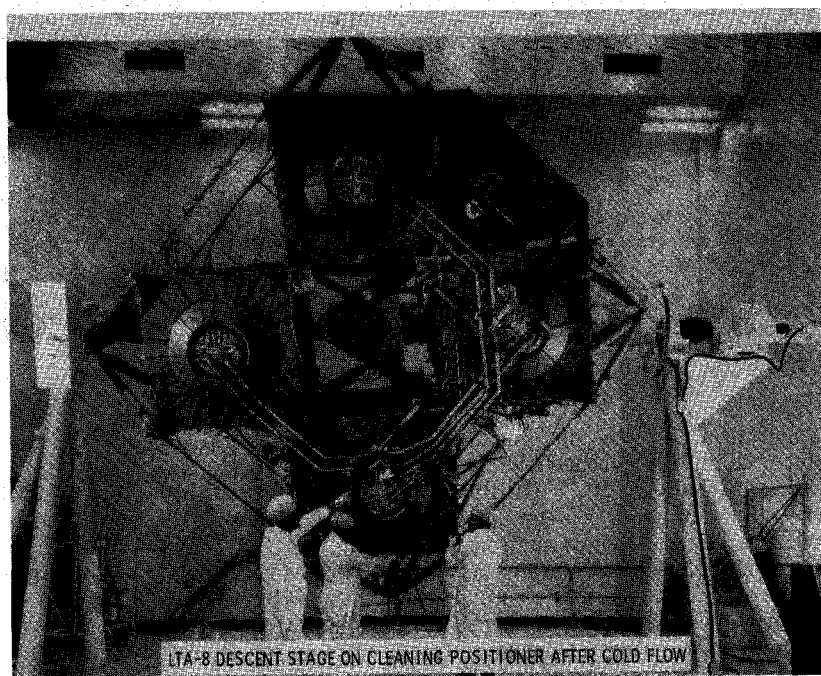


FIGURE 38

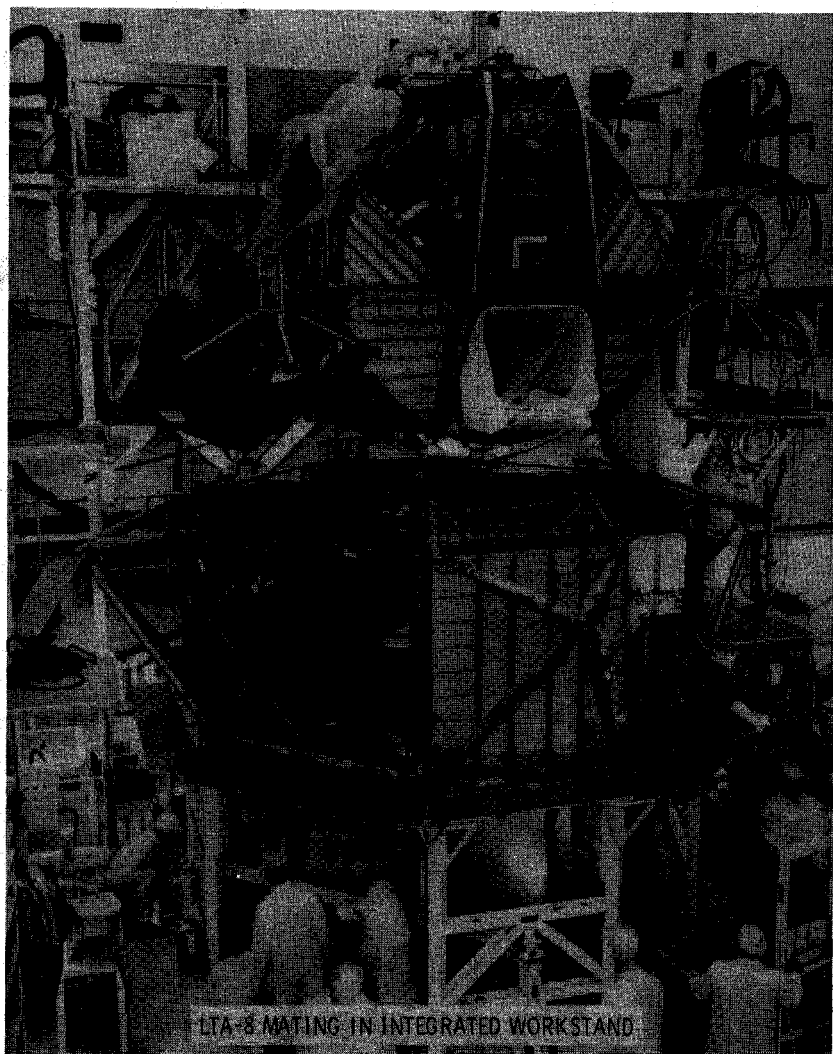


FIGURE 39

you are? Are these just known things that you can proceed with, without waiting for further tests?

Mr. GAVIN. Well, I think the answer is that the current vehicle status is the accumulation of a number of difficulties which have occurred. Probably not any one thing.

Representative WAGGONER. But in the overall, does it allow you to proceed to this point in time with LM-2 and the relationship of the several vehicles being such that the difficulty or the trouble that you have on LM-1 doesn't necessarily cause you to stop on the downstream vehicles? Is that what is going on?

PLANNED MAJOR MILESTONES AT BETHPAGE: 1967

- PLANT 5 BECOMES TEST AREA, PLANT 2 VEHICLE ASSEMBLY AREA
- LTA-3 STATIC & DYNAMIC STRUCTURAL TESTS
- LM DELIVERIES TO PERFORM FOLLOWING MISSIONS:
 - ✓LM-1: UNMANNED, EARTH ORBITAL, PROPULSION TEST
 - ✓LM-2: MANNED, EARTH ORBITAL
 - ✓LM-3: MANNED, EARTH ORBITAL, MISSION SIMULATION
 - ✓LM-4: } LUNAR MISSION CAPABILITY
 - ✓LM-5: }

FIGURE 40

KSC ACTIVATION MILESTONES SCHEDULED FOR 1967 COMPLETION

- LTA-2R: LAUNCH UMBILICAL TOWER - 2 MARCH
- LM-1
 - O&C
 - ✓ ASSEMBLY TEST AREA JANUARY
 - ✓ S-BAND & VHF LAB JANUARY
 - LC-37 FEBRUARY
- LM2
 - O&C
 - ✓ ALTITUDE CHAMBER APRIL
 - ✓ COMMUNICATIONS/RADAR LAB MARCH
 - ✓ S-BAND & VHF LAB MARCH
 - RADIO FREQUENCY TEST FACILITY MARCH
- LM-3: LC-39 SEPTEMBER
- LM MISSION SIMULATOR MAY

FIGURE 41

Mr. GAVIN. Yes; I would say so. There is a tendency for the downstream vehicles to keep coming while the difficulties are being solved on the earlier ones. The key point that we have to contend with here is that in solving the problems on the early vehicles, we don't allow ourselves to get trapped into doing the same thing on the later vehicle.

Representative WAGGONER. You just haven't made the same mistakes in two that you have made in one then?

KSC OPERATIONS MILESTONES: 1967

- RECEIVE, CHECK OUT, AND LAUNCH:

- LTA-10R (RECEIVED 1966)
- LTA-2R
- LM-1
- LM-2
- LM-3

FIGURE 42

MSC MILESTONES SCHEDULED FOR 1967 COMPLETION

- | | |
|------------------------------------|----------------------------|
| ● TEST PREPARATION AREA | FEBRUARY |
| ● THERMAL VACUUM CHAMBER "B" | JANUARY |
| ● INTERNAL ENVIRONMENTAL SIMULATOR | JUNE |
| ● LANDING RADAR TESTING | TM-6 JANUARY
TM-8 APRIL |
| ● LM MISSION SIMULATOR | NASA ACCEPT. MAY |
| ● RECEIVE & INSTALL LTA-8 | FEBRUARY |

FIGURE 43

Mr. GAVIN. We sincerely hope that's the case. When we put a change into the first one, in order to fix something there, we try to make very sure that we are also fixing the downstream vehicles at the same point.

Representative WAGGONER. Maybe that was a bad statement to have said, that you haven't made the same mistakes. You were able to apply to vehicle 2 what in the way of changes you couldn't do to vehicle 1?

Mr. GAVIN. Well, somebody once said that experience is an accumulation of mistakes, and I think we have accumulated a few.

I would like to press on here and to spend a little bit of time talking about manpower and cost. I think several of you have already gone ahead and looked at those charts already, judging from the early questions, but let me go on, in any event.

The next figure indicates total Grumman labor (fig. 45), and we seem to have peaked out in November with about 9,400 equivalent men. "Equivalent men" represents actual people on the job, plus their overtime converted to equivalent men.

Representative WAGGONER. Just for this program?

WSTF MILESTONES SCHEDULED FOR 1967 COMPLETION

- DESCENT PROPULSION TEST SERIES TO SUPPORT LM-2 & LM-4 (PD-2)
- ASCENT PROPULSION TEST SERIES TO SUPPORT LM-2 & LM-4 (PA-1)
- DESCENT STAGE TEST SERIES TO SUPPORT LM-1, 2, & 4 (LTA-5)

FIGURE 44

LM PROGRAM TOTAL LABOR

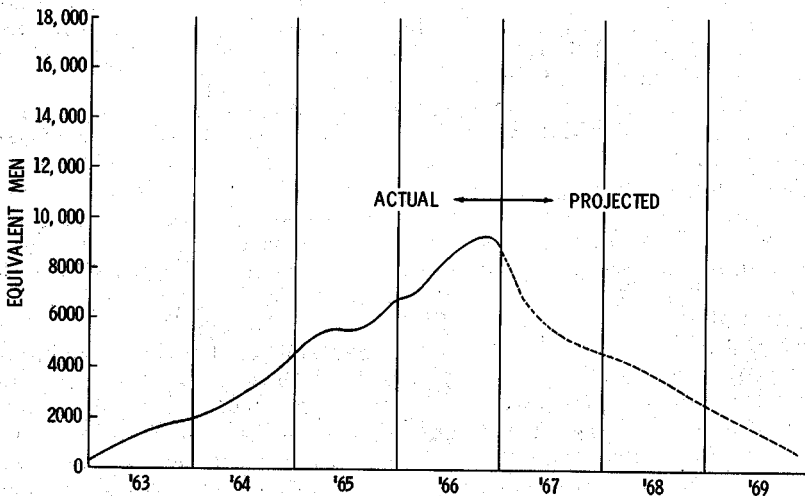


FIGURE 45

Mr. GAVIN. Yes, this is just for this program. Now——

Chairman TEAGUE. Joe, is this chart of man-hours or men?

Mr. GAVIN. Well, these are equivalent men.

Chairman TEAGUE. Equivalent men?

Mr. GAVIN. Yes; that's right.

Chairman TEAGUE. It doesn't necessarily mean that when it starts going down, you start laying off people or shortening working hours?

Mr. GAVIN. That's right, because that 9,400 peak represents 7,350 people, and then, beyond that, there is contracted labor, which represents another small portion. But in presenting a chart like this, I am sure it is bound to provoke questions because of the steepness of that slope, the down trend. I must point out that this has been analyzed by task and by the skills involved, and that we have established some very tight targets for our managers, and I think the proper statement for me to make is that we know we are over the hump, and the big question here is can we maintain the rate down in this forecast decline? It is also obvious that continuing delivery problems jeopardize the rate at which this trend can develop. If we were to be more conservative about presenting to you the slope or decline in labor, we would not be serving the best interests of either the program or ourselves in attempting to force the job down. The figures which back up this chart are the figures which we work with every day and are detailed to the extent of lists of people that are due to come off the job in the next months. So this is a serious problem for us and it is one of our most vital concerns right now.

Chairman TEAGUE. Who goes first, Joe? Who are the first people to go?

Mr. GAVIN. Well, I was just going to say something about that. It is interesting to note that different kinds of people come off the program first, and I have prepared another chart (fig. 46) which indicates the variation in three different engineering groups, the vehicle design people, the ground support equipment design people and vehicle test people; and as you might expect, vehicle test is at a peak right now, because that is where our major activity is. But on the other hand, I could go back and point out that the people who design the hardware for the vehicle actually passed their peak in August, and some of our analytical groups which constitute part of the vehicle design area passed their turndown in November. The GSE people passed their peak in July. These are all engineering people.

I could also point out that GSE manufacturing went through a sort of a flat peak in roughly July to September. On the other hand, the vehicle manufacturing people, part of those whom you saw this morning, appeared to peak in November. We had a slight downturn in December, and they are struggling with it right now to see if we can keep that downturn going. So the various skills tend to phase out of the program at different rates. I guess this isn't surprising when you dig into it, because many of the problems are behind us.

Chairman TEAGUE. I think NASA gave us the figure, going down to 200,000 people this year in the total manned space laboratory. Jim, is that correct?

Mr. WILSON. Yes. It's about 200,000.

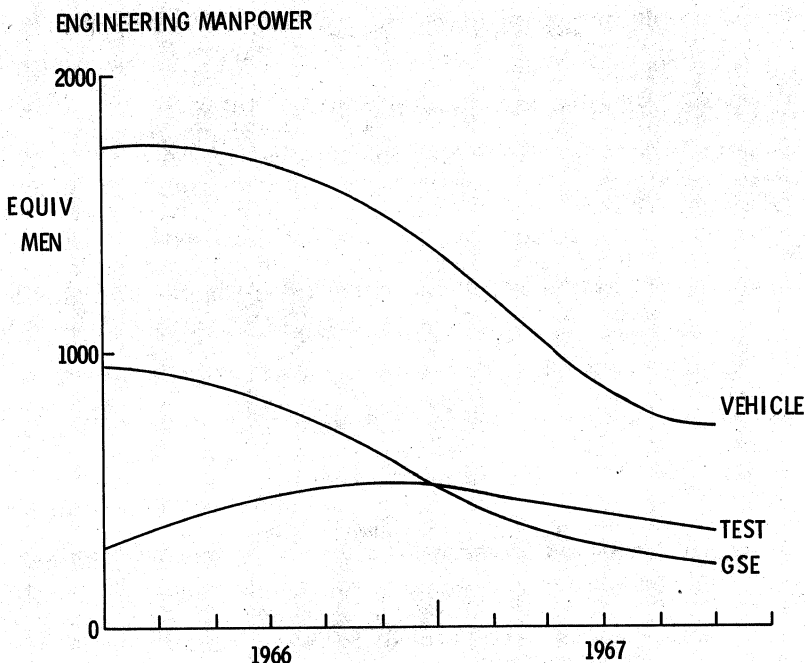


FIGURE 46

Mr. GAVIN. One thing I discovered is that if you add together enough groups, the rate of decline gets faster and faster, because each group has its normal rate of decline. If they peak at the same time the reduction rate could be very steep.

Chairman TEAGUE. Every man working himself out of a job?

Mr. GAVIN. This is the goal, and this is certainly happening.

Chairman TEAGUE. Do most people leave or do you replace them somewhere in the Grumman program, or what happens to them?

Mr. GAVIN. I think that one of the reasons that we have developed this scheme of lining up people by name some weeks before they are removed from the program, is to make sure that their next assignment is selected to best advantage. We have had numerous examples of people who moved into other programs.

It is also interesting to note that it isn't just the Indians that come off the job as you go past the peak of a job, because as you go on past, you find, I am sure, that you take off perhaps the majority of the workers, but you also tend to remove some of the chiefs at the same time. You can't afford to wind up with all chiefs and no Indians.

Chairman TEAGUE. Well, does this create a problem for you, of people anticipating these things coming about and, therefore, looking for other jobs in the competitive market which we have in this area? Well, we have it in this part of the country and I assume you have it in Long Island?

Mr. GAVIN. It creates many problems, because people do worry about job continuity, even within the company. In other words, when the end is in sight in a particular group, you find that some of the re-

sponsible people are looking for other jobs of equivalent responsibility, because they can see that one is beginning to narrow down.

Chairman TEAGUE. I see.

Mr. GAVIN. George, would you like to add anything?

Mr. TITTERTON. I might summarize for the company. No. 1, we have actually lost quite a few people for that reason. No. 2, fortunately, we are able to cut the overtime down, the equivalent people, as Chairman Teague realized earlier, so we didn't have a major cut-back in personnel. In addition, we have on board some six or seven hundred contract engineers and draftsmen who are people you hire to take care of peak loads. They obviously will be the first ones let out. About March of this year, we begin to face real difficulty in Grumman, for regular employees. On figure 47, we show you the total manpower, and our engineering, by the end of 1967, is down over a thousand engineers on a straight-time basis. This allows for all the DOD programs that we know of, including what we believe are planned and will be funded by supplementaries. We believe this is a realistic picture, so we will be facing a problem; and that's why Joe stressed this rapid falloff. It is going to take an awful lot of real hardheadedness in management to peel off at that rate.

Mr. GAVIN. George, I might mention that some of our earlier problems in this area have been eased to a small extent by a buildup in the field operation. Some of the people that were in Bethpage have moved to sites such as Cape Kennedy. This is a small thing, but it does affect the overall planning.

GRUMMAN MANPOWER (ALL PROGRAMS)

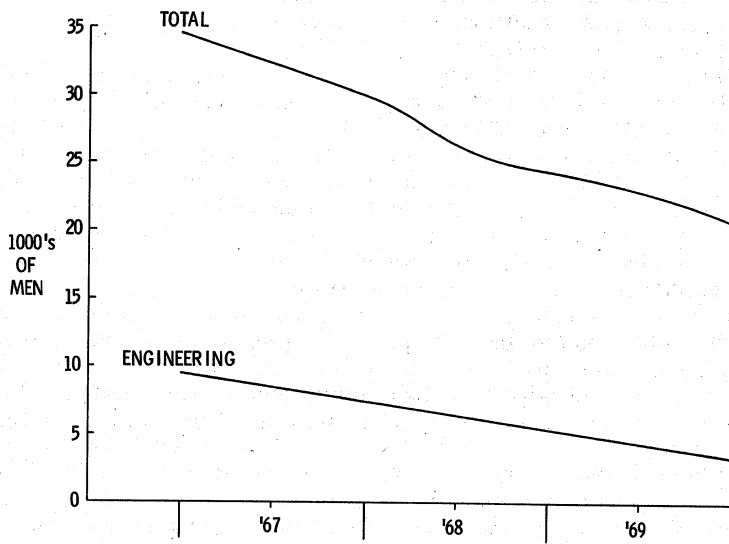


FIGURE 47

Chairman TEAGUE. Then there actually is no shortage of scientists, engineers, that category of people in this area?

Mr. TITTERTON. There are always shortages of the right people.

Chairman TEAGUE. Well, you go all over the country and all the newspapers have ads in them advertising for technical people. Now, let's see, Bob, I was out on the west coast where you were and I think it was Lockheed that was complaining considerably about the shortage of technical personnel.

Representative GIAIMO. Well, can I pursue this a little more? Just across the sound from you, where I live here in Connecticut, they are actually advertising for skilled help, and they have mobile units even going around looking for skilled help; and I assume also and understand to a degree, insofar as engineers and the higher degrees of skills are concerned. Now, knowing that this market exists and knowing that your program is going to terminate are some of your highly skilled people beginning to anticipate this and taking off and leaving you before the bad day comes along and taking advantage of these opportunities, what—

Mr. GAVIN. This is a problem.

Representative GIAIMO. Is it a problem with you?

Mr. GAVIN. Yes.

Mr. TITTERTON. We are advertising ourselves in the New York Times for special skills. For instance, radar people, we are very short of. Things of that nature.

Representative GIAIMO. Well then, there is a shortage of these skilled people?

Mr. TITTERTON. Yes.

Representative GIAIMO. Of the specially trained people?

Mr. TITTERTON. That's right.

Chairman TEAGUE. Well, is there a coordinated effort between unions, in Government, between you people, of trying to place these people that leave you, somebody watching over their shoulder somewhere down the road and know when there is a job for them and when somebody is looking for them?

Mr. TITTERTON. Well, conversely, we read the papers, and when we find out there is a major layoff, we immediately set up a hotel room in that area to hire needed people.

Representative GIAIMO. But aren't we also talking about the skills which are above the shop level, too?

Mr. TITTERTON. Yes.

Representative GIAIMO. Engineers and the like?

Mr. GAVIN. Yes.

Chairman TEAGUE. Any other questions?

(Apparently not).

Mr. GAVIN. The next slide (fig. 48), which I suspect you have already looked at, has to do with the buildup at the field sites, and the key point is that we are close to achieving the planned staffing of these sites; and I think from the earlier comments, it is pretty obvious that White Sands, WSTF, is the one area that has the most operational experience at this point. MSC is building up to receive the LTA-8 test vehicle you saw over in the final assembly floor, and Cape Kennedy is approaching its peak. It has the LTA-10R and

FIELD-SITE MANPOWER

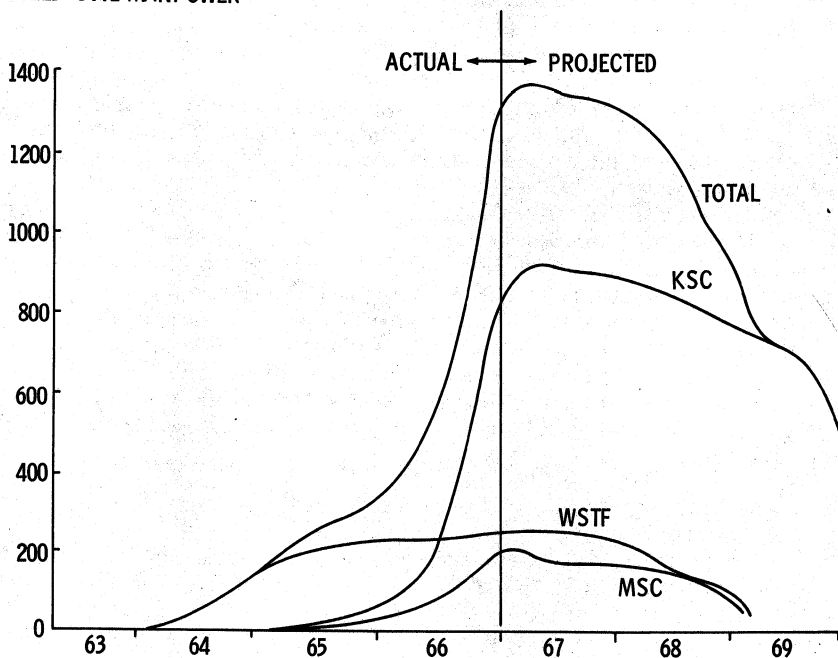


FIGURE 48

the LTA-2R, which are the vehicles which fly on the Saturn V boosters, and it will have LM-1 just as fast as we can get it there.

Mr. TITTERTON. I might highlight the fact, Mr. Chairman, and the question earlier as applied to Cape Kennedy is very, very pertinent. We have acquired any number of really skilled people who have been on the early programs in Kennedy and know exactly how that base works. Two-thirds of the people at Kennedy come from Bethpage. The rest we have tried to hire on site. Men who know the job and know the area, and this has worked out beautifully. We have some awfully good people down there.

Mr. GAVIN. Well, going on from the manpower situation to costs, I think I have already, in answer to one of the earlier questions, said just about what I was going to say as the summary. We have this forecast for the fiscal year of 1967, \$373 million (fig. 49). It appears to me to be attainable. It is going to be tough, and I think the earlier comments have pretty well covered this.

In looking beyond the fiscal year 1967—

Chairman TEAGUE. Before you leave this, do you people have any real problem between NASA and Grumman as far as money is concerned?

Mr. GAVIN. Well, there certainly is a great desire—

Chairman TEAGUE. I am sure there is something going on all the time.

Mr. GAVIN. There certainly is a great desire to decrease the expenditure rate all the time, and I would say that a very large part of

FISCAL '66 & '67 EXPENDITURES: TOTAL

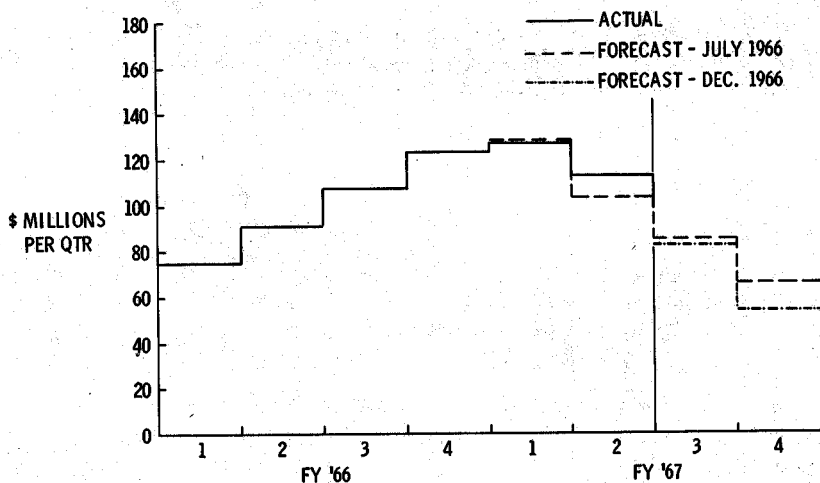


FIGURE 49

the management activity between MSC and ourselves is aimed at doing just this. I think that the MSC project group understands in great detail and very thoroughly what goes on inside the LM program, both at Grumman and its subcontractors. I think we work extremely closely together on this, and I think I can bear witness to the fact that they are continually urging every reasonable measure to decrease the expenditure rate. I am not sure urging is a strong enough term.

Representative WAGGONNER. Talking about money, what is the lapsed funding time between NASA and you for services rendered, the contract that is performed? Are you being funded at regular weekly, monthly intervals or how?

Mr. GAVIN. At various times we have been on different bases. At the close of the fiscal year last year, last June, we were down on a weekly basis, because things were pretty tight. Subsequent to that point, things have improved, and we are now in a position where we are, I think, about a month or two ahead as far as funding.

Mr. TITTERTON. Yes, that's about correct.

Representative WAGGONNER. All right. How do you relate this to services performed by your subcontractors? Do you adjust accordingly?

Mr. GAVIN. We reflect virtually instantaneously.

Representative WAGGONNER. That is, your relationship with NASA.

Mr. GAVIN. We reflect virtually instantaneously to our subcontractors our position with respect to NASA.

Representative WAGGONNER. Now, you say you are a month or two ahead. Are you telling me that you are in the unusual position of not having to worry about the high cost of borrowed money?

Mr. TITTERTON. No, no. May I restate that? Instead of putting a whole wad of contract money on the line and committing it to us, they only commit 2 to 3 months ahead. We only invoice after the fact.

Representative WAGGONNER. But how much after the fact?

Mr. TITTERTON. At the end of each month, we invoice for that month, and they pay quite promptly within a week or two.

Representative WAGGONNER. And there is no undue hardship there?

Mr. TITTERTON. That's right. This relationship and the payment of invoices is quite prompt and we, in turn, pay our subcontractors within 2 weeks, within a 2-week period of their submission.

Representative WAGGONNER. There are a number of people who do business with the Government who have been put in a bad position during this period of high-cost money because the Government has been too slow.

Mr. TITTERTON. We are in this position on many of our military programs, because, they have a very low-progress payment permissibility.

Representative WAGGONNER. But not with NASA?

Mr. TITTERTON. Not with NASA. This is quite current. But as far as the other question is concerned, you would almost think it was their personal dollars they were spending, as far as monitoring us is concerned.

Representative WAGGONNER. I see.

Chairman TEAGUE. Bob, do you want to ask anything?

Representative GIAIMO. Not on this point.

Mr. TITTERTON. May I go back to one of the earlier questions? One of the questions that was referred to here, on the question of slowdown, if you will, or extension. There are only some \$250 million to go beyond that. The point I was trying to make is that by the end of fiscal year 1967 we will have paid all our subcontractors, because they will have made their deliveries. That's the thing I was trying to show earlier. The hardware has been coming in from the subcontractors, so all those big subcontractor dollars are behind you at that point (fig. 2, p. 620). As of July 1, there are approximately \$250 million remaining in the contract. It shows \$230 million, and I can conservatively add another \$20 million in case we stub our toe.

Representative GIAIMO. To get us to what point?

Mr. TITTERTON. To finish it up right through 1969, the present program which terminates at the end of 1969. So from July 1, 1967, to the terminal point of 1969, it is a gross of \$230 million or \$250 million that will come to Grumman under the present program meeting the schedule. This is cost. We always talk cost here.

Representative GIAIMO. Going back to these figures that were prepared for the subcommittee here, is that including the \$400 million estimate in 1967, or is that in addition to that?

Mr. TITTERTON. No, this is culminating the present year, July 1, the present fiscal year, and we still feel we are going to hit the \$372 million.

Representative GIAIMO. For fiscal 1967?

Mr. TITTERTON. From that point on.

Representative GIAIMO. You are saying \$230 million?

Mr. TITTERTON. \$230 to \$250 million is our estimate, if we don't stub our toe. This is a success schedule.

Representative GIAIMO. Well then, my notation that the current fiscal year of 1967 estimate of \$400 million is not right, is that right?

Mr. TITTERTON. No, it depends on whether you are talking cost or price now.

Representative GIAIMO. I am talking cost.

Mr. TITTERTON. Well, cost to the Government, it is not \$372 million. It is \$372 million plus fee. We talk of cost only, because the fee is an incentive thing and it is a variable thing.

Representative GIAIMO. But the cost to the Government is \$400 million.

Mr. TITTERTON. Well, I hope I am going to get that much.

Mr. FREITAG. If you took their number of \$372 million, you are saying, and put an approximate number of \$25 or \$30 million in fee, then you have it.

Representative GIAIMO. But did he say \$372 million, or did he say two-something?

Mr. FREITAG. \$372 million, and you add about \$25 million in fee. That makes \$400 million.

Representative GIAIMO. All I am trying to arrive at is how much more money do you project in the future, that will go into the cost of these LM's? What is it that you are telling me now?

Mr. TITTERTON. This is costwise?

Mr. FREITAG. Yes.

Representative GIAIMO. Costwise.

Mr. TITTERTON. Because now you must add a fee to that.

Chairman TEAGUE. Money appropriated by Congress.

Representative GIAIMO. How will this total up with the original estimate? What is this LM going to cost?

Mr. TITTERTON. Well, we think that we are going to be between 5 and 10 percent over.

Representative GIAIMO. Total program?

Mr. TITTERTON. Total program. At the present time we are projecting a 5-percent total program overrun dollarwise. If we, from here on out, are as inefficient, let's say, or have as much trouble as in the past, then we will have 10 percent total. If we can hold it from here, it will end up at 5 percent.

Representative WAGGONER. If you can hold it from that, by comparison, you will perform amazingly well.

Mr. TITTERTON. Thank you. This is why there is a difference of opinion between us and NASA. They say it never happened before. We say we can do it.

Representative GIAIMO. Are you talking about an approximate cost of \$2 billion?

Mr. TITTERTON. No, right now we are projecting a cost of \$1.350 billion if we hold clean from here on out. Now, it could be \$1.4 billion, if we don't do better from here on out. This is cost.

Representative GIAIMO. All right, again cost. But then overall cost to the Government, including your fee, it's going to bring it very close to the \$2 billion mark.

Mr. TITTERTON. I would say \$1.5 billion. I don't know, your numbers may include other things than what we are talking about. But if it is directly to Grumman, \$1.5 billion should do it.

Chairman TEAGUE. We have a cost of prior to fiscal year 1967, \$757 million. We have another figure for fiscal year 1967, the original estimate was \$350 million. Current fiscal year estimate, \$400 million. Fiscal year 1968, \$345 million. Then you have added \$345 million as part of the \$250 million you talked about.

Representative GIAIMO. That brings it up close to \$2 billion.

Mr. TITTERTON. Well, NASA would have to go into that, because they haven't told us numbers like this.

Representative GIAIMO. But using your projected cost figures then, what is the total amount that you estimate it will cost?

Mr. TITTERTON. I would say \$1.5 billion.

Representative GIAIMO. \$1.5 billion, not including your fee?

Mr. TITTERTON. No; including the fee.

Representative GIAIMO. Including the fee?

Mr. TITTERTON. I can see about \$1.4 billion cost.

Representative GIAIMO. Yes?

Mr. TITTERTON. \$1.42 billion, something of that sort.

Chairman TEAGUE. Wasn't the original estimate about \$2 billion?

Mr. TITTERTON. No, sir.

Chairman TEAGUE. The original contract?

Mr. TITTERTON. The original contract was \$1.290 billion cost.

Representative CABELL. Cost again?

Mr. TITTERTON. Cost. You see, your costs and our costs are different.

Representative CABELL. That's right.

Mr. TITTERTON. We don't know about changes and things like that in the company. There has got to be an allowance for changes. We don't know what allowance NASA has made for changes.

Chairman TEAGUE. Maybe we are being told things that we shouldn't be told.

Mr. FREITAG. These are estimates of work.

Chairman TEAGUE. These are estimates; yes.

Mr. FREITAG. It has fee and it has other expenses.

Representative CABELL. You have your direct LM costs which then make up the total costs to LM. You see, that's where that discrepancy can easily well come into play.

Representative GIAIMO. Well, getting back to the question I think Mr. Teague asked you, are we going to wind up much over the estimate or did I hear approximately 5 percent.

Mr. TITTERTON. I said 5 to 10 percent.

Representative GIAIMO. Five to ten percent over?

Mr. TITTERTON. Would be our estimate at this point. Now, once again, I would like to restate that this is on a fairly successful schedule. If you run into all kinds of blockages downstream, then this might be something else again, which is, I suppose, what NASA's experience has been. This is why their viewpoint has to be different from ours.

Representative WAGGONER. What he is hedging on—and "hedging" is a bad word—they haven't really flown these vehicles and they don't know.

Mr. TITERTON. That's right.

Representative WAGGONER. They have been led to believe from the tests conducted that they will fly, but of necessity, they don't know. They don't know whether they will run into any trouble, and only God knows whether there will be any trouble.

Mr. TITERTON. Contingencies; yes.

Representative GAIMO. But this is not a problem of Grumman.

Mr. TITERTON. This, I am sure, is what NASA must or will have to allow for. But from our viewpoint, we have a contract. We are fighting to meet it. We have a minimum overrun, and this is what we are shooting for and hope to make, and—plan to make, more than hope.

Representative CABELL. Are you on a sliding scale type of incentive?

Mr. TITERTON. Very much so.

Representative CABELL. In other words, overrun costs you some, too?

Mr. TITERTON. We have about a \$70 million variation in fee, depending on whether we are good or bad. That is a lot of incentive.

Mr. GAVIN. The incentive is a function both of cost and performance. Performance is distributed throughout the program so that you can't make it at just one point. In the informal discussion, we have covered everything I was going to say on this particular subject. I think I might add that looking ahead, we have some confidence, because a good many difficult problems are behind us. We do anticipate some growing pains at the Cape. We have also a certain amount of sustaining activity that has to be kept going, both here and at our subcontractors, to support the Cape operation.

I think that in the interests of getting on to lunch, and in view of the fact that we have discussed most of these things informally, I would just like to summarize very quickly by saying that we are at a critical period right at this time. The design looks sound to us. The many different test programs that have been brought to completion have provided a very fine confidence in the equipment we are putting into the vehicle and into the vehicle itself. To a large extent we have finished designing. That's past. The program peak, we think, has passed. We are convinced it is past. The big question at this point is how fast do we go downhill from here.

I think that, in a nutshell, is about the summary as I see it today, and I think that if there are any questions about some of the things we have said, we can certainly pursue them in more detail.

Chairman TEAGUE. Any more questions? Comments anybody. Bob Freitag, do you have anything?

Mr. FREITAG. No.

Mr. FELTON. Regarding the subcontractor reorder date, what kind of money are you talking about here? This is beyond the present schedule.

Mr. GAVIN. That's correct. That is beyond LM-15, which is currently under contract.

Mr. FELTON. Now, going back where you show subcontractor expenditures, you do not include there any reorder (fig. 2, p. 620).

Mr. GAVIN. That's correct.

Mr. FELTON. Now, for (fig. 1, p. 619) what kind of money are you talking about?

Mr. GAVIN. I think we, rather than give you an offhand figure, I think we would like to supply that.

Mr. FELTON. Could you also, since 90 percent of your subcontracts have been cost-plus incentive fee could you also discuss as to whether or not you would continue this or whether you would go to fixed price and the reasons for it?

Mr. GAVIN. In looking downstream, I believe it is both to our advantage and the Government's advantage to try to reduce these to fixed price contracts. That is my impression. The only proviso that I would attach to that is that over the period of time that we gain experience with the current LM's, it is very likely that there will be some changes brought about. This then could raise the question of whether we should continue CPIF or fixed price; but if we can maintain the fact that most of the development is behind and done, we should strive for fixed price arrangement.

Mr. RATHKE. The first part of that question I think requires a little clarification as to how much reorder we are talking about.

Chairman TEAGUE. And what date. The later the reorder, the bigger the cost back to the man, working under the assumption that the reorder is good and valid.

Mr. GAVIN. I think we can give you those figures.

Chairman TEAGUE. Thank you very much, Joe. It is always a good pleasure to be with you.

Mr. GAVIN. Well, shall we adjourn for lunch?

Chairman TEAGUE. Yes.

(Whereupon, at 12:45 p.m., the hearing was adjourned.)

APPENDIX B

HEARINGS OF THE SUBCOMMITTEE ON MANNED SPACE FLIGHT, THE BOEING COMPANY, MICHoud ASSEMBLY FACILITY, NEW ORLEANS, LOUISIANA, FEBRUARY 11, 1967

INTRODUCTION

This document constitutes a record of the briefing presented by The Boeing Company to members of the Subcommittee on Manned Space Flight of the Committee on Science and Astronautics of the United States House of Representatives. The presentation was delivered at the Michoud Assembly Facility on February 11, 1967.

The attendees at the briefing were:

U.S. House of Representatives

Hon. O. Teague
Hon. J. Pettis
Hon. G. Vander Jagt
Hon. J. Hunt
Hon. R. Eckhardt

Subcommittee Staff

J. Wilson
P. Gerardi
J. Felton

NASA—Headquarters

Capt. R. Freitag
J. Cramer

NASA—Marshall Space Flight Center

Dr. W. von Braun
Dr. E. Rees

NASA—Marshall Space Flight Center—Continued

H. Gorman
Gen. E. O'Connor
H. Weidner
R. Kline
Dr. G. Constan

Boeing

G. Stoner
R. Nelson
C. Wilkinson
H. McClellan
L. Alford
J. Weber
A. Phillips
J. Horn
F. Coenen
J. Keller

BRIEFING TRANSCRIPT

Mr. NELSON. This is a very brief orientation on our Saturn program. We will start by a quick run through the agenda (fig. 1). I will give a short orientation of what we, Boeing, are doing in the Saturn program for NASA. First, Mr. Wilkinson, our Michoud Manager, will describe the work here at Michoud on the S-IC stage; Mr. McClellan will briefly describe the work we are doing at Huntsville in support of the Marshall Space Flight Center (MSFC) in what we call the Saturn V systems engineering and integration task; Mr. Alford will describe the Boeing task in support of the Kennedy Space Center (KSC) for the launch operations task; then, I will give you a brief summary of the costs and manpower situation. A question and answer period will follow next.

To start, the Boeing organization involved in the Saturn V tasks is the Space Division and is shown on this chart (fig. 2) with Mr. G. H. Stoner, who is here with us today, as Vice President and General Manager. All the work we are doing for NASA on the Saturn V is under one contract, NAS8-5608, but the contract is divided into

AGENDA

- BOEING SATURN PROGRAM ORIENTATION
- S-IC STAGE
- SATURN V SYSTEMS MISSION SUPPORT
- SATURN V LAUNCH OPERATIONS SUPPORT
- COSTS AND MANPOWER
- QUESTIONS AND DISCUSSION

FIGURE 1

BOEING SPACE DIVISION ORGANIZATION

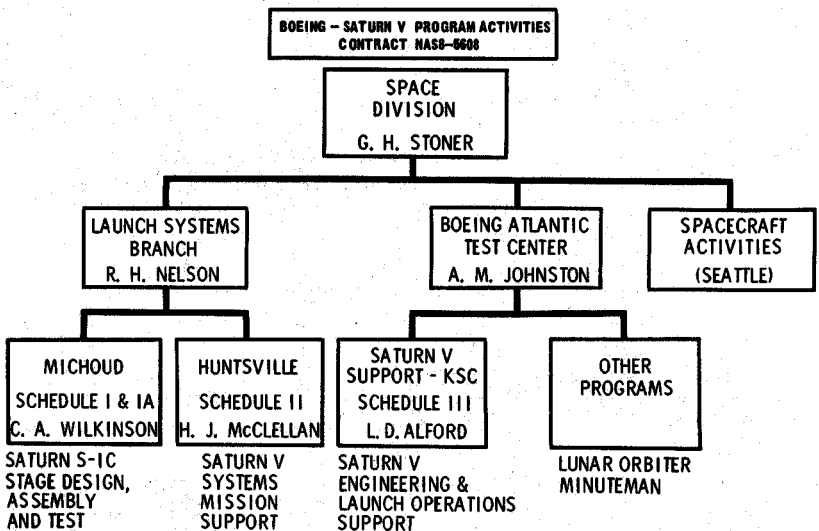


FIGURE 2

three parts that we call schedules I, II, and III. The three subparts of our contract are carried out at three locations: here at Michoud, Huntsville, and the Cape. The operations at Michoud and Huntsville are under the Launch Systems Branch, which is under my direction. The work at Michoud is Saturn S-IC stage design, assembly, and test operations, including static testing operations at the Mississippi Test Facility (MTF). This is covered under part I and I-A (schedule I and I-A) of the contract.

Part II or schedule II of the contract covers the work being done at Huntsville, supporting Marshall Space Flight Center in the systems mission area and is under the direction of H. J. McClellan.

The work we are doing at the Cape is under the direction of A. M. Johnston. We don't have him with us today. The Saturn portion of the work is under Mr. L. D. Alford. They are responsible for supporting the Kennedy Space Center for readying the vehicle for launch. So we have the three managers, who are responsible within Boeing, present today. There are other Boeing activities at Cape Kennedy such as Lunar Orbiter, Burner II, Minuteman, and there are other spacecraft activities within the Space Division in Seattle, such as the Voyager.

A look at the geographic picture (fig. 3) shows Boeing corporate headquarters located in Seattle, and Mr. Stoner's Space Division Headquarters located at Kent, Wash., just south of Seattle. Here, at Michoud, we do designs of the stage while at Huntsville our operations support Marshall Space Flight Center. Also the first three flight

BOEING SPACE DIVISION ACTIVITY LOCATIONS

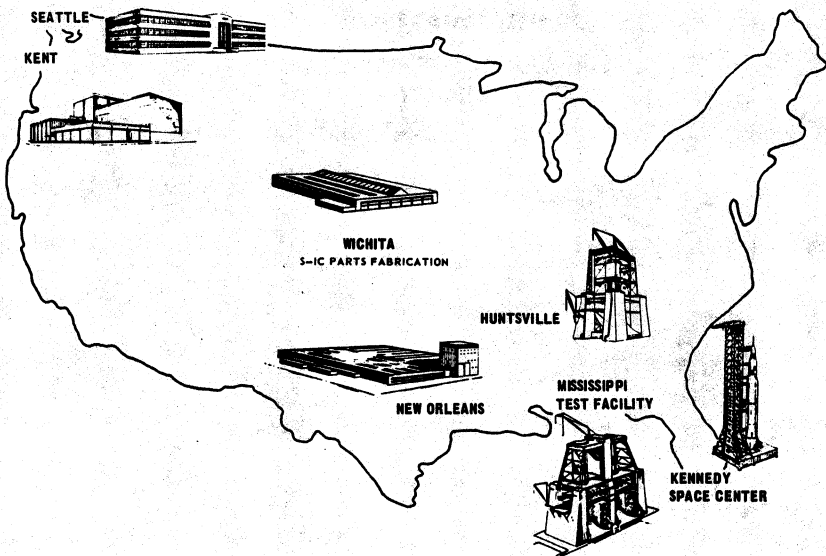


FIGURE 3

stages were static fired at the test stand you saw yesterday at MSFC, and I believe you also visited the dynamic test tower which we operate for MSFC. At MTF we will carry out static testing of the stages built at Michoud, and at the Cape they are supporting readiness for launch.

In addition to the work done in-house, we are supported by 4,400 vendors and subcontractors (fig. 5). We have subcontractors in 46 of the 50 States. The commitments total some \$270 million as of January 1, 1967. California receives a good-sized share, as does Louisiana, Alabama, and other States as shown. The distribution of these dollars is in proportion to the black circles on the chart.

Figure 5 provides a summary look at the schedule we are working on this program. The bottom three bars of this chart depict the three parts of our contract arranged on a time scale, while the top bar is a look at the principal testing activities for the launch vehicle. As depicted on the second bar, stage design, assembly, and test activities through the S-IC-15 stage, which is presently under contract, continue through 1969. Operations at the Cape to launch these 15 stages (bottom bar) carry through 1970 while the third bar, representing the mission support work at Huntsville, is contracted through 1968 for the first eight flight stages. This contract will have to be extended to include the additional stages. Looking at the top bar, there has been some very extensive testing going forward in support of the stage design and assembly. The first is the static firing activity on the propulsion test stage at Huntsville. In the qualification test program, we have tested over 1,100 parts critical to flight. Additionally, we are also doing reliability testing, dynamic testing, and very extensive structural testing. These test programs must be completed prior to launch of first manned missions.

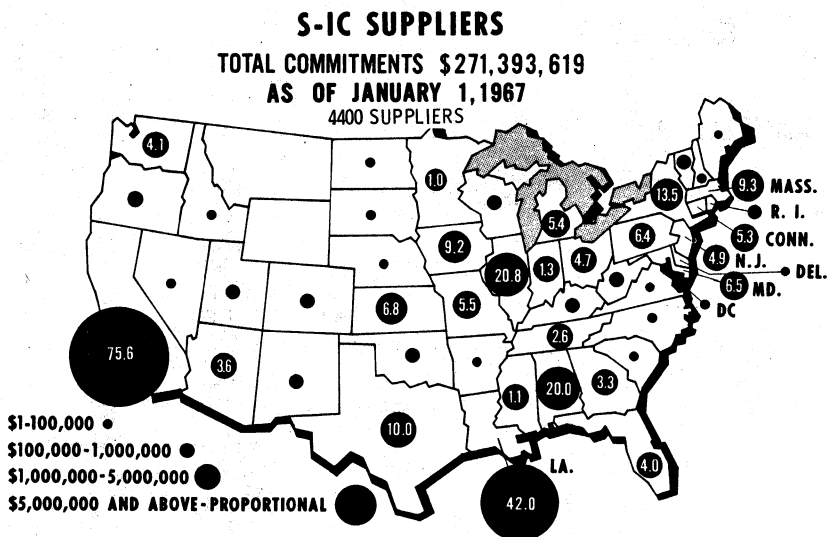


FIGURE 4

At this time, Mr. Wilkinson, who is in charge of our Michoud operations, will tell you briefly about the S-IC program.

Mr. WILKINSON. First of all, let's take a quick look at what the S-IC does for the Saturn V (fig. 6).

The S-IC must lift 6 million pounds off the pad and accelerate $1\frac{1}{2}$ million pounds (which is the weight of the upper stages plus payload) to 6,000 miles per hour at a 40-mile altitude in $2\frac{1}{2}$ minutes. An additional ground rule was that the liftoff thrust must exceed the weight by 25 percent. So we use five, $1\frac{1}{2}$ -million-pound-thrust F-1 engines to give us a total of $7\frac{1}{2}$ million pounds of thrust, which exceeds the weight by the required amount. That's what we call a simplified design requirement for the S-IC stage.

During your tour in the factory, you saw the S-IC-4 in the vertical assembly tower.

Figure 7 is a cutaway of the S-IC stage and, as you can see, the five engines mounted at the bottom are arranged with four outer engines, which are movable, and a center engine, which is fixed. The swiveling capability of the outer engines provides steering control during powered phases of the flight. The bottom tank contains the fuel, which is a high-grade kerosene (RP-1). The fuel tank contains 200,000 gallons of this fuel. The fuel is delivered by two 10-inch lines for each of the five engines. The liquid-oxygen tank, which is the uppermost tank of the S-IC, holds 327,000 gallons of liquid oxygen—this is the oxidizer. The liquid oxygen is delivered through five 20-inch lines that run through tunnels in the fuel tank. The

BOEING SATURN/APOLLO PROGRAM ACTIVITIES

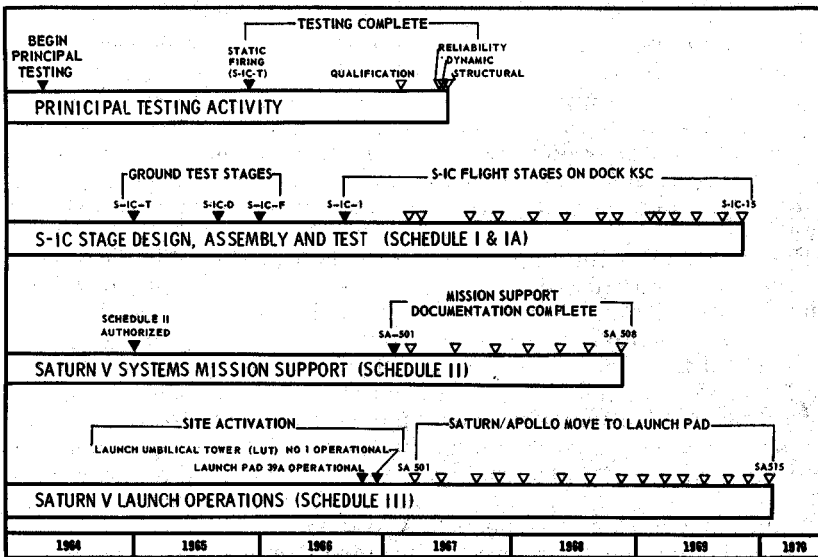


FIGURE 5

SATURN V/APOLLO

DESIGN REQUIREMENTS S-IC STAGE

LIFT 6,000,000 POUNDS OFF PAD

**ACCELERATE 1,500,000 POUNDS TO
6,000 MPH AT 40-MILE ALTITUDE**

**LIFT-OFF THRUST MUST EXCEED
INITIAL WEIGHT BY 25 PERCENT**

**1,500,000 POUNDS THRUST
PER ENGINE**

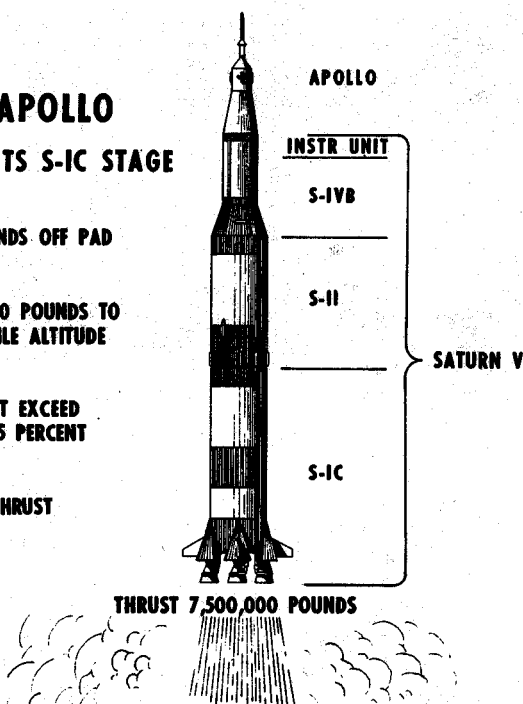


FIGURE 6

flow rate in these liquid oxygen delivery lines is two tons per second, while that in the RP-1 fuel lines is about one ton per second. The remainder of the equipment in the stage is sequencing equipment to start and stop the engines at the proper times, to pressurize the tanks to insure that proper flow rates of fuel and oxidizer are maintained, and a rather extensive instrumentation system to obtain performance data as the stage is checked out in the various phases of test and flight.

Figure 8 shows the sequence of the vertical assembly operation. On the left, the thrust structure is located in the fixture which contains leveling jacks. Next, the fuel tank is shown being placed on the thrust structure, then the intertank, which connects the liquid-oxygen and the fuel tanks, then the liquid-oxygen tank and, finally, the forward skirt and the forward handling ring, which is a fixture for aiding in lifting and transporting the stage. These components are mechanically fastened, unlike the tanks, which are assembled by welding. After vertical assembly, the stage is returned to the factory where the five engines and the remainder of the mechanical, electronic, and instrumentation systems are installed.

After the horizontal operation, the stage is moved to the stage test building, which is located behind the main plant. This stage test

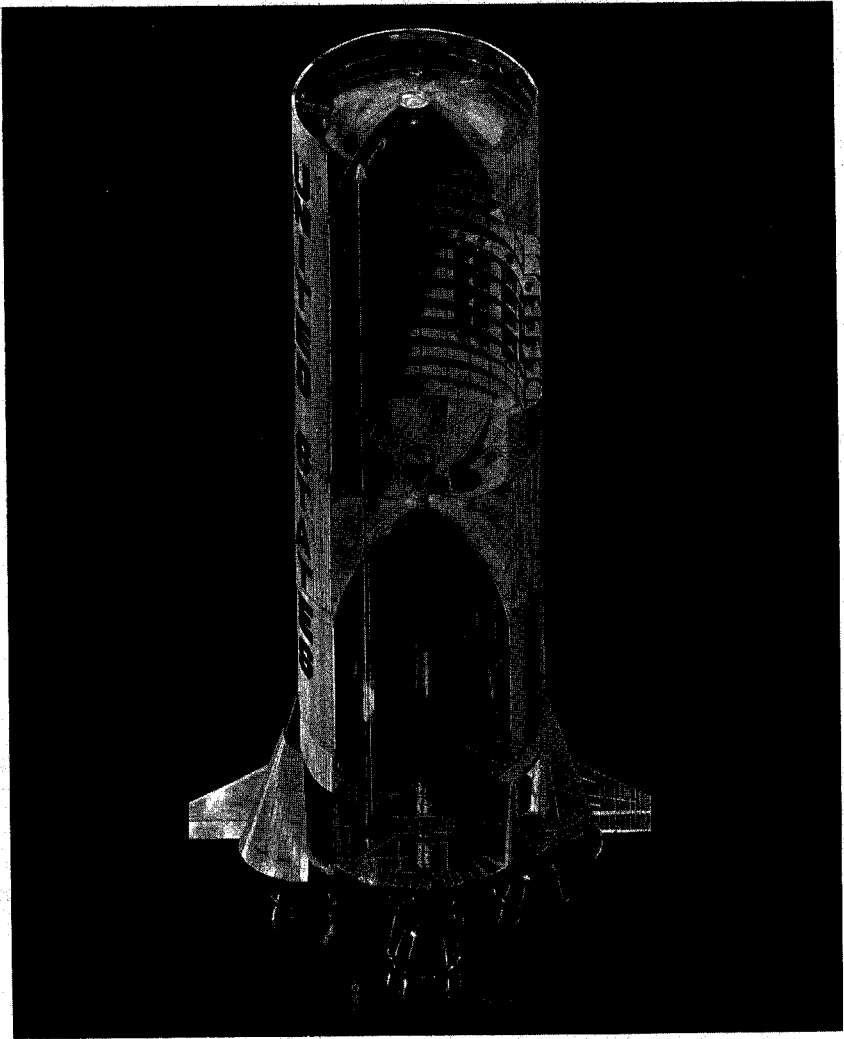


FIGURE 7

building (fig. 9) is a four-cell facility with sets of computers with electrical and electronic checkout equipment. About 2,500 tests on the S-IC stage systems are run in this facility. These tests provide assurance that the stage has been assembled correctly and that it will perform its intended mission.

I will now discuss the major test programs we are conducting for manned mission confidence (fig. 10). To verify structure, this major structural test program was conducted and is 90 percent complete (fig. 11).

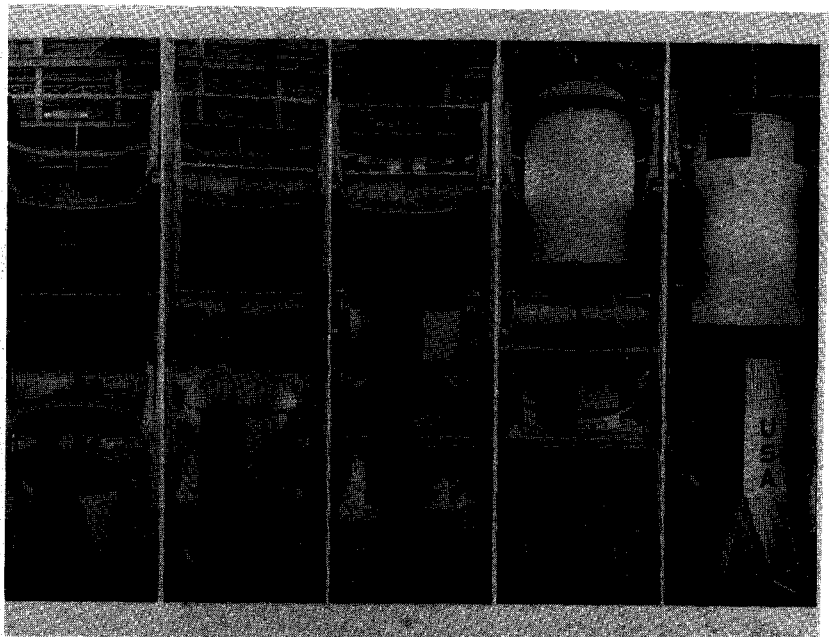


FIGURE 8

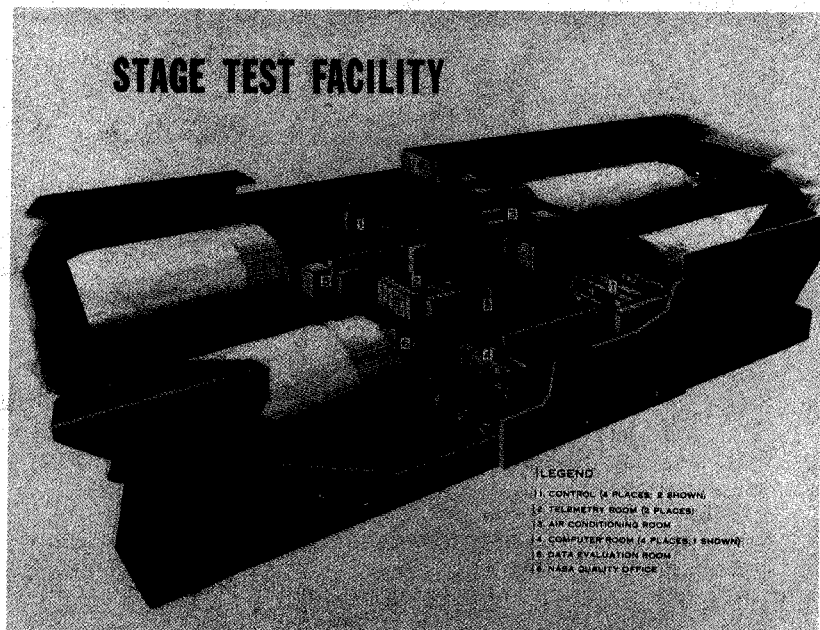


FIGURE 9

TESTING FOR MANNED MISSION CONFIDENCE

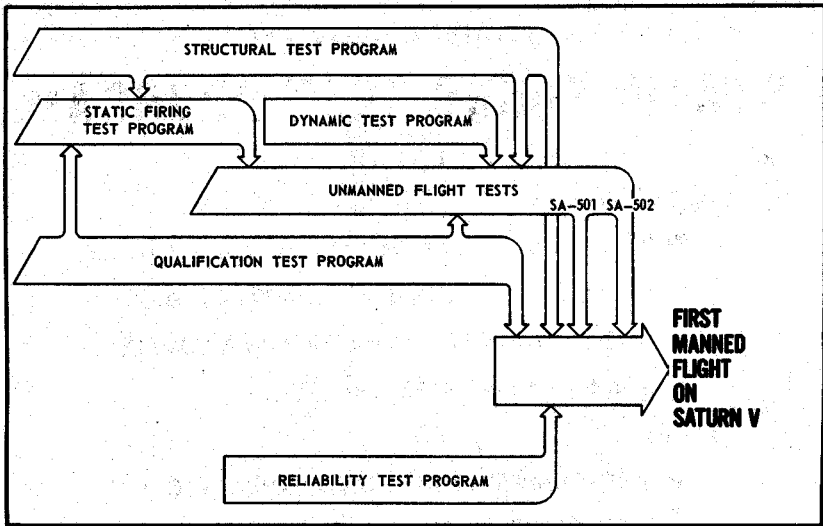


FIGURE 10

STRUCTURAL TEST PROGRAM

OBJECTIVE:

- VERIFY THE CAPABILITY OF THE STAGE STRUCTURE TO WITHSTAND THE MAXIMUM LOADS ENCOUNTERED DURING ITS MISSION

SCOPE:

- 25 TESTS OF MAJOR STRUCTURAL ASSEMBLIES INVOLVING 58 MAJOR TEST CONDITIONS

STATUS:

- 21 TESTS COMPLETE & 52 TEST CONDITIONS COMPLETED
- ONE TEST REMAINING FOR S-1C-1 (TO BE COMPLETE 3-1-67)

FIGURE 11

The static firing program (fig. 12) was carried out at Huntsville where the S-1C-T was test-fired 15 times for a total of 867 seconds. We accomplished that program in 1965, allowing us to make some minor design changes that came out of that testing before too much hardware had been built.

Next is the qualification test program (fig. 13). The objective of this program is to verify that components and subsystems perform their required functions when subjected to their most critical operational environments. The environment in a rocket is extremely severe

STATIC FIRING TEST PROGRAM

OBJECTIVE:

- VERIFY THAT ALL STAGE SYSTEMS WILL PERFORM TO THEIR OPERATIONAL REQUIREMENTS WHEN INTERACTING WITH EACH OTHER ON A COMPLETE STAGE IN A FIRING ENVIRONMENT

SCOPE:

- S-1C-T UNDERWENT 15 STATIC FIRINGS FOR TOTAL OF 867 SECONDS

STATUS:

- COMPLETE

FIGURE 12

QUALIFICATION TEST PROGRAM

OBJECTIVE:

VERIFY THAT COMPONENTS AND SUBSYSTEMS WILL PERFORM THEIR REQUIRED FUNCTIONS WHEN SUBJECTED TO THEIR MOST CRITICAL OPERATIONAL ENVIRONMENTS

SCOPE:

1136 PARTS TO BE QUALIFIED

STATUS:

1095 PARTS WITH TESTS SUCCESSFULLY COMPLETED
(96 PERCENT COMPLETE)
TWO PARTS FOR S-1C-1 REMAINING (TO BE COMPLETE 2-27-67)

FIGURE 13

in terms of vibration and temperature, and the functional performance requirements are therefore quite stringent. The qualification test program is 96 percent complete with only two items remaining to be qualified for the S-IC-1. Testing should be complete on these items by February 27, 1967.

The reliability test program is intended to determine how much margin there is between the qualification standards and the failure points. Figure 14 shows the statistics on that test program.

These test programs must be completed before we can move along to first unmanned flight and finally manned flight. Referring back to figure 10, all of the test programs are charted there, and the arrowheads there show when those programs must be completed to support the next activity in the total sequence. We refer to those arrowheads as constraints, but more simply stated, these events must occur in this sequence before we can proceed to the next major program event.

Thus far we have discussed our Boeing activities at Michoud and at the Marshall Space Flight Center. But, remember those 4,400 suppliers Dick Nelson told you about? How do we manage these suppliers to obtain a quality product? First, you start with rigorous, clear specifications and then set forth design requirements for the items. We specify quality-control system requirements, specify configuration-control systems requirements, etc. If we didn't hold to these stringent requirements, the suppliers would continue to make changes, and we might be in danger of having our qualifications testing invalidated. This is much the same type of control exercised by the Government. We survey the suppliers before we place an order. We place

RELIABILITY TEST PROGRAM

OBJECTIVE:

VERIFY THAT CRITICAL COMPONENTS CONTAIN AN
ADEQUATE PERFORMANCE MARGIN OF SAFETY TO
SATISFY THE ALLOCATED STAGE RELIABILITY GOALS.

SCOPE:

64 SUBSYSTEMS AND COMPONENTS ARE SUBJECTED
TO 27 TEST SERIES

STATUS:

20 TESTS COMPLETE (74 PERCENT)
SCHEDULED COMPLETION DATE: APRIL 30, 1967

quality-control representatives at major sources, and at other sources we have representatives that make periodic visits. In addition, we periodically audit the quality-control systems at all sources. We encourage the suppliers to have motivational programs, such as zero defects to attain quality products. We review their design using a preliminary design review and finally a critical design review using their final engineering. We have the suppliers qualify their parts to requirements we have specified under engineering and quality-control surveillance. We have almost 100 percent acceptance tests of hardware before delivery. There are Government personnel who conduct source surveillance at most of our suppliers' facilities to check our buy-off and the suppliers' systems. There is a retest upon arrival of parts at Michoud along with a careful receiving inspection. We select parts at random from our stores, and during assembly, we periodically do a teardown and inspection to see if the items are holding up. MSFC is also constantly providing us with information on problems other contractors are having with suppliers so we can hopefully identify potential problem areas and establish some corrective action before the problem can arise.

Still, we do get some real problems. For example, we are having problems with relays. Here in our Program Control Center where we are convened at the moment, you can see there is a wall panel that we devote to providing management with visibility to hardware problems that we are experiencing on the program. We have pictures of the problem parts posted on the panel. This is the relay under discussion (Fig. 15). We have encountered contamination in that relay, which obviously we can't have in a quality product.

Now, I would like to discuss our master schedule (Fig. 16). To explain the symbology used on the chart, I will describe the fifth flight stage schedule bar as an example. First, we buy material (denoted by the circle at the left of the bar), which has to start 17 months before we start to assemble a stage. After assembly, we test (identified as PMC on the chart) in that test building I told you about; we static fire or acceptance test (AT), refurbish (in which we replace certain test items with flight hardware), and run final poststatic testing; then we ship the stage to KSC. As you can see, we have started major assembly of the S-IC-10, and we have parts for the S-IC-11 through S-IC-15 already in the factory.

To summarize the S-IC program (Fig. 17), we are 5 weeks ahead of schedule. Of the total of three ground test stages and 15 flight stages, nine are now structurally complete; three flight stages have completed static firing and are in the various phases of being readied for shipment. The S-IC-1 is at the Cape, but has not yet been launched. Reflecting a bit on the status of this hardware, right now we have several stages already in being and more almost completed. Yet the first stage won't be flown until later this year. This means that if we have a problem, it will affect all of these other stages, and we are going to find that we have a problem eight or 10 times over.

To continue with our summary, the qualification test program is 96 percent complete; two parts for the first flight stage remain to be qualified. The structural test program is 90 percent complete with only one test remaining for the S-IC-1. The reliability test program, which is

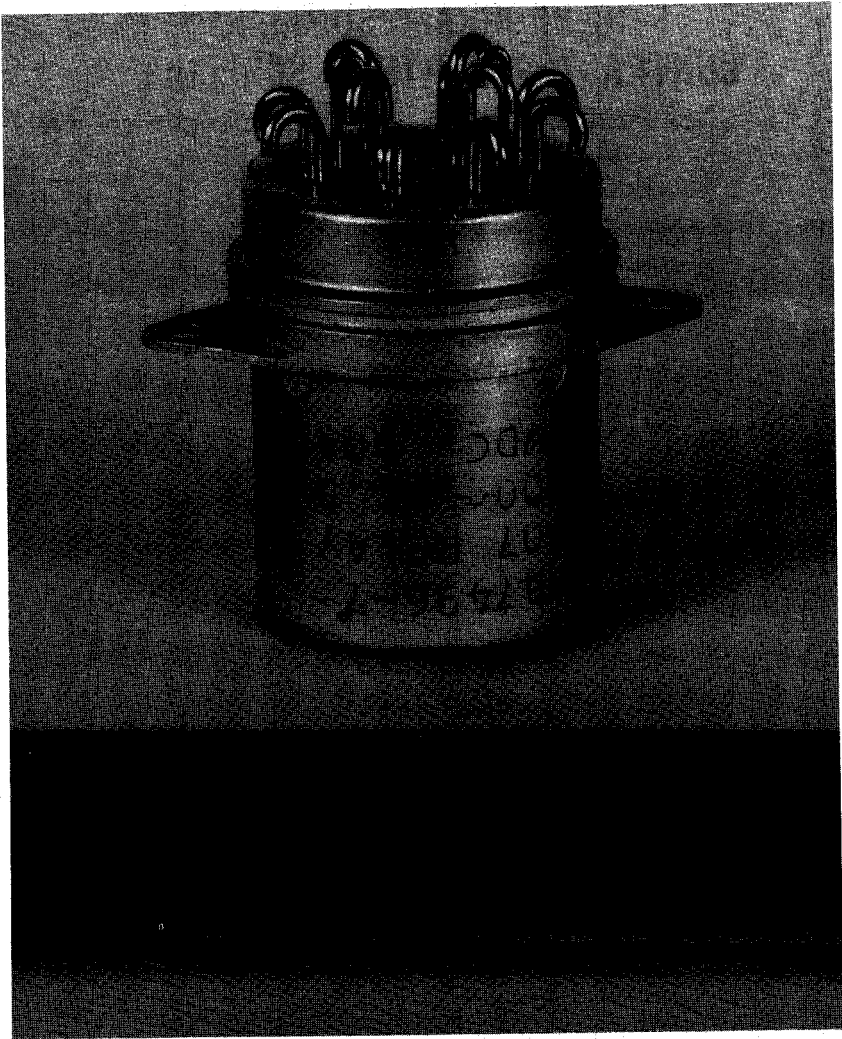


FIGURE 15

intended to be accomplished before we ship the third flight stage, is 74 percent complete and is programed for April completion. Our management is continuing to place concerted emphasis on resolving the problems as early as possible. Although we have problems that arise occasionally, such as the relays, today, we have no known problems that will impact stage deliveries or flight schedules.

This is a summary of the S-IC program. Now I would like to introduce Hal McClellan.

Mr. McCLELLAN. Thank you, Clint. I am going to discuss Boeing's role at Huntsville in support of the Marshall Space Flight Center.

S-IC PROGRAM SUMMARY CONTRACT REPORTING SCHEDULE

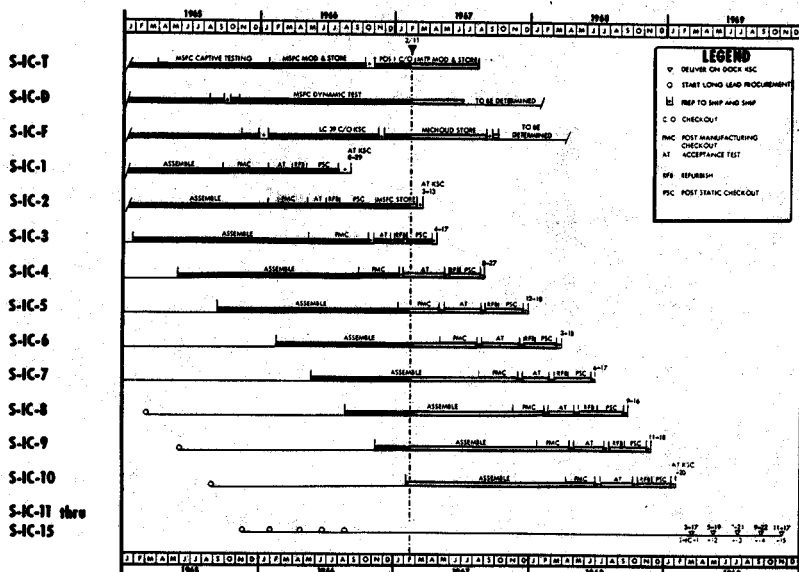


FIGURE 16

Our activities at Huntsville are concerned with the integration of the total launch vehicle (Fig. 18), that is, the marriage of each of the stages and certain ground support that goes with the total launch vehicle. We accomplish this activity under schedule II of our contract in support of Marshall at Huntsville. The four main task breakdowns (Fig. 19) are: Testing; systems engineering analysis and documentation associated with the prelaunch phase of the operation; similar activities after the vehicle is in flight; and certain program-management-support activities.

In the Saturn V vehicle-testing area, you saw in operation the Dynamic Test Vehicle at MSFC yesterday. The status of that program is shown on figure 20. Figure 21 is a photograph of the Dynamic Test Stand. The testing necessary before first launch will be complete in March of 1967.

We have completed, in December of 1966, the structural test of the upper portion of the S-IC stage and lower portion of the S-II stage (Fig. 22). This testing has been satisfactorily completed for unmanned SA-501.

We operate, for MSFC, what we call a Systems Development Facility or breadboard (Fig. 23), which is a set of checkout and launch-control equipment; mechanical simulations of the S-IC, S-II, and S-IVB; and the instrument unit. There also are other contractors involved in this program, but we operate this facility for MSFC. From this facility, the computerized test and checkout programs have been validated and delivered to the Cape for the SA-501.

The prelaunch systems engineering activities are summarized in figure 24. Figure 25 is a photograph of Launch Complex 39 at Cape Kennedy. All of the stages and Ground Support Equipment (GSE) comes together at the Cape. In the background you can see the Vehicle Assembly Building; there is assembly, checkout, and launch equipment in this building for which we provide engineering and integration at Huntsville. At Huntsville, our function is to assure that flight hardware, ground support equipment, and spares supplied by MSFC will meet the requirements of the processing that takes place at the Cape. The operations and maintenance analysis for the first flight is complete; the spares and GSE are on schedule; and our pre-launch vehicle-processing analysis is on schedule.

The third activity is concerned with the vehicle during flight (Fig. 26). In flight mission planning, we calculate the actual flight path or trajectory that the launch vehicle will take from Earth; we determine settings from the flight control system—the guidance and navigation system—which are then set into the instrumentation unit you saw in Huntsville yesterday. We predict, prior to flight, how the launch vehicle will perform and evaluate data for MSFC after the flight. The activity to support the 501, is complete—both the trajec-

S-IC PROGRAM SUMMARY

- S-IC PROGRAM IS 5 WEEKS AHEAD OF SCHEDULE
- OF THE TOTAL OF 3 GROUND TEST STAGES AND 15 FLIGHT STAGES, 9 ARE NOW STRUCTURALLY COMPLETE.
- 3 FLIGHT STAGES HAVE COMPLETED STATIC FIRING PROGRAMS.
- QUALIFICATION TEST PROGRAM IS 96% COMPLETE WITH ONLY 2 PARTS REMAINING FOR S-IC-I.
- STRUCTURAL TEST PROGRAM IS 90% COMPLETE WITH ONLY 1 TEST REMAINING FOR S-IC-I.
- RELIABILITY TEST PROGRAM IS 74% COMPLETE.
- BOEING MANAGEMENT IS CONTINUING TO PLACE CONCERTED EMPHASIS ON IDENTIFYING & RESOLVING POTENTIAL PROBLEMS AS EARLY AS POSSIBLE.
- KNOWN PROBLEMS WILL NOT IMPACT STAGE DELIVERIES NOR FLIGHT SCHEDULES.

FIGURE 17

SATURN V NASA/CONTRACTOR MAJOR ROLES

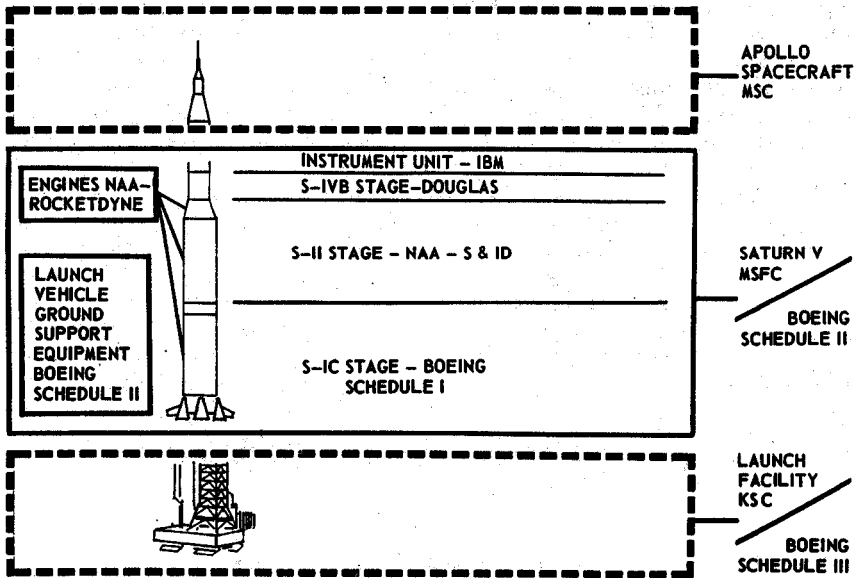


FIGURE 18

SATURN V SYSTEMS MISSION SUPPORT TASKS

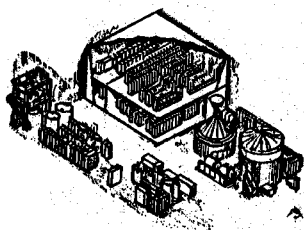
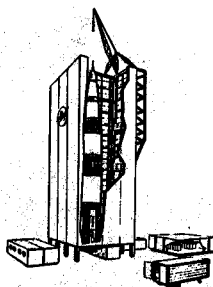
- SATURN V VEHICLE SYSTEMS TESTING
- PRELAUNCH SYSTEMS ENGINEERING
- FLIGHT SYSTEMS ENGINEERING
- PROGRAM MANAGEMENT SUPPORT

FIGURE 19

SATURN V VEHICLE SYSTEMS TESTING

FUNCTIONS:

- DYNAMIC TESTING
- MULTI-STAGE STRUCTURAL TESTING
- SYSTEMS DEVELOPMENT FACILITY OPERATION



STATUS:

- FULL SCALE DYNAMIC TESTING FOR SA-501 WILL COMPLETE MARCH 1967
- S-1C / S-11 INTERFACE STRUCTURE QUALIFIED FOR UNMANNED FLIGHT - TESTING COMPLETED DECEMBER 1966
- COMPUTERIZED TEST AND CHECKOUT PROGRAMS VALIDATED AND DELIVERED TO KSC NOVEMBER 1966 FOR SA-501

FIGURE 20

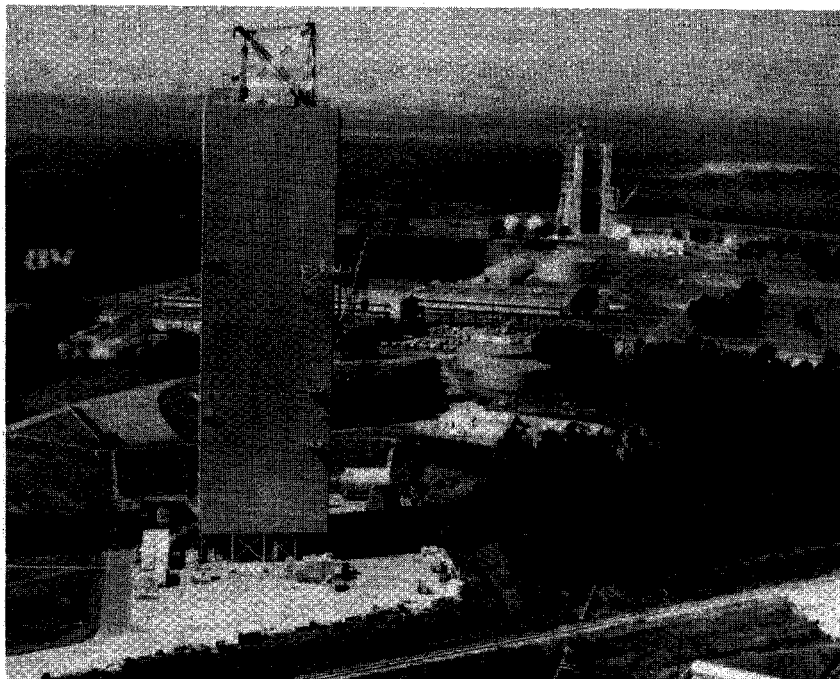


FIGURE 21

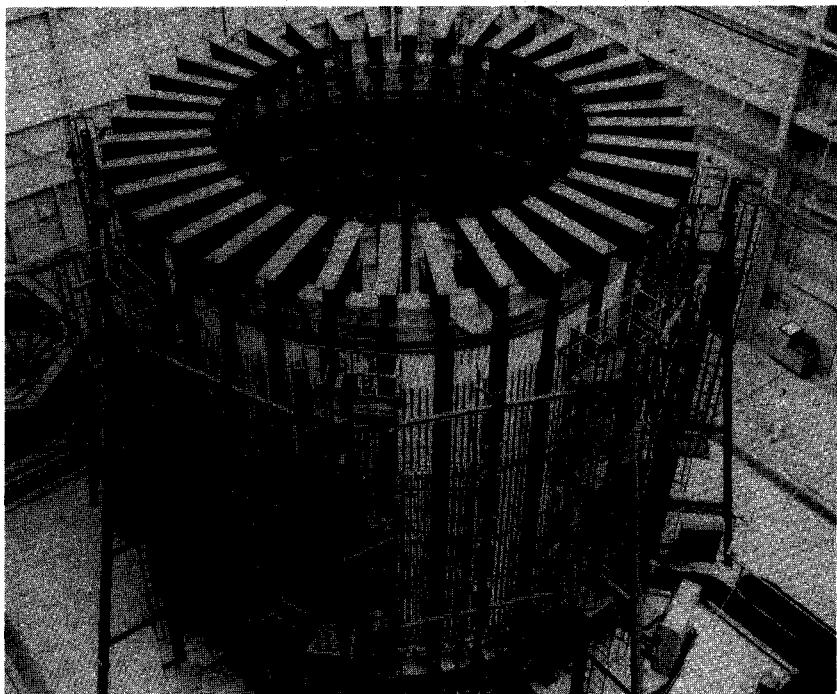


FIGURE 22

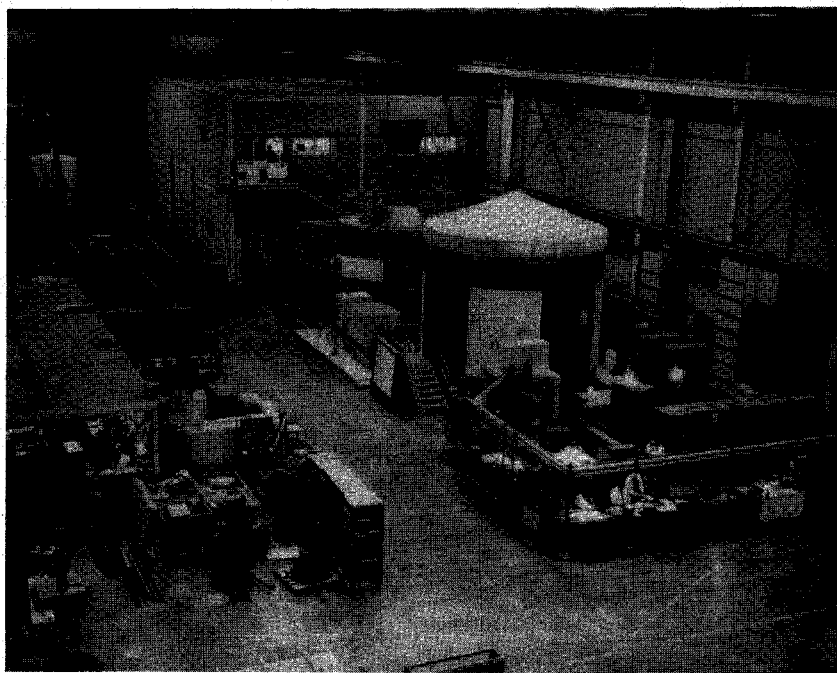


FIGURE 23

PRELAUNCH SYSTEMS ENGINEERING

FUNCTION:

ASSURE THAT FLIGHT HARDWARE, GROUND SUPPORT EQUIPMENT AND SPARES SUPPLIED BY MSFC WILL MEET REQUIREMENTS OF ASSEMBLY, CHECKOUT AND LAUNCH AT KSC.

STATUS:

- OPERATIONS AND MAINTENANCE ANALYSES FOR SA-501 COMPLETE.
- GROUND SUPPORT EQUIPMENT & SPARES ON SCHEDULE.
- PRELAUNCH VEHICLE PROCESSING ANALYSES ON SCHEDULE.

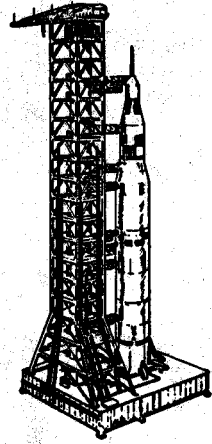


FIGURE 24

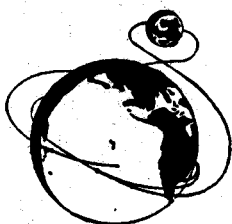
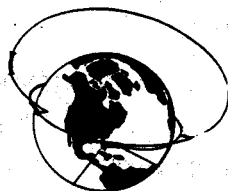


FIGURE 25

FLIGHT SYSTEMS ENGINEERING

FUNCTIONS:

- FLIGHT MISSION PLANNING
- FLIGHT PERFORMANCE PREDICTIONS
- FLIGHT EVALUATION



STATUS:

- SA-501 FLIGHT CONTROL SYSTEM DESIGN, GUIDANCE AND NAVIGATION EQUATIONS, AND MISSION TRAJECTORIES ARE COMPLETED
- SA-501 PERFORMANCE PREDICTIONS ARE COMPLETE
- EMPHASIS IS SHIFTING TO MANNED MISSION PLANNING

FIGURE 26



FIGURE 27

tories and performance predictions. In 1968, emphasis will shift from unmanned to the later complete lunar-orbital rendezvous flights with men in the spacecraft.

This work is done in the computing facility called the Boeing Simulation Center at Huntsville. Figure 27 shows a small part of that facility. This facility was activated 3 years ago.

The final activity is Program Management Support (Fig. 28).

In this area, there are two significant activities. Boeing provides assistance to MSFC with configuration management; that is, making sure that all of the documentation and the support equipment that go with the launch vehicle are identified as to configuration and change status. The baseline for the SA-501 preflight readiness review will be established April 1.

Again in the program management area, we helped MSFC activate their program control room (Fig. 29). Dr. Rudolph, the MSFC Saturn V program manager, uses this room to exercise management control. We are currently emphasizing "bubbling up" the uncertainties or problems to get action and resolutions. These problems are reviewed every month and action assigned to resolve the uncertainties.

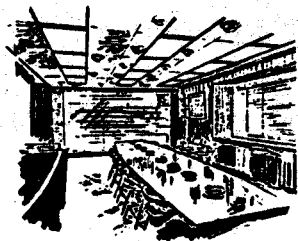
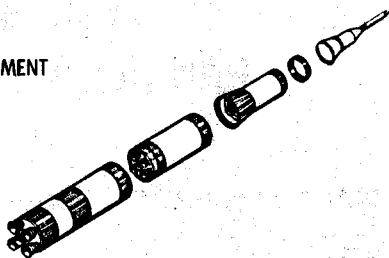
In summary (Fig. 30), our activity is on schedule. We have no known problems that will cause delay in the launch of the first Saturn V. In fiscal year 1968 our activity will continue to place emphasis on support to unmanned flight and will shift to support of the manned flight.

This is a quick summary of the Boeing Huntsville activity. I will now introduce L. D. Alford from the Cape.

PROGRAM MANAGEMENT SUPPORT

FUNCTIONS:

- CONFIGURATION MANAGEMENT
- PROGRAM CONTROL



STATUS:

- CONFIGURATION BASELINE UPDATED BY APRIL 1 FOR SA 501 PREFLIGHT READINESS REVIEW
- PROGRAM MANAGEMENT EMPHASIS:

PROBLEM RESOLUTION

FIGURE 28

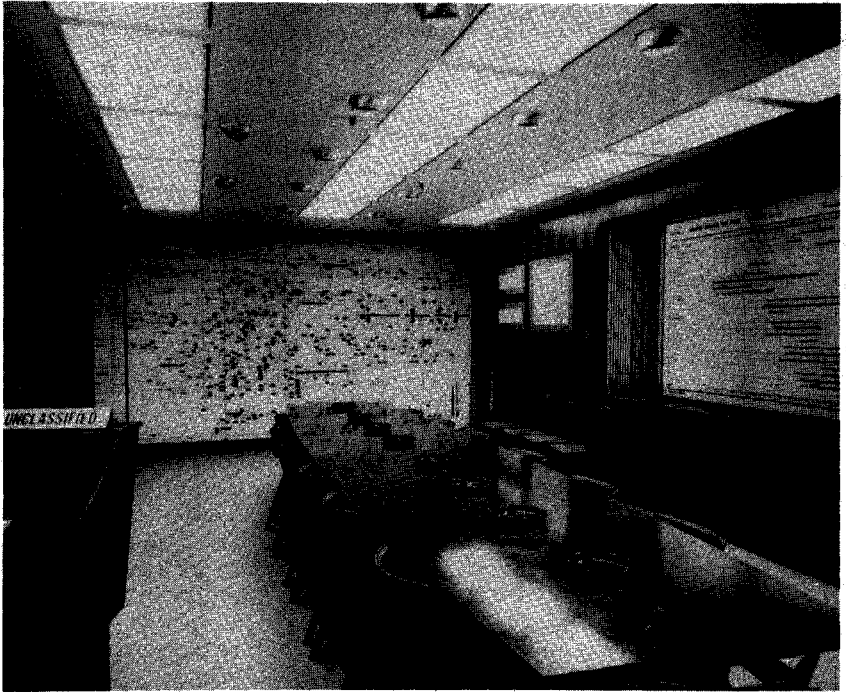


FIGURE 29

SATURN V SYSTEMS MISSION SUPPORT PROGRAM SUMMARY

SATURN V SYSTEMS MISSION SUPPORT IS ON SCHEDULE.

KNOWN PROBLEMS WILL NOT IMPACT SA-501 LAUNCH.

**UNMANNED FLIGHT SUPPORT AND MANNED FLIGHT PLANNING
WILL BE CONCURRENT IN FY 1968.**

FIGURE 30

Mr. ALFORD. I would like to express to you the excitement and concern we have at the Cape as we start the first flight vehicle through the processing cycle. If you could feel that, you would realize the effort taking place there. I know of nothing more exciting than to see the first launch of a vehicle.

I will be talking about Boeing's support to NASA's Kennedy Space Center, which is covered under our part three of our contract.

Our task is summarized on figure 31. It consists of accomplishing the site activation and launch operation functions relating to the S-IC stage and the stage ground support equipment. We also provide engineering design support for some of the equipment KSC is responsible for developing. This generally consists of equipment already designed and delivered to KSC, but which may require design changes to make it operationally usable. Boeing also provides support to maintain a Launch Complex 39 Control Center, similar to the one that Dr. Rudolph uses at Huntsville, but with more detailed vehicle processing visibility.

Congressman TEAGUE. Mr. Alford, four of our members haven't been to Kennedy, why don't you tell them what Launch Complex 39 is?

Mr. ALFORD. O.K. This is the Vehicle Assembly Building (Fig. 32). It has four high-bay areas in each of which a total vehicle can be stacked and processed. On the right can be seen three towers called launcher-umbilical towers. The vehicle is stacked on one of these towers and processed through the Vertical Assembly Building.

MAJOR TASKS

- LAUNCH COMPLEX 39 ACTIVATION SUPPORT
- LAUNCH OPERATIONS SUPPORT
- KSC ENGINEERING SUPPORT
- LAUNCH COMPLEX 39 CONTROL CENTER OPERATION SUPPORT

FIGURE 31

Launch complex 39 also has two launching pads, designated A and B. Figure 33 shows a crawler-transporter with vehicle moving to the launch pad. Figure 34 shows the crawler-transporter going up on a the pad. The crawler, as it moves up this incline, adjusts itself to keep the vehicle upright.

This is the program schedule (Fig. 35) we are accomplishing for part III of our contract. We have contract responsibility for 15 vehicles—501 through 515—going through March of 1970.

We are presently completing site activation of the first vehicle equipment. We have the 501 vehicle in its processing cycle in the Vertical Assembly Building. We had the S-IC-1 erected on October 27, 1966, and we had power on the vehicle on November 7. We are now getting ready to add the S-II stage with expected power—on March 2, 1967.

We anticipate moving to the launch pad on March 31, and then going into final countdown for launch.

In our Launch Complex 39 activation support activity (Fig. 36), set No. 1, which includes a launcher-umbilical tower (LUT), a launch-control center (LCC) firing room, and pad A, is 95 percent completed and on schedule. Set No. 2 is also on schedule, 60 percent complete, and set No. 3 is on schedule, 30 percent complete. In launch-operations support task (Fig. 37), we maintain, operate, and refurbish ground support equipment. On the S-IC stage we erect it, check it out, and help launch it. Figure 38 is a photograph of the S-IC arriving at the

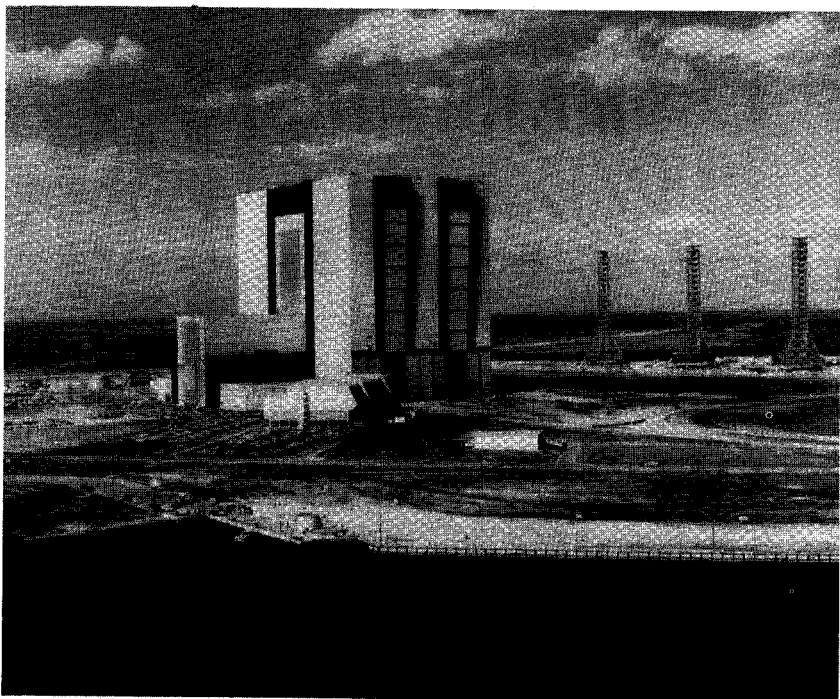


FIGURE 32

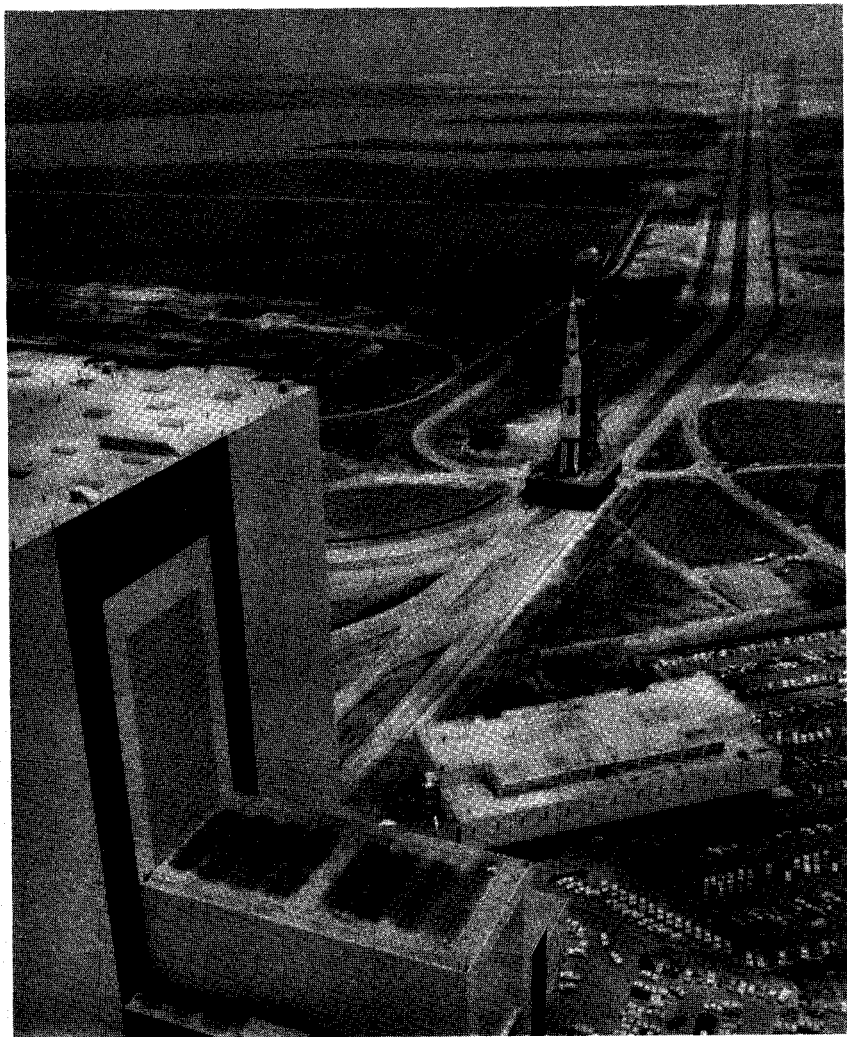


FIGURE 33

Vehicle Assembly Building by barge. The S-IC is then lifted into the assembly bay for erection of the launch vehicle building (fig. 39). The total stacked Saturn V launch vehicle without the spacecraft is shown in figure 40.

In the area of KSC engineering support, we provide sustaining mechanical design engineering support for the 17 systems listed on figure 41. We do systems engineering studies, reliability studies, logistics support (that is, get spares and documentation to support the system as required), and we procure certain items of hardware. We are re-

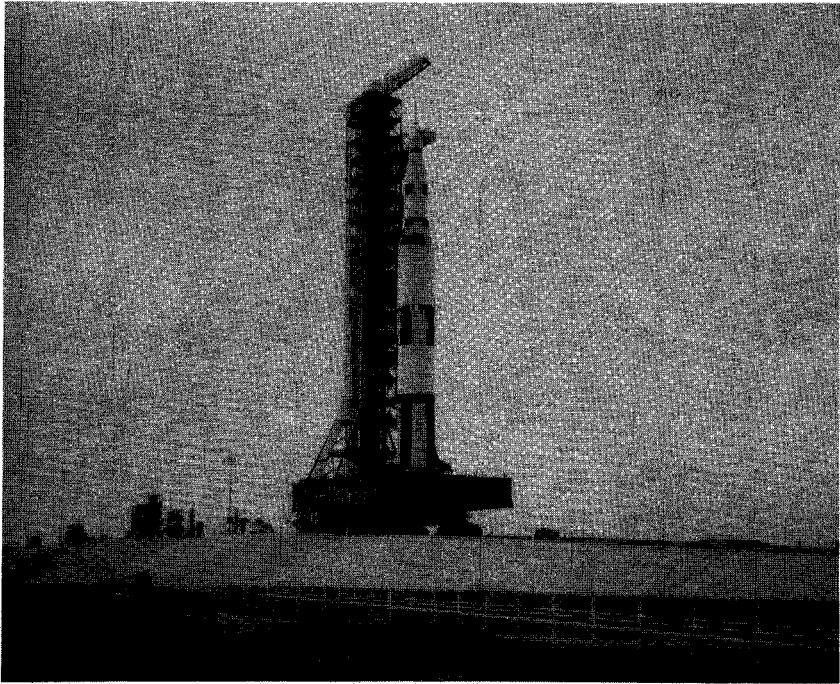


FIGURE 34

APOLLO SATURN V PROGRAM SCHEDULE

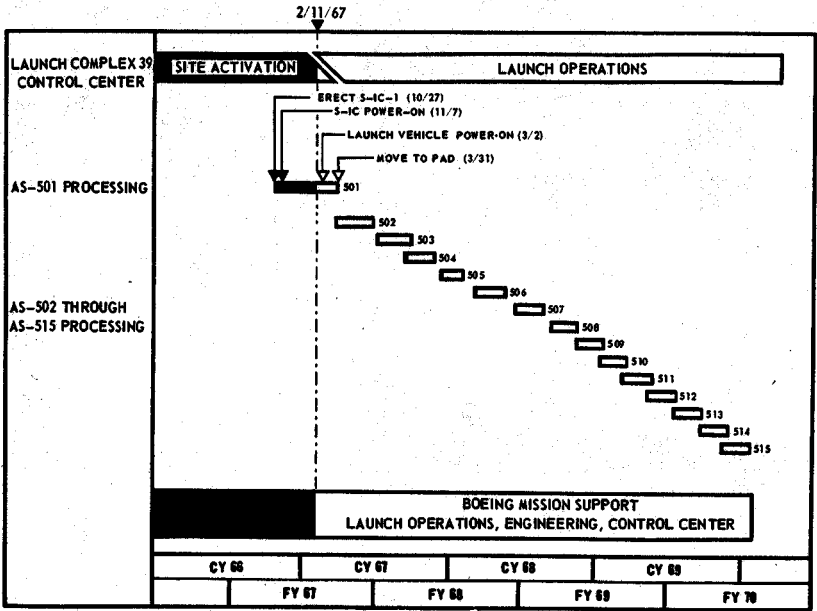


FIGURE 35

LAUNCH COMPLEX 39 ACTIVATION SUPPORT

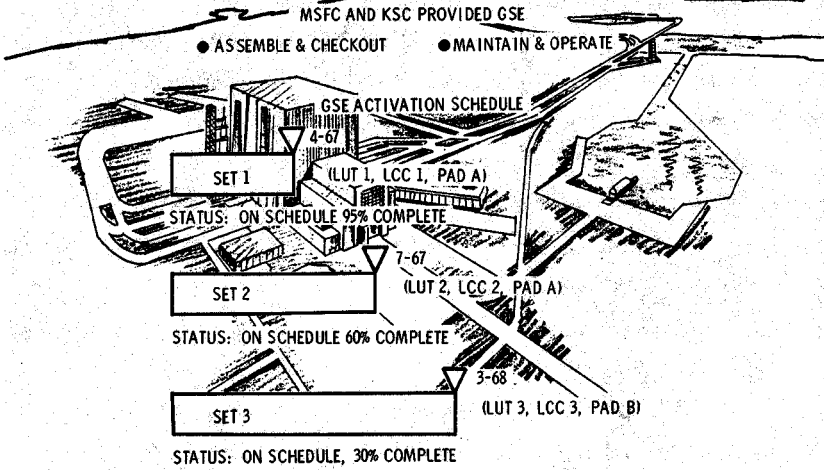


FIGURE 36

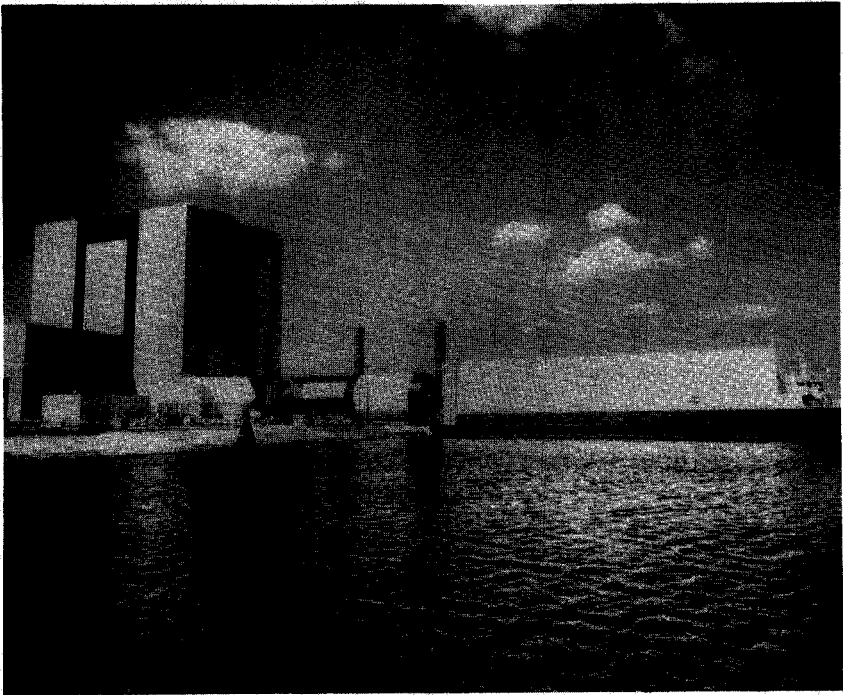


FIGURE 37

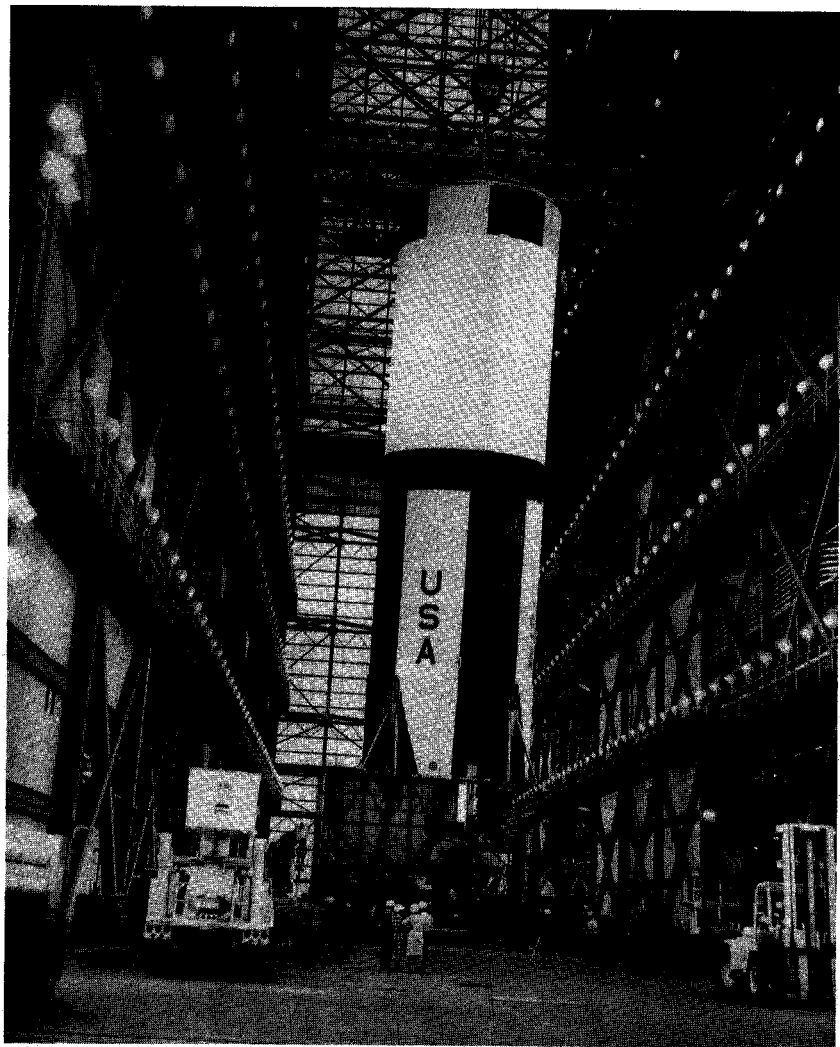


FIGURE 38

sponsible for making this equipment work as delivered to KSC. Among the 17 systems is the launcher-umbilical tower, which includes the service arms (Fig. 42). Figure 43 is a picture of the crawler-transporter. If this equipment has any problems, we must make the necessary design change to make the equipment operable.

Figure 44 shows the stacked vehicle on the launcher-umbilical tower with the service arms that carry electrical power as well as fuel to the various stages. These service arms have to operate before and during liftoff, and we must have assurance that these systems will operate properly.

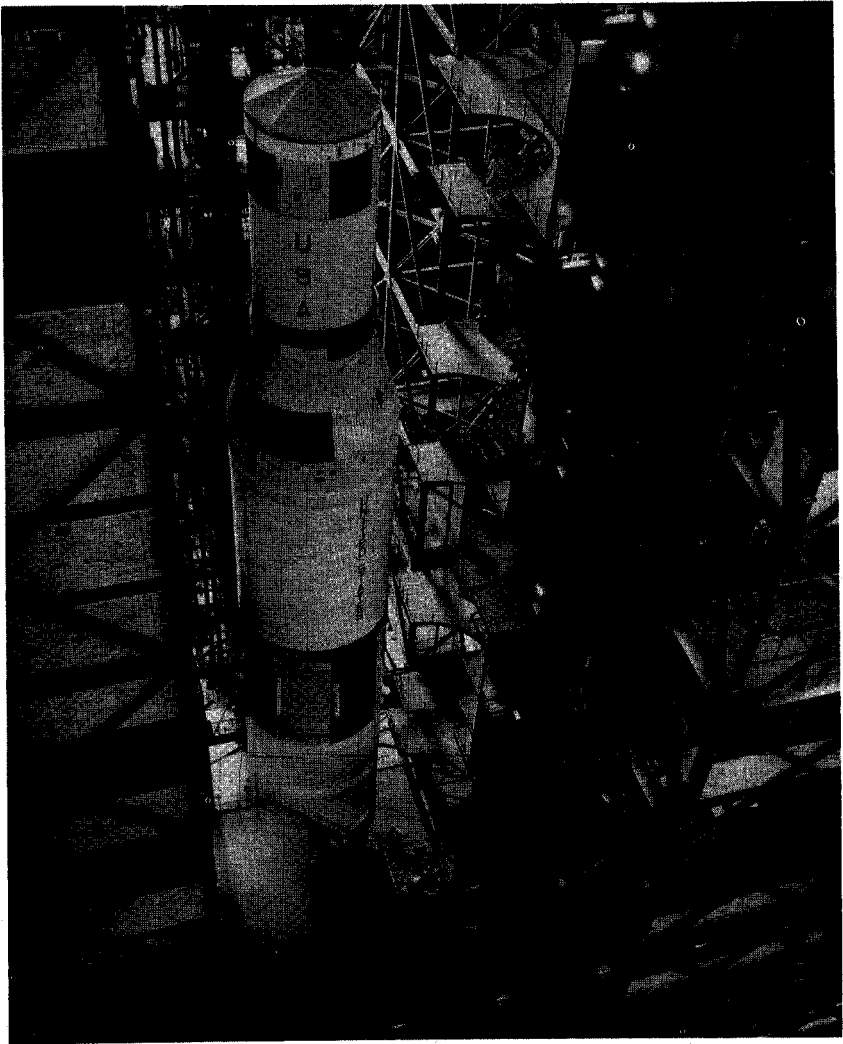


FIGURE 39

We also provide a launch complex 39 control center (Fig. 45), where schedules and equipment records (such as equipment coming in and equipment being modified, etc.) are displayed so the NASA launch operations manager can bring in contractors, review the schedules with them, and determine what activities must be accomplished on any given day. There is a daily meeting held with all the contractors to review the activities necessary in leading to a successful AS-501 launch. Figure 46 shows some of the displays in the control center. In summary (Fig. 47), our activities at KSC have been directed toward getting the site ready for processing of the AS-501 vehicle. We are

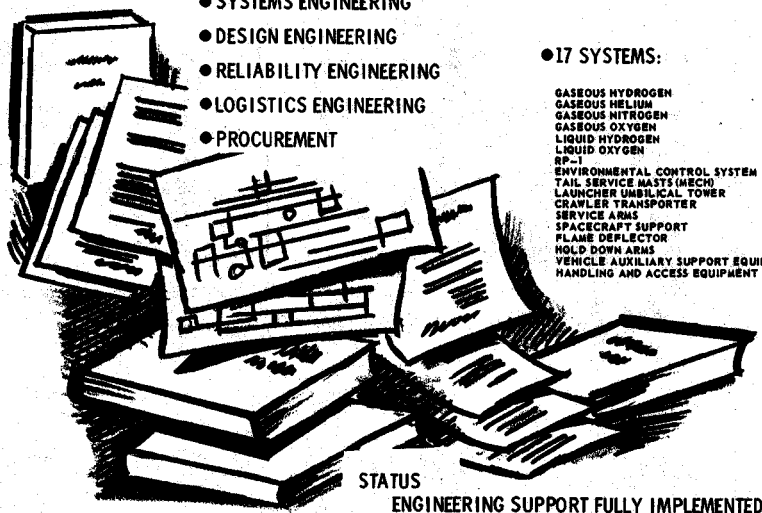
KSC ENGINEERING SUPPORT

●SUSTAINING MECHANICAL ENGINEERING

- SYSTEMS ENGINEERING
- DESIGN ENGINEERING
- RELIABILITY ENGINEERING
- LOGISTICS ENGINEERING
- PROCUREMENT

●17 SYSTEMS:

GASEOUS HYDROGEN
GASEOUS HELIUM
GASEOUS NITROGEN
GASEOUS OXYGEN
LIQUID HYDROGEN
LIQUID OXYGEN
RP-1
ENVIRONMENTAL CONTROL SYSTEM
TAIL SERVICE MASTS (MECH)
LAUNCHER UMBILICAL TOWER
CRAWLER TRANSPORTER
SERVICE ARMS
SPACECRAFT SUPPORT
FLAME DEFLECTOR
HOLD DOWN ARMS
VEHICLE AUXILIARY SUPPORT EQUIPMENT
HANDLING AND ACCESS EQUIPMENT



STATUS
ENGINEERING SUPPORT FULLY IMPLEMENTED

FIGURE 40

now directing our attention toward a launch operation and successful launch of the AS-501. To do that, we are assuring that equipment, papers, people, etc., are compatible and in reliable condition.

I will now turn the meeting back to Dick Nelson.

Mr. NELSON. Thank you. Now, I'd like to give you a brief rundown on the money and manpower situation as it relates to our tasks on the Saturn V program. Our actual expenditures on schedule I are under-running somewhat our contract forecast, and it appears we will under-run the complete cost of the program. We are about 80 percent expended. We have about 3 years left to go on the program. We are just getting started on schedule IA for the followon stages S-IC-11 through -15. At this point it is too early for forecasting any deviation from contract price. On schedule II, we are underrunning our forecast. We are about two-thirds expended with about 2 years to go. On schedule III, we have about 3 years to go through the launch of the SA-515 vehicle with about 20 percent expended, and no deviation from contract target cost is forecast. (The foregoing discussion on the contract expenditures contained some off-the-record discussion, which has been deleted from this transcript.)

Figure 48 shows our manpower profile. We peaked at 11,600 people at the end of 1965 and we have been coming down, and as of February 3, we had 10,837, for a reduction of about 800 people. In terms of people here in New Orleans, we peaked here at about 6,000 direct labor in early 1965 and have been coming down rather steadily since that time. We are currently, as of February 3, at 3,571. On schedule II (Huntsville), the manpower peak occurred in mid-1966

when we had 2,569 people. We have been declining since then and the Boeing Saturn V direct headcount now is 2,118. It is interesting to note that while we have been declining in the New Orleans and Huntsville areas, we have been able to maintain a fairly level employment in all three areas because we have been able to transfer people to the Cape to assist in their buildup.

Dr. VON BRAUN. How are your Mississippi Test Facility people carried in that chart?

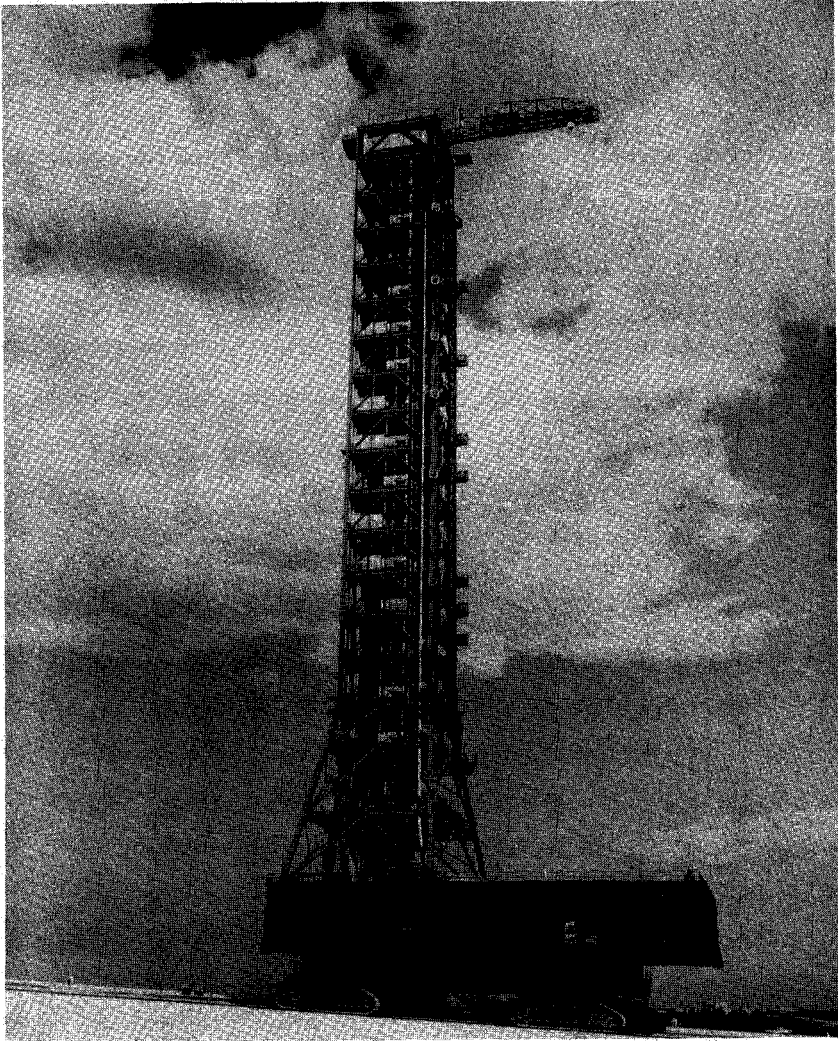


FIGURE 41

Mr. NELSON. The Boeing Mississippi Test Facility people are carried in the New Orleans part of this chart. We have about 300 of them.

At this point of time, we are at the point where we can no longer utilize people from Huntsville and New Orleans at the Cape since they are about to reach their peak. We are now in a declining manpower situation in the program and it will continue throughout the remainder of the program.

The area on figure 48, designated units 16-25, gives us a look at what impact the additional stages at three-per-year delivery has on the total manpower situation. As you can see, our manpower will still be decreasing. In order to prevent a dip in the manpower line, we will have to activate the S-IC-16 through S-IC-25 program very soon. If we don't, we will have to lay off and then bring people back at a later date to staff the work force. Figure 49 shows the schedule situation for those followon stages. The top bar is the schedule for the first eight flight stages built at Michoud through S-IC-10, which will be delivered late in 1968. Assembly of S-IC-11 will start April 20, 1967. In order to hold this delivery schedule for S-IC-11, it was necessary to place orders for long-lead items some 38 months before the delivery date of the 11th stage. This required that we place orders for S-IC-11 material in November 1965. In

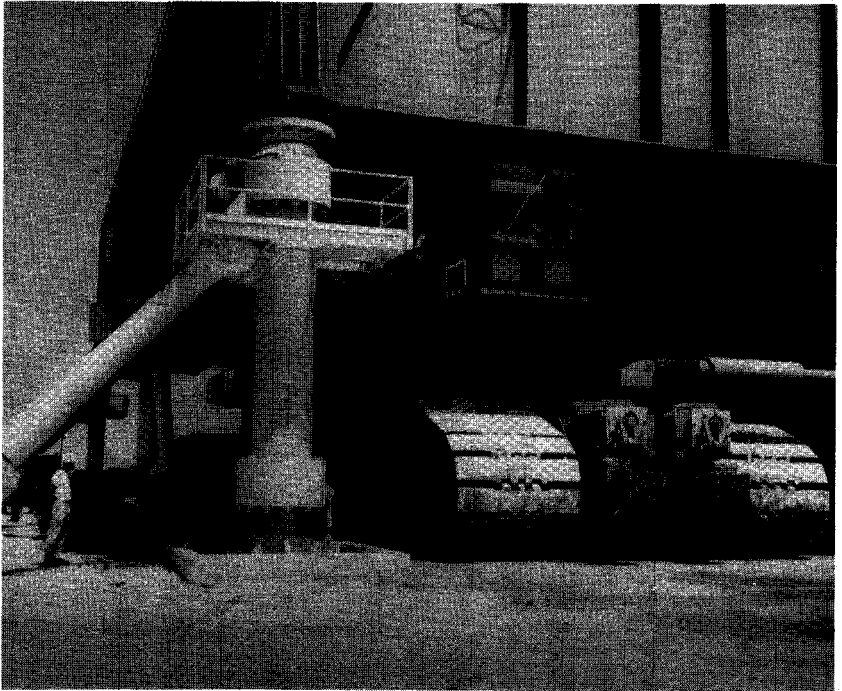


FIGURE 42

order to hold an uninterrupted schedule for the S-IC-16 stage with a 38-month leadtime, which is the optimum leadtime, it would have been necessary to place orders for these long-lead items this past December. This date has gone by; however, it is possible to shorten this leadtime to an absolute minimum of 31 months by doing out-of-sequence installations and compressing testing. We believe that we can hold the delivery schedule for the 16th article based on three-per-year rate in February 1970, if we get authorization by July 1, 1967. Doing it this way is something less than optimum from the standpoint of the cost picture. To use a homely analogy, you can build a house starting with the roof, then add the second floor, then jack the

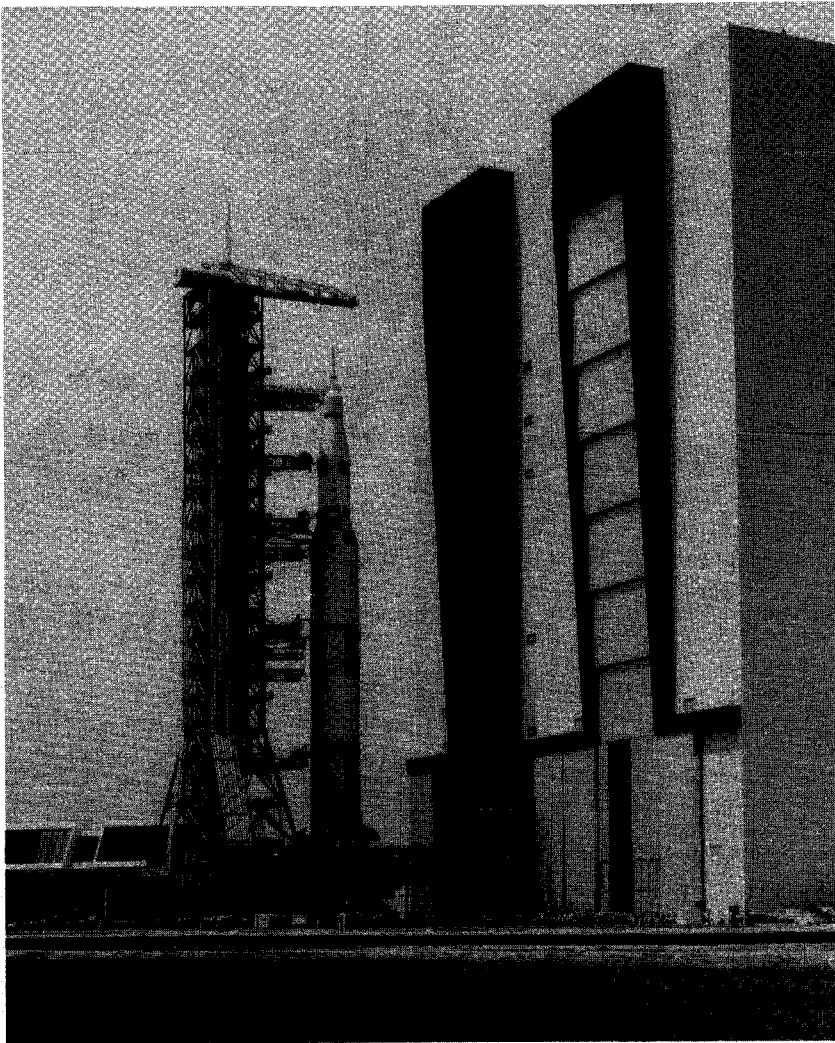


FIGURE 43

LAUNCH COMPLEX 39 CONTROL CENTER OPERATION SUPPORT



STATUS

- SITE ACTIVATION TASK TO BE COMPLETED JUNE 30, 1967
- LAUNCH OPERATIONS TASK BEING IMPLEMENTED

FIGURE 44

whole works up and add the first floor and a foundation. It's a costly way to operate, but it can be done. We prefer not doing it this way. It is just not the economical way to operate. To do an optimum job, we should have initiated procurement last December. We can still hold S-IC-16 delivery in February 1970 by managing the 38 months down to 31 months. It would appear the funds required for fiscal year 1968 for S-IC-16 and on would be approximately \$28 million (Fig. 50). The first 6 months of fiscal year 1968 expenditure will be something like \$6.4 million, with commitments of \$13.5 million.

To quickly summarize our Boeing Saturn program (Fig. 51) activities are on or ahead of schedule. Part I is 5 weeks ahead of schedule. Costs are running under targets. Testing activities are proceeding toward achieving the necessary confidence for manned mission. We have no known technical problems jeopardizing the program. We have converted schedules I and II to incentive-type contracts, and schedule III is an award-fee type of contract. We are phasing down manpower consistent with program requirements. We require authorization by July 1, 1967, as an absolute deadline for follow-on 16 and on stages. But in spite of these optimistic state-

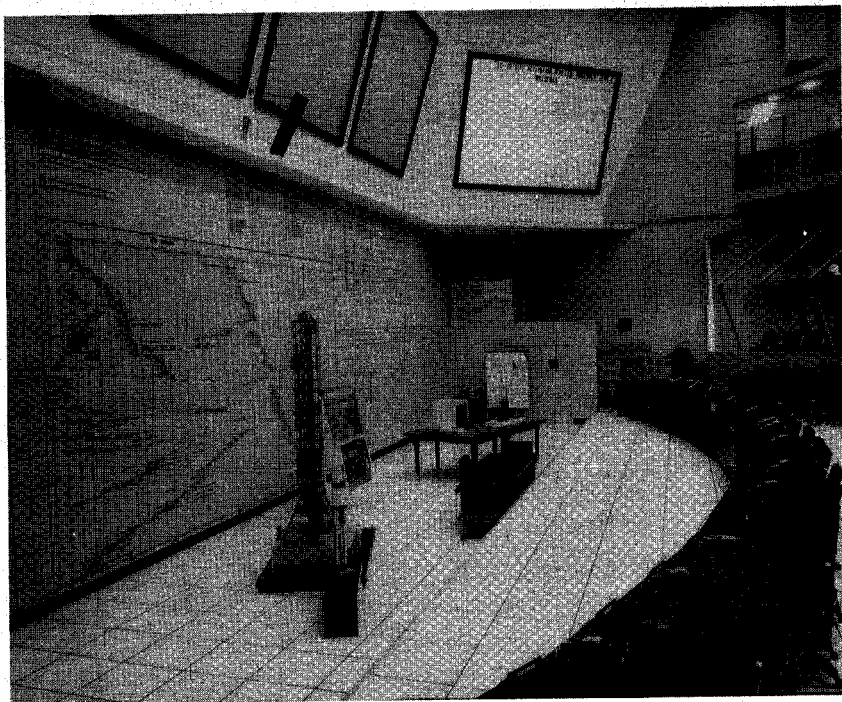


FIGURE 45

ments, I want to make one major point—we still have the critical flight test program ahead of us. This has been a real quick summary of the Boeing activities on the Saturn V program.

Mr. George Stoner would like to say a few words.

Congressman TEAGUE. George, would you comment on how the money flows from NASA to you, and from you to your subcontractors?

Mr. STONER. Well, the process is one of signing a contract with NASA, so we know what our budget is for doing a job both from a total cost standpoint and the time-phase standpoint. Then we engage in competitive selection of our suppliers much like the Government does. We have in our contracts the billing system for the contractors. When we can get fixed-price contracts with our suppliers, we do so. Where the development nature of the job makes fixed-price contracting impossible, we use other types such as incentive-fee or cost-plus fixed-fee contracts. Final flow of money to the contractor is as he discharges his contract for us, we pay him as he goes.

Congressman TEAGUE. What timelag is there?

Mr. STONER. Only a matter of a few weeks.

Congressman TEAGUE. Does this apply to subcontractors too?

Mr. STONER. When we get a bill from our subcontractors, within a few weeks on an average, the subcontractor has his money.

PROGRAM EMPHASIS AT KSC

- PREVIOUSLY DIRECTED TOWARD SITE ACTIVATION
- NOW DIRECTED TOWARD LAUNCH OPERATIONS - THE CONDUCT OF A SUCCESSFUL LAUNCH
 - CONFIGURATION ASSURANCE
 - SYSTEMS RELIABILITY
 - HUMAN ENGINEERING
 - TEST PROCEDURES
 - WORK CONTROL
 - SAFETY
 - QUALITY CONTROL
 - PERSONNEL SELECTION
 - TRAINING

FIGURE 46

BOEING PERSONNEL REQUIREMENTS FORECAST SATURN PROGRAM THROUGH SA-525

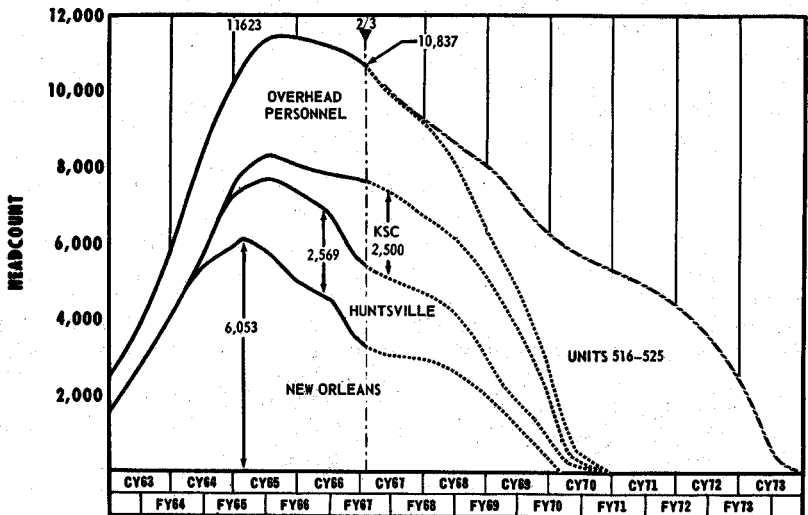


FIGURE 47

DELIVERY SCHEDULE S-IC-16 THRU -25

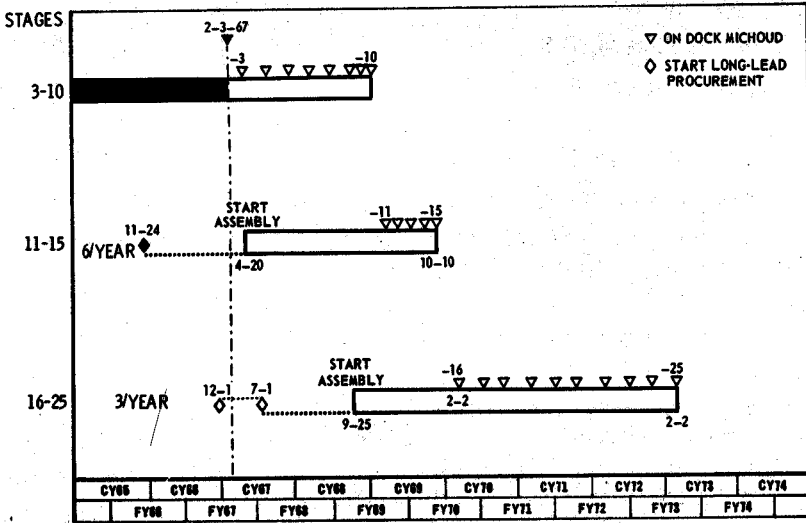


FIGURE 48

FUNDS REQUIREMENTS STAGES S-IC-16 THROUGH S-IC-25 S-IC PROGRAM

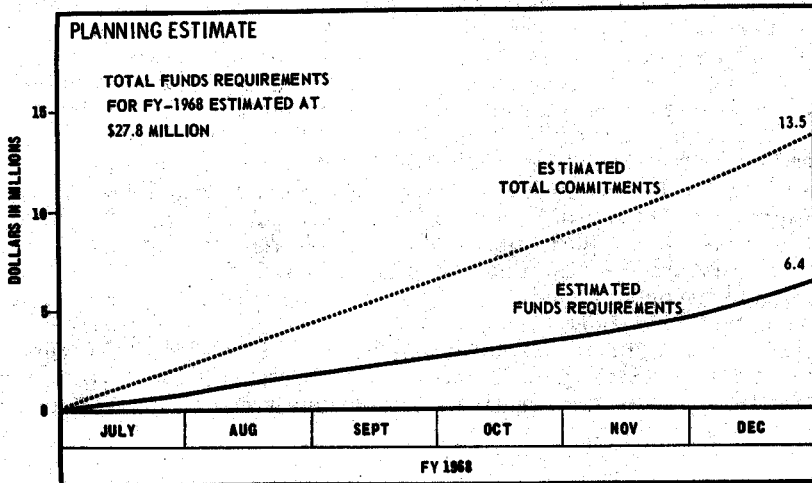


FIGURE 49

BOEING ACTIVITY SUMMARY

PRESENT STATUS:

- PROGRAM ACTIVITIES ON OR AHEAD OF SCHEDULE
- COSTS ON OR BELOW TARGETS
- TESTING ACTIVITIES ARE PROCEEDING TOWARDS ACHIEVING MANNED MISSION CONFIDENCE
- NO KNOWN TECHNICAL PROBLEMS JEOPARDIZING THE PROGRAM
- SCHEDULE I, IA & II OF CONTRACT NAS8-5608 HAVE BEEN CONVERTED TO INCENTIVE CONTRACTS. SCHEDULE III IS CPAF
- TOTAL MANPOWER IS PHASING DOWN CONSISTENT WITH PROGRAM REQUIREMENTS
- PROCUREMENT FOR FOLLOW-ON STAGES (S-1C-16 AND ON) REQUIRES CONTRACT AUTHORIZATION BY JULY 1, 1967

BUT:

- THE CRITICAL FLIGHT-TEST PROGRAM IS AHEAD

FIGURE 50

I want to comment on the fact that the first Saturn V flight has not yet been made. These Boeing people working on this program are well aware of that fact as you could tell from the presentation today. They have a terrific act to follow in another Boeing program called the Lunar Orbiter. Figure 52 shows that Boeing-built spacecraft, and figure 53 is a shot taken by the Lunar Orbiter II. This program is helping NASA to plan the Apollo Mission. The first two Lunar Orbiters were highly successful and a third one is in orbit around the Moon today. Each Lunar Orbiter takes about 18 miles of 35mm. film. This work has been done by Boeing people working with the NASA Langley Research Center. Most of the activity was centered in Seattle with a substantial number of people at Cape Kennedy.

The Boeing space division has about 14,500 people. The group you hear from today constitutes about 10,500; the remainder of people are working on Lunar Orbiter, Burner II, Minuteman, Voyager, and so forth, and these people have an act to follow. We are most pleased to have had the opportunity of briefing you today. Any questions?

Congressman PETTIS. There was an estimate of a projected under-run. The economic situation was better than you projected it when you signed your contract?

Mr. STONER. Both we and Marshall did our best around the negotiation table to arrive at the right figure for target cost for the contract. Then they gave us an incentive-fee provision which allows us to share in any cost underrun.

Thanks to Mr. Nelson and Mr. Wilkinson, they have been able to manage the program thus far well enough to project that underrun

at this time. It's not crystal clear until the whole program is over just what the costs will be. If there are no unexpected snakes to bite us, I believe we can realize a significant underrun as Dick Nelson projects it.

Mr. NELSON. Remember, when we negotiated the contract, we were sure that we would have some real tough problems to solve. So far we have been able to solve them, but with the flight-test program still ahead of us we may uncover something that we will have to fix which will eat up that underrun or possibly even more, but we hope not.

Mr. STONER. At the moment we think we've done the job and have enough confidence in having done that job that Dick was able to get up here today and project that underrun.

Congressman TEAGUE. Is there any doubt in your mind that when you turn loose of a vehicle to Kennedy it has been thoroughly tested, or are you limited in any way in the amount of testing you do? Or if you have doubts, can you continue testing?

Mr. STONER. I have never found Dr. von Braun or his staff unwilling to permit us to proceed with cost necessary to complete tests that we or they think ought to be done. If there are any suspicions, Dr. von Braun and his staff encourage us and recommend many testing ideas of their own.

The only qualification I can place on our having complete confidence in the stage is that we all are humans and we can make mistakes.

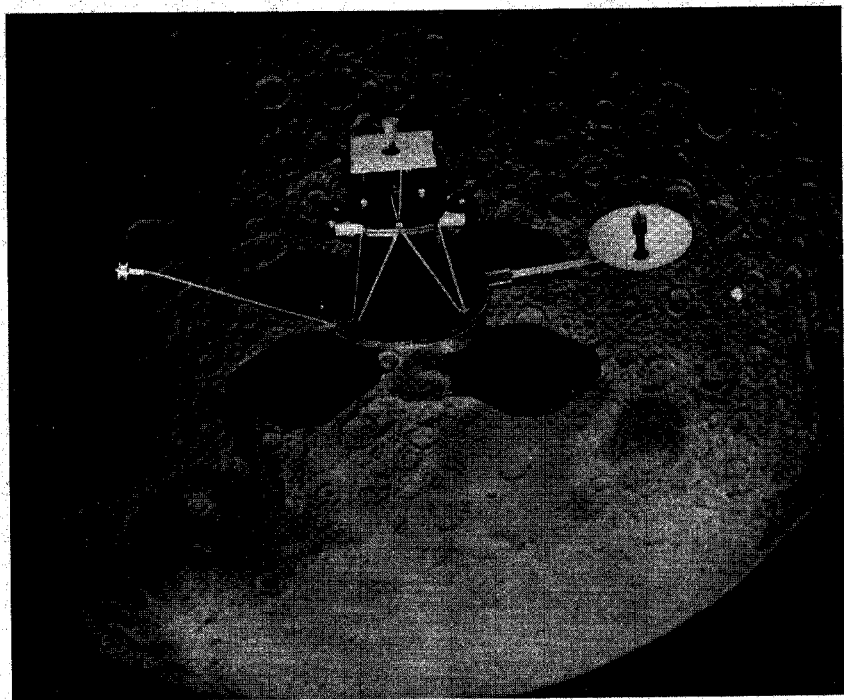


FIGURE 51

But I think the boys here have done the best job men can do—and some mighty fine men too, I might add.

Congressman TEAGUE. Thank you, George, we think they're mighty fine men too. Thanks Dick, for the fine briefing you and your people put together for us.

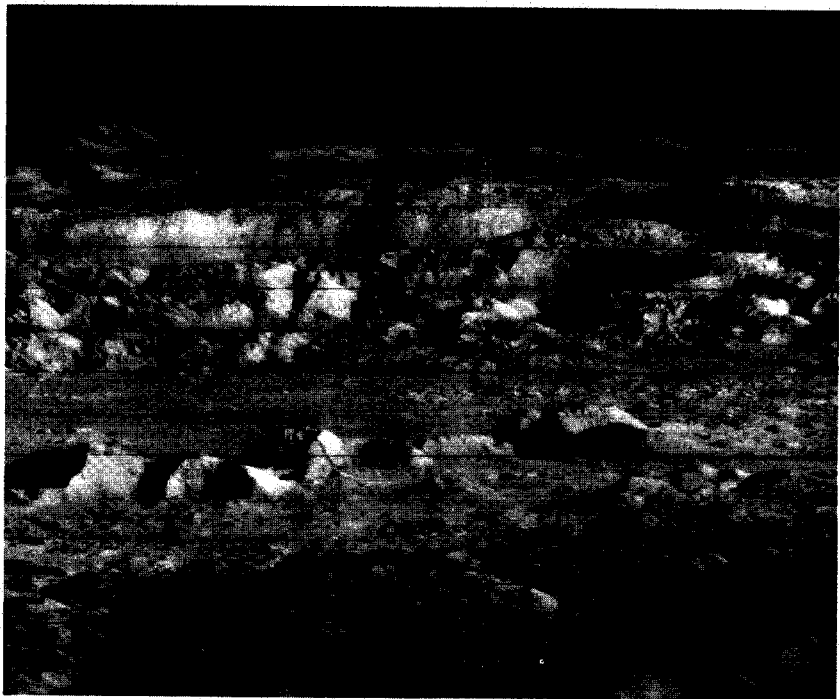


FIGURE 52

APPENDIX C

HEARINGS OF THE SUBCOMMITTEE ON MANNED SPACE FLIGHT, THE CHRYSLER CORP., MICHoud ASSEMBLY FACILITY, NEW ORLEANS, LA., FEBRUARY 11, 1967

ATTENDEES

Committee Members

Congressman O. Teague (Texas)
Congressman J. Pettis (California)
Congressman G. Vander Jagt (Michigan)
Congressman J. Hunt (New Jersey)
Congressman B. Eckhardt (Texas)

NASA Headquarters

Capt. R. Freitag
Mr. J. Cramer

NASA—MSFC—Michoud Assembly Facility

Dr. G. Constan
Mr. M. Hardee

Committee Staff

Mr. J. Wilson
Mr. P. Gerardi
Mr. J. Felton

NASA—MSFC—Huntsville

Dr. W. von Braun
Dr. E. Rees
Mr. H. Gorman
Mr. H. Weldner
Mr. R. Kline

Chrysler Space Division

Mr. H. D. Lowrey, President
Mr. B. J. Meldrum, Director Program Control Office
Mr. V. J. Vehko, Director Engineering
Mr. A. Trahern, Director Operations
Mr. D. Jolivet, Public Relations
Mr. J. Schmidt, Staff

Mr. LOWREY. Welcome to the Chrysler part of the Michoud operation. Just to begin with, I will show you how this thing—a model of the Saturn I vehicle—goes together, and the part that Chrysler makes. Here is the first stage. It has eight engines that have about 1,600,000 pounds of thrust; in other words it can lift just about 1,600,000 pounds. The second stage is made by Douglas in Huntington Beach, Calif. It has a single J-2 engine, with hydrogen and oxygen for propellants. The S-IB stage uses oxygen and kerosene. The work of the first stage is to put it into about a 40-mile position in the atmosphere. Then it burns out and the second stage is ignited. The vehicle is controlled by an instrument unit built by IBM, which is the black portion, here, and then the spacecraft is the responsibility, of course, of the people in Houston. This is a replica of the lunar module inside of the adapter, the service module, the command module, and the abort tower.

With that, Mr. Meldrum, I think you can give the committee members the status of how our program stands here today and what is expected.

Mr. MELDRUM. All right. What we intend to do here, in the course of about an hour, is to provide a program review for the complete Saturn program that we have here at Chrysler. I have about 40 charts here, so I'll spend something less than a minute and a half on each chart. This will be tape recorded. We have asked you to sign these tickets, so that when we type up a transcript, we will be able

SATURN PROGRAM REVIEW

**FOR
COMMITTEE ON SCIENCE AND ASTRONAUTICS
HOUSE OF REPRESENTATIVES**

FEB. 11, '67

to identify who asked what question, because one of our people will put "voice on voice" and say "that came from chair No. 1, or chair No. 10," and so on. Thank you. We want you to feel free to interrupt and bring up any point that you have any question on. At the conclusion of this presentation, we will give all of you who are interested 8½ by 11 inch copies of these charts. I think that on Monday or Tuesday we will have a transcript typed up and we will send that in to you, Mr. Wilson. You can have any number of copies that you desire.

In front of you is a two-page outline of what we are going to discuss so that, if you wish, you can see where we are as we go along. I will go through this outline very rapidly.

We will describe what our current contractual obligations are at the present time, and what our personnel history has been up to this time, and a cost summary of the complete program that is under contract at this time. We will then go into our largest schedule, schedule I, the schedule which has the 14 stages, and will tell you what our status is, what our engineering release status is, how we stand on our qualification and reliability program, our quality problems, our cost plans, and personnel projections. We will never talk about cost without talking about people at the same time, because you can't talk about one without talking about the other. We will then talk a little about what we call our schedule VI, which is the procurement of all long leadtime items, to protect our ability to stay in business. We have a contract to get the long leadtime items needed for the four birds, S-IB-13, 14, 15, and 16. We do not have a "follow-on" program. We just have the portion occurring between now and June 30 for doing those things that have to be done if we are not to have a break in the continuity of the program.

After that, logically, we will talk about what a "follow-on" program ought to be; what are the elements of planning for it, the "ground rules," the schedules, the cost plan, and the personnel projections. We will talk about personnel attrition.

Given time, we will talk about our schedule II, "vehicle integration," description, status, cost plans, and personnel projections. Our

schedule III, mechanical ground support equipment, description, status, cost plans, and personnel projections. Schedule IV, our launch mission work at Kennedy Space Center, description, status, cost plans, personnel projections, and then we will have a very brief rundown on the work that we are doing on other than our main contract, NAS 8-4016. We'll discuss two items, one, Saturn improvement studies (what we can do to increase the capability of this bird), and two, the work that we are doing in optical technology. Then we will have a summary.

Our main contract, NAS 8-4016, has these six items: schedule I, supply the stages; schedule II, the launch vehicle integration effort; III, the mechanical ground support equipment for which Marshall Space Flight Center has responsibility, as distinguished from the mechanical ground support equipment for which Kennedy has responsibility; schedule IV our launch mission; V is a small special test mission, involving about 20 people. It is going to end in a few months, and I'm not going to talk about it any further. Schedule VI is our procurement of long leadtime items.

OUTLINE OF REVIEW

DESCRIPTION OF CURRENT CONTRACT OBLIGATIONS

PERSONNEL HISTORY

COST SUMMARY

SCHEDULE I - (STAGE SUPPLY)-STATUS

- ENGINEERING INITIAL RELEASE STATUS
- QUALIFICATION PROGRAM STATUS
- RELIABILITY PROGRAM STATUS
- QUALITY CONTROL PROGRAM STATUS
- COST PLAN
- PERSONNEL PROJECTION

SCHEDULE VI (PROCUREMENT OF LONG LEAD TIME MAT'L) DESCRIPTION AND STATUS

- COST PLAN

FOLLOW-ON CONTRACT PLANNING

- "GROUND RULES"

- SCHEDULE

- COST PLAN

- PERSONNEL PROJECTION

- PERSONNEL ADDITION AND SEPARATION

OUTLINE OF REVIEW (CONT)

SCHEDULE II - VEHICLE INTEGRATION

DESCRIPTION
STATUS
COST PLANS
PERSONNEL PROJECTION

SCHEDULE III-MECHANICAL GROUND SUPPORT EQUIPMENT (MSFC)

DESCRIPTION
STATUS
COST PLAN
PERSONNEL PROJECTION

SCHEDULE IV- LAUNCH MISSION (KSC-I)

DESCRIPTION
STATUS
COST PLAN
PERSONNEL PROJECTION

WORK OTHER THAN NAS8-4016

A. SATURN IMPROVEMENT STUDIES

DESCRIPTION
IMPROVEMENT POTENTIAL

B. OPTICAL TECHNOLOGY

SUMMARY

Here is the way we look on personnel manning from 1962 to today. This is what we have here at Michoud, here is what we have at Huntsville static test. Here we have Huntsville, exclusive of static test, and here is what we have in Florida. Here is the Space Division as a whole. The ordinate scales are all the same. We hit our peak in the last quarter of fiscal year 1965 (the middle of calendar year 1965), 5,580 people. We are down to about 4,700 people now. We have gone down about 800 people. Here, at Michoud, our peak in that same period, was around 3,300 people and we are down to 2,700 people. We have dropped 600 people in that period of time. We are at a level at about 140 people at Huntsville on static test. At Huntsville, exclusive of static test, we have gone down from 1,450 to about 800, so we have about a 600 drop. We have gone up about 400 in that

period at the Cape. We have a thousand people, roughly, at the Cape. Two hundred and fifty of those people came from Huntsville when some of the responsibility for mechanical ground support equipment was transferred from Huntsville to the Cape.

To give you a bird's-eye view on how much these various activities cost, the work under contract as of the end of January is around \$200 million, and the big item is Schedule I which is half of it, stage supplies, with \$7 million for the long leadtime items. Call the subtotal \$103 million, and the work at the Cape is about \$70 million. These others are lesser amounts. In the case of Schedule II, as I'll get into it later, that (\$15.7 million) is what we have under contract. We expect another \$1 million a month for the next 24 months.

Now on stage supply. The best picture of stage supply (see chart 40) is produced from this wall chart. We have a 14-stage program. Each one of these bands represents one stage. These are calendar years at the base, and the end point of each of these strips represents the date when that stage will be available to ship to Kennedy. Five of these stages have been launched. The red arrow tips indicate the dates that they were launched. This stage (S-IB-5) is in storage. You saw it downstairs. S-IB-6 is at the Cape and S-IB-4 is at the Cape.

As we go down over the history, S-I-8 was successfully launched on the 25th of May and put Pegasus 2, the micrometeorite detection satellite, in orbit. S-I-10 was launched on the 30th of July. Pegasus 3 was put in orbit, and is still in orbit. S-IB-1 was launched on the 26th of February 1966. This was the "quarter lob" shot (a quarter of the way around the world), to help qualify the heat shield. We had maximum heat transfer rate across the heat shield. S-IB-3 was launched on the 5th of July. This was the liquid hydrogen experiment, and incidentally, that was launch number 80 for Chrysler Corp., 80 sequential successful launches.

S-IB-2 was launched on the 25th of August. This was a "three-quarter lob" shot (three-quarters of the way around the world), and came down near Hawaii. This was the qualification test of the heat shield from the standpoint of total quantity of heat transferred. S-IB-4 is at Kennedy. It was completed on schedule in June of 1966. S-IB-5 was completed on schedule in August of 1965. It is awaiting shipment. You saw it, with the blue cover on it, downstairs. S-IB-6 is at Kennedy. It was completed here in November of 1966. S-IB-7 is on schedule. It is in poststatic modification. It was the one closest to the far wall. S-IB-8 is on schedule. It's in poststatic firing mod. It has been static fired. S-IB-9 is up in Huntsville, undergoing static fire. S-IB-10 is on schedule. It is in prestatic fire checkout. You saw it in the checkout room. S-IB-11 and 12 are on schedule. They are in clustering. You saw them in the clustering fixtures downstairs.

From the standpoint of initial engineering releases the job is now 100 percent on S-IB-1 through 7 and 99.8 to 99.6 percent on the rest. The only thing left on some of these is the "ship loose" list of the items that are shipped with the bird and some of the electrical schematics for 11 and 12. From the standpoint of initial engineering releases the job is done. The engineering activity now has to be concerned with those changes (what we call the "make-it-fit, make-it-work" changes)

CONTRACT NAS-8-4016

DESCRIPTION

SCHEDULE I. SUPPLY OF 14 STAGES(S-I&S-IB)

SCHEDULE II. LAUNCH VEHICLE INTEGRATION
EFFORT

SCHEDULE III. MECHANICAL GROUND SUPPORT
EQUIPMENT (MSFC)

SCHEDULE IV. LAUNCH MISSION (KSC-I)

SCHEDULE V. SPECIAL TEST MISSION
(HUNTSVILLE)

SCHEDULE VI. PROCUREMENT OF LONG LEAD
TIME COMPONENTS FOR STAGES -
S-I-B-13, 14, 15. & 16.

CHART 1

required to solve the difficulties which occur on the floor of the plant at Huntsville and at the Cape.

On our qualification program status, all of the stage flight critical hardware has been qualified for first manned flight. There were 96 items qualified by analysis and 118 items qualified by test programs making a total of 214; 153 interim test figure reports were written on those 118 items. Some of those reports were written on failures that occurred outside of the required range of qualification requirements. Some were written on failures that happened within the requirements. Design changes have been developed, processed, and tested on 26 of the 118 items. There were 26 cases where the failures during the qualified test occurred within the requirements and where some change had to be made.

Under the reliability program, the program has been completed. Reliability test programs have been conducted on over 200 flight critical items. As of near the end of January, we have issued 284 test failure reports. Some of these occurred outside of the require-

NAS8-4016 MANNING HISTORY

TOTAL
PERSONNEL
DIRECT &
INDIRECT

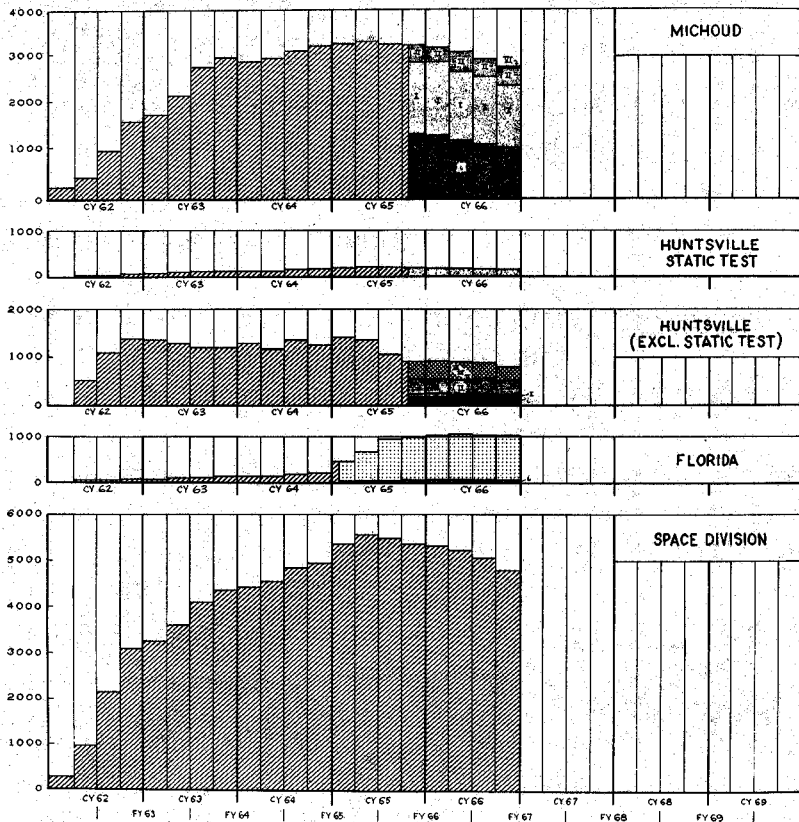


CHART 2

ments of reliability, and some occurred inside. In 54 cases, items have had to be changed. Changes have had to be developed on either the design of a part or of the processing and then have been successfully tested. That's what you get out of the reliability and qualification programs.

SLIDE PRESENTATION

Now, I'll show you just five or six of the more interesting test items in qualification and reliability. The first one is the slide which shows the qualification test on the tail. May I have the first slide. You saw this. There were over 600 channels of information connecting this with the data center while the loads were being applied, and the tail was qualified on the first test. Second slide. This is the 70-inch-diameter liquid oxygen tank. This has been tested up to 140 percent of design limit loads. It was the last major item to be quali-

COST SUMMARY

NAS 8-4016 (SINCE 1 NOV. '65)
 WORK UNDER CONTRACT (AS OF 27 JAN. '67)
 \$(MILLIONS)

			%
SCHEDULE I	STAGE SUPPLY 1 NOV. '68	97.130	49.10
SCHEDULE II	VEHICLE INTEGRATION	15.780	7.99
SCHEDULE III	MECHANICAL GSE (MSFC)	8.390	4.24
SCHEDULE IV	LAUNCH MISSION (SINCE 1 FEB '65)	68.903	34.81
SCHEDULE V	SPECIAL TEST MISSION	.441	.22
SCHEDULE VI	LONG LEAD TIME ITEMS	7.200	3.64
TOTAL		<u>\$197.844</u>	<u>100.0</u>

CHART 3

fied. We had to introduce design changes when we had a buckling failure at 135 percent of the load which wasn't good enough. We had something like 260 channels of information that flowed from this tank to the data center, and the message here, I think, is in the size of this operation. These are very large things. Let's look at our next slide, please. This is the typical buckling failure that occurred in the wall of the tank near the bulkhead at fin No. 4 position for which we had to work out a correction. Let's have the next slide, please. This is a typical test (both reliability and qualification) of a liquid oxygen line. This particular line is filled with liquid nitrogen. It's covered with frost because it's extremely cold. It is mounted on a shaker of 20,000 pound force capacity and it is under the same compressive load that it would have in normal installation.

These jacks reacting against heavy bungee cords are squeezing it with the proper loads. It is subject to sine wave vibrations and ran-

CONTRACT NAS-8-4016

SCHEDULE I

STAGE SUPPLY STATUS

- S-I-8 SUCCESSFULLY LAUNCHED (SA-8) 25 MAY 65 (PEGASUS II)**
- S-I-10 SUCCESSFULLY LAUNCHED (SA-10) 30 JULY 65 (PEGASUS III)**
- S-IB-1 SUCCESSFULLY LAUNCHED (AS-201) 26 FEB 66 (¼ LOB SHOT)**
- S-IB-3 SUCCESSFULLY LAUNCHED (SA-203) 5 JULY 66
(LIQUID HYDROGEN EXP.)**
- S-IB-2 SUCCESSFULLY LAUNCHED (AS-202) 25 AUG (¼ LOB SHOT)**
- S-IB-4 AT KSC.COMPLETED ON SCHEDULE JUNE 66**

- S-IB-5 COMPLETED ON SCHEDULE AUG 65 AWAITING SHIPMENT**
- S-IB-6 AT KSC COMPLETED ON SCHEDULE NOV. 66**
- S-IB-7 ON SCHEDULE IN POST STATIC FIRE MODIFICATION**
- S-IB-8 ON SCHEDULE IN POST STATIC FIRE MODIFICATION**
- S-IB-9 ON SCHEDULE AT STATIC TEST**
- S-IB-10 ON SCHEDULE IN PRE STATIC FIRE CHECK OUT**
- S-IB-11 ON SCHEDULE IN CLUSTERING**
- S-IB-12 ON SCHEDULE IN CLUSTERING**

CHART 4

dom vibrations and has qualified under all of the applicable stress environments. Next slide, please. This is a pair of the same lines mounted in the horizontal position so that we are testing two at the same time, mounted on the shaker, and excited in this direction for random and for sine wave vibrations over the complex frequency scale. Next slide. Here is a test of the complete "wraparound" line assembly. Here, again, the message here lies in the very large sizes involved (practically sewer pipe sizes), and again it has an excitation in the vertical direction. We have problems in this type of structure with bosses and with the bellow connections. Next slide, please. Here is a typical series of pictures of typical difficulties that you run into; some outside of the limits of qualification and reliability, and some inside. Here's one that was inside the limits, where the complete boss

NAS 8-4016

SCHEDULE 1

INITIAL ENG. RELEASE STATUS

(AS OF 25 JAN 1967)

S-I-B-1 THRU	S-I-B-7	100 %	
	S-I-B-8	99.8%	SHIP LOOSE LIST
	S-I-B-9	99.8%	
	S-I-B-10	99.8%	
	S-I-B-11	99.6%	SHIP LOOSE LIST SCHEMATICS
	S-I-B-12	99.6%	

CHART 5

breaks off. The design changes needed here were first, to reduce the mass of the boss (make it smaller), and secondly, to add a weld, not only on the outside but also on the inner ring, which was done. We have similar difficulties in the welds here and we have similar difficulties in the attaching points. May we have the next slide.

Here is a test of a 20-cubic-foot titanium sphere. We carry two of these on board and normally they are charged to something above 3,000 pounds per square inch pressure. These spheres had to be tested under pneumatic pressure (which is sort of a dangerous thing), because we couldn't test hydrostatically for this vibration environment, because of the change in mass, so this had to be done at a place that we call Fort Klaunch, which is built out in the "boon docks." It has a lot of sand bags on the outside, and is so arranged that if the test sample were to fail, we would blow the roof off but nothing else, and the

QUALIFICATION PROGRAM STATUS

1. ALL STAGE FLIGHT CRITICAL HARDWARE HAS BEEN QUALIFIED FOR FIRST MANNED FLIGHT.
2. 96 ITEMS QUALIFIED BY ANALYSIS
118 ITEMS QUALIFIED BY TEST
214 TOTAL
3. 153 INTERIM TEST FAILURE REPORTS ON THE 118 ITEMS
4. DESIGN CHANGES HAVE BEEN DEVELOPED, PROCESSED AND TESTED ON 26 OF THE 118 ITEMS

CHART 6

people are in a separate blockhouse at a safe distance. Here we had two shakers, 10,000-pounds force each, and the sphere was mounted on the exact mounting flanges that are used in flight. This is subjected to vibration in this horizontal plane through the sine wave and the random vibration called for by the specifications. This has been fully qualified on the first try. Next slide, please.

This is the same thing in the vertical direction. We have two 10,000-pound-force shakers, side by side, operating "in phase" and again we were able to get through with this with no failure and no difficulties. This is particularly interesting, Dr. von Braun, because of the great interest in titanium spheres since the Douglas incident. This will give you a feel for the kind of qualification work and reliability test work that go into development programs.

We are going to touch very briefly on where we stand on our quality program. The first thing to say is that the test results that have

occurred at static firing in Huntsville and at launch at Cape Kennedy (which are the real acid test of whether or not you have controlled your quality) are, as everybody knows, excellent. We have had no failures.

Our quality program is active in two places, first in the house, and secondly at our suppliers. The "in-house" program is called CARE. It is an acronym for "Chrysler Always Requires Excellence." It is a motivational program, an attempt to motivate people to get the job done right the first time. As you rode through the plant you saw quality charts at every work station, which indicated the quality rating for that work station for the past week. As you go through the plant you will find that we have quality problems everywhere. This is normal. The advantage of the program is that we become aware of these problems as they happen, so that we can institute corrective

NAS 8-4016

RELIABILITY PROGRAM STATUS

1. THE RELIABILITY TEST PROGRAM HAS BEEN COMPLETED
2. RELIABILITY TEST PROGRAMS HAVE BEEN CONDUCTED ON OVER 200 FLIGHT CRITICAL ITEMS
3. 284 TEST FAILURE REPORTS HAVE BEEN ISSUED. (27 JAN 67)
4. ON 54 ITEMS CHANGES HAVE BEEN DEVELOPED ON EITHER DESIGN OR PROCESSING AND HAVE BEEN SUCCESSFULLY TESTED (27 JAN 67)

CHART 7

QUALITY PROGRAM-STATUS

1. STATIC TEST & FLIGHT PERFORMANCE
RESULTS - EXCELLENT
2. QUALITY PROGRAM ACTIVE "IN HOUSE"
"AT SUPPLIERS"
3. CHRYSLER "CARE" PROGRAM (CHRYSLER
ALWAYS REQUIRES EXCELLENCE)
(COMPARABLE TO "ZERO-DEFECTS" PROGRAM)
4. USE OF PERMANENT & UP-DATED DISPLAYS
OF QUALITY RATINGS IN EACH KEY DEPT.
5. ACTIVE RATING PROGRAM FOR SUPPLIERS.

CHART 8

procedures at the source, and go downstream and make sure we have corrections before that hardware gets into the flight article.

The use of the permanent, updated displays of quality ratings in every key department is one of the key elements in trying to maintain quality "in-house."

We have an active rating program for our suppliers and here we have a very powerful tool. When we sit down, through our purchasing department, with our suppliers, each supplier is made aware of his quality ratings for the last period, and if he can't measure up to our quality standards, we yank him off the approval list. This is the most powerful tool that we have to insure quality in the supplier's house.

Now on schedule I, the big job, the job of supplying the 14 stages, on November 1, 1965, we had a milestone. This is when we incentivised all of our contracts. We entered into a contract to complete this job for \$97 million and chart 9 shows the distribution of these costs. About \$55 million is in labor and burden and about \$31 million is in material. As we have gone along on this program, from that day to this, as we stand today, our experienced costs in comparison

COST PLAN

NAS 8 - 4016

SCHEDULE I

1 NOV. '65 THRU COMPLETION 15 FEB. '69

\$ (MILLIONS)

ITEM	FY PARTIAL 1966	FY 1967	FY 1968	FY 1969	TOTAL
LABOR & BURDEN					
ENGINEERING	8,225	9,942	5,129	1,612	24,908
OPERATIONS	9,082	12,939	4,144	.265	26,430
OTHER	1,675	1,772	.772	.009	4,228
TOTAL LABOR & BURDEN	18,982	24,653	10,045	1,886	55,566
OTHER DIRECT CHARGES					
MATERIAL STAGE	13,608	3,426	1,733	.224	18,991
MATERIAL PROCUREMENT EXP.	1,476	1,951	.422	.004	3,853
OTHER DIRECT CHARGES	3,205	4,242	1,156	.076	8,679
TOTAL OTHER DIRECT CHARGES	18,289	9,619	3,311	.304	31,523
SUB-TOTAL	37,271	34,272	13,356	2,190	87,089
G&A & TARGET FEE	4,297	3,951	1,540	.253	10,041
GRAND TOTAL (COST G&A & TARGET FEE)	41,568	38,223	14,896	2,443	97,130

CHART 9

with that plan are some \$2 million less than we planned at the time we entered into this contract. Our projection for program completion indicates that that saving is going to be greater, rather than less when we get to the end of the program. We are going to save more than \$2 million over the agreed cost by the time we finish the program. Now costs are primarily people and here is chart 10 which shows personnel here at Michoud only—thousands of people—against time in calendar years.

This red line is today's date. On this chart, the black here is the direct people working on schedule 1. This powder blue is the people working on our schedule II, Vehicle Integration. As you can see, we are on a steep toboggan slide. Unless we enter into a contract for additional stages, we will have finished this program—for all intents and purposes—at the end of calendar year 1968. This light gray is the indirect people supporting all of the direct. Chart 11 shows the same

data broken up into major functions; our engineering and operation functions. At Huntsville we have "hardware" schedule I efforts—principally in manufacturing—shown in this black stripe. We have our schedule II efforts—Vehicle Integration—shown here in this gray at about two-thirds of the effort which we show here at Michoud for that same function. All of our schedule III work—our mechanical ground support equipment work—is shown here in black at Huntsville.

Now in order not to close up shop at the end of 1968, the Government has entered into a contract with Chrysler on schedule VI for the procurement of long leadtime components for four stages; S-IB-13, -14, -15, and -16, and our job is to do all things necessary between the 14th of October, when we signed the contract, and the end of fiscal year 1967—June 30, 1967—to protect our ability to deliver S-IB-13 on the first of November and stages 14, 15, and 16 at 3-month intervals thereafter. This chart—wall chart—is a picture of how we would approach building 16 more stages at the rate of four per year. We're here today, February 11, 1967. This broad red stripe is June 30, 1967, the end of fiscal year 1967. This chart shows S-IB-12, the last stage under current contract. This schedule VI says do everything you need, order the long leadtime parts, make the engineering releases for the first four birds—13, 14, 15, and 16—up to this date. Now, right here and now I would like to call your attention to one or two things. This November 1, 1968 available to ship date is 8 months

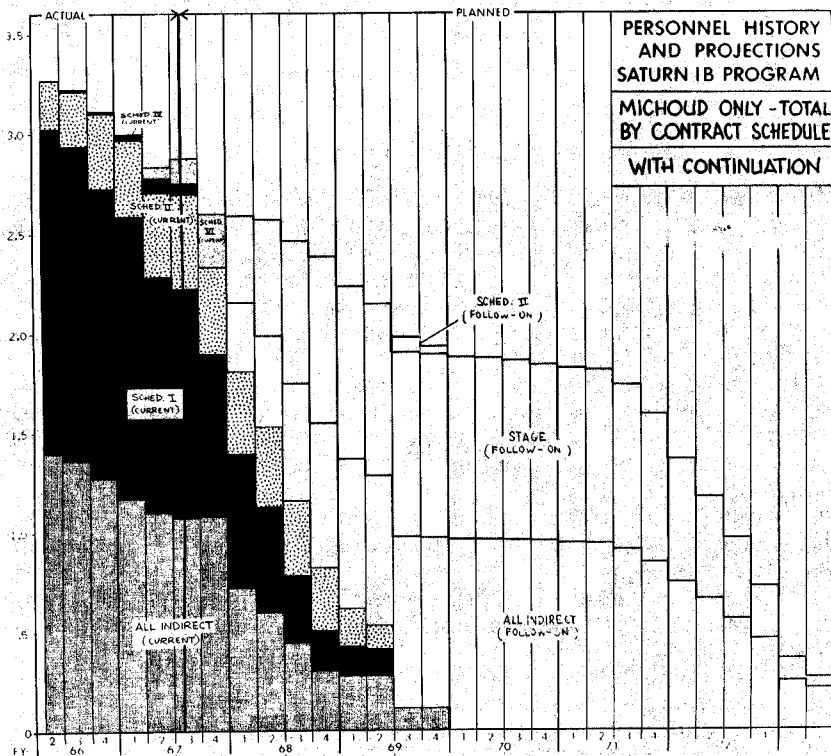


CHART 10

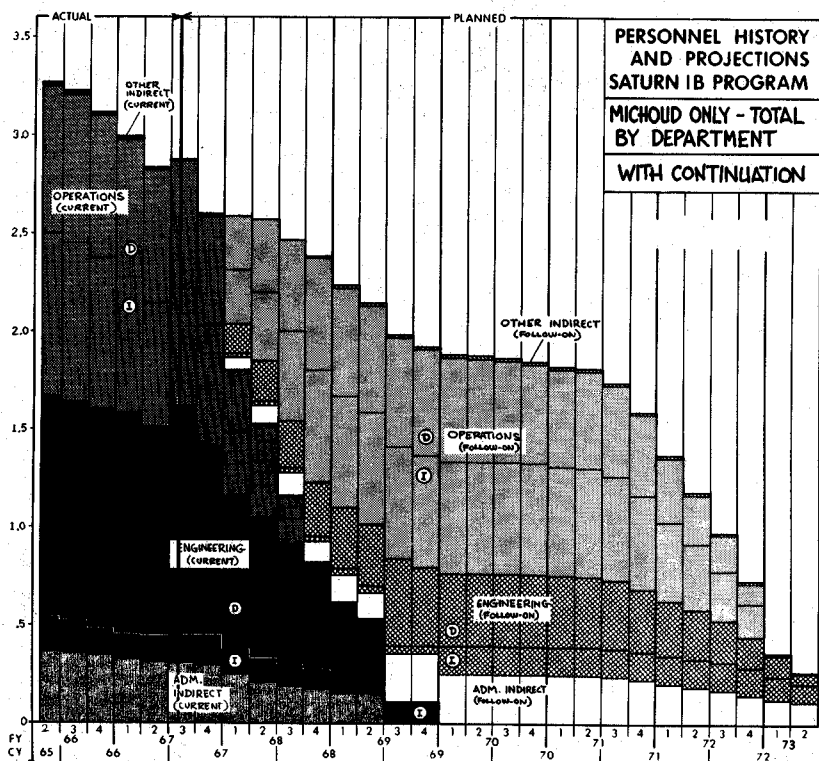


CHART 11

after the available to ship date for S-IB-12, but our plan for the accomplishment of this work calls for the elimination of static fire at Huntsville. We believe that when we get 212—both we and the Government believe—we will be in a position where static firing no longer provides us with useful information. It won't be necessary. We will be able to say, truthfully, "In the last four stages we didn't learn anything."

"We could have gone directly to the launch pad." We have one checkout instead of two and, accordingly, the time required is less than the time for S-IB-12, so that from the beginning of assembly on 12 to the beginning of assembly on 13 is one year. There's a gap from beginning to beginning 4 months greater than the gap from delivery to delivery. As you went out in the plant today you saw S-IB-12 on the assembly fixture. All of the preliminary manufacturing work on that stage has been done. That work, and the people associated with it, will not start again for a full year, so that for the next 12 months our operations in the plant are on a declining basis, even if or when we get a "follow-on" program.

We are on schedule on the schedule VI work. Our initial engineering releases on that whole block—13 through 28—are about 70 percent complete as of the end of January, which is what they should be. Our material procurement is on schedule. We have one and a half-

million dollars committed as of the end of January, which is what it should be.

We are using up \$7.2 million on this program to protect the ability to maintain program continuity, of which about \$2 million are labor and burden and the rest is materials. Now, this little block up here is the work going on between now and June 30, the preliminary work on schedule VI, to protect our ability to maintain program continuity. This leads us to the follow-on program, and at the present time, we don't have a follow-on program. We are specifically excluded from clustering any of the parts from schedule VI for example, but we did work out ground rules for the follow-on program with the Government in order to have schedule VI.

Our concept of this program calls for 16 stages, a delivery rate of four per year, with first delivery on November 1, 1968. The configuration is exactly like S-IB-12 with the exception of two changes. About one-third of the instrumentation will have been dropped out, in comparison with 12, and the discrete liquid level probes will have been dropped out, being no longer necessary. We will use a "frozen design," which means that only the "make-it-fit, make-it-work" changes needed to make the work flow will be permitted. There will be no product improvement work funded. There will be no qualification work, and no reliability improvement work. We've got a 100 percent qualified design, 100 percent reliability tested. The only exceptions here would be if we had a forced vendor change because of fire, floods, strike—you name it—and we had to bring in new vendors. In some instances we might have to qualify those vendors and establish their reliability characteristics.

There would be no static fire, with only one factory checkout. Our procurement lot size and our "make" lot size would be four; that is, we would do a years work at a time. S-IB-13, 14, 15, 16 would be the first batch, 17, 18, 19, and 20 and so on the second. We would include stage flight evaluation. We would deliver here at the Michoud dock. We would provide assistance to the Government in transporting the stage to the Cape, and we would maintain total stage design responsibility as we have it now, which means that if something goes wrong, at our vendors or otherwise, it's our problem, no one else's. We must have the solution to that problem. We have to maintain the hard core of people with the technical know-how to discharge this responsibility.

Mr. LOWREY. Mr. Meldrum, may I just interject one thing here. I don't want to give the wrong impression on the ground rules for this follow-on idea. In planning our work, we planned that it would be a frozen design, completely. Obviously we all know that should some missions require something else, then the missions would necessarily have to take care of some kind of a change.

Mr. MELDRUM. Yes, that's a separate contractual action, taken care of when you know what the change is.

Mr. LOWREY. Otherwise, the plan is to leave the birds as they are.

Mr. MELDRUM. Dr. von Braun pointed out to me at lunch that we should make sure that we understand that this type of thinking for the follow-on is tied up with missions above and beyond the mainstream Apollo missions, such as the Apollo Applications program missions and that you can't have one without the other.

You can't have the AAP if you shut this plant down and put it

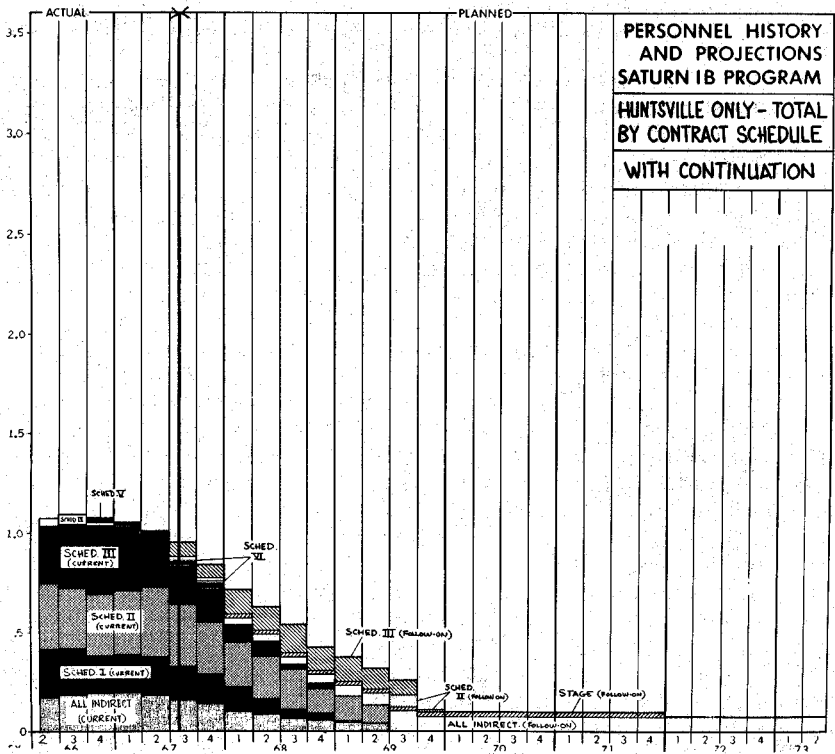


CHART 12

in mothballs for an indefinite period. You then face the tremendous cost of reestablishing an organization with technical competence. And you can't have program continuity unless you have the missions which require the use of the vehicles.

This is a budgetary and planning cost estimate of what a program of 16 birds costs. It's about \$139 million or about \$84½ million a stage. This low cost is possible principally due to the elimination of the static fire and cutting down checkout to just one checkout and having no qualification work, no product improvement work, and no reliability work.

I might say right now in order to do this we have to have a request for proposal out of the Government. We have to generate a formal proposal in response to that request. It has to be evaluated by the Government. We have to indulge in negotiations, and finally we have to have an executed contract. Historically, that's a 7-month job, so if we got the go-ahead tonight we'd be too late unless we figure out some way to expedite this process. So we need the action now—we're late—this isn't something that you can put off until a year from now. You can't put it off until June 30. Now, what happens if we go this way?

I show here in yellow, these are the charts that you saw before, if we go this way we will move from a 2,800-man organization to

NAS 8-4016

SCHEDULE VI

(PROCUREMENT OF LONG LEAD TIME COMPONENTS FOR STAGES S-I-B 13, 14, 15, 16, DESCRIPTION

DO ALL THINGS NECESSARY (BETWEEN 14 OCT '66 AND 30 JUNE '67) TO PROTECT ABILITY TO DELIVER S-I-B-13 ON 1 NOV '68 & STAGES S-I-B-14, 15 & 16 AT 3 MO. INTERVALS THEREAFTER.

STATUS

1. ON SCHEDULE
2. INITIAL ENGINEERING RELEASES S-I-B
13 THRU 28-69.6% COMPLETE (AS OF 25 JAN '67)
3. MAT'L PROCUREMENT ON SCHEDULE
(\$1,506,000 COMMITTED) (AS OF 25 JAN '67)

CHART 13

about a 1,900-man organization plateau occurring in calendar years 1969 and 1970 and tailing off in 1972. Here we are today, so we would lose about one-third of our people, instead of going down this toboggan slide to extinction at the end of 1968. In terms of the kind of people used you will notice that our engineering changes from this size (1,000) to this size (500). Our operations people change from this size to this size. At Huntsville, this part yellow shows the kind of people that would be involved. There's only a narrow strip of plain yellow that would be involved in handling the manufacturing support for this operation. Here in cross hatch we show the mechanical ground support equipment program that we expect will continue at Huntsville and here in the light blue cross hatch we show the kind of vehicle integration work that we think will continue.

Here is an interesting point to make in connection with losing and gaining large quantities of people. If we go back 19 months to June of 1965 when we were at our peak of 5,515, if we had not replaced any person who had left in this period from June of 1965 to mid-December of 1966, we would have lost 2,841 people. We have lost

NAS-8-4016

SCHEDULE VI**(LONG LEAD TIME MAT'L PROCUREMENT FOR STAGES S-I-B 13,14,15,16)****COST PLAN \$ IN MILLIONS**

ITEM	FY 1967
	14 OCT 66 - 30 JUNE 67
ENGINEERING L & B \$	1.074
OPERATIONS L & B \$	.932
OTHER L & B \$	.033
SUB-TOTAL L & B \$	2.039
OTHER DIRECT COST	
MATERIAL (STAGE) \$	3.600
MAT'L PROC. EXPENSE	.582
OTHER	.286
SUB-TOTAL	4.468
SUB-TOTAL	6.507
G & A EXPENSE & FEE	.694
GRAND TOTAL	7.201

CHART 14

over half of our people in 19 months. Now if we had retained every person that we had hired in that period and had lost none, we would be up to 7,647 people. We added 2,132 for a net loss of 709. This is an attrition rate up to this point, when our layoffs began, of a little over 3 percent per month, and this represents one of the most expensive aspects of this business. You have to hunt harder, take more trips, interview more people to get a man to come on roll when you have no assurance of program continuity. Without a follow-on program it becomes very difficult to induce people to join the team and as far as we know the only corrective means that will stop this rate of turnover is a follow-on program authorization. Nothing else will do it. Schedule VI won't do it because it is not a follow-on program.

We'll talk now about schedule II. What is it? Vehicle integra-

FOLLOW-ON CONTRACT PLANNING

'GROUND RULES'

- A. NUMBER OF STAGES 16
- B. DELIVERY RATE 4 PER YEAR
- C. FIRST DELIVERY 1 NOV 1968
- D. CONFIGURATION LIKE S-IB-12 WITH 2 CHANGES
- E. "FROZEN DESIGN" (ONLY "MAKE-IT-FIT/MAKE-IT-WORK" CHANGES)
 NO PRODUCT IMPROVEMENT WORK
 NO QUALIFICATION WORK } EXCEPT FOR FORCED
 NO RELIABILITY IMPROVEMENT WORK } VENDOR CHANGES ETC.
- F. NO STATIC FIRE-ONLY ONE FACTORY CHECK OUT
- G. PROCUREMENT LOT SIZE AND "MAKE" LOT SIZE -4
- H. STAGE FLIGHT EVALUATION INCLUDED
- I. DELIVERY AT MICHoud DOCK
- J. TRANSPORTATION ASSISTANCE INCLUDED
- K. CHRYSLER TOTAL STAGE DESIGN RESPONSIBILITY
CONTINUED

CHART 15

tion work. The effort is directed toward the creation and maintenance of all of the required preflight and postflight analyses for each mission and these are published as reports. The output of schedule II is books, not hardware. Trajectories, vehicle mass distributions, launch constraints and so forth. Current activities both here at Michoud and Huntsville is authorized until the middle of 1969 but a definitive contract is still under negotiation. This work is being authorized on a month by month basis at about \$1 million a month. We expect that this will continue for about 24 months.

This will give you a bird's eye view of what comes out of that work. All the preflight mission analysis reports on 1, 2, 3, and 4 were 100-percent complete 5.82, 6.51, 7.27, 8.27, and 9.14 percent, and we have not started on 10, 11, and 12. On the postflight mission analyses reports 1, 2, and 3 are complete and, of course, we can't start on the others until the flights take place.

COST PLAN

16 STAGE "FOLLOW-ON" PROGRAM
\$ IN MILLIONS

SCHED. VI →	FISCAL YEAR							TOTAL
	67	68	69	70	71	72	73	
ENGINEERING L&B \$	1.074	3.709	6.345	6.868	7.074	4.656	.919	30.645
OPERATIONS L&B \$	.932	7.437	9.691	9.982	8.347	2.899	.007	39.295
OTHER L&B \$	.033	.562	.505	.520	.401	.122	.001	2.144
SUBTOTAL L&B \$	2.039	11.708	16.541	17.370	15.822	7.677	.927	72.084
OTHER DIRECT COSTS								
MAT'L (STAGE) \$	3.600	11.700	9.300	9.299	2.973	.326	0	37.198
MAT'L PROC. EXP. \$	.582	1.365	2.204	2.269	2.069	1.041	0	9.530
OTHER \$	.286	.594	1.354	1.386	1.339	.955	.031	5.945
SUB TOTAL \$	4.468	13.659	12.858	12.954	6.381	2.322	.031	52.673
3% A EXPENSE & FEE \$	.694	2.982	3.390	3.497	2.561	1.153	.109	14.386
GRAND TOTAL \$	7.201	28.349	32.789	33.821	24.764	11.152	1.067	139.143

CHART 16

Congressman TEAGUE. What does a postflight analysis look like?

Mr. MELDRUM. The postflight analysis compares what actually did happen in flight with what was supposed to have happened and tracks down, with the analysis, what could have caused the difference. It is a feedback into the designer to make sure that he is able to predict with greater accuracy what is supposed to happen, or how to make what is supposed to happen, happen on the next flight. It involves everything, telemetry, instrumentation, powerplant analysis, structure, vibration, thermal environment, you name it, it covers the whole spectrum of technology.

Mr. LOWREY. It might be interesting to note that, in this regard, the first four vehicles were highly instrumented to tell a very great deal of information—S-IB-1, 2, 3, and 4. After that, we feel we will not have to get that much information on the other vehicles and so the telemetry and instrumentation have been cut from maybe 1,200 channels to something like 400.

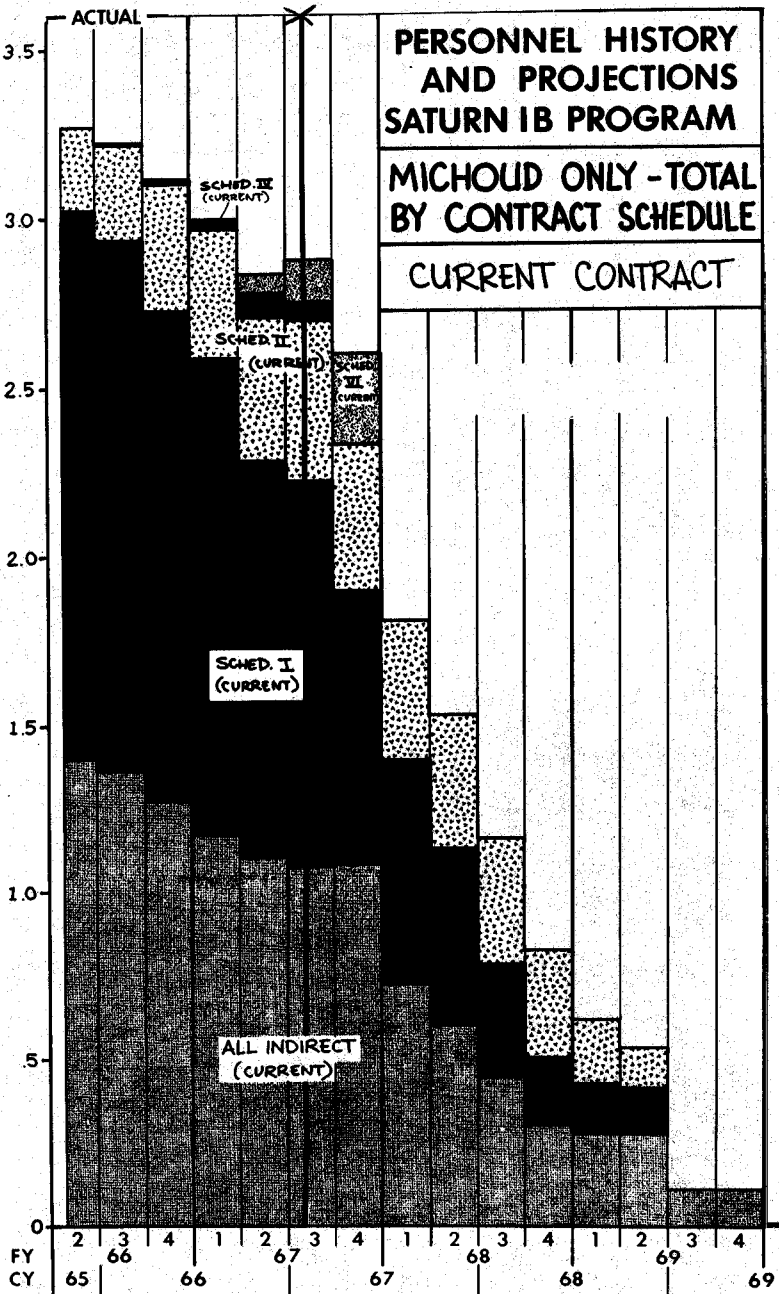


CHART 17

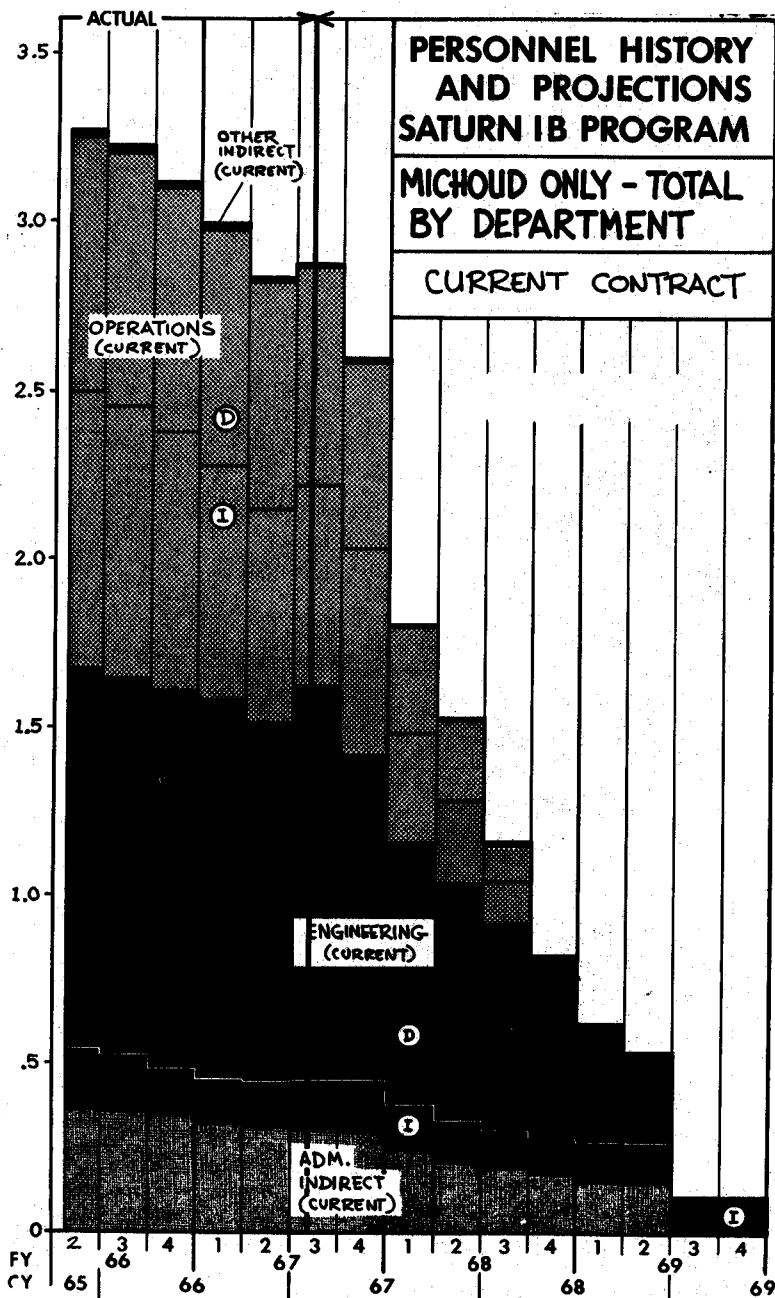


CHART 18

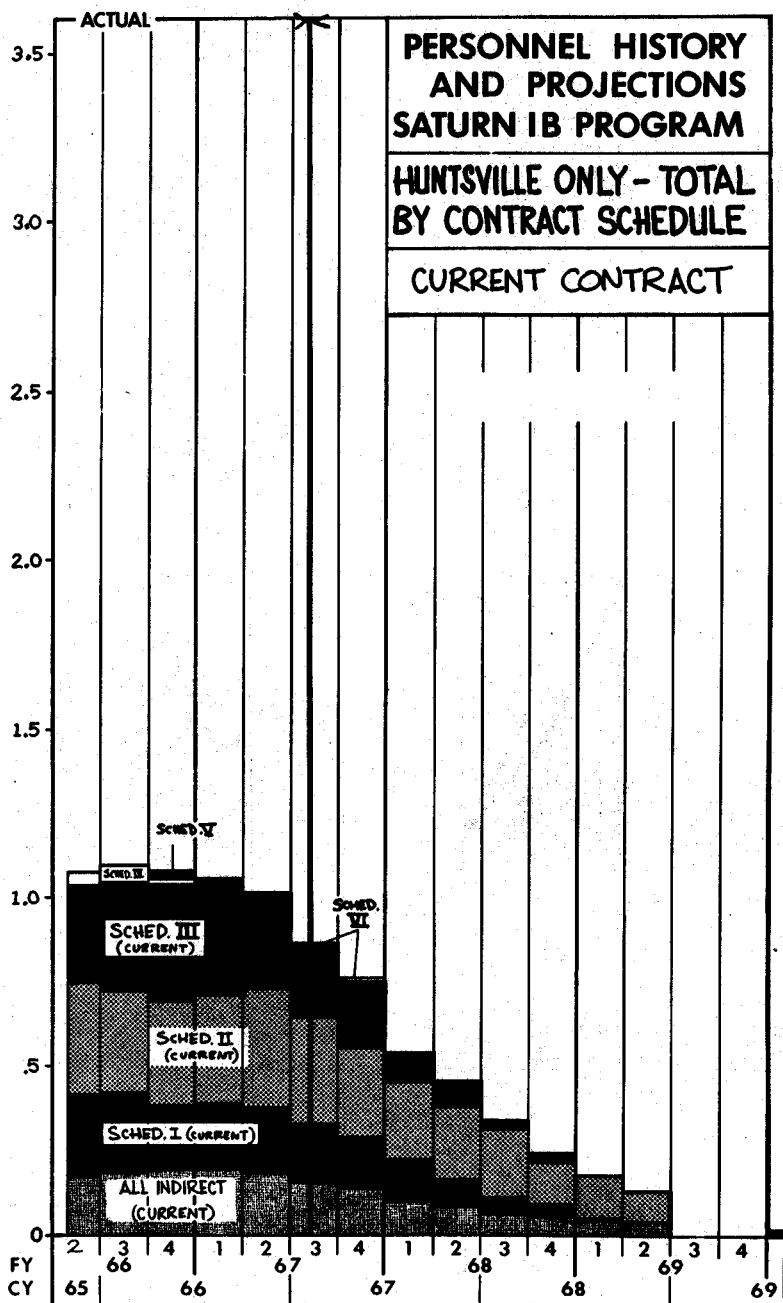


CHART 19

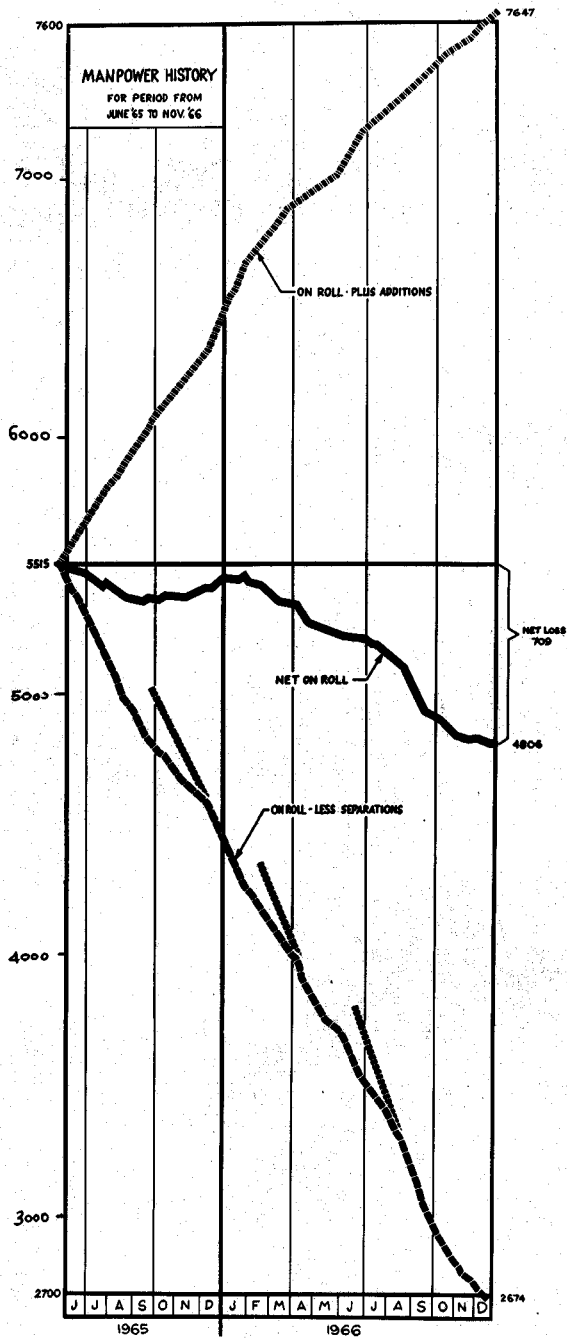


CHART 20

NAS 8-4016

SCHEDULE II-VEH. INTEGRATION (DESCRIPTION)

1. EFFORT IS DIRECTED TOWARD THE CREATION AND MAINTENANCE OF ALL REQUIRED PRE-FLIGHT & POST-FLIGHT ANALYSES FOR EACH MISSION. THESE ANALYSES ARE PUBLISHED AS REPORTS.
(TRAJECTORIES-VEHICLE MASS DISTRIBUTIONS, LAUNCH CONSTRAINTS, ETC.)
2. CURRENT ACTIVITY(AT BOTH MICHOU D AND HUNTSVILLE) IS AUTHORIZED UNTIL 30 APRIL 1969, BUT A DEFINITIVE CONTRACT IS STILL IN NEGOTIATION. WORK IS FUNDED ON A MONTH-TO-MONTH BASIS AT APPROXIMATELY \$1 MILLION PER MONTH.

CHART 21

Mr. MELDRUM. This is a picture (see chart 23) of what is actually under contract as of the end of January 1967; \$15.78 million, of which \$14.225 is labor and burden. You see it's almost all labor and burden, and as I mentioned, this authorization is flowing at the rate of about a million a month, and as far as looking at people is concerned, it's these people until the end of January.

It's these people at the end of January and we believe it's these people for the balance of the 12-bird program. Now I have not shown on any of these charts, this kind of work that would be continued when we go into a follow-on program. Some kind of work of that type will have to take place under some arrangement.

Now we are going to talk about schedule III, mechanical ground support equipment. What is it? It's sustaining engineering oriented to (1) design and maintenance of design of required mechanical ground support equipment, cooling units, pneumatic consoles, handling equipment, dollies, and so forth, for which MSFC has responsibility. This is distinguished from that for which KSC has

responsibility, associated with the launching tower and the umbilical tower. Secondly, the establishment and maintenance of a logistics supply system for the MGSE here and (3) (this is a little unusual) for the operation of what we call the Systems Development Breadboard Facility (SDBF). This is a computer-oriented facility at Huntsville at which all of the functions that take place on the launch pad are simulated electrically and it becomes possible to develop the program tapes which are delivered to the computer at Kennedy for the control of the launch process. All of this work is being done at Huntsville. It is currently authorized through June 30, 1968.

On status, we've delivered all of the materials that we should have delivered; the ground servicer cooling units, the wafer accumulators, the calibration in-place consoles, the flow control valve boxes. Our refurbishment program is 85 percent complete, which is what it should

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SCHEDULE II

VEHICLE INTEGRATION STATUS (AS OF 1 FEB. 1967)

VEHICLE NUMBER	PRE-FLIGHT MISSION ANALYSES REPORTS % COMPLETE	POST-FLIGHT MISSION ANALYSES REPORTS % COMPLETE
AS-201	100 %	100 %
AS-202	100	100
AS-203	100	100
AS-204	100	0
AS-205	82	0
AS-206	51	0
AS-207	27	0
AS-208	27	0
AS-209	14	0
AS-210 } AS-211 } AS-212 }	0	0

be, and we are running the engineering change proposals for modification kits on schedule.

Our logistics is on schedule. We've delivered the spare parts that are required.

On the breadboard, we've simulated the complete Saturn 1B Launch Vehicle System for AS 201, 202, and 203. On 204, all our computer programs have been "debugged," and we are now at work on the 206 computer program verification. We are 40 percent complete. We're on schedule.

We have \$8.4 million under contract. This is part by hardware, part by books, since we actually deliver some hardware. We expect another \$4.4 million to come, and it will be spread through this whole time period as I have shown on these "people" charts. This yellow, here, is that continuation and enlargement of that schedule III work.

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SCHEDULE II
VEHICLE INTEGRATION
COST PLAN
(1 NOV 65 - 31 JAN 67)
\$ (MILLION)

ITEM	PARTIAL FY 66 1 NOV 66 30 JUN 66	PARTIAL FY 67 1 JUL 66 31 JAN 67	TOTAL
L & B \$			
MICHOUD	4.363	4.830	9.193
HUNTSVILLE	2.376	2.631	5.007
OTHER	.012	.013	.025
SUB-TOTAL \$	6.751	7.474	14.225
OTHER DIRECT CHARGES \$	.164	.182	.346
SUB-TOTAL \$	6.915	7.656	14.571
G & A EXPENSE & FEES \$	.574	.635	1.209
TOTAL	7.489	8.291	15.780

NOTE : ADDITIONAL WORK IS BEING AUTHORIZED AT APPROX.
 \$1 M PER MONTH WHILE DEFINITIVE CONTRACT IS BEING
 NEGOTIATED. WORK WILL CONTINUE UNTIL 30 APRIL 1969

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SCHEDULE III-MECHANICAL GROUND SUPPORT EQUIPMENT

(MSFC RESPONSIBILITY)
DESCRIPTION

A. WORK IS SUSTAINING ENGINEERING ORIENTED TO :

1. (DESIGN & MAINTENANCE OF DESIGN OF REQUIRED MECHANICAL GROUND SUPPORT EQUIPMENT) (MGSE) (COOLING UNITS, PNEUMATIC CONSOLES, HANDLING EQUIP., DOLLIES, ETC.) FOR WHICH MSFC HAS RESPONSIBILITY.
2. THE ESTABLISHMENT & MAINTENANCE OF A LOGISTIC SUPPLY SYSTEM FOR THE MGSE OF (1) ABOVE, &
3. THE OPERATION OF THE SYSTEMS DEVELOPMENT "BREADBOARD" FACILITY (SDBF)

B. ALL OF THIS WORK IS BEING DONE AT HUNTSVILLE, ALA.

C. CURRENT ACTIVITY IS AUTHORIZED THROUGH 30 JUNE 1968.

CHART 24

Now we'll go to the Cape, schedule IV, the launch mission. We have 18 tasks. I'll point out only a few of them. Task I, which is one of the largest, is the actual job of launching the birds, with pre-launch and launch operations. Tasks 9, 10, 11, 12, and 13, are for the modification of launch complexes 34 and 37B. The rest of them are engineering support tasks.

With regard to launching the birds, we've already run through how we stood. We've launched SA 9, 8, and 10, 201, 203, and 202 on these dates successfully. 204 is at the Cape in prelaunch preparations. 206 is at the Cape in prelaunch preparations. We've completed the modification of launch complexes 34 and 37B on November 17, 1965, and May 17, 1966. From now on our work in these areas is to modify these launch complexes for different missions, as they come up from time to time.

SCHEDULE III

MECHANICAL GROUND SUPPORT EQUIPMENT (MSFC) STATUS

1. M.G.S.E.

- (1) DELIVERED AS 201, 202 AND 203 GROUND SERVICER COOLING UNITS, WATER ACCUMULATORS, CALIPS CONSOLES AND FLOW CONTROL VALVE BOXES. ALL OF THESE ARE SERVICEABLE.
- (2) AS 204 - REFURBISHMENT PROGRAM FOR ALL GROUND SERVICER COOLING UNITS - 85% COMPLETE (AS OF 1 FEB 67).
- (3) ENGINEERING CHANGE PROPOSAL/MODIFICATION-KITS ARE BEING DELIVERED ON SCHEDULE.

CHART 25

We look at the manpower involved along with the money we've got—\$69 million is involved here, of which \$46 million is labor and burden. We are operating a group of roughly 1,000 people. Our contractual coverage ends in the middle of 1968. When we go to a follow-on program, all of these birds will also be launched. We will need a continuation of this work for as long as birds are going to be launched. It will involve, say 550 people for launching, and the number of people in addition to that—say, up to 750—will depend upon the amount of other kinds of engineering work needed by Cape Kennedy.

That completes the program review on our Saturn work—on NAS 8-4016 work. That leaves me about two items that are not NAS 8-4016. One is the Saturn improvement study which we've done for NASA. This was done in two phases which we have finished at a cost of about a half-million dollars. The other is an optical technology study. This picture (see chart 33) shows the bird as we have it today. It is capable of putting about 40,000 pounds in near earth orbit. The next bird in line, George Stoner's Saturn V, has a capability of about seven times that or more, 280,000 to 300,000 pounds in near earth orbit. There isn't anything in between. This is the so called "payload gap." There is an intense interest in a lot of areas on what are some of the best means of filling this payload gap. What

SCHED. III (CONT'D.)**2. LOGISTICS**

- (1) PROGRAM PLAN DELIVERED 11 JAN 67
- (2) DELIVERED 2975 SPARE PARTS FOR AS 204 OF 3259 INITIALLY REQUIRED (AS OF 1 FEB 67). BALANCE TO BE DELIVERED PRIOR TO 1 MAR 67.
- (3) RELEASED 984 SPARE PARTS FOR PROCUREMENT FOR AS 205 AND SUBSEQUENT STAGE MECH. GROUND SUPPORT EQUIPMENT (AS OF 1 FEB 67). DELIVERY SCHEDULED FOR COMPLETION BY 30 APRIL 67.

CHART 26

SCHED. III (CONT'D.)**3. "BREADBOARD"**

AS 201 } SIMULATED THE COMPLETE SATURN
202 } IB LAUNCH VEHICLE SYSTEM AND
203 } ASSOCIATED SUPPORT EQUIPMENT.

AS 204 ALL COMPUTER PROGRAMS "DE-BUGGED".

AS 206 COMPUTER PROGRAM VERIFICATION IN PROGRESS. WORK 40% COMPLETE (1 FEB 67) AND IS ON SCHEDULE.

CHART 27

NAS-8-4016

SCHEDULE III**MECHANICAL GROUND SUPPORT EQUIP. (MSFC)
COST PLAN \$(MILLIONS)****1 NOV '65 THRU 30 JUNE '68**

ITEM	FY'66	FY'67	FY'68	TOTAL
LABOR & BURDEN \$	3.388	1.945	.946	6.279
OTHER DIRECT COST \$	1.154	.156	.0	1.310
SUB TOTAL \$	4.542	2.101	.946	7.589
G & A AND FEE \$	.479	.222	.100	.801
GRAND TOTAL	5.021	2.323	1.046	8.390

CHART 28

are some of the best means of going from 40,000 to 100,000 pounds with maximum economy? This configuration—center—shows this same vehicle equipped with four United Technology 120-inch diameter solid rockets of five segments. And this picture—right—shows one where the S-IB stage has been elongated 20 feet and is equipped with four United Technology 120-inch diameter solid rockets of seven segments.

Here are some of the capabilities that result from this. With this configuration—center—instead of 40,000 we can place 78,000 pounds in near earth orbit—105 nautical miles. For a space station at 200 nautical miles we go from 33,000 to 70,000 pounds on direct injection. If we use a Hohmann Transfer Ellipse we go from 36 to 73,000. For an elliptical orbit of about 85 to 200 miles, not circularized, we go from 41,000 to 78,000. For synchronous orbits—of space stations in the sky with no apparent movement—we go from zero, with what we have now, to 3,350 pounds. For escape out of this planetary system we go from 1,650 pounds to 18,000, and for near earth polar orbits from Kennedy we go from 30,000 to 60,000. If we go into the seven segments with the 20-foot extensions, we have over 100,000 pounds in near earth orbit. Here we have 11,150 pounds synchronous, 28,500 pounds escape, and 75,000 pounds for polar orbits.

Dr. VON BRAUN. Mr. Meldrum, it might be worth mentioning in this

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SCHEDULE IV LAUNCH MISSION(KSC-1)

DESCRIPTION

- TASK 1 PRE-LAUNCH AND LAUNCH OPERATIONS (MSFC FUNDED)
- TASK 2 GROUND SUPPORT EQUIPMENT OPERATIONS
- TASK 3 DOCUMENTATION OF GROUND SUPPORT EQUIPMENT
- TASK 4 SPARES SUPPORT G.S.E.
- TASK 5 REFURBISHMENT OF LAUNCH COMPLEXES (OFF-SITE)
- TASKS 6,7 AND 8 G.S.E. SUSTAINING ENGINEERING
- TASKS 9 AND 10 MODIFICATION OF LAUNCH COMPLEX 34
- TASKS 11,12 AND 13 MODIFICATION OF LAUNCH COMPLEX 37B
- TASK 14 APOLLO FLIGHT READINESS REVIEW REPORT INPUTS
- TASK 15 TESTING OF UPRATED SATURN I GROUND SUPPORT EQUIPMENT (FUNCTIONAL, QUALIFICATION AND RELIABILITY)
- TASK 16 INTEGRATION SUPPORT-(PROCEDURES-RULES-SCHEDULES, ETC.)
- TASK 17 TRAINING
- TASK 18 RELIABILITY ENGINEERING

CHART 29

connection that these UTC units are already man-rated in connection with the DOD Titan III program.

Mr. MELDRUM. That's a real good point, Dr. von Braun. All of this is here. This is not a scientific program. This is an engineering program.

Dr. VON BRAUN. You just stack them up.

Mr. MELDRUM. This is "state-of-the-art." We have this today.

Congressman ECKHARDT. Is there any reason that you plan to do this with separate tanks rather than with the setup that you have in Saturn V with a single tank?

Mr. MELDRUM. Well, this particular concept calls for using what we have, which is fully qualified and fully reliability tested; using it as it is and making only minor structural changes to attach the solid propellant boosters.

Mr. LOWREY. Mr. Meldrum, I would like to add something, if I may.

Mr. MELDRUM. Sure.

Mr. LOWREY. I think that we are in a somewhat similar position, in some respects, to that which we were in 5 to 6 years ago, in that it is difficult for us to know all of the payloads that are going to be required over the next 10-year span. As we get into them, one is going to develop another and change our pattern and change our need. With this kind of work, with this kind of strap-on unit added to this bird,

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SCHEDULE IV-LAUNCH MISSION (KSC-1)

STATUS

TASK 1 LAUNCH OPERATIONS

SA-9	16 FEB 65
SA-8	25 MAY 65
SA-10	30 JULY 65
AS-201	26 FEB 66
SA-203	5 JULY 66
AS-202	25 AUG 66

204 - IN PRE-LAUNCH PREPARATION
206 - IN PRE-LAUNCH PREPARATION

TASK 10 & 11 - MODIFICATION OF LAUNCH COMPLEXES 34 AND 37B

LC 34 COMPLETED 17 NOV 65
LC 37B COMPLETED 17 MAY 66

CHART 30

we can take a core vehicle and have the flexibility of going from a 40,000-pound load in orbit to 50,000 pounds by putting on two strap-ons. By putting on four we can get 78,000 pounds. By enlarging the core tanks and using the seven segment job we can go up to 106,000 pounds, and we can use the kind of vehicle needed to put up the kind of payload that develops over the next few years. Consequently, I think that this is a very worthwhile thing for us to get into as soon as we can.

Dr. von BRAUN. I would like to reinforce a statement here. We made a study on logistic supply of a permanent space station and it just is not so that you need to resupply the station only once a year. You might say why don't we fly up only once a year and use a big Saturn V. There are certain areas, for example, in the scientific area where a man has a job to do up there which may take only 3 months for collection of all the scientific data that he wants. Then the man wants to come home and evaluate his data on the ground. Now if there is only one airplane going every year to bring the man home we have the guy up there for three-fourths of the year without getting much out of it. On the other hand, our study also shows that every now and then there comes a bigger payload along that you don't want to break down into smaller modules, because you burden the operation with an additional assembly operation in orbit, which again is costly, so it is

SCHED. IV
LAUNCH MISSION (KSC-1)
COST PLAN (FOR WORK
UNDER CONTRACT AS OF 27 JAN 1967)
PERFORMANCE PERIOD - 1 FEB 65 THRU 30 JUNE 68
\$(MILLIONS)

ITEM	FY65	FY66	FY67	FY68	TOTAL
KSC L&B	3.377	14.255	13.802	11.975	43.409
OTHER L&B	1.781	.775	.749	0	3.305
TOTAL L&B	5.158	15.030	14.551	11.975	46.714
OTHER DIRECT COSTS	1.594	11.928	1.751	.226	15.499
SUB TOTAL	6.752	26.958	16.302	12.201	62.213
G&A EXPENSE & FEE	.754	2.898	1.726	1.312	6.690
GRAND TOTAL	7.506	29.856	18.028	13.513	68.903

CHART 31

really so that a flexible logistic supply system that gives you a free choice of 40,000 pounds, or 78,000 pounds, or 106,000 pounds in Earth orbit is a reasonable kind of thing. By the way, what we are really doing here is endorsing, on the next larger scale, the same findings as the Air Force made with their Titan II and Titan III philosophy. So I believe that there is great merit in this, particularly as we are addressing ourselves to permanent space stations and all these Apollo Applications of Earth resources, science, meteorology, air traffic control from orbit and those things that I illustrated yesterday. The elements are here. We have the advanced Saturn, the uprated Saturn in production. These 120-inch segmented units are available, man-rated so that all we have to do is put two and two together and there is that capability. If we don't take up the option, all of this capability goes to seed, and to put this together again after a hiatus in this whole thing is extremely costly.

Congressman TEAGUE. Mr. von Braun, is it feasible and logical to keep the production lines intact and put some of these in storage, even though, at the moment you make it, you may not have a mission for them?

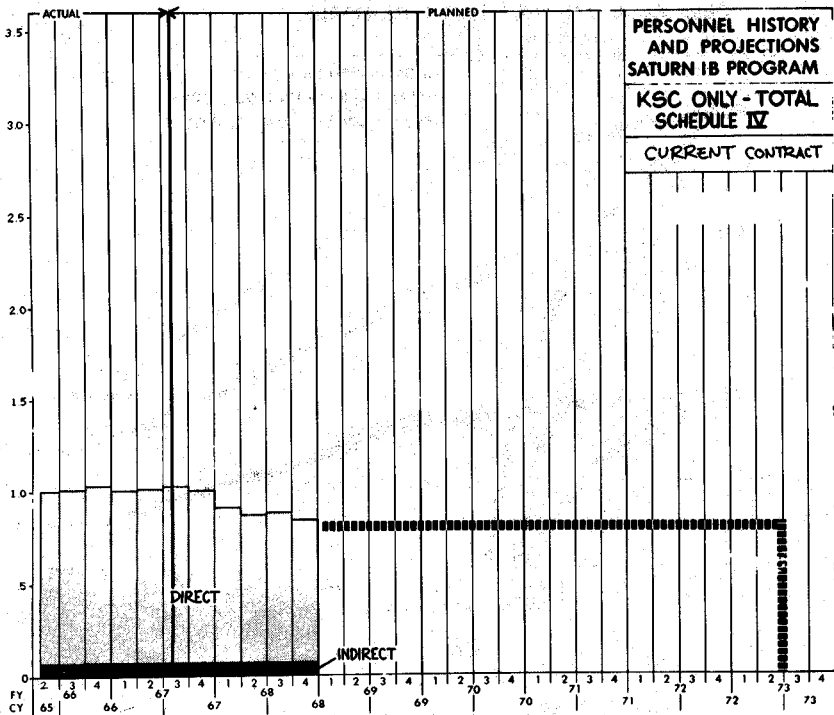


CHART 32

FUTURE IMPROVED SATURN PROGRAMS

MISSION	PAYLOAD - LBS.		
	VEHICLE TYPE		
	SA-212	+4-UTC 1205	+4-UTC 1207
NEAR EARTH ORBIT	40,000	78,000	106,000
SPACE STATIONS (200 N.M)			
DIRECT INJECT	33,000	70,000	94,500
HOHMANN	36,000	73,500	101,000
ELL. 85 x 200 (NOT CIRCULARIZED)	41,000	78,000	105,000
SYNCHRONOUS (1=0)	-	3,350	11,150
ESCAPE	1,650	18,000	28,500
NEAR EARTH POLAR FROM KSC	30,000	60,000	75,000

CHART 33

WORK OTHER THAN NAS-8-4016

B. OPTICAL TECHNOLOGY STUDIES

I. IDENTIFY, DEFINE & PROVIDE REQUIREMENT JUSTIFICATION FOR MAXIMUM VALUE OPTICAL TECHNOLOGY EXPERIMENTS.

II. DEVELOP A PLAN FOR ACCOMPLISHMENT OF THE EXPERIMENTS OF PART I, DO PRELIMINARY EXPERIMENT INTEGRATION, SPACE CRAFT AND SUB-SYSTEM CONCEPTUAL DESIGN & RESOURCE ANALYSIS

CHART 36

Dr. von BRAUN. We are doing it now and I would say the answer is "Yes." I think that it is probably much better over the 10-year haul to keep a limited production going, even though it is only four a year and keep that capability alive because that capability is people, really. It is not so much facilities or hardware, it is people and if that team is dissipated then we have to build up a new team. Not only is it very expensive to rebuild a new team, but we also go right back to the bottom of the learning curve. We start making mistakes again, things come apart, we may have mishaps in the launch, et cetera. Right now we are on top of the pole. I think the answer is "Yes." If we cannot identify all of our flight missions in the Apollo Applications area precisely for the next couple of years, I would say by all means let us keep a moderate production rate of these rockets going. Whatever few part-aging problems we have—and there are a few—O rings age and rubber gets a little brittle—these things can be taken care of. We can identify them and we can even assemble them without the O rings and stick the O rings in whenever we are down to T-minus 3 months.

Mr. LOWREY. Mr. von Braun, we are in agreement with that and would like to point out one thing that I feel is extremely important from the direction that you gave us on this job, and that was that we make full use of all the things that the Air Force had developed already. We did not begin something new or something different. We took full advantage in the uprated Saturn I-B's, of all the solid rockets that UTC was already building.

Dr. von BRAUN. It might be interesting to compare these figures of payload with the figures of Titan. The Titan II, which is the non-boosted type and which was used for the Gemini launches, has an Earth

orbital capability in the order of 8,000 to 9,000 pounds, and when you strap on the five segmented two boosters to the Titan II, making the Titan III-C out of it, you are at about 25,000 pounds payload. Now, we are already at 40,000 pounds with the unboosted version, and we go from there so you are actually talking about two different animals. You can see you are comparing the DC-9 with the Boeing 707 here. We can add on, and they can add on, but when they add on all that they can add on, they get to about the point where we start, unboosted, so that it is really incorrect to say that the Uprated Saturn I and the Titan III are two competing vehicles. No, it is a case of a small vehicle versus a big vehicle. I think it is as simple as that.

Mr. MELDRUM. To summarize this, the outstanding characteristic that attracts attention here is this versatility.

I want to thank you, Doctor, for the talk, I couldn't have done better myself. Here is another way of looking at the same data. Here we are with the Saturn I-B. With direct injection we run out of payload capability at around 500 nautical miles. With a Hohmann Transfer Ellipse, with S-IV-B restarting, we carry this up to 20,000 pounds escape capability.

Mr. LOWREY. You'd better tell them what a Hohmann Transfer is.

Mr. MELDRUM. Well, I'll quote Dr. von Braun. When you put the payload into an elliptical orbit, when you get it to the apogee (the furthest point away) you give it a kick in the apogee. This ability to restart, with a kick in the apogee, is the essence of the Hohmann Transfer Ellipse.

With the 7 segment bird, again, there's no great improvement in direct injection; possibly you run out between 500 and 1,000 nautical miles, but again, with the restart capability we can go up to 110,000 pounds in near Earth orbit and up to 29,000 pounds to escape.

Now what does this mean to us to do a job like this? Obviously we can't answer all of the questions on this because it depends upon how many would need to be made and when they would need to be made, but if we're here today and we were authorized to do this job today, this SIP (Saturn Improvement Program) shows the personnel involved to do the engineering job; all of these would be engineers. So that, at the end of calendar year 1970 (3 years from now) we would be able to launch say bird 219 and 220, the 7th and 8th birds that will come from the follow-on program in the new configuration and thereafter we would be able to have versatility (see chart 35).

The birds would flow, and they could be flown either with no solid boosters, with two 5 segments, and with four 5 segments, two 7 segments, four 7 segments (you name it), depending upon what was needed.

Mr. LOWREY. I would like to point out our purpose in showing that.

Mr. MELDRUM. We have the people right here.

Mr. LOWREY. We now have more than are really needed.

Mr. MELDRUM. You don't have to build a new team—we've got the people here. We won't have when we get to 1968, but we do have now.

Now the other item on work other than NAS 8-4016 is the optical technology study area. We have worked on this under two contracts with NASA and our work has been, in a first phase, to identify, define, and provide the requirement justification for maximum value optical technology experiments in space. Our second phase was to develop a plan for the accomplishment of the experi-

ments of part I; do the preliminary experiments integration for spacecraft and subsystems conceptual design and resource analysis. Now out of this work thus far has come a concept, for example, of a space station which is built up on the LEM structure. For example, in this area we have what is called a Mirror figure test well. The word "figure" here means "shape." Here on the surface of the Earth we are constantly surrounded with a boiling atmosphere. It really doesn't pay to try to make astronomical mirrors to superprecision because you can't use superprecision anyway. We are diffraction limited, but when you put your space station above the Earth's atmosphere, it pays to be able to maintain a shape to within a fraction of a wavelength of light and therefore, we have illustrated a concept, for example, of establishing a mirror attached to an extremely rigid backing plate with perhaps 30 or 40 tubes—metallic tubes—each tube under varying hydraulic or pneumatic pressure so that you can move a part of the reflecting surface a part of a wavelength of light.

As this mirror is subjected to varying thermal fields from radiation from the Earth or from the Sun; as it is subjected to the presence or absence of the gravitational fields, or it's own structural deflections, these things can be compensated for.

Here we have laser telescopes with some outstanding characteristics. One of course is that they utilize high frequency energy; much higher than any radio frequency, and so they have the capability of transmitting enormous quantities of information. The other is that they are extremely collimated, that is, parallel. A 3-inch laser on the surface of the Earth puts about a 300-foot spot on the surface of the Moon. And so it's a communication means from Earth to Moon or Earth to Planet, if it can be aimed with sufficient precision, or from satellite to satellite. Certainly the laser is going to be exploited, along with its pointing mechanism, as one of the first things that is done in space technology. We have stellar-oriented telescopes.

Dr. VON BRAUN. I might also mention the military significance of this. With such a laser communication system you have an inherently safe communication link, because there is no problem of code cracking, it is a problem of simply not looking at you.

Mr. MELDRUM. Aiming.

Dr. VON BRAUN. Aiming at you, and you can get messages from the Pentagon to Vietnam that nobody in principle can intercept because nobody receives any energy except the military receivers stationed at the far end.

Mr. MELDRUM. Here is our summary—all of our Saturn vehicle launchings have been successful. All Chrysler Saturn work is on or ahead of schedule. The S-IB stage which we make is fully qualified, fully reliability tested, and is man rated. Our experienced Chrysler Saturn program costs, and our cost projections to program completion, are less than the targeted amounts. Activity has been authorized up to June 30, 1967, for the continuation of the program that will protect our program continuity of four IB stages per year when a follow-on program is authorized before the 30th of June. There is urgent need for immediate authorization of such a follow-on program. Without that authorization the major program will terminate in mid-1968.

Are there any questions? If not, we're about 8 minutes after 1, I think we're running 8 minutes late. We'll probably have to move on to the Boeing area. Thank you Congressman Teague.

Congressman TEAGUE. Thank you, sir.

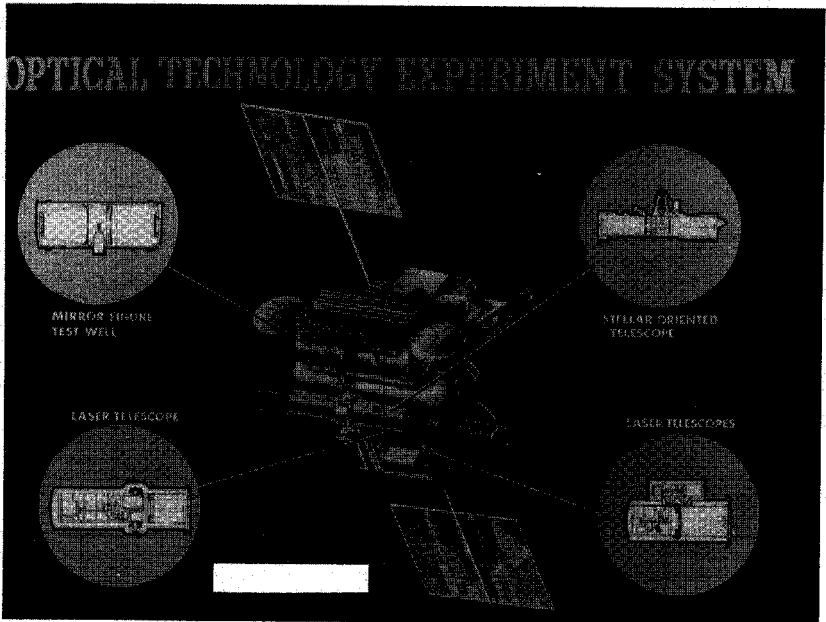


CHART 37

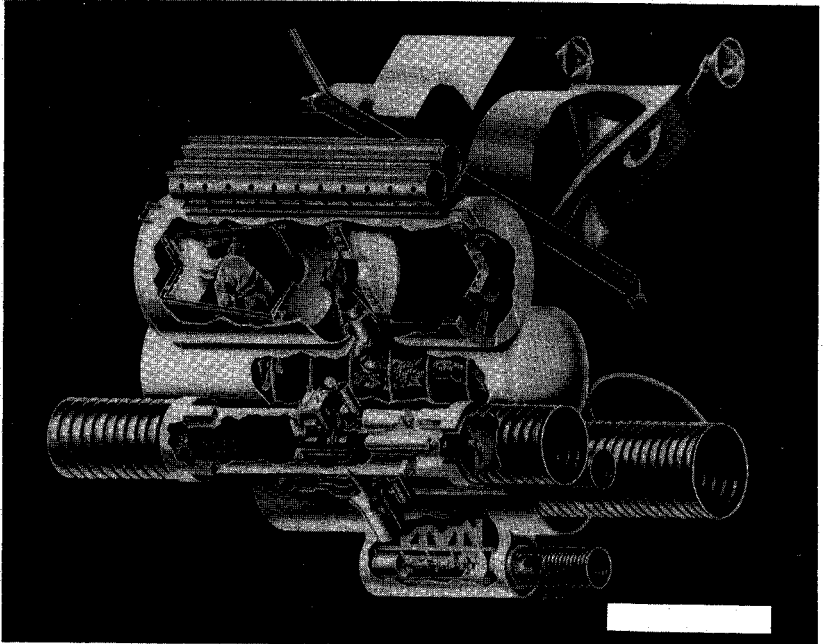


CHART 38

SUMMARY

- 1. ALL SATURN VEHICLE LAUNCHES HAVE BEEN SUCCESSFUL.
- 2. ALL CHRYSLER SATURN WORK IS ON OR AHEAD OF SCHEDULE.
- 3. THE S-I-B STAGE IS FULLY QUALIFIED, FULLY RELIABILITY TESTED, AND MAN-RATED.
- 4. EXPERIENCED CHRYSLER SATURN PROGRAM COSTS AND COST PROJECTIONS TO PROGRAM COMPLETION, ARE LESS THAN TARGETED AMTS.
- 5. ACTIVITY HAS BEEN AUTHORIZED IN FY67(SCHED. VI) THAT WILL PROTECT PROGRAM CONTINUITY OF 4 S-I-B STAGES PER YEAR IF A "FOLLOW ON" PROGRAM IS AUTHORIZED BEFORE 30 JUN 67.
- 6. THERE IS URGENT NEED FOR IMMEDIATE AUTHORIZATION OF SUCH A "FOLLOW ON" PROGRAM. WITHOUT SUCH AUTHORIZATION, THE MAJOR PROGRAM WILL TERMINATE IN MID 1968.

CHART 39

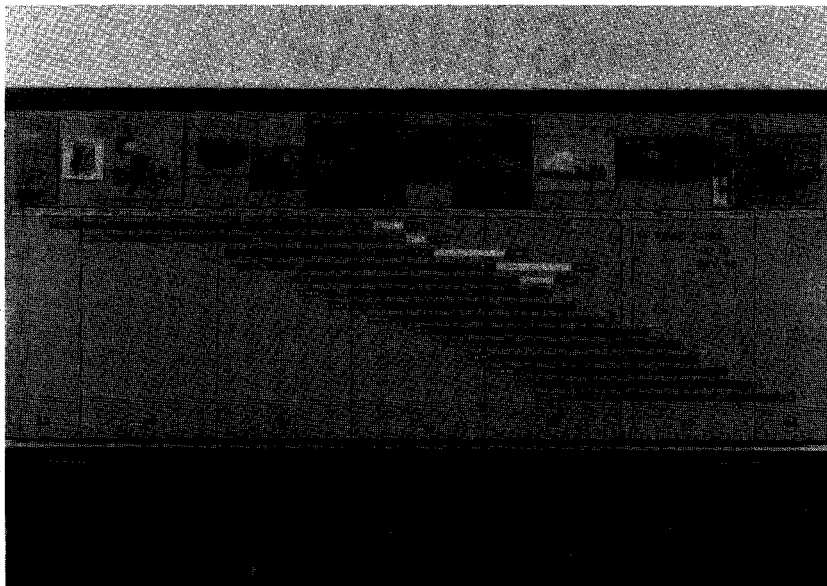


CHART 40

APPENDIX D

HEARINGS OF THE SUBCOMMITTEE ON MANNED SPACE FLIGHT, NORTH AMERICAN AVIATION, INC., SEAL BEACH, CALIFORNIA, FEBRUARY 17, 1967

SPACE AND INFORMATION SYSTEMS DIVISION

FOREWORD

Information in this document was presented to the Subcommittee on Manned Space Flight, Committee on Science and Astronautics, House of Representatives, by North American Aviation's Space and Information Systems Division, at Downey, Calif., on February 17, 1967.

Government personnel present were:

Subcommittee: Hon. Olin E. Teague, chairman, Hon. Edward J. Gurney, Hon. Earle Cabell, Hon. Jerry L. Pettis, Hon. Larry Winn, Jr.

Staff: James E. Wilson, technical consultant; Peter A. Gerardi, technical consultant.

NASA: Robert F. Freitag, Director, Manned Space Flight Field Center Development, NASA Headquarters; John S. Brown, Legislative Affairs, NASA Headquarters.

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HARRISON A. STORMS. Gentlemen, it is my pleasure to welcome you here today. As you are well aware, you are visiting the Space and Information Systems Division of North American Aviation, which is one of seven divisions in our corporation.

I would like to have Bob Greer, our program manager in the Saturn S-II, discuss that program with you.

OLIN E. TEAGUE. Bob, I'm not sure that Larry Winn knows exactly where the S-II fits in this total picture. Everybody else does, but I don't know whether Larry does or not. He hasn't been on a trip with us before. So, you might tell him first where the S-II fits in, exactly what it is and where it is.

ROBERT E. GREER. This will be approximately a 1-hour presentation on the S-II (slide 1). I have a chart here very early in the discussion which I believe will describe the position of the S-II in the Saturn V stack, but first I would like to give you an outline of what I am going to discuss (slide 2).

I will start out with a general orientation on the characteristics of the stage, and, at this time, I will also show where it fits into the stack; I will then talk for a few minutes on the broad scope of the program; I will then cover the major accomplishments for the calendar year 1966; then I will show you our master delivery schedule for our flight stages; I will discuss the major problems we are having and the solutions to those problems; I will then say a few words on our manpower and our funding requirements; and I will conclude by forecasting the accomplishments we propose to achieve in the calendar year 1967.

This is the Saturn V stack (slide 3). It's about 360 feet tall. We have the S-IC, first stage, which is built by Boeing; the second stage, the S-II, which I'll talk about this morning, built by S. & I.D.; the third stage is the S-IVB built by Douglas at Huntington Beach. Then we have the instrumentation unit, built by IBM, which provides

SATURN S-II PROGRAM

17 FEBRUARY 1967

SLIDE 1. SATURN S-II PROGRAM

OUTLINE

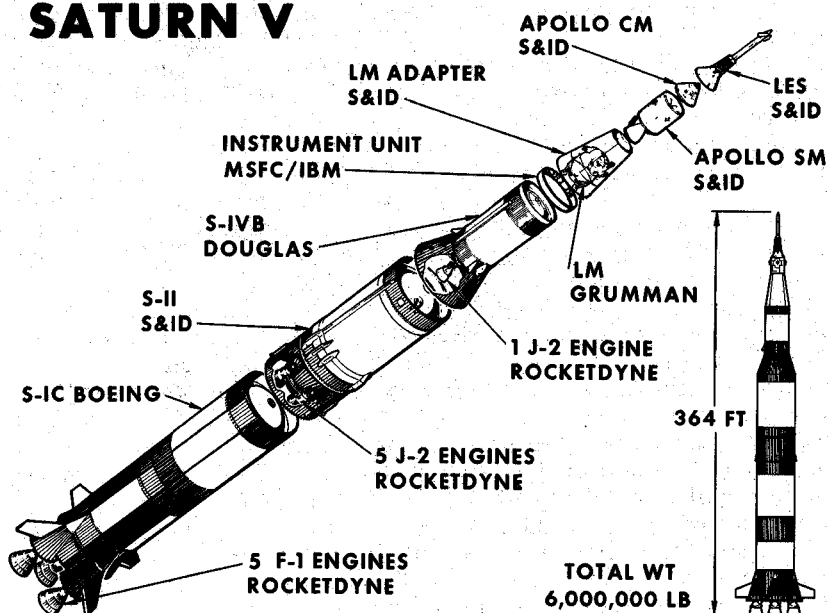
- I. ORIENTATION ON CHARACTERISTICS OF STAGE
- II. BROAD SCOPE OF PROGRAM
- III. PROGRAM ACCOMPLISHMENTS - CY 66
- IV. MASTER DELIVERY SCHEDULE
- V. MAJOR PROBLEM AREAS & SOLUTIONS
- VI. MANPOWER & FUNDING REQUIREMENTS
- VII. FORECAST ACCOMPLISHMENTS - CY 67

SLIDE 2. OUTLINE

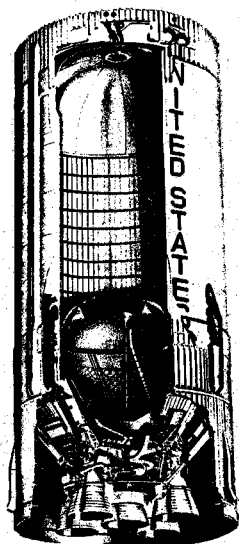
the guidance; the lunar module adapter, which S. & I.D. builds; and the lunar module, which is built by Grumman. Finally, we get to the Apollo service and command modules and the launch escape system, which you will hear discussed later today by Dale Myers.

Now, let's take a look at the S-II (slide 4). I have a picture, in case during the talk we want to discuss the location of some component in the stage.

SATURN V



SLIDE 3. SATURN V



SATURN S-II CHARACTERISTICS

DIAMETER	33 FT
LENGTH	81.5 FT
DRY WEIGHT	82,000 LB (W/O INTERSTAGE)
LIFTOFF WEIGHT	1,070,000 LB
BURNOUT WEIGHT	94,000 LB
PROPELLANT CAPACITY	970,000 LB / 349,800 GAL
LH ₂ (-423F)	155,000 LB / 264,400 GAL
LOX (-297F)	815,000 LB / 85,400 GAL
ENGINES	5 ROCKETDYNE J-2
THRUST	200,000 LB/ENGINE
BURN TIME	390 SEC
SPECIFIC IMPULSE	436 SEC
ULLAGE MOTORS	8 ROCKETDYNE
THRUST (TOTAL)	22,900 LB
BURN TIME	3.7 SEC
PERFORMANCE	
ALTITUDE AT IGNITION	200,000 FT (38 MI)
ALTITUDE AT BURNOUT	606,000 FT (114 MI)
VELOCITY TRANSITION	7,700-20,840 FT/SEC (5,460-14,770 MPH)

SLIDE 4. SATURN S-II CHARACTERISTICS

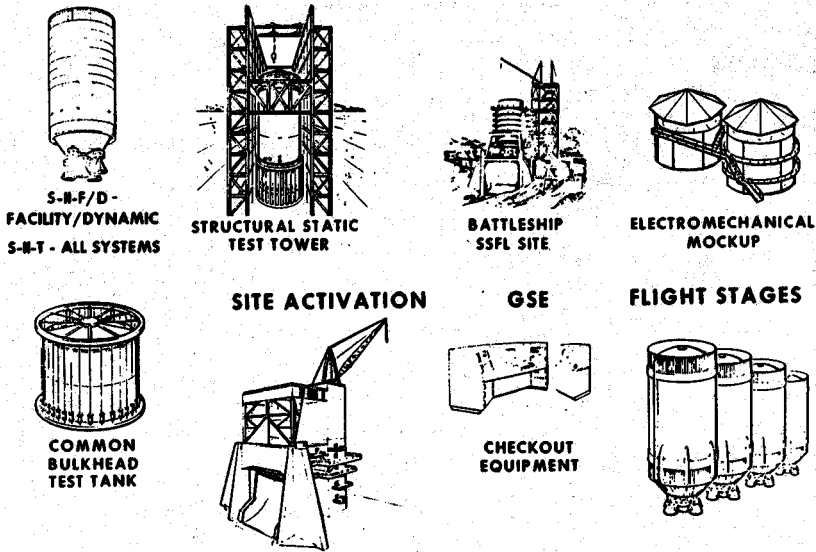
It's 33 feet in diameter, which is the same diameter as the stage under it. The stage above it has slightly lesser diameter. It's about 82 feet tall. With no propellants in it, it weighs about 82,000 pounds; fully fueled, it weighs a little over a million pounds. It has about 350,000 gallons of propellant in it. In the upper tank, beginning at

this bulkhead and going up to here, we have liquid hydrogen, liquid hydrogen at -423° F. There are about 260,000 gallons of liquid hydrogen. This tank here, which is almost, but not quite, a sphere right under the hydrogen tank, contains 85,000 gallons of liquid oxygen at -297° . There are five engines built by Rocketdyne, called the J-2 engines, which have a nominal thrust of 200,000 pounds each. There is an uprated version, at 230,000 pounds, which we will have on our later vehicles. The stage, after it separates from the S-IC, burns for about 390 seconds, a little over 6 minutes. A measure of how good the engine and propellant system are is called the specific impulse; it's the pounds of thrust per second of propellants burned which gives the value in seconds. At altitude, it's about 436 seconds. The specific impulse on the hydrogen-oxygen stages are characteristically quite high compared to liquid oxygen and kerosene. There are eight solid-propellant ullage motors that attach to the sides for a total thrust of about 23,000 pounds. When we separate from the S-IC, we momentarily go into zero g. These ullage motors are used to resettle all the propellants at the rear end of the tank, so that the engines will have plenty of pressure head. When the main engines are ready to light, we start these solid-propellant ullage motors and burn them for a little over 3 seconds; that moves the propellants to the bottom of the tank, and the main engines can start. After main engine start, we throw the ullage motors away.

The S-II stage lights at about 38 miles altitude, and burns out at about 114 miles. At engine start, it has been boosted by the S-IC to a velocity of 7,700 feet per second. It then gains about 14,000 feet per second, reaching an end velocity of 20,840 feet per second. At this time it shuts off, just before the S-IVB separates and continues the mission. This is somewhat short of orbital velocity, so this stage actually splashes back into the water. It does not go into orbit.

This is one way of getting a quick broad look at the program scope (slide 5). We manufactured three vehicles that for all intents and purposes are like the flight stage but were made for test purposes. One was made for static testing, to test the structural integrity of the stage. This was the S-II-S. It was tested at Seal Beach. Another one we call the S-II-F, "F" standing for facility. It was made to send down to Florida to check out the facility and make sure the stage would interface properly with the S-IC below it and the S-IVB above it, with the launch umbilical tower, the stand, and the other equipment. And then we had what we call the S-II-T, "T" standing for test, which had all the flight systems in it, including the five engines. This is the stage that we sent to Mississippi and fired a number of times to find out if we really had a good design and if it was all working. Test results were fed back into the design of the flight stages.

The Battleship (called that because it's made of boiler plate) is mainly to test out the engines. It is at Santa Susana, up above Canoga Park in the San Fernando Valley. We also had an electro-mechanical mockup which is here behind Building 2. We took the stage and cut it in the middle and put half of it here and set the other half next to it, which made it a little simpler to work with.



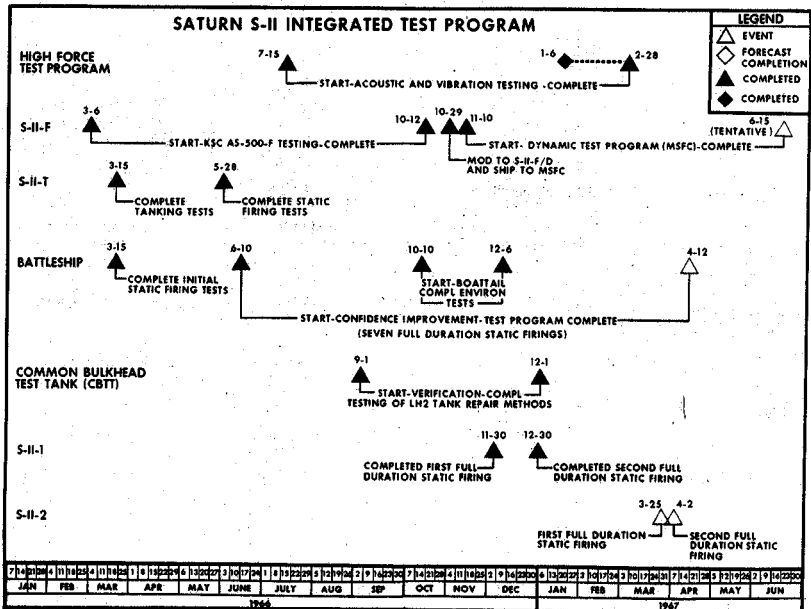
SLIDE 5. S-II PROGRAM SCOPE—TEST HARDWARE

We didn't have to build an 80-foot-tall tower. The two segments are hooked together electrically and mechanically. We did set up the basic GSE by which we check out, count down, and launch the stage. We did check out all this equipment and gained early information on whether the design of all the gear was satisfactory.

The common bulkhead test tank is also at Santa Susana, near the Battleship. The purpose of this tank was to verify the structural integrity of the bulkhead between the liquid hydrogen and the liquid oxygen tanks. This is a very sophisticated, lightweight bulkhead, and we felt it needed special test attention.

We have two stands at Mississippi where we can static-fire the S-II. One of them is activated and has been used; the other will be activated within a month. There is quite a bit of ground support equipment all through the test system. We have a set at Seal Beach; we have a partial set that we use to fire the Battleship engines; there are two sets at the Mississippi test facility that go with each of the stands there; and there are some partial sets at Kennedy Space Center.

Finally, we have 15 flight stages coming along. Ten are on firm contract, and we have proposed the followup on five. We are currently in negotiations on those five stages. This chart is meant to give you a quick picture of our test program (slide 6). All the black triangles are things that have been accomplished. We did have the high-force test program, which is to test stage response to acoustics and vibration. This test was performed at Huntsville. You take the stage and you subject it to the noise and vibration that it undergoes in its actual flight profile. The stage is highly instrumented and you analyze that test data and you find out if everything is going to hold



SLIDE 6. SATURN S-II INTEGRATED TEST PROGRAM

up all right in the flight environment. We completed that program ahead of schedule.

The facility stage I mentioned earlier did go to KSC last March and was used to check out the facility down there. At that time, we modified that stage and sent it to Huntsville, where it was stacked with the S-IC and the S-IVB for dynamic testing. That program will be completed in June. It's currently going on and is on schedule.

The all-systems test vehicle did go to Mississippi in October of 1965. We checked out the facility and had the tanking test in March. We completed a series of static firings on May 28. The original Battleship program was completed on March 15 with a series of static test firings. We then decided we needed additional confidence improvement tests, so we initiated a program in June that is still going on.

Here in the middle you see a bar that says "boattail environmental tests." The boattail is down where the engines are. The purpose of these tests was to put the liquid oxygen-liquid hydrogen on board, shroud the boattail, and get the temperature gradients like they will be on ascent when the S-IC sits below us with its cold oxygen here and our cold oxygen here. There is a circulation system where the oxygen is supposed to circulate through these engine pumps to chill them; we wanted to make sure that system is going to work. We simulated that environment on the Battleship and completed those tests in December.

We have had a set of full-duration firings through this period. In fact, one of them is scheduled for today at 1:30. We did complete the series of tests on the common bulkhead test tank successfully; and then, since we didn't get all the testing done on the S-II-T that

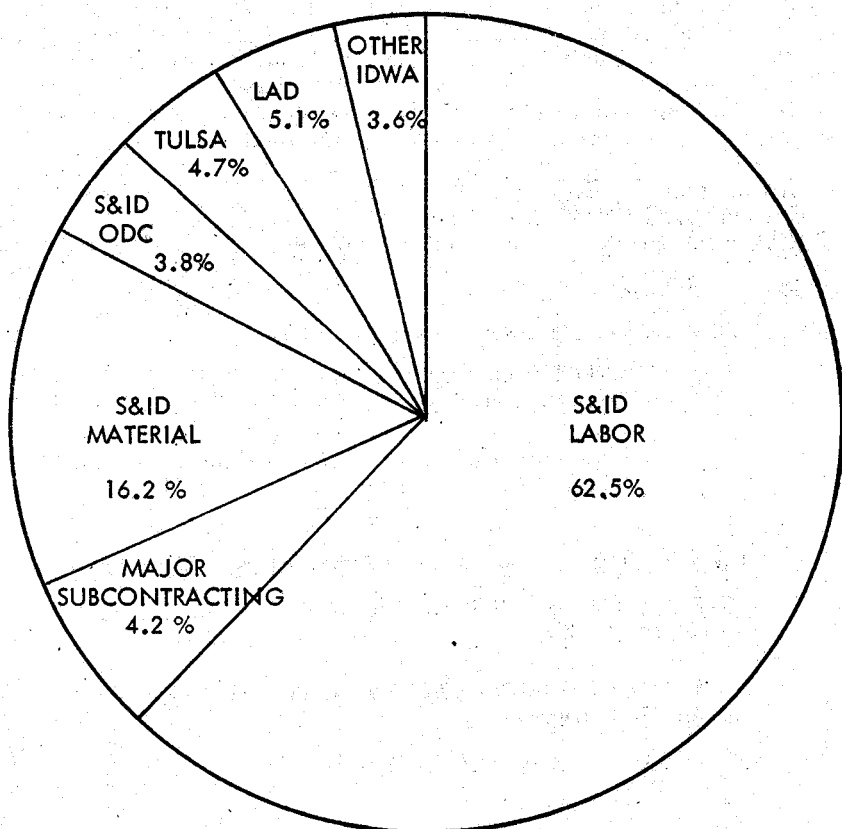
we felt desirable, we actually set up an extra firing on the S-II-1. In the original planning, the S-II-1 was going to have one acceptance firing, but we changed that to add another firing for confidence purposes. We did accomplish that at the end of December of last year. There were two completely successful full-duration static firings of the S-II-1.

The S-II-2, which I believe you gentlemen saw coming down the Pearl River the other day, is now at Mississippi and is set up for its first full-duration firing on March 25, and a second one, if required, shortly thereafter, early in April.

Continuing with the broad scope of the program, I have a percentage pie chart (slide 7). The total scope of the program here in

S-II TOTAL PROGRAM COST

EAC



SLIDE 7. S-II TOTAL PROGRAM COST—EAC

dollars, which will be shown on a subsequent chart, is about \$1.3 billion. The purpose of this chart is to show that most of the S-II program is at S. & I.D. as opposed to major subcontracting. Only about 4.2 percent of the work is with major subcontractors.

I would now like to review the major program accomplishments for calendar year 1966 (slide 8). We did have our battleship program, and we did complete four full-duration firings in August. We did complete the environmental boattail tests that I mentioned a moment ago. On the S-II-T, we achieved some very major milestones. We loaded the tank with hydrogen and oxygen, and we have this insulation on the side to hold down the boiloff. It's like a big vacuum thermos bottle, and there were some worries about whether the insulation would have structural integrity: would it remain in place on the side when it was chilled? And, sure enough, it did stay on; in fact, it worked quite well. This was a major milestone. Then with the stage all up and all the systems operating, including the five engines, we fired and did burn our full 365 seconds. The static burning time on the ground is a little less than it would be at altitude, in case you happen to remember that I used the number 390 seconds a moment ago for inflight firing. The nominal full duration on the ground is 365 seconds. That was a major milestone.

The completion of the facility vehicle, shipment to the Cape, and the successful checkout of the facility at KSC are major milestones (slide 9). The stack went together with no problems whatever. They turned on the electrical power, and everything worked quite well. We then modified the S-II-F, as I mentioned earlier, and shipped it to Huntsville. It's now being used as a dynamic test vehicle. When this is complete, it will be shipped back to the Cape to check out another LUT at KSC.

EDWARD J. GURNEY. Another what?

Mr. GREER. Sorry. Launch umbilical tower.

BATTLESHIP (HEAVYWEIGHT TEST STAGE)

CONFIDENCE IMPROVEMENT TESTING AT SANTA SUSANA

COMPLETED FOUR FULL DURATION (365 SECOND) STATIC
FIRINGS WITH ALL FIVE ENGINES ON 08-31-66

COMPLETED ENVIRONMENTAL TEST OF ENGINE COMPARTMENT
& THRUST CONE ON 12-06-66

S-II-T (FIRST FLIGHT WEIGHT SATURN II TEST VEHICLE)

COMPLETED TANK LOADING WITH LIQUID HYDROGEN & LIQUID
OXYGEN ON 04-23-66

FIRST FULL DURATION 365 SECOND 5 ENGINE FIRING OF FLIGHT-
WEIGHT STAGE ON 05-20-66

SLIDE 8. SATURN S-II PROGRAM ACCOMPLISHMENTS

Have you been to the Cape, Mr. Gurney?

Mr. GURNEY. That's my congressional district, I know it well, but I don't know about LUT's.

Mr. GREER. The high-force test vehicle was to test out the vibration and acoustic testing. That program was completed actually on January 6 (slide 10). I count it as an accomplishment for calendar year 1966 because most of it was accomplished in that year, ahead of

SATURN S-II PROGRAM ACCOMPLISHMENTS

S-II-F (SATURN II FACILITY CHECKOUT STAGE)

FABRICATION & TESTING AT SEAL BEACH COMPL 02-19-66

TESTED S-II-F SUCCESSFULLY AT KSC WITH S-IC-F, S-IV-BF
IN SATURN V CONFIGURATION. COMPLETED 10-12-66

MODIFIED FOR VIBRATION & DYNAMIC LOAD TESTING
(S-II-F/D) & SHIPPED TO MARSHALL SPACE FLIGHT CENTER
ON 10-29-66

S-II-F/D STACKED WITH S-IC & S-IV-B IN SATURN V
CONFIGURATION. DYNAMIC TESTING IN PROCESS 11-10-66

SLIDE 9. SATURN S-II PROGRAM ACCOMPLISHMENTS

HIGH FORCE TEST

(HIGH LEVEL VIBRATION & ACOUSTIC TESTING)

STRUCTURAL VIBRATION & ACOUSTIC TESTS
SUCCESSFULLY COMPLETED ON 01-06-67 (AHEAD OF
SCHEDULE) AT HUNTSVILLE, ALABAMA

CBTT (VERIFICATION TESTS)

VERIFICATION TESTING OF LH₂ & LOX TANK REPAIR
METHODS ON TEST TANK AT SANTA SUSANA COMPLETED
12-01-66 (ON SCHEDULE)

SLIDE 10. SATURN S-II PROGRAM ACCOMPLISHMENTS

schedule, quite successfully; and I'm happy to say we didn't find anything out there that caused us to make any substantial design changes in the stage. We did complete our common bulkhead test tank tests during calendar year 1966, and everybody was relieved when we found out that bulkhead was really going to work all right.

The first flight stage, another major milestone, was fabricated and tested at Seal Beach and shipped on July 30 (slide 11). We fired it twice at Mississippi successfully, and we did deliver it to KSC on January 21. It's in the low bay down there now, undergoing some late modifications. We will be moving to the high bay on February 23 for mating with the S-IC; and then the S-IVB goes on top of that, and the spacecraft on top of that about April 9. It should roll out to the pad and be ready for launch in May.

The second flight stage has been fabricated and tested at Seal Beach. It was shipped on January 27, and arrived at Mississippi on February 11. It is currently undergoing that part of the cycle known as prestatic firing checkout, preparing to fire later in March. Among our other major accomplishments is the qualification test of major components (slide 12). As you gentlemen may know, there are major components on the stage such as vent valves and other major valves in the hydrogen-oxygen system, certain electronic equipment, and disconnects where we hook up the facility to the stage.

SATURN S-II PROGRAM ACCOMPLISHMENTS

SATURN S-II FIRST FLIGHT STAGE (S-II-1)

FABRICATION & TESTING AT SEAL BEACH
COMPLETED 07-30-66

TWO FULL DURATION FIRING TESTS COMPLETED
AT MTF ON 12-30-66

DELIVERED TO KSC 01-21-67

SATURN SECOND FLIGHT STAGE (S-II-2)

FABRICATION & TESTING AT SEAL BEACH
COMPLETED 01-27-67

MTF ARRIVAL ON 02-11-67 FOR FIRING TESTS

SLIDE 11. SATURN S-II PROGRAM ACCOMPLISHMENTS

SATURN S-II QUALIFICATION TEST STATUS

	STAGE	GSE
TOTAL EQUIPMENT ITEMS QUALIFIED	211	22
TOTAL PROGRAM EQUIPMENT ITEMS REMAINING TO BE QUALIFIED	5	1

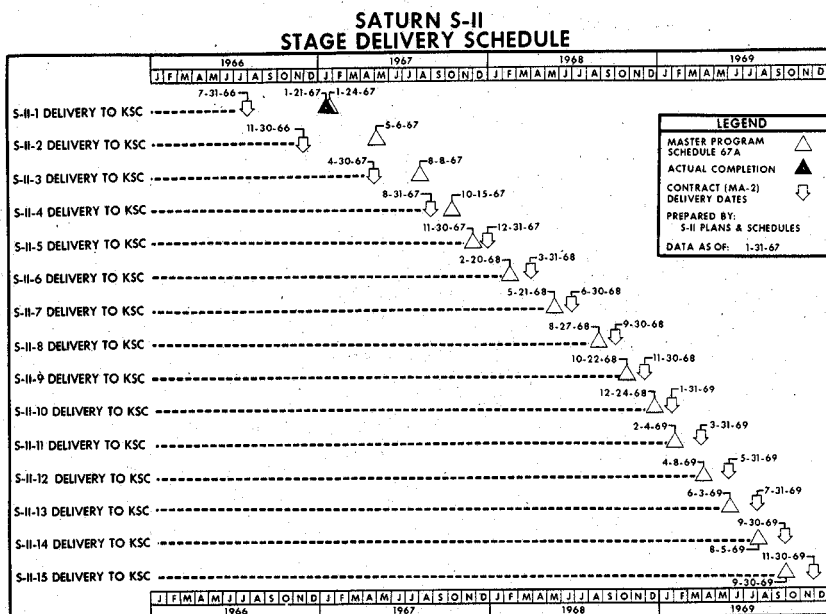
SCHEDULE FOR COMPLETION - REMAINING ITEMS:

DATE:	FEBRUARY	MARCH
QUANTITY:	5	1

SLIDE 12. SATURN S-II QUALIFICATION TEST STATUS

When the stage launches, they have to pull apart. These major components run through separate tests to qualify them. We subject them to rather severe vibrational environments and, in some cases, temperature cycling. This sort of thing, qualifying all these major critical components, is quite a task; and we are now drawing toward the end of the line on this problem. We have qualified 211 stage items, 22 ground support equipment items, and we have remaining only five for the stage and one for the ground support. These five are scheduled for completion this month and next, and I believe we are in real good shape here and should have qualified all our major components by the time we launch the first stage.

Now, looking at the master program schedule (slide 13), the symbol here stands for the contract delivery date. That's the date that we contracted to deliver the flight stages in our basic contract. The triangle is our master program schedule, against which we are currently projecting our deliveries. If it's black, we have already done it. You will notice on the S-II-1 we did deliver about 6 months past our contract date. The S-II-2, which has been following right behind the S-II-1, has been going through the same facilities, such as the checkout station at Seal Beach. In other words, it was constrained by the S-II-1 use of the facilities. We are running about 6 months down on that. For the third bird, we are pulling up on it here a



SLIDE 13. SATURN S-II STAGE DELIVERY SCHEDULE

couple of months—two and a half; by the fourth stage, we are very close, and finally, by the fifth, you will notice these two symbols reverse themselves. Then from the fifth item down to the end, we are currently running on a schedule that will deliver ahead of our contract schedule.

Now, we'll take a broad look at the problems that caused the bad schedule position I showed you on the last chart (slide 14). The first major problem is the insulation I mentioned earlier that goes on the outside of the stage to keep the hydrogen from boiling off. This was a new technology, as far as we're concerned. There are other stages, the Douglas S-IVB and the Centaur, that have used the insulation for liquid hydrogen; but we had a new approach to this, a lightweight approach, and we have had quite a few problems with it. None of them were really fundamental problems, but very much in the nuisance category—the kind of thing you can lose an awful lot of time on. Whenever you have to make a repair on this; for example, there are long cure cycles for bonding—48 hours just to make the simplest repair in this insulation. Where there is a pin hole or a rent, it takes you 2 or 3 days just to repair that simple defect.

LARRY WINN, JR. Mr. Greer, excuse me. Could you give us a little more information about the insulation? You say it's a new lightweight; what are you talking about, what type?

Mr. GREER. First, looking radially out from the stage it's about 1.6 inches thick. It's a plastic resin honeycomb. If you look down at it, looking in, you see a lot of little hexagonal cells about three-fourths inch across. On top of that there are two sheets of nylon

PROBLEMS CONTRIBUTING TO SCHEDULE REVISIONS

INSULATION

STRUCTURAL REWORK REQUIREMENTS INDICATED BY 'T'
TEST PROGRAM

ASSEMBLY WELDING OFFSET PROBLEM

ENGINEERING CHANGES

MATERIAL REVIEW ACTIONS

SLIDE 14. PROBLEMS CONTRIBUTING TO SCHEDULE REVISIONS

and one of Tedlar that comprise this blanket that has to be bonded onto the stage. We use a resin glue that we bake on in an oven at about 350°. We first have to put it on the quarter panels. These are major segments of the tank. Then we weld these quarter panels into a ring, and we weld the rings into the complete stage. Then we have to go back and put strips in to close out over the welds, and this requires more bonding. Originally, we had this material subcontracted out to a number of suppliers—Eldon Plastics, for one. We didn't exercise sufficient in-process control over these suppliers and, as a result, we got some material that was below standards. We put this material on the stage. During tanking, we purge with helium gas under pressure to insulate the hydrogen from the outside ambient air; and under this pressure, about four pounds per square inch, we found the insulation failing. It would just rip, pieces would break off or a hole would appear. We would have to repair it and pump it up again and some more would break off. And we went on fighting this insulation repair for months and months. Finally we pulled all

off the insulation in-house, and North American now makes this insulation. Beginning on the fourth stage, we have all North American-made insulation, and it's good. On the first three stages, we still have this supplier-made insulation. Every time we tank these stages and fire them at Mississippi, this insulation cracks when it chills down. While it's not dangerous, after we have detanked or fired, we have to go in and repair all those cracks. That runs us like 10 to 14 days, which is just lost time. Right now, down at the Cape in the low bay, we're repairing insulation damage left over from the last firing at Mississippi.

Does that sort of give you a feel for it?

Mr. WINN. How does the new thickness compare with what you were using in the past? You said 1.6 inches.

Mr. GREER. It went through the several design iterations, Mr. Winn. There were some assumptions on thermal coefficients back at the beginning which led them to believe that eighth-tenths inch would be sufficiently thick. The facility stage we built had eight-tenths-inch-thick insulation. We found out the boil-off rate of hydrogen could be too high. So, we increased the thickness to 1.6 inches. This was picked as a proper design point to control this boil-off rate of liquid hydrogen.

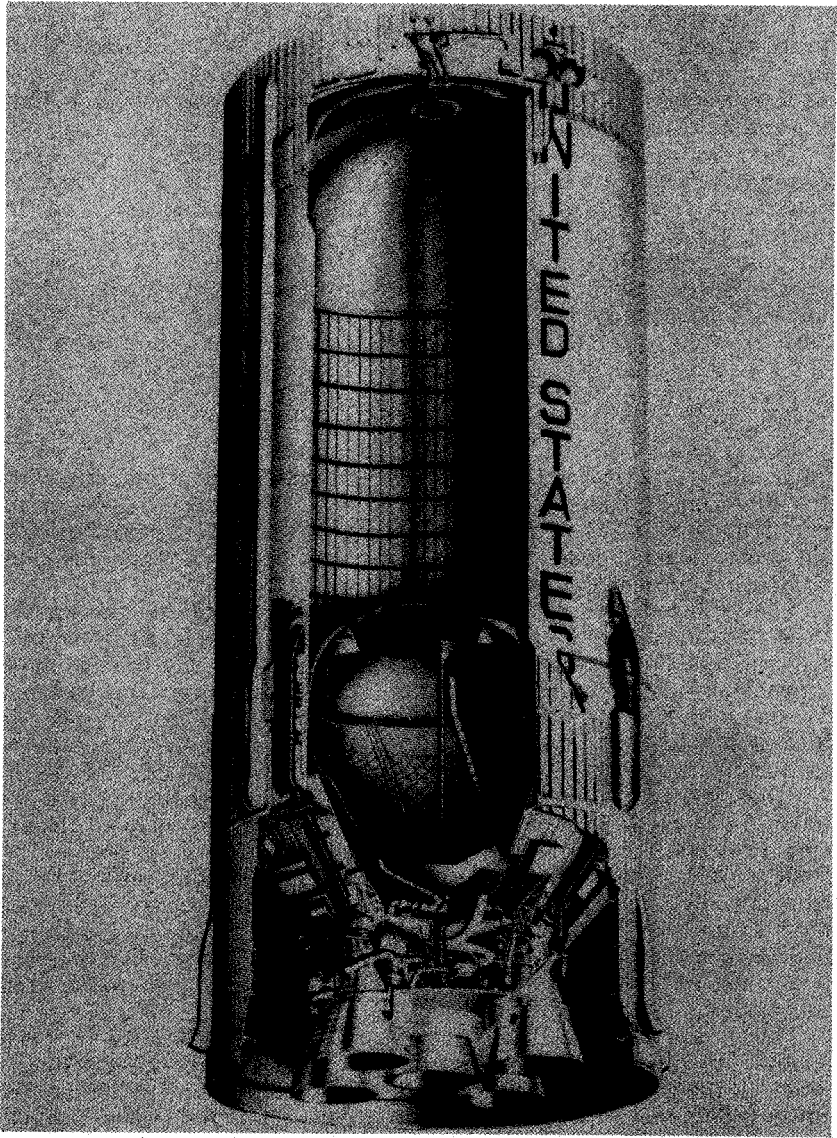
Mr. WINN. Thank you.

Mr. TEAGUE. Mr. Carroll, can we see some of that later?

ROBERT E. CARROLL. We have a piece of insulation being brought in.

Mr. GREER. We had the all systems test vehicle at Mississippi, and while completing our basic testing there, it did rupture under pressure. This rupture turned out to be, on close examination by putting the pieces together and looking at them, caused by a crack in a boss in the tank. This crack basically came from a sharp corner on the boss. It should have been radiused more. This caused us to look all through the tank at various other places on the stringer ends. You can't really see this too well, but there are stringers that run around here, and every place you change from one quarter panel to another these stringers terminate and there is a splice plate across them (slide 15). At the termination of these stringer ends we found small cracks, so we had to do something about that. We scalloped them out smoother and polished them down. There were some other bosses that we found that were prone to have cracks, so we radiused and smoothed those also. So, while these are very small cracks, really, the word is kind of a "scare" word. Although they were very small, we nevertheless had to do something about all of them. We thought we had a completely qualified structure; about June of this last year we suddenly found it wasn't qualified. The rework on all these problems set us back considerably on the schedule. That's another major item.

The fusion welding that we used on this stage in order to keep it lightweight is also pushing the state of the art somewhat in the welding business, and we have had various problems getting our welds up to our own specifications. We have lost quite a bit of time on this problem. I'll give you one example of the type of problem you run into.



SLIDE 15. S-II CUTAWAY

The No. 6 cylinder here, which is at the top of the stage, has to be welded to this bulkhead which runs over the top. We weld up to the No. 6 cylinder from quarter panels as a complete cylinder, then we weld gores, little pie-shaped pieces, in to make the bulkhead, then we have to make what is about a 1,200-inch weld all the way around to put this bulkhead on that cylinder. The thickness of the material that we are using there is slightly over a quarter of an inch, and we can't have a mismatch, an offset at any point, of more than 10 percent

or twenty-sixth one-thousandths of an inch. And we have had some problem getting these welds within that spec. What happens if it's too far out is you have to cut it out and reweld it, so there goes at least a week. We have lost quite a bit of time in our schedule fighting the welding problem.

Then we have the general statement here called "engineering changes." These are all the things that occur in an R. & D. program, where, as you progress downstream and you put the hardware together, you learn new things. You now have to go back and change the hardware you have already built. This is a process that goes on continuously throughout the life of almost any program, particularly R. & D. programs, such as this. But even the airplanes you gentlemen are flying in today are still getting minor changes on them. So it's a process that goes on continuously. We expect it; nevertheless, depending on how severe some of these changes are, they do impact the schedule.

Now, these changes (I'll just say one other word to clarify them) come about in part due to our own design not being just exactly right the first time. They also come about in part from changes that result from interfaces with the stage below us and the stage above us. So these changes come from all directions, both from the customer to North American and internally.

I have listed a thing here, which is probably not too familiar to most of you, called "Material review actions." This is the cycle, part technical and part administrative, that we get into any time we have a problem such as having made a weld which is not up to specification. We have to X-ray the weld; we have to read the X-ray; we have to discuss it with our quality control people and discuss it with our engineering people and our manufacturing people; we have to decide whether it's acceptable as is or whether we have to fix it; and we have to discuss it with the customer. Every time we have an insulation problem, or a weld problem, we get into one of these material review cycles. And if we get a number of these actions, quite a bit of time goes by. Every time you don't do something exactly right, you have to go back and do it over, and this is one of the major things that makes the schedule slip. If we could do every job right the first time, we'd save a lot of time. We wouldn't have to go through this cycle.

This is the 1.6 insulation. These are the hex cells I was talking about. It's filled with a foam material. This glues on the side of the stage, all the way around the hydrogen tank. This is the nylon-Tedlar cover. This piece was made by North American, and, while it looks pretty husky, we actually had trouble with that facing sheet ripping off under pressure. Now, we have had so much trouble with this insulation that we developed a simple foam insulation. We are proposing now, at about stage 7, to use this simple foam. We just spray this foam on the side like you would paint a garage. It foams up, then we go over it with the cutters and smooth it off and we wind up with about an inch thick of the foam which has similar thermal characteristics to current 1.6-inch insulation.

Mr. WINN. Doesn't Tedlar have a similar type of cover there? That's more like an onionskin paper, and that's more like cardboard.

Mr. GREER. There are three layers there; there are two nylon and one Tedlar.

Mr. WINN. I see.

Mr. GREER. The Tedlar is on top and the two underneath are nylon. This is the way foam looks after it's cut.

Mr. CABELL. Do you have to mill this to fit it to the contour of your bird? It's not flexible enough to be able to wrap it, is it?

Mr. GREER. Yes. You see, you have got a radius of about 200 inches, a very gentle curve.

Mr. CABELL. It will conform?

Mr. GREER. You get a big sheet 9 by 27 feet and it's got some play in it, actually just lays on it. It looks very stiff, but a large piece is quite pliable.

Mr. GURNEY. In an effort to understand how the program works a little better, let's go back to this insulation problem. How and when did you discover the defect in the original insulation you got from the subcontractors?

Mr. GREER. We really didn't discover it until we had put some on the quarter panels of the stage and had them in proof-pressure tests.

Mr. GURNEY. Is this the very first stage you are talking about?

Mr. GREER. Yes.

Mr. GURNEY. Incidentally, again, had you bought a lot for all of your stages or only for this one?

Mr. GREER. We procured a considerable amount and it was in the pipeline coming in and there was no good alternate source where we could just terminate that and get some new insulation right away. At that time we found we were in trouble, we were committed through about three stages. Now, we could have stopped right there. Then you would have seen a bigger schedule impact than I showed you a minute ago. So we chose to fight the repair cycle. When you pressure-test this and it rips, you repair it. You test again, and maybe you blow another place and repair it. Eventually, you get to where it's repaired and it works.

Mr. GURNEY. You are making your own now, you are not getting it through subcontractors?

Mr. GREER. That's right.

Mr. GURNEY. What was the matter with this? Was it poor workmanship, poor quality, poor design, or what?

Mr. GREER. The design is all right, it's OK, it works. There was lots of lab work done on this insulation by the engineer who designed it and built test items, and if you build it right and you glue it on right, it's great. In fact, it lulled us a little bit into complacency—we should have been more alert. For example, the actual pressure that this sees, when it's on the pad and we pump it up with helium, is like 4 pounds per square inch above atmospheric. As the stage goes aloft, then this vents off and you actually peak out somewhere around 5 or 6 pounds per square inch relative to the vacuum outside. We started out at 15 pounds per square inch proof test, because our laboratory samples would go to 40—they would all go to 40. We started blowing this up to 15 and it was ripping right and left, so then we went back and rechecked our real requirements for design and found that we could live with 7 pounds per square inch for proof-

pressure. Even that caused quite a few flaws to occur in this insulation.

Mr. GURNEY. What was the matter then, was it poor workmanship?

Mr. GREER. Yes, it just wasn't glued on well. A piece would rip off, a piece of this laminate, and underneath you would find some little piece of debris or something.

Mr. WINN. Do you think these constant repair systems or jobs that you have done are going to make an acceptable unit before you are done?

Mr. GREER. Yes, as I say, once you get all the bad spots repaired. The way you repair it depends on what the defect was. We would either cut out a whole piece like this and put a new piece in, or we would pull back the laminate and very carefully prepare the surface and then we would glue back on another piece of laminate. By the time we had done all the repairs, and there were quite a few of them on the S-II-1, it was okay.

Mr. WINN. Pretty expensive, though?

Mr. GREER. It was very expensive in time.

Mr. GURNEY. One other question: You said you had to commit yourself to three stages before you could cut it off. Why was that? Is it because it had come in before you really found out what was the matter?

Mr. GREER. That's correct. It was in the pipeline in various stages of being put on quarter panels and in our warehouse. We had about three stages worth when we found out we were in trouble. If we stopped right there, and decided to make it in-house and junk all that, I'd say we'd have lost several months. We decided we would live with it and repair it, and that's what we are doing.

Mr. GURNEY. I see. Thank you.

Mr. GREER. I have already given part of this, I believe. This is what we are doing to stop this schedule slippage type of problem I have just been talking about (slide 16). As I say, we have now brought all the insulation in-house, and not only in this laminate 1.6-inch foam insulation made by North American, and it's good stuff, but we have progressed from that to this foam-on insulation, which is a much simpler process and will save us a lot of time in manufacturing. We are going to pick that up on about the seventh stage. And that should eliminate once and for all the repair-type problem we have been having with insulation.

One of our problems in this material review world, that I mentioned earlier, was an actual shortage of X-ray equipment, because, after every weld, we X-ray that weld; and this is a long weld, and there are lots of X-ray pictures, and it's a lot of developing. Then people have to look at the welds. So we actually have moved the X-ray processing equipment; we have gotten more of it and moved it right to the manufacturing station, so that we can speed up this inspection of the weld after we have made it. It used to be quite a period of time from the time we made a weld until we had gotten all the X-rays. You have to clear all the people away because this is a very powerful X-ray machine. We would take the film and develop it over in another building; people would read it, and it would be a day later before we got the word back on whether we had porosity and oxide in the weld and where and how to repair it. So we shortened the

WHAT IS BEING DONE TO PRECLUDE FURTHER SCHEDULE REVISIONS

ALL INSULATION NOW FABRICATED IN NAA FACILITIES; IN-HOUSE PROCUREMENT HAS ELIMINATED LATE DELIVERY & DEFECT PROBLEMS

PROVIDING X-RAY PROCESSING EQUIPMENT IN MANUFACTURING STATIONS TO EXPEDITE WELD INSPECTIONS

PULLING BACK DEFERRED MODIFICATIONS TO SEAL BEACH WHERE WORK CAN BE DONE WITH LESS DIFFICULTY THAN AT FIELD SITES

ESTABLISHED JOINT NASA & NAA TEAM TO EXPEDITE MATERIAL REVIEW ACTIONS ON A 24-HOUR BASIS

IMPROVED WELDING TECHNIQUES: USING NASA (HAWTHORNE) CLAMPS REDUCES BULKHEAD/CYLINDER OFFSET

PROVIDING ADDITIONAL WELDING TOOLING & FIXTURES TO PREVENT STATION LOADING CONSTRAINTS

TRAINING & CERTIFYING ADDITIONAL SHOP TECHNICIANS

SLIDE 16. WHAT IS BEING DONE TO PRECLUDE FURTHER SCHEDULE REVISIONS

line of communication and got some more equipment there to speedup that process.

In the change world that I mentioned earlier, we found that a lot of the changes (we didn't like to do this, but it seemed like the best thing to do) were moving out into the field. In other words, we would come up late in the cycle, when we were about to ship a stage from Seal Beach, we would get a change that had to be made. And we would send the stage on to Mississippi and make the change there. The change traffic is dropping now. I think we have enough control over it so that, beginning with about stage 3, we should be able to pull almost all that work back to Seal Beach. It's always better to do the work back at the factory than it is out in the field. So we are moving in that direction, and I believe it's going to help us on the schedule.

As to the material review action, that I mentioned earlier, which does involve several of our own functional departments as well as the customer, we have formed a joint team. Twenty-four hours a day there is somebody available down at Seal Beach for rapid processing of these material review actions. And where we might have used a day before, now we get it done in an hour. All this adds up to quite a bit in the schedule.

We have improved our welding techniques. One of the things we have done is use a set of clamps spaced around these welds so that we can bring that offset in this 1,200-inch circumference well within specification. In other words, we zero it out all the way around before we put in the tack weld. These clamps have made it much

easier to get these welds without that offset I mentioned earlier. That's working out well. We found that we had just a few stations where we could do these welds, and, as we began to drift behind schedule on the first three stages, we were backing up. In other words, we were being constrained by weld stations, so we actually opened up additional weld stations, and now we have more welding tooling, and more fixtures where we can do these welds, and we are getting more done in parallel. This just happened in the last month, and it's paying off. Right along with this, we have trained and certified additional shop technicians in certain of these critical jobs, like welding. In other words, we have more of the specialized manpower on stream now than we had previously.

Still talking about things we are doing to preclude schedule revisions (slide 17): We found that the decision time was especially lengthy on those problems that involved us very heavily with Marshall Space Flight Center. Due to the distance and the communications, it was taking quite a while to get some of these major decisions. I am talking about cases where maybe a contractor had a slightly different point of view on what should be done than the customer, so that much discussion would take place. We decided to ask the customer to move more people right here to town, so we could sit down with them every day and talk over these things. The program manager, Colonel Yarkin, brought a staff from the labs at Huntsville, and is in residence here. We see him every day now, and it has really improved the time involved in getting decisions out on inspection and technical-type problems.

We found that some of our stage-handling equipment, things we lift the stage with and climb into the stage with, that sort of thing, had not had perhaps the same attention that we had been giving the stage and the primary ground support equipment. So to tighten down

WHAT IS BEING DONE TO PRECLUDE FURTHER SCHEDULE REVISIONS (CONTD)

NASA RESIDENT STAFF INCREASED TO PROVIDE IMMEDIATE ACTION FOR INSPECTION & TECHNICAL REVIEW FUNCTIONS

RECERTIFICATION OF ALL STAGE HANDLING EQUIPMENT, WORK PLATFORMS, ETC. TO PREVENT EQUIPMENT FAILURES

ESTABLISHED MORE DETAILED WORK PLANS & SCHEDULES (HOURLY PLANS OF CRITICAL OPERATIONS)

ESTABLISHED NASA/NA A TASK TEAM FOR PROBLEM INVESTIGATION & RESOLUTION

SEAL BEACH ENGINEERING & ADMINISTRATIVE FACILITY EXPANSION TO CONSOLIDATE SATURN PERSONNEL ON SITE

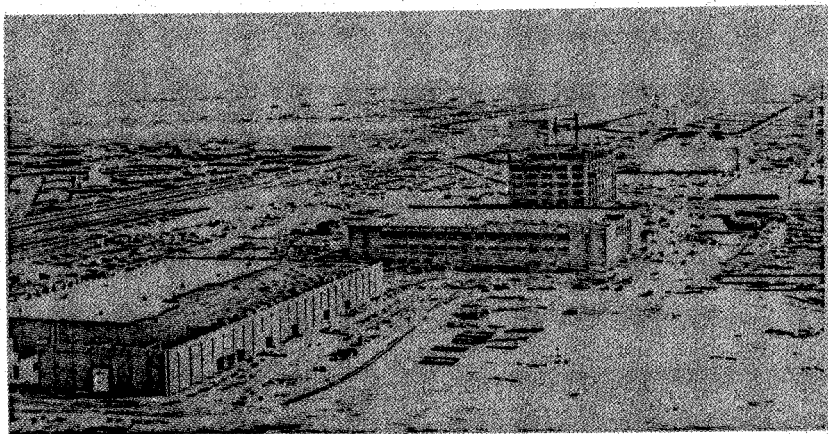
SLIDE 17. WHAT IS BEING DONE TO PRECLUDE FURTHER SCHEDULE REVISIONS—Continued

on small accidents, some of which could be traced to this handling equipment which had been built to somewhat less rigid specifications than our basic stage and GSE, we have reviewed all of that gear, how it is used, whether it's critical or not, and recertified it by proof loading as required. We X-rayed welds if that was indicated, and we have generally tightened down on the specifications of any new things we build. The object of this one is to prevent these small accidents which are so costly to schedule.

It became pretty obvious that we could do a lot better if we put a lot more attention on planning—sitting down and figuring out exactly what we're going to do before we would all rush out and start doing it. So I made this the year for more detailed planning, and I believe that's paying off. This is particularly true in the manufacturing and test world. And, while we spend a little more time before we start the job, the job goes much better after we start.

This item is actually related to this other item on the chart. We did have this task team in town under Colonel Yarkin. We do sit down with him, we do take all our major problems, and we have an action item list. We discuss these and take the necessary action to get our problems resolved. Some of these actually involve interfaces with other contractors. Some of these are just local problems right here. Finally, we have been living with the S-II program split geographically with a large number of my staff and workers—the engineering department particularly—here at Downey and at the manufacturing final assembly and part of our engineers down at Seal Beach. And, while it's not a long drive, it's 20 to 30 minutes—more like 20 now that the freeway is in—nevertheless, it's a little harder to get things done working from two major locations. So, we have a North American facility down there across the street from the basic manufacturing facility, which is NASA-owned; and we are moving down there beginning next week. By about June, I should have all my people down at Seal Beach.

I'll show you a picture just for quick orientation (slide 18). Off to the right there is south, this way is north, it's east across there,



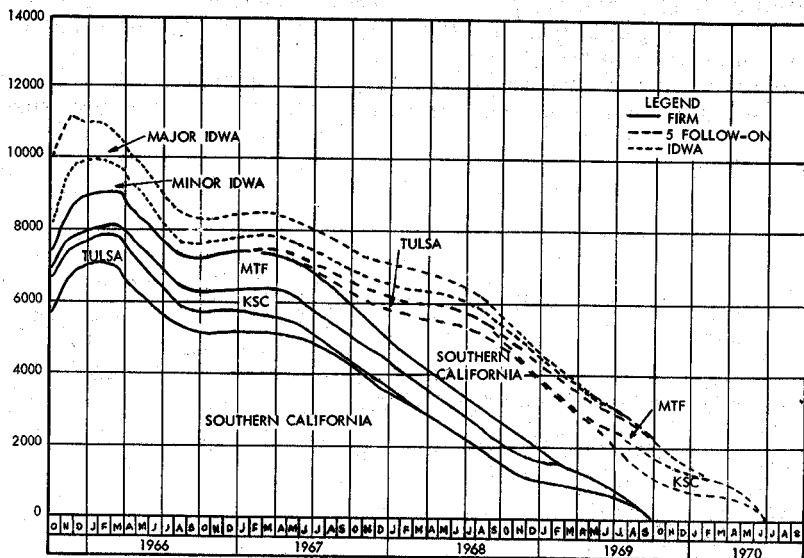
SLIDE 18. S-II FACILITIES

and west here. These are the North American buildings going up: administrative building, engineering building, warehouse. Across Bay Boulevard is the Seal Beach manufacturing plant. This is where we are accomplishing final assembly for the stage. This is the building I was just talking about—the one we're moving down to between now and June—and it will administratively make things go a lot smoother.

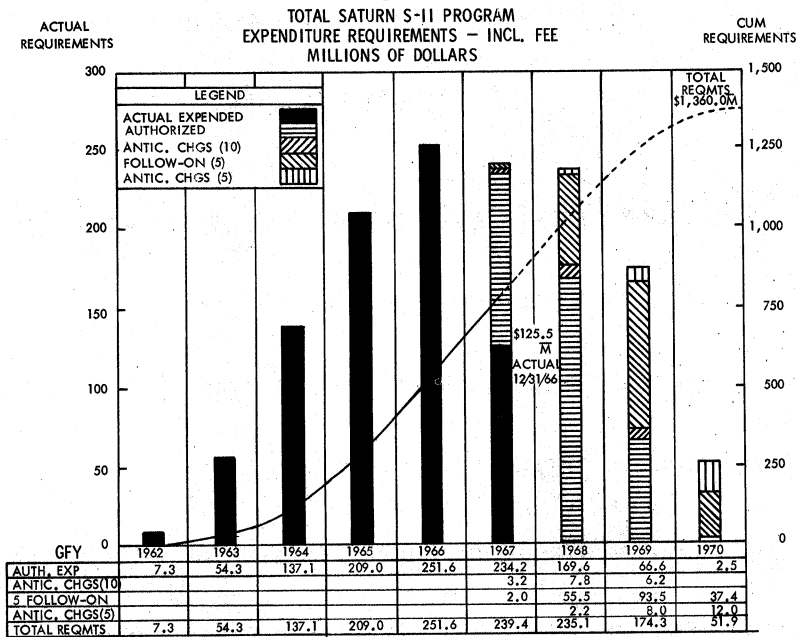
Back on my outline, I promised you a look at manpower and funding (slide 19). Here is our direct-labor load by location. These are equivalent personnel. Under this line is the load in southern California. We peaked out around 9,000 equivalent direct-labor personnel, and, as you see, when we move on toward 1970, this line comes on down. We have the manufacturing work that's done at Tulsa, and here's the manpower at Tulsa; we have the testing to be done at the cape, KSC, that's this increment here; testing that's done at Mississippi is the increment here. This is division work authorization. That is the term we use for work that goes out to other North American divisions, such as the Los Angeles Division and Autonetics Division, and there is a considerable amount of work we call minor IDWA and major IDWA that is shown by these lines. Beginning out in here, these lines do reflect the five follow-on stages, which are not on firm contract yet, but which we do have long leadtime procurement for.

The funding, these are actuals (slide 20): 7.3 million, 54, 137, 209, 251. This is the fiscal year we're in now. Our actuals were 125.5 to the end of December. We are going to come out for the year at about

TOTAL SATURN S-II DIRECT LABOR LOAD BY LOCATION



SLIDE 19. TOTAL SATURN S-II DIRECT LABOR LOAD BY LOCATION



SLIDE 20. TOTAL SATURN S-II PROGRAM EXPENDITURE REQUIREMENTS—INCLUDING FEE

234. This is the budget we said we would make when we started in the fiscal year, and we are going to make it. The whole program totals about 1.3 billion.

Finally, a projection for what we are going to accomplish in the next fiscal year (slide 21). Fabrication, checkout and delivery of the S-II's 2, 3, 4, and 5 to the cape and S-II-6 to Mississippi. We will have activated another checkout station at Seal Beach; we will have activated another stand at Mississippi; we will have completed these dynamic tests that are now going on at Marshall. We will have completed our battleship confidence improvement programs; and we have completed our qualification program. And finally, not on this chart, I'm sure we will have several successful launches.

Thank you, gentlemen.

Mr. CABELL. Could I raise one question? Is there any substance to the charge that some of your metal cracks and the failures were occasioned by excessive vibration on the test stand?

Mr. GREER. No. We found these cracks correlate back to the way we form these panels, to the way we put these splice plates in between stringers with heavy loads on the rivet guns to the pressure cycles we give it at Seal Beach, where we proof test it—pneumostat and hydrostat—with gas and water. There have been no cracks that have occurred after we have fired a bird that wasn't there before we fired it.

Mr. CABELL. Has vibration been a problem?

Mr. GREER. No. We have had enough experience since the last of June when we found these cracks that we have checked stages before

PROGRAM PROJECTIONS
FOR
CALENDAR YEAR 1967

FABRICATION, CHECKOUT & DELIVERY OF S-II-2, -3, -4, & -5 TO KSC

FABRICATION & DELIVERY OF S-II-6 TO MTF

ACTIVATION OF CHECKOUT STATION IX AT SEAL BEACH

ACTIVATION OF CHECKOUT A₁/C₁ TEST COMPLEX AT MTF

COMPLETION OF DYNAMIC TESTING AT MSFC (S-II-F/D)

COMPLETION OF BATTLESHIP CONFIDENCE IMPROVEMENT TEST PROGRAM
AT SANTA SUSANA

COMPLETION OF QUALIFICATION PROGRAM

SLIDE 21 PROGRAM PROJECTIONS FOR CALENDAR YEAR 1967

shipment from Seal Beach. We have gone in, found the cracks, and we have made the repairs and shipped it to Mississippi. We climbed in the tank and checked again, and the shipping didn't cause additional cracks. We have fired them, then we have been back in the tank now at the cape on the S-II-1, and there were no additional cracks. It all goes back to initial handling, really, and, in some cases, to design. We had some sharp corners where we should have had some smoother radii.

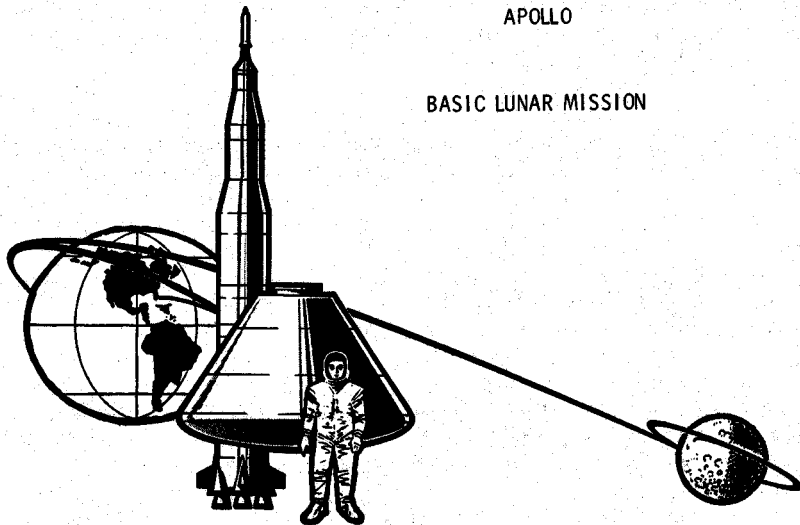
Mr. TEAGUE. Bob, we saw that big shaker at Huntsville working. The whole stack was in the shaker filled with water.

Bob, on your five follow-ups, tell us a little about your production line. What are the problems there? What happens to your production line when you have to have some firm decisions?

Mr. GREER. We need a full go-ahead in March. We have been living off the long leadtime procurement.

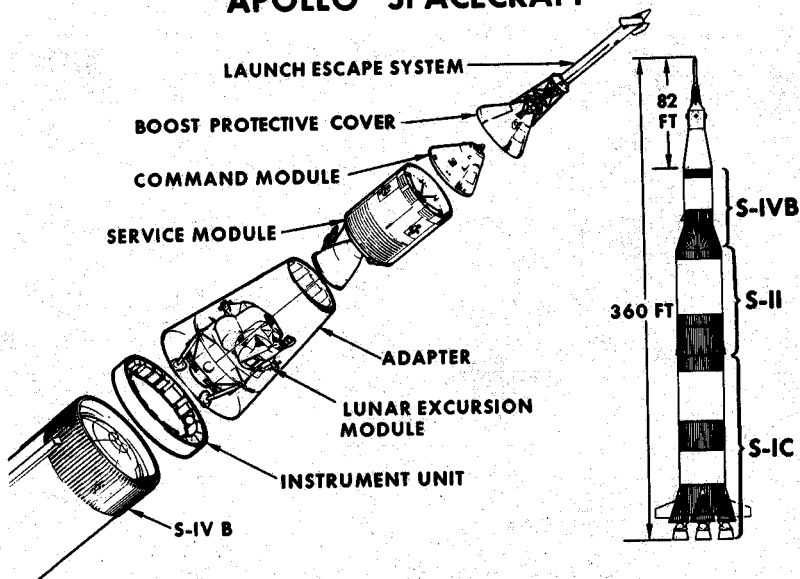
DALE D. MYERS. (Slide 22) Gentlemen, I'd like to go into the CSM portion of our work here at S. & I.D. and give you a quick rundown on the status of the program. I would like to keep this very informal. If there are any questions that occur to you as I run through these slides, don't hesitate to interrupt. Be sure to question me if I use an unfamiliar acronym in my briefing, because we use these extensively in the Apollo program as part of our communication system.

The portion that I'm responsible for is the launch escape system, the command module, the service module, and the spacecraft lunar module adapter, which is the carrier for the LM (slide 23). This adapter splits back after the end of the boost into orbit to expose the LM for the command module docking.



SLIDE 22. APOLLO BASIC LUNAR MISSION

APOLLO SPACECRAFT

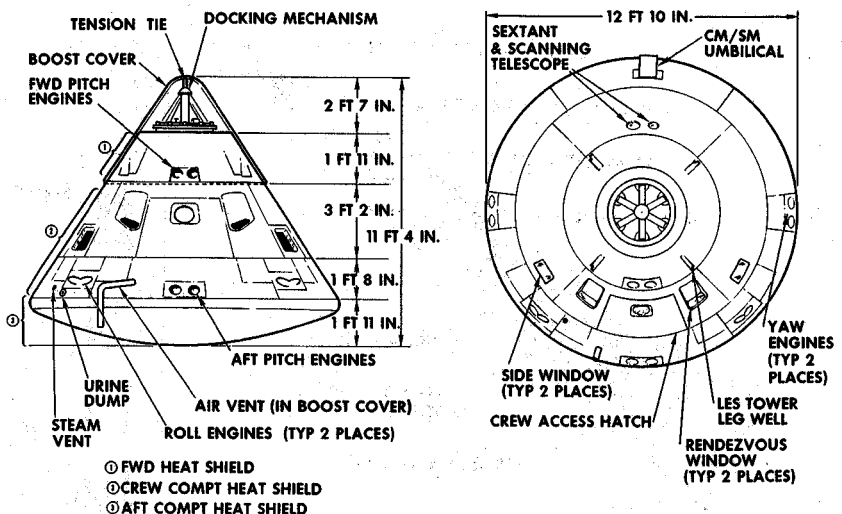


SLIDE 23. APOLLO SPACECRAFT

Just a brief feeling of the size of the spacecraft (slide 24): The command module is about 12 feet high and about 13 feet across at the widest place—down in the heat shield area. The service module looks like this with the engine bell (slide 25). However, you don't see the bell in building 290 since it is left off until we go to Florida. We actually check out the spacecraft engine actuation with a little adapter that hooks onto this frame. With the engine bell, the total service module is about 24 feet high and matches the 13-foot diameter at the base of the command module.

Now, giving you a little more depth in the areas that we have here in the division (slide 26), the command module is built here, and the service module is built here. However, some of the structure of the service module is built at our Tulsa facility. The launch escape system and the boost protective cover that goes over the command module for boost are built here. This is the spacecraft lunar module adapter; it is built at our Tulsa facility and is carried to Florida in the superguppy. Some of our early SLA's were flown to Florida, a helicopter dragged them through the air—quite an operation. Fortunately, we have the superguppy now for transport. Ground support equipment for support of all these activities, spare parts, the trainers, and the management of subcontractors that we have in large quantities constitute the balance of our responsibilities in the program. Of course, facility and test site activation down at Florida, where we do much of the ground support equipment installation, is also a major task. In some cases, the cases where equipment can be common to the Grumman LM, we supply GSE to support that program too.

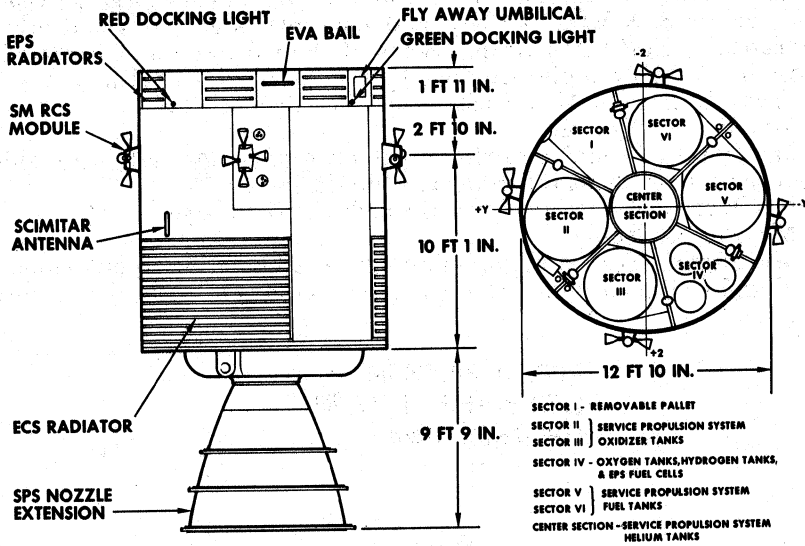
COMMAND MODULE EXTERIOR DIMENSIONS & DETAILS



SLIDE 24. COMMAND MODULE EXTERIOR DIMENSIONS AND DETAILS

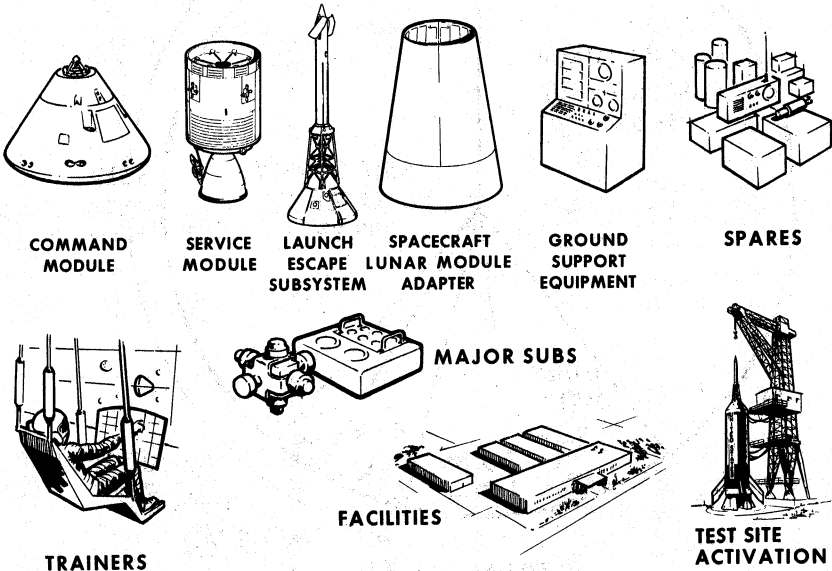
SERVICE MODULE

EXTERIOR DIMENSIONS & DETAILS



SLIDE 25. SERVICE MODULE EXTERIOR DIMENSIONS AND DETAILS

APOLLO SPACECRAFT S&ID RESPONSIBILITIES



INTERFACE WITH ASSOCIATE CONTRACTORS (GUIDANCE & NAVIGATION, ACCEPTANCE CHECKOUT EQUIPMENT, LUNAR EXCURSION MODULE, ETC.)

SLIDE 26. APOLLO SPACECRAFT S. & I.D. RESPONSIBILITIES

Distribution of costs in the program is shown here (slide 27). Through November of 1966, we have about 50 percent of our dollars going outside North American Aviation. We have a large percentage here at S. & I.D., Downey, and some pieces at Tulsa and other divisions of North American. Some of the more complex electronic assemblies, for example, are done by the Autonetics Division.

JERRY L. PETTIS. May I ask a question about that?

Mr. MYERS. Yes, sir.

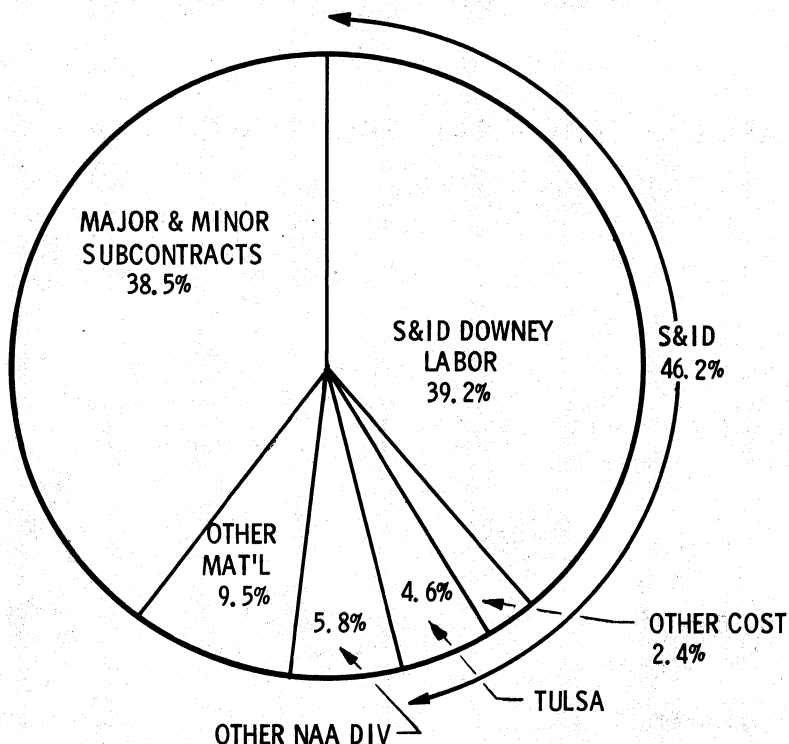
Mr. PETTIS. Would a further breakdown of major and minor subcontracts show about the same as yours in labor?

Mr. MYERS. As you go down through the tiers beyond us?

Mr. PETTIS. Yes.

Mr. MYERS. Yes; in major subcontractors like Minneapolis-Honeywell and Collins it does. If I can move to the next chart, I can show

APOLLO PROGRAM
DISTRIBUTION OF EFFORT
(THRU NOV 1966)

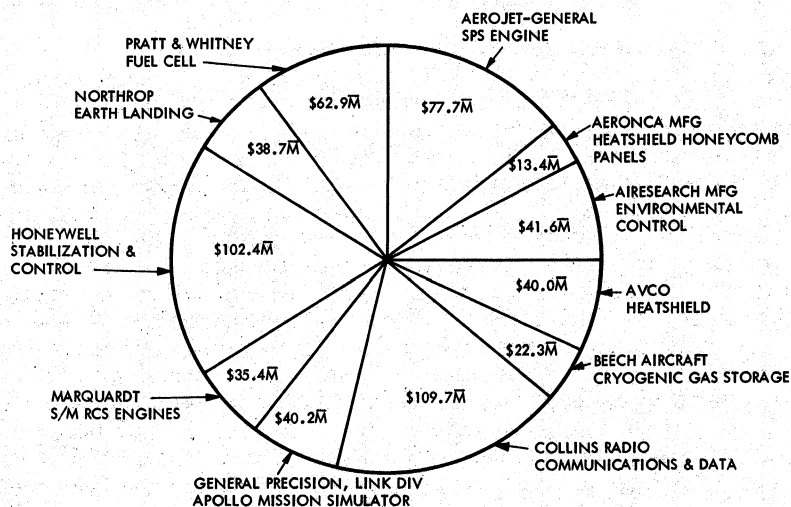


SLIDE 27. APOLLO PROGRAM DISTRIBUTION OF EFFORT—THROUGH NOVEMBER 1966

you some of the larger subcontract activities (slide 28). Honeywell, for example, the last time I saw their activity, was about 40 percent subcontracted below them. So, in that sense, the breakdown stays fairly much in the same pattern. I think the nature of the command module tends to break into these fairly heavy subcontracts and tiers of subcontractors below, as opposed to the boosters where there is so much basic fabrication involving a single contractor.

Here are the big ones for us: Honeywell, for stabilization and control of the spacecraft; Aerojet-General for the engine that brings us back from the moon. This is the service propulsion system engine, 22,000 pounds thrust, that's the bell that you see on the back of the service module. Collins supplies all the radio communications and data equipment for us. Other elements of the program: cryogenics storage, built by Beech in Colorado; AiResearch, over here at the Garrett Corp., builds our environmental control system; Northrop does the parachutes for us; Pratt & Whitney the fuel cells, and so on in these smaller groups. These have been the big ones, and these are the ones that we have the very special management system for within the division. We call it designated subsystem program management. Reporting to me, they do technical and funding management of these major subcontractors. We also have a lot of what we call associate contractors (slide 29). They are not subcontractors to us, but are primes to the NASA, and we have many pieces that fit together with other pieces supplied by these people. For example, MIT does the guidance and navigation equipment technical management; AC Electronics actually builds the guidance and navigation equipment, and we

APOLLO MAJOR SUBCONTRACTORS



TOTAL \$584.3M BASIC PROGRAM
EXPENDITURES THRU NOV 1966

SLIDE 28. APOLLO MAJOR SUBCONTRACTORS

APOLLO ASSOCIATE CONTRACTORS

MIT	GUID & NAV EQUIP. - TECH MGMT
AC ELECTRONICS	GUID & NAV EQUIP. - MFG
CHRYSLER	S-I
BOEING	S-IC
NAA S&ID	S-II
DOUGLAS	S-IV & S-IVB
GENERAL ELECTRIC	ACCEPTANCE CHECKOUT EQUIP.
GRUMMAN	LUNAR MODULE
HAMILTON	
STANDARD	SPACESUIT & PORTABLE EQUIP.

SLIDE 29. APOLLO ASSOCIATE CONTRACTORS

install that equipment in our spacecraft. So, they are not subcontractors to us, but we still have to have the right connections to tie all this stuff together. There is quite a management job in working with these other companies to develop what we call interface control documents which define exactly, to every little bit and piece, how these things all fit together, both technically in their performance and also physically.

Mr. TEAGUE. How do you coordinate that?

Mr. MYERS. We have interface meetings, as we call them, where we define with them all the interactions that occur with the spacecraft and the lunar module. Grumman is really one of the lesser problems in our coordination. The kinds of things we deal with, for example, would be in the docking probe to be sure all the meshes and mechanisms are right. We build a piece called the drogue, that is shipped to Grumman to install in their module, which provides the docking interface directly with us. In addition to that, we have to define the loads, the inertial loads, for example, as we dock, so their structure is built to properly match ours. Wire runs between us are worked out in these interface meetings, and all this is approved by NASA. They sit in on the meetings with us, or we have summary meetings where we finally settle these interface problems. It has worked out quite well with our interface with Grumman. Actually, we have had more problems in the areas of guidance and navigation because their wires sort of run like veins through the spacecraft, and there have been much more detailed technical interfaces there. It has taken more effort with the guidance and navigation equipment than it has with the lunar module.

To give you an idea of the things that have been accomplished in 1966, I have put down what I considered some of the highlights (slide 30). In January, we had our final water impact test for Spacecraft 007, which is structurally the same as our spacecraft and is dropped from our tower out here into a big pool to give worst-case landing conditions of the spacecraft in water. From White Sands we shot Spacecraft 002, also a spacecraft structure, in what we call the tumbling-abort test, where we simulate breakup of the booster and pulling away of the command module from the booster in a tumbling mode, which snaps the chutes out in that condition. It's a worst-case abort and we tested it in January.

In February, we had Spacecraft 009's mission. I have a chart on that I'd like to show you later. In March, 004A's thermal structural tests were completed. We heated the outside of the command module to simulate the reentry conditions.

Spacecraft 011's qualification tests were completed. We call it certification testing. Actually, it's a qualification program where we conduct tests under the worst conditions that we expect to occur to the equipment under vibrating conditions, atmospheric conditions, humidity, radio interference, and so on. This is to be sure, essentially, that we have designed the equipment with the factor of safety with respect to all the conditions that it can meet in flight. We call that a certifica-

APOLLO HI-LITES

1966

JAN	2ND (FINAL) SC 007 WATER IMPACT TEST SC 002 TUMBLING ABORT TEST
FEB	SC 009 MISSION ACCOMPLISHED
MAR	SC 004A THERMAL STRUCTURAL TESTS COMPLETED
APR	SC 011 CERTIFICATION TESTING COMPLETED 14-DAY MANNED ENVIRONMENTAL CONTROL SUBSYSTEM BREADBOARD TEST COMPLETED
JUN	SC 004 STRUCTURAL TESTING COMPLETED SERVICE PROPULSION SUBSYSTEM STANDPIPE FIX VERIFIED ON SC 001
AUG	CM-004A STRUCTURAL TESTING COMPLETED SC 008 THERMAL-VACUUM TESTS (NO. 1 & 2) AT MSC SC 011 MISSION ACCOMPLISHED
SEP	SC 011 TESTING AT WSTF COMPLETED SC 012 DESIGN CERTIFICATION REVIEW SC 007 FLOTATION TEST AT MSC

SLIDE 30. APOLLO HIGHLIGHTS

tion test plan. That was completed for Spacecraft 011 in April.

The 14-day manned environmental control test on a breadboard here at Downey was completed in April. Our structural testing was completed in June. We had a problem on Spacecraft 009 in flight that had never shown up in any of our ground testing. It was associated with not only zero-G environment, but with the combination of zero-G environment and thrusting of the service module. We found this from our flight data. We had completed our testing at White Sands in April, had to make correction, and retest the fix, as shown, in June.

In August, we completed our command module static tests; Spacecraft 008's thermal vacuum tests, in a large vacuum chamber at MSC Houston, were completed; and Spacecraft 011's mission was accomplished.

In September, we had the completion of our service propulsion system testing at White Sands. Spacecraft 012 had the design certification review, in which we reviewed all of the design criteria and systems, with Dr. Mueller and the various NASA program and technical people, and had one last look at the design elements of the system prior to the certification that the spacecraft was ready to go.

Spacecraft 007 flotation tests at MSC, where the astronauts participated in egress and recovery operations, were completed in September.

In October, we moved into our block II parachute qualification drops at El Centro (slide 31). We had our first 750-second block II

APOLLO HI-LITES (CONTINUED)

1966

OCT	FIRST BLOCK II PARACHUTE QUAL DROP AT EL CENTRO 750-SEC BLOCK II SERVICE PROPULSION SUBSYSTEM FIRING AT ARNOLD ENGINEERING DEVELOPMENT CENTER SC 008 THERMAL-VACUUM RETEST (NO. 3) AT MSC
NOV	FIRST 2S-1 WATER IMPACT TEST
DEC	FINAL 2S-1 WATER IMPACT TEST LUNAR MAPPING & SURVEY SUBSYSTEM PRELIMINARY DESIGN REVIEW

1967

JAN	SC 017/AS 501 TESTS COMPLETED AT KSC COMPLETED BLOCK II EARTH LANDING SYSTEM QUALIFICATION DROPS - EL CENTRO
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SLIDE 31. APOLLO HIGHLIGHTS

service propulsion subsystem firing in an altitude chamber back at the Arnold Engineering Development Center, and this is, by the way, about a factor of almost 2 over the longest running of the engine which we would require in a lunar-return operation. So, we satisfied ourselves that we have a topnotch service propulsion system engine.

Spacecraft 008's thermal vacuum retest No. 3 was completed at MSC. This is a condition where we operate in a vacuum chamber with the spacecraft operating as it would in flight. In November, we had our first block II water impact tests and completed that program in December. We have brought in the lunar mapping and survey subsystem as an element of additional equipment in the Apollo program, and in December we held a preliminary design definition with the NASA.

In January, Spacecraft 017-501 mating tests were completed at KSC, and we completed our block II earth landing system qualification drops at El Centro. That's the test program where a C-133 drops a boilerplate version of our spacecraft to verify the parachute operation.

I am going to talk about the program schedules. These schedules have not been adjusted for the impact of Spacecraft 012 (slide 32). The schedule effects of the considerations of the NASA board can't be included here because their considerations are not completed.

APOLLO CSM PROGRAM

IMPACT OF SC 012 IS NOT REFLECTED IN

PROGRAM PLANS PENDING NASA 204 BOARD CONCLUSIONS

AND RECOMMENDATIONS

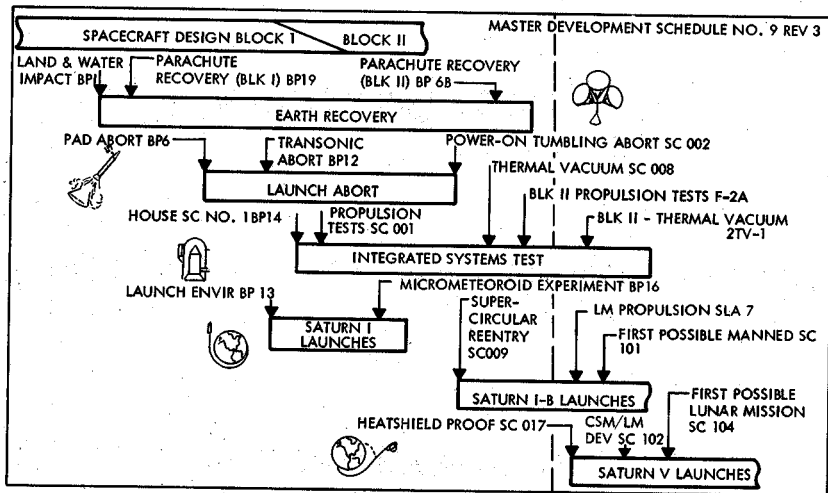
SLIDE 32. APOLLO COMMAND AND SERVICE MODULES PROGRAM

Based upon their conclusions and recommendations, we will be reviewing these schedules to see what, if any, impact there will be.

Mr. TEAGUE. Will you hold up, because of not knowing what is the impact on the program?

Mr. MYERS. Right now, nothing is being held up. We are moving as if there were no changes to be accomplished, and that seems the better part of valor at the moment because we don't really know what the impact will be. We have no idea whether there will be a large or small impact. If it's some small thing we can find, it may have no impact. If it is a larger design change, of course, then we will have to look back across the program to see what will slow down or stop in place or what will take care of this. Since the board had not reached any conclusions on that, we felt, with the NASA, that it was best to just keep things moving as they are right now. And now the overall picture of where we stand in the program at this time (slide 33). We have actually gone through many of the conceptual and design-definition phases of the program, and most elements of the program now have been proven in one series of tests or another. You can see that early in the program we put a lot of emphasis on the land and water impact and the parachute system—the things we could get on with as components in development. We then began to get to the place where we had to go through transonic aborts in tests down at White Sands (our launch abort operations where we are simulating conditions of loss of either the booster or other elements of launch operation). Here we tested, for the first time, all of the systems together in what we call the house spacecraft. Then we went

APOLLO PROGRAM

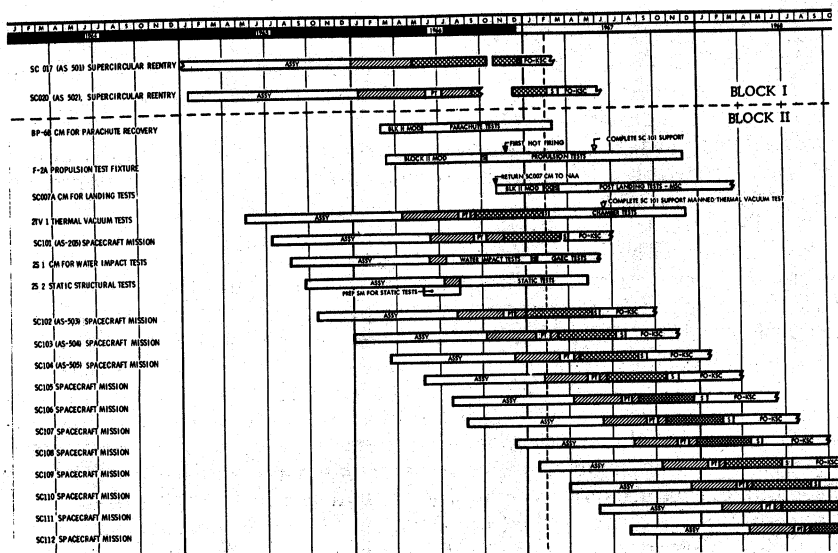


SLIDE 33. APOLLO PROGRAM

We went through launch environments where we determined the vibration environment and the "G" effects of the launch in the Saturn I launching; supported the micrometeoroid experiments with Boiler plate 16; went into our first of the real spacecraft flights here in February on Spacecraft 009; and had our Spacecraft 011 launch in August, which was a three-quarter Earth orbit flight. Then, we move to the position where we're getting ready for the first possible manned spacecraft flight for Spacecraft 101. These are all Saturn I-B launches, and down at the cape now we are getting ready for the first of the Saturn V launches with the unmanned flight of Spacecraft 017. That should be accomplished in the second quarter of this year. That flight, by the way, will be a flight which will reenter with lunar reentry velocities. It will be the first opportunity we have to actually match lunar reentry velocities of 36,000 feet per second on reentry to test our heat shield.

As far as program schedules are concerned, this is the status of the program at the moment (slide 34). Spacecraft 017 is down at the cape. It is just now being destacked from its mechanical fit with the Saturn V booster. We have some testing to do back at what we call the MSOB, the manned spacecraft operations building. Then we go back onto the stack with the Saturn S-II that's moving into position for this launch here in the second quarter.

GROUND & FLIGHT TEST SCHEDULE



SLIDE 34. GROUND AND FLIGHT TEST SCHEDULE

Spacecraft 020 is still here at Downey. You saw it out in building 290, and it will be shipped in about March to the field. Our Boilerplate 6-B parachute recovery test program is complete. Our propulsion test fixture at White Sands is moving along on schedule for the support of the program.

Spacecraft 007A is a modification. We have added the Block II configuration changes, and it will be shipped to Houston for post-landing tests there. Then we come to our vacuum-test model. This is a spacecraft which has essentially a flight spacecraft capability. It has a couple of things left out of it; we left out the cryotanks because we don't use them in the vacuum chamber at Houston. That is going to be moving down to Houston in the next month for extensive chamber tests in their large chamber down there. Spacecraft 101, which is the first manned spacecraft capability, is in building 290 going through its last part of checkout. It's about 2 weeks down on schedule. There have been some directions from the customer that have added work activity to it, and we have had some problems in the details of getting parts to support the manufacture of that ship. As we move on down the schedule, you can see all ships beyond this are on schedule within our manufacturing operation.

Mr. PETTIS. Mr. Chairman, may I ask what you mean when you say "customer"?

Mr. MYERS. NASA.

Mr. PETTIS. NASA is the customer?

Mr. MYERS. Yes. There are bits and pieces that come in as a direction from NASA that affect the spacecraft configuration and leave us open to negotiation of schedule impacts. They are generally, as you can see, quite detailed things. We are not having large changes.

Mr. PETTIS. This leads to one other question, if I may, Mr. Chairman?

Mr. TEAGUE. Go right ahead.

Mr. PETTIS. Then, when you have a simulated test or a test of one kind or another at the cape, it's the customer who calls for that test rather than you or someone else?

Mr. MYERS. Right. We work out the details of the test plan and the detailed procedures to be accomplished to meet an overall objective that NASA has.

Mr. TEAGUE. It's a cooperative effort, is it not?

Mr. MYERS. You bet. We work together on these things. In fact, it starts very early in the program in the definition of all the different types of tests that involve suppliers tests of their parts, then our tests of those parts in assembly, then the tests in the spacecraft—first, as individual systems tests, then as integrated tests, where we play them all together. We go through planning that involves sort of a trade-off with NASA—is it better to do a particular test here or in Florida. All that coordination activity is going on in a continuous operation. Then, when we get to Florida, what we call operational checkout procedures are written by us to meet these overall plans that have previously been worked out between us and NASA. So it's very much an integrated activity. Of course, they are the customer, they are the guys in charge, and if they direct us to make a change in a

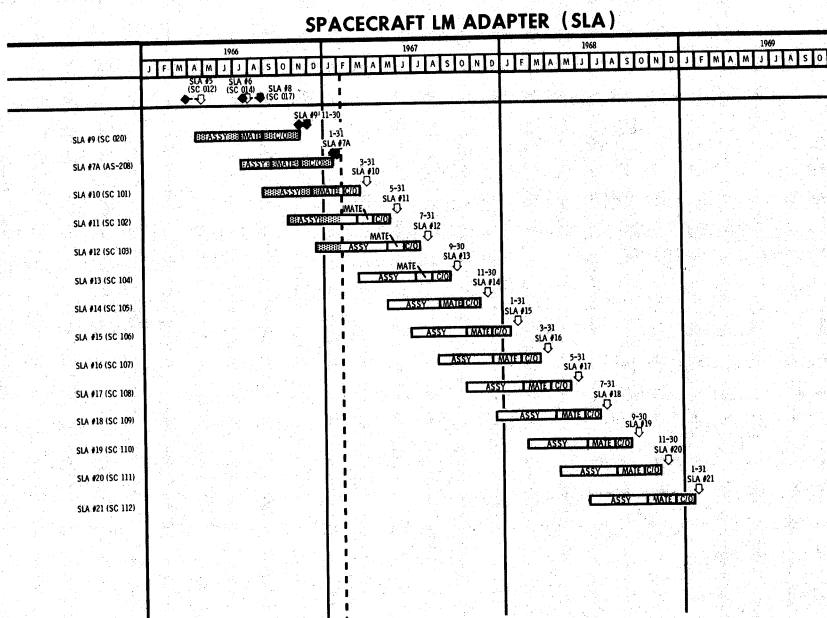
different way, why, we either go along with them, or I take it on up through Joe Shea, and we reach a conclusion that is satisfactory to both parties.

The other major element of hardware that's involved—the spacecraft lunar module adapter (SLA)—is built at our Tulsa facility. They have been on schedule throughout the program and are continuing to meet schedule (slide 35).

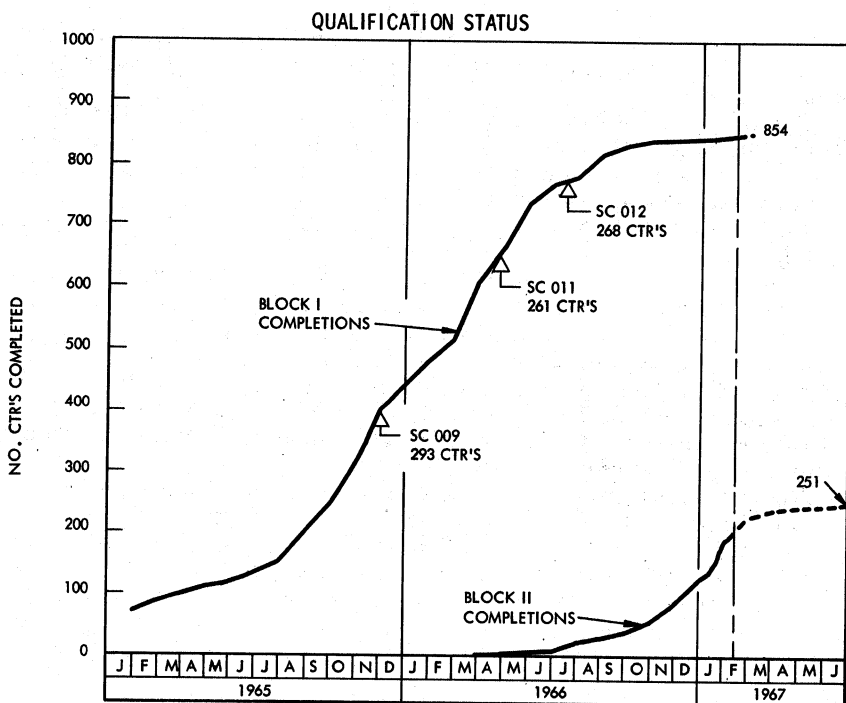
This qualification program is something that we track almost daily (slide 36). This is one of the key elements of the program, for without qualified parts you are always in a position that next week some test may fail which will require a change back in the spacecraft. So we press very hard on these qualifications, and we have pressed to meet qualification at a time prior to delivery of the spacecraft. That is our goal and our objective in the program. We don't always meet this because, as you see in some of our problem areas that we have had in the program this year, there are things that do cause trouble and do need correction and requalification before we can actually fly.

ROBERT F. FREITAG. Dale, can you mention the difference between block I and block II? I don't think you mentioned that.

Mr. MYERS. I'm sorry, I had planned that to be in the first chart that I had. The basic change between block I and block II is the docking capability. What happened is that when the program began there were decisions yet to be made concerning the mode of operation to make the lunar landing. So, we went ahead with the early defini-



SLIDE 35. SPACECRAFT LUNAR MODULE ADAPTER



SLIDE 36. QUALIFICATION STATUS

tion of the Apollo. When the lunar module came into the program, there was a requirement to change the top of the spacecraft to include a docking mechanism so the LM could dock with the command module. At that time, there was also additional identification of some of the environments of space that had come out of the Mercury and Gemini programs; so, there were other changes that were coming into the program at that time, and we felt we ought to group those changes, make the docking change, and include some of the elements that had come out of the Gemini and Mercury programs. We called it the block II configuration and defined what we had been building as block I. Detailed changes in panel configuration, lighting of the panels, and some weight saving in the service module all came in and were defined as block II configuration.

As you can see, the block I qualification is essentially completed. We have two items yet to complete in support of spacecraft 017 and 020. They are special items that weren't needed in these earlier spacecraft, so they had been planned out beyond 012 certification completion.

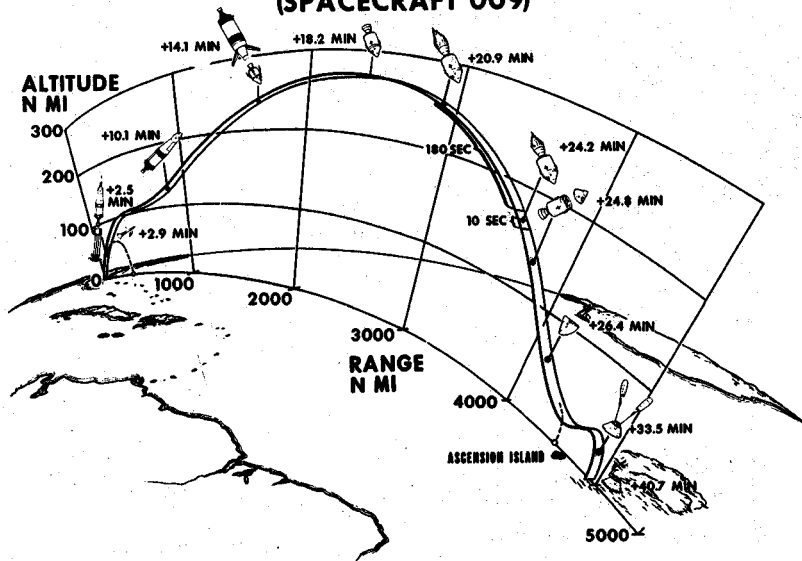
In the block II program, we are moving up just about on schedule—a plan that we had set up about a year ago. We're about 2 weeks behind in our qualification of block II, and we put a tremendous amount of our management effort into trying to complete this qualification prior to delivery of that spacecraft. It looks like we're going to do it.

The big payoff came in these flights. Spacecraft 009 was launched in February (slide 37). It was a fairly complex mission for the first unmanned mission in the program. We went through boost and separation at about 10 minutes; we separated the command and service modules from the spacecraft LM adapter here in about 14 minutes. We use many of the systems of the spacecraft for that separation. We then went through a realignment of the spacecraft for a first burn, which lasted 180 seconds, on our service propulsion system. We stopped it, had a restart for 10 seconds, did a turnaround and separation, reentry, parachutes out, and landing. The major problem that we had in it was this helium ingestion problem in the service propulsion system, and I think that's interesting in itself. There was an ingestion of helium into the engine which changed the mixture ratio and changed the thrust of the engine. It didn't give us any safety problems on the flight; however, it did make the thrust of the engine uneven, so we changed the standpipe to eliminate that helium ingestion for the flight of spacecraft 011 and subsequent vehicles.

Mr. TEAGUE. Dale, did these objects come out of 009?

Mr. MYERS. Yes, those are pieces of 009's heat shield. As you can see, they aren't very heavily burned. The reentry velocities on 009 and 011 were up in the 29,000 feet-per-second range. We drive back in with the service module to increase the velocity higher than the normal reentry of an earth-orbiting satellite, but we don't get up to the lunar reentry velocities of 36,000 feet per second, so the heat shield doesn't really get burned too badly from these flights with the Saturn I-B.

APOLLO SATURN 201 MISSION (SPACECRAFT 009)



SLIDE 37. APOLLO SATURN 201 MISSION—SPACECRAFT 009

Spacecraft 011 was an even more complicated mission (slide 38). We had four service propulsion system burns. We had tests of our reaction control system during this flight. This was a three-quarter earth-orbit flight and used many of the elements of the ground tracking network that will be used in the Apollo program. That flight was essentially 100 percent successful. I think the only anomaly in it was an argument we ended up with finally, on whether the ground system or the spacecraft system was causing some decrease in the power output of an antenna system on reentry. But it was a highly successful flight.

Mr. PETTIS. Mr. Chairman, may I interrupt there on a question not related to this exactly?

Do we use nationals of other countries in these tracking stations as employees, or are they all American?

Mr. TEAGUE. Yes; many. Jerry, I think when I was in Australia, we had five Americans down there and I don't know how many thousand British and Australians. In Madrid just as soon as they can they will turn it over to nationals. We put the minimum number of Americans in tracking stations.

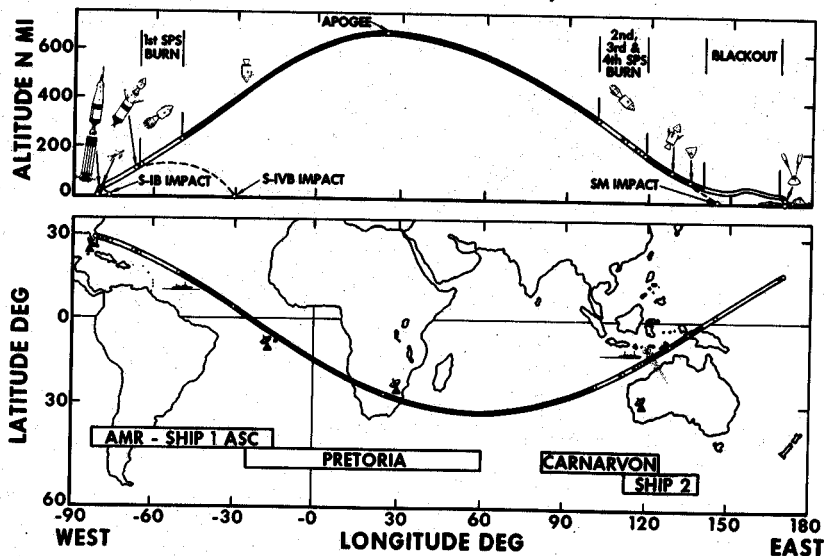
Right, Bob?

Mr. FREITAG. That's right, sir. And they have access to information.

Mr. TEAGUE. Carnarvon, as I remember, was mostly British.

Mr. MYERS. Here is a list of what I call problems and solutions in 1966 (slide 39). They deal with the kinds of things we have run into during the development program and as we have moved toward completion of the major problems in the program. You will find that

APOLLO SATURN 202 MISSION (SPACECRAFT 011)



SLIDE 38. APOLLO SATURN 202 MISSION—SPACECRAFT 011